BUREAU OF RECLAMATION

The 2021 Annual Monitoring Report for the coordinated 2019 National Marine Fisheries Service and 2020 U.S. Fish and Wildlife Service Biological Opinions on Klamath Project Operations

Klamath Project, Oregon/California
Interior Region 10 California Great Basin

U.S. Department of the Interior **March 1, 2022**

Mission Statements

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The Department of the Interior plays a central role in how the United States stewards its public lands, increases environmental protections, pursues environmental justice, and honors our nation-to-nation relationship with Tribes.

Abbreviations and Acronyms

USFWS 2020 BiOp	*Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker*
NMFS 2019 BiOp	*Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response: Klamath Project Operations from April 1, 2019, through March 31, 2024: NMFS Consultation Number: WCR-2019-11512, WCRO-2019-00113*
AF	acre-feet
AFA	Annual Funding Agreement
BA/Modified 2018 Operations Plan	*Final Biological Assessment on the Effects of the Proposed Action to Operations Plan Operate the Klamath Project from April 1, 2019, through March 31, 2024, that was transmitted to the Services on December 21, 2018, with associated addenda dated February 15, 2019, March 25, 2019, and October 11, 2019.*
C. shasta	*Ceratonova shasta*
CA-NV FHC	California-Nevada Fish Health Center
CDFW	California Department of Fish and Wildlife
cfs	cubic-feet-per-second
CPUE	Catch Per Unit Effort
DCP	Data Collection Platform
EWA	Environmental Water Account
ESA	Endangered Species Act
FES	A Canal Fish Evaluation Station
FY	Fiscal Year
IGD	Iron Gate Dam
IOP	Interim Operating Plan (2020-2022)
KBAO	Klamath Basin Area Office Klamath
KBHDB	Basin Hydrologic Database
KBPM	Klamath Basin Planning Model
KID	Klamath Irrigation District
KLS	Klamath largescale sucker
KRCR	Klamath River Coho Restoration
KSARP	Klamath Sucker Assisted Rearing Program
KSD	Klamath Straits Drain
LKNWR	Lower Klamath National Wildlife Refuge
LKR	Lower Klamath River
LRS	Lost River sucker
LRD	Link River Dam

LRDC	Lost River Diversion Channel
LVID	Langell Valley Irrigation District
M&RR	Monitoring and Reporting Requirement
mm	millimeter
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
OSU	Oregon State University
PIT	Passive Integrated Transponder
POM	Prevalence of mortality
POR	period of record
PORmax	period of record maximum
Project	Klamath Project
QA/QC	Quality Assurance/Quality Control
Reclamation	Bureau of Reclamation
RIT	Recovery Implementation Team
RR	Reporting Requirement
SCADA	Supervisory Control and Data Acquisition
SL	Standard length
SNS	shortnose sucker
SONCC	Southern Oregon Northern California Coast
T&Cs	Terms and Conditions
TID	Tulelake Irrigation District
TLS1A	Tule Lake Sump 1A
TOP	Temporary Operating Procedures
UKL	Upper Klamath Lake
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WY	Water Year

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Introduction and Background

The purpose of this 2021 Annual Monitoring Report is for the Bureau of Reclamation (Reclamation) to meet and report certain requirements outlined in the separate, but coordinated U.S. Fish and Wildlife Service's (USFWS) *Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker* (USFWS 2020 BiOp) issued on April 10, 2020, and the National Marine Fisheries Service's (NMFS) *Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Klamath Project Operations from April 1, 2019 through March 31, 2024* (NMFS 2019 BiOp) issued on March 29, 2019 (collectively; "Services" and "BiOps"). Under both BiOps, Reclamation is required to provide the Services with an Annual Monitoring Report due March 1 every year, for the purpose of conveying information related to progress on implementing the conservation measures, Terms and Conditions (T&Cs), and associated monitoring requirements. To implement this requirement, Reclamation consulted with the Services to develop a format for the Annual Monitoring Report.

Annual reporting is required to address progress on: (1) implementation of the Environmental Water Account (EWA); (2) implementation of the T&Cs and associated monitoring; (3) budgeting for implementation of the T&Cs; and (4) implementing the conservation measures that were included in the Proposed Action described in Reclamation's *Final Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project from April 1, 2019, through March 31, 2024* that was transmitted to the Services on December 21, 2018, with associated addenda dated February 15, 2019, March 25, 2019, October 11, 2019 in addition to the 2020-2022 Interim Operations Plan (IOP; herein referred to as the Proposed Action or Modified 2018 Operations Plan/IOP) agreed to under a 2020 Stipulated Stay of Litigation between the Yurok Tribe, Pacific Coast Federation of Fishermen's Associations, Institute for Fisheries Resources, the Klamath Water Users Association, and the NMFS.

Table 1 indicates the T&Cs and associated monitoring and reporting requirements (M&RR; RR) required under the Services' BiOps.

Reclamation and the Services have determined that one annual meeting is sufficient to meet the intention of the RR under both BiOps and will work toward formal clarification in the near future.

Reclamation has worked diligently since receipt of both BiOps to ensure all T&Cs and associated monitoring requirements were met in a timely manner.

Implementation of Terms and Conditions and Associated Monitoring Requirements

Reclamation has made considerable progress implementing the T&Cs and conducting the associated M&RR for both BiOps (Table 1). Table 1 provides a summary of the T&Cs included in BiOps and the status of completion.

Progress on Implementation of Conservation Measures

Table 1. Summary of Terms and Conditions (T&C), Monitoring and Reporting Requirements (M&RR), and Reporting Requirements from 2019 and 2020 BiOps and Implementation Status.

	Title of Requirement	Page Number	Implemented
	USFWS Requirements		
T&C 1a	Ensure that No Unnecessary Actions are Taken that Increase Entrainment of Listed Suckers at Link River Dam (LRD)	212	Y
T&C 1b	Actions to Determine Klamath Project (Project) Supply and Take Corrective Actions to Avoid Going below Minimum Elevations in Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A	212	Y
T&C 1c	Take Corrective Actions to Ensure Upper Klamath Lake (UKL) Elevations are Managed within the Scope of the Proposed Action	213	Y
T&C 1d	Activate the A Canal Pumped-bypass System Annually by August 1	214	Y
T&C 1e[3]	Develop and Implement a Hydrologic Data Management Plan	214	Y
T&C 1f	Annual Identification and Installation of Needed Water-Level and Flow-Measurement Gages in the Project	214	Y
T&C 1g[1]	Monitor Keno Impoundment and UKL Project-Related Diversions	215	Y
T&C 1h[4]	Operation Updates	215	Y
T&C 1i[2]	Consultation with the Services on Release of Project Call Water	216	Y
T&C 1j	Ensure Project Impacts on Spawning access in Clear Lake are not Greater than Anticipated	216	Y
	Monitoring and Reporting Requirements		
M&RR 1.1a	Methods, results, and recommendations to improve monitoring related to A Canal Fish Evaluation Station monitoring efforts.	217	Y, Appendix B
M&RR 1.1b	Flow monitoring at the A Canal, and Link River, Clear Lake Reservoir, Gerber Dams as surrogate for larval sucker entrainment monitoring.	218	Y,

M&RR 1.1c	Canal Salvage Report	219	Y, Appendix C
M&RR 2	Adult Lost River Sucker and Shortnose Sucker Monitoring in Project Reservoirs	219	Y, Appendix D
M&RR 3.3a	Project Implementation and Hydrologic Monitoring using the Klamath Basin Planning Model	219	Y
M&RR 3.3b[5]	Project Implementation and Hydrologic Monitoring Monitor and Maintain Water-Level and Flow-Measurement Gages throughout the Project	220	Y
	NMFS Requirements		
T&C 1A	Take actions to Ensure Environmental Water Account (EWA) Distribution and Iron Gate Dam (IGD) Flows are Managed within the Scope of the Proposed Action	280	Y
T&C 1B[1]	Monitor Keno Impoundment and UKL Project-Related Diversions	281	Y
T&C 1C[2]	Consultation with the Services on Release of Project Call Water	281-282	Y
T&C 1D[3]	Develop and Implement a Hydrological and Biological Data Management Plan	282	Y
T&C 1E[4]	Operations Spreadsheet	282-283	Y
T&C 1F	Development of a Post-Facilities removal Operations plan	283	Y
T&C 1G	Abundance, prevalence of infection, and predicted mortality of emigrating juvenile salmon in the Klamath River	283-284	Y
T&C 1H	In the event of funding lapses, fund the monitoring and reporting requirements of DFW Shasta River Rotary Screw Trap	284	Y
T&C 1I	Fund Development and Refinement of Klamath River Decision Support Tools	284	Y
T&C 1J	Fund Fish Modeling to evaluate the effects of *Ceratonovashasta* spore concentrations on the survival of out-migrating coho salmon in the Klamath River	285	Y
T&C 2A*	Terms and Conditions Implementation Plan	285	Y
T&C 2B	**Reporting Requirements**	**285-286**	**Y**
T&C 2B RR 1	Report all measured accretion data (LRD to Keno Dam) and all measured and estimated accretion data (Keno Dam to IGD) in addition to all of the EWA, Project and Refuge information.	286	Y
T&C 2B RR 2	Assessment in coordination with the Services of EWA used and EWA remaining on May 1 of each calendar year.	286	Y
T&C 2B RR 3	Report of daily and monthly reductions of IGD releases due to UKL control logic on a monthly basis (particularly important in the March through June period).	286	Y

T&C 2B RR 4	Monthly update reports for the formulaic approach during the fall/winter operations including reductions to IGD flows due to UKL control logic, UKL net inflow, LRD to IGD accretions, UKL levels, winter Project deliveries, Refuge deliveries, and any other relevant data NMFS identifies during implementation of the Proposed Action.	286	Y
T&C 2B RR 5	Rolling monthly and annual graphs of the observed, smoothed UKL net inflow and observed IGD flows versus the one and two week forecasted IGD flow schedules for the entire water year.	286	Y
T&C 2B RR 6	Report on the type and location of each restoration project implemented. The monitoring report shall include the total number of coho salmon captured, relocated, injured, or killed for each restoration project, and will be submitted annually by March 1 to the NMFS Northern California office.	286	Y
T&C 2C[5]	Monitor and Maintain Water Level and Flow Management Gages Throughout the Project	286-287	Y

[1,2,3,4,5] Term and Condition similar in both BiOps.

*This requirement follows the T&C in USFWS's 2020 BiOp and is unnumbered whereas, it was listed as a T&C from NMFS.

Budgeting for Implementation of Terms and Conditions

As specified in the BiOps, Reclamation committed to fund actions related to species monitoring, research, and recovery. Table 2 provides a summary of funding actions Reclamation has taken to comply with the BiOps.

Table 2. Summary of Funding Actions for Terms and Conditions.

	USFWS Requirements			
Title		**Organization**	**Funding Amount**	**Funded in Fiscal Year (FY) 2021**
SARP telemetry in Upper Klamath Lake (UKL)		USFWS	$ 415,504.27	Y
Thiamine Deficiency Evaluation in SNS and LRS life stages (USFWS)		USFWS	$ 17,419.16	Y
Thiamine Deficiency Evaluation in SNS and LRS life stages (USGS)		USGS	$ 29,900.00	Y
Semi-Natural Wetland		USFWS	$ 440,296.52	Y
UKL juvenile sucker cohort tracking		USGS	$ 143,285	Y
UKL Adult Monitoring		USGS	$ 654,445	Y
Clear Lake Adult Monitoring		USGS	$ 175,190	Y
Sucker Captive Propagation		USFWS	$ 300,000	Y
	NMFS Requirements			
	Coho Salmon Disease	Oregon State	$ 834,951	Y
		USFWS CA- NV FHC[1]	$ 117,201	Y
	Outmigration and disease modeling (S3)	USFWS-Arcata and USGS	$ 171,750	Y
Ensure Key Monitoring	Outmigrant Screw trapping FY2021	USFWS Arcata	$ 238,935	Y
		Yurok Tribe	$113,742	Y
		Karuk Tribe	$25,581	Y

	NMFS Requirements			
Title		**Organization**	**Funding Amount**	**Funded in Fiscal Year (FY) 2021**
	Yurok AFA	Yurok Tribe	$ 250,000	Y
	Hoopa Valley Tribe AFA	Hoopa Valley Tribe	$ 127,071	Y
Other Requirements	Klamath River Coho Restoration Grant Program	Competitive Grant	$500,000 Combined with FY 2020 funding ($700,000) for a total of $1.2 Million awarded in November 2021[2]	N
	Karuk Annual Funding Agreement (AFA)	Karuk Tribe	$339,940	Y

[1]California-Nevada Fish Health Center (CA-NV FHC).

[2] In 2020 Reclamation worked to secure a new grant administrator for the program as the existing 5-year agreement for program administration was scheduled to conclude at the end of fiscal year 2020. However, due to extenuating circumstances, the new funding agreement for a new grant administrator was not able to be awarded in 2020. Reclamation therefore extended the administrative duties of NFWF to September 30, 2021. In November 2021, Reclamation awarded a new funding agreement to NFWF to administer the program until September 2024. Conservation funding for FY 2020 ($700,000) was combined with FY 2021 ($500,000) funding for a total of $1.2 Million awarded in November 2021.

Reclamation successfully implemented Conservation Measures in 2021 as indicated in (Table 3).

Table 3. Summary of 2019 and 2020 BiOp Conservation Measures and Implementation Status.

Summary of Conservation Measures			
Title of Conservation Measure	**Requirement Reference**	**Page Number**	**Implemented**
U.S. Fish and Wildlife Service (USFWS) Conservation Measures			
Canal Salvage	4.6.1	60	Y, Appx. B
Sucker Assisted Rearing Program	4.6.2	60-61	Y, USFWS CM
Sucker Monitoring and Recovery Program Participation	4.6.3	61-62	Y, M&RR2
National Marine Fisheries Service Conservation Measures			
Coho Restoration Grant Program	1.3.5.1	54	Y, T&C 2B RR 6

Estimating Incidental Take of Lost River Suckers and Shortnose Suckers

Section 9 of the Endangered Species Act (ESA) makes it unlawful for any person to "take" any endangered species. The ESA defines "take" to mean to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." However, under ESA section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of an agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with an Incidental Take Statement. The USFWS 2020 BiOp provided Reclamation with allowable annual take of ESA-listed suckers in the Incidental Take Statement. Appendix E contains estimates

for the incidental take of federally endangered Lost River suckers (*Deltistes luxatus; LRS)* and shortnose suckers (*Chasmistes brevirostris; SNS)*, by life-stage and activity, resulting from Reclamation's Klamath Project (Project) operations analyzed in the USFWS 2020 BiOp.

Coordinated (U.S. Fish and Wildlife Service & National Marine Fisheries Service) Reporting Requirements and Terms and Conditions

T&C 2B-RR 2 (NMFS)- Progress of Implementation of Environmental Water Account

Requirement

The NMFS 2019 BiOp states:

"Reclamation shall complete an assessment in coordination with the Services of EWA used and EWA remaining on May 1 of each calendar year."

Results

On October 15, 2019, Reclamation requested clarification regarding the due date of the EWA assessment required under Reporting Requirement 2B.2 as the information necessary to complete the assessment is not available until after the due date included in the 2019 NMFS BiOp. Reclamation requested that the assessment be completed and transmitted to the Services as soon as practicable, but no later than May 15 of each year. On October 22, 2019, NMFS concurred with Reclamation's clarification thereby modifying the due date of the assessment. In early January 2021 Reclamation began coordinating with the Services to determine the causative factors for potentially falling outside BiOp "boundary conditions." From this, it was determined the causative factors were consecutive critically dry years and extraordinary hydrologic conditions. In coordination with the Services, Reclamation developed Temporary Operating Procedures (TOP) for Project operations for the April through September 2021 time period to address immediate and temporary competing resource needs. The TOP was transmitted to the Services on April 13, 2021, and Reclamation then transitioned to TOP on April 14, 2021, after the completion of environmental compliance. On May 26, 2021, Reclamation transmitted an assessment of the EWA management to NMFS. Based on this assessment and as a result of critically dry and extraordinary hydrologic conditions, it was determined that EWA distribution would not materialize in the amounts necessary to meet the June 1 EWA spending threshold of 61 percent nor the September 30 EWA spending threshold of 95 percent. On June 11, 2021, NMFS responded to Reclamation's assessment and corrective actions. It was recognized by NMFS that Reclamation has taken action to closely coordinate with the Services consistent with the process outlined in T&C 1A of the NMFS 2019 BiOp.

Additionally, under T&C 1A Reclamation is required to immediately notify NMFS and confer with the Services to determine causative factors and in-season corrective actions, as well as complete an assessment of EWA used and EWA remaining on May 1 of each calendar year. For more details on actual EWA expenditures during the 2021 spring/summer irrigation season, refer to the T&C 1A results section.

T&C Implementation Plan (USFWS) and T&C 2A (NMFS)

Requirement

The NMFS 2019 BiOp states:

> *"Reclamation shall develop an "Implementation Plan" in consultation with the Services describing how Reclamation intends to implement the Terms and Conditions in this opinion. The Implementation Plan shall describe the process Reclamation will follow to ensure necessary resources are allocated to implement the Terms and Conditions and to complete required monitoring and reporting by the due dates. Having this agreement will ensure that terms and conditions are reliably and fully implemented and will aid in identifying any problems as early as possible and help avoid any additional incidental take of listed species above those considered in this opinion.*
>
> *We understand that this Opinion contains multiple requirements for deliverables and that it might be infeasible for Reclamation to have all of them prepared by the stated due dates because of staffing and funding limitations; therefore, we will work with Reclamation to develop an acceptable implementation schedule. Reclamation shall develop the draft Implementation Plan in consultation with the Services, provide the Services a draft Implementation Plan for review and comment by October 1, 2019, provide the Services a final Implementation Plan that addresses the Services' comments by December 15, 2019, and implement the final Implementation Plan thereafter; these dates can be adjusted to ensure a high quality product if Reclamation, NMFS and USFWS agree that it is necessary."*

Results

Reclamation's Term and Condition Implementation Plan was developed, and the first draft was delivered to the Services on October 1, 2019. Reclamation's final draft was submitted to the Services on December 13, 2019 and is still in effect as of 2021.

T&C 1e (USFWS) and T&C 1D (NMFS) – Develop and Implement a Hydrological and Biological Data Management Plan

Requirement

The USFWS 2020 BiOp and NMFS 2019 BiOp state:

> *Effective management of hydrological and biological data is essential to ensure that take and other Project effects can be evaluated and to maintain a period of record for future consultations. Therefore, Reclamation shall develop a data management plan that will include the details of how data will be stored and shared with the Service and other agencies. Reclamation shall develop the plan in coordination with the Service, providing a draft plan by October 1, 2020, and a final plan by December 1, 2020; these dates can be adjusted to ensure a high-quality product if both Reclamation and the Service agree that it is necessary.*
>
> *The plan shall include standard operating procedures for collecting, reviewing, finalizing, storing, and presenting Project reservoir elevation, flow, diversion, and pumping data as well as biological data collected during salvage, FES monitoring, and Gerber Reservoir monitoring. The plan shall include annual updates to hydrological data sets, including those described in Section 7.1, as well as plans for finalizing historical data sets such that official versions are available upon request or via web hosting. The plan shall also include an annual update of the KBPM, with output provided to the Service.*

Results

Reclamation submitted the final *Hydrological and Biological Data Management Plan – Klamath Project Operations* to USFWS and NMFS on December 1, 2020. Consistent with T&C 1e (USFWS) and 1D (NMFS) Reclamation submitted a draft of the Plan to the Services on October 1, 2020, for review and comment such that a final Plan could be submitted on December 1, 2020, and implemented thereafter. Based on feedback received during that review, Reclamation revised the draft Plan.

While the Klamath Basin Hydrologic Database (KBHDB) is in continuous development, the database is in full production mode. Web-hosted KBHDB data query services are publicly accessible via the following link:
https://www.usbr.gov/lc/region/g4000/riverops/_HdbWebQuery.html.

KBAO Water Operations Division staff typically use KBHDB on a daily basis for daily operations tasks.

Reclamation has developed two biological databases in Microsoft Access for A Canal Fish Evaluation Station (FES) and Gerber Reservoir. These continue to be updated and they have been shared with USFWS. The most recent version of the Gerber database was sent to USFWS on January 20, 2022, and the most recent version of the FES database was sent on January 25, 2022. Reclamation continues to pursue the development of a more robust database in coordination with USFWS.

T&C 1g (USFWS) and T&C 1B (NMFS) – Monitor Keno Impoundment and Upper Klamath Lake Project-Related Diversions

Requirement

The USFWS 2020 BiOp and 2019 NMFS BiOp states:

> *"Reclamation shall monitor Project-related diversions in the Keno Impoundment and around UKL to reduce uncertainty associated with the unknown volumes of water delivered to these lands under operation of the Klamath Project. Monitoring and annual reporting of these Project-related diversions helps ensure that the diversion volumes are consistent with what was modeled in the KBPM for the POR and will provide NMFS with more certainty regarding KBPM output, specifically IGD flows, Project deliveries and UKL elevations. More certainty in water allocations will help improve the KBPM and reduce error through time, and aid in in-season management to address disease issues and minimize incidental take. Reclamation shall also compile monitoring data for these diversions on an annual basis for the duration of the proposed action and assemble the data into a complete data set to be reported in the Annual Monitoring Report and incorporated into the next proposed action."*

The USFWS 2020 BiOp T&C 1g and NMFS 2019 BiOp T&C 1B requires Reclamation to monitor Project-related un-gaged diversions adjacent UKL and along the Keno Impoundment. This data collection effort will help minimize uncertainty in the unknown volume of water delivered to lands operating within the Project; these data will increase accuracy and overall skill in the Klamath Basin Planning Model (KBPM); and NMFS will be provided more certainty per KBPM outputs—specifically, Iron Gate Dam (IGD) flows, Project deliveries, and UKL elevations. Additionally, Reclamation is required to compile monitoring data for these diversions on an annual basis for the duration of the Proposed Action and assemble data into a complete data set to be reported in the Annual Monitoring Report and incorporated into the next Proposed Action.

Results

Reclamation staff continued to engage Keno Impoundment and UKL Project-related contractors during the 2021 spring-summer irrigation season in order to obtain flow-measurement and/or delivery data. Due to the exceptionally dry water year and lack of adequate supply to fully support irrigation operations, Reclamation ordered Keno Impoundment contractors (who are all Warren Act contract holders) to cease all diversions along the Keno Impoundment.

T&C 1h (USFWS) and T&C 1E (NMFS)- Operation Updates and Operations Spreadsheet

Requirement

The USFWS 2020 BiOp and 2019 NMFS BiOp states:

> *As of early February 2019, Reclamation was developing one or more operations spreadsheets that will be used to implement the proposed action. The spreadsheet(s) translate the code in the KBPM and the detailed written description of the proposed action provided in Appendix 4 of Reclamation's biological assessment (USBR 2018a Appendix 4) into an operations spreadsheet(s). The operations spreadsheet(s) will bring together the input data (e.g., UKL net inflow, UKL elevations, NRCS forecasts), equations (e.g., seasonal water supply allocations, daily EWA releases), and relationships (e.g., EWA is calculated before Project Supply, methods by which the Lower Klamath Lake Refuge may be delivered water) that Reclamation will use on a daily basis to implement the proposed action. Reclamation shall provide the Services with the proposed action implementation and operation spreadsheet(s) by June 1, 2020, and at least annually thereafter. Reclamation shall provide updates to the Service within 2 weeks of Reclamation's acceptance and use of an updated operations spreadsheet(s). Reclamation shall provide the Services with a tutorial explaining how Reclamation uses the spreadsheet, which data may be updated, and which data should remain fixed and not be changed or updated. This tutorial will be offered, as Reclamation operations' staff are available, to new Service employees with relevant designations (e.g., hydrologist) as they join Services' staff throughout the life of this BiOp.*

Results

Reclamation provided operations updates to the Services throughout the 2021 season via weekly Flow Account Scheduling Technical Advisory coordination meetings, periodic phone calls, and other meeting platforms. A current copy of the operations spreadsheet (referred to as the "PA Calculator") is provided to the Services whenever they request it.

T&C 1i (USFWS) and T&C 1C (NMFS)- Consultation with the Services on Release of Project Call Water

Requirement

In USFWS T&C 1i, and NMFS T&C 1C, Reclamation is required to produce a robust water quantification tool or method by June 1, 2021, to quantify an amount of inflow that may result from a Project Call.

Specifically, the USFWS BiOp states:

> *"As of early February 2019, Reclamation was developing one or more operations spreadsheets that will be used to implement the proposed action. The spreadsheet(s) translate the code in the KBPM and the detailed*

written description of the proposed action provided in Appendix 4 of Reclamation's biological assessment (USBR 2018a Appendix 4) into an operations spreadsheet(s). The operations spreadsheet(s) will bring together the input data (e.g., UKL net inflow, UKL elevations, NRCS forecasts), equations (e.g., seasonal water supply allocations, daily EWA releases), and relationships (e.g., EWA is calculated before Project Supply, methods by which the Lower Klamath Lake Refuge may be delivered water) that Reclamation will use on a daily basis to implement the proposed action. Reclamation shall provide the Services with the proposed action implementation and operation spreadsheet(s) by June 1, 2020, and at least annually thereafter. Reclamation shall provide updates to the Service within 2 weeks of Reclamation's acceptance and use of an updated operations spreadsheet(s). Reclamation shall provide the Services with a tutorial explaining how Reclamation uses the spreadsheet, which data may be updated, and which data should remain fixed and not be changed or updated. This tutorial will be offered, as Reclamation operations' staff are available, to new Service employees with relevant designations (e.g., hydrologist) as they join Services' staff throughout the life of this BiOp."

Results

Reclamation received a presentation from U.S. Geological Survey (USGS) in May 2019 on potential approaches for quantifying call water. The approaches did not completely satisfy the requirements and after internal discussions, development of a more suitable methodology was included in a proposed scope of work for a consulting contract to be obligated at the start of fiscal year (FY) 2021. The consultant identified several critical data areas (including crop mixtures and additional evaporation data) necessary for completing work on this task. Coordination with Reclamation's Technical Services Center indicated this information would become available as part of the Natural Flow Study and quantification needed to wait until then, including a revised bathymetry of Upper Klamath Lake (field work largely completed in 2021). In addition, a Project call was not made in 2021, thus, Reclamation did not consult with the Services on such an action in water year (WY) 2021.

Based on upcoming data collected by newly installed stream gauges and evaporation platforms, along with the new technical studies, and no recent calls from irrigators, Reclamation continues to develop a regulatory call tool that will incorporate new information and will be robust enough to withstand technical and legal scrutiny. Our earliest estimate for completion of such a tool is the end of 2022. In the meantime, Reclamation will provide the Services with quarterly progress reports during 2022.

M&RR 3.3b (USFWS) and T&C 2C (NMFS) - Monitor and Maintain Water Level and Flow-Measurement Gages throughout the Project

Requirements

M&RR 3.3b of the USFWS 2020 BiOp requires:

"Water level and flow measurement gages shall be maintained throughout the Project in accordance with the Hydrological and Biological Data Management Plan developed under T&C 1e. Water levels in Project reservoirs shall be monitored at frequent intervals, at least daily, and Reclamation shall make those data available to the Services via a secure website or other appropriate means. An annual summary of reservoir water level and flow-monitoring compliance shall be included in the Annual Monitoring Report due March 1 every year.

Accurate hydrologic data are needed to calculate Project water use and effects on listed suckers and ensure compliance with this Incidental Take Statement. Monitoring shall be conducted at the following, and the list

shall be evaluated annually and could include additional monitoring if needed.

1. A Canal
2. Lost River to Lost River Diversion Channel at Lost River Diversion
3. Ady Canal (at the point of common diversion for agriculture and the Lower Klamath Lake NWR, and at the point of entry into the Refuge)
4. North Canal
5. Straits Drain at State Line and at pumps F and FF
6. West Side Power Canal at Link River Dam
7. Station 48
8. Miller Hill Pumping Plant
9. Miller Hill spill
10. UKL, Clear Lake, Gerber Reservoir*, and Tule Lake Sump 1A**
11. Link River Dam
12. Keno Dam
13. Iron Gate Dam
*14. Reductions to IGD flow due to UKL control logic ***
*15. EWA spending ***
*16. Ungaged Project diversion in Keno Impoundment and around UKL***

The NMFS 2019 BiOp includes T&C 2C requires water level and flow measurement at the same sites but excludes a few that have been identified above with *. Additionally, items above with ** are not listed in NMFS 2019 T&C 2C but are requirements listed elsewhere.

Results

All of the required locations (See Table 4 and Figure 1) were successfully monitored on a daily basis during the 2021 WY and the following was observed:

The Klamath Basin experienced an exceptionally dry water year in 2021. Snowpack was 74 percent of median on January 31, the snow water equivalent Basin Index percent of median increased to 96 percent by February 28, decreased to 84 percent by March 31, and sharply dropped to 39 percent by April 30, 2021. Water Year-to-Date precipitation at the SnoTel sites was 69 percent by April 30. The 2021 WY (October 2020 – September 2021) cumulative precipitation at the Klamath Falls airport was 5.90 inches, 43 percent of the water year average. There were no flood control operations during the 2021 WY.

Table 4. 2021 BiOp Gaging Station Summary.

Gaging Station	Operator	Gage	Data Collection
A Canal	Klamath Irrigation District (KID)	Flow, level	Radio Telemetry
Lost River Diversion Channel at Lost River Diversion Dam	Bureau of Reclamation (Reclamation)	Flow, reservoir elevation	Satellite Telemetry
Ady Canal at point of common agriculture diversion	U.S. Geological Survey (USGS)	Flow, level	Satellite Telemetry
Ady Canal at the point of entry into the Refuge	USGS	Flow, level	Satellite Telemetry
North Canal	USGS	Flow, level	Satellite Telemetry
Klamath Straits Drain (KSD) at Stateline	Reclamation	Flow, level**	Site Visit (daily)
KSD at Pumps F and FF	USGS	Flow, level	Satellite Telemetry
West Side Power Canal	NA	NA	NA
Station 48	Tulelake Irrigation District (TID)	Flow	Radio Telemetry
Miller Hill Pumping Plant	KID	Flow	Radio Telemetry
Miller Hill spill	KID	Flow **	Site Visit (daily)
Upper Klamath Lake (UKL)	USGS	Reservoir elevation	Satellite Telemetry
Clear Lake Reservoir	Reclamation/Langell Valley Irrigation District (LVID)	Flow**, reservoir elevation	Satellite Telemetry
Gerber Reservoir	Reclamation/LVID	Flow**, reservoir elevation	Satellite Telemetry
Tule Lake Sump 1A	TID	Sump elevation**	Site Visit (daily)
Link River Dam	PacifiCorp	Flow, level	Satellite Telemetry
Keno Dam	PacifiCorp	Reservoir elevation	Satellite Telemetry
Iron Gate Dam (IGD)	PacifiCorp	Reservoir elevation	Satellite Telemetry
IGD flow reductions due to UKL control logic	Reclamation	Calculation	NA
Environmental Water Account spending	Reclamation	Calculation	NA
Ungaged Klamath Project Diversions around Keno and UKL	Property owners	Site visit/Landowner reporting	Site Visit (annual)

** indicates measurement taken by daily site visit

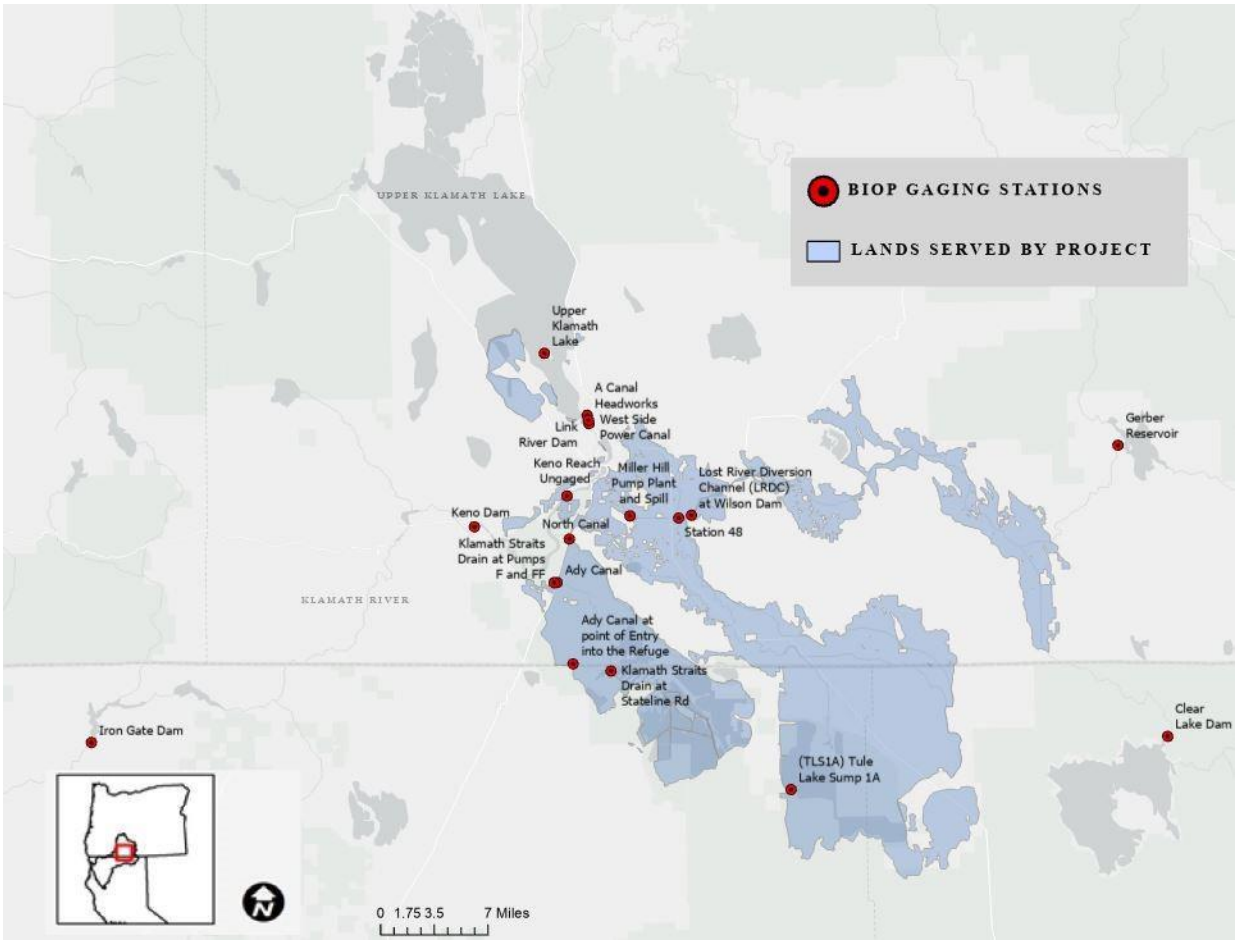

Figure 1. NMFS 2019 and USFWS 2020 BiOp Required Gaging Station Locations.

Upper Klamath Lake Hydrology and Project Diversions

In 2021, based on the Interim Operations Plan and requirements of the BiOps, resulted in an allocation of 33,000 AF of Project Supply for the spring/summer irrigation season. Based on operations constraints that require considerably more volume for an operation project (including canal watering up, contractual delivery requirements, etc.) Reclamation announced that no water was available for agricultural diversions for the spring/summer irrigation season. In response, A Canal, Station 48, Miller Hill, and Ady Canal were shut during the season. KDD did divert 32,200 AF through North Canal citing their supplemental water right from the State of Oregon. The 32,200 AF is 9.2 percent of the 350,000 AF full supply, and approximately 9.9 percent of the 324,000 AF delivered from UKL during a typical spring/summer irrigation season.

Figure 2 shows the UKL elevations versus the central tendency in WY 2021. The central tendency is an estimate of UKL elevations as modeled for the USFWS 2020 BiOp. If UKL elevations fall below the central tendency, outflows are reduced. Figure 2 shows that UKL elevations remained below the central tendency throughout the 2021 WY.

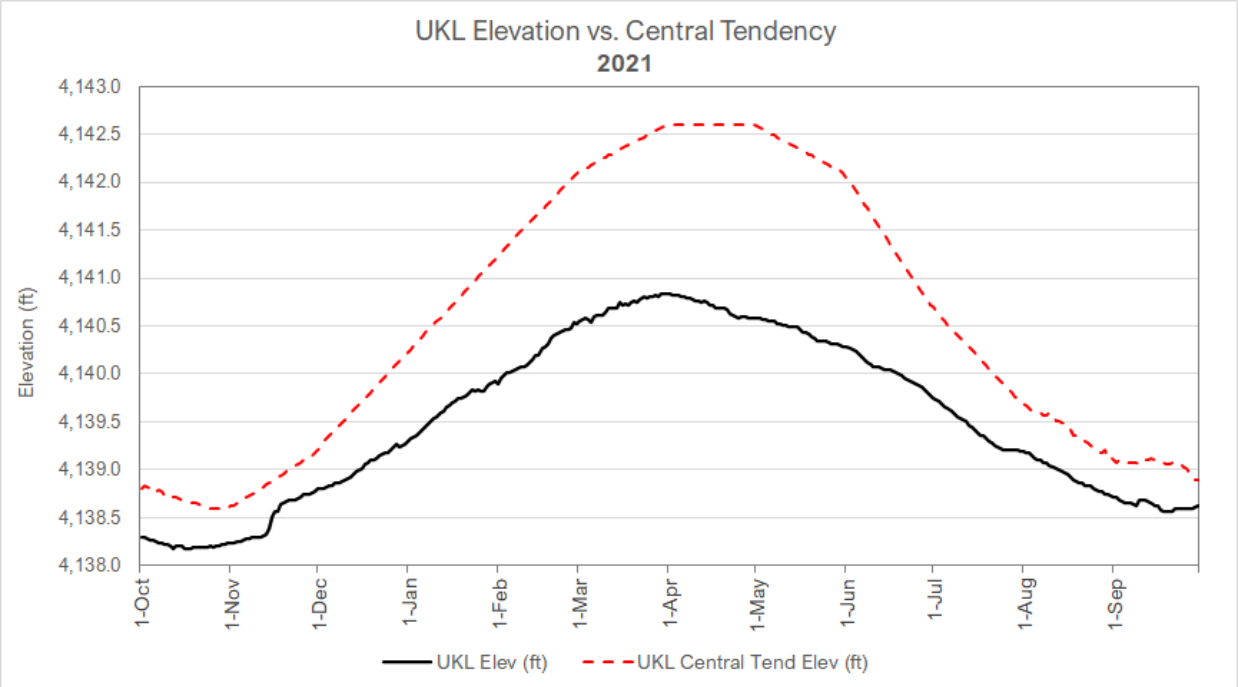

Figure 2. Upper Klamath Lake (UKL) and Central Tendency Elevations in Water Year 2021.

Clear Lake Reservoir Hydrology and Releases

Clear Lake Reservoir releases totaled 22,619 AF during WY 2021. Deliveries from Clear Lake Reservoir began April 19, 2021, and continued through August 9, 2021, to meet Eastside irrigation demand. Historically, Clear Lake Reservoir deliveries have ranged between 30,000 and 40,000 AF of water annually, with a daily average discharge of 186 AF, except during drought or flood control conditions.

Clear Lake Reservoir began WY 2021 with an elevation of 4,525.95 feet on October 1, was 4,525.60 feet on March 1, and ended the water year with an elevation of 4,521.57 feet on September 30 (Figure 3). Reservoir elevations remained above the required minimum elevation of 4,520.6 feet throughout the entire 2021 WY.

On average, Clear Lake Reservoir has an elevation of 4,528.5 feet on March 1 and an elevation of 4,526.4 feet on September 30.

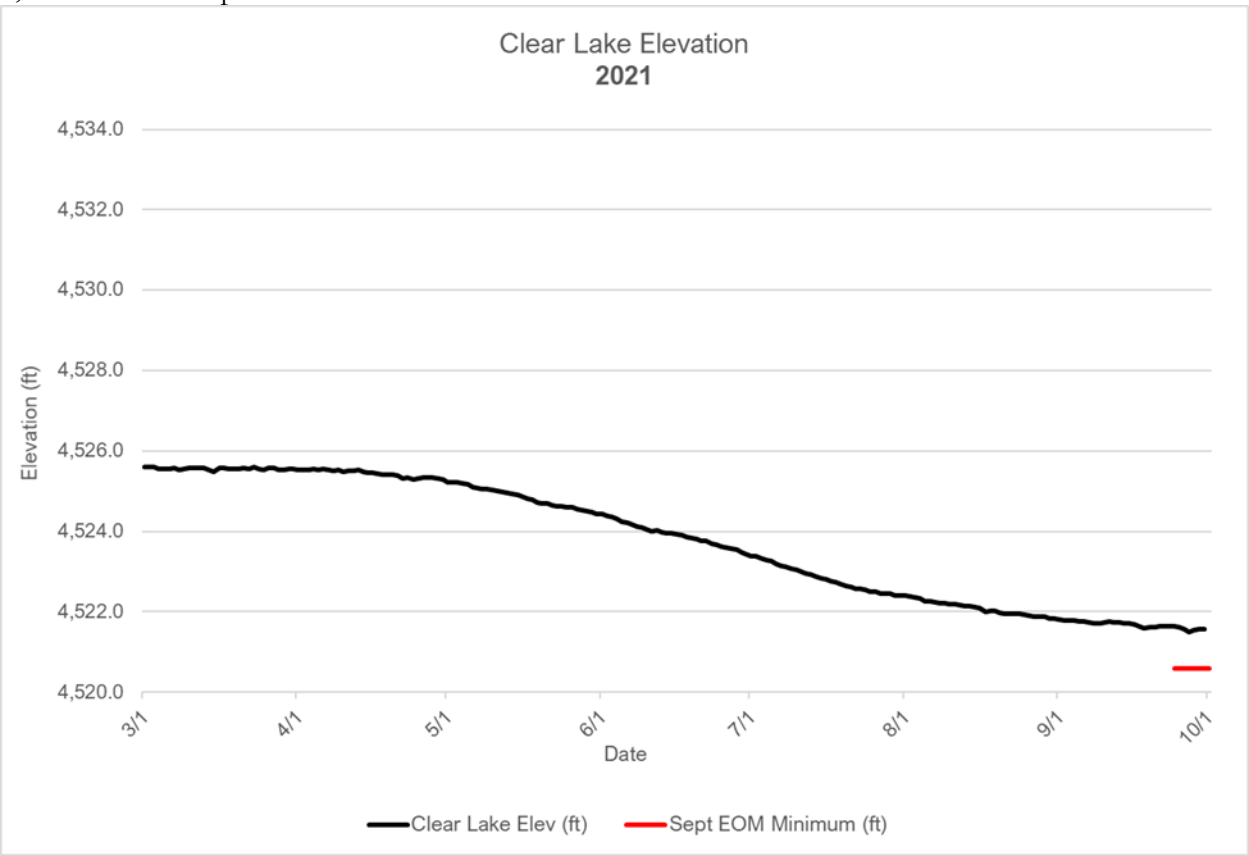

Figure 3. Clear Lake Reservoir Elevations in 2021 and end of September Minimum.

Gerber Reservoir Hydrology and Releases

Gerber Reservoir releases totaled 22,640 AF during WY 2021. Water was delivered from April 14, 2021, and continued through August 19, 2021, to meet Eastside irrigation demand. Historically, Gerber Reservoir deliveries have ranged between 30,000 and 40,000 AF of water with an average daily discharge rate of 180 AF, except during drought or flood control conditions.

Gerber Reservoir began WY 2021 with an elevation of 4,815.74 feet on October 1, was 4,814.21 feet by March 1, and ended the water year with an elevation of 4,799.57 feet on September 30. As depicted in Figure 4 below, Gerber Reservoir maintained elevations above the required minimum elevation of 4,798.1 feet throughout WY 2021.

On average, Gerber Reservoir has an elevation of 4,820.8 feet on March 1 and an elevation of 4,815.2 feet on September 30.

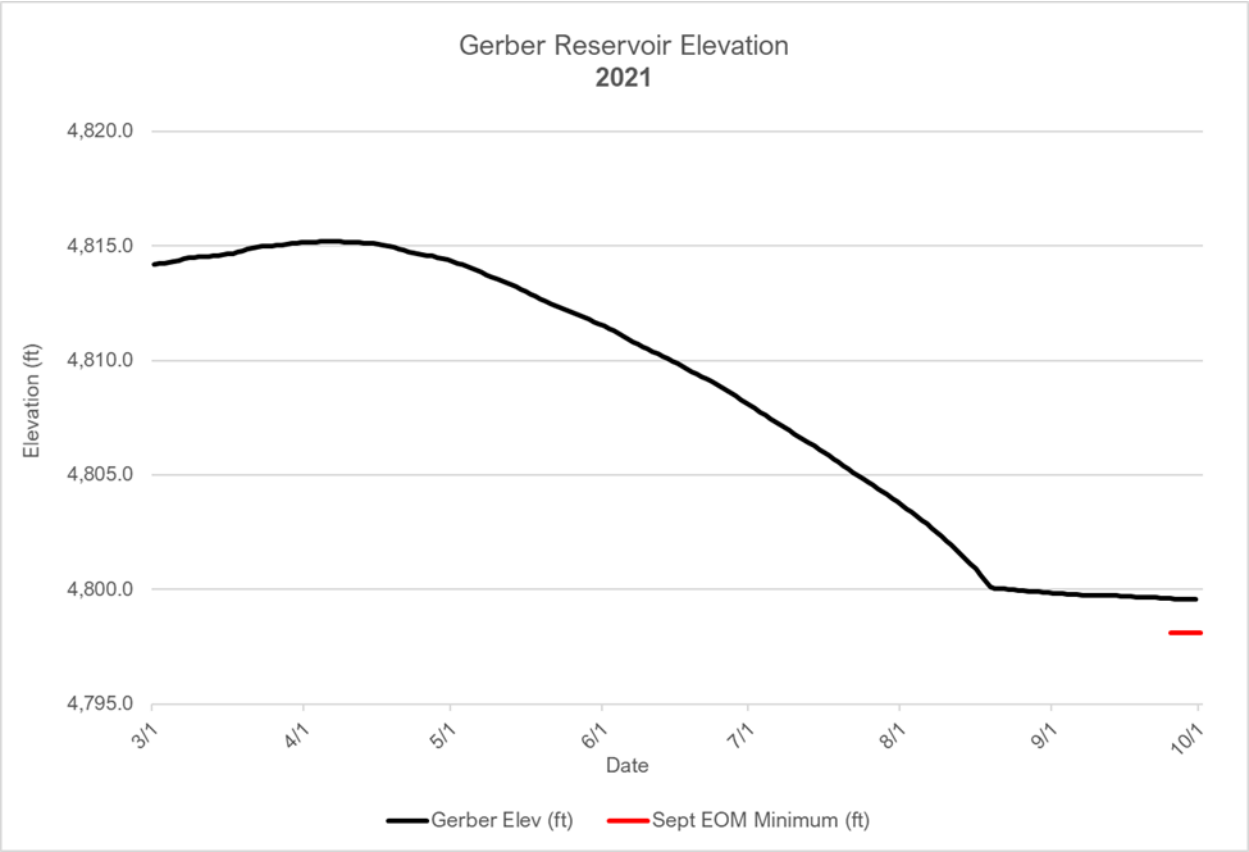

Figure 4. Gerber Reservoir Elevations in 2021 and End of September Minimum.

Tule Lake Sump 1A

Tule Lake Sump 1A (TLS1A) operations were adjusted in 2021 to account for the lack of Project return flows due to ongoing drought conditions and operations deviated from those described in the Modified 2018 Operations Plan/IOP (minimum elevation of 4,034.0 feet all season from April 1 to September 30). The Tule Lake Sumps are normally maintained through return flows from irrigation. However, with no Klamath Project diversions allowed in 2021, TLS1A began the season slightly above 4,034.0 feet and began rapidly decreasing early in the season. Reclamation assisted TID and USFWS at their requests to salvage suckers from Sump 1A and relocate them along with remaining Sump 1A water to Sump 1B, which would experience less evaporation due to its smaller surface area. Sump 1A subsequently went dry by July. When Sump 1B also began rapidly declining, PacifiCorp provided a loan of water to maintain elevations in 1B to benefit suckers as well as provide habitat for waterfowl on the Pacific flyway. to an elevation of 4,030.0 feet or below by late June (Figure 5).

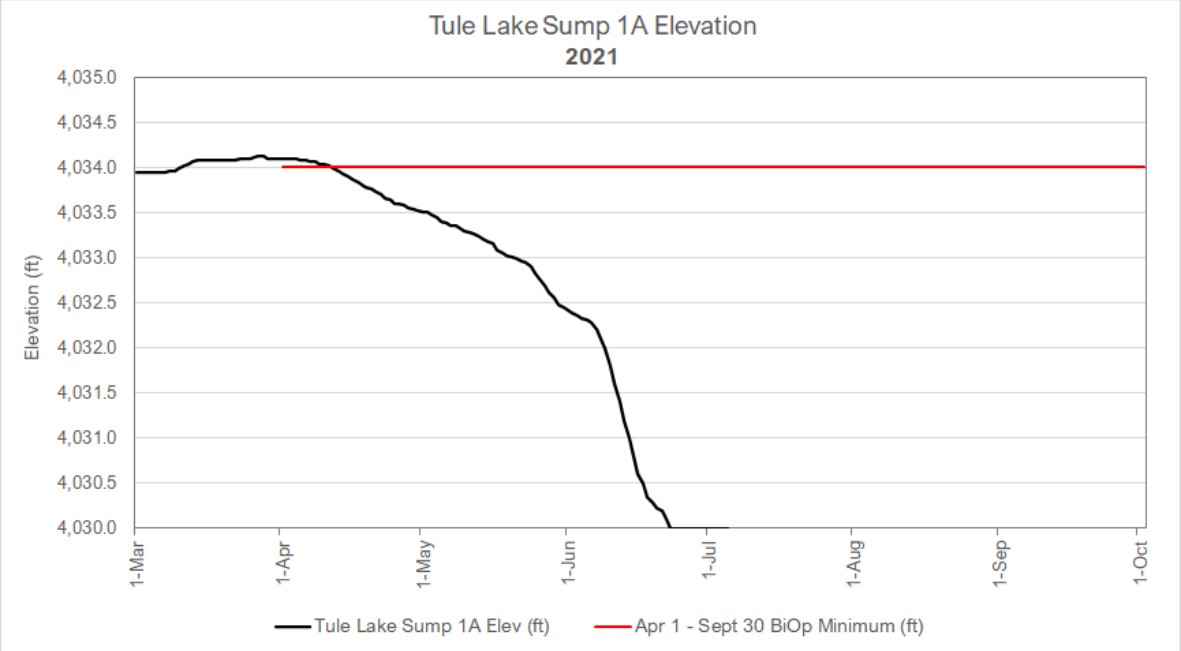

Figure 5. Tule Lake Sump 1A Elevations in 2021 and Seasonal Minimum.

Project Diversions

The Project has five major points of diversion: A Canal, Miller Hill, Station 48, North Canal, and Ady Canal. Water released from UKL and diverted for Project irrigation counts against Project Supply. All water released from UKL and not diverted for Project irrigation counts against the EWA. When flows through the LRDC are not adequate to meet demands at Station 48, Miller Hill, North Canal, and Ady Canal, some of the Klamath River flow released at Link River Dam (LRD) is diverted for agricultural use. Project deliveries at these points were tracked daily with gage records entered into a spreadsheet, which was shared with resource agencies, irrigators, and other interested stakeholders. A summary showing the 2021 March through September irrigation deliveries versus historical statistics is included as Table A-13 in Appendix A. Values for daily flows are graphed in Figure 6 to Figure 17 and also shown as Tables A-1 to A-12 in Appendix A.

The irrigation season that is shown in the graphs below runs from March through November for Area 1 deliveries through Link River, A Canal, Station 48, and Miller Hill. Area 2 irrigation season deliveries through North and Ady canals occur from March through October. Reclamation announced that no Project Supply was available from UKL in 2021 due to the ongoing drought. Although some diversions did occur from the Lost River system, deliveries at all points except North Canal were less than the average for the expanded period of record (POR) used in the Modified 2018 Operations Plan/IOP (1981-2019 WYs) as shown in Figure 6 to Figure 17.

Link River Dam Releases

During WY 2021, LRD released a total of 502,780 AF of water during the irrigation season, 71 percent of the POR average of 710,000 AF. Figure 6 displays daily discharges from LRD plotted against the POR average. (Note: Keno Canal is also known as West Side Power Canal. It runs parallel to the Link River and its flows are combined with the releases to Link River to calculate full releases from UKL, although it has not been used to generate power for several years.)

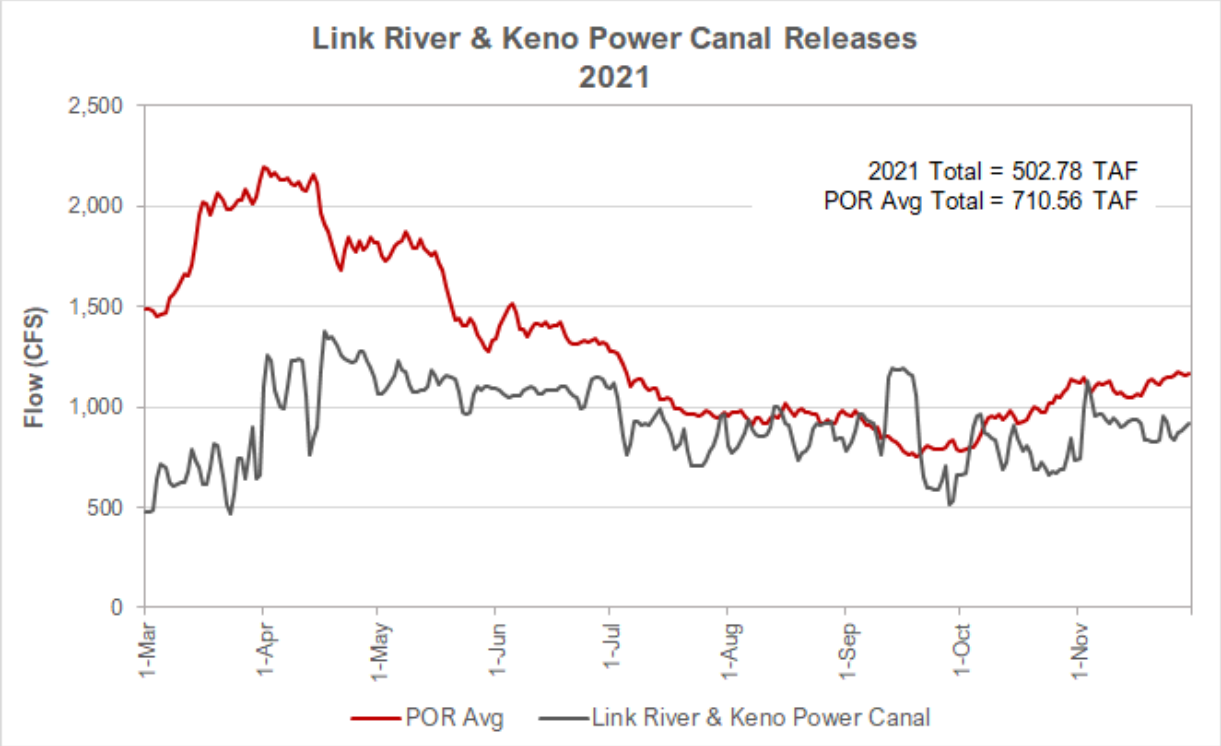

Figure 6. Seasonal Link River Dam plus Keno Canal Discharges. (Note: TAF=thousand acre-feet)

A Canal Diversions

Figure 7 plots WY 2021 A Canal diversions against the POR average. Due to the lack of available Project Supply, no deliveries were made through the A Canal headworks in 2021.

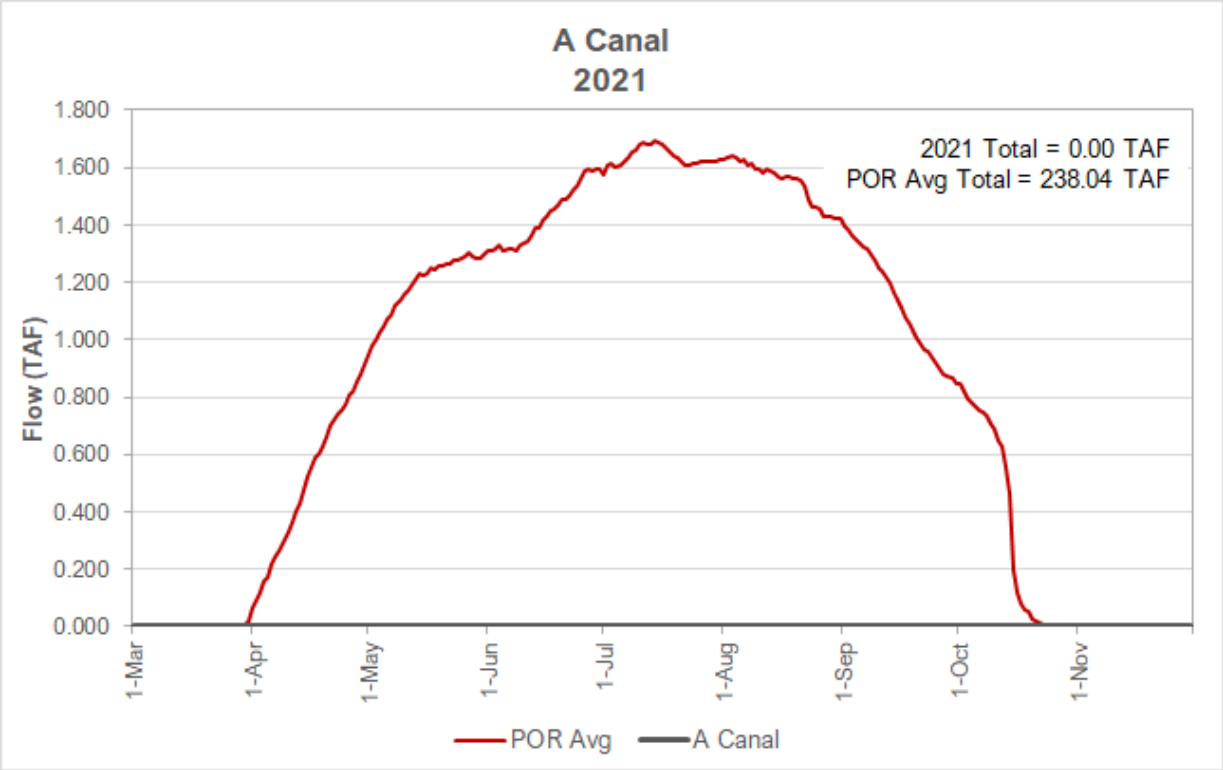

Figure 7. Seasonal flows through the A Canal.

Lost River Diversion Channel Flows

The LRDC connects the Lost River to the Klamath River and serves as a bi-directional channel to convey flow from, as well as return flows to, the Klamath River. LRDC flows are measured directly downstream of the Lost River Diversion Dam. Station 48 and Miller Hill diversions are located along the LRDC, downstream of the LRDC gaging station. The flows into the LRDC in 2021 were significantly less than the POR average as depicted in Figure 8.

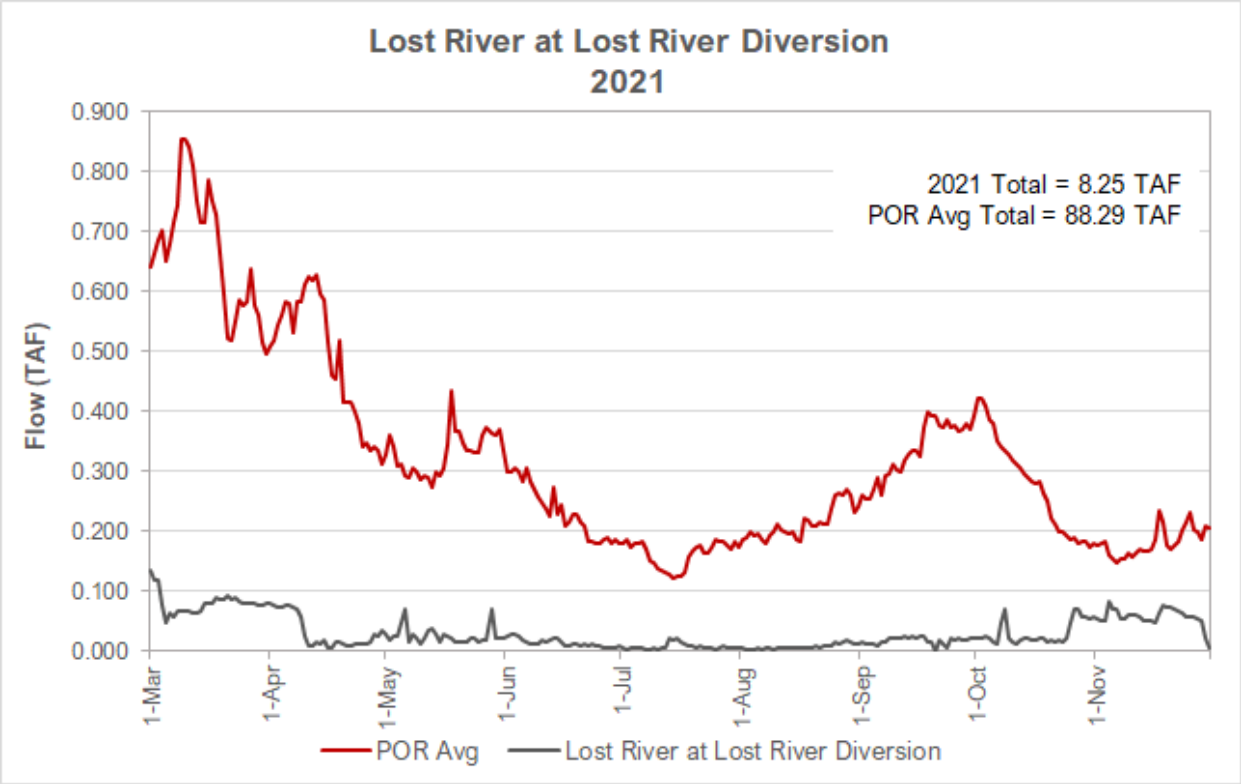

Figure 8. Seasonal flows through the Lost River Diversion Channel.

Miller Hill Pumps and Miller Hill Spill

Figure 9 shows that, in 2021, Miller Hill Pump station pumped small amounts to convey non-Project groundwater throughout 2021, resulting in pumping volumes well below the POR average. Figure 10 shows that spills (flow routed back into the LRDC) at the Miller Hill station were zero in 2021.

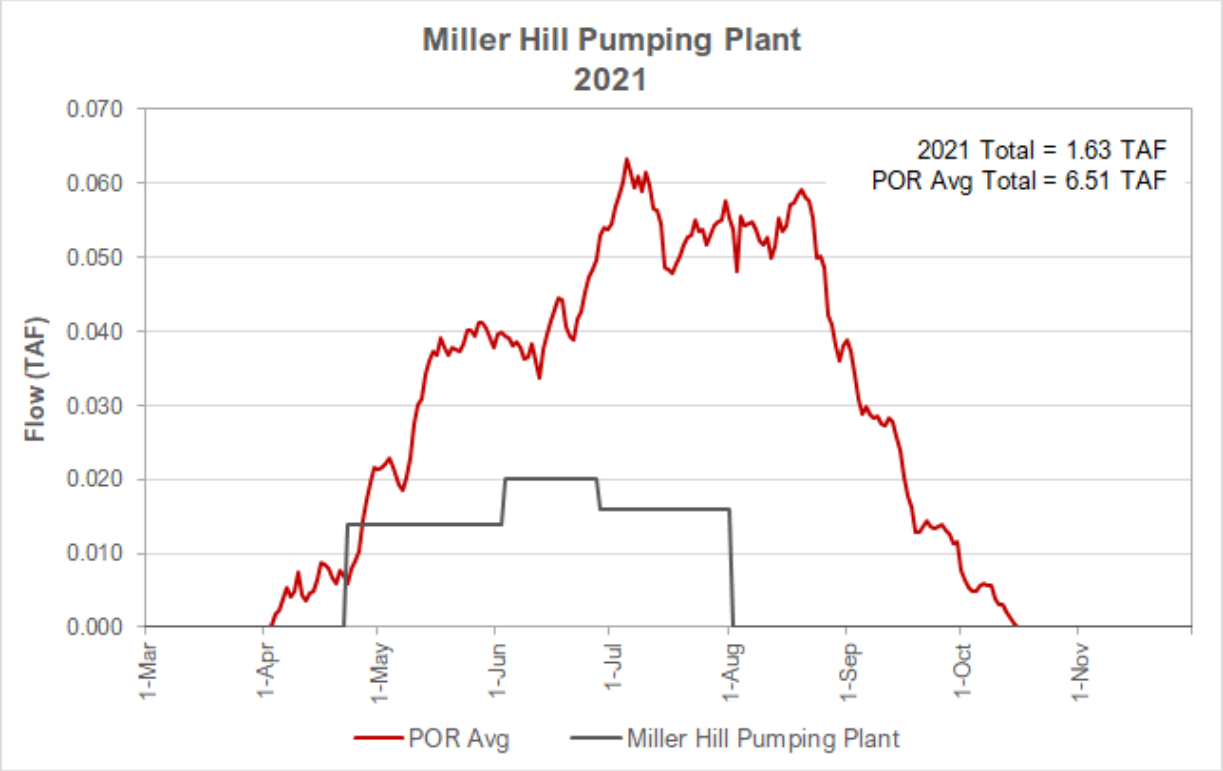

Figure 9. Seasonal Pumping at Miller Hill Pumps.

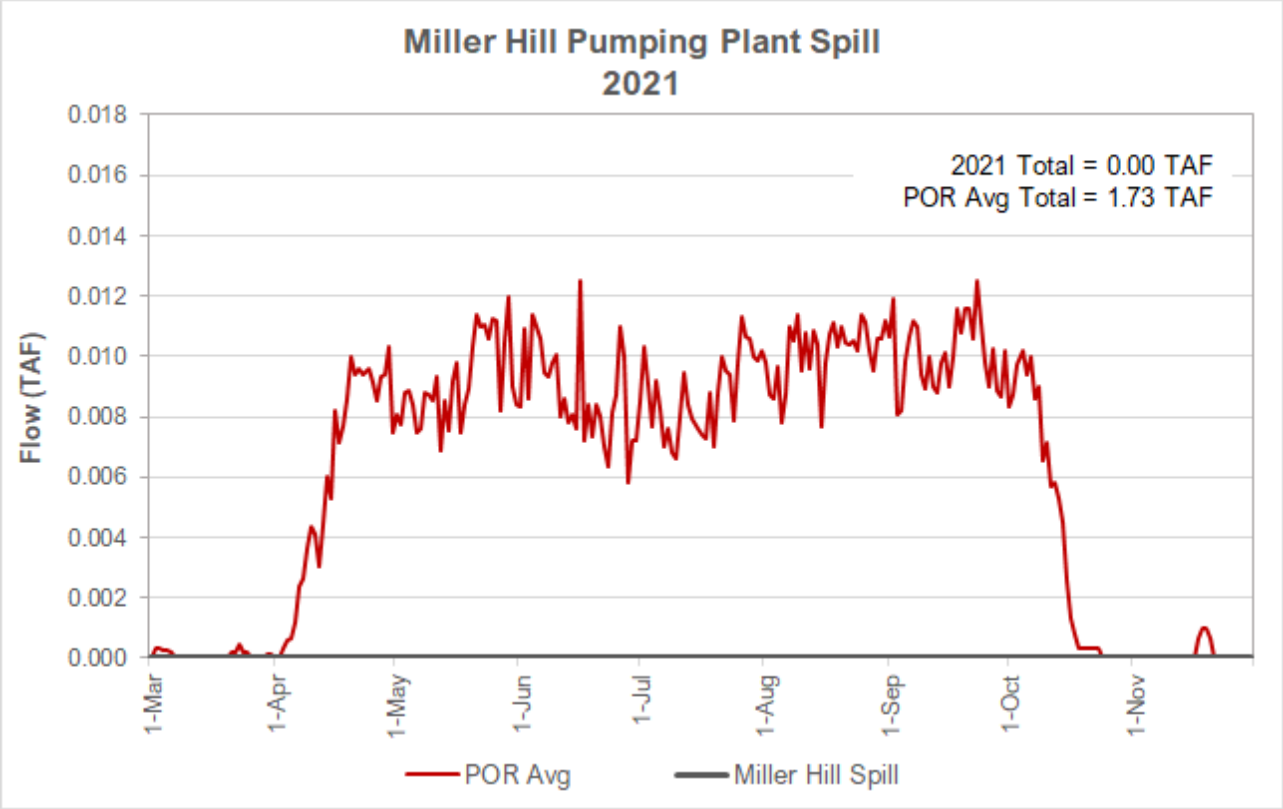

Figure 10. Seasonal Spill Volumes at Miller Hill.

Station 48 Diversions

Figure 11 shows that Station 48 total diversions in 2021 were well below the POR average. Early in the season the diversions were limited by the return flows available out of the LRDC. In August and early September, the increased flow was due to the volume borrowed from PacifiCorp to replenish Tule Lake Sump 1B volume. Beginning in October, diversions were once again limited to return flows from LRDC.

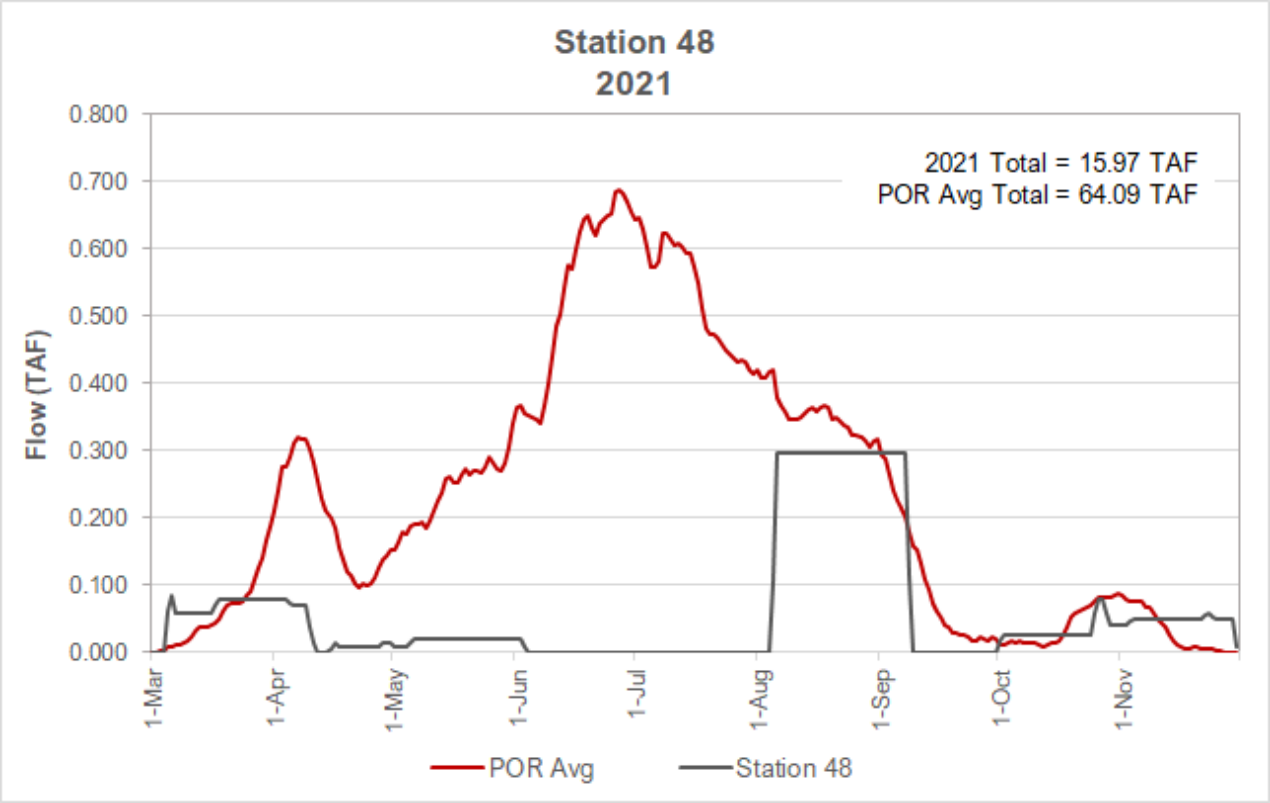

Figure 11. Seasonal Flows at Station 48.

North Canal Diversions

North Canal diversions in 2021 were approximately 178 percent of the POR average (Figure 12). KDD claimed to be diverting under their supplemental water right from the State of Oregon after being notified that no Klamath Project water was available.

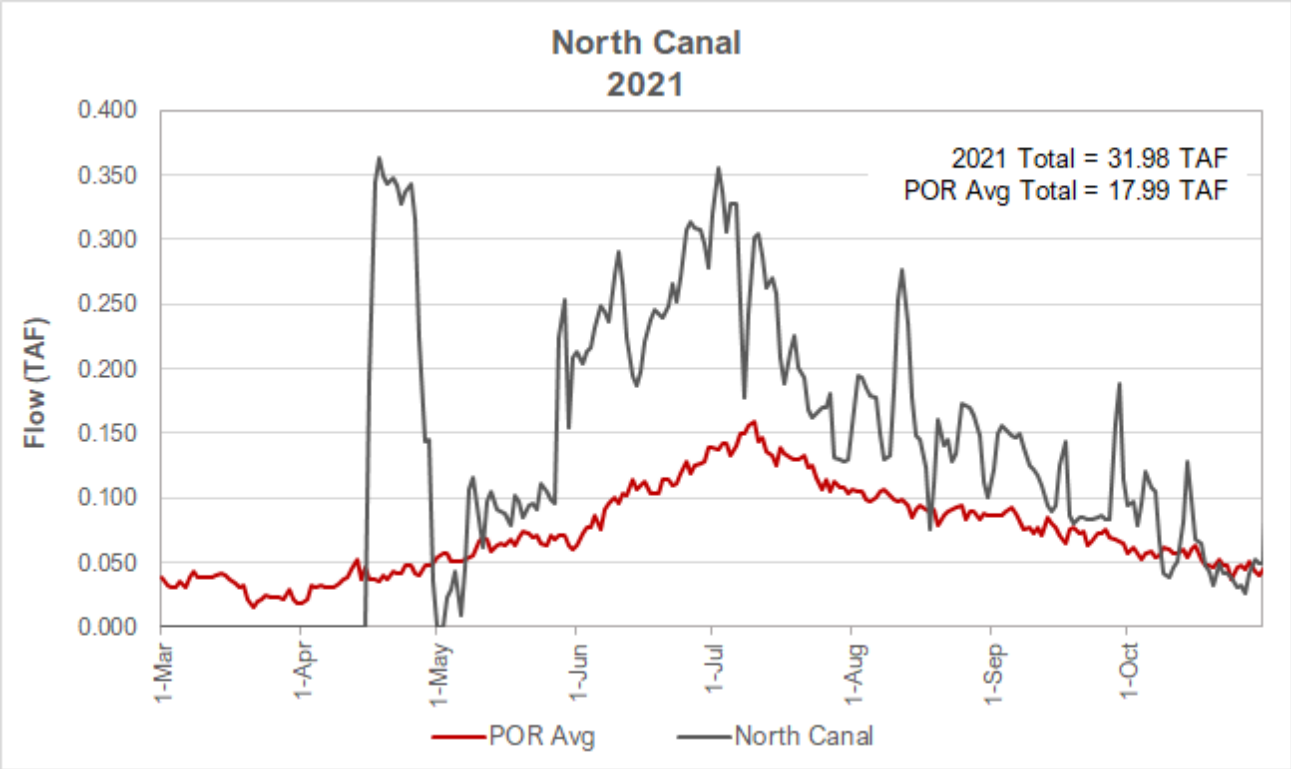

Figure 12. Seasonal Flows through North Canal.

Ady Canal Diversions

Deliveries in WY 2021 through the Ady Canal headgates are shown in Figure 13 whereas Figure 14 shows water conveyed via Ady Canal for delivery to the Lower Klamath National Wildlife Refuge (LKNWR).

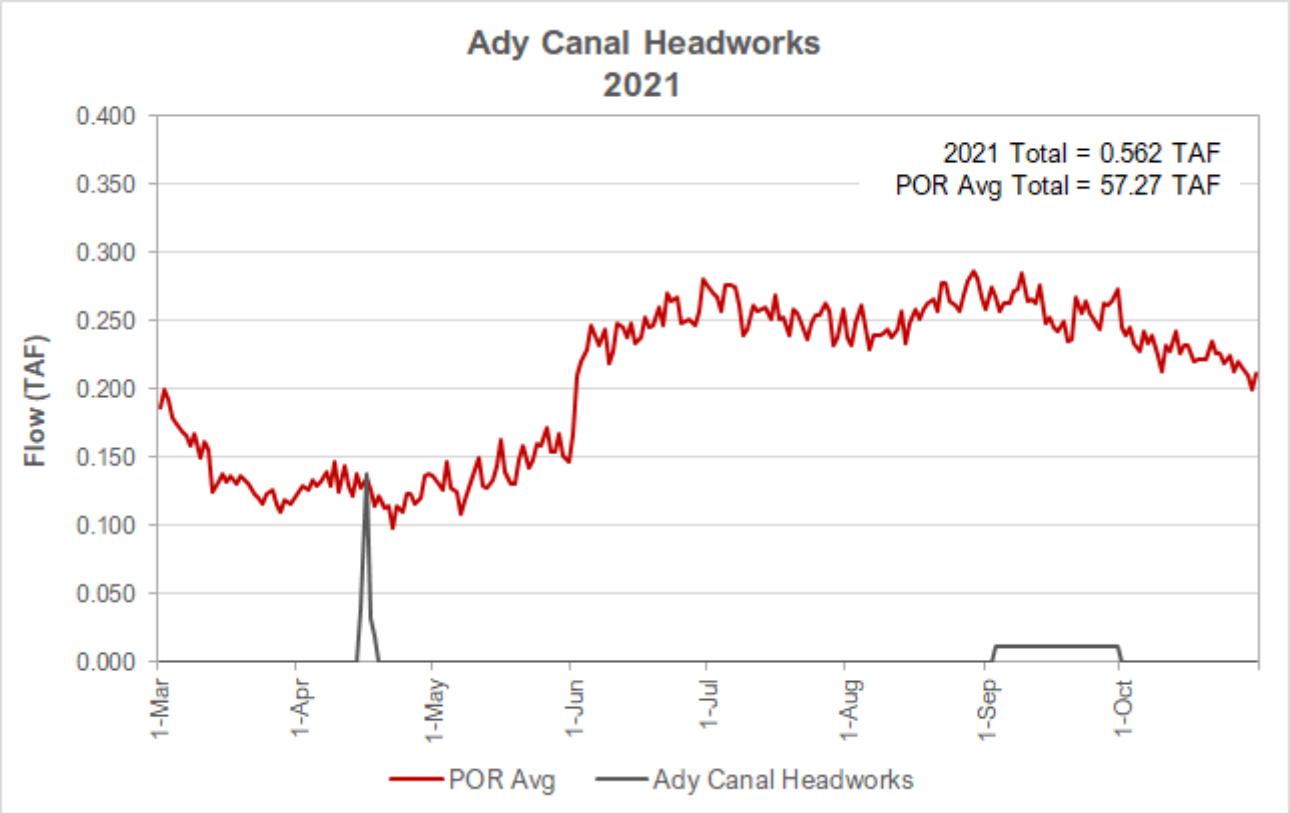

Figure 13. Flows at Ady Canal Headgates.

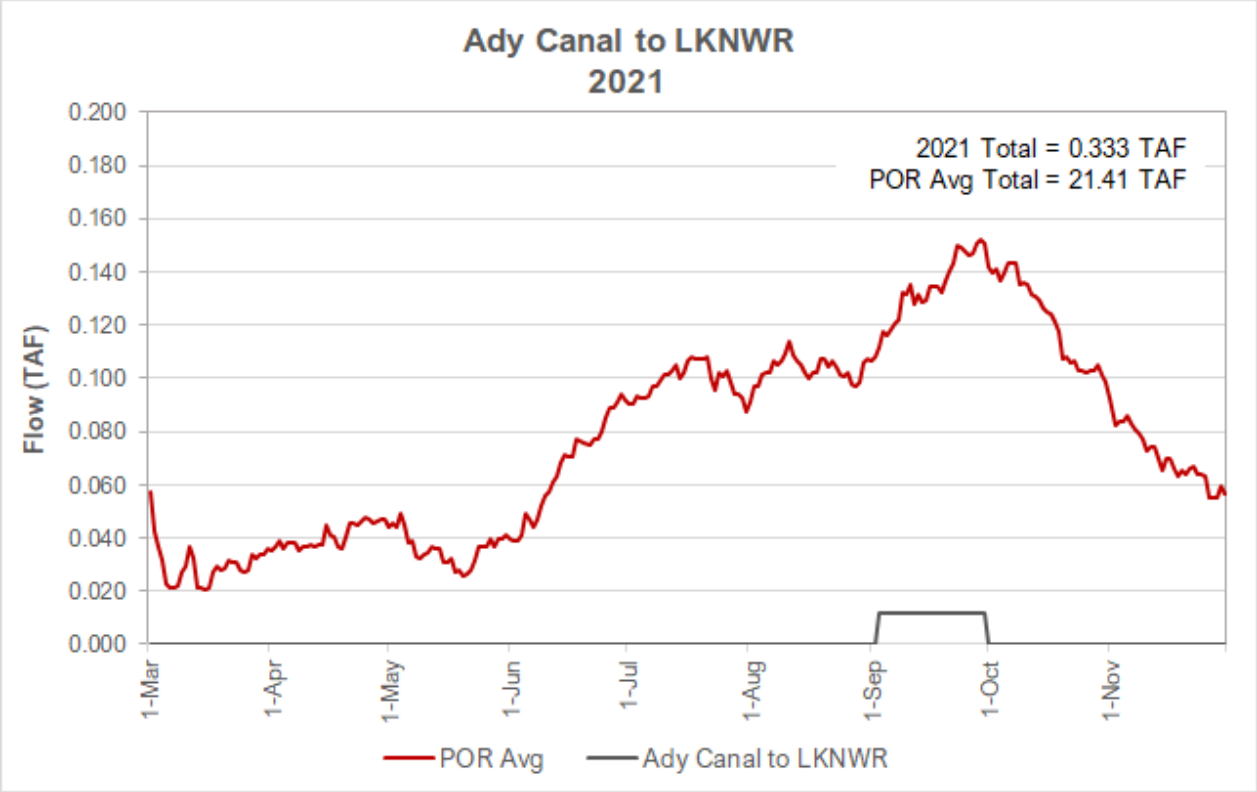

Figure 14. Flows through Ady Canal to Lower Klamath National Wildlife Refuge (LKNWR).

Klamath Straits Drain (KSD) at Stateline

Figure 15 shows the flows returning from LKNWR as measured at the KSD at Stateline. Due to the drought, KDD increased recirculation of return flows.

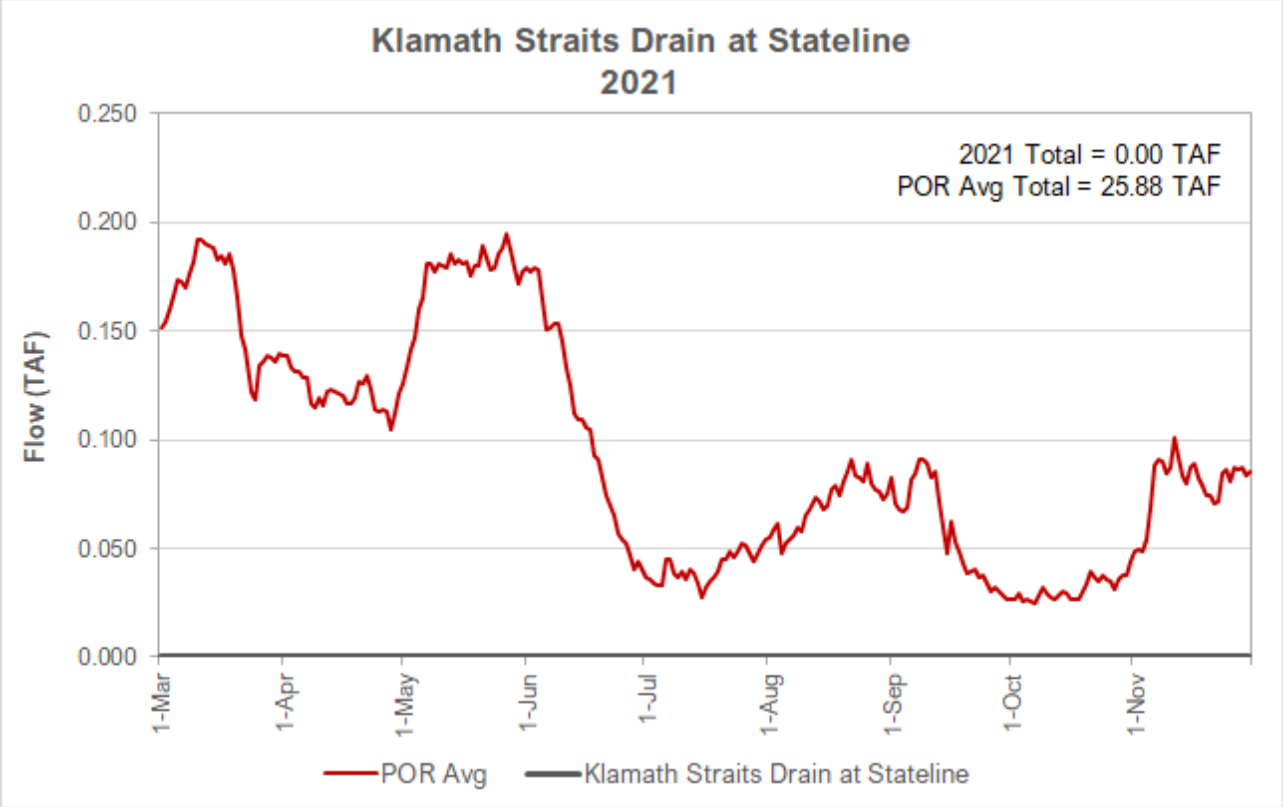

Figure 15. Flows through Klamath Straits Drain at Stateline Road.

Klamath Straits Drain at Pumps F/FF

The pumps at Pumping Plants F and FF return water from the KSD to the Klamath River. Due to the excessively dry hydrologic conditions, the F/FF pumps were not run during the irrigation season in 2021 (Figure 16).

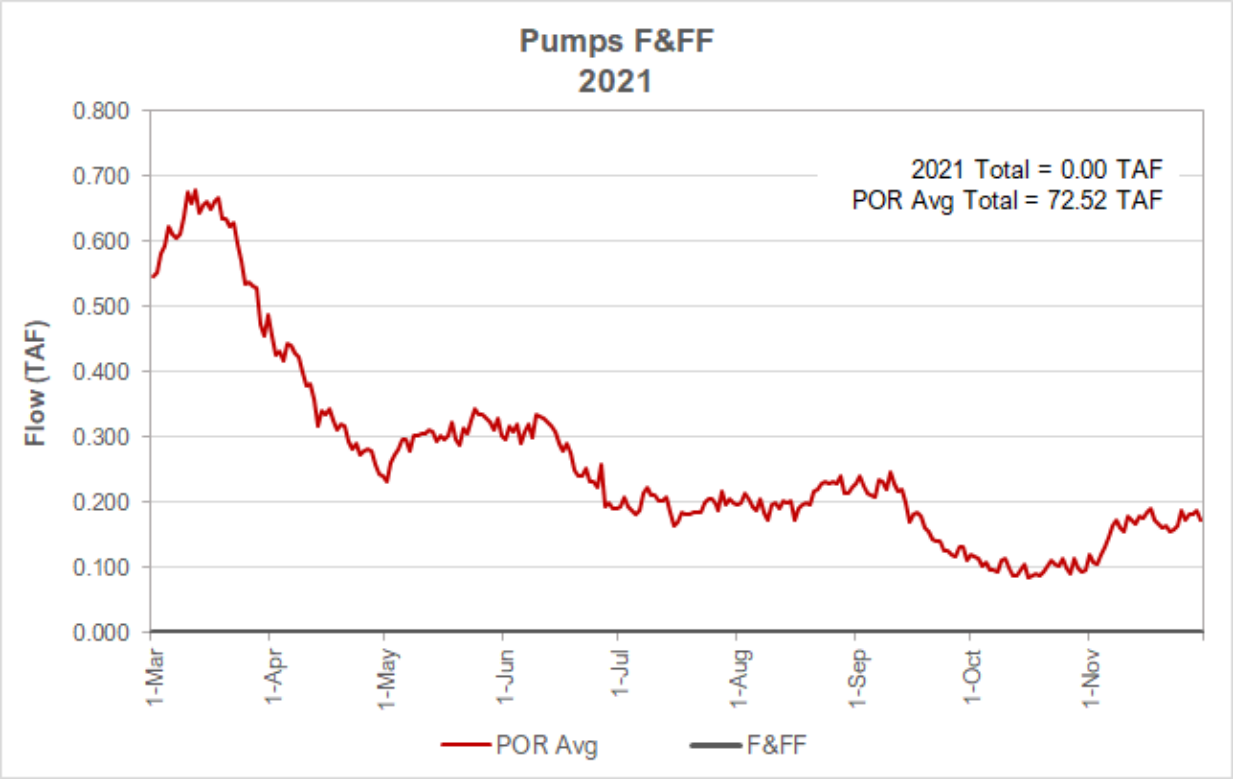

Figure 16. Flows through Klamath Straits Drain at Pumping Stations F and FF.

West Side Power Canal Diversions

In the past, PacifiCorp has used the West Side Power Canal, also known as the Keno Canal, for power generation at times throughout the year. Flows are self-reported by PacifiCorp. The canal usually runs at a constant rate during generation, though it is no longer used for power generation. Reclamation received confirmation that the Keno Canal conveyed an estimated 15 cubic-feet-per-second (cfs) in 2021, as depicted in Figure 17.

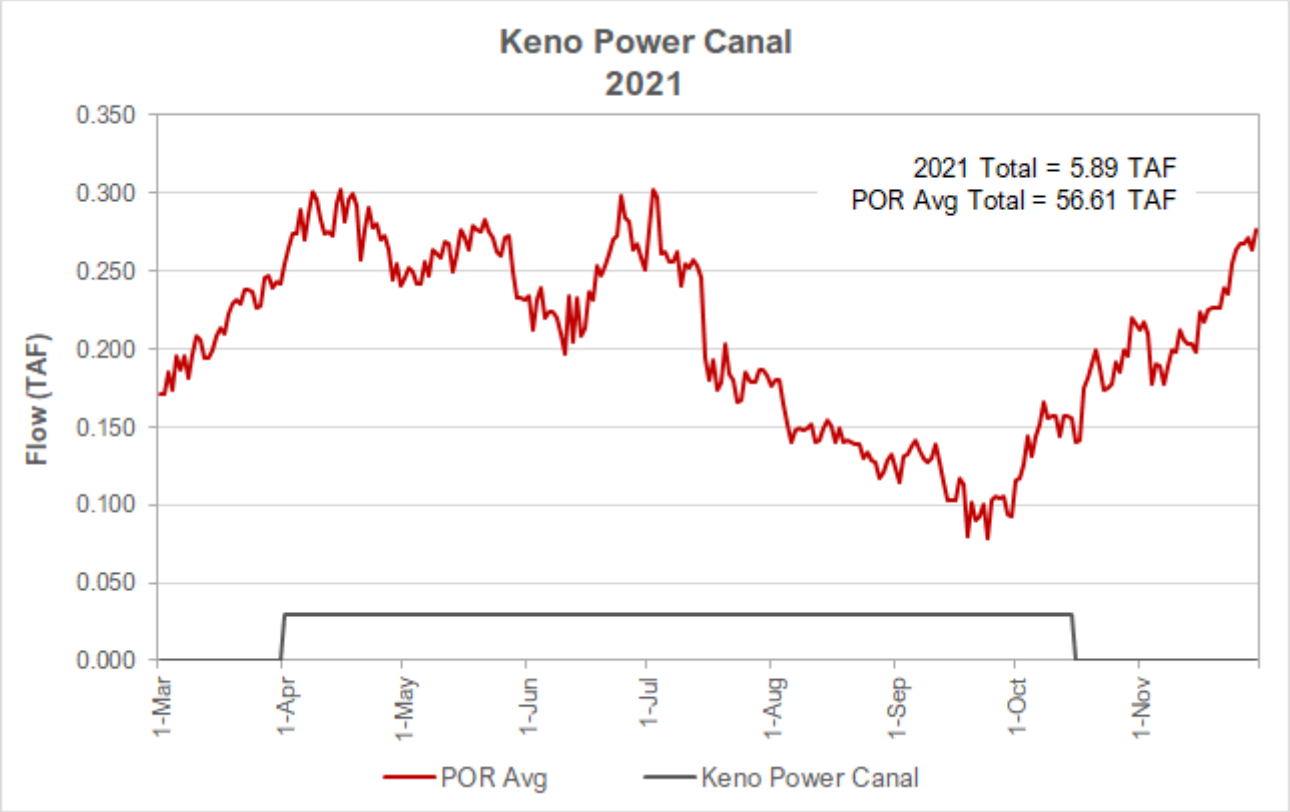

Figure 17. West Side (Keno) Power Canal Operation.

U.S. Fish and Wildlife Service Reporting Requirements

T&C 1a – Ensure that No Unnecessary Actions are Taken that Increase Entrainment at the Link River Dam.

Requirement

Reclamation shall coordinate with USFWS to ensure that no unnecessary actions are taken that increase entrainment at the LRD. T&C 1a requires Reclamation to monitor the numbers of age-0 and older suckers moving through the FES to determine the timing of the peak and determine a reasonable estimate of total abundance.

Results

Reclamation coordinated with USFWS before the typical irrigation season to ensure that no unnecessary actions that would increase entrainment of age-0 suckers would occur at the LRD. Reclamation was not able to monitor the number of age-0 and older suckers moving through the FES in the summer of 2021 because no water deliveries for irrigation was made through the A Canal. Thus, there was no peak of entrainment at the Fish Evaluation Station (FES) to monitor. The 2021 abundance estimate through FES was zero suckers. The forebay of the A Canal was charged in March prior to the typical irrigation season. Reclamation was unable to salvage the A canal forebay until September 20, 2021; 82 suckers were salvaged from the A Canal forebay and 82 suckers were found dead during the salvage effort. The 82 salvaged suckers were transported to the USFWS Hatchery where they were PIT-tagged prior to release at Rocky Point. Reclamation has summarized the results of these efforts under the A Canal FES Annual Monitoring Summary (M&RR 1.1a) and Appendix B includes the full report.

T&C 1b – Actions to Determine Irrigation Supply and Take Corrective Actions to Avoid Going Below Minimum Elevations in Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A.

Requirement

The USFWS BiOp states:

> *"Prior to initiation of deliveries to irrigators or prior to April 15, whichever comes first, of each year, Reclamation shall assess projected inflows and water levels in Clear Lake and Gerber Reservoirs to determine an anticipated irrigation supply from each reservoir along with projected end of season lake elevations. Reclamation shall coordinate with the Service to ensure the anticipated irrigation supply falls within the effects analyzed and incidental take authorized in this BiOp. This coordination is to ensure that releases, particularly those above and beyond typical historical releases, will not result in increased harm to listed suckers in Clear Lake Reservoir due to reduced access to spawning habitat in Willow Creek. Projected end of September targets shall be at or above minimum elevations.*
>
> *Irrigation releases from Clear Lake Reservoir greater than the typical historical demand could result in Clear Lake Reservoir elevations that are consistently lower than those analyzed in this document, which in turn may reduce the*

likelihood of adequate lake elevations to allow access to spawning habitat in Willow Creek (see Section 7.4.1). Therefore, the Service expects that deliveries from Clear Lake Reservoir will be similar to those typical across the 1986 through 2016 period, exclusive of atypical conditions (i.e., flood control releases, other releases for public health and safety, inadequate water supply, etc.). Typical total annual irrigation releases across the 1986 through 2016 period were as high as 40,376 AF, and the proposed action indicates that Reclamation expects typical annual irrigation releases to be approximately 35,000 AF.

At least once a week throughout the year, Reclamation shall assess projected water levels to determine if they are likely to fall below proposed minimums for Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A for that relevant time period. If conditions indicate that these reservoirs are likely to experience hydrologic conditions that would likely result in water levels going below the minimums, Reclamation shall alert the Service to determine the most appropriate action to minimize risk to affected listed species. Reclamation's required water-level monitoring for Clear Lake Reservoir, Gerber Reservoir, and Tule Lake Sump 1A is described below under section 11.4."

Reclamation shall take actions to determine Project Supply and take corrective actions to avoid going below minimum elevations in Clear Lake Reservoir, Gerber Reservoir, and TLS1A prior to initiation of deliveries to irrigators or April 15, whichever comes first. Reclamation shall coordinate with USFWS to ensure anticipated irrigation supply falls within the effects analyzed and incidental take authorized in USFWS 2020 BiOp.

Results

Reclamation initially coordinated with the USFWS on March 8, 2021, to assess water levels in and projected inflow to Clear Lake Reservoir, Gerber Reservoir, and TLS1A after receiving the March inflow forecasts from Natural Resources Conservation Service, with close coordination continuing throughout the irrigation season. Modeling showed that end of September surface elevations were expected to remain above minimums in Clear Lake Reservoir and Gerber Reservoir. TID expressed concern over potential drops in TLS1A due to lack of irrigation return flows since the Klamath Project was shut off. Reclamation coordinated with USFWS (both the Klamath office and the refuges) as well as TID. TID suggested relocating suckers from Sump 1A to Sump 1B to minimize evaporation. When that proved insufficient, TID suggested borrowing water from PacifiCorp reservoirs to maintain Sump 1B elevations. At the request of USFWS, Reclamation assisted with both the sucker relocation and the PacifiCorp borrowing operation. Sump 1B elevations were successfully maintained through the end of 2021. For specific incidental take estimates see section M&RR 1.1b in the USFWS 2020 BiOp. Additionally, for specific water level measurements see the USFWS 2020 BiOp section M&RR 3.3b -Monitor and Maintain Water Level and Flow-Measurement Gages throughout the Project.

T&C 1c – Take Corrective Actions to Ensure Upper Klamath Lake Elevations Are Managed within the Scope of the Proposed Action

Requirement

Reclamation shall monitor and take corrective actions to ensure UKL elevations are managed within the scope of the Modified 2018 Operations Plan/IOP described in the USFWS 2020 BiOp. Reclamation shall also determine causative factors of decreases in lake surface elevation and determine if factors are within the scope of the Proposed Action and the effects analyzed in the USFWS 2020 BiOp. Reclamation shall consult with USFWS if adaptive actions are necessary and take corrective actions.

Results

Reclamation monitored surface elevations for UKL during WY 2021 to ensure surface elevations

were not outside the bounds of those analyzed in USFWS' effects analysis in WY 2021. Surface elevation for UKL missed the seasonal thresholds owing to the drought conditions in the Klamath Basin in 2021. Surface elevation was 4140.28 feet on June 1 and 4139.40 feet on July 15 in 2021. June 1 threshold is 4,141.28 feet and the July 15 threshold is 4,140 feet. Upper Klamath Lake did stay above 4,138.26 feet which is the minimum lake elevation allowed at all times. UKL surface elevations are summarized in M&RR 3.3b - Monitor and Maintain Water Level and Flow-Measurement Gages throughout the Project.

T&C 1d – Activate the A-Canal Pumped-bypass System Annually by August 1

Requirement

Reclamation shall coordinate with USFWS by July 1 each year and activate the A-Canal Pumped-bypass System Annually by August 1. The A-Canal bypass is to begin being operated continuously no later than August 1 until no age-0 suckers are observed in FES or diversions into the A-Canal are terminated.

Results

Reclamation coordinated with USFWS before July 1, 2021, to confirm that the A-Canal Pumped Bypass System could not be operated in 2021 due to no deliveries from the A-Canal. Thus, Reclamation did not activate the A-Canal Pumped Bypass System in 2021 because no water deliveries were made from the A-Canal. The 2021 A-Canal FES Report can be found in Appendix B.

T&C 1f – Annual Identification and Installation of Needed Water-Level and Flow-Measurement Gages in the Project

Requirements

The USFWS 2020 BiOp requires that Reclamation consult with USFWS hydrologists and other appropriate agencies at least annually to assess the need for additional gages in the Project area beginning July 1, 2019.

Results

Reclamation took appropriate actions to identify and install new gages, as well as troubleshoot and maintain existing gages, within the Project. Regarding gage installations, in March 2020, gate position sensors were installed at Gerber Dam and wired into a previously installed Data Collection Platform (DCP). Edits were made to the DCP to enable the broadcast of hydrologic data via satellite to Reclamation databases for flow calculations, data archive, and data dissemination across the Internet.

Similar measures were taken at Clear Lake Dam during June 2020. A gage position sensor was installed on the operational gate and wired to a previously installed DCP. Edits were made to the DCP configuration to enable the broadcast of additional hydrologic data via satellite to Reclamation databases for flow calculations, data archive, and data dissemination across the internet.

During April 2020, a new stream gage was installed by the USGS at the A Canal Headworks. The gage reports near-real time hydrologic data to the National Water Information System (NWIS) and is accessible via a web interface. A number of discharge measurements were made to begin

calibration of the velocity sensor (indexing) for flow calculations. Indexing efforts are ongoing. The new USGS gage serves as a backup to the primary A Canal Headworks flow sensor, which reports flow information to a Supervisory Control and Data Acquisition (SCADA) network. operated by Klamath Irrigation District (KID).

Also, during April 2020, a cable was installed to connect the A Canal Headworks primary flow sensor to the DCP of the new stream gage installed by USGS. Edits were made to the USGS DCP configuration to enable the broadcast of KID A Canal flows via satellite to Reclamation databases for data archive and dissemination across the Internet. This enables the continued reporting of A Canal flows to Reclamation databases during periodic interruptions of KID SCADA communications.

During May 2020, Reclamation staff worked with the Langell Valley Irrigation District to repair a velocity sensor previously installed in the East Malone Lateral at Malone Dam. The velocity sensor was wired to a newly installed data radio. Sensor readings are transmitted across the reservoir to a data radio and DCP previously installed in a stilling well upstream of the dam. Edits were made to the DCP configuration to enable the broadcast of additional hydrologic data via satellite to Reclamation databases for flow calculations, data archive, and data dissemination across the Internet.

Reclamation staff have identified the following existing hydrologic data collection sites—listed by priority—whose respective quality of data would benefit from improving channel conditions at and/or near the measurement location: Oregon Drain upstream LKNWR; Station 48; Ady Canal; and North Canal.

T&C 1j - Ensure Project Impacts on Spawning access in Clear Lake Reservoir are not Greater than Anticipated

Requirement

This T&C requires that Reclamation provide to USFWS an analysis on Project impacts to Clear Lake Reservoir spawning habitat access by March 1, 2020. The T&C specifies that:

> *"Reclamation shall coordinate with the Service to perform an analysis synthesizing the hydrologic conditions for sucker spawning" using anticipated data from monitoring at Clear Lake Reservoir."*

Results

Reclamation began working on this T&C in 2019, continued to work on it in 2020, then completed the analysis in 2021. Prior to completion, Reclamation met with USFWS to discuss this T&C on July 30, 2019, 10:00-12:00, October 15, 2019, 10:00-11:00, April 2, 2021 9:00-10:00, and April 20, 2021 3:30-4:30. Reclamation provided USFWS with consistent updates, as they were received from USGS regarding the analysis of adult sucker demographics in Clear Lake Reservoir.
Due to delays in receiving a draft of Hewitt et al. (2021), a revised completion date of May 1, 2021, was agreed upon by both agencies on February 26, 2021.

Reclamation received a courtesy copy of USGS's Clear Lake Adult Sucker Demographics Report on January 4, 2021, and a final copy in April of 2021. In a meeting on April 2, 2021, Reclamation agreed to provide USFWS with an exploratory assessment directed at using available data from the then draft Open File Report of Hewitt et al. (2021) *Dynamics of Endangered Sucker Populations in Clear Lake Reservoir, California* and identify possible approaches to better understand conditions hydrologic limitations in Clear Lake Reservoir.

Reclamation coordinated closely with the Services to assess and understand new data provided by USGS in Hewitt et al (2021). Reclamation and USFWS have identified several new analyses that can be performed on existing data, as well as improvements to current methods that could better answer management questions. Several of these recommendations have been developed into new methods and research projects that have been or will be funded in FY22. Reclamation completed this analysis and sent it to USFWS on April 30, 2021. Reclamation presented the results of this analysis to USFWS on May 17, 2021.

Entrainment Monitoring: at Project Facilities

M&RR 1.1a (USFWS) - A Canal Fish Evaluation Station Monitoring Annual Report

Requirement

The 2020 USFWS BiOp states:

> *"Reclamation shall monitor entrainment of age-0 and age-1 juvenile suckers at the A Canal FES annually from July 15 to September 30. The level of effort shall be sufficient to determine when the peak of entrainment occurs and to provide an accurate estimate of the numbers of suckers entrained during the peak. An estimation of the number of juveniles moving through the bypass system during the peak period requires sufficient samples taken both within and among days.*
>
> *Monitoring at the FES shall begin approximately July 15 of every year with sampling on one night per week until at least 10 juvenile suckers are captured in a night or August 1, whichever comes first, after which sampling will continue four nights per week until no additional suckers are collected in the FES in a given week, September 30, or a date agreeable to the Service. Reclamation will sample consistent with recent FES sampling to ensure comparisons can be made among years.*
>
> *Samples need to be taken at night because that is when most sucker movement occurs. All suckers in FES samples will be counted, and measurements (such as length, weight, and other data as coordinated with the Service) will be collected from a representative sample. A brief summary report of numbers of suckers collected shall be provided to the Service every week via email, no later than the close of business on each Friday. This will provide the Service with the opportunity to assess patterns and provide comments to Reclamation concerning any adjustments that may be implemented to avoid unnecessary entrainment. The results of the monitoring shall be included in the Annual Monitoring Report due to the Service by March 1 of every year. The report shall describe the methods, results, and recommendations to improve monitoring in coordination with the Service to ensure appropriate analyses are performed."*

Results

Sampling at the FES for suckers did not occur in 2021 because irrigation water was not delivered through the A Canal to the Klamath Project. As a result, there was no peak of entrainment to determine and abundance was zero. A full description of typical annual sampling is in Appendix B.

M&RR 1.1b (USFWS)– Flow Monitoring at the A Canal, and Link River, Clear Lake Reservoir, and Gerber Dams as a Surrogate for Larval Sucker Entrainment Monitoring

Requirement

The 2020 USFWS BiOp states:

> *"Entrainment monitoring of larval suckers at the A Canal, and dams at Link River, Clear Lake Reservoir, and Gerber Reservoir is impracticable because of difficulty in identifying sucker larvae, expense, limited and sometime difficult or dangerous access at Clear Lake and Gerber reservoirs, and human safety concerns associated with night sampling at Gerber and Clear Lake dams. Therefore, Reclamation shall monitor flows at each dam during the larval period: Link River Dam - April 1 to July 15; Clear Lake Dam - April 1 to June 1, and Gerber Dam - April 1 to June 1. The use of flow as a surrogate for larval entrainment is reasonable and appropriate because entrainment of suckers has been determined to be proportional to flow at two of these facilities (additional information on the flow and entrainment is found in both the Environmental Baseline (section 7) and Effects of the Action (section 8) of this BiOp (Gutermuth et al. 2000a, 2000b). The studies that Gutermuth et al. (2000a, 2000b) conducted at the A Canal and Link River Dam found that the numbers of larval suckers entrained was a function of flow and that entrainment increased with increasing flow, and thus was proportional. Therefore, measurement of flow is a reasonable and appropriate surrogate for monitoring larval entrainment. The flow data, reported as acre-feet per day, shall be included in the March 1 Annual Monitoring Report described below, and presented as total flow through the A Canal, and the Link River, Clear Lake, and Gerber Dams. Reclamation shall know if they have likely exceeded authorized take of LRS and SNS larvae at these facilities when the discretionary monthly flow volumes, in acre-feet, exceeds those that occurred during the POR analyzed in this BiOp. We recognize that there are likely to be uncontrolled flow releases ("spills") at these dams, or emergency releases, due to high lake levels and concerns for large inflow events resulting from storms. Because these events are outside of Reclamation's discretion, any entrainment occurring during those events would not result in unauthorized take."*

Results

The results of the flow monitoring for this requirement are shown in Figure 18 through Figure 21 below. All locations were below maximum values calculated for the POR. In all instances, Reclamation released less water than was analyzed in the POR.

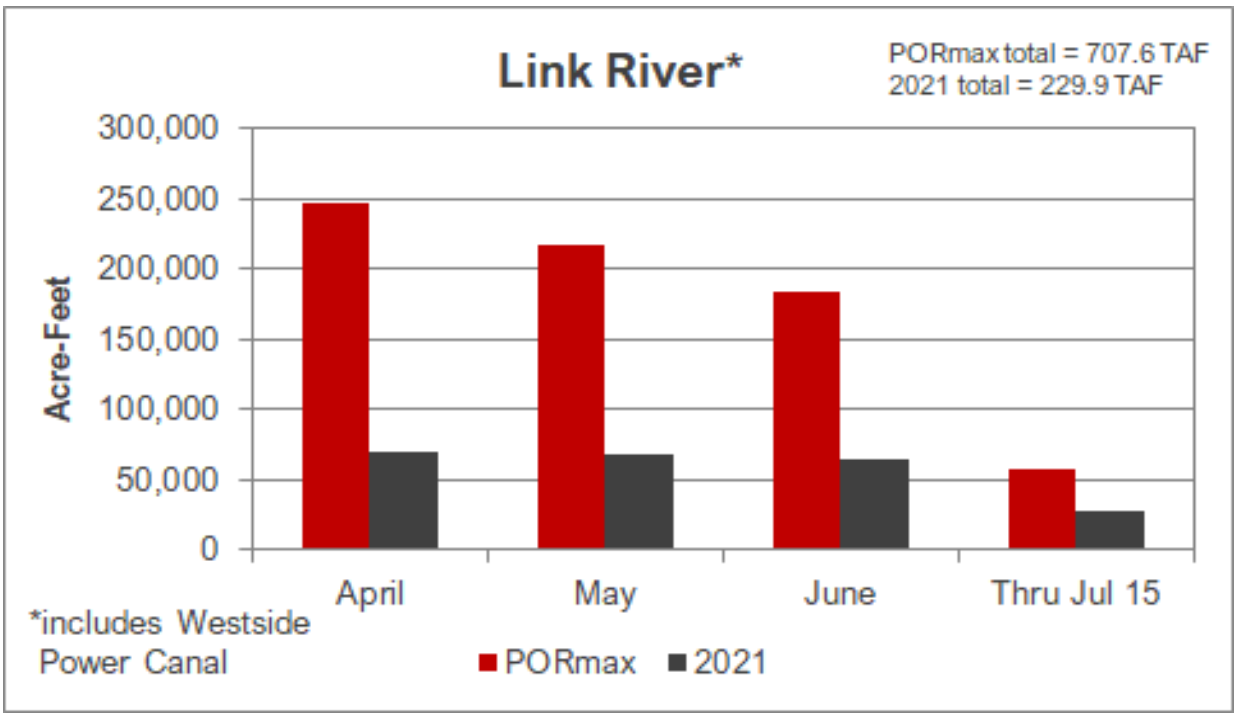

Figure 18. Link River Total Monthly Flows as Surrogate for Larval Sucker Entrainment.
PORmax = period of record maximum.

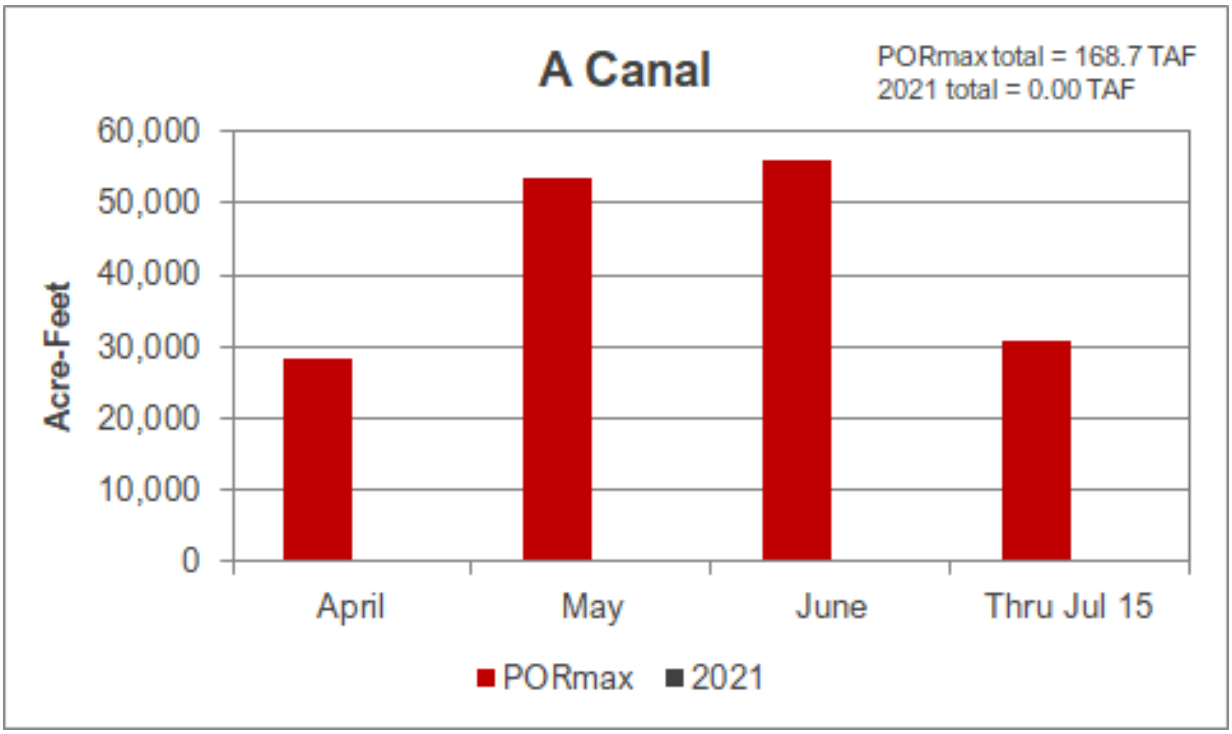

Figure 19. A Canal Total Monthly Flows as Surrogate for Larval Sucker Entrainment.

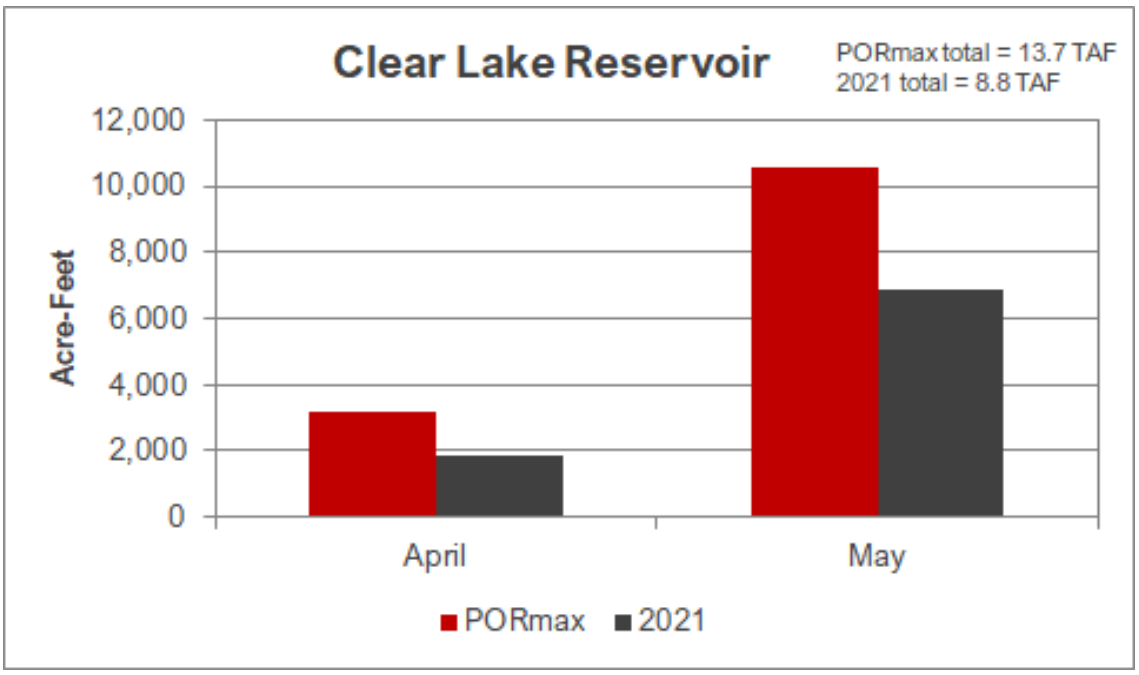

Figure 20. Clear Lake Reservoir Total Monthly Flows as Surrogate for Larval Sucker Entrainment.

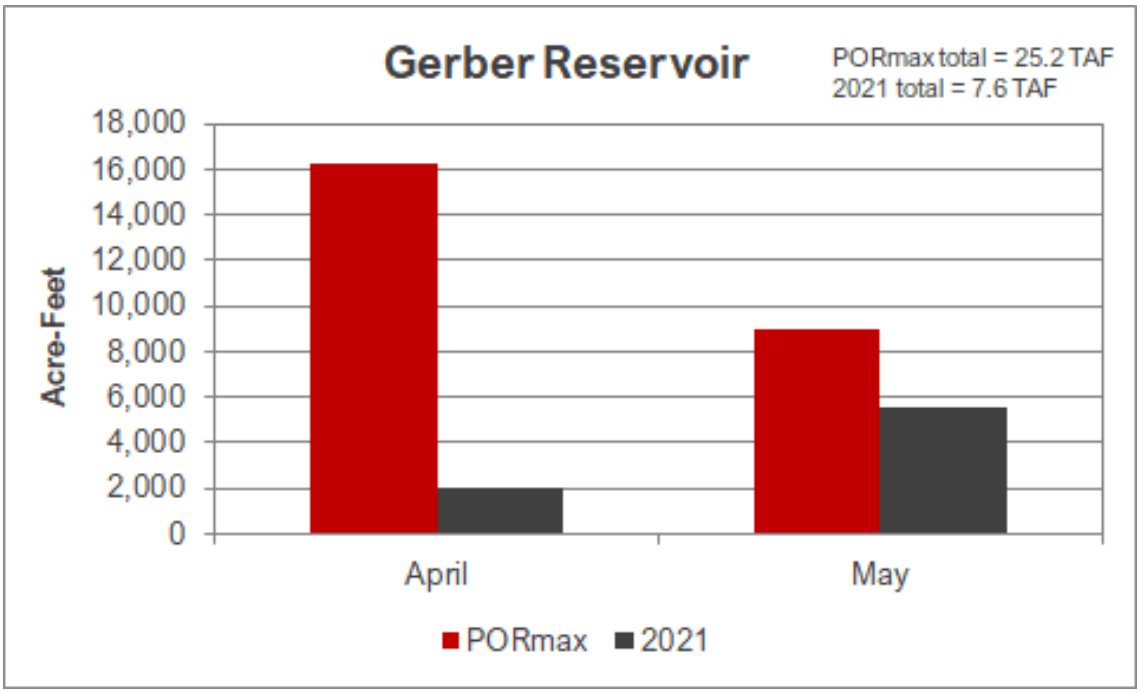

Figure 21. Gerber Reservoir Total Monthly Flows as Surrogate for Larval Sucker Entrainment.

M&RR 1.1c (USFWS)- Canal Salvage Report

Requirement

The 2020 USFWS BiOp states:

> *"Reclamation has proposed to salvage suckers entrained into the irrigation canal system during drawdown in the fall. Salvage efforts include take of individuals through capture, and the results of this salvage effort will be*

included in the Annual Monitoring Report…Reclamation will also continue to pursue alternative methods of dewatering canals, laterals, and drains and which could result in less sucker presence within these facilities at the end of the irrigation season."

Results

During the 2021 salvage effort a total of 149 juvenile suckers were captured from Project canals; 82 suckers were captured in the A Canal forebay, and 67 from Miller Creek (Table 5). 17 suckers from the J Canal within California, and 22 suckers from the J Canal within Oregon. Zero juvenile sucker were captured in the C, D, and J canals. All suckers salvaged from the A canal forebay were taken to Klamath Sucker Assisted Rearing Program (KSARP Appendix C, Figure C-2 by the USFWS. The USFWS PIT-tagged, weighed, measured, and treated affected suckers for parasites and disease as necessary. All suckers salvaged from Miller Creek were released into Gerber Reservoir. The Miller Creek salvage is summarized in Appendix D with other sampling in Gerber Reservoir.

During the last 5 years, Reclamation has engaged staff from USFWS, KID, and TID in conversation on how to reduce entrainment through operational shifts or dewater the canals differently at the end of each year. Each irrigation season is operationally different from the previous years. To date, the conversations have not yet identified a clear solution to reduce the quantity of fish, and endangered suckers, in the canal system.

Table 5. Summary of juvenile suckers salvaged from Klamath Project canals in 2021.

STATE	Canal	Site	Location description	UTM East	UTM North	2021
Oregon	A		A canal Forebay	598743	4676963	82
	C4	22	Miller Hill pumping plant	603128	4666343	0
	C4	22/23	between 22 & 23			-
	C4	23	Mac Check	603917	4665123	0
	C4	24	¼ mile S of Old Midland Rd.	603434	4664140	-
	C4	24/25	between 24 & 25	602753	4664526	-
	C4	25	¼ mile N of Old Midland Rd.	602141	4664625	-
	C4	26	1/8 mile west of Tingley Lane	601002	4664872	0
	C4	26b	¼ mile W of Tingley Lane	600900	4664736	0
	C4	26c	Check ¼ mile E of Tingley Ln.	601426	4665318	-
	C1	21	Adam's Flume area (S lat.)	613764	4654852	0
	C1	21a	Adam's Flume area (¼ S lat.)	613714	4654847	0
	D3	21	the check near site 21			-
	D3	20	Adam's Flume area (E lat.)	614120	4654933	-
	J	51	Anderson-Rose Dam	619184	4651944	-
	J	52	Check 1 and flume	621505	4651289	-
	J	53	S end of siphon	621537	4651657	-
	J	54	Check 2 (Check # C61010)	623272	4651694	-
	J	55	Check 3 (Check # C61016)	625700	4651923	-
	J	56	Check 4	627334	4651403	-
	J	57	Check 5	631061	4650688	-
	J	57a	North of stateline Rd at RR Xing	629028	4651413	-
	Miller Creek		Plunge Pool Gerber Dam Spillway			67
California	J	58	Check 6 – S of Stateline Road	632352	4650628	-
	J	59	Check 7	634861	4648454	-
	J	60	Check 8 - D&J confluence	636333	4646278	-
	J	61	Check 9	636947	4643589	-
	J	62	Check 10	637823	4642453	-
	J	63	Check 11	637985	4640807	-
	J	64	Check 12	636846	4638865	-
	J	64/65	Culvert between sites 64 & 65	636056	4639656	-
	J	65	Check 13 (Check # C71113)	635770	4639596	-
	J	65/66	Culvert between sites 65 & 66	635360	4639471	-
	J	66	Culvert E of Highway 139	634874	4639183	-
	J	67	RR Bridge W of Highway 139	634282	4638730	-
	J	68	Check 14	633607	4638622	-
	J	69	Culvert at County Rd. 112	632874	4637953	-
	J	70	Pump 24 (tail end of J-canal)	631334	4636676	-
					Total:	149

- site was not salvaged or could not be salvaged due to low water levels or because canals remained full.

Adult Lost River Sucker and Shortnose Sucker Monitoring in Project Reservoirs

M&RR 2 (USFWS) – Adult Lost River Sucker and Shortnose Sucker Monitoring in Project Reservoirs

Requirement

Reclamation is required to continue to support monitoring efforts for adult sucker monitoring in UKL and Clear Lake Reservoir.

Additionally, Reclamation is required to undertake annual trammel net sampling at Gerber Reservoir to monitor populations, including the collection of size frequency data, implanting PIT-tags, and scan suckers for previously implanted PIT-tags.

Results

Adult sucker monitoring for both UKL and Clear Lake Reservoir occurred in 2021 consistent M&RR 2. The most recent UKL Adult Monitoring report was published in 2018 by USGS. A draft Clear Lake Reservoir Adult Monitoring Report was shared with Reclamation in January 2021. USGS Adult Sucker Monitoring reports are publicly available on their website (https://www.usgs.gov/centers/wfrc).

To better understand sucker abundance in Gerber Reservoir, Reclamation reinitiated an adult sucker monitoring program in 2018. To better understand sucker abundance in Gerber Reservoir, Reclamation reinitiated an adult sucker monitoring program in 2018. Reclamation set trammel nets 30 days in 2018, 23 days in 2019, 20 days in 2020, and 10 days in 2021 at Gerber Reservoir. Annual spring sampling in Gerber Reservoir was curtailed so Reclamation staff could assist USFWS in a sucker relocation effort in Tule Lake Sump 1A. As part of a 2021 Gerber Dam inspection, Reclamation salvaged suckers from Miller Creek plunge-pool downstream of Gerber Reservoir on April 6, 2021. Suckers from this salvage effort were PIT-tagged and released in Gerber Reservoir and this effort is summarized herein. Reclamation captured and PIT-tagged 1215 suckers in 2018, 1148 suckers in 2019, 442 suckers in 2020, and 166 suckers in 2021. Reclamation recaptured 33 suckers in 2018, 8 suckers in 2019, 1 sucker in 2020, and 3 suckers in 2021 that were PIT-tagged by USGS from 2000 to 2005 (Barry et al. 2007). Including recaptures from suckers tagged in other years but excluding recaptures of the same individual (identified by PIT-tag) within the year, Reclamation captured a total of 1249 PIT-tagged suckers in 2018, 1200 PIT-tagged suckers in 2019, 461 PIT-tagged suckers in 2020, and 178 suckers in 2021.

Klamath Project Implementation and Hydrologic Monitoring

M&RR 3.3a (USFWS) – Klamath Basin Planning Model

Requirements

Under the USFWS 2020 BiOp, Reclamation is required to use WRIMS 2.0 software platform for annual updates. Reclamation may update software to new versions as they are published and verified, and Reclamation shall inform USFWS prior to doing so. The potential use of software other than WRIMS will be evaluated in coordination with the Services.

Results

Reclamation has continued to use WRIMS 2.0 software platform for annual updates to the KBPM. Reclamation is also evaluating the use of the RiverWare software platform to support future operations.

U.S. Fish and Wildlife Service Conservation Measures

Reclamation proposed the following Conservation Measures in its 2020 BA.

1) Canal Salvage (pg. 164)
2) Sucker Captive Rearing Program (pgs. 165-167)
3) Sucker Monitoring and Recovery Program Participation (pgs. 167-168)
4) Coho Restoration Grant Program

Canal Salvage

See section: M&RR 1.1c (USFWS)- Canal Salvage Report and Appendix B.

Sucker Assisted Rearing

Requirement

> "*Reclamation proposes to provide funding to the Service to support assisted rearing of the LRS and the SNS with the purpose of increasing the number of suckers reaching maturity in UKL. As discussed above in this BiOp there has not been significant recruitment into the UKL adult population of the LRS and the SNS since the late 1990s. The current adult breeding population of suckers is aging and is nearing the end of their*

expected life span. The disappearance of juvenile suckers from UKL beginning in August and extending into October accounts for this situation. An assisted rearing effort is needed to prevent extinction until the causes of juvenile mortality are addressed (Burdick et al. 2018, Hewitt et al. 2018).

Specifically, Reclamation proposes to continue contributing approximately $300,000 per year to the Service that would be used for capital and operating costs associated with an assisted rearing program. Oversight of the assisted rearing program will continue to be provided by the Service with input from the Klamath Sucker Recovery Program, in coordination with Reclamation. Reclamation's support of the assisted rearing program will continue for the term of this consultation (April 1, 2022 to September 30, 2022)."

Results

Reclamation contributed $300,000 in 2020 to USFWS for the assisted rearing program.

Sucker Monitoring and Recovery Program Participation

Requirement

In the Modified 2018 Operations Plan/IOP, Reclamation proposed a Conservation Measure to support sucker recovery efforts. Reclamation proposed involvement and financial support of $1.5 million per year, with an additional $700,000 in FY 2020; and providing additional funding in later years, as funds are available.

Results

Consistent with the USFWS 2020 BiOp USFWS has plans to restructure the sucker recovery effort. Reclamation will participate and contribute funds to this effort in ways that will advance the needs of sucker recovery at the discretion of USFWS. Reclamation funds that have been used for research and monitoring projects for FY 2021 are summarized in Table 6.

Table 6. The List of Projects that Received Fiscal Year 2021 Recovery Funding.

Title	Funding Amount
SARP telemetry in Upper Klamath Lake (UKL)	$ 415,504.27
Thiamine Deficiency Evaluation in SNS and LRS life stages (USFWS)	$ 17,419.16
Thiamine Deficiency Evaluation in SNS and LRS life stages (USGS)	$ 29,900.00
Semi-Natural Wetland	$ 440,296.52
UKL juvenile sucker cohort tracking	$ 143,285
UKL Adult Monitoring	$ 654,445
Clear Lake Adult Monitoring	$ 175,190
Sucker Captive Propagation	$ 300,000

National Marine Fisheries Service Reporting Requirements

T&C 1A (NMFS)- Take actions to Ensure Environmental Water Account Distribution and Iron Gate Dam Flows are Managed within the Scope of the Proposed Action

Requirement

NMFS 2019 BiOp states:

> *"NMFS uses flow thresholds described in the Amount or Extent of Take section as surrogates to measure the amount or extent of incidental take. Monitoring annual EWA volumes and distribution and IGD flows and whether they are within the scope of the proposed action will provide Reclamation and NMFS with the information needed to determine whether incidental take surrogates are met. Therefore, as the irrigation season progresses from March 1 – September 30, Reclamation shall manage EWA distribution and IGD flows to meet the following surrogates and monitor EWA distribution and IGD flows (including reductions to IGD flows due to UKL control logic) to determine whether the following surrogates are met:*
>
> - *The minimum daily average flows described in Table 33 are met.*
> - *The daily reduction to IGD flow due to UKL control logic shall not exceed the largest daily reduction to IGD flow modeled in the POR of 74 percent.*
> - *The percentage of the final EWA volume based on June 1 supply and used between March 1 and June 30 shall not be less than 61 percent.*
> - *Based on annual June 1 EWA supply, EWA released between March 1 and September 30 shall not be underspent by more 5 percent.*
>
> *Based on monitoring, if Reclamation determines any of the thresholds listed above have not been met or EWA spending and/or IGD flows are expected to potentially fall outside the thresholds listed above, Reclamation shall immediately notify NMFS and consult with the Services to determine the causative factors. If EWA spending and/or IGD flows have not yet fallen outside the thresholds listed above and NMFS determines that causative factors are not due to extraordinary hydrologic conditions, Reclamation, in consultation with the Services, shall determine and take in-season corrective actions including adjustments to avoid falling outside the thresholds listed above.*
>
> *In addition, to reduce the likelihood of underspending EWA by greater than five percent by September 30th, Reclamation shall complete an assessment, in coordination with the Services, of EWA used and EWA remaining on May 1 of each calendar year to ensure that the percentage of EWA used in March and April is consistent with EWA distribution modeled in the KBPM for the POR and is not expected to fall outside the thresholds listed above."*

Results

The PA Calculator used to direct daily operations beginning in March 2021 tracks the percent of EWA expended by the dates in this T&C as well as logic that constrains the reduction in IGD flows based on the UKL control logic. Minimum daily average flows (cfs) for IGD were greater than those required in NMFS 2019 BiOp Table 33. Daily reductions to IGD flow due to UKL control logic did not exceed 74 percent, the largest daily reduction to IGD flow modeled in the POR.

The EWA allocation was 400,000 AF on June 1 in 2021. During the 2021 water year, 226,531 AF of EWA had been used between March 1 and June 30. In 2021, EWA was underspent on October 1 by approximately 10.5 percent, with a total release of 361,686 AF because there was no flushing flow and flows remained at minimums due to severe drought conditions.

Table 7. Minimum daily average flows (cubic-feet-per-second (cfs)) for Iron Gate Dam (IGD) from NMFS 2019 BiOp and actual daily minimum flows (cfs) for IGD for each month.

Month	Minimum Target Flow (cfs)	Actual daily minimum (cfs)
March	1,000	1,019
April	1,325	1,371
May	1,175	1,195
June	1,025	1,026
July	900	917
August	900	930
September	1,000	994

T&C 1F (NMFS)- Development of a Post-Facilities removal Operations plan

Requirement

NMFS 2019 BiOp states:

> *"To minimize incidental take of listed coho salmon as a result of Project Operations and ensure that Project Operations are implemented as analyzed in the opinion, Reclamation shall, by October 2020 or at least four months prior to the scheduled commencement of facilities removal, develop and provide to the Services an Operations plan that incorporates a flow release strategy from Keno Dam. The Operations plan shall include at least the following elements (1) ramp down rates at Keno Dam that minimize risks to stranding coho fry; (2) EWA releases consistent with the proposed action analyzed in the opinion; and (3) development of minimum flow releases at Keno Dam that represent conditions below IGD currently met through IGD minimum flows."*

Results

In 2019, Reclamation began the steps necessary for development of a Post-Facilities removal Operations Plan. This has included coordination with KRRC's contractor. The NMFS and USFWS BiOps for dam removal only became available during late December of 2021 and still lack operational details. Reclamation is working out these details with the services prior to the scheduled commencement of facilities removal. Reclamation's Denver Office for Safety of Dams produced a Condition Assessment report from the information collected during the 2019

inspections. The Condition Assessment report will be finalized to produce a Comprehensive Review report as Reclamation approaches title transfer. Reclamation is participating in ongoing planning efforts with the Klamath River Renewal Corporation contractors and PacifiCorp for operations during and subsequent to dam removal.

T&C 1G (NMFS)- Abundance, prevalence of infection, and predicted mortality of emigrating juvenile salmon in the Klamath River

Requirement

NMFS 2019 BiOp states:

> *"Reclamation shall fund monitoring and estimation of the abundance, prevalence of infection, and predicted mortality of emigrating juvenile Chinook and coho salmon disease in the lower Klamath River, with emphasis on determining the effects of flushing and dilution flow releases under the proposed action, updating data and recalibrating the 80 percent outmigration model. Continued operation of downstream migrant traps will support the further understanding of, among other things, population-level effects of disease on coho and Chinook salmon and the better estimation of associated mortality. This will support better in-season management of flows and minimization of incidental take of listed species."*

Results

In late FY 2019, Reclamation entered an Interagency Agreement with USFWS-Arcata to: 1) estimate weekly abundance of juvenile Chinook at a site near Orleans (determined as Weitchpec in 2020); 2) collect, preserve, and deliver weekly-stratified samples of young-of-the-year Chinook Salmon to California-Nevada Fish Health Center (CA-NV FHC); 3) estimate season-wide population-level effects of *Ceratonova shasta* (*C. shasta*) in Chinook Salmon; 4) estimate weekly-stratified outmigration rates for juvenile Chinook and Coho Salmon to overlay with *C. shasta* spore information to determine disease exposure for the following tasks; 5) collect pertinent biological data of outmigrating juvenile salmon at a monitoring site near Weitchpec; and 6) estimate relative abundance of Coho Salmon and steelhead near Weitchpec.

In FY 2021, efforts to monitor at other river sites continued as it had in previous years; however, after a review of lower river sites, a determination was made that the Weitchpec site offered the best opportunity at juvenile salmon monitoring success in the lower Klamath River (LKR). This prompted the renegotiation of the original agreement in FY 2019. In FY 2021, Reclamation has provided funding for the FY 2021 fudnign cycle for this effort with USFWS-Arcata, Yurok Tribe, and Karuk Tribe.
The Yurok Tribe and the Karuk Tribe FY 2021 efforts were funded directly by Reclamation through annual funding agreements (Public Law 93-638). During the 2021 field season, data will be collected from the Weitchpec and other locations. Reclamation intends to fund each of the three entities pending available fiscal appropriations.

Additionally, and related, an Interagency Agreement between Reclamation and the USFWS CA-NV FHC was funded in late FY 2020 for efforts through September 2022. This agreement will need to be revisited by Reclamation and USFWS to redefine the effort and associated budget with anticipated samples from the additional Weitchpec site. Those conversations started in 2020, and there is sufficient funding in the current agreement for work to continue through at least September 2022 without revisions.

In 2021, Reclamation funded Klamath River Juvenile Health Monitoring. This research was conducted by the CA-NV FHC. Their final report titled *Myxosporean Parasite (Ceratonova shasta* and *Parvicapsula minibicornis) Prevalence of Infection in Klamath River Basin Juvenile Chinook Salmon, March – July 2021* was published in January 2022. The report can be requested from the address on their website:

https://www.fws.gov/canvfhc/

A summary of the report is as follows[1]:

Juvenile Klamath River Chinook Salmon (*Oncorhynchus tshawytscha*) were assayed from late March through July 2021 by quantitative polymerase chain reaction (QPCR) and histology for myxosporean parasite infection of *Ceratonova shasta* and *Parvicapsula minibicornis*. The annual prevalence of *C. shasta* infection in 2021 by QPCR was 59%.

Natural fish were monitored in real-time for the first 10 weeks of the season in order to provide timely data to fishery managers. *Ceratonova shasta* was first detected in fish sampled on March 20 at the Kinsman rotary screw trap (~ river mile 147). Iron Gate Hatchery did not release smolts in the summer of 2021, and therefore no hatchery fish were monitored for *C. shasta* this year.

The addition of the Weitchpec rotary screw trap (~ 44.2 rm) provided a lower river sampling opportunity in 2021. *Ceratonova shasta* was detected in 56% of fish tested from the initial sample collected the week of April 4. That result raises questions about when and where those fish were exposed and if there is an infectious zone in the lower river.

Two additional studies were conducted in 2021. The first was a continuation from 2020 looking at the relationship between DNA copy number and histological disease rating. The DNA threshold greater than three logs will continue to be used by the fish health center to describe *C. shasta* infections likely to lead to mortality (under spring and summer conditions). The second was a pilot study in which daily juvenile Chinook Salmon mortalities collected from the Weitchpec rotary screw trap were screened for myxospores. Presumptive *C. shasta* myxospores were observed in 20% of the juvenile mortalities screened by microscopy.

Key Points

In 2021, 962 juvenile Chinook Salmon were collected from the mainstem Klamath River. Natural fish accounted for 97% (930/962) of fish collected, and fish of unknown origin accounted for 3% (32/962). This was an unprecedented year (2021) without hatchery fish, and therefore the highest proportion of natural fish ever collected. In previous years, the proportion of natural fish has ranged from 21-69%.

Monitoring of waterborne stages of *C. shasta* from river water showed a pattern of decreased spore density in spring 2021.

Several questions arose from the sampling at the Weitchpec trap, especially with the magnitude of *C. shasta* POI and DNA copy number detected in early April. In March, spore counts at all OSU index sites were ≤ 2 spores/L, and in early April, spore counts at Seiad Valley measured 17 spores/L and Orleans at 7 spores/L (Oregon State University, 2021). Even though spore counts were increasing in early April, fish would have to been exposed earlier for the parasite to be detected in intestinal tissue. Determining when initial intestinal infection occurred may be useful and would require fish to be collected from the trap earlier in the season.

These early detections also raise the question of exposure location. The amount of time spent in the main-stem Klamath River is unknown, since we have no history of the fish prior to their collection in the trap. The size of the juvenile Chinook Salmon collected the week of April 4 and April 11 ranged from 31 to 40mm (fork length). It is not known if these small fish were beginning to migrate downstream soon after emergence from the gravel or if they were holding in rearing habitat prior to collection. Additional information is needed on whether there is a separate infectious zone in the lower river, or the infectious zone is larger than previously thought.

The pilot study examined daily juvenile Chinook Salmon mortalities collected from the Weitchpec rotary screw trap screened for myxospores. Presumptive *C. shasta* myxospores were observed in 20% of the juvenile mortalities screened by microscopy. While many unknowns and collection bias exist in this pilot study, the results reiterate the discussion of True et al., 2012 and Robinson et al., 2020. Juvenile Chinook Salmon could be a source of myxospore production and input throughout the Klamath River. This myxospore contribution may be considerable, especially in years with favorable environmental conditions (e.g.- low flows and warm water temperatures) and large juvenile salmon populations.

[1] Citation: Voss, A., Foott, J., & Freund, S. (2021). Myxosporean Parasite (Ceratonova shasta and Parvicapsula minibicornis) Prevalence of Infection in Klamath River Basin Juvenile Chinook Salmon, March – July 2021. U.S. Fish & Wildlife Service. California – Nevada Fish Health Center, Anderson, CA. http://www.fws.gov/canvfhc/reports.html.

T&C 1H (NMFS)- In the event of funding lapses, fund the monitoring and reporting requirements of California Department of Fish and Wildlife (CDFW) Shasta River Rotary Screw Trap (Trap)

Requirement

The NMFS 2019 BiOp states:

> *"Reclamation shall coordinate with CDFW to determine whether CDFW will continue to fund and operate the trap after 2019. In the event that CDFW will not continue to fund and operate the trap from 2020 through 2023, Reclamation shall ensure the trap is operated or operation is fully funded and reports are generated to inform the necessary requirements of data collection to evaluate incidental take of coho salmon described in the ITS."*

Results

Operation of the Trap was funded by CDFW in 2020 and 2021.

T&C 1I (NMFS)- Incidental Take relative to disease as prevalence of mortality (POM)

Requirement

The NMFS 2019 BiOp states:

> *"Reclamation shall fund the development of (1) a spore concentration submodel, (2) updates to S3 model parameters, and (3) scenario model runs to evaluate the effect of in-season disease triggers on simulated prevalence of infection and mortality."*

By March 1 of the following year, Reclamation will provide an annual report on (1) the percent of *C. shasta* infection rates for Chinook Salmon in the mainstem between the Shasta River and the Trinity River during the months of May through July, and (2) the weekly actinospore genotype II concentrations in the mainstem Klamath River immediately upstream of Beaver Creek during mid-April to June. The requirement date was modified to May 1 for the in a communication exchange on February 4 and 5, 2020, between Reclamation and the Services.

Results

In late FY 2019, Reclamation entered an Interagency Agreement with USFWS-Arcata for the following tasks: 1) update Salmonid Stream Simulator (S3) model structure to include *C. shasta* spore concentration submodel and a function of among- and within-year flow events to better inform management decisions; 2) update S3 model with refined disease model based on an extended sentinel trial experiment, incorporate recent data, and re-calibrate model with new disease model structure (including updating flow and temperature data in RBM10); 3) run scenarios to support in-season management decision-making; and 4) model effects of *C. shasta* on out-migrating Coho Salmon in the Klamath River.

The agreement with USFWS-Arcata includes the joint effort with USGS-Columbia River Research Laboratory for updating the S3 model. The tasks are separated by periods of performance based on federal FYs starting in FY 2020 through FY 2023, and to date, most effort has been expanded on

Tasks 1 and 2. It is assumed that Tasks 1 and 2 will be annually occurring efforts based on the availability of new information. More effort is expected on Tasks 2, 3, and 4 in FY 2021 to the end of FY 2023 (the proposed effort end date in the current multiple-year agreement). In late FY 2020, Reclamation fully-funded the existing agreement with USFWS-Arcata for efforts through September 2023 based on work described in the current agreement.

Reclamation and Oregon State University (OSU) renewed their Klamath River Fish Health Studies contract in 2020. The Klamath River Fish Health Studies contract is monitoring of *C. shasta* total actinospore and genotype II concentrations in the mainstem Klamath River at five index sites mid-April to June and expedite analysis and data dissemination. In addition to the waterborne spore quantification, the contract with OSU also includes support to monitor prevalence of *C. shasta* infection in sentinel-exposed Chinook Salmon, Coho Salmon and Rainbow Trout, the densities of *C. shasta* in water samples at six Klamath River sites, and the abundance and prevalence of infection in annelids. The data presented here are provisional and the final report is anticipated by mid-June 2022. The following is a summary of OSU's water sampling methods and results from the 2021 field season:

1. To detect total parasite abundance, water samples were collected weekly from six mainstem index sites. Each 1-liter water sample was filtered through a nitrocellulose membrane using a vacuum pump and any captured DNA was extracted using a kit. A qPCR specific for *C. shasta* was used to detect and quantify any parasite DNA present. Cq values generated by the qPCR were converted to numbers of parasite spores per liter of water using reference samples with known quantities of spores. Actinospore densities in water samples collected at the index sites throughout the 2021 monitoring period are presented in Figure 22 (Table 8). As typical, parasite abundance in the mainstem increased in the spring: abundance was low (< 1 spore per liter) through mid-March; levels above 1 spore per liter were first measured at KOR on March 22 and two weeks later (April 5) at all index sites. Density first surpassed 10 spores per liter at two sites this week (Figure 23 and Table 8). Spore densities then rapidly increased (an order of magnitude) at most sites to peak 2 - 4 weeks later at the 4 uppermost sites (e.g. at 79 spores per liter 3 weeks later at KBC). Spore densities fluctuated throughout spring and summer with >10 spores per liter measured at every site at some time. Densities were often twice as high at the uppermost 3 sites (KI5, KBC, and KMN) than at the lowermost 3 sites (KSV, KOR, and KTC) (Table 8). The highest densities were recorded at upstream sites KI5, KBC and KMN in mid-late April, with up to 79 spores per liter measured (at KBC). Densities decreased early summer but increased again in late summer and were higher than usual early fall and did not decrease to below 10 spores per liter at all sites until mid-fall (early November).

2. There are multiple genotypes (strains) of *C. shasta* simultaneously present in the Klamath River that differentially impact various salmonid species: type I infects Chinook Salmon, type II infects Coho Salmon, type 0 infects Steelhead and Redband Trout. Data are measured in two ways: a qPCR assay that determines the density of genotype II, and DNA sequencing that can determine the proportion of each genotype. For the last several years, OSU has determined the proportion of each genotype in water samples collected from the Klamath River Beaver Creek index site from April 1, until 1 week after 80 percent of juvenile Chinook are estimated to have passed the Kinsman trap. In 2019, this was expanded to include all index sites on the Klamath mainstem. Samples can only be genotyped when spore densities are at least 1 - 2 spores per liter (the detection limit of the assays). In 2021, genotype II was detected at all index sites at some time. It was first detected April 12 at KTC (1 spore/L) and by May 17 exceeded 5 spores per liter at two sites (6 - 8 spores per liter at KI5 and KBC). The Coho Salmon 40% mortality threshold of 5

type II spores per liter was met at the 4 uppermost index sites (KI5, KBC, KMN, and KSV). In 2021, spore density was relatively high for genotype II plus it comprised a relatively high proportion of total spore density (for example, 14.3% KOR – 72.2% KSV). The highest density measured was 32 spores per liter on June 21 at KI5.

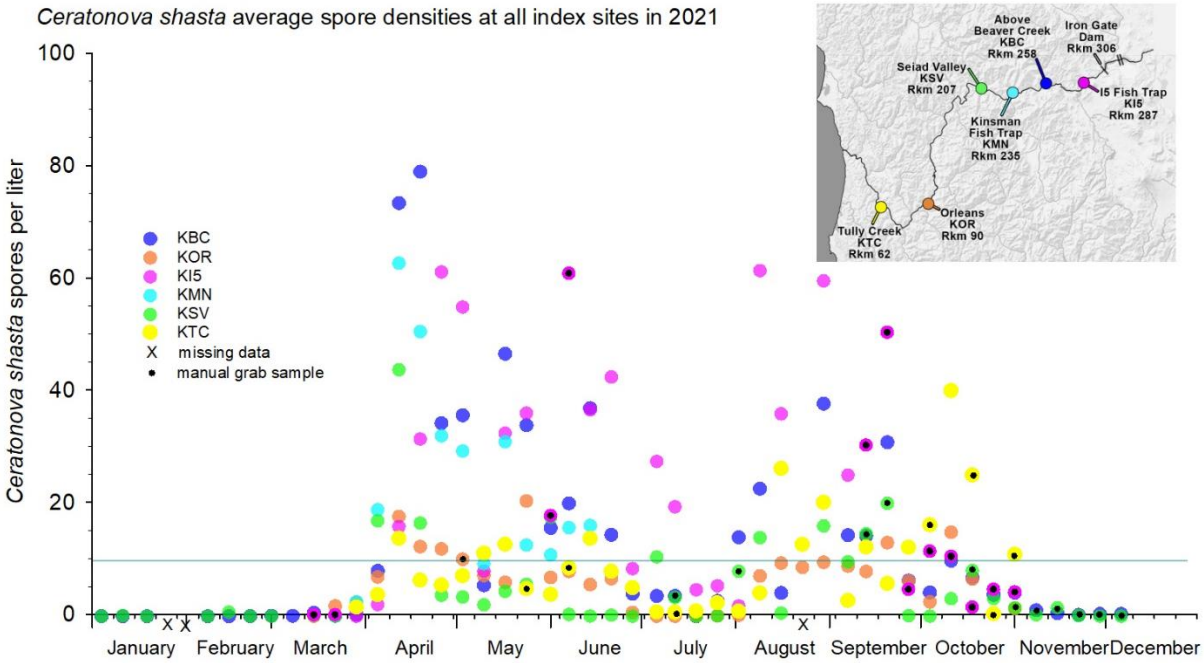

Figure 22. Density (average spores per liter) of *Ceratonova shasta* in 24-hour composite water samples collected at the mainstem index sites in 2021. The data points are the average of three 1-liter water samples. Dots indicate manually collected grab samples (as opposed to the rest, which are ISCO automatic 24-hr composite samples). Note that KMN is sampled only during salmonid outmigration, KBC and KSV year-round and remaining sites April through October. KI5 = near I5 bridge, KBC = upstream of Beaver Creek, KMN = Kinsman Fish Trap, KSV = Seiad Valley, KOR = Orleans, and KTC = Tully Creek.

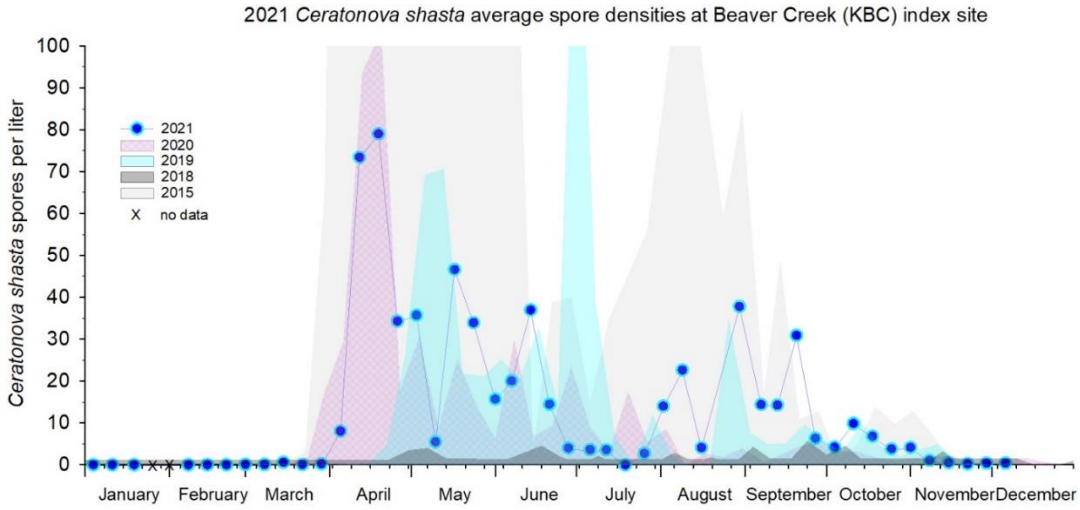

Figure 23. Density (spores per liter) of *Ceratonova shasta* in water samples collected in Klamath mainstem near confluence with Klamath River Beaver Creek (site KBC) in 2021. The data points are the average of three 1-liter water samples. Shading indicates spore density profiles for previous years for comparison. The prescribed April surface flushing flow is indicated.

Table 8. Density (spores per liter) of *Ceratonova shasta* in water samples collected at index sites in 2021. The bold data value represents the highest density recorded in 2021. Cells with zero (0) indicates no spores were sampled or spores were undetectable. Cells "x" indicate sites that were not sampled on those dates. KI5 = near I5 bridge, KBC = upstream of Beaver Creek, KMN = Kinsman Fish Trap, KSV = Seiad Valley, KOR = Orleans, and KTC = Tully Creek. (Further details will be included in Oregon State University's 2021 annual report due to Reclamation June 2022.)

COLLECTION DATE	INDEX SITE (Upstream Sites to Downstream Sites)					
	KI5	KBC	KMN	KSV	KOR	KTC
01/04/2021	x	0	x	0	x	x
01/11/2021	x	0	x	< 1	x	x
01/19/2021	x	0	x	0	x	x
01/26/2021	x	x	x	x	x	x
02/02/2021	x	x	x	x	x	x
02/08/2021	x	0	x	0 g	x	x
02/15/2021	x	0	x	< 1	x	x
02/22/2021	x	0	x	0	x	x
03/01/2021	x	< 1	x	0	x	x
03/08/2021	x	< 1	x	< 1 g	x	x
03/15/2021	0 g	< 1	< 1	0	0 g	x
03/22/2021	0 g	< 1	< 1	0	2	x
03/29/2021	0	< 1	3	2	3	1
04/05/2021	2	8	19	17	7	4
04/12/2021	16	73	**63**	**44**	18	14
04/19/2021	31	**79**	51	17	12	6
04/26/2021	**61**	34	32	4	12	5
05/03/2021	55	36	29	4	10 g	7
05/10/2021	8	5	9	2	7	11
05/17/2021	33	47	21	4	6	13
05/24/2021	36	34	13	6	**20**	5 g
06/01/2021	18	16	11	18	7	4
06/07/2021	61 g	20	16	< 1	8	8 g
06/14/2021	37	37	16[5]	0	6	14
06/21/2021	43	14	x	< 1	7	8
06/28/2021	8	4	x	0	1	5
07/06/2021	28	4	x	11	0	1
07/12/2021	19	4	x	3 g	0	< 1
07/19/2021	5	0	x	0	0	1 g
07/26/2021	5	3	x	0	< 1	6 g
08/02/2021	2	14	x	8 g	< 1	1
08/09/2021	61	23	x	14	7	4
08/16/2021	36	4	x	1	9	26
08/23/2021	x	x	x	x	9	13
08/30/2021	60	38	x	16	10	20
09/07/2021	25	14	x	10	9	4
09/13/2021	30 g	14	x	15 g	8	12
09/20/2021	50 g	31	x	20 g	13	6
09/27/2021	5 g	6	x	< 1	6	12 g
10/04/2021	11 g	4	x	0	3	16 g
10/11/2021	10 g	10	x	3	15	**40**
10/18/2021	1 g	7	x	8 g	7	25 g
10/25/2021	5 g	4	x	3 g	inhib g	< 1 g
11/01/2021	4 g	4	x	2 g	1 g	11 g
11/08/2021	x	1	x	< 1	x	x
11/15/2021	x	< 1	x	2 g	x	x
11/22/2021	x	< 1 g	x	< 1 g	x	x

11/29/2021	x	< 1 g	x	0 g	x	x
12/06/2021	x	< 1	x	0 g	x	x
12/13/2021	x	nd	x	nd	x	x
12/20/2021	x	nd	x	nd	x	x
12/27/2021	x	nd	x	nd	x	x

g - manual 1-L "grab" samples taken at one time point (all other samples are ISCO 24-h composites)
5 - Kingsman Fish Trap site (KMN) sampling finished for the season.
x - Data not available (sample not collected as planned, sample unable to be collected – wildfires)
nd - data not determined: samples not yet received by OSU or not yet assayed
inhib g - sample contained contaminants and no assay data were obtainable

Table 9. Density (spores per liter) of genotype II of *Ceratonova shasta* in water samples collected at index sites March - July 2021, determined by qPCR assay. The "g" indicates manually collected grab samples (as opposed to the rest, which are ISCO automatic 24-hr composite samples); "-" = insufficient total *Cs* to assay; "x" = site not sampled; and "nd" = not yet determined. KI5 = near I5 bridge, KBC = near Beaver Creek, KMN = Kinsman Fish Trap, KSV = Seiad Valley, KOR = Orleans, KTC = Tully Creek. (Further data will be included in Oregon State University's 2021 annual report due to Reclamation June 2022.)

COLLECTION DATE	INDEX SITE (Upstream Sites to Downstream Sites)					
	KI5	KBC	KMN	KSV	KOR	KTC
03/15/2021	-	x	x	x	x	-
03/22/2021	-	x	x	x	x	-
03/29/2021	-	nd	x	x	x	x
04/05/2021	0	0	0	0	0	0
04/12/2021	nd	nd	nd	nd	nd	nd
04/19/2021	< 1	< 1	3	< 1	< 1	2
04/26/2021	1	< 1	1	0	2	1
05/03/2021	2	4	3	< 1	1 g	1
05/10/2021	1	1	1	0	1	1
05/17/2021	6	8	4	1	2	2
05/24/2021	7	5	1	1	1	1
06/01/2021	12	6	5	13	1	0
06/07/2021	22 g	8	6	< 1	2	< 1 g
06/14/2021	17	9	4	0	< 1	< 1
06/21/2021	32	9	x	0	< 1	2
06/28/2021	4	2	x	0	0	0
07/06/2021	5	1	x	3	0	0
07/12/2021	4	< 1	x	< 1 g	0	0
07/19/2021	2	0	x	0	0	< 1 g
07/26/2021	2	1	x	0	0	1 g

FWS-Arcata/USGS Update

Results of S3 modelling – POM Estimates for Coho and Chinook salmon (Southern Resident killer whale (SRKW))

Consistent with section 2.5.1.3. of the NMFS 2019 BiOp, Reclamation is required to report POM for Chinook salmon as a surrogate of effects to SRKW.

Chinook Salmon - Dr. Russ Perry, with the USGS Western Fisheries Research Center, simulated POM on naturally produced juvenile Chinook Salmon in water year 2021 at Reclamation's request. In order to complete this simulation, USGS needed to compile the following inputs from water year 2021 for use in the Stream Salmonid Simulator (S3) model: 1) water temperature data; 2) flow data; 3) spawner abundance, timing, and distribution data; 4) spore concentration data; and 5) tributary juvenile abundance and timing data. Because meteorological data required to run the Klamath Basin RBM10 water temperature model were unavailable, USGS used water temperature data collected throughout the Klamath River to develop the timeseries of daily water temperature data required to run S3. In addition, because of the ongoing COVID-19 pandemic, water temperature data were not available at all monitoring locations. To fill these gaps, USGS applied methods from previous S3 POM simulations. USGS estimated temperatures for these missing locations by using historical temperature data to estimate the difference between the next upstream monitoring station and the missing station, and then adding this difference to temperature from the upstream monitoring location.

Given these inputs, USGS ran the S3 model as described in Perry et al. (2018), parameterized in Perry et al. (2019), and applied to assess disease effects in Plumb et al. (2019). To remain consistent with how POM was defined and calculated for Coho Salmon by the USFWS, Arcata Fish and Wildlife Office, USGS defined the POM to be the simulated proportion of juvenile Chinook Salmon passing the Kinsman Creek Juvenile Salmon Monitoring Site that are predicted to eventually die from ceratomyxosis. This metric does not account for ceratomyxosis mortalities occurring upstream of the Kinsman Creek monitoring Site.

The results from the S3 simulation were provided to Reclamation from Dr. Perry in an email on February 3, 2022 (attached letter dated January 29, 2021 [*sic*]). The key points of the simulation are as below.

1. Simulated abundance for 2021 (0.720 million juveniles passing the Kinsman Trap) was slightly less than the mark-recapture estimates of abundance (0.896 million juveniles). Differences between S3 model output and mark-recapture estimates were within the range expected given statistical uncertainty in S3 model calibration, Kinsman abundance estimates (95% CI: .513 – 1.348 million juveniles), and rotary screw trap abundance estimates for juveniles entering the Klamath River from tributaries.

2. The S3 model simulated an overall POM of 44.6% for naturally produced juvenile Chinook Salmon. That is, the S3 model simulated that 44.6% of the naturally produced juvenile Chinook Salmon passing the Kinsman Trap site were infected with *C. shasta* and expected to eventually succumb to ceratomyxosis. This POM was driven by a sharp increase (>70 spores / L) for two weeks in April, followed by multiple weeks in May in which total spore concentration exceeded 20 spores / L.

3. It is important to note that infected fish that die from ceratomyxosis upstream of the Kinsman Trap site will reduce the apparent prevalence of mortality calculated at the Kinsman Trap because infected fish are removed from the population prior to being censused. The amount of disease-caused mortality occurring upstream of the Kinsman Trap will depend on the time to mortality after infection, which in turn depends on spore concentration, water temperature, and exposure duration (Perry et al. 2019). Increases in either of these variables will reduce the time to death, thereby increasing disease caused mortality upstream of the Kinsman Trap. For example, S3 simulations for 2021 revealed that substantial disease-caused mortality occurred upstream of the Kinsman Trap for juvenile Chinook Salmon originating from Klamath River spawners and Bogus Creek (Figure 1).

4. One uncertainty with our simulations for 2021 is the assumed location of the *C. shasta* infectious zone. The S3 model used for this analysis was constructed and calibrated under the assumption that the *C. shasta* infectious zone occurred between Interstate 5 and Seiad Valley. However, field observations from fish trapping efforts identified fish with visible signs of ceratomyxosis as far upstream as the USFWS-operated fish trap in the Klamath River near Bogus Creek. Thus, the POM values simulated by S3 may be conservative given field observations of an expanded infectious zone. Field data from 2021 could be used in future model updates to construct and calibrate a version of the model that accounts for a spatially variable infectious zone.

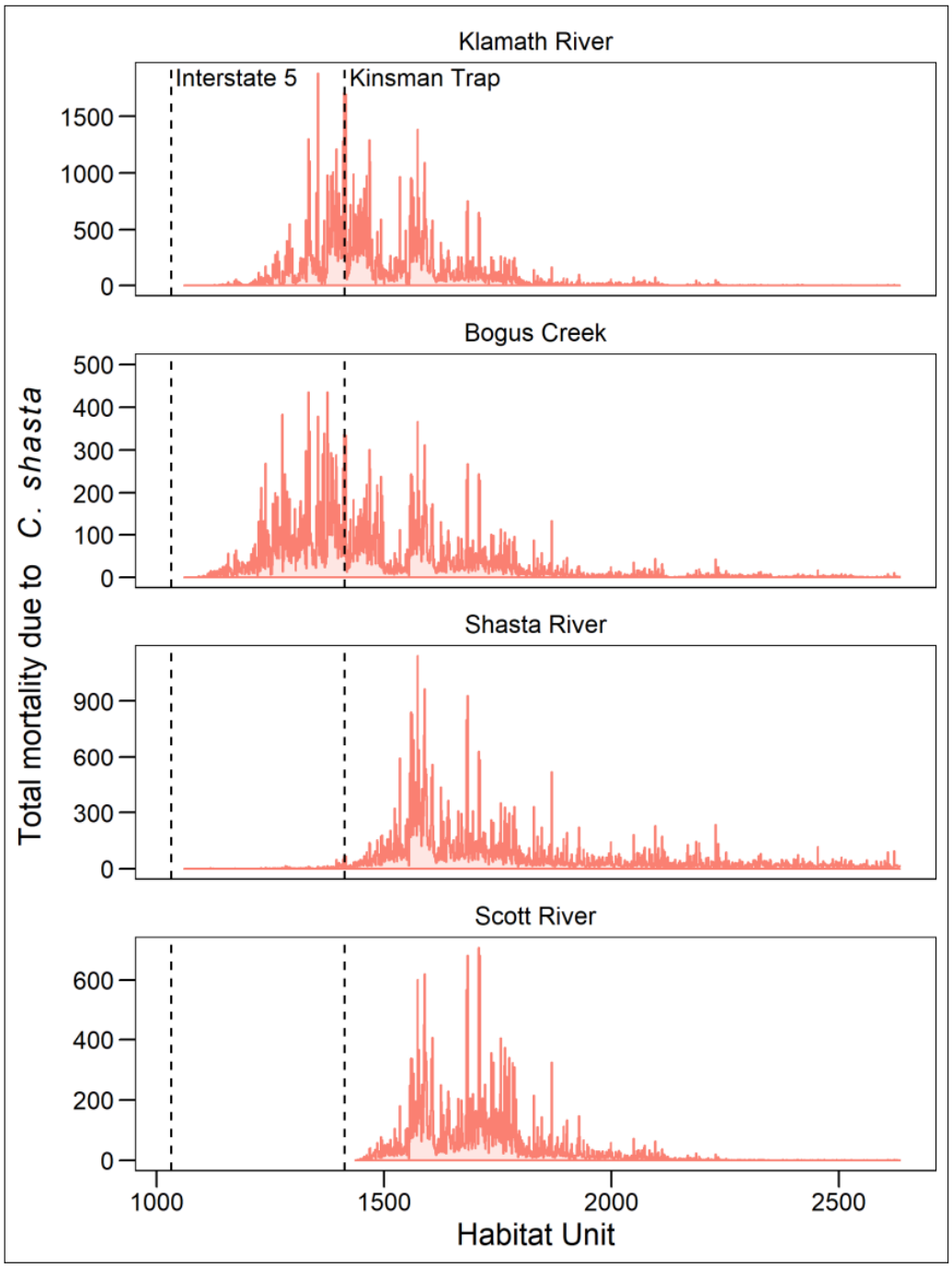

Figure 24. Location of simulated mortality due to ceratomyxosis in 2021 for different populations of juvenile Chinook salmon migrating through the Klamath River. Habitat units start at Iron Gate Dam (Unit 930) and end at the ocean (Unit 2,635). Vertical dashed lines mark the locations of the Interstate 5 and the Kinsman trap.

Coho Salmon – USFWS' Arcata Office Fish and Aquatic Conservation Program (Dr. Nicholas Som and Mr. Nicholas Hetrick) applied the methods of Som et al. (2019) to compute the estimated POM resulting from ceratomyxosis for Shasta River-origin Coho Salmon that entered the Klamath River mainstem in spring 2021. Computing these estimates requires data from several sources, including weekly outmigrant estimates provided by the CDFW, water temperatures occurring in the vicinity of the Beaver Creek confluence with the Klamath River mainstem provided by a monitoring program

jointly run by the Karuk Tribe Department of Water Resources and OSU, and the concentration of infectious spores as provided by OSU.

The results from the S3 simulation were provided to Reclamation from a Technical Memorandum from Dr. Som and Mr. Hetrick in a letter dated January 25, 2022. The key points of the simulation are as below.

1. "After gathering these data and applying the POM methods described in Som et al. (2019), for Shasta River-origin juvenile Coho Salmon entering the mainstem Klamath River, Coho Salmon POM is estimated to have been around 12 percent in 2021. However, comparing this value to POM estimates for prior years is complicated by the fact that the CDFW's sampling season stopped approximately a month earlier than most years, which corresponded to a period when the concentration of infectious spores and water temperatures were both relatively high, and mortality risk for Coho Salmon was elevated."

2. "For the majority of the spring outmigration and redistribution period in 2021 when Coho Salmon entered the mainstem Klamath River from the Shasta River, the concentrations of infectious spores specific to Coho Salmon (commonly called Type-II) were at or near zero spores/liter. In late April 2021, spore concentrations began rising above 0 spores/liter and continued to increase through May. This increasing trend in spore concentrations appears to occur when the numbers of Shasta River outmigrants were declining. It's difficult to say this with certainty, however, because the month of June was not sampled in 2021 and in previous years, pulses of outmigrant Coho Salmon have been observed in June. For example, for the years of data used to fit the Coho Salmon POM model of Som et al. (2019), the percent of annual outmigrants entering the Klamath mainstem in June or later averaged 25% (range 5% - 77%). The peak spore concentration of Type-II spores over the 2021 period when the Shasta River outmigrants were monitored was approximately 8 spores/liter, which is close to that maximum reported for June 2021 at 9 spores/liter. These peak concentrations are higher than the peak observed in 2020 (4 spores/liter). It should be noted that at the time this memo was prepared, spore data provided by OSU are still labeled as provisional and will be finalized at a later date. We do not expect, however, that finalized data will change these results in any substantive way (i.e., more than a few percentage points)."

Results of Ceratonova shasta (C. shasta) monitoring used in modeling

In 2021, 962 juvenile Chinook Salmon were collected from the main-stem Klamath River. Natural fish accounted for 97% (930/962) of fish collected, and fish of unknown origin accounted for 3% (32/962). This was an unprecedented year without hatchery fish due to the drought conditions (warm water temperatures and low flows), and therefore the highest proportion of natural fish ever collected. In previous years, the proportion of natural fish has ranged from 21-69%.

Ceratonova shasta was detected by QPCR in 58% (536/930, ci = 54-61%) of natural fish in 2021. Prevalence of infection has ranged from a low of 4% in 2012, to a high of 75-76% during the drought years of 2014-2015. *Ceratonova shasta* POI for natural fish in 2021 ranks as the fourth highest since 2009. *Parvicapsula minibicornis* was detected in 64% (592/930, ci = 60-67%) of naturally produced Chinook Salmon by QPCR, compared to 75% in 2020.

The annual prevalence of *C. shasta* infection in all juvenile Chinook Salmon tested in 2021 by QPCR was 59% (567/962, confidence interval [ci] = 56-62%). *Ceratonova shasta* was first detected on March 30 in the Shasta River to Scott River reach. Annual *C. shasta* POI by QPCR was higher in

2021 than 2020 (65% and 61%, respectively). The slight increase in POI is was observed even though there were lower spore densities in spring 2021. Monitoring of waterborne stages of *C. shasta* from river water showed a pattern of decreased spore density in spring 2021. *Ceratonova shasta* was detected at a mean spore density of 3 spores/L in late March 2021 at the Kinsman water sampling location (Oregon State University, 2021), compared to 35 spores/L the previous year. A similar pattern occurred in mid-April when *C. shasta* was detected at 63 spores/L in 2021, compared to 180 spores/L during the same time period the previous year. The annual *C. shasta* POI by histology for all fish tested in 2021 was 52% (37/71, ci = 40-64%), and for *P. minibicornis* POI was 36% (22/61, ci = 24-49%).

The "disease threshold" (2-4 logs of *C. shasta* DNA that correlates with clinical infection by histology) was repeated again in 2021, and the threshold greater than three logs of *C. shasta* DNA will continue to be used by the fish health center to describe infection that is likely to lead to mortality. In the Shasta River to Scott River (K4) reach, the DNA copy number peaked at 3.6 logs in early May, and collections in K4 (May 2, May 9 and May 30) had a high number of samples over three logs of *C. shasta* DNA (ranging from 50-63%). Three collections in K3 (May 2, May 16, and May 30) had samples over three logs of *C. shasta* DNA (ranging from 10-15%). The mean DNA copy number in K4 was 2.6 logs in 2021, compared to 3.0 logs in 2020. The mean DNA copy number in the K3 reach was 1.8 logs in 2021, compared to 2.7 in 2020.

Prevalence of *C. shasta* infection during peak out-migration increased in both QPCR and histology in 2021, relative to previous years (Table 10). Prevalence of *C. shasta* infection by QPCR from May through July was 82% (368/447, ci = 78-86%) in 2021, compared to 73% in 2020. Prevalence of infection was also higher than the average of 49% for the past thirteen years (2009-2021). Prevalence of *C. shasta* infection by histology was 75% (24/32, ci = 57-89), compared to 60% observed in 2020 (Table 2). The 13-year average of *C. shasta* infection by histology is 26%. *Parvicapsula minibicornis* prevalence of infection by QPCR in Chinook Salmon above the Trinity River confluence for the same time period was 94% (422/447, ci = 92-96%), compared to 99% in 2020 and also higher than the 13-year average of 86%.

For further detail beyond the summary provided here, the full report (Voss et al. 2021) can be accessed at (https://www.fws.gov/canvfhc/CANVReports.html).

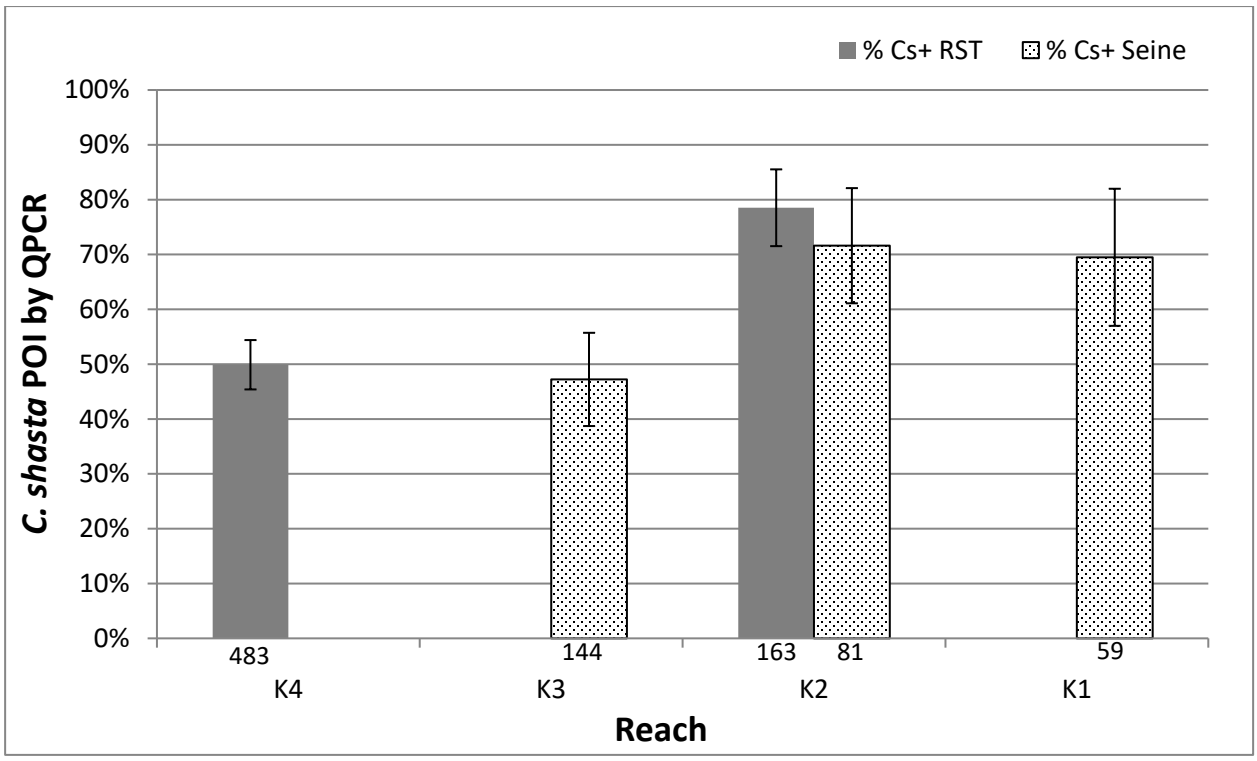

Figure 25. *Ceratonova shasta* prevalence of infection (POI) in natural juvenile Chinook Salmon captured by reach. Rotary screw trap collection method shown in solid gray columns and seine collection method shown in pattern filled columns. K4 rotary screw trap site = Kinsman. K2 rotary screw trap site = Weitchpec. Standard errors of the mean bars are displayed on top of the columns and sample numbers are displayed below the columns.

Table 10. Historic annual prevalence of *Ceratonova shasta* infection in all juvenile Chinook Salmon collected from the main-stem Klamath River between Iron Gate Dam and Trinity River confluence during May through July, 2009-2021. Percent positive by assay is reported, as well as the number positive/number tested in parenthesis.

Year	Histology	Histology	qPCR	qPCR
	% Positive	Numbers	% Positive	Numbers
2009	54%	(50/93)	47%	(264/561)
2010	15%	(22/146)	17%	(128/774)
2011	3%[1]	(3/118)	17%	(62/374)
2012	9%[1]	(9/98)	30%	(160/526)
2013	16%[1]	(6/37)	46%	(234/508)
2014	42%[1]	(20/48)	81%	(467/576)
2015	62%[1]	(37/60)	91%	(437/482)
2016	14%[1]	(8/58)	48%	(243/504)
2017	8%[1]	(3/40)	26%	(153/600)
2018	4%[1]	(1/27)	20%	(114/570)
2019	40%[1]	(16/40)	68%	(395/581)
2020	60%[1]	(18/30)	73%	(433/593)
2021	75%[1]	(24/32)	82%	(368/447)
MEAN	**26%**	**(217/827)**	**49%**	**(3458/7096)**

[1]- Histology limited to two reaches in 2011 (K4 and K1); and two reaches in 2012-2021 (K4 and K3).

T&C 1J (NMFS) - Fund Fish Modeling to evaluate the effects of *Ceratonova shasta* (*C. shasta*) spore concentrations on the survival of out-migrating Coho Salmon in the Klamath River

Requirement

The 2019 NMFS BiOp states:

> *"Reclamation shall fund the application of a Bayesian hierarchical Cormack-Jolley-Seber model to assess the effects of C. shasta spore concentrations on the survival of actively migrating coho salmon in the Klamath River and provide results of that modeling to NMFS."*

Results

Reclamation funded USFWS-Arcata for FY 2021 to conduct Mark Recapture survival analysis based off screw-trap sampling conducted in the LKR and its tributaries.

In late FY 2019, Reclamation entered an Interagency Agreement with USFWS-Arcata for the following tasks: 1) update S3 model structure to include *C. shasta* spore concentration submodel and a function of among- and within-year flow events to better inform management decisions; 2) update S3 model with refined disease model based on an extended sentinel trial experiment, incorporate recent data, and re-calibrate model with new disease model structure (including updating flow and temperature data in RBM10); 3) run scenarios to support in-season management decision-making; and 4) model effects of *C. shasta* on out-migrating Coho Salmon in the Klamath River (using a Bayesian hierarchical Cormack-Jolley-Seber model).

The agreement with USFWS-Arcata includes the joint effort with USGS-Columbia River Research Laboratory for updating the S3 model. The tasks are separated by periods of performance based on federal FYs starting in FY 2020 through FY 2023, and to date, most effort has been expanded on Tasks 1 and 2. It is assumed that Tasks 1 and 2 will be annually occurring efforts based on the availability of new information. More effort is expected on Tasks 2, 3, and 4 in FY 2021 to the end of FY 2023 (the proposed effort end date in the current multiple-year agreement). In late FY 2020, Reclamation fully-funded the existing agreement with USFWS-Arcata for efforts through September 2023 based on work described in the current agreement.

T&C 2B-RR 1 (NMFS)- Weekly Updates

Summary of accretion data in addition to all of the Environmental Water Account, Project, and Refuge information.

Requirement

The 2019 NMFS BiOp states:
"Reclamation shall report all measured accretion data (Link River Dam to Keno Dam) and all measured and estimated accretion data (Keno Dam to IGD) in addition to all of the EWA, Project and Refuge information."

Results

An example of the Reclamation Daily Numbers report is presented as Table A-14 in Appendix A, as are the other tables in Appendix A. The first eight columns show daily values for water deliveries,

along with the elevation of UKL. The final two columns shown deal with Link River to Keno Dam accretions. (Additional columns showing more delivery points are omitted for clarity.) Releases from the dams and accretion data for LRD to Keno Dam is shown as Ewauna (Keno Net) Accretions in the bottom section, alongside the Keno to IGD Accretions. PacifiCorp distributes an accretion forecast update that shows the calculated Keno to IGD accretions which is shown as Table A-15. PacifiCorp's numbers are periodically checked for accuracy by Reclamation based on confidential reservoir data shared by PacifiCorp.

T&C 2B-RR 4 (NMFS) -Monthly Reports for fall/winter Operations

Summary of Environmental Water Account and Fall/Winter flow management

Requirement

The 2019 NMFS BiOp states:

> *"Reclamation shall provide monthly update reports for the formulaic approach during the fall/winter operations including reductions to IGD flows due to UKL control logic, UKL net inflow, Link River Dam to IGD accretions, UKL levels, winter Project deliveries, Refuge deliveries, and any other relevant data NMFS identifies during implementation of the proposed action."*

Results

The tables shown as A-14 and A-15 are produced year-round and show accretions between LRD and Keno and between Keno and IGD, respectively.

Link River releases are shown in Figure 26. Lake Ewauna accretions remained consistently low (Figure 27) as they are dependent largely on irrigation returns. Keno releases remained consistently low (Figure 28), reflecting the dry hydrologic conditions in the upper Klamath Basin.

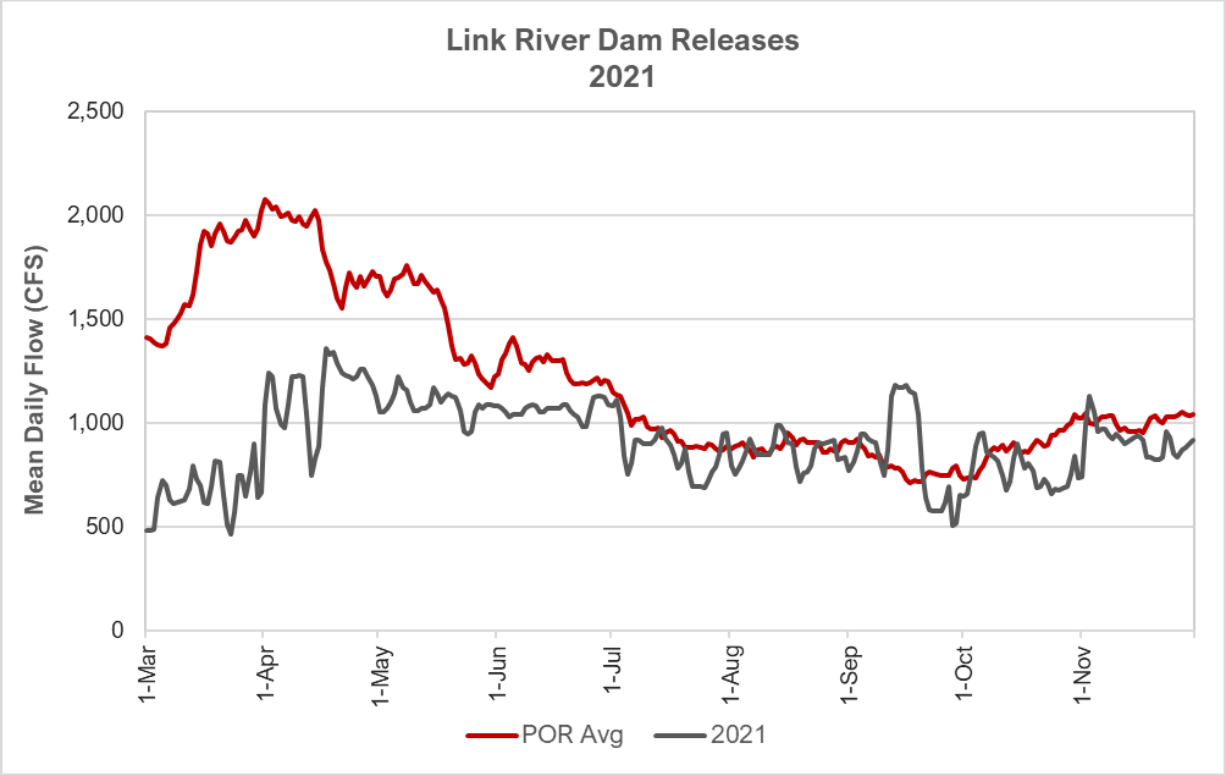

Figure 26. 2021 Link River Releases and Period of Record Average for March-September.

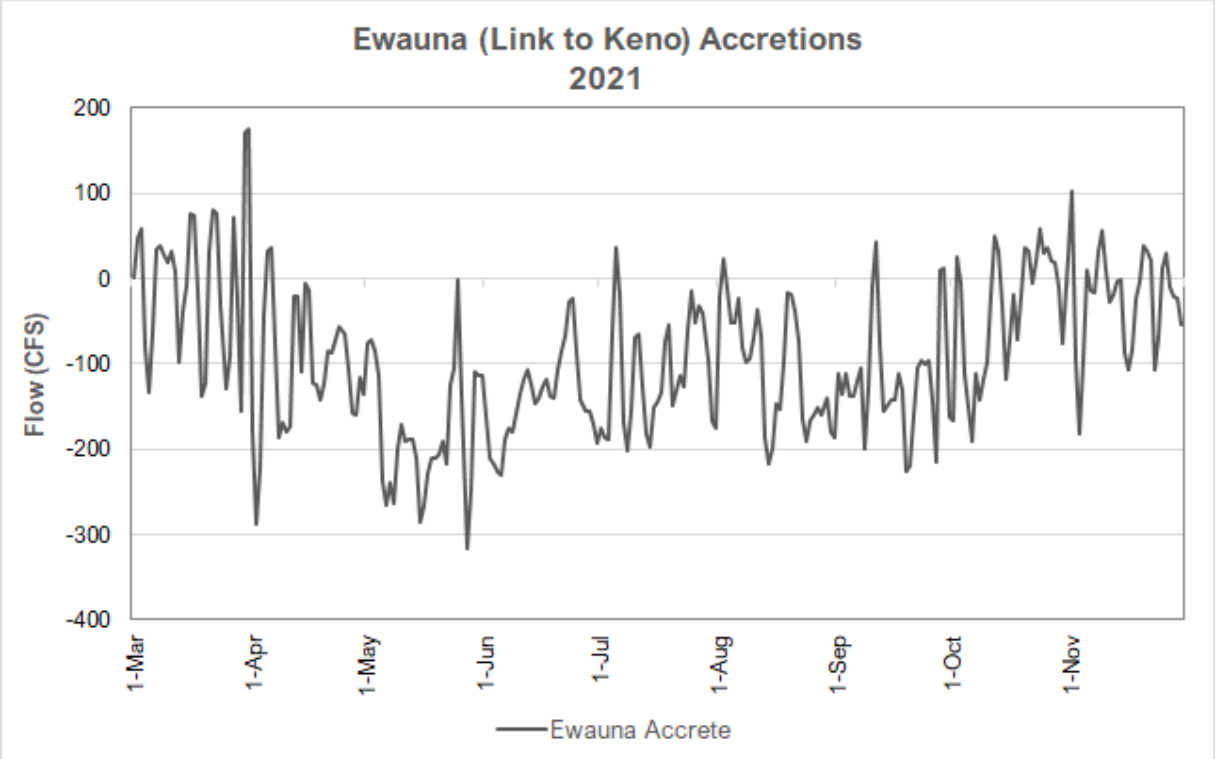

Figure 27. Ewauna 2021 Accretions.

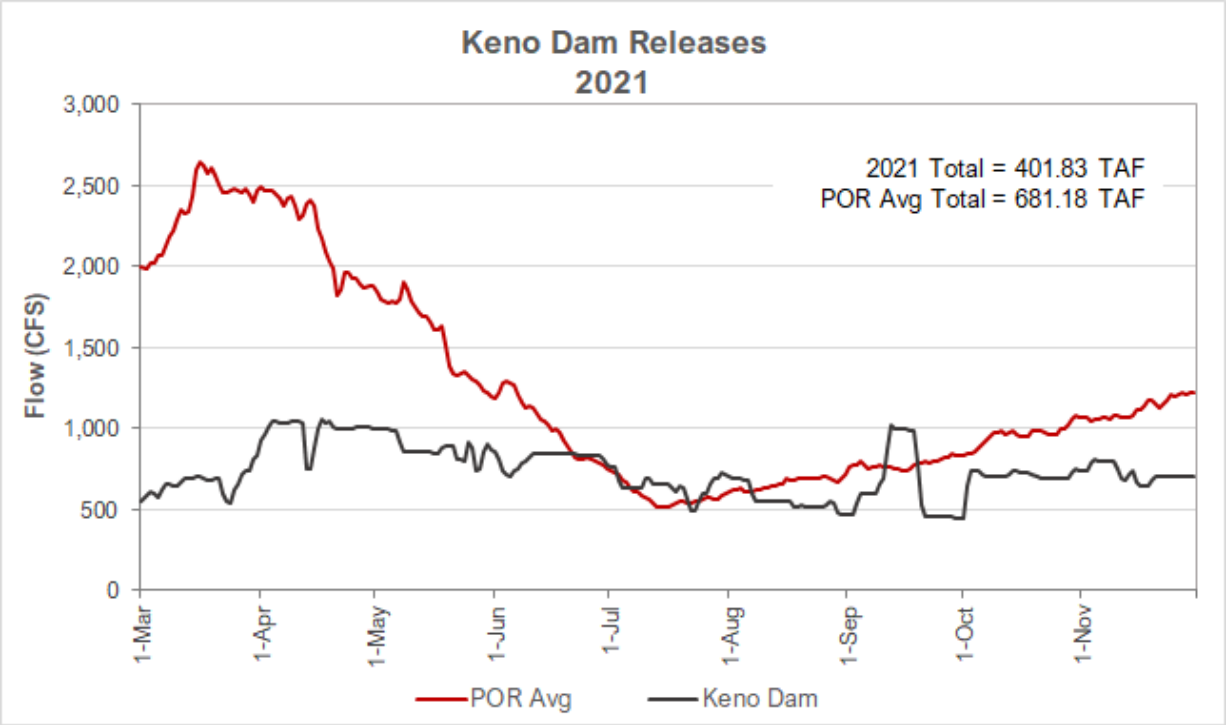

Figure 28. Keno Dam and Period of Record Average Releases during 2021.

The Keno to IGD accretions shown in Figure 29 and Figure 30 show that the projected values from PacifiCorp on a daily basis from November through February frequently differed slightly from the values calculated afterwards by Reclamation based on actual reservoir elevations and flow releases. On average, PacifiCorp projected 614 AF/day and the calculated Reclamation totals were 665 AF/day.

Figure 31 shows that although there was more day to day variability with the USBR estimates, the average flows were similar. The largest differences occurred during managed events from late-April through mid-June that impacted reservoir volumes.

On average, accretions for March through October projected by PacifiCorp were quite similar, 563 AF/day whereas those calculated by Reclamation were 570 AF/day.

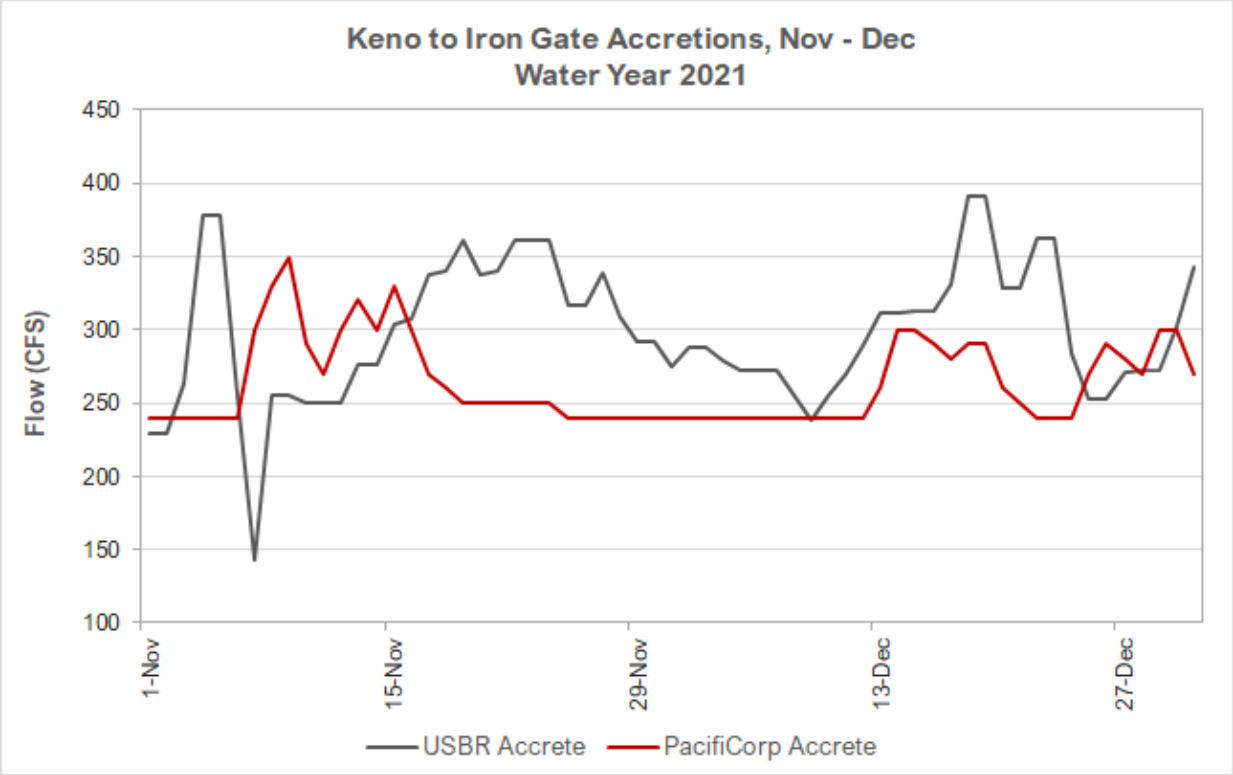

Figure 29. Keno to Iron Gate Accretions, November-December 2020 (Water Year 2021).

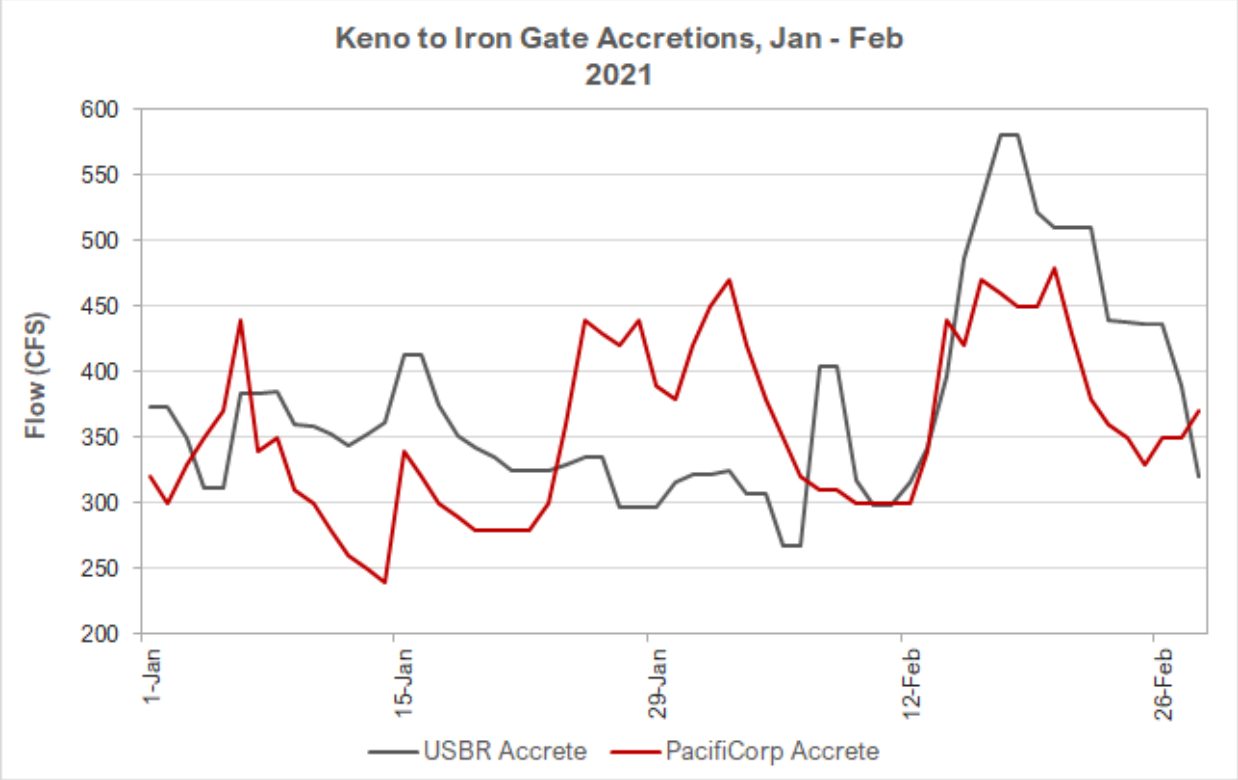

Figure 30. Keno to Iron Gate Accretions, January-February.

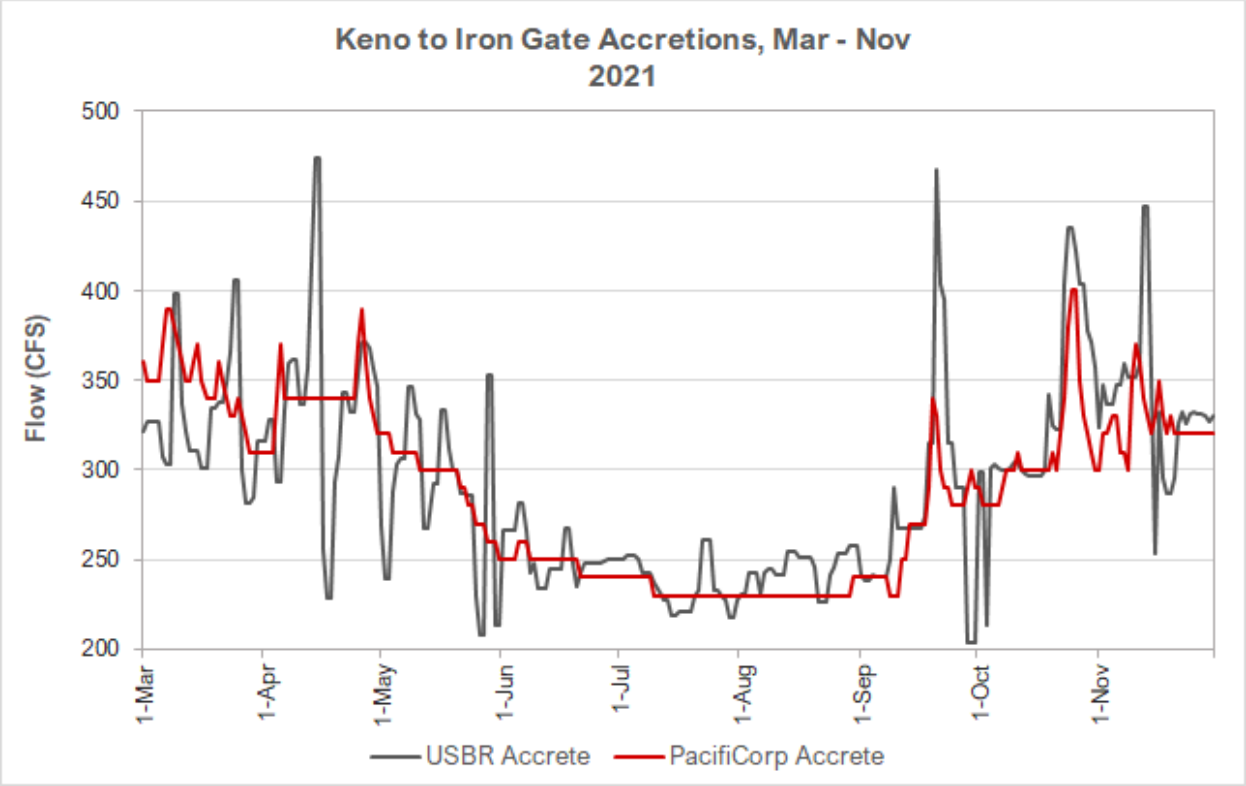

Figure 31. Keno to Iron Gate Accretions, March-November.

The graphs comparing observed and projected daily flows for IGD are shown as Figure 32 through Figure 35. Figure 32 shows flows at or near minimums throughout the water year. Calculated and actual IGD releases closely track each other. Figure 35 shows a similar congruence and that actual IGD releases closely fit the scheduled flows.

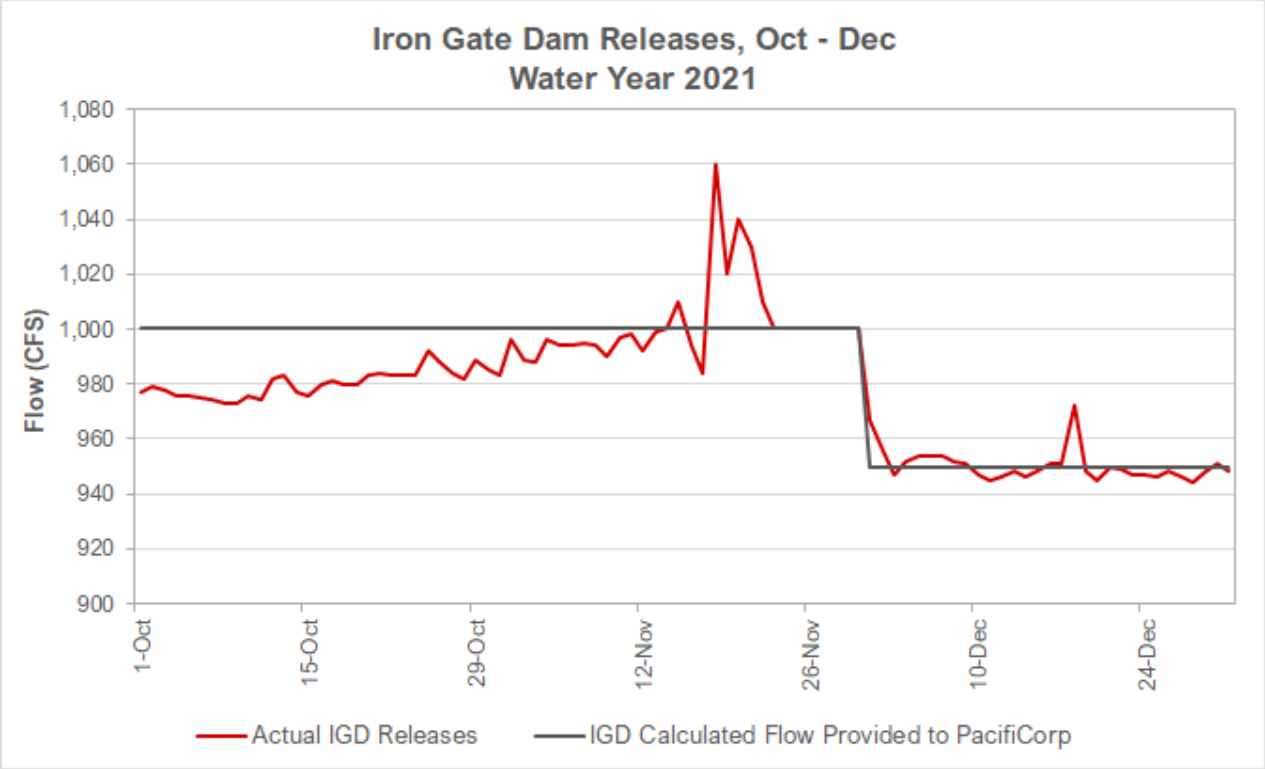

Figure 32. Iron Date Dam Daily Flows Projected Versus Actual (October-December).

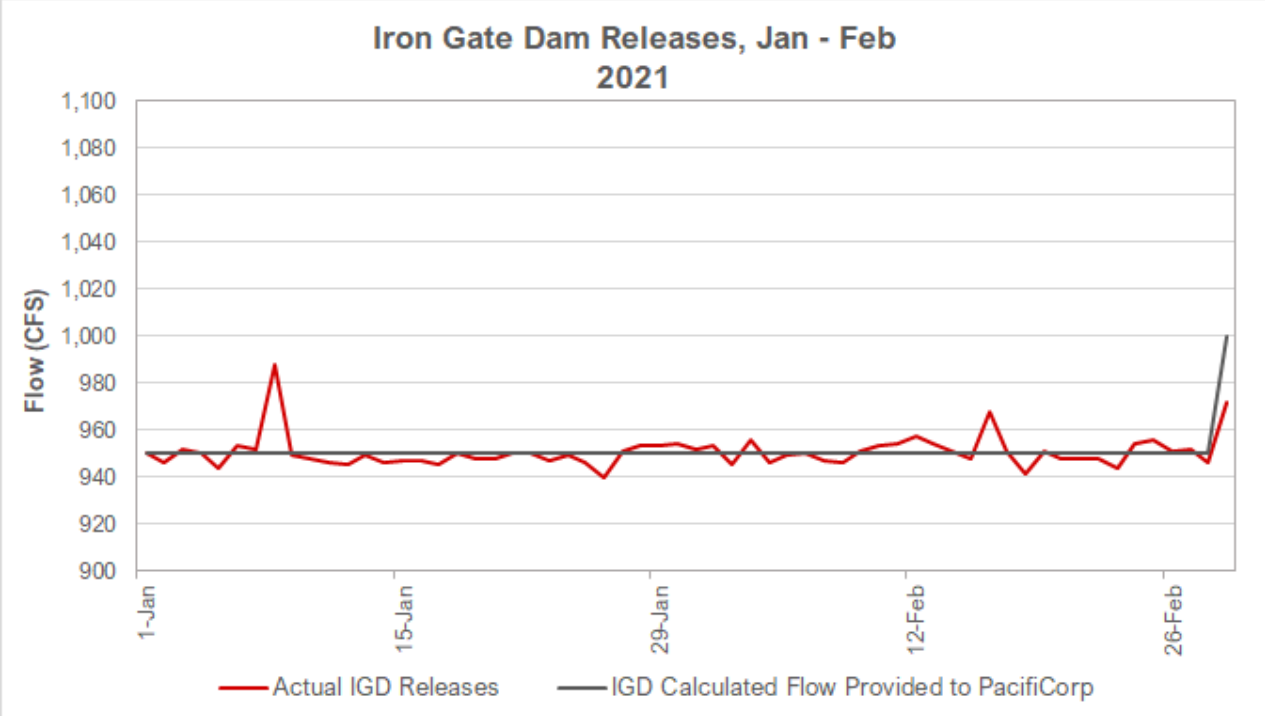

Figure 33. Iron Gate Dam Daily Flows Projected Versus Actual (January-February).

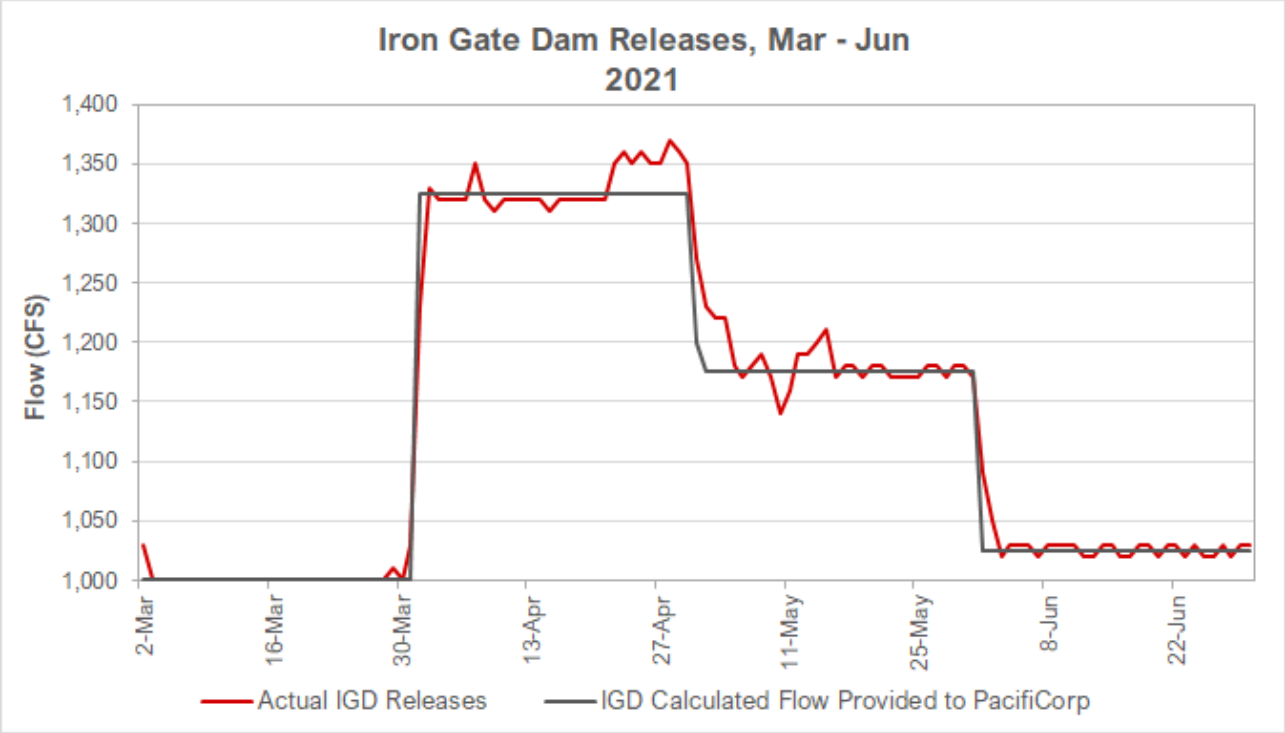

Figure 34. Iron Gate Dam Daily Flows Projected Versus Actual (March-June).

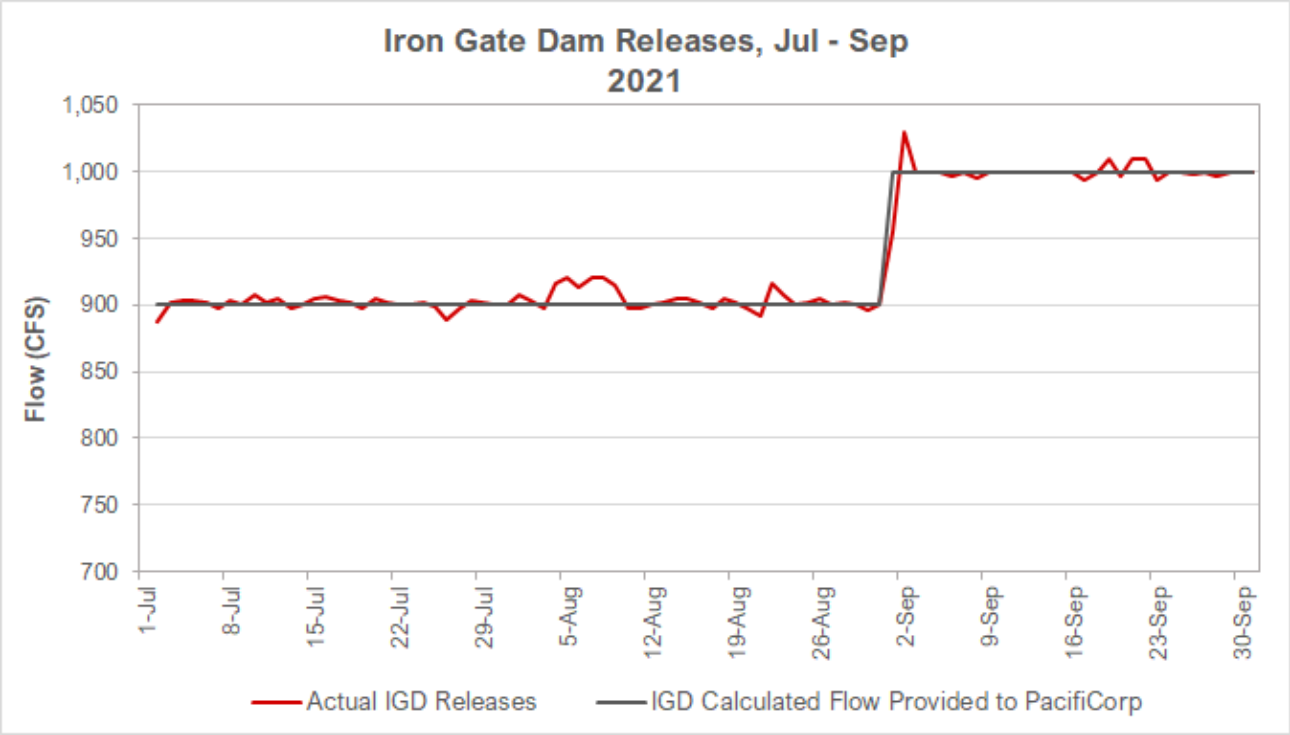

Figure 35. Iron Gate Dam Daily Flows Projected Versus Actual Flows (July-September).

T&C 2B-RR 6 (NMFS) Klamath River Restoration

Requirement

The 2019 NMFS BiOp states:

> *"Reclamation will provide an annual report on the type and location of each restoration project implemented. The monitoring report shall include the total number of coho salmon captured, relocated, injured, or killed for each restoration project, and will be submitted annually by March 1 to the NMFS Northern California office:*
>
> *National Marine Fisheries Service*
> *Jim Simondet, Klamath Branch Supervisor*
> *1655 Heindon Road*
> *Arcata, California 95521*
>
> *All coho salmon mortalities encountered must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NMFS."*

Regarding the Klamath River Coho Restoration Program, the NMFS 2019 BiOp specifically states:

> *"On March 25, 2019, NMFS received a letter from Reclamation entitled "Addendum 3 to the Proposed Action (PA) included in the Bureau of Reclamation's December 21, 2018, Final Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project (Project) from April 1, 2019 through March 31, 2029, on Federally-Listed Threatened and Endangered Species, as modified on February 15, 2019 (modified 2018 BA)" (USBR 2019c). In their letter, Reclamation clarified the proposed Klamath River Coho Restoration Program will be at a level of $700,000 in each of fiscal years 2019 and 2020, and $500,000 in each of the successive fiscal years beginning with fiscal year 2021 and ending with fiscal year 2024."*

Results

Restoration and recovery actions in the Klamath Basin are improving habitat and water quality conditions for anadromous salmonids. Reclamation provided $500,000 per year from 2013 – 2018 (approximately $3 million) and $700,000 for the 2019 grant cycle for the Klamath River Coho Habitat Restoration Program. Reclamation awarded a grant to the National Fish and Wildlife Foundation (NFWF) to administer the Klamath River Coho Restoration Program. NFWF has completed four grant cycles (2016, 2017, 2018, and 2019) for restoration and research/monitoring projects, selecting a total of 25 projects for funding (partial and full funding). A grant cycle was initiated in 2019 and completed in early 2020, and those grants, and funded projects, are included in this description. In 2020 Reclamation worked to secure another grant administrator as the 5-year agreement with NFWF was schedule to conclude. However, due to extenuating circumstances the new funding agreement for a new grant administrator was not able to be awarded in 2020. Reclamation therefore extended the administrative duties of NFWF to September 30, 2021. In November 2021, Reclamation awarded a new funding agreement to NFWF to administer the program until September 2024. Conservation funding for FY 2020 ($700,000) was combined with FY 2021 ($500,000) funding for a total of $1.2 Million, with an additional $500,000 planned for FY 2022 through FY 2024.

Project descriptions and funding amounts (Table 11) were described using information organized by NFWF. NFWF requested proposals in 2016, 2017, 2018 and 2019, where they received a total of 69 pre-proposals. Of these proposals, they requested full proposals for 35 applications, and a total of 25 projects were selected for funding. A total of $3,178,696.65 has been obligated for the Klamath River Coho Restoration Program. Matching contributions of over $3,400,000 (cash and in kind) have leveraged approximately $6,500,000 in restoration funds as a result of the program.

NFWF funded 4 full proposals in the 2019 grant cycle, and two projects were not selected for submission of a full proposal. NFWF received full proposals and developed contracts for these projects (Table 12). Additionally, in March 2021 $139,001.99 of unused NFWF administrative funds was reallocated toward previously selected grant projects.

Project Descriptions of Awarded Projects during Calendar Year 2020/Grant Year 2019 Funds

Upper Parks Creek Water Conservation Assessment Project
Parks Creek is a critical Creek for coho salmon enhancement in the Shasta River. Upper Parks Creek is a 6.1-mile reach of Parks Creek with the downstream boundary being the Interstate 5 bridge. The project will also analyze methods to combine existing irrigation diversion points and survey the irrigation entities to increase irrigation delivery and efficiency, reducing the need for diversion. In turn, Parks Creek Ranch and Edson-Foulke Ditch will provide 5.8 cfs of conserved water for instream benefit to aid coho salmon. An instream flow schedule was developed with the irrigation entities, CDFW and NOAA under a voluntary effort to enhance coho salmon. This phase would end with a conceptual design for the diversion structure(s)as well conceptual designs for the water conservation projects for Parks Creek Ranch and Edson-Foulke Ditch. Work conducted includes data collection surveying, monitoring, mapping, engineering and geomorphological investigations as well as permitting and approvals.

Restoration Feasibility and Planning in Blue Creek, Lower Klamath River, CA.
The Yurok Tribal Fisheries Program is proposing to conduct priority planning tasks to support development of comprehensive, feasible, and effective stream and floodplain restoration designs within ~5.7 miles of Blue Creek, the largest and highest value tributary to the LKR, California. Restoration objectives for Blue Creek include significantly enhancing existing cold water habitats within a key salmonid spawning and rearing area, and increasing floodplain connectivity and complexity to expand the amount of diverse, productive habitats available to native salmonids, including ESA listed Southern Oregon/Northern California Coast (SONCC) coho salmon and directly support tribal, state, and federal SONCC coho recovery priorities in the Klamath Basin.

Klamath River Tributary and Mainstem Planning and Design Project
This planning and design project will improve habitat for coho salmon on the mainstem Klamath River and four priority tributaries. One objective is to engage landowners of sites identified in the Middle Klamath River Floodplain Habitat Enhancement and Mine Tailing Remediation Project (April 2019) who are willing to have a floodplain fisheries restoration project occur on their property, and further project development in this subset of 15 mainstem Klamath reaches. Additionally, planning and/or design will be completed on four miles of Upper Klamath River tributaries. The Upper Klamath River tributary reaches that will have plans and/or designs created for improving coho habitat are: 1) ¾ mile of Seiad Creek (just below Panther Gulch), 2) 2-1/2 miles of Horse Creek between Fish Gulch and Salt Gulch, 3) ½ mile of Middle Creek (a tributary to Horse Creek), and 4) a ¼ mile of Beaver Creek.

Fisheries Restoration Planning and Design for Junior Creek on the Lower Klamath River
LKR salmonids are vitally important to the Klamath Basin, including to the Resighini Rancheria. Our Reservation lies at the upstream end of the Klamath River estuary, and this location is of key importance to juvenile salmonids in the main stem river. Reservation lands contain two tributaries Waukell and Junior Creeks-both small, low-gradient watersheds that have been shown to be crucial over-wintering refugia habitats for juvenile salmonids. The project seeks to complete one 100% and two 30% conceptual-level engineering restoration designs, cost estimate, and funding strategy to improve juvenile fish passage through existing culverts in Junior Creek to improve connectivity with the LKR. The project would also complete a Junior Creek fisheries restoration plan, including a prioritized list of potential fisheries restoration projects based on physical and fisheries conditions that emphasize benefits for ESA-listed coho salmon & other Tribally important fisheries.

Table 11. Grant Year, National Fish and Wildlife Foundation (NFWF) EZG Number, Project Titles, and general location, Project Type and amount of funding provided by Reclamation for the restoration effort.

Grant Year	NFWF -- EZ Grant Number	Project Title	Basin	Stream	Project Type	Funding Provided by Reclamation Funding
2019[1]	67279	Upper Parks Creek Water Conservation Assessment Project	Shasta	Parks Creek	Planning Design	$ 149,540
2019	67264	Restoration Feasibility & Planning in Blue Creek, Lower Klamath River, CA.	Lower Klamath	Blue Creek	Planning	$ 80,864
2019	67200	Klamath River Tributary and Mainstem Planning and Design Project	Klamath	Klamath River Seiad Creek Horse Creek Middle Creek Beaver Creek	Planning Design	$ 328,829
2019	67105	Fisheries Restoration Planning and Design for Junior Creek on the Lower Klamath River	Klamath	Junior Creek	Planning Design	$ 93,500

[1] – Four projects were selected in calendar year 2020 utilizing fiscal year 2019 funds.

Table 12. Summary of the number of funded projects Reclamation has supported over the years with assistance from NFWF as the Grant Administrator.

Grant Cycle Or Year	NFWF Number of Pre-Proposals	NFWF Number of Full-Proposals	NFWF Number of Projects Funded
2016	31	12	12
2017	20	9	4
2018	12	10	5
2019	6	4	4
Totals	69	35	25

Appendix A – Supporting Information for Water Level and Flow Measurements Gages

M&RR 3.3b (USFWS)- Monitor and Maintain Water Level and Flow-Measurement Gages Throughout the Project, Summary of reservoir water level and flow monitoring compliance

Table A- 1. Link River 2021 flows (Thousand Acre-Feet).

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.950	2.192	2.112	2.172	2.172	1.599	1.551	1.315	1.472
2	0.952	2.489	2.112	2.152	2.231	1.523	1.634	1.329	1.974
3	0.970	2.450	2.152	2.112	2.073	1.583	1.747	1.563	2.241
4	1.273	2.152	2.212	2.073	1.696	1.650	1.908	1.789	2.083
5	1.428	1.995	2.291	2.093	1.521	1.738	1.906	1.904	1.904
6	1.390	1.964	2.450	2.093	1.624	1.864	1.862	1.920	1.920
7	1.242	2.192	2.350	2.093	1.845	1.773	1.835	1.732	1.920
8	1.210	2.450	2.331	2.152	1.845	1.708	1.827	1.706	1.864
9	1.218	2.450	2.212	2.172	1.813	1.704	1.670	1.684	1.831
10	1.240	2.469	2.132	2.192	1.815	1.704	1.507	1.650	1.872
11	1.248	2.450	2.132	2.172	1.813	1.710	1.753	1.505	1.843
12	1.351	2.093	2.152	2.112	1.851	1.791	2.271	1.365	1.777
13	1.571	1.507	2.152	2.112	1.920	1.987	2.370	1.446	1.805
14	1.450	1.676	2.192	2.152	1.960	1.993	2.350	1.670	1.835
15	1.390	1.785	2.350	2.152	1.855	1.932	2.350	1.811	1.857
16	1.220	2.350	2.291	2.152	1.797	1.819	2.370	1.672	1.859
17	1.216	2.727	2.212	2.152	1.708	1.809	2.311	1.553	1.815
18	1.380	2.668	2.251	2.192	1.575	1.587	2.291	1.601	1.654
19	1.622	2.688	2.291	2.192	1.628	1.454	2.093	1.525	1.654
20	1.607	2.588	2.271	2.132	1.769	1.527	1.575	1.363	1.636
21	1.295	2.489	2.251	2.093	1.547	1.541	1.295	1.371	1.636
22	1.018	2.469	2.132	2.073	1.404	1.607	1.184	1.440	1.652
23	0.924	2.450	1.932	1.972	1.402	1.763	1.176	1.392	1.896
24	1.131	2.430	1.908	1.978	1.400	1.827	1.170	1.303	1.837
25	1.480	2.450	1.930	2.132	1.396	1.813	1.166	1.351	1.694
26	1.482	2.529	2.112	2.251	1.460	1.827	1.258	1.339	1.658
27	1.279	2.529	2.192	2.271	1.545	1.831	1.404	1.363	1.730
28	1.519	2.450	2.152	2.271	1.595	1.843	1.027	1.371	1.753
29	1.787	2.370	2.192	2.251	1.712	1.666	1.049	1.490	1.777
30	1.267	2.271	2.192	2.192	1.902	1.674	1.321	1.668	1.821
31	1.317		2.172		1.912	1.682		1.458	
Total	40.427	69.771	67.813	64.306	53.786	53.528	51.235	47.647	54.270
Avg	1.304	2.326	2.188	2.144	1.735	1.727	1.708	1.537	1.809
Max	1.787	2.727	2.450	2.271	2.231	1.993	2.370	1.920	2.241
Min	0.924	1.507	1.908	1.972	1.396	1.454	1.027	1.303	1.472

Note: Westside Power Canal is no longer used for power generation, however, its data is included in above table.

Table A- 2. A Canal 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A- 3. Lost River Diversion Channel 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.136	0.078	0.029	0.025	0.006	0.004	0.014	0.021	0.053
2	0.119	0.076	0.019	0.027	0.002	0.003	0.011	0.022	0.051
3	0.117	0.073	0.026	0.029	0.004	0.003	0.011	0.024	0.049
4	0.075	0.073	0.025	0.025	0.006	0.003	0.012	0.023	0.084
5	0.047	0.075	0.046	0.018	0.004	0.005	0.010	0.015	0.071
6	0.062	0.075	0.069	0.014	0.005	0.003	0.016	0.012	0.070
7	0.058	0.073	0.016	0.013	0.003	0.005	0.015	0.046	0.055
8	0.067	0.071	0.027	0.013	0.001	0.005	0.020	0.069	0.055
9	0.068	0.056	0.023	0.013	0.005	0.003	0.023	0.022	0.059
10	0.066	0.025	0.012	0.018	0.003	0.004	0.023	0.016	0.059
11	0.066	0.009	0.023	0.016	0.004	0.005	0.023	0.013	0.059
12	0.065	0.010	0.035	0.017	0.004	0.006	0.024	0.019	0.057
13	0.064	0.016	0.036	0.022	0.020	0.004	0.023	0.020	0.052
14	0.067	0.013	0.028	0.020	0.018	0.006	0.025	0.022	0.049
15	0.079	0.017	0.014	0.015	0.021	0.004	0.020	0.017	0.052
16	0.079	0.005	0.027	0.009	0.016	0.004	0.026	0.017	0.048
17	0.080	0.004	0.025	0.008	0.013	0.005	0.024	0.021	0.064
18	0.089	0.014	0.022	0.013	0.008	0.005	0.016	0.022	0.076
19	0.085	0.014	0.014	0.012	0.007	0.005	0.016	0.016	0.074
20	0.086	0.011	0.016	0.009	0.006	0.007	0.000	0.017	0.073
21	0.091	0.009	0.015	0.011	0.008	0.006	0.018	0.016	0.070
22	0.086	0.010	0.016	0.009	0.004	0.007	0.013	0.018	0.068
23	0.089	0.012	0.021	0.012	0.004	0.009	0.006	0.015	0.062
24	0.084	0.011	0.020	0.010	0.005	0.010	0.020	0.021	0.058
25	0.081	0.013	0.016	0.009	0.003	0.014	0.019	0.046	0.057
26	0.078	0.011	0.018	0.006	0.005	0.012	0.022	0.070	0.057
27	0.079	0.015	0.019	0.004	0.008	0.016	0.017	0.070	0.055
28	0.079	0.028	0.069	0.006	0.005	0.018	0.019	0.058	0.052
29	0.077	0.024	0.021	0.006	0.005	0.016	0.020	0.057	0.022
30	0.075	0.033	0.023	0.007	0.005	0.013	0.020	0.055	0.006
31	0.080		0.020		0.006	0.011		0.057	
Total (TAF)	2.474	0.954	0.790	0.416	0.214	0.221	0.526	0.937	1.717
Avg	0.080	0.032	0.025	0.014	0.007	0.007	0.018	0.030	0.057
Max	0.136	0.078	0.069	0.029	0.021	0.018	0.026	0.070	0.084
Min	0.047	0.004	0.012	0.004	0.001	0.003	0.000	0.012	0.006

Table A- 4. Miller Hill Pumps 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.014	0.014	0.016	0.016	0.000	0.000	0.000
2	0.000	0.000	0.014	0.014	0.016	0.000	0.000	0.000	0.000
3	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
4	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
5	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
6	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
7	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
8	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
9	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
10	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
11	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
12	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
13	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
14	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
15	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
16	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
17	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
18	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
19	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
20	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
21	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
22	0.000	0.000	0.014	0.020	0.016	0.000	0.000	0.000	0.000
23	0.000	0.014	0.014	0.020	0.016	0.000	0.000	0.000	0.000
24	0.000	0.014	0.014	0.020	0.016	0.000	0.000	0.000	0.000
25	0.000	0.014	0.014	0.020	0.016	0.000	0.000	0.000	0.000
26	0.000	0.014	0.014	0.020	0.016	0.000	0.000	0.000	0.000
27	0.000	0.014	0.014	0.020	0.016	0.000	0.000	0.000	0.000
28	0.000	0.014	0.014	0.016	0.016	0.000	0.000	0.000	0.000
29	0.000	0.014	0.014	0.016	0.016	0.000	0.000	0.000	0.000
30	0.000	0.014	0.014	0.016	0.016	0.000	0.000	0.000	0.000
31	0.000		0.014		0.016	0.000		0.000	
Total (TAF)	0.000	0.112	0.434	0.576	0.496	0.016	0.000	0.000	0.000
Avg	0.000	0.004	0.014	0.019	0.016	0.001	0.000	0.000	0.000
Max	0.000	0.014	0.014	0.020	0.016	0.016	0.000	0.000	0.000
Min	0.000	0.000	0.014	0.014	0.016	0.000	0.000	0.000	0.000

Table A- 5. Miller Hill Spill 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A- 6. Station 48 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.079	0.010	0.020	0.000	0.000	0.298	0.018	0.040
2	0.000	0.079	0.010	0.020	0.000	0.000	0.298	0.028	0.040
3	0.000	0.079	0.010	0.008	0.000	0.000	0.298	0.028	0.046
4	0.000	0.079	0.010	0.000	0.000	0.000	0.298	0.028	0.050
5	0.061	0.073	0.016	0.000	0.000	0.105	0.298	0.028	0.050
6	0.085	0.069	0.020	0.000	0.000	0.298	0.298	0.028	0.050
7	0.060	0.069	0.020	0.000	0.000	0.298	0.298	0.028	0.050
8	0.060	0.069	0.020	0.000	0.000	0.298	0.115	0.028	0.050
9	0.060	0.069	0.020	0.000	0.000	0.298	0.000	0.028	0.050
10	0.060	0.038	0.020	0.000	0.000	0.298	0.000	0.028	0.050
11	0.060	0.014	0.020	0.000	0.000	0.298	0.000	0.028	0.050
12	0.060	0.000	0.020	0.000	0.000	0.298	0.000	0.028	0.050
13	0.060	0.000	0.020	0.000	0.000	0.298	0.000	0.028	0.050
14	0.060	0.000	0.020	0.000	0.000	0.298	0.000	0.028	0.050
15	0.060	0.006	0.020	0.000	0.000	0.298	0.000	0.028	0.050
16	0.060	0.016	0.020	0.000	0.000	0.298	0.000	0.028	0.050
17	0.069	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.050
18	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.050
19	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.050
20	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.050
21	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.050
22	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.056
23	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.060
24	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.028	0.054
25	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.058	0.050
26	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.079	0.050
27	0.079	0.010	0.020	0.000	0.000	0.298	0.000	0.079	0.050
28	0.079	0.016	0.020	0.000	0.000	0.298	0.000	0.058	0.050
29	0.079	0.016	0.020	0.000	0.000	0.298	0.000	0.040	0.050
30	0.079	0.016	0.020	0.000	0.000	0.298	0.000	0.040	0.010
31	0.079		0.020		0.000	0.298		0.040	
Total (TAF)	1.922	0.899	0.571	0.048	0.000	7.841	2.198	1.049	1.444
Avg	0.062	0.030	0.018	0.002	0.000	0.253	0.073	0.034	0.048
Max	0.085	0.079	0.020	0.020	0.000	0.298	0.298	0.079	0.060
Min	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.018	0.010

Table A- 7. North Canal 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	0.000	0.000	0.000	0.212	0.319	0.156	0.121	0.094
2	0.000	0.000	0.000	0.204	0.355	0.195	0.150	0.097
3	0.000	0.000	0.023	0.212	0.337	0.193	0.156	0.079
4	0.000	0.000	0.029	0.216	0.305	0.185	0.152	0.095
5	0.000	0.000	0.043	0.232	0.327	0.179	0.148	0.120
6	0.000	0.000	0.009	0.248	0.327	0.178	0.146	0.109
7	0.000	0.000	0.046	0.244	0.250	0.149	0.149	0.105
8	0.000	0.000	0.107	0.236	0.177	0.130	0.139	0.065
9	0.000	0.000	0.115	0.272	0.242	0.133	0.125	0.041
10	0.000	0.000	0.083	0.290	0.301	0.184	0.121	0.037
11	0.000	0.000	0.061	0.266	0.303	0.254	0.116	0.046
12	0.000	0.000	0.097	0.224	0.288	0.277	0.109	0.051
13	0.000	0.000	0.104	0.195	0.262	0.234	0.094	0.082
14	0.000	0.000	0.090	0.187	0.270	0.177	0.090	0.128
15	0.000	0.000	0.089	0.197	0.258	0.148	0.093	0.098
16	0.000	0.192	0.087	0.220	0.208	0.145	0.125	0.067
17	0.000	0.345	0.078	0.238	0.189	0.123	0.143	0.064
18	0.000	0.363	0.102	0.246	0.212	0.076	0.086	0.047
19	0.000	0.349	0.098	0.242	0.226	0.110	0.080	0.043
20	0.000	0.343	0.085	0.240	0.200	0.160	0.085	0.032
21	0.000	0.347	0.094	0.248	0.192	0.141	0.085	0.048
22	0.000	0.341	0.095	0.266	0.168	0.145	0.083	0.041
23	0.000	0.327	0.091	0.252	0.162	0.128	0.083	0.041
24	0.000	0.337	0.111	0.270	0.165	0.134	0.085	0.039
25	0.000	0.343	0.105	0.307	0.170	0.173	0.087	0.031
26	0.000	0.315	0.099	0.313	0.170	0.172	0.083	0.031
27	0.000	0.223	0.096	0.309	0.180	0.170	0.083	0.026
28	0.000	0.143	0.224	0.307	0.131	0.164	0.157	0.041
29	0.000	0.145	0.254	0.297	0.130	0.148	0.188	0.052
30	0.000	0.035	0.155	0.278	0.128	0.113	0.114	0.050
31	0.000		0.208		0.130	0.100		0.050
Total (TAF)	0.000	4.150	2.880	7.469	7.085	4.970	3.476	1.950
Avg	0.000	0.138	0.093	0.249	0.229	0.160	0.116	0.063
Max	0.000	0.363	0.254	0.313	0.355	0.277	0.188	0.128
Min	0.000	0.000	0.000	0.187	0.128	0.076	0.080	0.026

Table A- 8. Ady Canal 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.103
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.156
3	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.162
4	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.171
5	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.190
6	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.191
7	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.234
8	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.266
9	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.278
10	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.300
11	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.305
12	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.288
13	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.274
14	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.260
15	0.000	0.039	0.000	0.000	0.000	0.000	0.012	0.000	0.258
16	0.000	0.138	0.000	0.000	0.000	0.000	0.012	0.000	0.244
17	0.000	0.032	0.000	0.000	0.000	0.000	0.012	0.000	0.250
18	0.000	0.019	0.000	0.000	0.000	0.000	0.012	0.000	0.220
19	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.208
20	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.204
21	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.200
22	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.186
23	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.175
24	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.187
25	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.189
26	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.188
27	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.187
28	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.187
29	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.184
30	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.189
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.229	0.000	0.000	0.000	0.000	0.333	0.000	6.434
Avg	0.000	0.008	0.000	0.000	0.000	0.000	0.011	0.000	0.214
Max	0.000	0.138	0.000	0.000	0.000	0.000	0.012	0.000	0.305
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.103

Table A- 9. Ady Canal to Refuge (flow to Lower Klamath National Wildlife Refuge) 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000
Avg	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A- 10. Klamath Straits Drain at Stateline (flows from Lower Klamath National Wildlife Refuge) 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A- 11. Klamath Straits Drain at F&FF Pumps 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000		0.000		0.000	0.000		0.000	
Total (TAF)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Avg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Max	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table A- 12. Keno Canal 2021 flows (Thousand Acre-Feet)

DAY \ MONTH	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
2	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
3	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
4	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
5	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
6	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
7	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
8	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
9	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
10	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
11	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
12	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
13	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
14	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
15	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
16	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
17	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
18	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
19	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
20	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
21	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
22	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
23	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
24	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
25	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
26	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
27	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
28	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
29	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
30	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000
31	0.000		0.030		0.030	0.030		0.000	
Total (TAF)	0.000	0.892	0.922	0.892	0.922	0.922	0.892	0.446	0.000
Avg	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.014	0.000
Max	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.000
Min	0.000	0.030	0.030	0.030	0.030	0.030	0.030	0.000	0.000

Table A- 13. Klamath Project Deliveries and Demands. (Example shown from 2020. This table was not produced in 2021 as there were no project deliveries.

Agricultural Deliveries in TAF (POR 1981-2019, excluding 2001 and 2010) through Monday, November 30, 2020

BiOp Calculated Project Supply (TAF) **140.000**
Available Project Supply (TAF) **164.000**

		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Mar-Sep Total	Oct-Nov 15th Total	Estimated Remaining Demand (A1,A2 Mar-Sep)	Estimated Remaining Demand (Oct-Nov)	Estimated Remaining Spring/Summer Demand (A1 Mar-Nov, A2 Mar-Sept)
A Canal	min	0.00	1.35	12.48	27.68	33.23	29.70	16.16	1.16	0.00	120.60	1.16			
	median	0.00	14.51	40.59	45.56	53.68	50.91	36.46	10.95	0.00	241.71	10.95			
	average	0.03	16.04	39.26	45.42	53.30	49.34	35.30	10.73	0.00	238.69	10.73	0.00	0.00	0.00
	max	0.38	28.42	53.50	56.06	62.16	58.41	45.04	17.53	0.03	303.97	17.56			
	est 2020 distribution	0.00	12.94	15.28	14.57	20.36	21.71	14.80	4.69	0.00	99.65	4.69			
	2020 YTD	0.00	12.94	15.28	14.57	20.36	21.71	14.80	4.69	0.00	99.65	4.69			
Miller Hill	min	-0.12	-0.45	-0.22	0.10	0.47	0.20	-0.23	-0.33	-0.13	-0.25	-0.46			
	median	0.00	0.00	2.49	3.58	4.70	3.61	1.04	-0.05	0.00	15.41	-0.05			
	average	0.00	0.26	2.23	3.20	4.23	3.49	1.25	0.02	0.00	14.65	0.02	0.00	0.00	0.00
	max	0.04	2.76	5.95	6.06	6.45	5.91	3.78	0.80	0.00	30.96	0.80			
	2020 YTD	0.00	1.42	1.82	1.99	3.63	3.82	2.51	0.88	0.00	15.19	0.88			
Station 48	min	0.00	0.00	0.43	4.03	9.39	2.64	0.31	0.00	0.00	16.80	0.00			
	median	1.02	4.48	6.71	17.71	17.20	11.30	2.91	1.10	0.13	61.34	1.22			
	average	1.82	6.31	8.00	17.10	17.19	10.90	3.02	1.28	0.92	64.33	2.20	0.00	5.87	5.87
	max	8.09	24.96	18.99	25.34	25.17	20.52	10.24	5.20	7.88	133.30	13.08			
	2020 YTD	1.42	4.26	2.12	7.60	8.99	12.67	9.45	7.62	2.01	46.51	9.62			
North Canal	min	0.00	0.00	0.80	1.76	1.64	0.98	0.52	0.10		5.70	0.10			
	median	0.62	1.10	2.02	3.27	4.53	3.06	2.27	1.38		16.86	1.38			
	average	0.95	1.20	2.05	3.26	4.16	2.94	2.37	1.67		16.93	1.67	0.00	0.00	0.00
	max	4.71	3.04	4.19	4.81	5.84	4.58	4.00	4.93		31.18	4.93			
	2020 YTD	1.45	0.65	0.56	1.93	2.33	1.67	1.57	1.50		10.15	1.50			
Ady Canal to Ag	min	0.11	0.00	0.14	0.27	0.77	0.16	0.06	0.05		1.52	0.05			
	median	4.12	2.25	3.76	5.68	4.79	5.26	3.75	3.17		29.60	3.17			
	average	3.77	2.58	3.46	5.51	4.87	4.71	3.90	3.32		28.79	3.32	0.00	0.00	0.00
	max	7.40	6.92	7.45	9.74	9.34	8.99	7.95	6.93		57.79	6.93			
	2020 YTD	1.85	2.55	1.45	3.03	4.54	2.78	2.85	1.43		19.05	1.43			
GW to LRDC	2020 YTD	0.00	0.00	0.45	0.64	0.53	0.45	0.37	0.00	0.00	2.44	0.00			
Total Ag	min	0.23	2.22	21.51	42.08	52.47	37.68	27.39	2.97	0.34	183.58	3.31			
	median	7.22	25.21	55.12	75.86	89.39	73.75	47.58	17.47	6.94	374.13	24.41			
	average	6.69	27.14	55.81	75.33	84.46	72.00	46.47	17.21	7.19	367.89	24.40	0.00	0.09	0.09
	max	14.07	61.68	86.53	97.28	101.34	87.85	57.81	29.10	13.63	506.56	42.72			
	est 2020 distribution	4.72	21.81	21.23	29.12	39.85	42.65	31.17	16.12	3.94	190.55	20.06			
	2020 YTD	4.72	21.81	21.23	29.12	39.85	42.65	31.17	16.12	3.85	190.55	19.97			
Ag From UKL	min	0.00	1.89	15.86	33.80	48.84	35.46	25.89	1.19	0.00	161.73	1.19			
	median	0.44	20.91	48.11	69.07	83.15	65.63	41.38	11.11	0.00	328.68	11.11			
	average	1.65	22.16	49.17	68.11	78.63	64.83	39.68	11.13	0.30	324.23	11.43			
	max	9.63	60.43	85.08	87.37	95.77	82.10	56.11	18.30	3.15	476.49	21.44	0.00	0.00	0.00
	est 2020 distribution	0.14	17.20	17.81	24.18	37.69	33.87	22.29	8.29	0.00	153.18	8.30			
	2020 YTD	0.138	17.204	17.814	24.176	37.690	33.868	22.286	8.295	0.001	153.18	8.30			
Ady to Refuge	2020 YTD	0.00	0.31	0.09	0.00	0.94	1.84	1.87	0.90	0.00	5.05	0.90	27.37	18.15	45.52
														Project Supply Used YTD (TAF) =	**161.472**

Table A- 14. Example of Reclamation Daily Numbers report.

Water Information*

Date	UKL ELEV	UKL STORAGE	LINK RIVER DAM	KENO POWER CANAL	A CANAL	KENO DAM	IRON GATE DAM	WILSON DAM	STATION 48	MILLER HILL PUMPS	LOST RIVER DIVERSION CHANNEL (LRDC)	TO LOST River FROM Klamath	FROM LOST River TO Klamath	SUKRAW WELLS	STUKEL PUMPS (KID)	ADAMS PUMPS (KID)	F+FF TO Klamath River	NORTH Canal	ADY Canal	ADY To Refuge	North+ADY TOTAL	(F/FF - North/ADY) NET TO Klamath River	Keno Impoundment Net Accretions	Net Increase/Decrease Inflow to Klamath River
	FT	AF	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS	CFS
1/13/2022	4140.06	280,191	321	0	0	395	927	0	0	0	113	0	113	0	0	0	0	39	0	0	39	(39)	1	**73**
1/14/2022	4140.08	281,719	328	0	0	394	926	0	0	0	83	0	83	0	0	0	0	42	0	0	42	(42)	26	**40**
1/15/2022	4140.11	284,019	393	0	0	432	973	0	0	0	67	0	67	0	0	0	0	42	0	0	42	(42)	15	**24**
1/16/2022	4140.13	285,563	424	0	0	456	947	0	0	0	64	0	64	0	0	0	0	39	0	0	39	(39)	7	**25**
1/17/2022	4140.14	286,335	459	0	0	457	948	0	0	0	61	0	61	0	0	0	0	35	0	0	35	(35)	(28)	**26**
1/18/2022	4140.16	287,880	457	0	0	457	952	0	0	0	54	0	54	0	0	0	0	35	0	0	35	(35)	(19)	**19**
1/19/2022	4140.18	289,424	449	0	0	511	949	0	0	0	50	0	50	0	0	0	0	38	0	0	38	(38)	49	**13**

*These data are provisional and subject to change

400	Friday, January 21, 2022
400	Saturday, January 22, 2022
430	Sunday, January 23, 2022
460	Monday, January 24, 2022
450	Tuesday, January 25, 2022
460	Wednesday, January 26, 2022
460	Thursday, January 27, 2022
440	Friday, January 28, 2022
430	Saturday, January 29, 2022
420	Sunday, January 30, 2022

Table A- 15. Example of PacifiCorp Accretions Forecast.

Appendix B – A Canal Fish Evaluation Station Endangered Sucker Monitoring Annual Report, 2021

Klamath Project, Oregon/California
Interior Region 10 California Great Basin

Cover Photo: Sampling flume in the Fish Evaluation Station at A Canal, Klamath Project. Photo by Darin Taylor.

Executive Summary

Reclamation's A Canal is the largest agricultural diversion in Oregon and draws water from UKL, home to the largest populations of two species of endangered catostomids: LRS, and SNS. A fish screen was installed at the A Canal intake in 2003 and includes a pumped bypass that returns screened fish to the lake. To estimate entrainment of suckers at the screen each year, Reclamation samples the bypass facility one night a week until sucker catches are greater than ten in one 6-hour sampling period or until August 1 to ensure Reclamation captures the peak of juvenile sucker entrainment, and the ascending and descending limbs of the catch curve. Once Reclamation reaches this limit, sampling occurs four days a week at 30-minute intervals during the peak period (20:00 – 02:00 hours) until September 30.

Sampling at the FES for suckers did not occur in 2021 because water was not delivered through the A canal for Klamath Project irrigators. As a result, there was no peak of entrainment to determine and abundance was zero.

Introduction and Background

The purpose of this A Canal FES Entrainment Monitoring Report (Report) is to meet certain requirements outlined in the USFWS April 2020 *Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2020 through September 30, 2022, on the Lost River sucker and the Shortnose sucker* (BiOp).

The BiOp requires Reclamation to monitor entrainment of listed suckers resulting from Project operations. T&C 1a requires Reclamation ensure that no unnecessary actions are taken that increase entrainment [of listed suckers] at the LRD. The associated M&RR l.la requires monitoring of entrainment at the A Canal FES. Specifically, M&RR l.la requires that Reclamation monitor entrainment of age-0 and age-l suckers at the A Canal FES annually from August 1 through September 30 with a level of effort enough to determine when the peak of entrainment occurs, and to provide an accurate estimate of the number of suckers entrained during the peak.

Monitoring entrainment at the A Canal FES is a cost-effective method for obtaining the information required under M&RR 1.la and provides a good indication of annual juvenile sucker production and condition. Historic monitoring data shows there is a defined pulse and resultant entrainment peak. The goal of the monitoring effort is to collect data that covers the peak entrainment period for suckers. As such, Reclamation, in close coordination with the Service, developed the A Canal FES Entrainment Monitoring Plan (Plan).

This report was developed to meet the RRs outlined in the 2020 BiOp, and includes monitoring results, estimates of entrainment, and notable observations associated with entrainment and fish condition.

The BiOp specifies that the A Canal FES entrainment monitoring effort will begin no later than August 1 of every year and continue until no suckers are collected at the FES in each week or through September 30, whichever comes first. According to the BiOp, under certain circumstances, it may be necessary to implement entrainment monitoring earlier than August 1 and later than September 30. In all such instances, Reclamation will coordinate with the Service to determine whether initiation or shutdown is warranted outside of the dates specified in the Plan and the BiOp.

Nightly monitoring begins at 2000 hours and continues until 0200, unless through coordination with the Service it is decided that sampling should occur during other periods. If the scheduled sampling period falls on a federal holiday or weekend, samples are not taken.

Methods

The A Canal fish screen and bypass system collects fish which have been screened from entrainment and returns them back to UKL above the LRD (Figure B-1; Figure B-2). The bypass system is bifurcated into a primary pump-based system and a secondary gravity-based system. The primary pump bypass system is operated with a fish-friendly hydrostal helical pump which lifts fish into a pressurized pipeline then flows through an open flume inside the FES before fish are discharged through an outfall pipe in UKL. The secondary bypass is a 3,500-foot gravity flow system which discharges fish into the Link River immediately downstream of LRD.

The gravity bypass operates from the start of the irrigation season (typically April 1) until the pump

system begins to operate (always prior to August 1, typically around July 15). In 2021, sampling did not occur because no water deliveries were made from the A-Canal. However, when sampling does occur, the pump system operated from early or mid- July to October 31. Fish are monitored at FES when the pumped bypass system is operated, typically from August 1 through September 30, with a level of effort enough to determine when the peak entrainment occurs and to provide an accurate estimate of the numbers of suckers larger than 30 mm entrained during the peak (see the Plan for further information).

Fish are sampled using a modified 0.25-inch mesh net fitted securely into reinforced slots within the flume walls. The net consists of an aluminum frame mouth 6 feet wide by 5 feet high, with four semi-rigid rings that hold the throat of the net open and taper it down over fifteen feet, terminating in a customized, triangular-shaped aluminum trap box. The reinforced cod end connects to the trap box via pipe clamps over a cylindrical opening. The interior of the trap box is baffled to prevent fish impingement against the terminal end. There are two removable slide gates to release the fish and water trapped within the box when sampling is complete: a main gate in the box floor and a second at the terminal end.

Sampling is conducted by first lowering the trap box and then the net mouth frame into the flume slots using a 1,000-lb bridge crane. The net throat and trap box are pulled downstream to remove bends and to ensure that fish are swept into the trap box. At the end of the sample, the bridge crane is used to lift the net mouth frame and then the trap box out of the flume. The trap box is partially drained before its contents are released into holding containers of UKL aerated water with appropriate conditions (e.g., similar temperature) to reduce stress to the fish. Additionally, water quality measurements are taken every hour to ensure suckers are being held in a suitable environment and to prevent shock or additional stress to suckers.

Sampling crews visually inspect the trap to ensure that all fish and debris are removed. Suckers and non-suckers (bycatch) are sorted from this holding tank as quickly as possible. Processing consists of a complete count of captured suckers and the following measurements on all suckers: SL (mms), weight (grams), and fish health observations (abrasions, parasites, etc.). When 100 suckers are present, every tenth sucker is measured according to the process outlined in the Plan, with a minimum of 50 individuals measured. This is done to minimize risk to suckers while still obtaining the targeted information.

Bycatch is estimated for each species in each net pull using bins: 1-10, 11-25, 26-50, 51-100, 101-200, 201-300, 301-500, and 501-1000. These bins have been used since 2016. Juvenile suckers, sculpin, and lamprey cannot be identified to species because phenotypic characteristics are not well developed, and species-specific identification is extremely difficult, and time consuming. The general physical condition of suckers was recorded, and specific health information was documented including incidence of injuries, disease, and parasites.

To estimate the total number of juveniles (> 30 mm SL) entrained into the A Canal and returned to the lake through the pumped bypass system over the entire season, Reclamation used a simple 5-day smoothing average, and then simply interpolated between nearest neighbors for the nights that weren't sampled. The earliest two and last two samples of the season were only averaged across three and four samples because of the limits of the data.

To quantify take for all nights, each interpolated or calculated CPUE was multiplied by 12 (reflecting 12, 30-minute sample periods between 20:00 and 02:00) and summed to yield an estimated number of juvenile suckers processed through the FES during the sample period. Previous studies (Laeder

and Wilkens 2010) found the majority of entrainment of juvenile suckers occurs between 2000 hours and 0200 each night, thus Reclamation samples during these hours to originate our entrainment estimate. Water quality measurements were taken hourly using sondes in front of the trash rack at FES.

Results

Sampling at the FES for suckers did not occur in 2021 because water was not delivered through the A canal for Klamath Project irrigators. As a result, there was no peak of entrainment to determine and abundance was zero suckers.

Reclamation and the Service should consider the following recommendations to further improve the sampling process and/or maximize the utility of the FES sampling effort to benefit federally listed suckers:

1. Reclamation should continue to begin sampling at the FES prior to August 1. The earlier sampling could occur one night a week, until catches meet a certain Catch Per Unit of Effort. With this approach Reclamation would coordinate with the Service and agree to a CPUE at which full-time sampling (four nights a week) should commence. This approach could provide more accurate entrainment estimates and improve the likelihood of capturing the peak timing by collecting more data during the ascending and descending limbs of the catch curve.

2. Continue to establish more robust data collection for afflictions observed. For example, typically only the most severe affliction per sucker is identified while many fish have several afflictions. Additionally, a fish health rating system could be established to better analyze afflictions observed at FES Station. More consistent and robust affliction data collection would allow for the comparison of afflictions among years.

3. Conduct a robust analysis on all years, including pre 2013 data before more establish protocols were established and report of all FES entrainment data available and assess trends relative to other research and monitoring efforts including juvenile and adult sucker monitoring, water quality, and weather patterns.
4. In 2020, Reclamation recaptured a juvenile PIT-tagged sucker for the first time in FES sampling history. The sucker was originally captured during salvage event at A Canal forebay in 2019. It was held and treated by USFWS and released at Malone Springs in December of 2019. With more suckers be introduced back into UKL, FES could be a useful site in tracking and assessing movement of juvenile suckers if used in coordination with other antenna arrays.

Figures and Tables

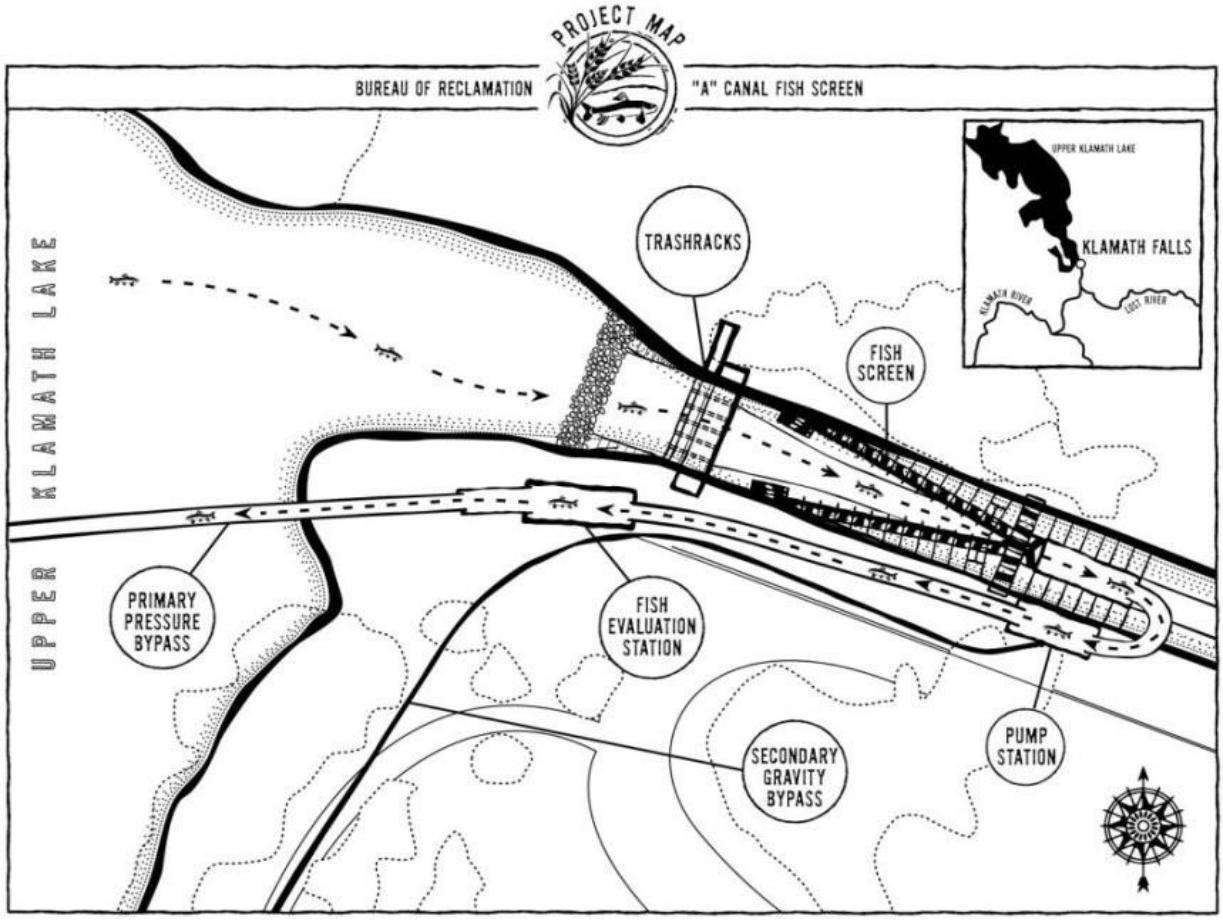

Figure B- 1. The Fish Evaluation Station at the A Canal headworks in Klamath Falls, Oregon

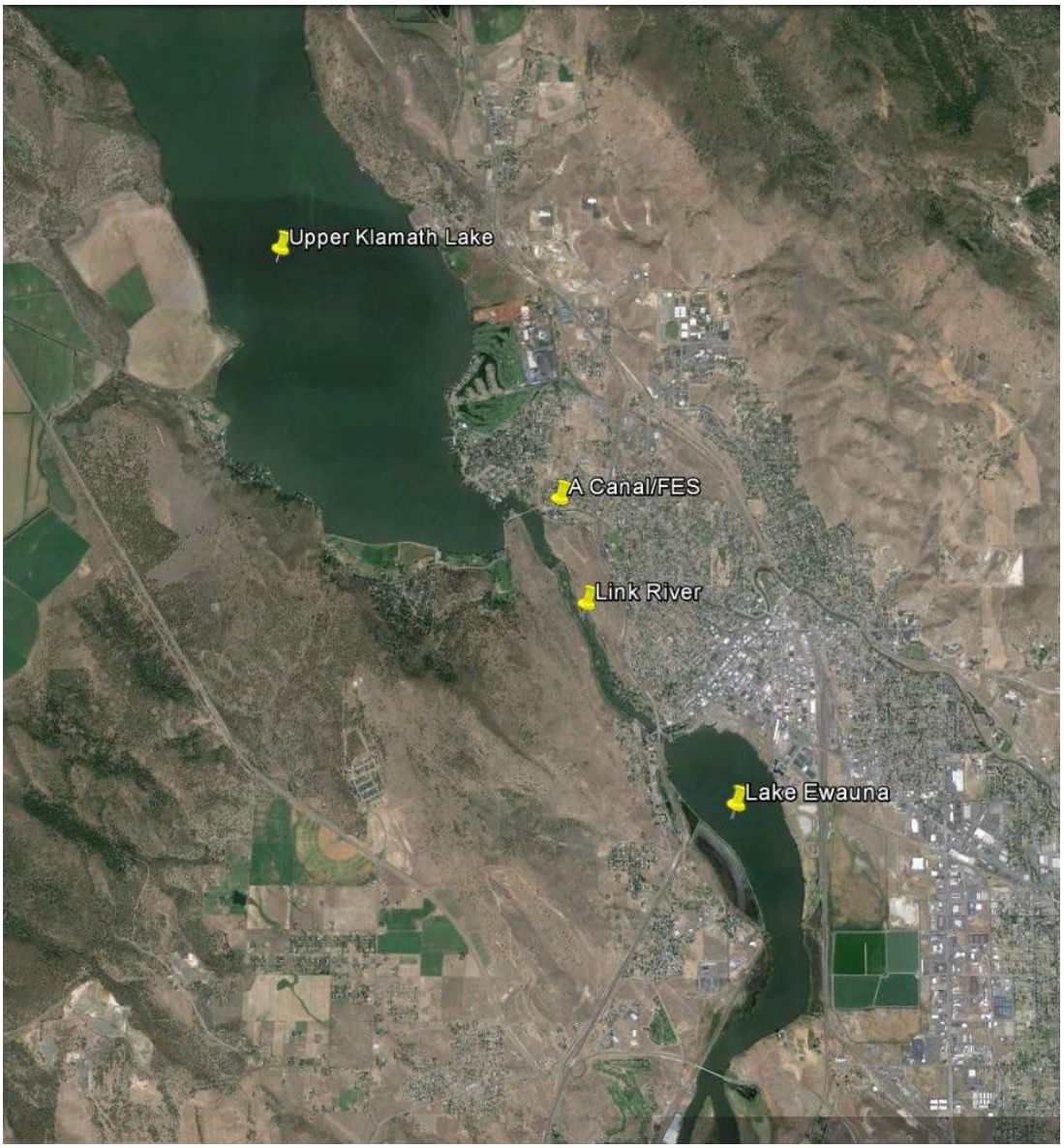

Figure B- 2**.** Location of the A Canal and Fish Evaluation Station in relationship to Upper Klamath Lake, the Link River, and Lake Ewauna.

References

Foott J. Scott, 2018, Comparison of bacterial and parasitic infection between Upper Klamath Lake and out-migrant (Fish Evaluation Station, FES) 0+ suckers and chubs

Korson, C., A Wilkens, and D. Taylor. 2011. Klamath Project: A Canal Endangered Sucker Monitoring, 2010. U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office.

Laeder, J. and A. Wilkens. 2010. Klamath Project: A Canal Endangered Sucker Monitoring, 2006-2009. U.S. Bureau of Reclamation, Mid-Pacific Region, Klamath Basin Area Office 6600 Washburn Way, Klamath Falls, Oregon 97603.

North State Resources (NSR). 2005. Monitoring and Evaluation of the A Canal Fish Screen and Bypass Facility, Scale Loss and Physical Injury Tests. Redding, California.

Simon, D.C., Terwilliger, M.R., and D.F. Markle. 2012. Larval and Juvenile Ecology of Upper Klamath Lake Suckers: 2011. Annual Report for Great Basin Cooperative Ecosystems Studies Unit. Agency Program USBR#2-FG-81-0813.

Stone, Ron, J. Jacobs, N. Som and J. Foott, 2017, Lost River Sucker Fry Sentinel Survival in Upper Klamath Lake (July-September 2015)

U.S. Bureau of Reclamation. 1961-2011. MODSUM Water Records. Klamath Basin Area Office, Klamath Falls, Oregon

U.S. Bureau of Reclamation. 2011-2019. Annual Compliance Reports. Klamath Basin Area

U.S. Bureau of Reclamation, Tracy Fish Facility Studies. 2005. Effects of Short-Term Holding on Fishes: A Synthesis and Review

USFWS (U.S. Fish and Wildlife Service). 1992. Formal Consultation on the Effects of the Long-term Operation of the Klamath Project on the Lost River Sucker, Shortnose Sucker, Bald Eagle and American Peregrine Falcon. Klamath Falls, Oregon

USFWS (U.S. Fish and Wildlife Service). 2002. Biological/Conference Opinion Regarding the Effects of Operation of the U.S. Bureau of Reclamation Project on the Endangered Lost River Sucker (*Deltistes luxatus*) Shortnose Sucker (*Chasmistes brevirostris*) Threatened Bald Eagle (*Haliaeetus leucocephalus*) and Proposed Critical Habitat for the Lost River/Shortnose Suckers For June 1, 2002 – March 31, 2012. Klamath Falls, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2008. Biological/Conference Opinion Regarding the Effects of Operation of the U.S. Bureau of Reclamation's Proposed 10-Year Operation Plan (April 1, 2008-March 31, 2018) for the Klamath Project.

USFWS (U.S. Fish and Wildlife Service). 2013. Biological/Conference Opinion Regarding the Effects of Operation of Klamath Project Proposed 10-Year Operation Plan (May 31, 2013-March 31, 2023), on Five Federally Listed Threatened and Endangered Species for the Klamath Project.

USFWS (U.S. Fish and Wildlife Service). 2015a. Visual Implant Elastomer Tagging and Fish Evaluation Station Recirculation Combination Pilot Project 2015. Final Report. Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

USFWS (U.S. Fish and Wildlife Service). 2015b. Pilot Project: Short-term Rearing of Endangered Klamath Suckers at the Fish Evaluation Station in 2015. Final Report. Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon.

Appendix C – Klamath Project Canal Salvage Annual Report, 2021

Klamath Project, Oregon/California
Interior Region 10 California Great Basin

Cover Photo: Reclamation's fisheries field crew salvaging fish from the J Canal during irrigation drawdown, December 2017. Photo credit: Darin Taylor.

Executive Summary

The Project delivers water to approximately 200,000 acres of irrigated land in the Upper Klamath River Basin, located in southern Oregon and northern California. The Project includes hundreds of miles of irrigation canals, and several large lakes and reservoirs, including UKL, Clear Lake, and Gerber Reservoir (Figure C-1). In most years, nearly 260,000 AF of water is delivered through the A Canal system from UKL during the irrigation season of April through September. Additional irrigation water is supplied to parts of the Lost River drainage from multiple surface and groundwater inputs throughout the Lost River sub-basin. Salvage operations occur at the end of irrigation season during dewatering of the canals.

Since 2005, salvage efforts have focused on the A Canal forebay, and sites within J, C, and D Canals. Since 2008, suckers salvaged from the A Canal forebay and from sites in the KID and TID have been implanted with PIT tags.

During the 2021 salvage effort 149 juvenile suckers were salvaged from the Project; 82 suckers were captured in the A Canal forebay, no suckers were salvaged from J canal. J canal was not dewatered at the end of irrigation season and was not salvaged. Zero juvenile sucker were captured in the C and D Canals. Miller Creek at the base of Gerber Dam was dewatered and salvaged due to facility maintenance. A total of 67 suckers were salvaged from Miller Creek, electrofishing 0.39 hours, for a catch per unit effort (CPUE) of 171.8 (Figure C-4). A Canal electrofishing effort does not reflect actual effort due to the use of nets to capture fish, therefore CPUE was not calculated. All salvaged suckers from A canal forebay were taken to Klamath Sucker Assisted Rearing Program (KSARP Figure C-2). Miller Creek suckers were transported, PIT tagged, and released into Gerber Reservoir (Table C-3).

Introduction and Background

The purpose of this Project LRS and SNS Salvage Report is to meet certain requirements outlined in USFWS April 2020 *Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2020 through September 30, 2022, on the Lost River sucker and the Shortnose sucker* (BiOp). The Proposed Action analyzed in the BiOp includes a Conservation Measure proposed by Reclamation to continue fish salvage in certain Project Canals, in cooperation with the USFWS, consistent with the salvage efforts that have occurred in Project canals since 2005. Specifically, the Conservation Measure proposed to perform salvage activities in the C4, D1, and D3 Canals within the KID, and the J Canal within TID. Other locations proposed for salvage by the Service will be considered by Reclamation on a case-by-case basis. As part of the canal Salvage Conservation Measure, Reclamation may also research alternative methods of dewatering canals, laterals, and drains which could result in reduced sucker presence within these facilities at the end of irrigation season. Should Reclamation determine that fish salvage at specific locations is no longer needed or can be modified, Reclamation would coordinate with the Service.

The 2020 BiOp also includes Mandatory Monitoring 1c which requires Reclamation to optimize salvage of listed suckers from Project canals and include these results in the *Annual Monitoring Report.* Effective salvage operations are especially critical in years when there is an abundance of age-0 suckers. As such, Reclamation is also required to consider potential production in its annual salvage plans. Reclamation's A Canal FES monitoring provides for a variety of information including the relative abundance of age-0 suckers in UKL and has been used to inform the level of salvage effort necessary. Project canal salvage is a cost-effective method for returning suckers to their natural environment where the opportunity exists for long-term survivorship and contribution to population growth. As such, in the fall of 2015, and, in close coordination with the Service, Reclamation developed the *Klamath Project Lost River and Shortnose Sucker Salvage Plan* (Plan). The goal was to salvage LRS and SNSs in a collaborative manner as soon as irrigation season ends and to affect the most benefit to the species. Therefore, the Plan provides for an efficient and cost-effective method to salvage LRS and SNSs from Project canals that maximizes the benefit to the species as required by the BiOp.

Coordination

As required by the BiOp and the Plan, Reclamation coordinated with the Service, TID, and KID prior to implementing the 2021 salvage operations and throughout canal dewatering. Due to drought conditions, there were no water deliveries from Upper Klamath Lake during the 2021 irrigation season, although canals could be charged through ground water. Some effort was made to salvage C and D canals but no suckers were found. The Service, aided salvage efforts at the A-Canal forebay, which significantly reduced sucker handling time. KID staff was also on site during A-Canal forebay salvage activities and assisted in monitoring water levels associated with dewatering the canal forebay. Additionally, Reclamation had communication by phone with TID in November of 2021 and coordinated with the Service to discuss timing of J Canal dewatering. Reclamation was informed by TID that J canal would not be dewatered in order to recharge ground water supply. As a result, there was no salvage effort within the J canal at the end of 2021 irrigation season.

Timing

Bulkheads were removed in anticipation for KID water deliveries, which charged the forebay. Salvage activities in the A Canal forebay were performed on September 20, 2021. C and D canals were salvaged November 2, 2021. TID did not dewater J canal after the 2021 irrigation season. Miller Creek at the base of Gerber dam was dewatered and salvaged April 5, 2021.

Methods

Salvage efforts at the A-Canal forebay upstream of the fish screen were performed in coordination with the Service. Bulkheads were removed at the beginning of irrigation season in anticipation for deliveries. Due to drought conditions the bulkheads were put back before any water was delivered. As a result, the forebay was charged with water and aerators were put throughout. For reasons of safety, salvage did not occur until September 20, 2021. Aerators remained on between the time the bulkheads were placed until the date of salvage. KID and Reclamation monitored the forebay during the dewatering process until fish salvage occurred. Standard operating procedures for dewatering the forebay goes as follows; during the first 24 hrs, water levels in the forebay were dropped nearly four feet. The resulting water level in the forebay was maintained for 24 hours to allow groundwater around the structure to drain. After the initial 48 hours, the valve providing bypass flow around the bulkhead was opened to provide water flow-through. Water levels were then lowered at an approximate rate of one foot per 24-hour period by allowing slightly more water to drain through the head gates than was provided through the bypass valve.

Salvage of the A Canal forebay was conducted on September 20, 2021, using seines, block nets, and backpack electrofishers once a water depth of approximately 18-24. For effective and safe capture of fish, conductivity measurements were taken prior to canal electroshocking to help determine the necessary voltage. A Canal forebay conductivity tends to measure around 100 μS/cm, and canal salvage sites vary between 100 and 500 μS/cm. Bycatch was immediately returned to Upper Klamath Lake (UKL), west of the bulkheads at the trash rack. Suckers were held on site in tanks with KSARP aerated water and appropriate temperature and salinity (approximately 1%) to reduce stress to the fish. Once the majority of the fish were removed, as determined by fewer than 100 fish captured during a sweep of the forebay, bypass flows were ceased and the forebay and fish screen was fully dewatered to a depth of 4 inches.

All suckers salvaged within the canal system were handled and processed expeditiously, then transported to KSARP in aerated holding tanks supplied with canal water that was treated with salt (approximately 1%) and NovAqua (stress coat/water conditioner 1 once per 60 gallons).

Suckers caught in Miller Creek were measured, PIT tagged, transported, and released back into Gerber Reservoir (Table 3). In coordination with USFW suckers salvaged at the A canal forebay were transported to KSARP and transferred to the responsibility of the U.S. Fish and Wildlife Service.

The abundance of bycatch was estimated as they were released back into the system from which they were collected. Collected suckers were transported in covered tanks according to the *Fish Handling Guidelines for Salvaged and Transported Klamath Basin Suckers* protocol developed by Reclamation (2008).

Results

A summary of suckers caught during the 2021 salvage season, related to past years results are

included in Figure C-3. In total 149 suckers were salvaged from the Klamath Project Canals between April and December 2021, 82 juvenile suckers from A canal forebay, and 67 from Miller Creek (Table C-1). Zero suckers were captured in the C, D, and J Canals. All suckers from A canal forebay were transported and released at KSARP under the responsibility of the U.S. Fish and Wildlife Service. All suckers salvaged from Miller Creek were released into Gerber Reservoir. The Miller Creek salvage is summarized in Appendix D with other sampling in Gerber Reservoir.

Reclamation estimated non-sucker bycatch as follows: blue chub (13,500), tui chub (72,000), fathead minnow (2361), yellow perch (2,850), sculpin spp. (480), goldfish (295), brown bullhead (10), Sacramento perch (58), speckled dace (650), crappie (30), pumpkinseed (30) and lamprey (4) (Table 2). Bycatch at A Canal forebay were released back into Upper Klamath Lake above the headgates, whereas bycatch within Miller Creek, J, C, and D canals were released at the site of capture.

Discussion

Suckers salvaged from the A canal forebay, and canals, and subsequently tagged and released into UKL and Gerber Reservoir may provide biologists with meaningful information about juvenile suckers.

A comparison of the numbers of endangered suckers salvaged throughout Project Canals over the last 16 years reveals substantial variation in sucker capture rates. It is possible that some of this variation may be attributed to fluctuating water deliveries or salvage effort, more in depth anaylisis would be required to understand any relationship between suckers salvaged and project water release. There does not seem to be a direct coorelation between high FES captures and high A-Canal forebay salvage captures (e.g., 2016 where FES catches were high and A Canal salvage numbers were low).

Recommendations

Future recommendations include:

1) Continue to give salvaged suckers to KSARP.
2) Continue to use 100 percent canal water, or on-site water, with one percent salt concentration for holding and transporting.
3) Continue the same level of coordination between agencies, along with weekly salvage updates during salvage operations.
4) Continue to gradually acclimate suckers to temperature differences between holding tanks and release ponds at KSARP.
5) Continue postponing PIT tagging, weighing, and measuring of salvage suckers until a time that they have been acclimated to KSARP environments.

References

Bennetts, D., C. Korson, and R. Piaskowski. 2004. A Canal Fish Screen Monitoring and Evaluation Activities in 2003. U.S. Bureau of Reclamation, Klamath Falls, Oregon.

Bennetts, D., and C. Korson. 2005. A Canal Fish Screen Monitoring and Evaluation Activities in 2004. U.S. Bureau of Reclamation, Klamath Falls, Oregon.

Marine, K.R., and M. Gorman. 2005. Monitoring and Evaluation of the A Canal Fish Screen and Bypass Facility – Scale Loss and Physical Injury Tests, 2005. North State Resources, Redding, California.

Reclamation. 2008. Handling Guidelines for Klamath Basin Suckers. October 2008. 7p.

Tables and Figures

Table C- 1**.** Summary of juvenile suckers salvaged from Klamath Project canals in 2021.

STATE	Canal	Site	Location description	UTM East	UTM North	Count
Oregon	A		A canal Forebay	598743	4676963	82
	C4	22	Miller Hill pumping plant	603128	4666343	0
	C4	22/23	between 22 & 23			-
	C4	23	Mac Check	603917	4665123	0
	C4	24	¼ mile S of Old Midland Rd.	603434	4664140	-
	C4	24/25	between 24 & 25	602753	4664526	-
	C4	25	¼ mile N of Old Midland Rd.	602141	4664625	-
	C4	26	1/8 mile west of Tingley Lane	601002	4664872	0
	C4	26b	¼ mile W of Tingley Lane	600900	4664736	0
	C4	26c	Check ¼ mile E of Tingley Ln.	601426	4665318	-
	C1	21	Adam's Flume area (S lat.)	613764	4654852	0
	C1	21a	Adam's Flume area (¼ S lat.)	613714	4654847	0
	D3	21	the check near site 21			-
	D3	20	Adam's Flume area (E lat.)	614120	4654933	-
	J	51	Anderson-Rose Dam	619184	4651944	-
	J	52	Check 1 and flume	621505	4651289	-
	J	53	S end of siphon	621537	4651657	-
	J	54	Check 2 (Check # C61010)	623272	4651694	-
	J	55	Check 3 (Check # C61016)	625700	4651923	-
	J	56	Check 4	627334	4651403	-
	J	57	Check 5	631061	4650688	-
	J	57a	North of stateline Rd at RR Xing	629028	4651413	-
	Miller Creek		Plunge Pool Gerber Dam Spill Way			67
California	J	58	Check 6 – S of Stateline Road	632352	4650628	-
	J	59	Check 7	634861	4648454	-
	J	60	Check 8 - D&J confluence	636333	4646278	-
	J	61	Check 9	636947	4643589	-
	J	62	Check 10	637823	4642453	-
	J	63	Check 11	637985	4640807	-
	J	64	Check 12	636846	4638865	-
	J	64/65	Culvert between sites 64 & 65	636056	4639656	-
	J	65	Check 13 (Check # C71113)	635770	4639596	-
	J	65/66	Culvert between sites 65 & 66	635360	4639471	-
	J	66	Culvert E of Highway 139	634874	4639183	-
	J	67	RR Bridge W of Highway 139	634282	4638730	-
	J	68	Check 14	633607	4638622	-
	J	69	Culvert at County Rd. 112	632874	4637953	-
	J	70	Pump 24 (tail end of J-canal)	631334	4636676	-
					Total:	149

- site was not salvaged, or could not be salvaged due to low water levels or because canals remained charged

Table C- 2. Estimated non-sucker species catch during 2021 fish salvage efforts. FHM-fathead minnow, PS-pumpkinseed sunfish, GF-goldfish, YP- yellow perch, SP- Sacramento perch, SCP- unidentified sculpin species, SD- speckled dace, BB- brown bullhead, CR- unidentified crappie species, LMB- largemouth bass.

2021 Salvage	Blue Chub	Tui Chub	FHM	PS	GF	YP	SP	SCP	SD	BB	CR	LMB	LMP
A-CANAL /FORBAY	13,500	72,000	736			2,700	450		450				
C4-22			200		40			1					
C4-22/23													
23			1000		200			20					
24													
24/25													
25													
26			400		50			30					
26b													
26c			25		5			7					
D1-21													
D1-21a													
D3-21													
D3-20													
J-51													
J-52													
J-53													
J-54													
J-55													
J-56													
J-57													
J-57a													
Miller Creek				30		150	30		200	10	30		
J-58													
J-59													
J-60													
J-61													
J-62													
J-63													
J-64													
J-64-65													
J-65													
J-65-66													
J-66													
J-67													
J-68													
J-69													
J-70													
Totals=	**13,500**	**72,000**	**2,361**	**30**	**295**	**2,850**	**480**	**58**	**650**	**10**	**30**	**0**	**0**

Table C-3. Species identification, PIT tag, length and presumed sex of suckers salvaged from Miller Creek Plunge Pool and relocated to Gerber Reservoir in 2021.

Date/Time	Species	PIT Tag	Length	Sex	Comments
4/5/2021 12:50:47 PM	Sucker spp	3DD.003D485987	231		
4/5/2021 12:58:36 PM	Sucker spp	3DD.003D4859A1	197		
4/5/2021 1:03:02 PM	Sucker spp	3DD.003D485973	186	Female	
4/5/2021 1:05:03 PM	Sucker spp	3DD.003D485995	212	Female	
4/5/2021 1:06:38 PM	Sucker spp	3DD.003D4859A5	202	Female	
4/5/2021 1:08:58 PM	Sucker spp	3DD.003D4859A9	200	Female	
4/5/2021 1:10:27 PM	Sucker spp	3DD.003D485989	199	Female	
4/5/2021 1:11:57 PM	Sucker spp	3DD.003D485999	196	Female	
4/5/2021 1:13:37 PM	Sucker spp	3DD.003D4859A6	187	Female	
4/5/2021 1:15:28 PM	Sucker spp	3DD.003D48595C	206	Female	
4/5/2021 1:19:13 PM	Sucker spp	3DD.003D485966	254	Female	
4/5/2021 1:21:22 PM	Sucker spp	3DD.003D48596E	162	Female	
4/5/2021 1:24:59 PM	Klamath Largescale	3DD.003D48597B	206	Female	
4/5/2021 1:26:36 PM	Sucker spp	3DD.003D485958	191	Male	
4/5/2021 1:28:12 PM	Klamath Largescale	3DD.003D485996	196	Female	
4/5/2021 1:30:15 PM	Klamath Largescale	3DD.003D48599C	187	Female	
4/5/2021 1:31:46 PM	Klamath Largescale	3DD.003D485998	169	Female	
4/5/2021 1:33:30 PM	Klamath Largescale	3DD.003D48598F	179	Male	
4/5/2021 1:35:27 PM	Klamath Largescale	3DD.003D485990	199	Female	
4/5/2021 1:37:39 PM	Klamath Largescale	3DD.003D485981	212	Female	
4/5/2021 1:46:48 PM	Klamath Largescale	3DD.003D485962	192	Female	
4/5/2021 1:48:45 PM	Sucker spp	3DD.003D485980	125		
4/5/2021 1:50:17 PM	Klamath Largescale		175	Female	
4/5/2021 1:52:52 PM	Klamath Largescale	3DD.003D485992	156	Female	
4/5/2021 1:54:36 PM	Klamath Largescale	3DD.003D48595A	196	Female	
4/5/2021 1:56:22 PM	Klamath Largescale	3DD.003D48597A	182	Female	
4/5/2021 1:57:48 PM	Sucker spp	3DD.003D485993	175	Female	
4/5/2021 1:59:27 PM	Klamath Largescale	3DD.003D485982	190	Female	
4/5/2021 2:01:03 PM	Klamath Largescale	3DD.003D485985	179	Male	
4/5/2021 2:02:20 PM	Sucker spp	3DD.003D485975	151	Female	
4/5/2021 2:04:36 PM	Klamath Largescale	3DD.003D48595F	181	Female	
4/5/2021 2:06:06 PM	Klamath Largescale	3DD.003D48595B	208	Female	
4/5/2021 2:08:20 PM	Klamath Largescale	3DD.003D48598A	184	Female	
4/5/2021 2:09:26 PM	Klamath Largescale	3DD.003D4859AC	153	Female	
4/5/2021 2:10:23 PM	Sucker spp	3DD.003D4859A0	127	Female	
4/5/2021 2:11:19 PM	Sucker spp	3DD.003D4859B9	171	Female	
4/5/2021 2:12:18 PM	Klamath Largescale	3DD.003D485997	130	Female	
4/5/2021 2:13:21 PM	Klamath Largescale	3DD.003D485961	186	Female	
4/5/2021 2:14:04 PM	Klamath Largescale	3DD.003D4859AD	196	Female	
4/5/2021 2:15:05 PM	Klamath Largescale	3DD.003D4859A7	180	Female	

4/5/2021 2:16:15 PM	Klamath Largescale	3DD.003D485971	157	Female	
4/5/2021 2:17:18 PM	Klamath Largescale	3DD.003D485979	169	Female	
4/5/2021 2:18:23 PM	Klamath Largescale	3DD.003D48599B	205	Female	
4/5/2021 2:19:16 PM	Klamath Largescale	3DD.003D4859B0	233	Female	
4/5/2021 2:20:54 PM	Klamath Largescale	3DD.003D485957	162	Female	
4/5/2021 2:21:31 PM	Sucker spp	3DD.003D4859A2	164	Female	
4/5/2021 2:22:07 PM	Sucker spp	3DD.003D48595E	193	Female	
4/5/2021 2:22:42 PM	Sucker spp	3DD.003D485963	180	Male	
4/5/2021 2:23:23 PM	Sucker spp	3DD.003D48596B	163	Female	
4/5/2021 2:23:55 PM	Sucker spp	3DD.003D485965	188	Male	
4/5/2021 2:24:51 PM	Sucker spp	3DD.003D4859AE	190	Female	
4/5/2021 2:25:22 PM	Sucker spp	3DD.003D4859A4	160	Female	
4/5/2021 2:26:00 PM	Sucker spp	3DD.003D485976	197	Female	
4/5/2021 2:26:35 PM	Sucker spp	3DD.003D48599E	165	Female	
4/5/2021 2:27:21 PM	Sucker spp	3DD.003D485991	196	Female	
4/5/2021 2:28:02 PM	Sucker spp	3DD.003D4859A8	189	Male	
4/5/2021 2:28:46 PM	Sucker spp	3DD.003D48598D	147	Female	
4/5/2021 2:29:21 PM	Sucker spp	3DD.003D485968	162	Female	
4/5/2021 2:30:07 PM	Sucker spp	3DD.003D48597C	177	Female	
4/5/2021 2:30:33 PM	Sucker spp	3DD.003D485960	161	Male	
4/5/2021 2:31:24 PM	Sucker spp	3DD.003D485959	181	Male	
4/5/2021 2:31:48 PM	Sucker spp	3DD.003D4859B1	191	Male	
4/5/2021 2:32:26 PM	Sucker spp	3DD.003D4859AB	174	Female	
4/5/2021 2:33:09 PM	Sucker spp	3DD.003D485978	154	Female	
4/5/2021 2:33:48 PM	Klamath Largescale	3DD.003D4859B8	211	Male	
4/5/2021 2:34:53 PM	Klamath Largescale		169	Male	mortality
4/5/2021 2:36:50 PM	Sucker spp	3DD.003D48598C	144	Female	

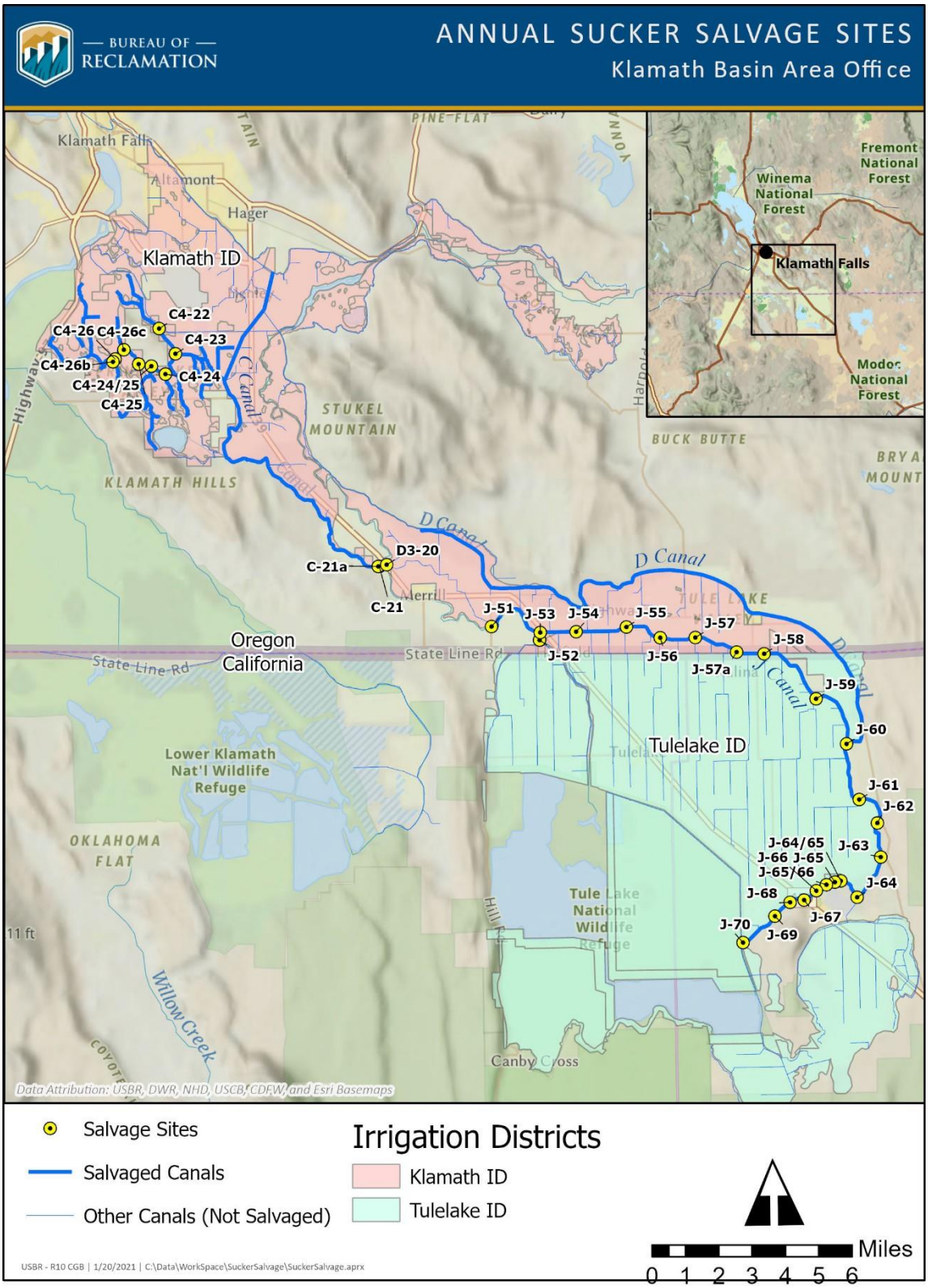

Figure C- 1. Map of Klamath Project canal system and canal salvage sites.

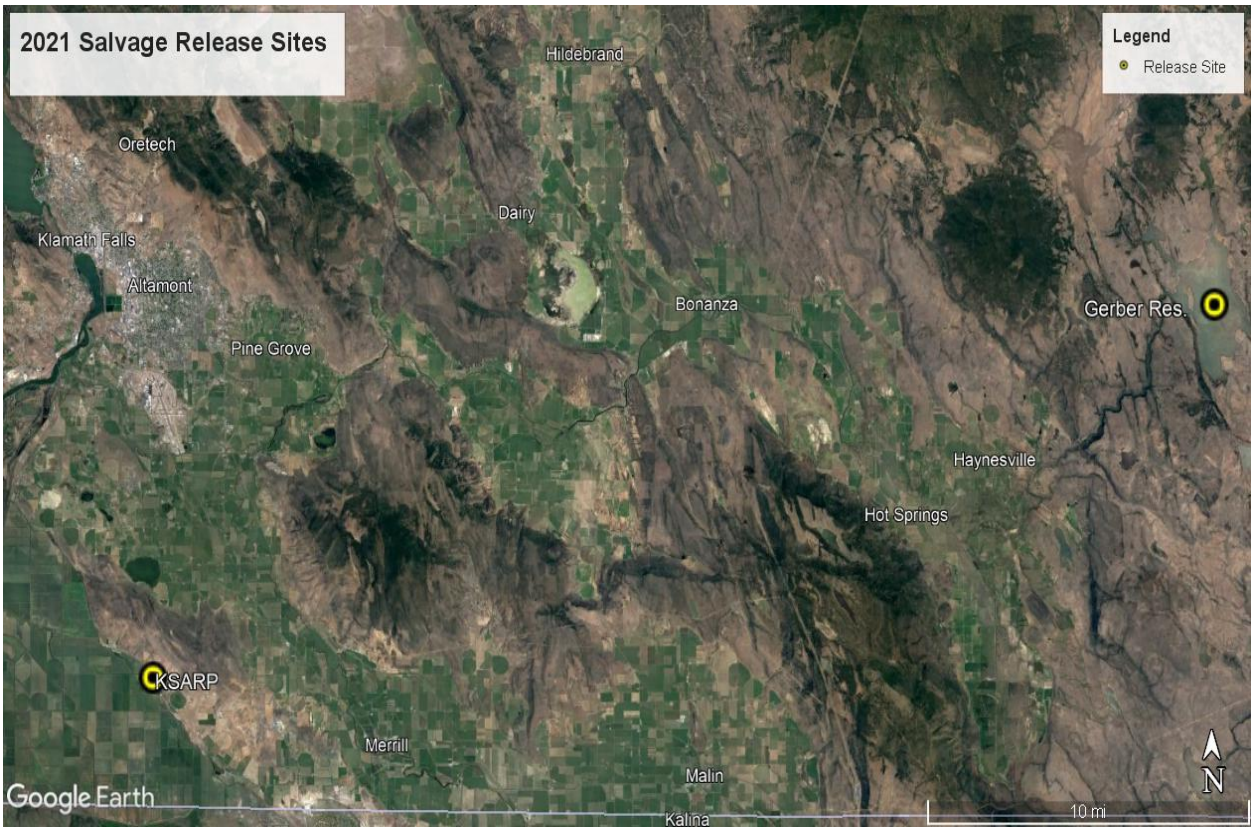

Figure C- 2. Map of sucker release sites in 2021.

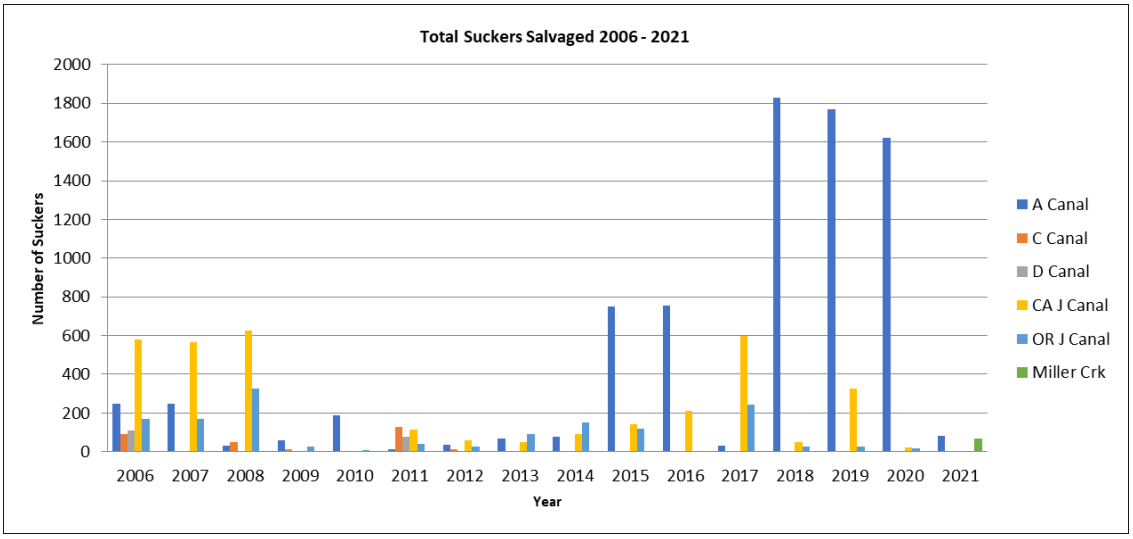

Figure C- 3. Number of endangered suckers captured at several Klamath Project canals, 2006-2021.

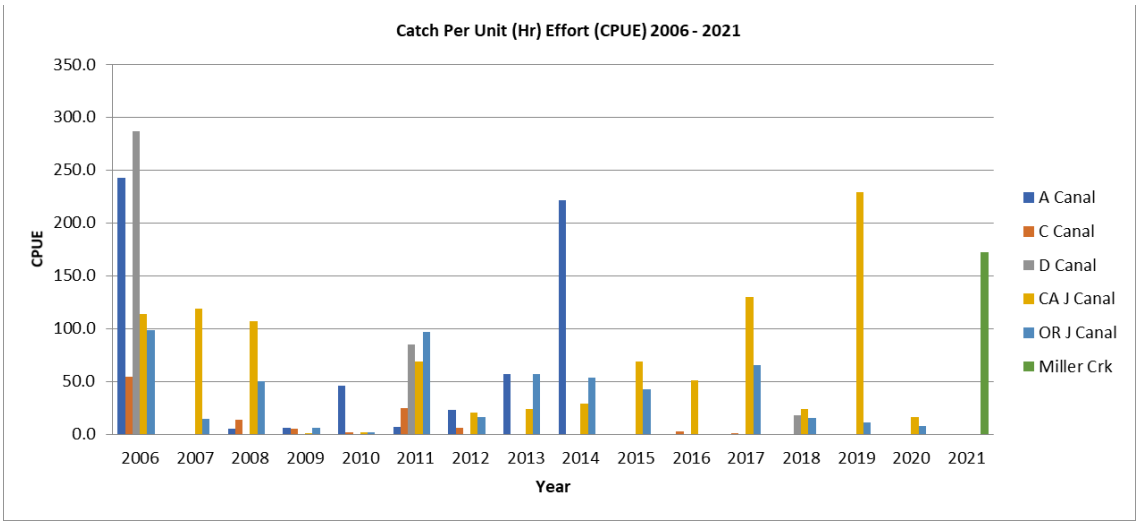

Figure C- 4. Comparison of catch per unit effort between sites (suckers/hour electrofished) from 2006-2021.

Appendix D – Passive Integrated Transponder-tagging Endemic Adult Suckers in Gerber Reservoir, 2021

Klamath Project, Oregon/California
Interior Region 10 California Great Basin

Cover Photo: Adult sucker identified as Klamath largescale x shortnose sucker hybrid.

Executive Summary

Gerber Reservoir is one of three major reservoirs in the Upper Klamath Basin in south-central Oregon inhabited by endangered SNSs (USFWS 1988). The dam was built in 1925 by Reclamation to store water from Miller Creek for irrigation of lands in Langell Valley and to prevent flooding of agricultural lands in Tule Lake district (Darr 1925). Suckers in Gerber Reservoir have been intermittently monitored during the last three decades. More recent monitoring efforts were conducted by USGS in 2000, 2003, 2004, and 2005 (Piaskowski and Buettner 2003, Leeseberg et al. 2007, Barry et al. 2007). Over 2,000 suckers were PIT-tagged in 2004 and over 2,200 were PIT-tagged in 2005 by USGS. While relatively large numbers of suckers have been captured in Gerber Reservoir, it is unclear how large these populations are especially as available habitat for suckers has fluctuated with surface elevations. Gerber was below the 2013 BiOp minimum of 4,798.1 ft (4,797.9 feet) in 2016, then increased to 4,835.4 ft and spilled in 2017 and 2019 (NMFS and USFWS, 2013). Recently, surface elevations were intermediate at the end of water year 2020 (4,815.74), and low at the end of water year 2021 (4,799.57ft) Suckers in Gerber Reservoir have been geographically isolated from other sucker populations since the construction of Gerber Dam (Piaskowski and Buettner 2003, Reclamation unpublished data 2018) and species identification is especially challenging as some individuals have characteristics of non-listed KLS, suggesting introgression

To better understand sucker abundance in Gerber Reservoir, Reclamation reinitiated an adult sucker monitoring program in 2018. Reclamation set trammel nets 30 days in 2018, 23 days in 2019, 20 days in 2020, and 10 days in 2021 at Gerber Reservoir. Annual spring sampling in Gerber Reservoir was curtailed so Reclamation staff could assist USFWS in a sucker relocation effort in Tule Lake Sump 1A. As part of a 2021 Gerber Dam inspection, Reclamation salvaged suckers from Miller Creek plunge-pool downstream of Gerber Reservoir on April 6, 2021. Suckers from this salvage effort were PIT-tagged and released in Gerber Reservoir and this effort is summarized herein. Reclamation captured and PIT-tagged 1215 suckers in 2018, 1148 suckers in 2019, 442 suckers in 2020, and 166 suckers in 2021. Reclamation recaptured 33 suckers in 2018, 8 suckers in 2019, 1 sucker in 2020, and 3 suckers in 2021 that were PIT-tagged by USGS from 2000 to 2005 (Barry et al. 2007). Including recaptures from suckers tagged in other years but excluding recaptures of the same individual (identified by PIT-tag) within the year, Reclamation captured a total of 1249 PIT-tagged suckers in 2018, 1200 PIT-tagged suckers in 2019, 461 PIT-tagged suckers in 2020, and 178 suckers in 2021. Suckers ranged in size from 290 to 589 mm fork length in 2018, 235 to 584 mm in 2019, 277 to 559 mm in 2020, and 125 to 558 mm in 2021. The smallest (<313 mm) suckers were salvaged from Miller Creek Plunge Pool, whereas larger suckers were captured in trammel nets. Captures in all years had bimodal size distributions, though large adults were more common in 2018, and small adults were more common in 2019 and 2020. The proportion of large adults relative to small adults increased again in 2021 captures.

Small and large adult suckers are present in Gerber Reservoir, suggesting suckers are successfully spawning and recruiting into the adult population on a semi-regular basis. At least two (and likely more) year classes of suckers inhabit Gerber Reservoir. While species composition remains unclear, small and large-bodied suckers in Gerber Reservoir have characteristics of KLSs, SNS and SNS x KLS hybrids.

While over 2,500 suckers have been PIT-tagged at Gerber Reservoir, not enough adult suckers have been PIT-tagged for population level estimates of abundance or survival though a continuation of Reclamation's efforts may make these estimates achievable in the next few years.

Introduction

Shortnose suckers were federally listed as endangered in 1988 throughout their range (USFWS 1988). SNSs are endemic to the Klamath Basin and co-occur with LRSs), another federally listed endangered sucker endemic to the Klamath Basin, and KLSs, a non-listed species that is similar in morphology to SNSs (Markle et al. 2005). SNSs are long lived fish and have been aged up to 30 years in UKL (Scoppettone 1988, Buettner and Scoppettone 1990, Terwilliger et al. 2010).

Gerber Reservoir is one of three major reservoirs in the Upper Klamath Basin in south-central Oregon. The dam was built in 1925 by Reclamation to store water from Miller Creek for irrigation of lands in Langell Valley and to prevent flooding of agricultural lands in Tule Lake district (Darr 1925). Ben Hall Creek and Barnes Valley Creek are major tributaries to Miller Creek and now, Gerber Reservoir. There is one federally listed species in Gerber Reservoir; SNSs. LRSs are not known to occur in Gerber Reservoir. Ben Hall Creek, Barnes Valley Creek, and possibly Barnes Creek provide spawning habitat for suckers. Suckers make spawning migrations in the spring, in years when tributary flows and lake elevations are sufficient for suckers to access these habitats. Spawning surveys in 2006 detected approximately 1,700 SNSs of the nearly 2,400 that had been tagged the previous year (Barry et al. 2007a). Spawning migrations have not been regularly monitored by remote antennas. However, in 2006 suckers were present in tributaries from early March to mid-May (Barry et al. 2007). Some suckers in Gerber have demonstrated great mobility; moving among spawning tributaries at opposite ends of the reservoir within 24 hours (Barry et al. 2007).

Due to fluctuations in surface elevation, suckers in Gerber Reservoir have endured large fluctuations in habitat size (reservoir down to 4,796 feet in the early 90s and 4,797.9 feet in 2016) and have remained geographically isolated from other sucker populations in the basin since dam construction in 1925 (Piaskowski and Buettner 2003). Gerber has a maximum (spill) surface elevation of 4,835.4 ft, and a Biological Opinion minimum of 4798.1 ft (USFWS 2020). Reduced habitat and physical isolation from other sucker populations has likely restricted genetic variation and population size in the region.

In the field, KLS are differentiated from SNS based on habitat type and morphology of feeding structures characters. KLS, primarily residents of rivers, have larger, fleshy lips, while SNS have smaller lips and are primarily residents of lakes that make spawning migrations into river tributaries each spring (Markle et al. 2005). Species identification using morphology varies geographically and has been especially challenging in Gerber Reservoir and most reports have combined Klamath Largescale and SNS species (Piaskowski and Buettner 2003, Leeseberg et al. 2004, Barry et al. 2007). LRSs do not inhabit Gerber Reservoir. While lip morphology, mouth position, snout shape, and body shape are characteristics used in the field to identify species, other species-identification methods are lethal, such as counting vertebrae and gill rakers (Markle et al. 2005). Many factors influence sucker phenotype including habitat, age, size, region, and genetics. While recent advanced genetic analyses have been able to differentiate KLS and SNS in UKL and the Upper Williamson River, these assays have not yet identified different genetic markers between KLS and SNS in Gerber Reservoir (Smith et al. 2020). Due to the similarities between KLS and SNS, Reclamation follows USFWS guidance and treats all suckers in Gerber Reservoir as endangered.

Suckers in Gerber Reservoir have been intermittently monitored in the last three decades and less is known about suckers in Gerber than sucker populations in UKL and Clear Lake Reservoir. Reclamation tagged an unknown number of suckers with floy tags and/or PIT-tags from 1992 to

1996 (Piaskowski and Buettner 2003) and USGS conducted monitoring in 2000 and 2003, and in 2004 PIT-tagged 2,023 suckers with 125 kHz PIT-tags and in 2005 PIT-tagged 2,275 suckers with 134.2 kHz PIT-tags.

In an effort to better understand the population dynamics and species status in Gerber, USBR began monitoring adult suckers in Gerber Reservoir in 2018. This report is a summary of Reclamation's efforts as of 2021.

Methods

Trammel nets were set on nine days in Gerber Reservoir in the spring from March 17 and to April 1, 2021 to target adult suckers. An additional day of sampling was conducted on April 28, 2021 was in coordination with USFWS as part of a thiamine sample collection. Reclamation's spring sampling was curtailed so Reclamation staff could assist USFWS in a sucker relocation effort in Tule Lake Sump 1A. Nets were set in areas intended to target adult suckers. Due to low surface elevations in 2021, nets were typically set in deeper areas accessible from the South Gerber Boat Ramp near the dam. Nets were typically set perpendicular or parallel to the shoreline and in at least 6 feet of water. In 2021, nets were usually set once per day due to low catch numbers in the second set. Nets were typically set between 0700 and 0800.and fished for approximately 2-4 hours. On some occasions, nets were pulled after 1 or 2 hours, especially when captures were high or when it appeared that many fish were in a net. Trammel nets were 91.4 m long, 1.8 m tall, and consisted of two outer panels with 30 cm bar mesh, an inner panel with 3.8 cm bar mesh, a foam core float line, and a lead core sink line.

Electrofishing was used on April 5, 2021, to salvage suckers from the Miller Creek Plunge Pool adjacent and downstream of Gerber Reservoir during a routine Dam Inspection. Suckers were netted and held in containers of water from Miller Creek until they were PIT-tagged and released into Gerber Reservoir. This salvage effort is included in this report.

All fish were removed from trammel nets as they were pulled from the water. Non-target species were identified to species, enumerated, and returned to the reservoir. Suckers were placed in a large, aerated holding container with water from Gerber Reservoir on the boat or a net pen in the reservoir. Suckers were measured to fork length and checked for the presence of a PIT-tag. If a PIT-tag was not detected, then a PIT tag was implanted under the skin anterior to the pelvic girdle using a hypodermic needle. Sucker sex and spawning condition was identified by the presence of gametes and morphology (e.g., tubercles and anal fin shape). Full and firm bodies were indicative of maturing ova in females. Any parasites, signs of disease, or other afflictions were recorded. Suckers were identified as SNS, KLS, KLS x SNS hybrids, or unknown sucker. As described earlier, species identification between KLSs and SNSs is challenging. Field biologists typically assign species to the best of their ability using primarily lip morphology, but also mouth position, snout shape, and body shape. Suckers are returned to Gerber Reservoir as quickly as possible. A subsample of trammel-netted adult suckers and small salvaged suckers from the Miller Creek plunge pool were fin-clipped for genetic analysis. Samples were preserved in 95% ethanol and sent to USFWS Abernathy Fish Technology Center for extraction and analysis.

PIT-tags were detected on BioMark handheld PIT-tag antennas, and PIT-tag IDs were automatically populated into data fields. Data was collected on Trimble Ranger 3 handheld computers in the spring and on Dell Latitude 7212 rugged extreme tablets in the fall. Data was downloaded onto office computers daily. In 2020, Reclamation built a Gerber database which improved our ability to

account for recaptures of the same individual within and among years, and track species and sex determinations among capture occasions. For summary purposes, and to the best of our ability, we have counted each PIT-tag only once per year. Reclamation has also, to the best of our ability, described our accounting for suckers by species-group and sex. In our database, Reclamation retains the history for all sex and species-group calls but for the purposes of this report, we have summarized as follows. Sex conflicts were assigned most often or in the case of a tie, most recent sex call under the presumption that sex may be more difficult to identify for younger fish. For all species-conflict suckers first identified as an "unknown" species, then subsequently identified into a species group, Reclamation quantified these individuals into the species group (instead of "Unknown species"). No suckers were identified as KLS, KLS x SNS, or SNS on their first capture then subsequently recaptured "unknown" species. Because the majority of suckers with field identification species conflicts were identified as "KLS x SNS" once, or "KLS" once and "SNS" once, Reclamation quantified all these species-conflicts into the "KLS x SNS" count statistics. In contrast to the 2019 Compliance Report, Reclamation summarized species identification by proportion only (see Results).

Due to low surface elevations and low inflow, USGS PIT-tag antenna arrays were not installed in Ben Hall Creek and Barnes Valley Creek in 2021. In coordination with USFWS, USBR placed one wagon wheel antenna in each tributary from March 11 to April 8, 2021. Antennas were placed in a deep spot though neither antenna spanned the entire creek.

Results

Effort Summary

Trammel nets were set on 10 days in 4 weeks in 2021 at Gerber Reservoir. In the spring, 50 nets were set on 10 days and the Miller Creek Plunge Pool was dewatered and suckers were salvaged for one day during a dam inspection. Four to eight nets were set each day with an average of 5 nets per day. Sampling occurred only in the spring of 2018, 2019, and 2021 and 224, 165, and 50 nets were set each year, respectively. In 2020, sampling occurred in the spring and fall with a total of 135 nets set in 2020.

Capture Summary

Reclamation captured and PIT-tagged 166 suckers in 2021 (Table D-1). Including recaptures from suckers tagged in other years but excluding recaptures of the same individual (identified by PIT-tag) within the year, Reclamation captured a total of 178 PIT-tagged suckers in 2021 (Table D-1). PIT-tags were detected or implanted in all but two suckers captured in the spring of 2021 (n=178). Both non-PIT tagged suckers were captured during the Miller Creek plunge pool salvage effort, one sucker (169 mm) did not survive the salvage effort and the second (175 mm) appeared stressed and was released without a PIT-tag (Table D-1). Fin clips were collected from 50 suckers during spring trammel netting, and 31 suckers salvaged from Miller Creek plunge pool.

Of the suckers captured in 2021, 7% (n=9) of females and 6.5% of males (n=3) were recaptures. All 2021 recaptures except three were tagged by Reclamation tagged in 2018, 2019, or 2020. In 2018, 2019, 2020, and 2021 Reclamation recaptured 33, 8, 1, and 3 suckers respectively that were PIT-tagged from 2000 to 2005 by USGS (Barry et al. 2007; Table D-4).

Sex ratios were biased towards females in all years; bias was strong in 2018 (1.67), similar in 2019

(1.18), and 2020 (1.25) and strongest in 2021 (2.80); Table D-3), though many of these suckers were small and may have been mis-identified as female in 2021 (Table D-5, Figure D-2). Sex was not identified for three small suckers in 2021. The number of suckers recaptured among years varied among years and by sex (Table D-4). Of the suckers that were recaptured in 2021, 8 were recaps from 2018, 3 were recaps from 2019, and zero were recaps from 2020. A total of 43 suckers (29 females and 14 males) were captured in 2018 and 2019. Fewer (n=10) suckers were captured in 2019 and 2020, in 2018 and 2020 (n=8), or in 2018 and 2021 (n=8; Table D-4)). No PIT-tagged suckers were captured in more than two years.

On average, female suckers captured in 2018 (495.7 ± 44.9 mm) were over 100 mm larger than suckers captured in 2019 (380.0 ± 101.9 mm) and 2020 (371.7 ± 68.0 mm) but by 2021, female suckers captured in Gerber in 2021 were 447.2 ± 75 mm; Table D-5). On average, male suckers captured in 2018 (430.3 ± 58.2 mm) were over 90 mm larger than suckers captured in 2019 (338.4 ± 59.1 mm) and 60 mm larger than male suckers captured in 2020 (363.0 ± 40.4 mm; Table D-5). Male suckers captured in Gerber Reservoir were 420.8 ± 44.5 mm. Suckers captured in Gerber in 2018 ranged from 290 to 589 mm fork length, 235 to 584 mm in 2019, 277 to 559 mm in 2020, and 313 to 558 in 2021(Table D-5). Captures in 2018 and 2019 had bimodal size distributions with peaks slightly larger than 300 mm and 500 mm (Figure D-1). Larger suckers were less abundant in 2020 catches, especially for males (Figures D-1 and D-2).

The number of adult suckers sampled from Gerber Reservoir identified as sharing characteristics of Klamath largescale suckers and shortnose suckers decreased from 2018 to 2020 and then increased in 2021(Table D-6; females: 23% in 2018, 11% in 2019, 15% in 2020, and 33% in 2021; males 21% in 2018, 9% in 2019, 8% in 2020, 31%). The proportion of suckers identified as SNSs has decreased substantially in the last four years (females: 45% in 2018, 28% in 2019, 2% in 2020, 3% in 2021; males 40% in 2018, 13% in 2019, 1% in 2020, and 0% in 2021) and the proportion of suckers identified as unknown species has remained low (females: 6% in 2018, 1% in 2019, and 0% in 2020 and 2021; males 4% in 2018, <1% in 2019, <1% in 2020, and 0% in 2021).

No suckers were detected on BioMark wagon wheel antennas that were placed in Ben Hall Creek and Barnes Valley Creek from March 11 to April 8, 2021. In 2020, 12 PIT-tagged suckers were detected on the array in Barnes Valley Creek as water temperatures were approached 50°F (10°C) between April 8 and April 15, 2020, and no suckers were detected on the Ben Hall Creek Array.

Discussion

Field activities were curtailed in the spring of 2021 when USFWS requested Reclamation fisheries staff to assist in the trap and haul of suckers from Tule Lake Sump 1A to Sump 1B and in the spring of 2020 due to public health restrictions associated with COVID-19. While trammel netting efforts resumed in the fall of 2020, overall, sampling efforts were reduced in recent years relative to 2018 and 2019. Low surface elevations prevented Reclamation from sampling in the fall of 2021 and as a result, fewer suckers were captured in 2021 (n=111) and 2020 (n= 461) relative to 2018 (n=1249) and 2019 (n=1200), even when the Miller Creek plunge pool salvage was included (n=180).

Sucker populations in Gerber Reservoir are comprised of both small and large adult suckers, suggesting that the population has more than one age class, and likely several year classes. Fewer large suckers were captured in Gerber Reservoir in 2019 and 2020 relative to 2018 and the proportion of large adults captured in 2021 increased again (Figure D-1, Figure D-2). Annual recaptures were too few to quantify growth rates, however the annual growth of the small-adult

cohort first captured 2019 is apparent in annual histogram plots. This cohort is less prominent in the 2021 histogram due to limited sampling. 2021 was unique because it included many small suckers salvaged from the Miller Creek plunge pool during the Gerber Dam inspection. Only trammel nets were used in 2018, 2019, and 2020; trammel nets typically select for suckers greater than 250 mm.

Reclamation has not aged any of the suckers from Gerber Reservoir, and size to age relationships vary among species, water bodies, and other factors in the Upper Klamath Basin. Therefore, it is not possible to use size to age relationships from UKL or Clear Lake Reservoirs to estimate age for suckers in Gerber Reservoir. Non-lethal methods for aging suckers are available (e.g. fin ray) though these methods may be less accurate for larger suckers. Consistent monitoring of sucker populations in Gerber will provide data to estimate age of reproductive maturity and maximum life expectancy for these suckers. Fewer large suckers in 2019 and 2020 relative to 2018 may be indicative of age-related mortality. As a larger proportion of the population is tagged, observed patterns will better inform population trends.

The majority of large and small suckers captured in 2020 and 2021 were identified as female (Table D-1, Table D-5). It is likely that some of the smallest suckers were not sexually mature and were mis-identified as female. Large male suckers may be less common in Gerber and may have lower survival and shorter life expectancy that can be attributed to increased duration and risky behavior during spawning season. Male suckers in UKL and Clear Lake Reservoir typically have lower survival than females, because they are more vulnerable to predation when they spend more time at spawninggrounds. Male SNSs in UKL and Clear Lake Reservoir have lower survival than female SNSs (Hewitt et al. 2018, Hewitt et al. 2021).

Based on the size of the suckers salvaged from Miller Creek plunge pool, it is likely that they were spawned in 2018, 2019, or 2020 and left Gerber Reservoir through the unscreened gates in the dam. Typically, very few or no suckers are salvaged from Miller Creek during annual water shut-off salvage efforts though e-fishing is typically not conducted during water shut-off.

Species identification in Gerber Reservoir remains challenging, especially because many suckers appear to have characteristics of both KLSs and SNSs. Other researchers have called all suckers "shortnose suckers" in reports (Piaskowski and Buettner 2003, Leeseberg et al. 2007, Barry et al. 2007). When analyzed in 2019, a sucker's species was identified consistently among capture occasions 80 percent of the time. Additional years of monitoring and capturing the same individuals in Gerber may identify individuals with especially challenging characteristics. At present, it is unclear if characteristics change (and thus field species-identification) with size or other factors such as environment.

The proportion of suckers identified as KLS x SNS or SNS has decreased in the last four years while the proportion of KLS has increased. This is likely associated with human behavior and not changes in the species composition of the sucker population in Gerber Reservoir. In 2020, USFWS Abernathy Fish Technology Center published a study that used RADseq genomic data to differentiate KLS and SNS in the Klamath Lake subbasin (Smith et al. 2020). These same methods were unable to genetically differentiate KLS and SNS in the Lost River subbasin (Smith et al. 2020). Genetic fin clips collected by Reclamation in 2021 have been processed and will be assessed using these methods by USFWS and are outside of the scope of this report.

It is likely that low surface elevations in Gerber Reservoir and low flows in Barnes Valley Creek and Ben Hall Creek prevented all or most suckers from spawning in 2021. No suckers were detected on small wagon wheel antennas placed in these creeks, though only one antenna was placed in each

creek for about one month. Suckers could have avoided this area, spawned before or after placement of these antennas, or not spawned at all. In 2020, the Barnes Valley Creek antenna array detected a small group of 12 suckers attempting to make a spawning run over seven days in early April when the average daily water temperatures were approximately 50°F (10°C; Figure D-3; B. Hayes, USGS, personal communication, May 11, 2020; August 13, 2020). For sucker populations in Gerber, estimates of population dynamics parameters such as abundance and survival are not achievable until detection probabilities (recaptures) are at least 10-12 percent per year. If over 1000 suckers are tagged each year, antenna arrays are consistently operated, and suckers are able to make spawning migrations, it may be possible to derive meaningful estimates of population size and survival of suckers in Gerber Reservoir within a few years. Maintaining antenna arrays in spawning tributaries will markedly increase detection probability and reduce the number of years until these population parameters are estimable. In addition to life history population trends, growth rates and afflictions may vary with conditions in Gerber Reservoir. Additional years of trammel netting and antenna arrays will provide key information about the timing, seasonality, duration, and conditions necessary for spawning migrations in each tributary which will allow researchers and managers to compare populations within and among reservoirs throughout the Klamath Basin. These findings may help make informed management decisions to benefit the species.

Recommendations

1) Continue PIT-tagging and monitoring suckers annually in Gerber Reservoir.
2) Collect fin rays from a subsample of small and large suckers for age analysis.
3) Collect morphometric measurements and fin-clips for genetic analysis on suckers identified as KLS, KLS x SNS, and SNS.
4) Maintain antenna arrays in Barnes Valley Creek and Ben Hall Creek.
5) Increase frequency of flow measurements at Barnes Valley Creek and Ben Hall Creek.

References

Barry, P.M., B.S. Hayes, E.C. Janney, R.S. Shively, A.C. Scott, and C.D. Luton. 2007. Monitoring of Lost River (*Deltistes luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Gerber and Clear Lake Reservoirs 2005-2006. U.S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 25p.

Buettner, M. and G. Scoppettone. 1990. Life History and Status of Catostomids in Upper Klamath Lake, Oregon. Completion Report. U.S. Fish and Wildlife Service, National Fisheries Research Center, Reno Field Station, Nevada. 119p.

Darr, A.L. 1925. Construction Gerber Dam. Bureau of Reclamation, Klamath Project. 156p.

Hayes, B. 2020. Gerber Arrays. Personal communication. Email to USBR Torrey Tyler and Danielle Hereford May 11, 2020.

Hewitt, D.A., and B.S. Hayes. 2013. Monitoring of adult Lost River and shortnose suckers in Clear Lake Reservoir, California, 2008-2010. U.S. Geological Survey Open-File Report 2013-1301, 26 p.

Hewitt, D.A., Janney, E.C., Hayes, B.S., and Harris, A.C., 2018. Status and trends of adult Lost

River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) sucker populations in Upper Klamath Lake, Oregon, 2017: U.S. Geological Survey Open-File Report 2018-1064, 31 p., https://doi.org/10.3133/ofr20181064.

Hewitt, D.A., Hayes, B.S, Harris, A.C., Janney, E.C., ., Kelsey, C.M., Perry, R.W., and Burdick, S., 2021, Dynamics of endangered sucker populations in Clear Lake Reservoir, California: U.S. Geological Survey Open-File Report 2021-1043, 59 p. , https://doi.org/ 10.3133/ ofr20211043.

Leeseberg, C.A., P.M. Barry, G. Whisler, and E. Janney. 2007. Monitoring of Lost River (*Deltisies luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Gerber and Clear Lake reservoirs: Annual Report 2004. U. S. Geological Survey, Western Fisheries Research Center, Klamath Falls Field Station. 24p.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service. 2013. Biological Opinions on the Effects of the Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species. NMFS file number: SWR-2012-9372. FWS file number: 08EKLA00-2013-F-0014.

Piaskowski, R. and M. Buettner. 2003. Review of Water Quality and Fisheries Sampling Conducted in Gerber Reservoir, Oregon with Emphasis on the Shortnose Sucker and its Habitat Needs. Klamath Basin Area Office, U.S. Bureau of Reclamation, Klamath Falls, Oregon. 90p.

Scoppettone, G.G. 1988. Growth and longevity of the Cui-ui and longevity of other Catostomids and Cyprinds in western North American. Transactions of the American Fisheries Society 117:301-307.

Smith, M., J. VonBargen, C. Smith, M. Miller, J. Rasmussen, D. A. Hewitt. 2020. Characterization of the genetic structure of four sucker species in the Klamath River Basin. Abernathy Fish Technology Center, U.S. Fish and Wildlife Service, Longview, Washington. 34p.

Terwilliger, M.R., T. Reece, and D.F. Markle. 2010. Historic and Recent Age Structure and Growth of Endangered Lost River and Shortnose Suckers in Upper Klamath Lake, Oregon. Environmental Biology of Fishes 89:239-252. U.S. Fish and Wildlife Service (USFWS). 1988. Endangered and Threatened Wildlife and Plants: Determination of Endangered Status for the Shortnose Sucker and LRS. Federal Register, Vol. 53, No. 137:27130-27134.

Tables and Figures

Table D- 1. Total number of suckers captured with Passive Integrated Transponder (PIT) tags or implanted with PIT-tags, new PIT-tags implanted, and number of suckers released without a PIT-tag in 2018, 2019, and 2020 for each sex. To the best of our ability, each PIT-tag was counted once per year, recaptures within year are not included in these totals (See Table D-2).

	All PIT-tagged captures					**New PIT-tagged fish**					**Not PIT-tagged**			
Sex	**2018**	**2019**	**2020**	**2021**		**2018**	**2019**	**2020**	**2021**		**2018**	**2019**	**2020**	**2021**
female	781	646	256	129		754	609	252	120		-	11	3	1
male	468	549	205	46		461	534	190	43		-	6	-	1

unknown	-	5	-	3		5		3		-	-	1	-
all	1249	1200	461	178		1215	1148	442	166		-	17	4	2
F:M ratio	1.67	1.18	1.25	2.8		1.64	1.14	1.33	2.8*		-	1.83	-	1

[1] In 2019, PIT-tags were implanted in three male suckers (1 Klamath largescale sucker (KLS), 1 KLS x SNS, 1 SNS) where body length measurements were not recorded. These suckers are included in this table but are only included in Table D-6 as *not measured*. [2] Sex was unknown for one fish captured in 2020. A total of four suckers captured in the fall 2020 were not PIT-tagged in 2020 due to poor condition.

Table D- 2. Total number of suckers recaptured with Passive Integrated Transponder (PIT) tags (including PIT tags implanted in suckers earlier in the year) and recaptures of suckers PIT-tagged with non-3DD tags (not Reclamation's effort) Each recaptured PIT-tag was counted once per year (see Methods).

	All PIT-tag recaptures					**Recaptures of Non- 3DD tags**			
Sex	**2018**	**2019**	**2020**	**2021**		**2018**	**2019**	**2020**	**2021**
female	67	50	5	9		26	7	-	3
male	28	39	16	3		7	1	1	-
all	95	89	21	12		33	8	1	3
F:M ratio	2.39	1.28	0.31	3		3.71	7	-	-

Table D- 3. Number of Passive Integrated Transponder (PIT)-tagged suckers recaptured within years in Gerber Reservoir.

	Within Year Recaptures[1]				
Sex	**2018**	**2019**	**2020**	**2021**	**Total**
female	39	13	1	0	53
male	18	24	1	0	43
all	57	37	2	0	96

[1] Within year recaptures includes only suckers that were recaptured one or more times within each year. Suckers that were captured twice within one year, and subsequently recaptured again in another year, are counted once.

Table D- 4. Number of Passive Integrated Transponder (PIT)-tagged suckers recaptured among years in Gerber Reservoir. Suckers that were captured twice within one year, and recaptured within another year, are counted in the among year recaptures. No PIT-tagged suckers were captured in all four years. Females are listed above the diagonal; males are listed below the diagonal.

	Among Year Recaptures			
	2018	**2019**	**2020**	**2021**
2018		29	2	7
2019	14		2	1
2020	6	8		0
2021	1	2	0	

Table D-5. Number, average, standard deviation, and range of sizes of suckers captured in 2018 - 2021in Gerber Reservoir, and salvaged from Miller Creek Plunge Pool in 2021. Suckers summarized by sex and capture location. Only Passive Integrated Transponder-tagged suckers were included. Suckers released without a PIT tag (n=17 in 2019, n= 4 in 2020, n=2 in 2021) are not included in this summary.

Year	Sex	Site	N	Mean ± SD	Range
2018	female	Reservoir	781	495.7 ± 44.9	(303-589)
2018	male	Reservoir	468	430.3 ± 58.2	(290-540)
2019	female	Reservoir	646	380.0 ± 101.9	(239-584)
2019	male	Reservoir	549	338.8 ± 59.1	(235-549)
2019	unknown	Reservoir	5	431.2 ± 111.1	(307-528)
2020	female	Reservoir	256	372.0 ± 68.0	(285-559)
2020	male	Reservoir	205	363.0 ± 40.4	(277-509)
2021	female	Reservoir	76	447.2 ± 75	(313-558)
2021	male	Reservoir	35	420.8 ± 44.5	(350-508)
2021	female	Plunge Pool	52	182.0 ± 24.4	(127-254)
2021	male	Plunge Pool	10	185.0 ± 12.7	(161-211)
2021	unknown	Plunge Pool	3	184.3 ± 54.1	(125-231)
2021	female	All	128	339.3 ± 143.9	(127-558)
2021	male	All	45	368.4 ± 106.8	(161-508)

Table D-6. Percentage of Passive Integrated Transponder-tagged suckers captured at Gerber Reservoir identified for each species group in 2018, 2019, 2020, and 2021. Suckers salvaged from the Miller Creek Plunge pool have been separated as their small size made species identification based on morphological characteristics less certain.

	Female					Male				
Site	Gerber Reservoir				Plunge Pool	Gerber Reservoir				Plunge Pool
Species	2018	2019	2020	2021	2021	2018	2019	2020	2021	2021
Klamath Largescale Sucker (KLS)	27%	61%	83%	64%	46%	35%	77%	91%	69%	30%
KLS x shortnose sucker (SNS)	23%	11%	15%	33%	-	21%	9%	8%	31%	-
SNS	45%	28%	2%	3%	-	40%	13%	1%	-	-
Unknown	6%	1%	-	-	53%	4%	<1%	<1%	-	70%

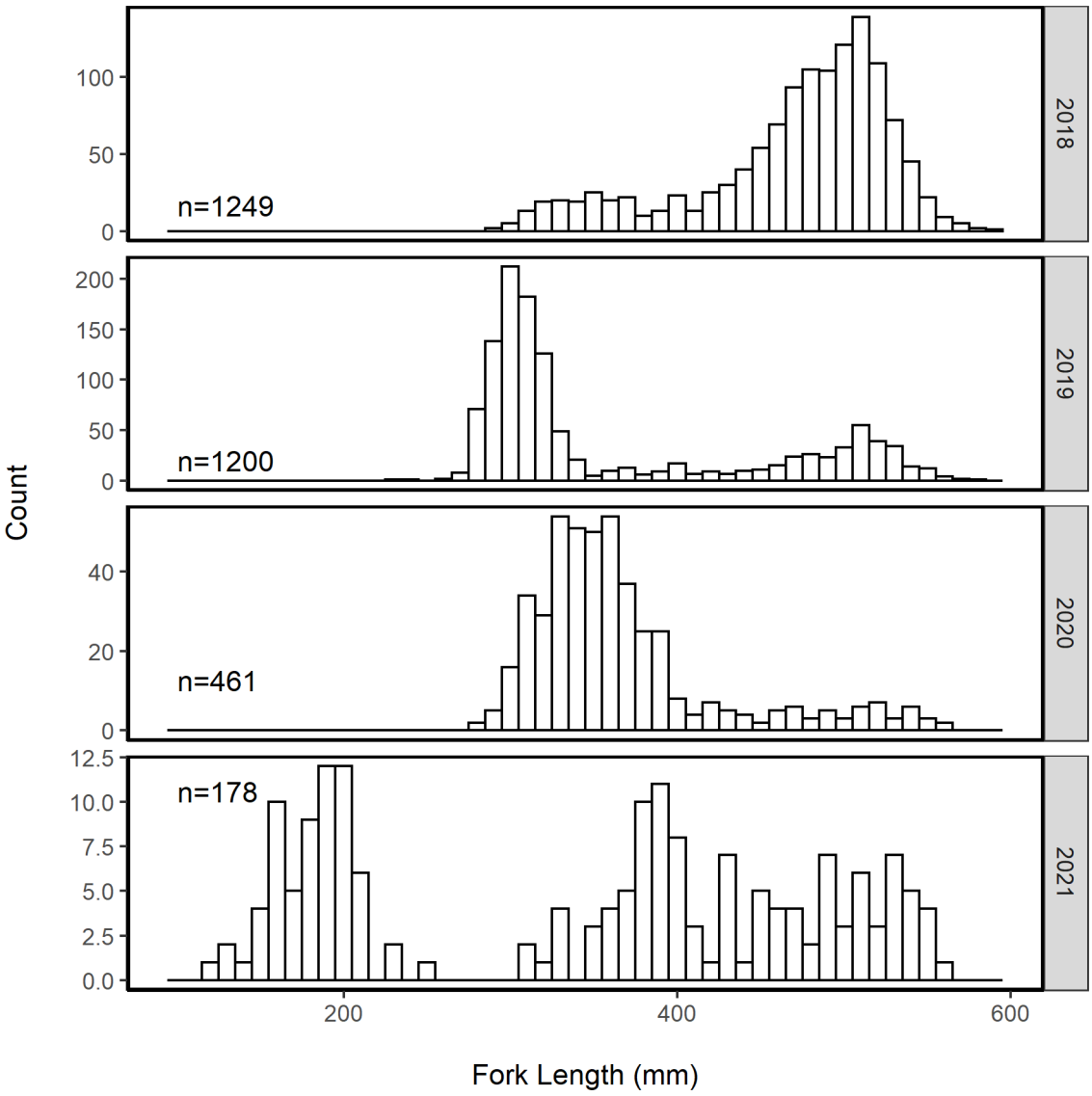

Figure D- 1. Fork length (measured in millimeters) frequencies and sample size for Passive Integrated Transponder-tagged suckers (male and female combined) captured from Gerber Reservoir in 2018, 2019, 2020 and 2021. Mean fork length was calculated for individuals captured more than once within each year. Note, y-axis varies among years. Suckers released without a PIT-tag and mortalities are not included (Table D-1), however unknown sex suckers are included.

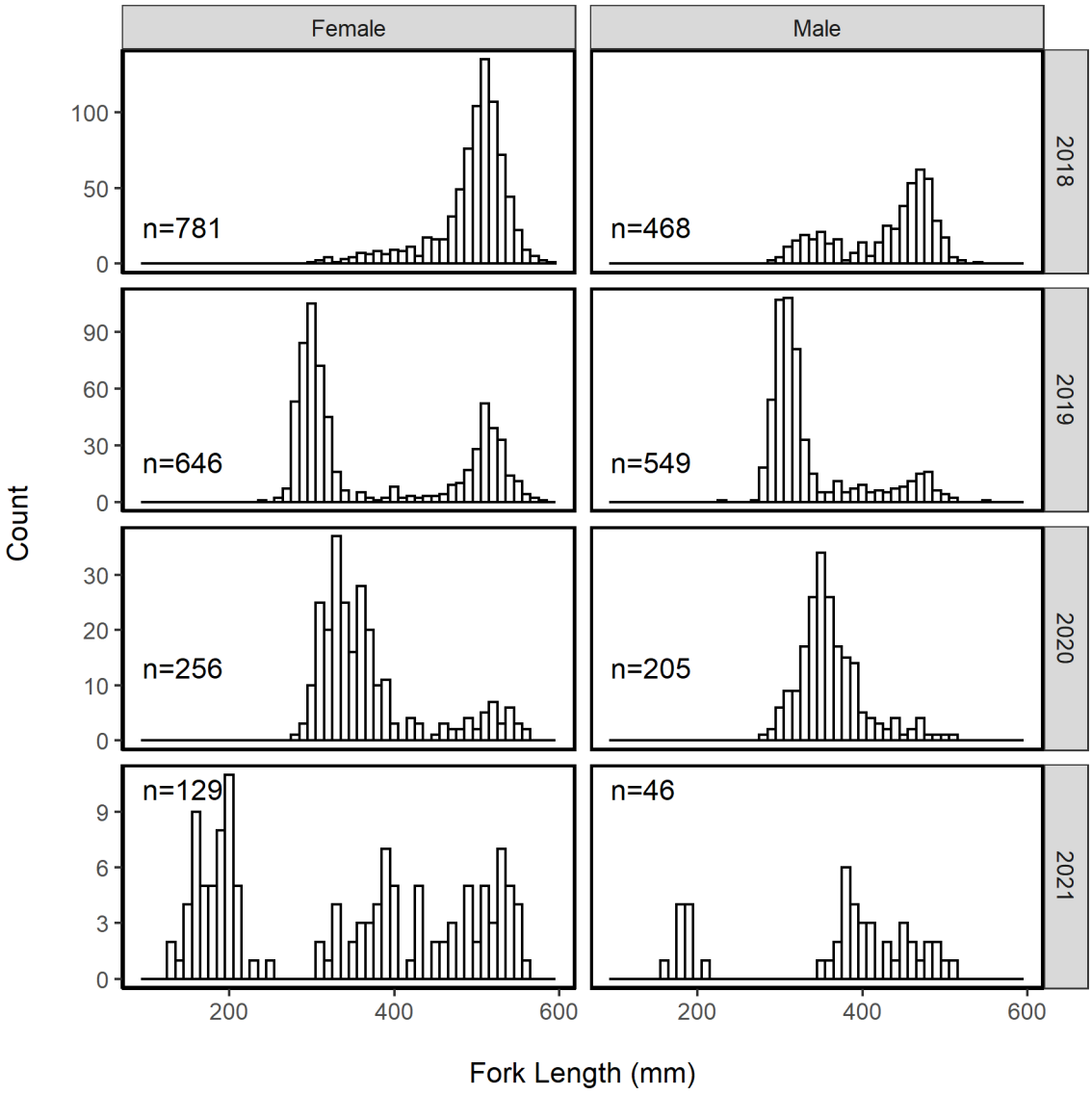

Figure D- 2. Fork length frequencies (measured in millimeters) and sample size for Passive Integrated Transponder-tagged female and male suckers captured at Gerber Reservoir in 2018, 2019, 2020 and 2021. Mean fork length was calculated for individuals captured more than once within each year. Suckers of unknown sex were removed including N=5 from 2019 and N=3 from 2021.

Appendix E – Incidental Take Report for Endangered Suckers of the Upper Klamath Basin, 2021 Operational Season

Klamath Project, Oregon/California
Interior Region 10 California Great Basin

Cover Photo: B. Phillips and J. Ross conduct fish salvage of Klamath Project canals, 2014. Image credit D. Taylor, USBR.

Executive Summary

Using water data from the 2021 Project operations and assumptions explained by the USFWS in the *Biological Opinion on the Effects of Proposed Interim Klamath Project Operations Plan from April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker.* After assessing the impact of water deliveries and several monitoring and conservation measures, Reclamation concludes that cumulative incidental take was not exceeded in WY 2021 according to requirements outlined in the Biological Opinion, Reclamation provides detailed estimates of 2021 incidental take in this report to further validate incidental take was not exceeded. Reclamation did not monitor at the Fish Evaluation Station near A Canal in 2021 as A Canal did not provide irrigation deliveries to the Klamath Project. Also related to the unusual irrigation season in 2021 was a reduced effort and result to salvage fish from canals. The USFWS 2020 biological opinion analyzed the impacts of surface elevation change as it relates to sucker access to habitat. Reclamation acknowledges that surface elevations were below thresholds were impacts are anticipated in 2021 for spawning and juvenile sucker rearing. These impacts remain largely unquantified but are characterized in the 2020 biological opinion. Detailed calculations of incidental take estimates summarized in this report and their associated assumptions are found in Appendix a to this report.

Table E-1. Summary of Reclamation's estimated incidental take of Lost River and shortnose suckers resulting from Water Year 2021 Klamath Project operations compared with the maximum annual amount of incidental take authorized in the 2020 Biological Opinion (USFWS 2019, Section 11).

Activity Description	**Number of Suckers "Harassed" in 2021**	**Maximum Annual Incidental Take ("Harass") Allowed in 2020 Biological Opinion**	**Number of Suckers "Harmed" in 2021**	**Maximum Annual Incidental Take ("Harm") Allowed in 2020Biological Opinion**
A Canal Larvae	0	140,011	0	140,011
A Canal Juveniles	0	1,200	0	1,200
A Canal Adults	0	0	0	0
Link R Larvae	853,604	2,333,460	17,421	46,669
Link R Juveniles	2,992	31,627	60	633
Link R Adults	3	111	1	2
Other Larvae	< 1,160,904	1,160,904	< 23,692	23,692
Other Juveniles	< 24,821	24,821	< 1,508	1,508
Other Adults	0	0	0	0
Canal fish salvage	149	1,500 juveniles	17	240 juveniles
Fish Evaluation Station	0	20,000 juveniles	0	200 juveniles
Gerber Adult Monitoring and Tule Lake Sump	333	15,000 adults	4	150 adults
O&M fish salvage	0	All encountered	0	10 of all stages

Introduction

Section 9 of the ESA makes it unlawful for any person to "take" any endangered species. The ESA defines "take" to mean to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." However, under ESA section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of an agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with an Incidental Take Statement. The *Biological Opinion on the Effects of Proposed Interim Klamath Project Operations Plan from April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker* (BiOp) issued by the USFWS provided Reclamation with allowable annual take of ESA-listed suckers in the Incidental Take Statement (USFWS 2020). This document estimates the incidental take of federally endangered LRSs and SNSs, by life-stage and activity, resulting from Reclamation's Project operations analyzed in the 2020 BiOp**.**

Estimated Incidental Take

A Canal and Link River Dam (South End of Upper Klamath Lake)

Entrainment Estimates and Assumptions

In the 2020 BiOp (USFWS 2020; Table 11-1, p. 200), USFWS calculated the maximum amount of allowable incidental take of endangered suckers at the A Canal and LRD based on sampling during the late 1990's at both locations (e.g., Gutermuth et al. 2000a, 2000b). The maximum amount of incidental take was adjusted from the 1990's numbers to reflect reduced abundances of both sucker species in UKL (e.g., Hewitt et al. 2011). The USFWS used the specific assumption that there has been an 80 percent reduction in adult populations since Gutermuth et al. (2000a, 2000b) evaluated entrainment at the A Canal and Link River (USFWS 2020, p. 112-113). The 80 percent reduction is applied to each life history stage: larvae, juveniles, and adults.

The maximum amount of incidental take for larvae, juveniles, and adult suckers was also adjusted to account for the reduced likelihood of entrainment due to construction of the A Canal fish screen in 2003. The A Canal fish screen prevents the entrainment of fish with total length greater than 30 mm and reduces entrainment by 50 percent of fish with a total length less than 30 mm (Bennetts et al. 2004). Recent efforts to evaluate entrainment in 2012 and 2013 at the A Canal suggests the fish screen reduces fish entrainment by a greater percent than the previously reported 50 percent for fish with a total length less than 30 mm and that the reduction is variable based on the size ofindividuals (i.e., <15 mm, <20mm, and <30mm) approaching the fish screen (Markle et al. 2014). USFWS estimated that 20 percent of small fish (i.e., <30mm) that approach the A Canal fish screen are entrained through the screen into the canal system (USFWS 2020). All larvae that pass through the A Canal fish screen are assumed to die (USFWS 2020).

Using the 2021 WY conveyance data, Reclamation has quantified entrainment at the A Canal and LRD following the same assumptions outlined in the 2020 Biological Opinion Incidental Take Statement. Specifically, Reclamation's estimates for entrainment of endangered suckers at the A Canal and LRD rely on earlier entrainment measurement efforts (Gutermuth et al. 1999, 2000a, 2000b), a reduction of

sucker populations by 80 percent in UKL since the 1990s (Hewitt et al. 2011), the assumption that 80 percent of larval suckers with total length less than 20 mm are prevented from the A Canal (Bennetts et al. 2004, Simon et al. 2014, USFWS 2019, 2020), all suckers with total length greater than 30 mm are prevented from entering the A Canal (Bennetts et al. 2004), and 50 percent of all suckers that are bypassed at the A Canal fish screen via the pumped bypass are subsequently entrained at the LRD. More detailed calculations of incidental take estimates summarized in this report and their associated assumptions can be found in Appendix A. The flow of this report is organized similar as the 2013, 2019, and 2020 biological opinions and only addresses incidental take of endangered suckers associated with implementation of Reclamation's Project operations.

A Canal Entrainment Estimates

A Canal: Larvae

The larval sucker life-history stage is present from April 1 through July 14 (USFWS 2008; Appendix, p. A6). In 2021, water deliveries were not made through the A Canal. The 2019 biological opinion assumes that all larval suckers passing through the A Canal fish screen are "harmed" (USFWS 2020). No larval suckers were "harmed" at the A Canal fish screen or harmed as a result of traveling the bypass to below Link River Dam.

A Canal: Juveniles

During previous entrainment monitoring, juvenile suckers were most readily observed from July 15 through October 31 (Gutermuth et al. 2000a). Reclamation monitoring of the A Canal pumped bypass from mid-July until the end of September informs the estimated number of juvenile suckers that are passed from the A Canal fish screen to UKL (USFWS 2019, p. 112). This estimate is used to represent incidental take of juvenile suckers during the irrigation season of July 15 through October 31 (or end of delivery from the A Canal). In 2021, no water deliveries were made through the A Canal and no monitoring was conducted at the pumped bypass. It is assumed that 2% of the estimated juvenile suckers that enter the pumped bypass are harmed (USFWS 2020). In 2021, no juvenile suckers were harmed or harassed at the A Canal or the pumped bypass.

A Canal: Adults

Reclamation and USFWS (2020) expect entrainment of adult suckers at A Canal to be prevented at the trash rack. It is assumed that no adult suckers were near the trash rack in 2021 resulting from water deliveries. Zero adult suckers were harmed or harassed at this location in 2021.

Table E-2. Summary of endangered sucker take incidental to the operation and conveyance of water through A Canal during the 2021 irrigation season (April 1 - October 31). Refer to USFWS (2020) for additional background information. No water was conveyed through the A Canal in 2021.

A Canal Entrainment – Estimated Incidental Take	Number of Suckers "Harassed" in 2021	Maximum Annual Incidental Take ("Harass") Allowed in 2020 Biological Opinion	Number of Suckers "Harmed" in 2021	Maximum Annual Incidental Take ("Harm") Allowed in 2020 Biological Opinion
Larval Suckers	0	140,011	0	140,011
Juvenile Suckers	0	1,200	0	1,200
Adult Suckers	0	0	0	0

Link River Entrainment Estimates

Link River: Larvae

The larval sucker life-history stage is present between April 1 through July 14 (USFWS 2008; Appendix, p.A6). Based on the sum of daily average flows of 224,943 AF (Link River gauge 11507500) of water passed through the LRD from April 1 through July 14, 2021. Assuming the entrainment of larval suckers is equal to 19.361 fish/AF (Appendix a), consistent for each day throughout the 2021 irrigation season, and an update since Gutermuth et al. measured entrainment at this location, Reclamation's Project operations entrained an estimated 871,025larval suckers below the LRD during 2021 (4,355,122 larvae * 0.2 for those remaining after an 80 percent reduction). The 2020 biological opinion assumes that 98 percent of suckers passing through LRD are "harassed" and 2 percent are "harmed" (USFWS 2020); therefore, 853,604 (871,025 * 0.98) were "harassed" and 17,421 (871,025 * 0.02) were "harmed" in 2021.

Link River: Juveniles

During previous entrainment monitoring, juvenile suckers were most readily observed from July 15 through October 31 (Gutermuth et al. 2000a). Based on the daily average flow (gage 11507500), approximately 177,839 AF of water was conveyed below the LRD from July 15 through October 31, 2021. Assuming the entrainment of juvenile suckers is equal to 0.0841 fish/acre-foot (Appendix a), and the density is consistent for each day throughout the 2021 irrigation season, Reclamation's Project operations entrained an estimated 2,992 juvenile suckers (14,957 * 0.2 for those remaining after an 80 percent population reduction) below the LRD. In 2021, an additional 0 (50 percent of 0) juvenile suckers were entrained below the LRD after being bypassed from the A Canal.
Thus, the total number of juvenile suckers entrained at the Link River in 2021 was 2,992. The 2020 biological opinion assumes that 98 percent of suckers are "harassed" when they pass through the

LRD and 2 percent are "harmed" (USFWS 2020); therefore, 2,933 (2,992 * 0.98) were "harassed" and 60 (2,992 * 0.02) "harmed" in 2021.

Link River: Adults

Adult suckers may be present in front of the LRD throughout the year; however, Gutermuth et al. (1999, pp. 15-17) indicated most of the entrainment likely occurs April 1 through October 31. Based on the sum of daily average flows (gauge 11507500), approximately 402,782 AF of water passed through the LRD from April 1 through October 31, 2021. Assuming the entrainment of adult suckers is equal to 0.000025 fish/acre-foot (Appendix a), is consistent for each day throughout the 2021 irrigation season, and an 80% reduction in population, Reclamation's Project operations entrained 3 adult suckers below LRD. In 2021, an additional 0 (50 percent of0) adult suckers were entrained below the LRD after being bypassed at the trash rack from the A Canal. The 2020 biological opinion assumes that 2 percent of the 0 adult suckers entrained at the LRD are "harmed". Therefore, 0 adult sucker was "harmed" in 2021.

Table E-3. Summary of endangered sucker take incidental to the operation and conveyance of water through Link River Dam during the 2021 irrigation season (April 1 through October 31). Details of Reclamation's estimated 2021 incidental take can be found in Appendix a of this document.

Link River Entrainment - Estimated Incidental Take	Number of Suckers "Harassed" in 2020	Maximum Annual Incidental Take ("Harass") Allowed in 2019 Biological Opinion and Memoranda	Number of Suckers "Harmed" in 2020	Maximum Annual Incidental Take ("Harm") Allowed in 2019 Biological Opinion and Memoranda
Larval Suckers	853,604	2,333,460	17,421	46,669
Juvenile Suckers	2,992	31,627	60	633
Adult Suckers	3	111	1	2

Entrainment at other Project Facilities

Table E-4. Summary of endangered sucker take incidental to the operation and conveyance of water at Klamath Project (Project) facilities, principally Clear Lake Reservoir and Gerber Reservoir, other than A Canal and Link River Dam in 2021 (USFWS 2020). Reclamation's assumptions for these estimates are explained below and are based on the operations within the context of the USFWS effects analysis.

Other Project Facilities - Estimated Incidental Take	Number of Suckers "Harassed" in 2021	Maximum Annual Incidental Take ("Harass") Allowed in 2020 Biological Opinion	Number of Suckers "Harmed" in 2021	Maximum Annual Incidental Take ("Harm") Allowed in 2020 Biological Opinion
Larval Suckers	< 1,160,904	1,160,904	< 23,692	23,692
Juvenile Suckers	< 24,821	24,821	< 1,508	1,508

Other Project Facilities - Estimated Incidental Take	Number of Suckers "Harassed" in 2021	Maximum Annual Incidental Take ("Harass") Allowed in 2020 Biological Opinion	Number of Suckers "Harmed" in 2021	Maximum Annual Incidental Take ("Harm") Allowed in 2020 Biological Opinion
Adult Suckers	0	0	0	0

Data is lacking to estimate entrainment at other Project facilities (USFWS 2020). Where some fish entrainment information exists, such as data from Miller Creek downstream of Gerber Dam, the information is limited (Reclamation 2012, p. 6-47), or represents only one year at Clear Lake (USFWS 2020). The USFWS explains assumptions used to determine numbers of incidental take at other Project facilities in the current BiOp (2020).

Reclamation provides the rationale for the statement that incidental take of endangered suckers did not exceed the maximum allowable take in 2021 in the following tables for Clear Lake and Gerber Reservoirs. This statement is based on the 2021 Project operations remaining within the range of deliveries and surface elevations at Project reservoirs and points of diversion that were analyzed in the POR by USFWS within the 2020 BiOp. During water shutdown at Gerber Reservoir, Reclamation staff did not observe suckers in Miller Creek directly downstream of the dam.

Clear Lake and Gerber Reservoirs Entrainment Estimates and Assumptions

Water deliveries during 2021 from both reservoirs (Gerber and Clear Lake) were within the ranges analyzed in the 2020 Biological Opinion. In 2021, Reclamation's monthly flows did not exceed those from the POR analyzed in the 2020 BiOp; therefore, incidental take was not exceeded (Tables E-5 and E-6).

Table E-5. Water releases from Clear Lake Reservoir by month, 1986 through 2021. Water releases were made through the dam gates during months when irrigation releases are made and may include releases for purposes other than irrigation delivery such as flood control. These releases are identified with an asterisk in the table below. Values for each time period are displayed as thousand acre-feet. In 2020, the September and October column includes total releases September through December.

Year	April 15-30	May 1-31	June 1-30	July 1-31	August 1-31	September & October	Total
1986	2.276	0.234	0	0	0	0	2.510
1987	3.181	8.077	6.256	8.527	10.442	6.613	43.097
1988	0.692	4.936	8.636	14.180*	11.176	7.038	46.658*
1989	0.089	5.836	8.814	8.975	8.993	5.757	38.464
1990	1.931	9.278	6.782	10.912	10.353	6.822	46.079
1991	1.233	5.848	11.246*	15.261*	14.514*	2.556	50.658*
1992	0	2.594	7.270	3.111	1.210	0	14.184
1993	0	6.143	5.987	7.502	6.827	6.990	33.449
1994	2.842	5.850	8.688	12.406	11.004	1.557	42.345
1995	0.234	1.618	5.782	9.469	8.507	7.288	32.898
1996	0.056	6.942	7.412	7.036	7.077	4.513	33.037
1997	0.561	5.051	5.253	7.686	5.743	4.979	29.273
1998	13.352*	61.348*	26.203*	9.461	8.672	6.467	125.502*
1999	8.493	6.012	7.153	7.575	5.981	5.326	40.540
2000	0.147	5.140	7.103	6.520	11.630	54.205*	84.745*
2001	0.149	13.823*	22.812*	24.657*	36.360*	6.681	104.482*
2002	0.125	6.544	8.505	9.514	12.455	7.510	44.653
2003	0	2.296	8.495	7.155	6.252	5.457	29.656
2004	0.718	6.732	7.157	7.676	7.817	8.957	39.057
2005	0	0.071	5.503	7.268	5.195	1.573	19.610
2006	0	4.472	8.440	9.919	7.946	7.571	38.347
2007	0.077	6.877	6.586	7.046	7.541	6.225	34.352
2008	0.075	5.826	5.826	7.756	7.518	6.320	33.320
2009	1.374	5.297	4.008	2.227	0	0	12.905
2010	0	0	0	0	0	0	0
2011	0	3.532	5.769	6.270	6.893	5.665	28.129
2012	0	4.890	5.610	6.262	6.601	1.918	25.281
2013	0.188	5.507	5.221	5.061	0	0	15.977
2014	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2016	0.325	5.014	5.949	6.835	6.536	1.589	26.248
2017	0	0.964	6.645	7.107	7.145	6.534	28.394
2018	0.375	6.868	5.154	6.517	5.414	4.482	28.810
2019	0	4.921	5.496	6.014	6.361	3.846	26.638
2020	1.842	5.334	6.052	7.114	7.207	11.564	39.113
2021	1.779	6.903	6.917	6.424	0.596	0	22.619
MIN	0	0	0	0	0	0	0
MAX	8.493	9.278	8.814	12.406	12.455	8.957	46.079

Table E-6. Water releases from Gerber Reservoir by month, 1986 through 2021. Water releases were made through the dam gates during months when irrigation releases are made and may include releases for purposes other than irrigation delivery such as flood control. Values for each time period are displayed as thousand acre-feet. In 2020, the September and October column includes total releases September through December.

Year	April 15-30	May 1-31	June 1-30	July 1-31	August 1-31	September & October	Total
1986	2.352	6.032	8.410	7.867	8.003	4.402	37.066
1987	2.544	7.853	6.851	6.597	8.299	6.425	38.569
1988	0.220	5.556	5.533	8.073	7.129	6.213	32.724
1989	0.083	5.977	8.134	8.939	6.768	5.880	35.781
1990	0.389	7.020	6.627	8.333	6.635	6.582	35.586
1991	0	1.287	7.063	3.532	0	0	11.882
1992	0	1.057	0	0	0	0	1.057
1993	0.028	4.765	5.168	7.763	6.554	6.830	31.108
1994	2.475	4.696	7.339	8.243	7.775	6.177	36.705
1995	0.055	2.466	5.310	8.582	8.172	7.335	31.920
1996	0	2.407	7.085	7.754	7.438	5.602	30.286
1997	1.382	6.824	6.233	7.781	6.893	5.723	34.836
1998	4.283	0.270	2.203	7.906	7.224	6.770	28.656
1999	3.969	6.625	7.639	8.357	7.529	6.940	41.059
2000	0.442	6.116	8.323	8.202	7.997	5.267	36.347
2001	0.384	7.816	7.895	7.750	7.710	5.101	36.656
2002	0.748	6.387	8.061	8.249	8.245	6.992	38.682
2003	0.032	2.5432	8.633	8.649	7.338	6.255	33.450
2004	1.471	5.696	6.977	8.143	7.944	5.961	36.192
2005	0	0	6.554	8.3084	8.350	7.089	30.301
2006	0	4.532	6.757	8.153	7.636	6.376	33.454
2007	0.040	7.107	7.339	7.679	7.838	6.077	36.080
2008	0.045	6.237	5.656	7.843	7.910	6.997	34.688
2009	1.389	5.133	4.347	7.998	7.777	6.657	33.301
2010	0	3.080	6.757	7.991	7.738	5.669	31.235
2011	0	3.693	6.492	7.731	7.277	6.515	31.708
2012	0	5.575	6.781	7.734	7.855	6.030	33.975
2013	0	7.005	6.748	7.230	6.554	5.098	32.635
2014	0.066	6.165	5.933	2.759	0	0	14.923
2015	0.629	5.349	6.004	1.149	0.094	0	13.225
2016	0.444	5.526	6.363	7.378	7.275	5.397	32.383
2017	0	4.253	5.891	6.718	5.891	5.207	27.959
2018	0.213	5.275	5.629	6.181	5.951	5.128	28.377
2019	0	4.360	3.981	6.716	6.579	3.594	25.230
2020	2.496	5.882	6.540	7.174	7.250	10.370	39.712
2021	2.024	5.583	5.949	5.887	3.197	0	22.640
MIN	0	0	0	0	0	0	1.057
MAX	4.283	7.853	8.633	8.939	8.35	7.335	41.059

Incidental Take Caused by Seasonal Reductions in Habitat Due to Water Management and Reduced Instream Flows

In USFWS' 2020 effects analysis, it was determined that annual reductions in habitat due to water diversions could adversely affect suckers through take in UKL and Clear Lake Reservoir (USFWS 2020). The adverse impacts are related to surface elevations in each of the reservoirs.

Upper Klamath Lake did not achieve a surface elevation of 4141.0 ft in 2021. A surface elevation below 4142 ft from the end of March to the end of May in UKL is assumed to reduce sucker spawning activity at shoreline springs similar to observations from 2010. The impact is estimated at 20% of the spawning activity, or 20% of the eggs laid at this area. Reclamation has determined through a review of 2021 surface elevations that take of spawning suckers at the shoreline springs could have occurred in UKL in 2021. However, Reclamation has no means to accurately quantify the amount of take relative to low lake elevations during sucker spawning at the eastern shoreline March through May.

Upper Klamath Lake was at 4139.25 ft by July 15, 2021. A reduction of wetland habitat could impact larval suckers when surface elevation in UKL drop below 4140 ft by July 15 (USFWS 2020). Adverse impacts from loss of habitat could lead to increased mortality at this life history stage; however, there is no data to indicate the magnitude of the impact. In 2021, UKL surface elevations were below 4140 ft by mid-June. Thus, Reclamation assumes that unquantified take of suckers was associated with loss of wetland habitat in 2021.

Similar to surface elevation and habitat relationships in UKL, USFWS has described that adverse impacts in the form of stranding take can occur at Clear Lake Reservoir at surface elevations below 4522 ft (USFWS 2020). Take associated with access to the Willow Creek for spawning suckers has not yet been determined, but adverse impacts at access Willow Creek are recognized to occur at a similar elevation (USFWS 2020). Reclamation assumes no take due to stranding occurred at Clear Lake Reservoir as surface elevations were maintained above 4522 ft.

Incidental Take Caused by Lost River Sucker and Shortnose Sucker Monitoring Activities in Project Reservoirs

In addition to incidental take of endangered suckers that was analyzed by the USFWS as part of Reclamation's Proposed Action to operate the Project, the USFWS requires Reclamation to salvage and monitor suckers under multiple T&Cs (USFWS 2020). Only the take associated with Reclamation's fish salvage of canals, monitoring at the FES, fish salvage with O&M activities, and adult sucker monitoring at Gerber Reservoir is reported here. The USGS reports adult sucker take associated with adult sucker monitoring at UKL and Clear Lake Reservoir to USFWS annually under their Section 10 permit.

Since 1992, USFWS has required Reclamation to salvage suckers from Project water delivery systems (i.e., canals, drains, headgates) at the end of irrigation season (USFWS 1992, 2001, 2008). In 2012, Reclamation proposed to continue fish salvage of irrigation canals as part of Project operations (Reclamation 2012) and currently continues that commitment in 2021.

The numbers of suckers reported here are from the 2021 salvage effort of canals reported to

USFWS in greater detail as another chapter in the 2021 annual compliance report. Reclamation captured 82 young of the year and older juvenile suckers from the A Canal forebay in 2021. All suckers were transferred to USFWS at an aquaculture facility on Lower Klamath Lake Road. In addition, Reclamation salvaged an additional 67 juvenile suckers from Project canals in both Oregon and California (e.g., Miller Creek below Gerber Dam).

Reclamation applied an assumed "harm" rate to juvenile suckers that were salvaged from canals of 11% as specified in the 2020 BiOp to determine that 17 juvenile suckers were harmed during fish salvage of canals.

Reclamation has monitored the pumped bypass at the A Canal fish screen during the irrigation season since 2003 when the screen was installed. Consistent with the 2020 BiOp, monitoring for suckers at the pumped bypass is a condensed effort from July through September to evaluate the peak timing and abundance of suckers at this location (USFWS 2020). No monitoring at the pumped bypass occurred in 2021 as water was not delivered through the A Canal.

In 2020, Reclamation captured 180 adult suckers in trammel nets at Gerber Reservoir as part of monitoring the population. No direct harm was observed; however, Reclamation and USFWS both assume that 1% of these adults (2) could be harmed during capture and handling prior to release.

Every year, Reclamation conducts routine maintenance activities related to the Project infrastructure. Some activities, particularly those requiring the dewatering of an area that remains watered throughout the year or impact water flow structures, could impact suckers. The USFWS has allowed take of individuals of all life history stages to be incidentally harassed or harmed during these activities (USFWS 2020). Only one such O&M activities that required fish salvage was conducted in 2021. No juvenile suckers were captured.

Table E-7. Additional incidental take caused by salvage of suckers from Klamath Project (Project) canals and during O&M of infrastructure, monitoring of suckers at the Fish Evaluation Station, and adult suckers in Project reservoirs (USFWS 2020).

Monitoring Activities - Estimated Incidental Take	Number of Suckers captured in 2020	Maximum Annual Capture Allowed in 2019 Biological Opinion	Number of Suckers Harmed during Capture in 2020	Maximum Annual Capture Harm Allowed in 2019 Biological Opinion
Canal fish salvage	149	1,500 juveniles	17	240 juveniles
Fish Evaluation Station	0	20,000 juveniles	0	200 juveniles
Gerber Adult Monitoring	333	15,000 adults	4	150 adults
O&M fish salvage	0	All encountered	0	10 of all stages

References

Bennetts, D., C. Korson, and R. Piaskowski. 2004. A Canal fish screen monitoring and evaluation activities in 2003. Unpublished report prepared by United States Bureau of Reclamation, Klamath Falls, Oregon.

Gutermuth, B., C. Watson, and R. Weider. 1999. Link River Hydroelectric Project—Eastside and Westside Powerhouses Annual Entrainment Study Report (March 1997 - July 1998). New Earth Corp., Klamath Falls, Oregon. 98p.

Gutermuth, B., E. Pinkston, and D. Vogel. 2000a. Link River hydroelectric project (eastside and westside powerhouses) final entrainment study report. Cell Tech, Klamath Falls, Oregon and PacifiCorp Environmental Services, Portland, Oregon.

Gutermuth, B., C. Watson, and J. Kelly. 2000b. A Canal fish entrainment during 1997 and 1998, with emphasis on endangered suckers. Completion Report. New Earth/Cell Tech, Klamath Falls, Oregon and Natural Resource Scientists, Inc., Red Bluff, California.

Hewitt, D.A., B.S. Hayes, E.C. Janney, A.C. Harris, J.P. Koller, and M.A. Johnson. 2011. Demographics and Run Time of Adult Lost River (*Deltistes luxatus*) and Shortnose (*Chasmistes brevirostris*) Suckers in Upper Klamath Lake, Oregon 2009. USGS Open File Report 2011-1088.

Markle, D.F., D.C. Simon, T. Tyler, and M. Terwilliger. 2014. The impact of entrainment and vagrancy on larval fish survival in Upper Klamath Lake. Chapter 2 in Simon, D.C., M.R. Terwilliger, and D.F. Markle. 2014. Larval and juvenile ecology of Upper Klamath Lake suckers: 2009-2013. Final report to Reclamation for Agreement R09AC20029. 172p.

U.S. Bureau of Reclamation (Reclamation). 2012. The Effects of the Proposed Action to Operate the Klamath Project from April 1, 2013 through March 31, 2023 on Federally-Listed Threatened and Endangered Species. December 2012. 364p.

U.S. Fish and Wildlife Service (USFWS). 1992. Formal consultation on the effects of the long- term operation of the Klamath Project on the Lost River sucker, shortnose sucker, bald eagle, and American peregrine falcon. July 22, 1992. 62p.

U.S. Fish and Wildlife Service (USFWS). 2001. Biological/Conference opinion regarding the effects of operation of the Bureau of Reclamation's Klamath Project on the endangered Lost River (*Deltistes luxatus*), endangered shortnose sucker (*Chasmistes brevirostris*), threatened bald eagle (*Haliaeetus leucocephalus*) and proposed critical habitat for the Lost River/shortnose suckers, April 2001. Klamath Falls, Oregon.

U.S. Fish and Wildlife Service (USFWS). 2008. Formal consultation on the Bureau of Reclamation's Proposed Klamath Project Operations from 2008 to 2018. Klamath Falls Fish and Wildlife Office, Oregon. 197p.

U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 2013. Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species. 590p.

U.S. Fish and Wildlife Service (USFWS). 2019. Biological Opinion on the Effects of Proposed Klamath Project Operations from April 1, 2019, through March 31, 2024, on the Lost River Sucker and the Shortnose Sucker (TAILS # 08EKLA00-2019-F-0068). 210p.

U.S. Fish and Wildlife Service (USFWS). 2020. Biological Opinion on the Effects of the Proposed Interim Klamath Project Operations Plan, effective April 1, 2020, through September 30, 2022, on the Lost River Sucker and the Shortnose Sucker (Tails# 08EKLA00-2020-F-0059). 250p.

Appendix E-a

Detailed summary of calculations and assumptions used to estimate incidental take of Lost River and shortnose suckers resulting from implementation of the Klamath Reclamation Project, 2021

A Canal: Larvae

Larval sucker entrainment at A Canal was estimated at 3.3 million in 1996 and 1.7 million in 1997 (Gutermuth et al. 1998, p. iii). In 1996 and 1997, the amount of water entering A Canal from UKL during the larval life history stage of April 1 through July 14 (as defined in USFWS 2008 Appendix, p. A6) was 121,488 AF and 136,760 AF, respectively. These numbers were derived from multiplying daily averaged flow for dates of interest from Reclamation's water record by 1.983. The product is the total AF during a specific date or range of dates.

For the purpose of reporting incidental take, Reclamation is combining the estimated larval fish and water conveyance in A Canal for both years to derive a fish per volume of water. Both years are combined to capture more variability than using one year. The total estimated entrainment of larval suckers at A Canal over both years was 5.0 million larvae and total water conveyance through A Canal from April through mid-July during both years was 258,248 acre- feet. The equation to derive a fish per AF multiplier that can be applied to the volume of water in future years is 5,000,000 / 258,248, or 19.361 larvae per acre-foot of water (for 1996 and 1997).

Water deliveries into A Canal in 2021 did not occur. From April through July 14, 2021, 0 AF of water was drawn into A Canal (sum of 2021 daily averaged flow in A Canal for date range). The estimated number of larval suckers on that water, before applying assumptions for reduced sucker populations in UKL or assumptions on the efficiency of the fish screen to bypass larvae, was 0 (from 0 AF * 19.361 sucker larvae/acre-foot).

Two principal assumptions need to be applied to this estimate in order to provide for other changes in UKL since the time that Gutermuth et al. sampled for larval entrainment at A Canal. Assuming that larval sucker production is reduced by 80 percent from both 1996 and 1997 to 2021 (USFWS 2020), an estimated 0 larval suckers (0 larvae * 0.2 for those remaining after an 80 percent population reduction) are available to entrainment at A Canal without a fish screen in 2021. The fish screen is assumed to bypass 80 percent of the larvae and entrain the other 20 percent at A Canal (USFWS 2020), harming all that pass through the fish screen. With both assumptions applied, Reclamation harmed an estimated 0 larval suckers by passing them through the fish screen at A Canal through the fish screen in 2021. The other 0 larval suckers were bypassed to below the LRD resulting in an additional 0 (2%) harmed (USFWS 2020). Total harmed larval suckers at A Canal fish screen were 0.

A Canal: Juveniles

The period when juvenile suckers were most readily observed during previous entrainment studies was from July 15 through October 31 (Gutermuth et al. 2000a). In 1998, Gutermuth et al. (2000a, p. 14) estimated that 246,524 juvenile suckers were entrained at the then unscreened A Canal. From July 15 through October 16 (end of irrigation season), 148,596.11 AF of water was diverted through A Canal in 1998.

In 2021, 0 AF of water entered A Canal from July 15 through October 31. All juvenile suckers at A Canal avoid entrainment by entering a pumped bypass at the fish screen. Reclamation monitors the pumped bypass from mid-July through end of the September for suckers and models an estimate of entrainment into the bypass at A Canal. That estimate is the current basis for incidental take at the A Canal. It is assumed that 2% of the estimated juvenile suckers that enter the pumped bypass are harmed (USFWS 2020).

In 2021, Reclamation estimates that 0 juvenile suckers entered the pumped bypass from the A Canal fish screen. Of the juvenile suckers in the pumped bypass, 0 (2%) were harmed as a result of passing through the pump.

A Canal: Adults

Based on information from the 2008 biological opinion (USFWS 2008, Appendix p. A19), Gutermuth et al. (2000a) estimated that entrainment of adult suckers at A Canal was 411 individuals. Estimated 1998 entrainment of adult suckers and the 1998 A Canal water delivery indicates that a fish density of 0.00173 (411 adults/236,939.747 AF) adults/acre-foot would be expected prior to any other assumptions. Applying this fish density to the 2021 A Canal delivery indicates that potentially 0 adult fish (0.00173 adults/acre-foot * 0 AF) could encounter the trash rack at the fish screen prior to any adjustments for reduction in sucker production. Considering an estimated 80 percent reduction in sucker populations of UKL, the number of adult suckers that could encounter the A Canal fish screen is 0 (0 adults * 0.2 for those remaining after an 80 percent reduction). These 0 adult suckers are prevented by the trash rack at A Canal from approaching the fish screen and the bypass. Reclamation assumes no harm or harassment to adult suckers as they encounter and turn away from the trash rack which is designed with 2-inch openings.

Link River: Larvae

The value of 19.361 larvae/acre-foot from combining Gutermuth et al. results (both 1996 and 1997) also represents entrainment in Link River power canals (combined East and West) as larval entrainment through A Canal and Link canals (combined East and West) is thought to be similar as the mean diversions for both locations during larval entrainment period of April through mid-July were similar (USFWS 2008 Appendix, p. A12). In the Link River, about 40% of the total flow previously passed through the dam and the associated fishways (USFWS 2008 Appendix, p. A12). However, the current conditions apply the "larvae/acre-foot" density to the total flow from the Link River gage station (USGS gage 11507500) that accounts for all flow (power canals, dam gates, causeways, and some accretions), as very little water enters the power canals and causeways.

In 2021, the Link River gage (11507500) registered 224,943 AF of water from April 1 through July 14. This number is based on the daily average flow (cfs). The estimate of flow in the Link River (224,943 AF) multiplied by the density of larvae/acre-foot (19.361) would indicate that 4,355,122 larval suckers would be entrained prior to any adjustments for present-day sucker production.

Assuming that 80 percent reduction in adult sucker populations translates to the same reduction in larval production, Reclamation likely entrained 871,025 larval suckers in the Link River during 2021 (4,355,122 larvae * 0.2 for those remaining after an 80 percent reduction). The 2020 biological opinion assumes that 98 percent (853,604) are harassed and 2 percent (17,421) are harmed (USFWS 2020).

Link River: Juveniles

Gutermuth et al. (2000a, p. 31) estimated 30,466 young suckers (mostly young-of-the-year) passed the West- and Eastside power canals at the Link River on 361,916 AF. Gutermuth et al. (2000a) represents the number of suckers by the volume of water during these observations creates a means to estimate the entrainment in subsequent years (30,446 suckers/361,916 AF = 0.0841 juvenile suckers/acre-foot).

The sum of the 2021 daily flows from July 15 through October 31 in Link River (gage 11507500) was 177,839 AF. The seasonal flow multiplied by the fish/acre-foot density equals 14,957 juvenile suckers that were entrained at the Link River before adjusting for an 80 percent decline in UKL sucker production. After adjusting for a reduction in sucker production, 2,992 (14,957juvenile suckers*0.2 for those remaining after an 80 percent reduction) were carried on the discharge at the LRD. There were an additional 0 (50 percent of 0) juvenile suckers in 2021 that were entrained at the Link River after being bypassed from the A Canal. Thus, the total number of juvenile suckers entrained at the Link River in 2021 was 2,992. The 2020 biological opinion assumes that 98 percent (2,933) are harassed and 2 percent (60) are harmed (USFWS 2020).

Link River: Adults

Based on information from the 2008 (USFWS 2008, Appendix p. A19), Gutermuth et al. (2000a) estimated that entrainment of adult suckers at the Link River power canals (both West- and Eastside) was 14 individuals. Using the assumption that 20 percent of the total Link River flows pass through the dam and associated fishways in 1998 (USFWS 2008, Appendix p. A19), an estimated 17 adult suckers were entrained at the Link River in 1998 (combining entrainment for both power canals and the dam gate flows). Link River flow from Link River gage (11507500) April 1 through October 31, 1998, was 686,512.62 AF. Thus, 1998 adult sucker density on the Link River flow was (17 adults/686,512.62 AF) or 0.000025 fish per acre-foot in Link River.

Flow from April 1 through October 31, 2021, in the Link River was 402,782 AF. Thus, the number of adult suckers entrained at the Link River in 2021 was 11 (0.000025 adults/acre-foot * 402,782 AF) before considering a reduction of 80 percent in UKL sucker production. In 2021, Reclamation's operation of the LRD entrained 3 adult suckers (11 adult suckers * 0.2 for those remaining after an 80 percent reduction, plus 0 additional adult suckers (50%) bypassed from the A Canal). Of these 3 adult suckers entrained (harassed) at the LRD, 1 is harmed.