

# Juvenile Salmonid Collection System: Report on Field Operations 2023



Department of Water Resources  
Riverine Stewardship Program  
715 P St, Sacramento, CA, 95814

Prepared by: Theo Claire<sup>1</sup>, Tyler Keys<sup>1</sup>, and Maureen Downing-Kunz<sup>2</sup>

<sup>1</sup> California Department of Water Resources    <sup>2</sup> Environmental Science Associates

# Table of Contents

Table of Contents	2
List of Figures	4
List of Tables	7
Section 1: Introduction	8
1.1: Executive Summary	8
1.2: Study Area and Setting	8
1.3: Treaty Rights and Land Tenure on the McCloud River	10
1.4: Shasta Dam and the McCloud River	11
1.5: Urgent Actions to Recover the Winter-run Chinook Salmon Population	12
1.6: Study Objectives	13
1.7: Overview of 2023 Field Operations	13
1.8: Purpose and Approach of this Document	13
1.9: Major Findings	14
Section 2: 2023 Pilot Study Planning	15
2.1: Inter-Agency Coordination and Collaboration	15
2.2: Internal Planning Documents	15
2.3: Site Selection	16
2.4: Logistics	19
2.5: Trap Evaluation Needs	20
2.6: Contracting	21
2.7: Permitting	21
2.8: Procurement	21
2.9: Training	21
Section 3: Changes and Additions to JSCS from 2022	23
3.1: Location	23
3.2: Configuration of System	26
3.3: Fish Trap and Platform Design and Fabrication	27
3.4: Boat Gates	28
3.5: Fish Trap Operation and Sampling	28
Section 4: Methods for the 2023 Field Season	31
4.1: Physical Setting: Study Area	31
4.2: Installation, Relocation, and Demobilization	32
4.3: Panel Adjustments	33
4.4: Trap Operation Methods: Physical Component Evaluation	33
4.5: Environmental Data Collection Methods	34
4.5a: Temperature and Water Quality	34

California Department of Water Resources  
Juvenile Salmonid Collection System: Report on Field Operations 2023

4.5b: Velocity	39
4.5c: Meteorological Data	40
4.5d: Drone Use and Aerial Data	41
4.6: Fisheries Data Collection Methods	42
4.6a: Daily Trap Operation	42
4.6b: Efficiency Trials	45
4.6c: Hook and Line Sampling	46
4.6d: Traditional Ecological Knowledge, Western Fisheries Science, and Salmon Sampling	48
4.7 Operational Issues	48
4.7a: Dropping Water Levels	48
4.7b: Debris	48
<b>Section 5: Results and Observations</b>	<b>50</b>
5.1: Hydrology and Water Surface Elevation	50
5.2: Water Temperatures	57
5.2a: River Temperatures	57
5.2b: Longitudinal Profiles of Near-Surface and Near-Bed Water Temperature	59
5.2c: Effects of Guidance Net on Water Temperature	61
5.2d: Effects of Temperature Curtain on Water Temperatures	64
5.3: Velocity	66
5.3a: Cross-sectional velocity from ADCP	66
5.3b: Point Velocity from ADV	76
5.3c: Summary of velocity data for comparison with JSCS efficiency study	80
5.4: Meteorological Data	80
5.5: Drone Imagery	81
5.6: Fish Sampling	83
5.6a: Trap Catch	84
5.6b: Fork Length	87
5.6c: Correlation	89
5.6d: Efficiency Trials and Capture Probability	90
5.6e: Bass Stomach Contents	93
5.6f: Hook and Line Sampling	95
<b>Section 6: Conclusions and Recommendations</b>	<b>99</b>
<b>Section 7: Acknowledgements</b>	<b>102</b>
<b>Section 8: References</b>	<b>103</b>

## List of Figures

<b>Figure 1.1-1.</b> McCloud River watershed with key project locations	10
<b>Figure 2.3-1.</b> Five initial proposed sites for the 2023 field season	18
<b>Figure 2.3-2.</b> Site alternatives for the 2023 field season	19
<b>Figure 2.5-1.</b> Juvenile winter-run Chinook Salmon with lower caudal clip and Bismarck Brown-Y dye	20
<b>Figure 3.1-1.</b> Time series showing available data for water surface elevation in Shasta Reservoir during JSCS siting phase in early August 2023	24
<b>Figure 3.1-2.</b> Overview map of McCloud Arm of Shasta Reservoir showing region considered for JSCS siting in 2023 (Study Area).	25
<b>Figure 3.2-1.</b> JSCS System with major components labeled	26
<b>Figure 3.2-2.</b> Overhead view of platform and guidance nets with “V” shape.	27
<b>Figure 3.3-1.</b> PNP design drawing of JSCS fish trap	28
<b>Figure 3.5-1.</b> JSCS platform with structure elements labeled	29
<b>Figure 3.5-2.</b> Drawing of JSCS fish trap side view with key components labeled	30
<b>Figure 4.1-1.</b> Map of 2023 Field Sites	30
<b>Figure 4.1-2.</b> Overhead views of JSCS installed at Site 1 (left) and Site 2 (right)	31
<b>Figure 4.5-1.</b> Location map for water temperature arrays used in 2023 study.	35
<b>Figure 4.5-2.</b> Aerial image of JSCS deployment at Site 1 on September 21, 2023 showing locations of ADCP-derived velocity data collection	39
<b>Figure 4.5-3.</b> Schematic of JSCS trap platform from construction plans showing locations of ADV-derived velocity data collection at discrete points and depths between the upstream end of the trap platform and the Fry Box	30
<b>Figure 4.5-4.</b> Regional Context and Project Area for JSCS Drone Experiments and Surveys.	41
<b>Figure 4.6-1.</b> Sampling Paths for Target Fish Captured at JSCS	42
<b>Figure 4.6-2.</b> Identification key for Chinook Salmon encountered at JSCS fish trap	43
<b>Figure 4.6-3.</b> Fish sampling station set up on JSCS platform	44
<b>Figure 4.6-4.</b> Unmarked Nur (above) with dual-marked efficiency fish (below) on measuring board	45
<b>Figure 4.6-5.</b> Map of hook and line sampling treatment and control zones for Site 1	47
<b>Figure 5.1-1.</b> Time series of daily water surface elevation in Shasta Reservoir as reported by the United States Bureau of Reclamation (USBR).	49
<b>Figure 5.1-2.</b> Retrospective <u>2023</u> time series of performance of USBR June and July 2023 forecasts compared to observed data	51
<b>Figure 5.1-3.</b> Retrospective <u>2022</u> time series of performance of USBR June and July 2022 forecasts compared to observed data	53
<b>Figure 5.1-4.</b> Time series of river flow upstream of JSCS in McCloud River ( <i>Winnemem Waywaket</i> ) as measured at USGS Gage 11368000 (CDEC MSS)	55
<b>Figure 5.1-5.</b> Time series of daily change in water surface elevation (WSE) in Shasta Reservoir as reported by USBR (CDEC SHA) for September 1, 2023 – December 1, 2023	56
<b>Figure 5.2-1.</b> Time series of water temperature in the river upstream of JSCS (McCloud River, <i>Winnemem Waywaket</i> ) as measured at USGS gage 11368000	58
<b>Figure 5.2-2.</b> Comparison of in-river water temperatures for 3.8 days at juvenile salmonid collector upstream of JSCS versus at MSS gage further upstream	59
<b>Figure 5.2-3.</b> Longitudinal profile of near-surface (S4) and near-bed (B1) water temperatures	60

during JSCS deployment at <a href="#">Site 1</a>	
<b>Figure 5.2-4.</b> Longitudinal profile of near-surface (S4) and near-bed (B1) water temperatures during JSCS deployment at <a href="#">Site 2</a>	61
<b>Figure 5.2-5.</b> Time series of water temperatures at near-surface (S4), mid-depth (S7), and near-bed (B1) difference between sensors located upstream and downstream of JSCS trap platform at Site 1.	62
<b>Figure 5.2-6.</b> Time series of water temperature difference between sensors located upstream and downstream of JSCS trap platform at Site 1	63
<b>Figure 5.2-7.</b> Time series of water temperature difference between sensors located upstream and downstream of JSCS temperature curtain	65
<b>Figure 5.3-1.</b> Aerial image of JSCS deployment at Site 1 on September 21, 2023 showing locations of ADCP-derived velocity data collection and selected cross-sections for further analysis	67
<b>Figure 5.3-2.</b> Velocity contour plots collected during baseline survey prior to JSCS deployment on September 1, 2023	68
<b>Figure 5.3-3.</b> Velocity contour plots collected during JSCS operations at Site 1 on September 21, 2023.	69
<b>Figure 5.3-4.</b> Velocity contour plots collected during JSCS operations at Site 1 on September 28, 2023.	70
<b>Figure 5.3-5.</b> Velocity contour plots collected during JSCS operations at Site 1 on October 5, 2023	71
<b>Figure 5.3-6.</b> Velocity contour plots collected during JSCS operations at Site 1 on October 12, 2023.	72
<b>Figure 5.3-7.</b> Velocity contour plots collected during JSCS operations at Site 1 on October 19, 2023	73
<b>Figure 5.3-8.</b> Velocity contour plots collected during JSCS operations at Site 2 on November 2, 2023	74
<b>Figure 5.3-9.</b> Velocity contour plots collected during JSCS operations at Site 2 on November 9, 2023.	75
<b>Figure 5.3-10.</b> Boxplots illustrating ADCP cross-sectional velocity distributions over the course of the season.	76
<b>Figure 5.3-11.</b> Time series of velocity components measured with an ADV downstream of the trap entrance fyke (location B in Figure 4.6-3) at two depths	77
<b>Figure 5.3-12.</b> Time series of velocity components measured with an ADV within the Fry Box downstream of the Fry Box	78
<b>Figure 5.3-13.</b> Time series of velocity magnitude measured with an ADV at two locations—downstream of trap entrance fyke and downstream of Fry Box fyke	79
<b>Figure 5.5-1.</b> Aerial imagery of JSCS location within McCloud Arm channel at Site 1 August 31 – November 9 2023	81
<b>Figure 5.5-2.</b> Aerial imagery of JSCS location within McCloud Arm channel at Site 2 August 31 – November 9 2023	82
<b>Figure 5.5-3.</b> Shifting of JSCS platform and docks over time at Site 1. Background imagery is from September 21, 2023	83
<b>Figure 5.6-1.</b> Daily Nur catch at the RST and JSCS	85
<b>Figure 5.6-2.</b> Daily catch of non-target species at the RST and JSCS. Note: the y-axis is scaled separately in each panel	86
<b>Figure 5.6-3.</b> Fork length at date of winter-run Chinook Salmon captured at the JSCS	87
<b>Figure 5.6-4.</b> Fork length by species groups caught at the JSCS	88
<b>Figure 5.6-5.</b> Fork length of predators caught at the JSCS through the trapping season. The first	89

three periods were conducted at Site 1 and the last was at Site 2	
<b>Figure 5.6-6.</b> Proportion of marked winter-run Chinook Salmon recaptured in the days following release from trap efficiency trials at the JSCS	91
<b>Figure 5.6-7.</b> Fork length of released and recaptured winter- run Chinook Salmon as part of trap efficiency trials at the JSCS. No fish were measured for the first release	91
<b>Figure 5.6-8.</b> Distribution of daily average water velocity through the JSCS trap during the release-recapture periods	92
<b>Figure 5.6-9.</b> Distribution of daily water depth at the JSCS trap during the release-recapture periods	91
<b>Figure 5.6-10.</b> Fork length distribution for black bass caught in the JSCS trap relative to the presence of juvenile salmon in the stomach	94
<b>Figure 5.6-11.</b> Relationship between the fork lengths of black bass predators and the juvenile salmon prey found in their stomachs	95
<b>Figure 5.6-12.</b> Fork length distribution for species caught by hook-and-line sampling from August to November 2023	96
<b>Figure 5.6-13.</b> CPUE by month and species group for hook-and-line sampling	97
<b>Figure 5.6-14.</b> CPUE by sampling zone and species group for hook-and-line sampling.	98

## List of Tables

<b>Table 4.5-1.</b> <i>Summary of buoys deployed to investigate water temperature throughout the reservoir during JSCS deployment at Site 1 from before JSCS installation on September 13, 2023 until October 25, 2023.</i>	36
<b>Table 4.5-2.</b> <i>Summary of buoys deployed to investigate water temperature throughout the reservoir during JSCS deployment at Site 2 between November 1 – 15, 2023.</i>	37
<b>Table 4.5-3.</b> <i>Dates, conditions, and water depths at trap for longitudinal profiles shown in Figures 5-11 and 5-12 comparing longitudinal profiles of near-surface and near-bed water temperatures.</i>	38
<b>Table 4.6-1.</b> <i>Schedule of weekly efficiency trials for 2023 field season</i>	45
<b>Table 5.1-1.</b> <i>Comparison of water surface elevations in Shasta Reservoir for 2022 and 2023 at important dates during the project</i>	51
<b>Table 5.1-2.</b> <i>Comparison of U.S. Bureau of Reclamation water surface elevation forecasts in Shasta Reservoir for 2023 by month of issue (columns).</i>	52
<b>Table 5.1-3.</b> <i>Comparison and performance of U.S. Bureau of Reclamation water surface elevation forecasts in Shasta Reservoir for 2022 by month of issue (columns)</i>	54
<b>Table 5.2-1.</b> <i>Summary of average water temperature difference upstream and downstream of trap platform by depth at Site 1</i>	63
<b>Table 5.2-2.</b> <i>Summary of average water temperature difference upstream and downstream of temperature curtain by depth for September 12 – November 15, 2023</i>	65
<b>Table 5.3-1.</b> <i>Dates, conditions, and water depths at trap for ADCP data shown in Figures 5-18 through 5-25 comparing velocity transects upstream of JSCS trap platform over time.</i>	66
<b>Table 5.3-2.</b> <i>Summary of water depth and velocity data for JSCS efficiency release dates</i>	80
<b>Table 5.6-1.</b> <i>RST and JSCS catch by species group.</i>	84
<b>Table 5.6-2.</b> <i>RST and JSCS non-target catch by species group</i>	85
<b>Table 5.6-3.</b> <i>JSCS catch by species group and site.</i>	87
<b>Table 5.6-4.</b> <i>Correlation matrix for key covariates. Values are Spearman’s rho statistic.</i>	89
<b>Table 5.6-5.</b> <i>Summary output for three generalized additive models that were fitted to JSCS catch for three species groups as a function of velocity and temperature.</i>	90
<b>Table 5.6-6.</b> <i>Releases and recaptures of marked WRCS from trap efficiency trials at the JSCS.</i>	90
<b>Table 5.6-7.</b> <i>Total catch from hook-and-line sampling by species and month.</i>	96
<b>Table 5.6-8.</b> <i>ANOVA table for CPUE by month and species group for hook-and-line sampling</i>	97
<b>Table 5.6-9.</b> <i>ANOVA table for CPUE by sampling zone and species group for hook-and-line sampling.</i>	97

# Section 1: Introduction

## 1.1: Executive Summary

The Department of Water Resources (DWR) deployed and operated the Juvenile Salmon Collection System (fish trap, platform, guidance nets, debris boom, and temperature curtain) in the McCloud Arm of Shasta Reservoir between the McCloud Bridge and Ellery Creek from September 18, 2023, through November 15, 2023. The California Department of Fish and Wildlife (CDFW), NOAA National Marine Fisheries Service (NOAA Fisheries), and the Winnemem Wintu Tribe (WWT) reared 80,000 winter-run Chinook Salmon eggs in remote site incubators (heath trays and nature-based Nur systems) at Ah Di Na. CDFW released juveniles from the heath trays directly into the McCloud River and juveniles in the nature-based Nur systems volitionally entered the river at the same location. DWR targeted these fish for capture at the JSCS to assist with relocation in support of a pilot study by CDFW, NOAA Fisheries, and the Winnemem Wintu Tribe to assess the feasibility of a long-term reintroduction project. The JSCS was the most downstream point-of-capture and was operated at the riverine-reservoir interface in head-of-reservoir conditions.

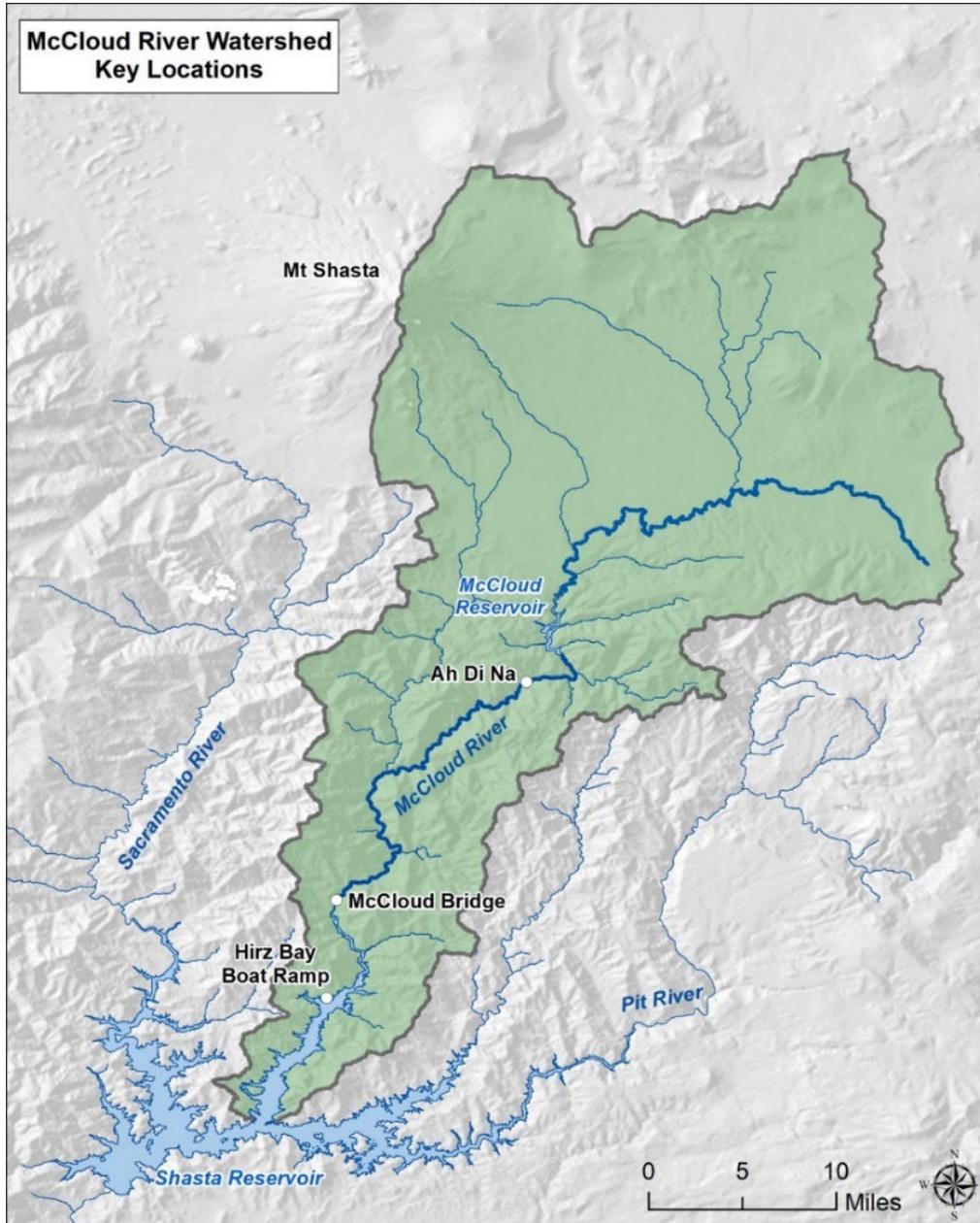
The 2023 field season provided an opportunity to evaluate the JSCS and how it operated under various physical field conditions. DWR conducted studies to evaluate the impact of JSCS structure and deployment on water temperatures and water velocities using daily and weekly sampling methods to identify ideal conditions for trap operations. DWR monitored reservoir conditions at the JSCS site, including reservoir depth and structure position. DWR conducted weekly mark-and-recapture trap efficiency trials to evaluate capture probability and trap efficiency as reservoir conditions and trap configurations changed over the course of the season. DWR identified and enumerated all fish captured at the JSCS. DWR sampled a subsection of juvenile salmon captured at the JSCS for length measurements and transferred all salmon to CDFW for relocation and release into the Sacramento River downstream of Keswick Dam. In total, the JSCS captured 497 winter-run Chinook Salmon from Ah Di Na (river-reared fish, *Nur*) and 356 additional marked winter-run Chinook Salmon (efficiency fish). Average capture probability across the season was 22.3%, with a maximum recapture rate of 51.5% and a minimum recapture rate of 0.3%. The JSCS operated at peak capture probability when reservoir depth at the trap site was between 10–12 feet and water velocity at the trap entrance was within the range of 1.3–2.1 feet per second. The deployment of the temperature curtain and guidance nets both effectively lowered temperatures directly upstream of the structure. Further research in subsequent field studies is necessary to corroborate the conclusions from this season and determine ideal methods and conditions for effective JSCS deployment and operation.

## 1.2: Study Area and Setting

The McCloud River (Wintu name: *Winnemem Waywaket*) drains a 427-square mile area across the lower Cascade Range and Mount Shasta before flowing into Shasta Reservoir (USGS 2023a). Mean annual precipitation in the McCloud River watershed exceeds 70 inches, with 80 percent falling as rain and the remainder as snow (USBR, 2016). The river runs 59 miles from its spring-fed stream headwaters, past the lava flows of Mount Shasta, and through steep canyons and mixed conifer forest until it meets the McCloud Arm of Shasta Reservoir. The complex topography of the McCloud River supports dozens of microhabitats and rich biodiversity; the river is known for an excellent trout fishery with cold water

temperatures and good water quality. Historically, the McCloud River supported robust populations of all four runs of Sacramento River Chinook Salmon as well as Bull Trout and steelhead, but dam construction in the watershed resulted in the extirpation of anadromous species from the river (Moyle, Lusardi, & Samuel 2017). Early developments on the McCloud River included timber harvest, mining, and recreational development by wealthy settlers for fishing. The majority of land along the McCloud River is privately owned and used predominantly for timber harvest and hydropower. Shasta Reservoir is owned and operated by the U.S. Bureau of Reclamation (USBR), and adjacent land is managed by the United States Forest Service. A California State Wild & Scenic River designation protects the lower McCloud River from further development.

The McCloud River is dammed twice: first by Lakin Dam, originally constructed by the McCloud River Lumber Company for mill operations and water supply and currently owned by the United States Forest Service; and then by McCloud Dam, built in the 1960's for private hydropower by PG&E. The McCloud Dam forms Lake McCloud and diverts up to 80% of the McCloud River flow into the Pit River for hydropower generation (USGS 2020). Below the dam, the reduced flow of the McCloud River continues for 23 miles until it reaches Shasta Reservoir. The daily average McCloud River discharge below McCloud Dam was 222.5 cubic feet per second in 2021 (USGS 2023). During the 2023 JSCS field season, the average McCloud River discharge below McCloud Dam was 243 cubic feet per second. Hydropower operations negatively impact the temperature and turbidity conditions in the lower McCloud River, and erosion and timber management practices contribute to sediment events throughout the wet season (USBR 2016). The McCloud River flows into the McCloud Arm of Shasta Reservoir, which submerges the last 14.5 miles of the historic river channel, riparian zone, and adjoining land.



**Figure 1.1-1.** McCloud River watershed with key project locations

### 1.3: Treaty Rights and Land Tenure on the Winnemem Waywaket

The McCloud River (Winnemem Waywaket) watershed encompasses the traditional territory of the Winnemem Wintu Tribe, whose name translates to “middle waters people.” The Winnemem Wintu have lived along the McCloud River since time immemorial and trace their origin as a people to relationship with salmon (Nur) who provided humans with a voice during creation. The California Genocide and the Gold Rush brought cultural devastation and ecological degradation to the McCloud River: mining and logging practices choked streams with sediment and pollution while settlers targeted Winnemem communities and means of subsistence for annihilation (Madley 2019; WWT 2011; WWT 2019). The Reading Rancho Treaty of Peace and Friendship, also known as the Cottonwood Treaty,

formally reserved a large area along the McCloud River for the Winnemem Wintu in 1851. Congress failed to ratify the treaty and sealed it to secrecy, leaving the Winnemem Wintu without federally recognized treaty rights to land or fish (Anderson, Ellison, and Heizer 1978).

The Winnemem Wintu continued to live along the McCloud River and work to protect salmon until the construction of Shasta Dam in the mid-1940's. Many Winnemem Wintu secured legal title to land for homesteads along the McCloud River under Grover Cleveland's 1893 amendment to the Dawes Allotment Act (Sisk 2002). Operations at Baird Station, the first national fish hatchery, relied heavily on Winnemem Wintu labor and ecological knowledge (Yoshiyama and Fisher 2001). Livingston Stone, the director of Baird Station, wrote in 1873 that "the presence of the [Wintu] is the great protection of the supply of Sacramento salmon" (Smith 1995 p.129, see also Wolfe-Hazard 2019). However, the Winnemem Wintu were not equal, consenting partners to hatchery practices and protested the encroachment of hatchery operations upon their fishery. Without the permission of the Winnemem Wintu Tribe, Livingston Stone exported Chinook Salmon eggs from the McCloud River worldwide in an attempt to establish commercial salmon fisheries elsewhere. Today, wild Chinook Salmon from the McCloud River survive in several New Zealand rivers.

#### 1.4: Shasta Dam and the McCloud River

Shasta Dam, one of the initial developments of the Central Valley Project, sits just below the confluence of the Sacramento, Pit, and McCloud Rivers and forms a reservoir which covers a surface area of over 29,000 acres and holds up to 4.5 million acre-feet of water. Upon its completion in 1945, Shasta Dam flooded over 250 Winnemem Wintu sacred places, ceremony sites, village locations, burial grounds, and allotments (Ngo 2009). Over 90% of the traditional land of the Winnemem Wintu lies below the reservoir line (Garrett 2010).

Although the 1941 Use of Indian Lands for the Central Valley Project Act promised compensation or the provision of like land for submerged allotments, the Winnemem Wintu did not consent to the transfer or inundation of their land and recompensation never reached the Tribe. Ownership of the remaining allotments along the McCloud River was transferred to the United States Forest Service, who manages the land around Shasta Reservoir for recreation; many village sites and allotments were developed into public campgrounds. Notably, DWR conducted Juvenile Salmonid Collection System efficiency trials at the McCloud Bridge Campground, which was developed on top of a ceremonial site at William Curl's allotment and orchard. In 1985, the Bureau of Indian Affairs failed to include the Winnemem Wintu in a comprehensive list of federally recognized tribes. Although this technical error did not go through the mechanisms for formal termination, it nonetheless resulted in the loss of federal recognition and associated rights and benefits. Despite attempts at the state and federal level, federal recognition has not been restored to the Winnemem Wintu Tribe. Chief Caleen Sisk, leader of the Winnemem Wintu Tribe, explains that "the loss was more than 26 miles of river, our dance grounds, our way of life that had been known by older people in my tribe. But we also lost a lot of dignity that came with being run out of our homeland and with no place to go" (McLeod 2013).

Shasta Dam was constructed without fish passage, and its construction in the 1940's permanently blocked salmon access to the McCloud, Pit, and Upper Sacramento rivers. Statewide, over 95% of salmon habitat is blocked by dams, and above-dam river systems have lost more salmonid species to extirpation and extinction than any other habitat type in California (Moyle, Lusardi, & Samuel 2017). The loss of access to high-quality cold-water spawning and rearing habitat has especially impacted winter-

run Chinook Salmon, who spawn and hatch during the warmest parts of the year (Yoshiyama, Fisher, & Moyle 1998). Shasta and Keswick dams restrict the population of winter-run Chinook Salmon to the warmer waters of the mainstem Sacramento River and egg survival generally depends on managed cold-water releases from Shasta Dam (NMFS 2014). Winter-run Chinook Salmon populations declined after dam construction and the species was declared federally endangered in 1994. Livingston Stone National Fish Hatchery was constructed below Shasta Dam in 1997 to supplement the population with hatchery production and prevent further species decline. The 2014-2016 drought shrank the cold-water pool in Shasta Reservoir, and temperature-dependent mortality among winter-run Chinook Salmon in the wild spiked to 77% of eggs in 2014 and 86% in 2015 (NOAA 2023). Thiamine deficiency also contributes to low survival rates among juveniles, and although 2021 saw the best return of adults in fifteen years, juvenile survival reached a new record low. Without restored access to suitable habitat upstream of Shasta Dam, the population of Sacramento River winter-run Chinook Salmon is unlikely to recover (Lindley et al 2004; NMFS 2014).

### 1.5: Urgent Actions to Recover the Winter-run Chinook Salmon Population

The decline of winter-run Chinook Salmon is of great concern to the Winnemem Wintu Tribe, who maintain important kinship relationships with the salmon. Chinook Salmon (Nur) are a cultural keystone species (Garibaldi and Turner 2004), and their presence or absence deeply impacts lifeways in the McCloud River watershed. If there are no Nur, then the Winnemem Wintu Tribe cannot exist. The Winnemem Wintu Tribe has advocated for the reintroduction of Chinook Salmon to the McCloud River for over two decades on the basis that ecological and cultural conditions have declined without the presence of salmon. In 2010, the Winnemem Wintu Tribe received word from New Zealand that a population of McCloud Chinook Salmon survived in the Rakaia River and members of the Tribe travelled to meet their salmon relatives. In 2016, the Winnemem Wintu Tribe submitted a Salmon Restoration Plan to the U.S. Bureau of Reclamation (USBR) advocating for the reintroduction of the New Zealand salmon to the McCloud River and the construction of a swimway to provide voluntary fish passage around Shasta Dam. As warm water temperatures below Shasta and Keswick dams continue to drive species decline in the wild, it is of great importance to the Winnemem Wintu Tribe to restore winter-run Chinook Salmon access to the cold-water rearing habitat in the McCloud River.

The reintroduction of winter-run Chinook Salmon to the McCloud River is also a priority for NOAA Fisheries, who included reintroduction as a priority action in the Species in the Spotlight: Sacramento River Winter-run Chinook Salmon Report. The Steering Committee for the Shasta Dam Fish Passage Evaluation effort (USBR 2016) determined juvenile salmon survival through Shasta Reservoir to a juvenile collection system at or near the dam was likely to be low. Therefore, the juvenile collection portion of a reintroduction program was to focus on the riverine-reservoir interface in head-of-reservoir conditions (Clancey et al 2017). In 2017, USBR awarded DWR a contract for the design, construction, installation, and operation of juvenile fish collection devices in the lower McCloud River and the McCloud Arm of Shasta Reservoir; USBR support was halted in 2019 after the initial fabrication of JSCS components.

In 2022, NOAA Fisheries, CDFW, and the Winnemem Wintu Tribe undertook urgent actions to mitigate temperature-dependent mortality in the mainstem Sacramento River and placed 40,000 winter-run Chinook Salmon eggs from Livingston Stone National Fish Hatchery in remote-site incubators on the McCloud River at Ah Di Na. This marked the first time that salmon had swum in the McCloud River in almost 80 years and the beginning of the McCloud River Salmon Restoration Project, a collaborative,

multi-agency pilot study to assess the feasibility of a long-term reintroduction project. During the 2022 field season, DWR modified and deployed components of the JSCS structure (platforms, guidance net, debris boom, and temperature curtain) to support the pilot study by testing a novel style of trap for head-of-reservoir fish collection. In 2023, CDFW and the Winnemem Wintu Tribe placed 80,000 winter-run Chinook Salmon eggs in two different types of remote site incubators for release at Ah Di Na. Also in 2023, DWR fabricated the fish trap component and installed and operated the complete JSCS downstream of CDFW's traps for its inaugural field season.

## 1.6: Study Objectives

DWR designed the JSCS to operate as a passive collection system targeting juvenile salmon in head-of-reservoir conditions. In good environmental conditions, the JSCS is intended to provide a high-efficiency collection method to maximize the successful relocation of juvenile salmon reared above rim dams. The main objectives of JSCS deployment in the second year of the McCloud River Salmon Restoration Project were to: (1) test JSCS trap efficiency and performance in field conditions and develop safe and effective methods of trap operation; (2) study the effect of JSCS deployment and operation on the biota and habitat of the McCloud Arm; (3) collect juvenile salmon for relocation; and (4) to collect data on winter-run Chinook Salmon growth, survival, and outmigration timing.

## 1.7: Overview of 2023 Field Operations

During the 2023 field season, the JSCS was operated at two sites: at Site 1 for 35 days from September 20 to October 25, 2023, and at Site 2 for 15 days from November 1 to November 15, 2023. In total, the JSCS captured 489 Nur and 349 dual-marked efficiency fish for a combined total of 843 juvenile winter-run Chinook Salmon. Juvenile winter-run Chinook Salmon were captured at both sites and average capture probability across both sites was 22.5% (34.5% at Site 1 and 4% at Site 2). The temperature curtain, deployed at Site 2 for the duration of the season, successfully influenced water temperatures around the JSCS structure and the guidance nets also had a significant cooling effect. The JSCS trap was checked daily and the trap components worked generally as intended. The impermeable panels successfully increased velocity through the trap while fykes within the trap created localized increases in velocity at the entrance of the trap and trap box.

The success of 2023 JSCS field operations required multi-agency collaboration and strong communication with project partners before, during, and after the field season. The Winnemem Wintu Tribe, CDFW, NOAA Fisheries, and Livingston Stone National Fish Hatchery (LSNFH) all provided crucial knowledge, guidance, and time to support JSCS field operations.

## 1.8: Purpose and Approach of this Document

This report is intended to inform the reader about the context, objectives, methods, and results for DWR's 2023 JSCS field operations in the McCloud Arm of Shasta Reservoir during 2023.

This document proceeds in five sections. **Section 1:** Introduction - provides background information to explain the purpose and context of JSCS operations in the McCloud River during the 2023 field season. **Section 2:** 2023 Pilot Study Planning - explains the work of coordination and logistical planning that went into organizing JSCS field operations and outlines research objectives and priority research questions. **Section 3:** Changes and Additions to JSCS from 2022 - outlines changes to the operation of the JSCS from

the previous field season in response to lessons learned and the implementation of new trap components and associated research objectives. **Section 4:** Methods for the 2023 Field Season - provides a description of methodological approaches and research protocols utilized to collect environmental data and fisheries data during the field season. **Section 5:** Results and Observations - includes a summary and explanation of relevant environmental, water quality, and fisheries data. **Section 6:** Conclusions and Recommendations - discusses the results from Section 5 and provides suggestions for future JSCS field seasons.

Note on units: some data described in this report, such as velocity and depth, was collected in the United States customary system of measurement (e.g., feet or feet per second or cubic feet per second). Other data, such as fork length, was collected in the Metric system of measurement (e.g., millimeters). Data is described in this report by the units it was originally collected in to preserve clarity and accuracy of findings.

### 1.9: Major Findings for 2023

Several key takeaways from the 2023 field season will influence future study design and trap operation. First, JSCS trap efficiencies reached their highest rates of capture when reservoir depth at the trap site ranged between 10-12 ft and velocities at the trap entrance ranged between 1.3-2.1 ft/s. This indicates that depth and velocity likely play a key role in trap capture efficiency and are important variables to consider during the siting process. Second, predation and/or juvenile salmon behavior in the vicinity of the JSCS structure may have affected capture probability and survival. Further research is needed to fully understand the effects of predators on JSCS capture probability, and predation is a focus area for future field seasons. Third, system components generally worked as intended, but several adjustments need to be made for improved efficacy and safety. Specifically, the management of guidance nets and impermeable panels needs to be modified to ensure that both remain taut as velocities increase later in the season. Finally, reservoir water surface elevation (WSE) played a major role in siting and planning of the JSCS. The WSE in 2023 was ~100 ft higher than in 2022, which resulted in substantially different environmental conditions and locations for the JSCS.

## Section 2: 2023 Pilot Study Planning

### 2.1: Inter-agency Coordination and Collaboration

DWR attended and conducted a variety of meetings with agency partners to prepare for the 2023 JSCS field season. Weekly McCloud River Action Team meetings coordinated by CDFW and NOAA Fisheries provided a forum for all project partners (including representatives from the Winnemem Wintu Tribe, DWR, UC Davis, UC Santa Cruz, and the United States Forest Service (USFS), among others) to engage in dialogue about project goals, scope, and status. Bi-weekly McCloud River Science and Monitoring meetings facilitated discussion between agency, academic, and tribal scientists to share knowledge across methods and objectives. Monthly Winnemem Wintu Nur/Salmon Rematriation Meetings coordinated by the Winnemem Wintu Tribe provided agency partners with the opportunity to learn about the Tribe's scientific methods and priorities. DWR attended the final egg delivery and ceremony hosted by the Winnemem Wintu Tribe at Ah Di Na. DWR coordinated meetings with CDFW and NOAA Fisheries on an as-needed basis to develop fish trap design, operation, and sampling protocols consistent with partner agency methods and also hosted monthly project update meetings. These interagency coordination meetings ensured that DWR's 2023 Pilot Study aligned with other efforts on the McCloud River and provided a jumping-off point for internal project development.

### 2.2: Internal Planning Documents

DWR and Environmental Science Associates (ESA) developed an internal Science Plan to structure the 2023 JSCS field season planning and protocols. The Science Plan identified the following priority research questions:

- How do the varying water depths along the McCloud Arm (a function of reservoir water level and river discharge) influence JSCS siting and performance?
- What is the range of reservoir water depths that are allowable/optimal for JSCS operation? What is the range of widths of the McCloud Arm that are allowable/optimal JSCS operations? What is the range of McCloud River discharges that are allowable/optimal for the operation of JSCS? How should the guidance net panels be configured as a function of river discharge, water depth, and wind?
- As a function of location and river discharge, what are the water velocities in the vicinity of the JSCS under baseline conditions prior to JSCS deployment? How does JSCS deployment affect water velocities and flow patterns? What are the approach velocities at/within the floating trap?
- As a function of location, river discharge, and wind, what are the water temperatures in the McCloud Arm during baseline conditions? During JSCS deployment and for specific locations inside the JSCS (i.e., the trap location)?
- What is the range and distribution of water quality parameters (e.g., temperature, dissolved oxygen) across space and time in the McCloud Arm during baseline conditions? During JSCS deployment? Does the temperature curtain maintain appropriate water temperatures (below a certain threshold) at the notch for the required water depths?

- What will be the preferential migratory pathway (within the water column/river cross-section) and transit time of juvenile Chinook Salmon down the McCloud Arm and into the JSCS? What is the relationship between physical and environmental variables and transit time?
- When should JSCS be deployed to capture out-migrating juvenile winter-run Chinook Salmon?
- What is the trap efficiency of the head-of-reservoir JSCS? What is the optimum minimum/maximum area of the McCloud Arm upstream of the JSCS to optimize trap efficiency? In other words, does trap efficiency diminish as the trap is moved downstream and the area of reservoir upstream of it increases? What factors play a role in trap efficiency and capture probability? Both physical (e.g., temperature) or biological (e.g., predation).
- What is the survival rate of juvenile Chinook Salmon in the McCloud Arm and what is the relationship between physical and environmental variables and survival rate?
- What is the relative abundance of fish species in the McCloud Arm during baseline conditions? During JSCS deployment? What is the relative abundance of other aquatic species in the McCloud Arm during baseline conditions? During JSCS deployment? What is the predator fish species assemblage?
- What is the predation risk to Chinook Salmon along the McCloud Arm upstream of JSCS during deployment? What potential predator deterrent measures are feasible to reduce predation risks?
- How can the floating trap be designed to facilitate debris and predator management?
- How will resident fish passage devices affect resident fish? Do resident fish species use the passage devices? Under what conditions?
- What will trigger the need to move the JSCS to maintain allowable and/or optimal water depths? How frequently might this be during an average trapping period, during a wet (high river flow) trapping period, etc.?
- Which water conditions are most important to understand and quantify during JSCS deployment and can they be forecast to better plan JSCS deployment?

DWR and ESA formed sub-teams to coordinate JSCS deployment and develop specific study plans to answer the above questions. The sub-teams met weekly or as needed, and included JSCS Mission Planning, JSCS Modifications and Fish Trap Design, JSCS Logistics Operations Siting and Technology (LOST), JSCS Data Management, JSCS Science Plan Coordination, JSCS Fish Trap Operations, JSCS Water Quality and Technology, and JSCS Predator Management. DWR and ESA compiled three specific study plans to outline research priorities and protocols for the 2023 JSCS field season: the JSCS Capture Efficiency Study Plan; the JSCS Environmental Data Collection Study Plan; and the JSCS Resident Fish Study Plan. In accordance with these study plans, the sub-teams created and adopted Standard Operating Procedures for water quality measurements, instrument calibration, fish trap operation, and fish sampling methods to ensure standardized data collection.

### 2.3: Site Selection

The McCloud Arm of Shasta Reservoir had previously been identified as a suitable location for Chinook Salmon capture, and the stretch of the McCloud Arm between the McCloud Bridge and Hirz Bay was a logistically feasible area for deployment (USBR 2014; NMFS 2014). The goal was to select a location as

close to the head-of-reservoir as possible while minimizing the number of mid-season system movements and disturbance of culturally significant sites. DWR, ESA, and the Winnemem Wintu Tribe collaboratively selected locations for the 2023 JSCS deployment. Hydrology, water level forecasts, culturally sensitive areas, and anchoring requirements factored into site selection.

DWR proposed five initial sites that would be suitable for fish collection (**Figure 2.3-1**). To identify a suitable area for proposed sites, the head-of-reservoir location was first estimated using forecasted monthly water levels provided by USBR and a bathymetric map of the McCloud River and Shasta Reservoir (see **Section 3.4: Location**). Forecasted WSE from USBR were superimposed onto the bathymetric map to estimate water depths over time across the riverine-reservoir interface. Ideal locations sustain relatively shallow depths (ideally 20 ft or less) without becoming too shallow for operations (~6 ft). Based on these criteria, a section of the river ranging from approximately 0.5-1 mile downstream of the McCloud Bridge was identified as suitable. Additional coordination with Pacific Gas and Electric (PG&E), who operates the McCloud Dam and controls the flow of water into the McCloud River upstream of the site, confirmed that discharge would remain constant at ~300 cubic feet per second (cfs) for the entire season. Hydraulic modeling confirmed that the selected location would have suitable depths given this inflow and the forecasted lake levels.

Once an optimal stretch of the river/reservoir was identified based on hydrologic criteria, specific sites were proposed within the designated suitable area to avoid culturally sensitive areas identified by the Winnemem Wintu Tribe. Five alternatives were mapped to help with this process (**Figure 2.3-2**). Of the proposed alternatives, DWR and the Winnemem Wintu Tribe identified two sites as agreeable options.

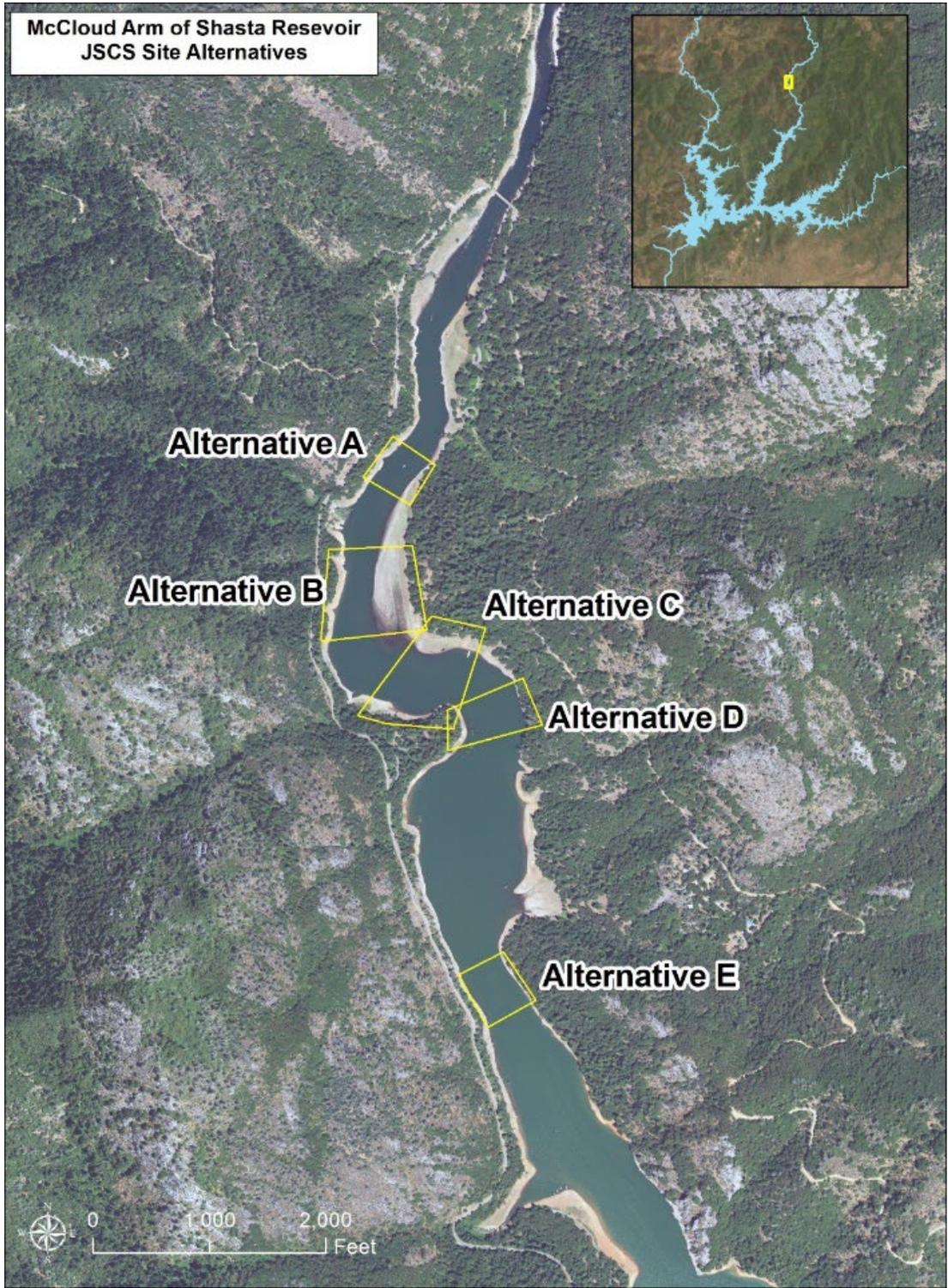


Figure 2.3-1. Five initial proposed sites for the 2023 field season

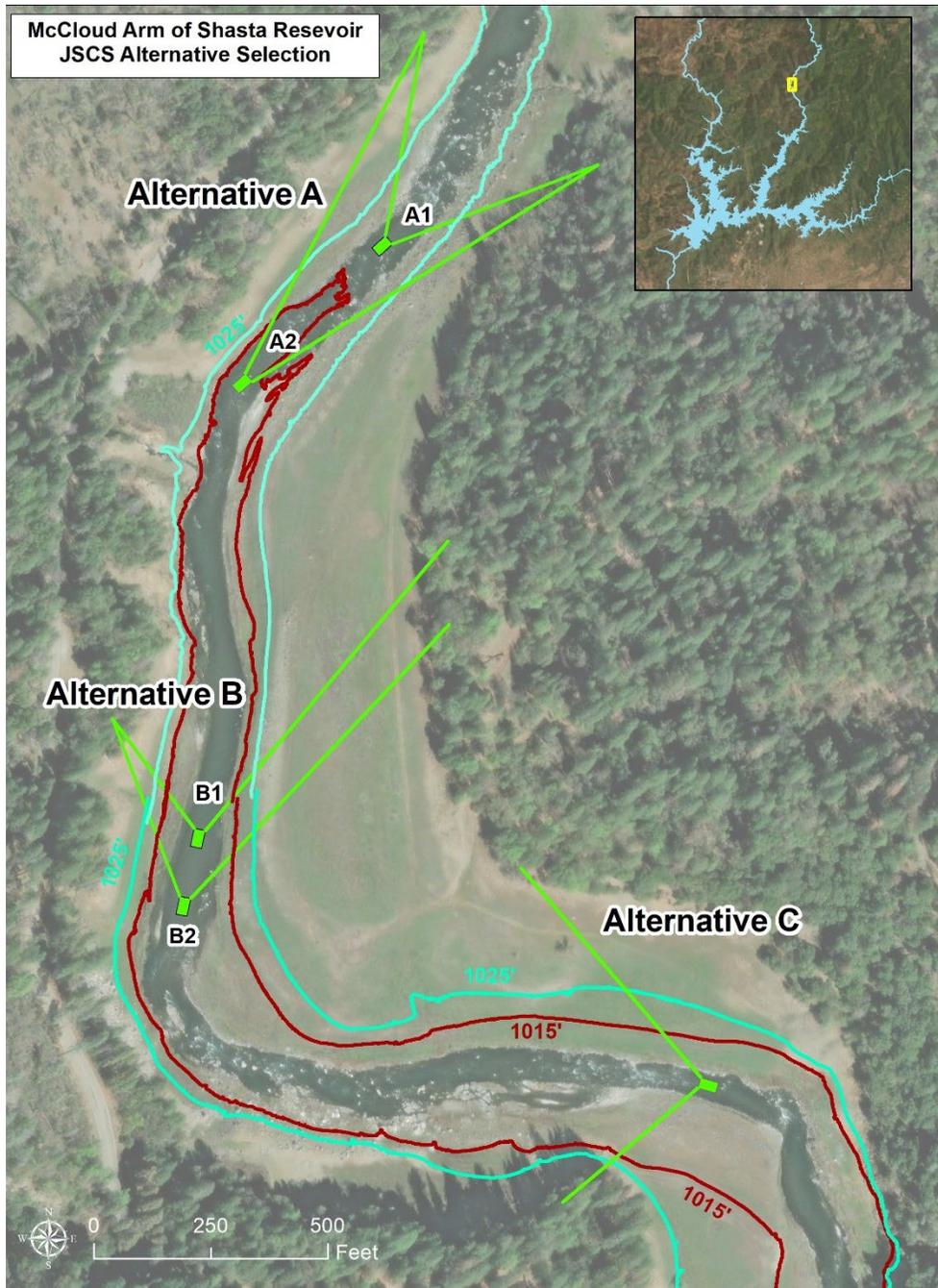


Figure 2.3-2. Site alternatives for the 2023 field season.

#### 2.4: Logistics

DWR planned logistics for transporting staff and materials to the site to ensure safe access to the site and minimize unnecessary travel. During mobilization, site relocation, and demobilization, DWR used the Hirz Bay Boat Ramp parking area as a staging area due to its large parking areas and multiple boat ramps. During normal field operations, DWR used the Pine Point and Ellery Creek campgrounds as meeting locations for Sites 1 and 2, respectively. Staff drove a minimum of three vehicles to the site and

kept them parked at the designated meeting location in case of an emergency. DWR primarily utilized state fleet trucks for transportation of staff and materials.

From the campgrounds, staff ferried to the site via a pontoon boat, which was anchored on shore overnight. ESA used an additional jet boat for regular transport of staff and other field tasks. PNP utilized several boats to transport materials to the site during mobilization, site relocation, and demobilization. Staff used a houseboat throughout the season for equipment storage, shelter, and lab space.

During normal operations, the JSCS crew consisted of a field lead, at least one Winnemem Wintu Tribe cultural resource specialist, a lead fisheries biologist, two staff biologists, an engineering lead, and a staff engineer. Daily field activities occurred from 8am until 5pm. From 5pm until 8am, Ardent Security observed the site and ensured its security.

## 2.5: Trap Evaluation Needs

The Fish Trap Operations sub-team and Data Management sub-team determined that weekly mark-and-recapture trials would be necessary to evaluate trap efficiency across reservoir conditions and answer research questions about trap efficiency, capture probability, and juvenile Chinook Salmon survival. Mark-recapture efficiency trials were designed according to standard CDFW methods in which a known number of dual-marked fish are released a set distance upstream from the JSCS trap (Starr and Day 2020; ICF 2016). In consultation with CDFW and NOAA Fisheries, DWR decided to use Bismark Brown-Y dye as the primary mark and a caudal fin clip as the secondary mark (upper caudal fin clip for CDFW and NOAA Fisheries efficiency trials, lower caudal fin clip for JSCS trials, **Figure 2.5-1**).



**Figure 2.5-1.** Juvenile winter-run Chinook Salmon with lower caudal clip and Bismark Brown-Y dye

All winter-run Chinook Salmon used in JSCS efficiency trials (“efficiency fish”) originated from Livingston Stone National Fish Hatchery (LSNFH) but were not marked with an adipose fin clip or coded wire tag. Efficiency fish had similar spawn and hatch dates to the eggs placed at Ah Di Na (“river-reared fish” or Nur) but came from different genetic crosses. DWR submitted a fish request and supporting documentation to LSNFH and coordinated with the hatchery to arrange weekly marking events.

## 2.6: Contracting

The 2023 JSCS Pilot Study was led by DWR Riverine Stewardship Program with the assistance of staff from DWR's Northern Region Office. Environmental Science Associates (ESA) was the project consultant, supporting DWR staff in planning and project management, field work, and data analysis. Pacific Netting Products (PNP) was the contractor that helped develop and fabricated the components of the JSCS, including the fish trap in the summer of 2023. With their subcontractor, JF Brennan, PNP provided all logistics related to mobilization, deployment, assembly, anchoring and installation, relocation, demobilization, and transportation of the JSCS to storage locations. Ardent Security provided unarmed security for the JSCS and all equipment when field work was in progress and when staff was not present and during installation, relocation, and removal.

## 2.7: Permitting

For the 2023 JSCS field season, DWR acquired a USFS Special Use Permit, a CDFW Scientific Collection Permit, and a CDFW California Endangered Species Act Memorandum of Understanding. DWR completed an addendum to Mitigated Negative Declaration CEQA document with updated information about planned project undertakings.

NOAA Fisheries designated and authorized the release of a nonessential experimental population of winter-run Chinook Salmon into the McCloud River above Shasta Dam and adopted limited protective regulations under the Endangered Species Act Sections 10(j) and 4(d).

## 2.8: Procurement

DWR developed a list of equipment, supplies, and materials needed and evaluated options based on cost and quality. All purchases either went through DWR via a purchase order or were subcontracted to ESA for purchasing if it was determined that materials couldn't be acquired in time for the field season.

## 2.9: Training

Prior to the season, all DWR staff took a Wilderness First Aid training as well as a Swift-water Rescue training course with Sierra Rescue International. All DWR staff completed internal trainings for Work over Water, Heat Illness Prevention, and CEQA Compliance. Additionally, all DWR boat operators took a Motorboat Operators Training Course and obtained their California Boater Card.

All DWR staff named as authorized individuals on the JSCS Scientific Collection Permit received up to 40 hours of training on best practices in fish handling and field fisheries methods prior to the start of field season. Training included the provision of text materials (standard operating procedures; fish identification guides; reports summarizing other field projects) and opportunities for hands-on learning (shadowing the DWR Division of Integrated Science and Engineering field crew on the Yolo Bypass fyke and rotary screw traps; rotary screw trap and fish sampling training at the UC Davis rotary screw trap on Putah Creek; morphometric and fish handling training at the UC Davis Center for Aquatic Biology and Aquaculture). Additional training in fish identification and proper handling and sampling techniques was provided on an as-needed basis in the field by the lead fisheries biologists.

ESA provided training on proper data collection methods and use of digital data forms to DWR JSCS staff. DWR provided internal training on data quality assurance and quality control procedures. All DWR JSCS staff received additional training on proper calibration, use, and maintenance of water quality measurement equipment from a representative of Xylem, the manufacturer of all water quality equipment used for the study.

All JSCS staff participated in cross-training while operating the JSCS trap and other components.

# Section 3: Changes and Additions to JSCS from 2022

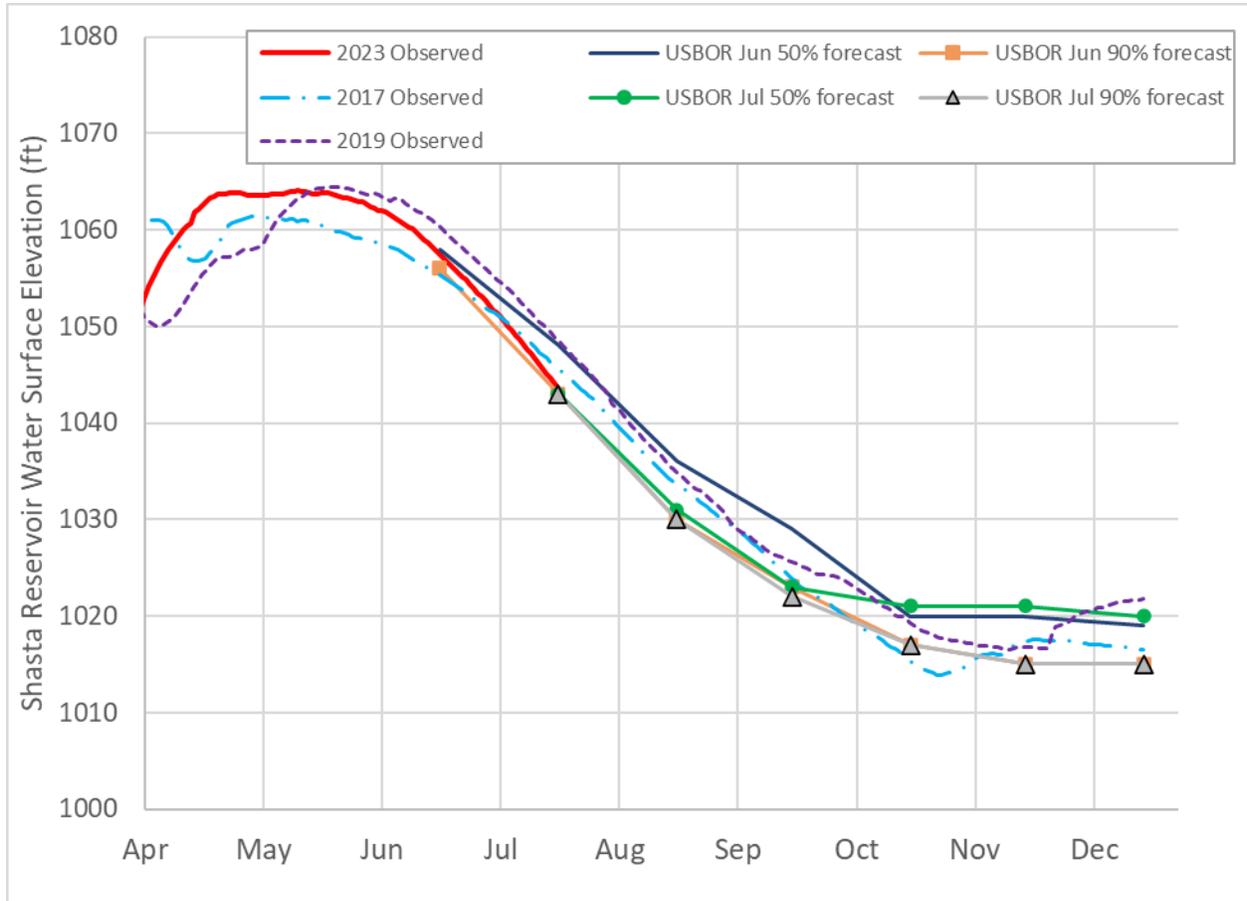
## 3.1: Location

A key objective for the 2023 season was to operate the JSCS as close to the McCloud River as possible. In 2022, the JSCS was located more than 1.5 miles downstream of the riverine-reservoir interface in deep (>30 ft), stagnant water. The initial site for the 2023 JSCS was located approximately 1000 feet downstream of the interface in shallower (~16 ft) water with higher velocity. Additionally, the initial WSE of Shasta Reservoir at the start of the 2022 season was 930 feet NAVD-88 compared to 1040 feet NAVD-88 at the start of the 2023 season. Along with the reservoir being fuller, this resulted in the head-of-reservoir being much farther upstream in 2023.

Regional hydrology determines where the JSCS structure is placed for each field season and has a large effect on conditions during the deployment. Because the JSCS is deployed in the highly controlled conditions of Shasta reservoir, observations and operations forecasts should provide guidance on expected reservoir WSE over time. USBR issues monthly forecasts of WSE based on chance of exceedance—90% and 50%, defined as follows (USBR, 2023):

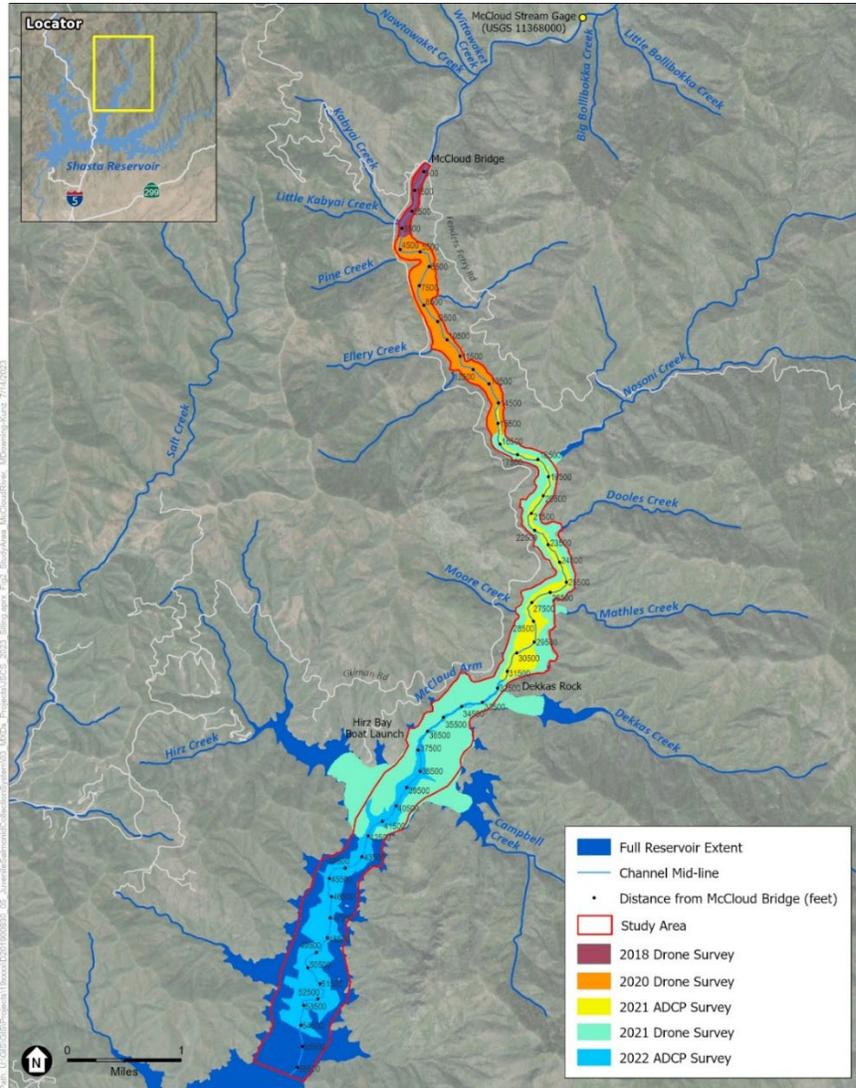
- *The 90% chance of exceedance forecast (or 90%)* is for dry conditions—there is a 90% chance the actual WSE will exceed this forecast value. This forecast is considered conservative for reservoir operations but may lead to a higher demand for reservoir outflows.
- *The 50% chance of exceedance forecast (or 50%)* is for wet conditions—there is a 50% chance the actual WSE exceed this forecast value. This forecast is considered in the middle of the range of possible runoff volumes that are possible for current conditions.

These two forecasts are based on probable reservoir inflows for natural flow conditions (i.e., unimpeded by dams or diversions). The forecasts are issued once a month for future months and the latest forecast supersedes previous versions. For siting the JSCS in 2023, the two forecasts were monitored over time and compared to observed data (**Figure 3.1-1**). The forecast that most closely matches available observations was considered most appropriate to use for determining expected water depths during deployment. The primary effort for JSCS siting occurred in late July and early August of 2023. As of August 1, 2023, only the June and July USBR forecasts were available and the trend of observed WSE more closely followed the July 90% forecast, so JSCS WSE predictions were made using the USBR July 90% forecast assuming linear elevation changes between forecast dates.



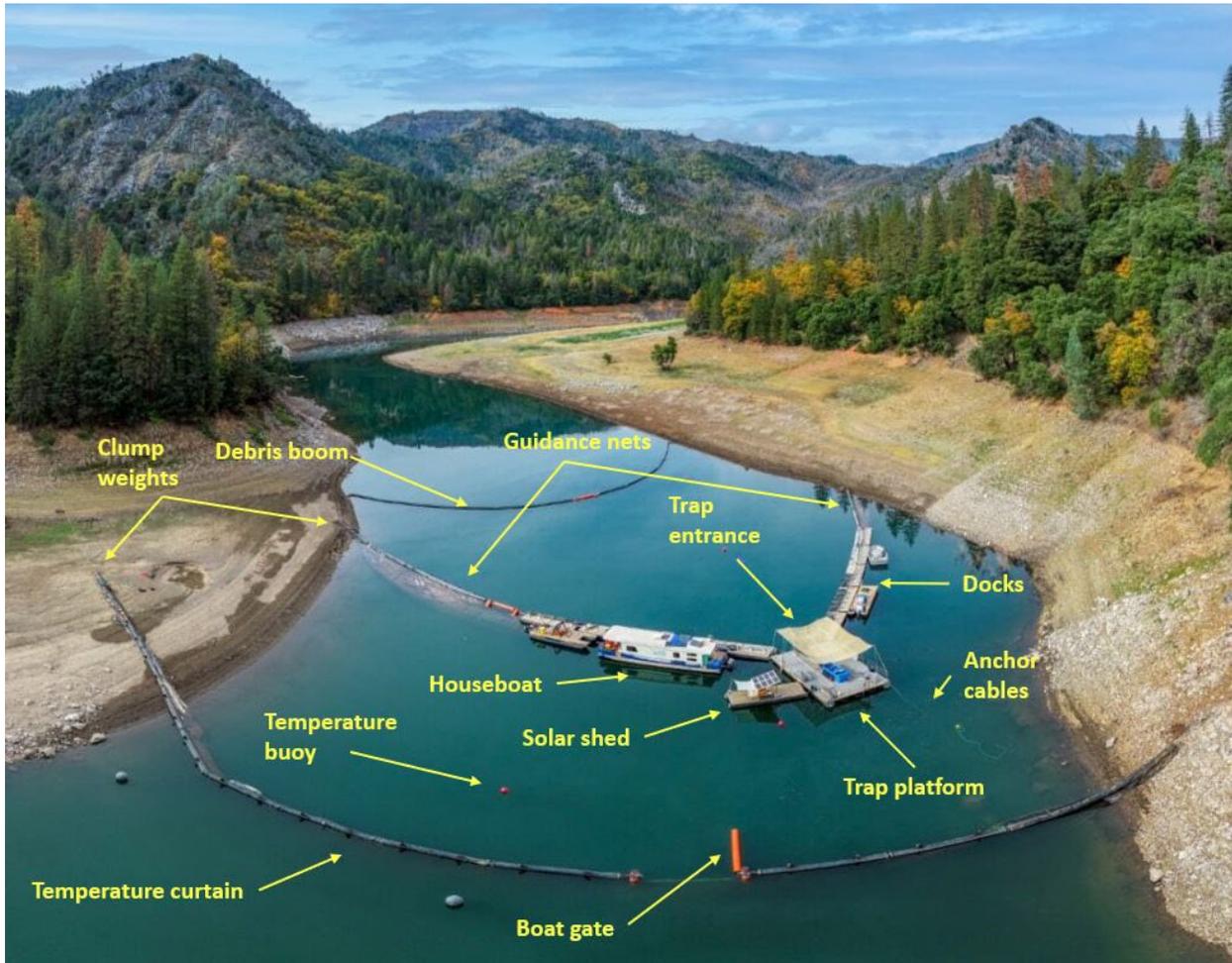
**Figure 3.1-1.** Time series showing available data for WSE in Shasta Reservoir during JSCS siting phase in early August 2023. Current-year and historical (2017, 2019 – when the reservoir was at a similar elevation) observations were evaluated along with forecasts of WSE over time issued by USBR in June and July 2023.

To estimate where in the reservoir had favorable depths and widths for JSCS deployment, previously collected bathymetry data was used in addition to reservoir operations observations and forecasts. This combination of data was used to identify potential sites where JSCS would span the entire reservoir width at suitable depth ranges and when structure relocation would be needed. A visual inventory of reservoir bathymetry data sources is presented in **Figure 3.1-2**. Potential sites for the JSCS were determined for 2023 based on hydrologic conditions (e.g., reservoir WSE), targeted water depths, site characteristics, and cultural and environmental resource constraints. For 2023, targeted water depths at the JSCS were 8 – 15 ft, given the design of the fish trap and a project objective to operate the JSCS as close to the river as possible. Given the expected WSE and targeted water depth, potential siting locations were determined. Further refinement of sites was done by evaluating the channel morphology (e.g., seek straight reaches of river) and feedback during reconnaissance site visits with interested parties such as the Winnemem Wintu tribe.



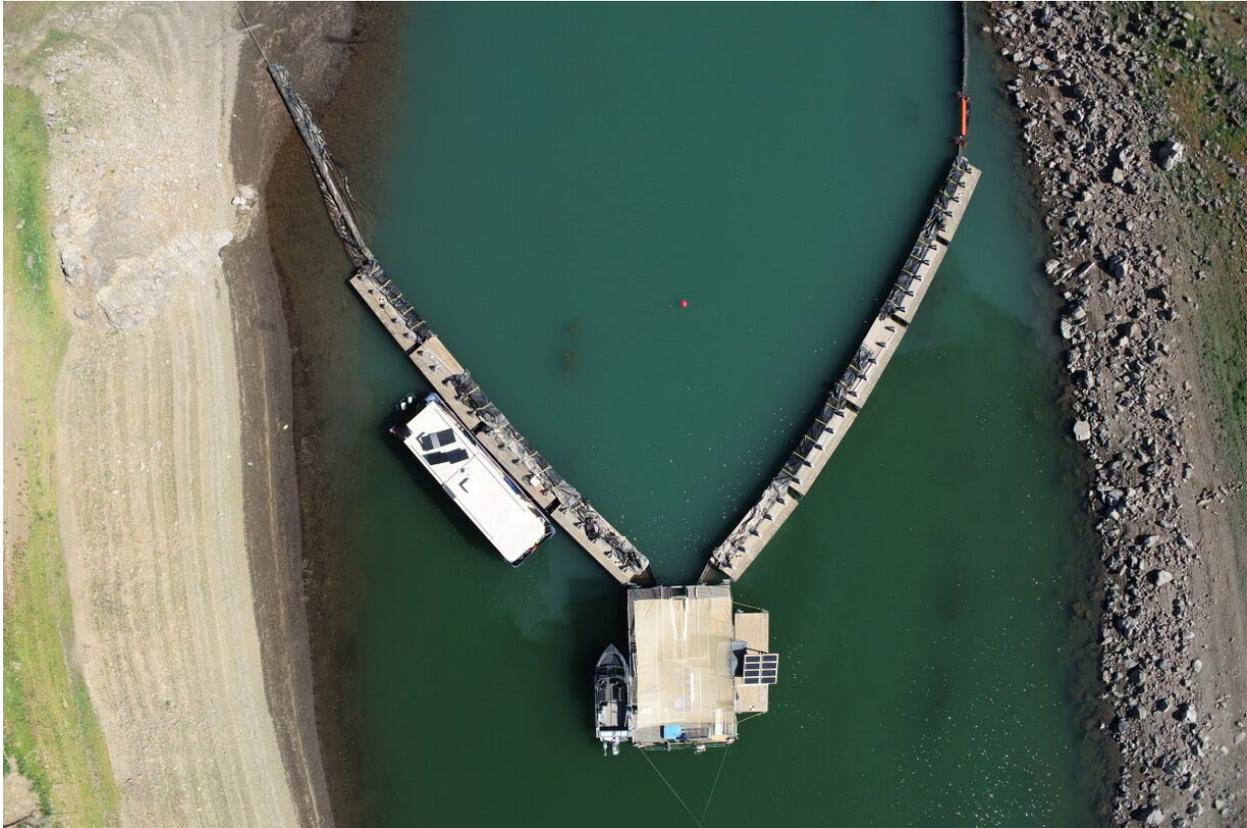
**Figure 3.1-2.** Overview map of the McCloud Arm of Shasta Reservoir showing region considered for JSCS siting in 2023 (Study Area). Topographic and bathymetric datasets are shown by collection year and survey type. Drone: aerial survey with unoccupied aerial vehicle; ADCP: boat-based survey with acoustic Doppler current profiler.

### 3.2: Configuration of System



**Figure 3.2-1.** JSCS System with major components labeled. Imagery is from Site 2 taken on November 3, 2023.

The configuration of JSCS 2023 differed from the previous configuration in 2022. The overall configuration of the structure is shown and labeled in **Figure 3.2-1**. In 2022, the JSCS was set up in a very wide portion of the reservoir, which resulted in a very large angle between the guidance nets. Because the guidance nets were almost perpendicular to flow, they were subjected to greater pressure. This caused the guidance nets and docks to deform into a “U” shape. In 2023, a much narrower, shallower portion of the reservoir was selected for the site and the angle between the guidance nets was much smaller, more parallel to flow as opposed to perpendicular to flow. This resulted in more of a “V” shaped guidance system which is illustrated by aerial imagery of the initial site in 2023 (**Figure 3.2-2**). Because the guidance system was much narrower in 2023, fewer docks were required along the guidance nets. In 2022, six docks were used on each side of the notch. Whereas in 2023, five docks were used on the river left side of the platform and four docks were used on the river right side of the platform. The anchoring system used anchor cables attached to trees and clump weight anchors on the ground to secure the guidance nets, debris boom, and temperature curtain. In 2023, the same trees anchored both the debris boom cable and the guidance net cable.



**Figure 3.2-2.** Overhead view of platform and guidance nets with “V” shape. Imagery is from Site 1 taken on September 21, 2023.

### 3.3: Fish Trap and Platform Design and Fabrication

To prepare for fish trap operations in the 2023 field season, DWR created a design team consisting of engineers and scientists from a wide range of organizations including DWR, ESA, NMFS, CDFW, USBR, USGS, Trout Unlimited, and the Winnemem Wintu Tribe. The design team met weekly from January 2023 until June 2023, with initial trap concepts developed by the team in the first quarter of 2023. PNP developed design drawings based on the preferred concept (**Figure 3.3-1**) and the design team worked with them through an iterative process to develop the final design by the end of the second quarter of 2023. PNP fabricated the trap and platform from June through August of 2023 and delivered them to the site at the start of the field season.

California Department of Water Resources  
 Juvenile Salmonid Collection System: Report on Field Operations 2023

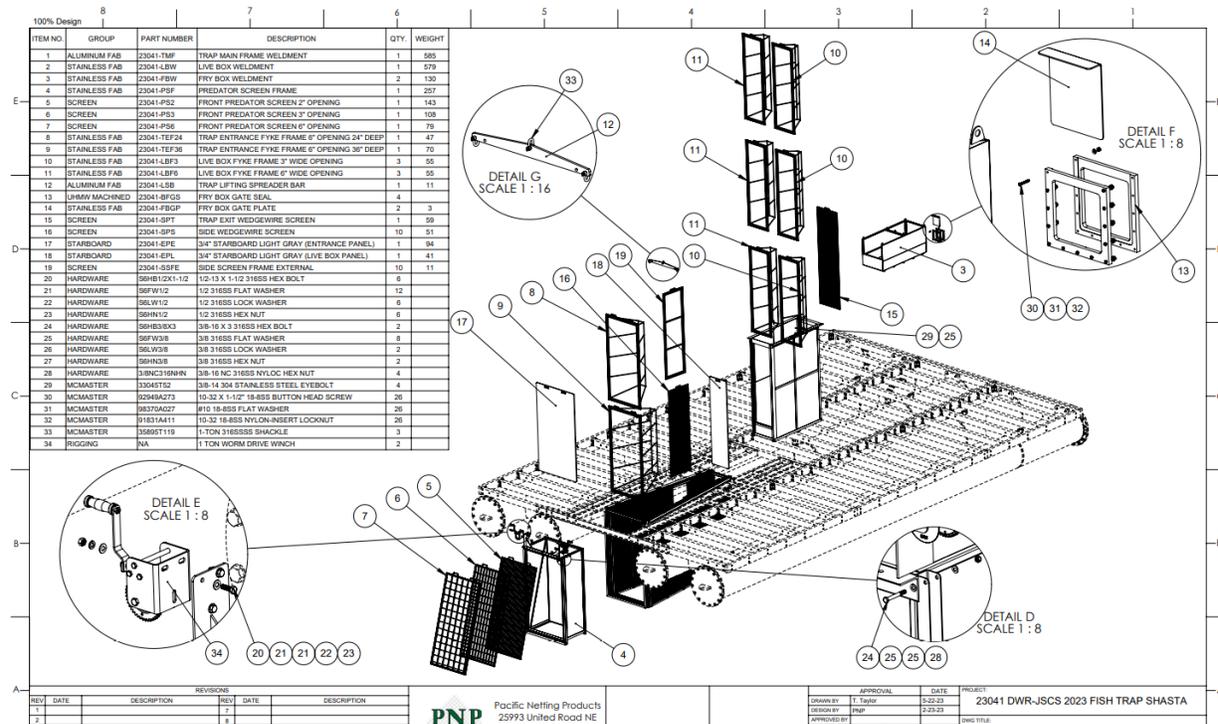


Figure 3.3-1. PNP design drawing of JSCS fish trap

### 3.4: Boat Gates

In 2022, portions of the temperature curtain, guidance nets, and debris boom were left open for boat passage. For the 2023 season, PNP designed boat gates to close these gaps but also allow boats to navigate through the system. For the most part, the gates worked as intended but were difficult to open and close without the force of a motor and difficult to operate from kayak or canoe. They also had gaps which allowed water and potentially fish to pass.

### 3.5: Fish Trap Operation and Sampling

The 2022 JSCS operation did not include a fish trap and instead deployed an open frame in the notch where the fish trap would later be placed. The fish trap components of the JSCS were designed, fabricated, and deployed for the first time in 2023. The JSCS has a 15-foot-long passive trap which relies on induced velocity and fish behavior rather than pumped attraction flow to collect juvenile salmon. The trap is set into the notch in the JSCS platform where the guidance nets meet and is composed of an aluminum frame, 10 side wedgewire screen panels, 10 perforated porosity control panels, 2 impermeable closure panels, a wedgewire exit screen panel, a debris exclusion grate, entrance fyke, trap box, internal fyke, and fry box (Figure 3.5-1, Figure 3.5-2). The entrance fyke funnels fish into the entrance section and prevents escape; the internal fyke (screened with vexar) allows only smaller fish into the trap box and provides refuge from larger predators. The main frame, trap box frame, fry box frame, trap box walls, and gantry crane are aluminum. The debris exclusion grate, wedgewire screen panels, and fyke frames are stainless steel. The control panels and fykes are made of perforated aluminum plates with varying porosity to control velocity. Screens along the sides of the main frame and at the exit are made of wedgewire. Impermeable panels are made of 3/4" HDPE and UHMWPE. The fry

box contains a 7" x 7" square valve that can be opened to drain excess water or transfer fish to live wells. Live wells, plumbed into a water pump, provide additional holding capacity for cold water or live fish.

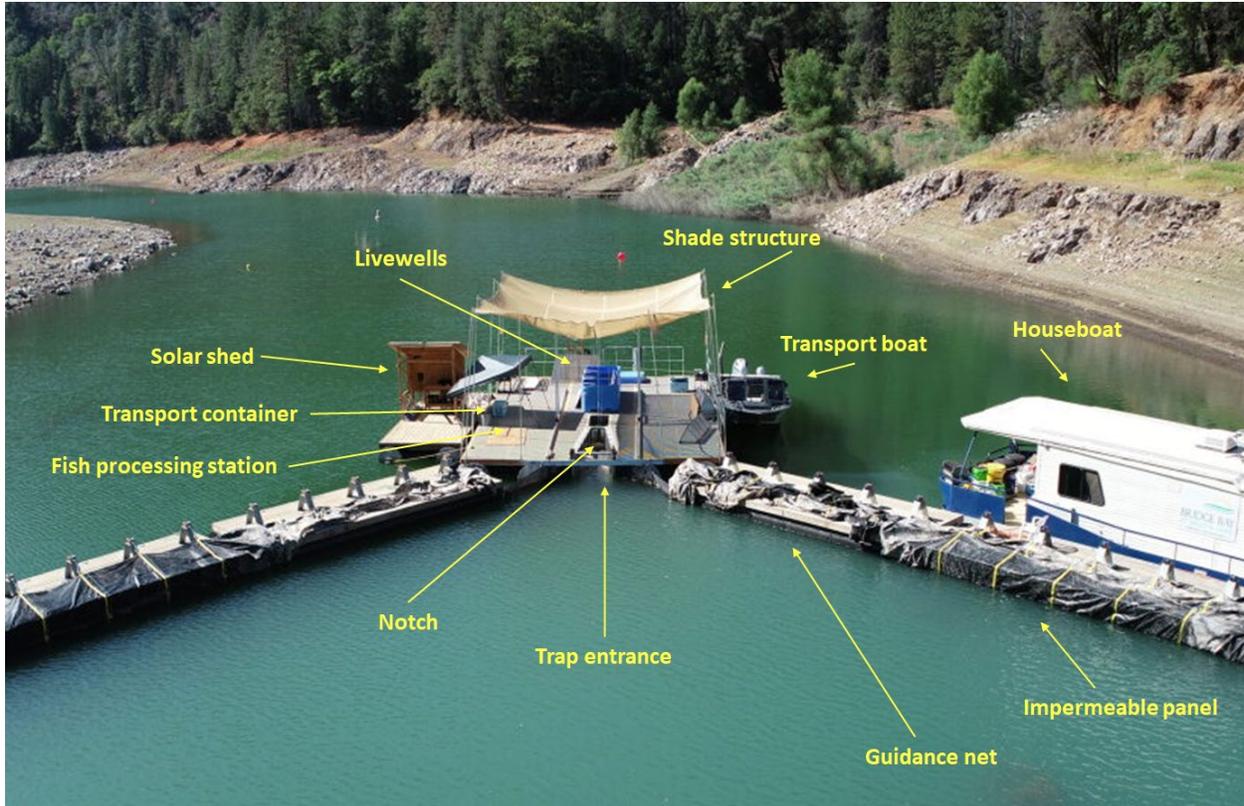
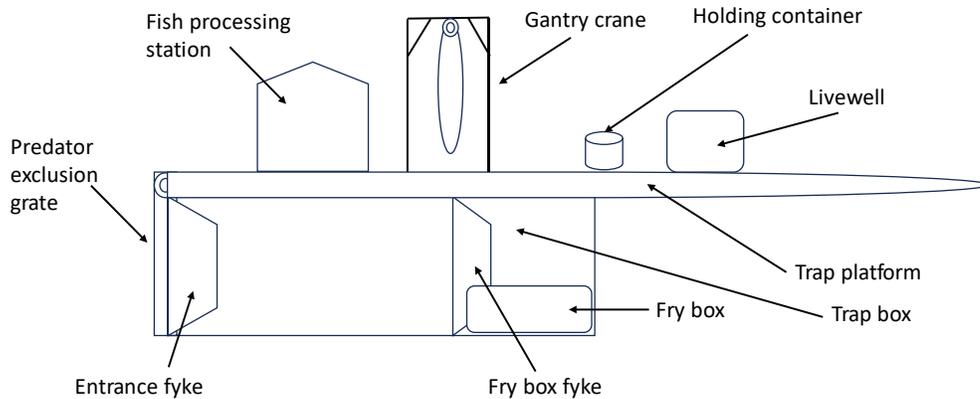


Figure 3.5-1. JCS platform with structure elements labeled



**Figure 3.5-2.** Drawing of JSCS fish trap side view with key components labeled. Not to scale.

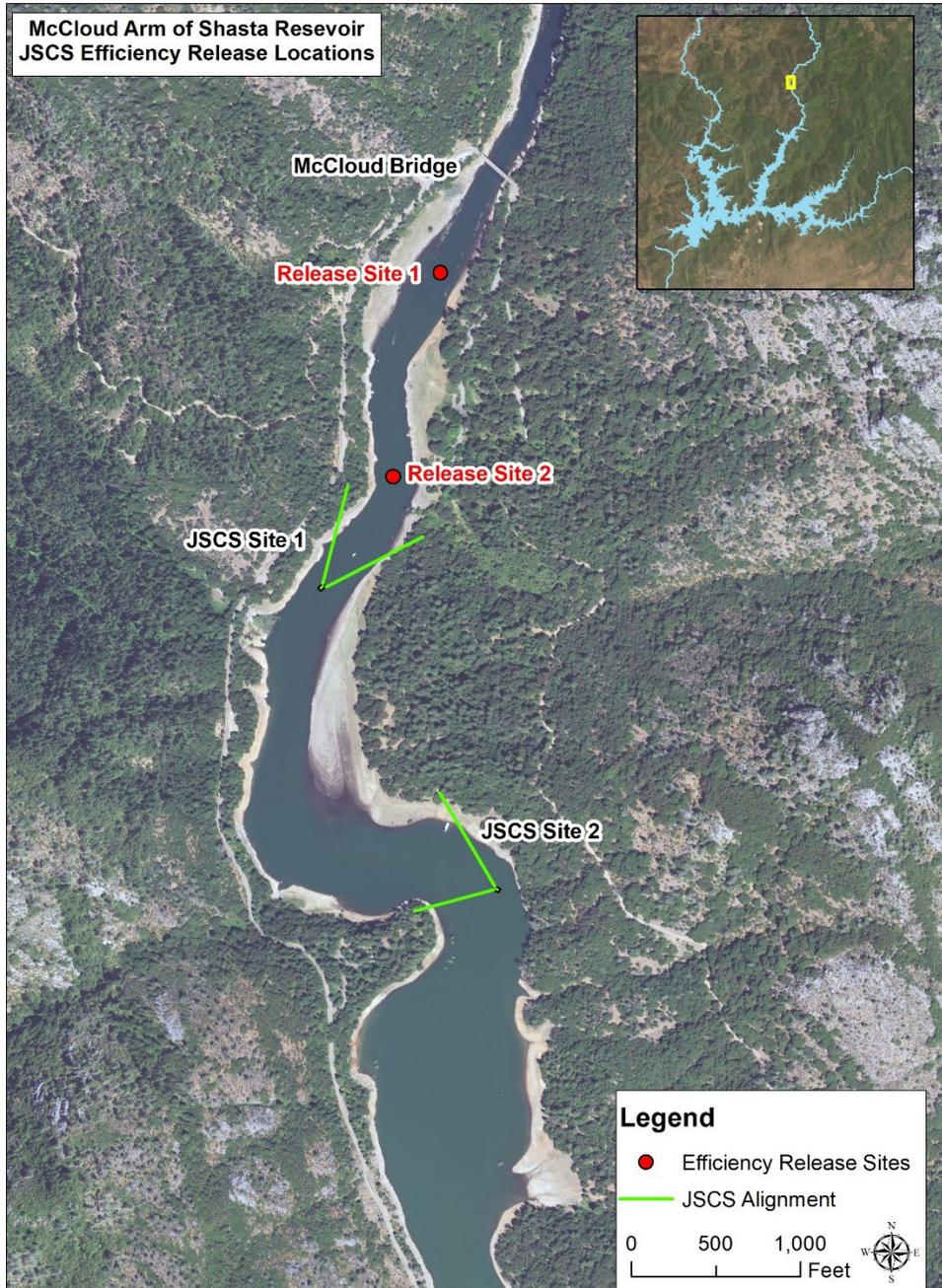
The JSCS fish trap was sampled at least once daily depending on catch and debris load. To sample the trap, the trap was closed with impermeable panels at the entrance fyke slot and the trap box fyke slot. Crews removed large debris and floating leaf litter from the trap and held debris in buckets with water for sorting. The fry box was raised with the gantry crane until it cleared the trap platform and was set across the notch. From there, the staff netted out fish and transferred them to holding containers (coolers) with adequate water quality and aeration. If conditions warranted (e.g., heavy debris load or many fish), the fry box could be raised and contents transferred to a livewell for sorting. The fry box was then lowered back into the trap and the trap box fyke closure board was removed. Crews crowded the entrance to corral any remaining fish into the trap box, and then closed the trap box off and raised the fry box again to sample the crowded fish. This was repeated until all fish were safely transferred from the trap to holding containers from which they could be identified, enumerated, and sampled.

The fish trap was cleaned of debris at least once daily; all screens and fykes were scrubbed to remove biofouling and debris. The daily structure inspection required a thorough check of all trap components daily to ensure that all is in working order.

Operating the fish trap on the JSCS required a minimum crew of three people dedicated to fish sampling-related tasks.

# Section 4: Methods for 2023 Field Operations

## 4.1: Physical Setting: Study Area



**Figure 4.1-1.** Map of 2023 Field Sites. The JSCS trap locations are at the apex of the green alignment lines. Efficiency release sites marked with red dots.

JSCS was deployed at two locations during the 2023 field season, both in the stretch of the McCloud Arm of the reservoir between Ellery Creek Campground and the McCloud Bridge Campground (**Figure 4.1-1**). Site 1 was located at coordinates 40.933331° N, -122.24886° W, directly above Kabyai Creek downstream of the McCloud Bridge Campground at William Curl's orchard. For access to the JSCS at Site 1, staff parked at Pine Point Campground and navigated a steep trail down the bank and over the exposed reservoir bed to reach the transport boat. Site 2 was located 0.55 mi downstream of Site 1 at 40.928429° N, -122.245120° W, at the Pine Point Campground river bend above Ellery Creek Group Camp and Eagle Rock. Staff accessed the transport boat from the paved lower parking lot at the Ellery Creek Campground via a footpath across the exposed reservoir bed. Both JSCS Sites were characterized by steep banks with annual grasses and flowers, mixed conifer and oak forest, and close proximity to recreational amenities and cultural resources. Sites were selected based on the hydrology, water level forecasts, and consideration of sensitive cultural resources (see **Section 2.3** Site Selection Process). The JSCS was positioned in the center of the channel aligned with the thalweg with guidance nets in a "V" position (**Figure 4.1-2**). The water level at each site consistently dropped by ~0.3 ft/day throughout the season, and conditions at Site 1 were riverine by the time the trap was moved to Site 2.



**Figure 4.1-2.** Overhead views of JSCS installed at Site 1 (left) and Site 2 (right)

#### 4.2: Installation, Relocation, and Demobilization

Staging for the initial JSCS install started on August 28, 2023. During this first week, PNP and their subcontractor brought equipment to the Hirz Bay boat ramp area for staging and set up anchoring systems for the site. During the second week, the larger components of the system, along with more equipment and materials, were brought to the staging area, the contractors began assembling and transporting the system to Site 1 via boat. The debris boom was installed first, followed by the main JSCS platform, docks, and nets, and then finally the temperature curtain, which was installed downstream of

Site 2. During this initial setup, DWR staff conducted biological monitoring and construction monitoring, while ESA staff conducted archaeological surveys and bat surveys. Prior to operating the trap, PNP provided a demonstration on how to operate the system to DWR, ESA, and the Winnemem Wintu Tribe. Communication protocols were established and radios were given to CDFW to maintain contact for coordinating fish transfer. Starlink internet was installed on the houseboat for communication beyond the field. Trap operations at Site 1 began on September 18, 2023.

Once the first site became too shallow for operations (reservoir depth approximately 6 ft), the JSCS was relocated to the second location downstream. The relocation process started on October 25. The contractors conducted the relocation by releasing the JSCS guidance nets/fish trap platform and debris boom from their anchoring systems and moving them downstream via boat. This process took approximately six days, which was longer than expected due to challenges created by retrieving dock sections and other equipment in low water levels and high velocities. Trap operations at the second site began on November 1. The JSCS was not fishing during relocation.

Staging for demobilization started on November 13 at Hirz Bay and the final day of trap operations was November 15. Once trap operations were completed, each of the system components was detached from its anchoring system and transported downstream to Hirz Bay via boat. The demobilization process was finished by November 22.

#### 4.3: Panel Adjustments

During times with low river flows and low near-field velocities, impermeable panels were lowered on top of the guidance nets to block flow through the nets and increase velocity through the trap. Blocking off parts of the guidance nets forced water to flow through the trap, increasing velocities. Each of the nine docks along the guidance nets had separate but overlapping impermeable panels, allowing for certain panels to be lowered while others remained raised. Chains were attached to the bottom of each impermeable panel to ensure that the panel would stay taut when lowered. Lines were attached along the front of the impermeable panels and threaded through mechanical winches. Winches were manually rotated to lower and raise impermeable panels.

At the first site, seven of the nine impermeable panels were initially lowered, with panels on the two docks immediately upstream of the trap left open to bleed off excess flow. This was found to produce suitable velocities through the trap for the first few weeks of deployment. However, as water levels decreased and river velocities increased over time, impermeable panels were gradually raised to bleed off more flow and reduce the load on the system. By October 16, the impermeable panels were fully raised due to average velocities of approximately 0.75 ft/s in the river and 3 ft/s within the trap. Due to very low velocities at the second site, impermeable panels were lowered to their full depth and remained completely lowered on all docks for the entirety of operations at the second site.

#### 4.4: Trap Operation Methods: Physical Component Evaluation

Prior to regular operations, DWR engineering staff checked system components to ensure that all trap elements were delivered and functioned properly. Daily structure inspections were performed to ensure that the various components of the system were functioning properly and to identify any changes from the previous day. The debris boom was inspected daily and no major debris was observed throughout the season.

Guidance nets were inspected daily and remained functional throughout the season. However, the nets experienced high levels of biofouling and formed billows when fully lowered (see **Section 4.8** Operational Issues).

The temperature curtain was regularly inspected and did not experience any major issues. The temperature curtain was deployed further downstream and had no effect on temperatures at the first site, but it had a minor effect on temperatures at the second site (see **Section 5.2d**: Effects of Temperature Curtain on Water Temperatures).

Docks along the guidance nets were inspected daily and worked well with some minor issues. When the load on the system was high during mid-October, two of the rope connections between the back portions of the docks broke and tension on the guidance net lines formed several minor indentations in the dock boards when lifting the guidance nets. The central trap platform was inspected daily and had no major issues during the season.

The fish trap worked as intended with several minor issues. First, the mechanical hoist was loud and caused vibrations, both of which may have caused stress to fish. A new electric hoist was ordered, but did not arrive until near the end of the season and will be installed in 2024. Second, leaf litter and debris accumulated overnight on vexar screens used within the trap and posed risk of impingement.

#### 4.5: Environmental Data Collection Methods

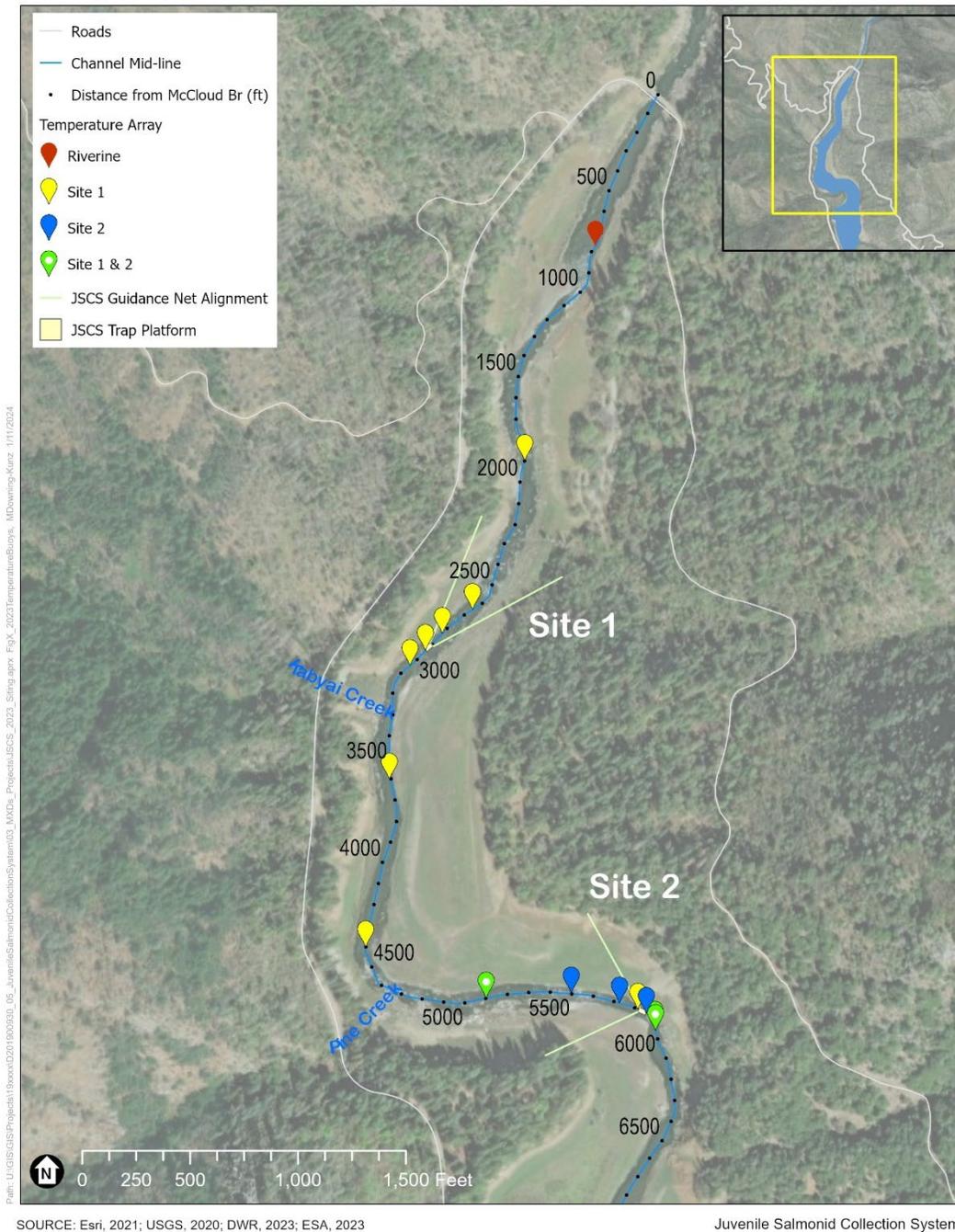
Environmental data (hydrology, water quality data, meteorological data, water velocity, structure depth, orthomosaic aerial imagery) were collected with various instruments throughout the season. Depending on the parameter being collected, data were collected daily, weekly, or continuously to evaluate the structure's effects on environmental conditions.

The JSCS was deployed in the McCloud Arm of Shasta Reservoir, which is the reservoir inundated section of the McCloud River (Winnemem Waywaket). Inflow from this river is controlled by another reservoir upstream (McCloud Reservoir), operated by Pacific Gas and Electric (PG&E), which diverts water to the Pit River watershed to generate power. River inflow affects water temperature, water velocity, and other water-quality parameters at the head of reservoir where the JSCS was deployed. River flow is measured at a gage a few miles upstream of the maximum reservoir extent operated by PG&E (CDEC Gage MSS, USGS 2023b); daily mean values of river flow were retrieved from the California Data Exchange Center.

##### 4.5a: Temperature and Water Quality

Water temperature at known depths was collected continuously using an array of electronic temperature sensors equipped with data storage. Onset sensor models MX400 and MX2201 were used with sampling frequencies of 30 minutes early in the project, revised to 15 minutes in mid-September 2023. Periodic profiles of water quality were collected approximately biweekly to understand vertical variations in water temperature and other parameters using a YSI ProDSS with calibrated sensors. For this report, only water temperature data are presented and analyzed, though water-quality profiles were used for QA/QC. Data were reviewed for accuracy and out-of-water periods were removed from the final dataset.

A map with temperature array locations and JSCS sites is presented in **Figure 4.5-1**. Note the temperature sensor labeled 'Riverine' is part of the work conducted by CDFW upstream at the in-river salmonid collection system. Only a subset of this dataset was available at the time of this writing and was used to investigate the relationship between in-river water temperatures at the in-river collection site compared to the upstream USGS gage.



**Figure 4.5-1.** Location map for water temperature arrays used in 2023 study. JSCS locations shown for Site 1 and Site 2. Continuous temperature arrays were deployed for the duration of the study.

For the period of deployment at Site 1, eleven buoys were deployed throughout the reservoir, from near the river inflow to the temperature curtain. Due to varying water depths, some buoys had more sensors than others. **Table 4.5-1** summarizes the buoys deployed during the JSCS deployment at Site 1.

**Table 4.5-1.** Summary of buoys deployed to investigate water temperature throughout the reservoir during JSCS deployment at Site 1 from before JSCS installation on September 13, 2023 until October 25, 2023. Right columns marked with “X” indicate the depths at which sensors were deployed. Sensors were deployed either relative to water surface (BWS, below water surface) or relative to reservoir bottom (HAB, height above bed). S4-4 ft BWS; S7-7 ft BWS; S13-13 feet BWS; S23-23 ft BWS; B1-1 ft HAB. Note that buoy #'s 8, 10, and 11 were also deployed at Site 2 (Table 4.6-2).

Buoy #	Distance from McCloud Bridge (feet)	Description of location	S4	S7	S13	S23	B1
1	1900	1000 feet upstream of trap at Site 1	X	X			X
2	2650	250 feet upstream of trap at Site 1	X	X			X
3	2825	75 feet upstream of trap at Site 1	X	X			X
4	2950	50 feet downstream of trap at Site 1	X	X			X
5	3050	150 feet downstream of trap at Site 1, where temperature curtain would be deployed if used at Site 1	X	X			X
6	3600	1/4 distance from initial Site 1 to relocation Site 2	X	X	X		X
7	4400	1/2 distance from initial Site 1 to relocation Site 2	X	X	X		X
8	5100	3/4 distance from initial Site 1 to relocation Site 2	X	X	X		X
9	5800	At approximate location of trap at Site 2 (before moving to Site 2)	X	X	X	X	X
10	5940	15 feet upstream of temperature curtain at Site 2	X	X	X	X	X
11	5960	30 feet downstream of temperature curtain at Site 2	X	X	X	X	X

For the period of deployment at Site 2, six buoys were deployed throughout the reservoir, from near the river inflow to the temperature curtain. Due to varying water depths, some buoys had more sensors than others. **Table 4.5-2** summarizes the buoys deployed during the JSCS deployment at Site 2.

**Table 4.5-2.** Summary of buoys deployed to investigate water temperature throughout the reservoir during JSCS deployment at Site 2 between November 1, 2023 and November 15, 2023. Right columns marked with “X” indicate the depths at which sensors were deployed. Sensors were deployed either relative to water surface (BWS, below water surface) or relative to reservoir bottom (HAB, height above bed). S4-4 ft BWS; S7-7 ft BWS; S13-13 ft BWS; S23-23 ft BWS; B1-1 ft HAB. Note that buoy #'s 1, 5, and 6 were also deployed at Site 1 (Table 4.6-1).

Buoy #	Distance from McCloud Bridge (feet)	Description of location	S4	S7	S13	S23	B1
1	5100	800 feet upstream of trap at Site 2	X	X			X
2	5500	250 feet upstream of trap at Site 2	X	X	X		X
3	5725	75 feet upstream of trap at Site 2	X	X			X
4	5900	50 feet downstream of trap at Site 2	X	X			X
5	5940	15 feet upstream of temperature curtain at Site 2	X	X	X	X	X
6	5960	30 feet downstream of temperature curtain at Site 2	X	X	X	X	X

To analyze the water temperatures along the reservoir, a longitudinal profile of water temperatures near surface (4 ft below water surface) and near bed (1 ft above bottom) was developed for all buoys for the dates shown in **Table 4.5-3**. At noon of each day shown in Table 4.6-3, the water temperature at the two sensors for each buoy was plotted as a function of distance from McCloud Bridge. The purpose of this comparison is to analyze how the vertical variation in water temperature changes along the reservoir near the JSCS.

**Table 4.5-3.** Dates, conditions, and water depths at trap for longitudinal profiles shown in Figures 5-11 and 5-12 comparing longitudinal profiles of near-surface and near-bed water temperatures.

Date	Condition	Water Depth at Trap (ft)
9/7/23	Baseline conditions prior to deployment at Site 1	18
9/14/23	1 day after JSCS installation at Site 1	15
9/21/23	8 days after JSCS installation at Site 1	13
9/28/23	15 days after JSCS installation at Site 1	12
10/5/23	22 days after JSCS installation at Site 1	10
10/12/23	29 days after JSCS installation at Site 1	9
10/19/23	36 days after JSCS installation at Site 1	7
10/25/23	42 days after JSCS installation at Site 1	6
11/2/23	1 day after JSCS installation at Site 2	28
11/9/23	8 days after JSCS installation at Site 2	25
11/16/23	13 days after JSCS installation at Site 2	24

The presence of the JSCS structure elements, specifically the guidance net (with impermeable panels) and the temperature curtain, influence conditions within the reservoir by impeding water flow. The effects of the guidance net and temperature curtain were investigated by comparing water temperature at buoys located upstream and downstream of each structure element.

For the guidance net, Buoy 3 (2825) was approximately 75 ft upstream and Buoy 4 (2950) was approximately 50 ft downstream of the center of the guidance net at trap entrance (**Table 4.5-1**). Both buoys had temperature sensors at 3 depths (**Table 4.5-1**): 4 ft below water surface (S4); 7 ft below water surface (S7); and 1 ft above the bed (B1). Note this analysis is only shown for Site 1 due to unavailability of data at Site 2. For the temperature curtain, Buoy 10 (5940) was approximately 15 ft upstream and Buoy 11 (5960) was approximately 30 ft downstream (**Table 4.5-1**). Both buoys had temperature sensors at 5 depths: 4 ft below water surface (S4); 7 ft below water surface (S7); 13 ft below water surface (S13); 23 ft below water surface (S23); and 1 ft above the bed (B1). Because the reservoir depths decreased over the deployment, the B1 sensor changed position relative to the other two sensors but remained at a constant height above the bottom of the reservoir. Assuming the locations of these sensors are equivalent for each buoy, an analysis of the difference between downstream and upstream sensors at the three depths was conducted over time.

#### 4.5b: Velocity

During the 2023 JSCS deployment, hydraulic data were collected from various locations in proximity to the JSCS structure elements to understand spatial and temporal variations in hydraulics and evaluate the effects of the JSCS on environmental conditions and fish habitat. All velocity data were collected regularly over time to observe changes in environmental conditions and effects of structure operation. Additional details are available in ESA (2023b).

The primary sources of data were the following:

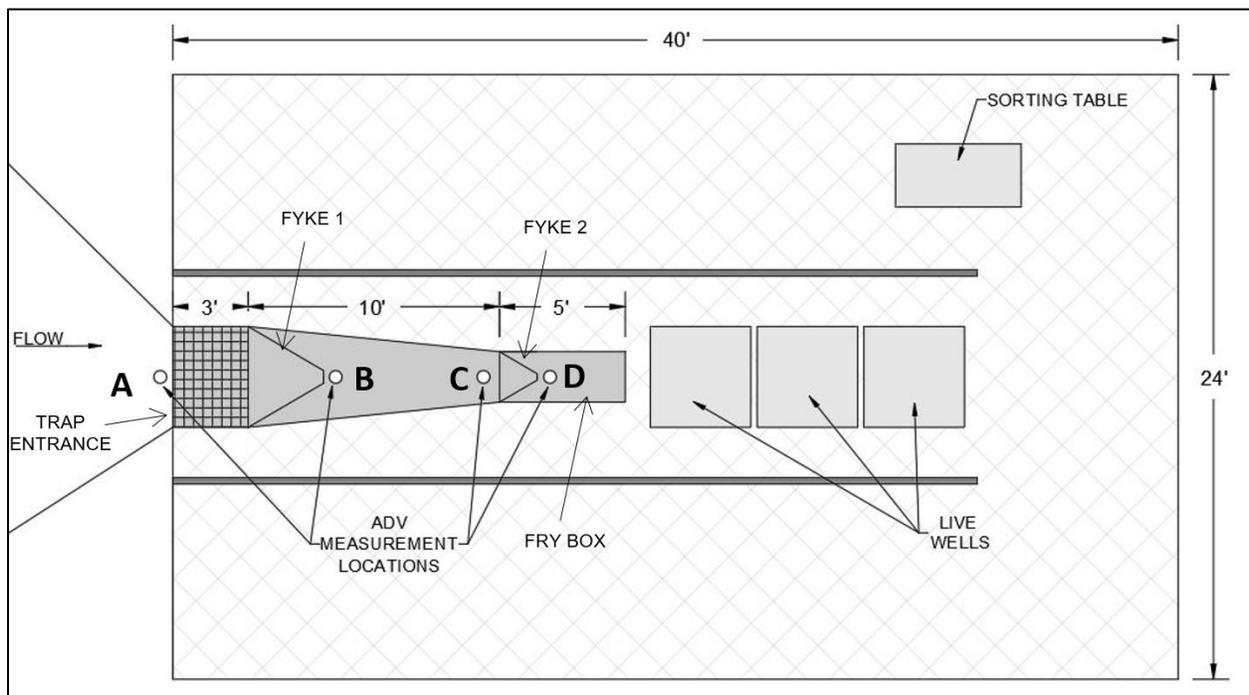
1. Velocity transects using ADCP (acoustic Doppler current profiler, Sontek M9) mounted to a shallow-draft watercraft (rQPOD Modular Remote Survey Boat).
2. Point velocity measurements along the JSCS trap inlet using a handheld ADV (acoustic Doppler velocimeter, Sontek FlowTracker 2).

The ADCP data were primarily collected in “transects” that involved starting at one position and ending at another to collect profiles of 3-D velocity data in either cross sections of the reservoir or along JSCS structure elements (e.g., along one wing of the guidance net). ADCP data were collected in cross-sectional transects prior to deployment of the JSCS at two proposed locations of the guidance net (total 2 locations). During deployment, ADCP transects were collected at approximately four cross sections from the upstream end of the guidance net to the downstream end near the trap inlet, and along both guidance net wings (total 6 locations, **Figure 4.5-2**). To ensure data quality, compass calibration of the ADCP was performed at the start of data collection, and pairs of transects were collected at each location and reviewed immediately after collection. When inconsistencies were present (e.g., total flow differed by more than 10% between the pair, poor GPS signal, etc.), a third transect was collected to determine which of the previous two was more repeatable. ADCP data were collected at boat speeds less than current velocity when possible. ADCP data were collected approximately weekly.



**Figure 4.5-2.** Aerial image of JSCS deployment at Site 1 on September 21, 2023 showing locations of ADCP-derived velocity data collection: parallel to the right and left wings of the guidance net (quantity 2) and along transects (XS1 – XS4) perpendicular to primary flow direction (quantity 4).

The ADV data were collected at discrete locations and depths to obtain point measurements of 3-D velocity to assess how velocity structure changed along the trap inlet from upstream of the trap platform to within the fry box. ADV data were collected at two depths (1 ft below water surface and 3 ft below water surface) at 2 – 4 horizontal positions along the trap inlet (**Figure 4.5-3**). At a minimum, the two horizontal positions were downstream of the first fyke at the trap inlet and downstream of the second fyke inside the fry box. Occasionally two additional locations were measured: upstream of trap inlet and platform and upstream of the second fyke. Generally, ADV data were collected in the morning prior to trap cleaning; during the start of leaf loading, additional data were collected after trap cleaning to evaluate effects of leaf loading on hydraulics. Each ADV measurement was collected for 2 minutes. ADV data were collected approximately daily. To facilitate comparison of velocities, velocity magnitude was calculated as the square root of sum of the square of each directional component (x, y, z).



**Figure 4.5-3.** Schematic of JCS trap platform from construction plans showing locations of ADV-derived velocity data collection at discrete points and depths between the upstream end of the trap platform and the fry box: A—upstream of trap platform; B—downstream of trap entrance fyke (fyke 1); C—upstream of fry box; and D—downstream of fry box entrance fyke (fyke 2) within fry box.

#### 4.5c: Meteorological Data

Meteorological data was collected continuously by a meteorological station set up near Hirz Bay. Meteorological data was collected every hour from September 5 until November 17, 2023. Specific meteorological variables that were measured include air temperature, rain, wind speed, wind direction, pressure, dew point, relative humidity, and solar radiation. Data from the weather station was downloaded weekly throughout the season.

#### 4.5d: Drone Use and Aerial Data

Aerial imagery was also collected weekly on the same day that ADCP measurements were taken. Georeferenced imagery was obtained using a DJI Phantom 3 RTK drone and a Trimble R10 base station. For each flight, the drone was flown at an altitude of 300 ft and followed a predefined flight path (**Figure 4.5-4**). Images taken during the flights were stitched together using photogrammetry post-processing software and final orthomosaics and digital elevation models were made for each weekly flight throughout the season.



Figure 4.5-4. Regional Context and Project Area for JSCS Drone Surveys.

#### 4.6: Fisheries Data Collection Methods

The JSCS fish trap was checked daily. The trap was fished overnight, closed when sampling begins first thing in the morning, and opened again at the end of trap processing. All salmon captured at the JSCS were transported to CDFW for downstream relocation and release. Weekly hook-and-line sampling provided data on predator assemblages in the vicinity of the trap. Weekly mark-recapture trials (efficiency releases) provided data on capture probability.

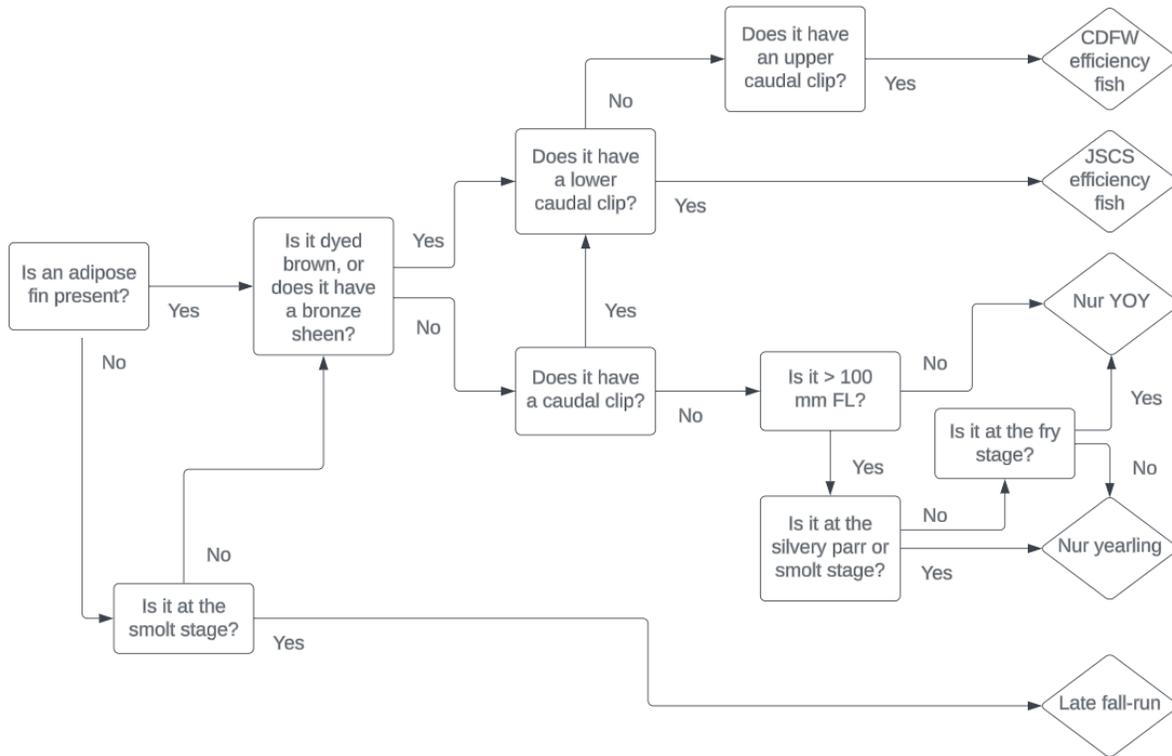
##### 4.6a: Daily Trap Operation

Methods for daily trap sampling on the JSCS followed the DWR Shasta Juvenile Salmonid Collection System: Fish Sampling Standard Operating Procedures (2023). The trap was sampled at least once daily according to the general method described in Section 3.5 Fish Trap Operations and Sampling. All species caught in the trap were identified and enumerated during trap processing; target species (salmon; predators) were held for sampling and non-target species were released downstream of the trap (**Figure 4.6-1**).



**Figure 4.6-1.** Sampling Paths for Target Fish Captured at JSCS. Note that anesthesia (bicarb) was not used for juvenile salmon sampling after October 5, 2023.

Captured salmon were individually checked to confirm species, check health status, and identify any marks (**Figure 4.6-2**). Of the day's catch, up to 50 efficiency fish (marked, hatchery-reared winter-run Chinook Salmon) and 25 Nur (unmarked, Ah Di Na-reared winter-run Chinook Salmon) were subsampled at the fish sampling station on the trap platform (**Figure 4.6-3**).



**Figure 4.6-2.** Identification key for Chinook Salmon encountered at JSCS fish trap

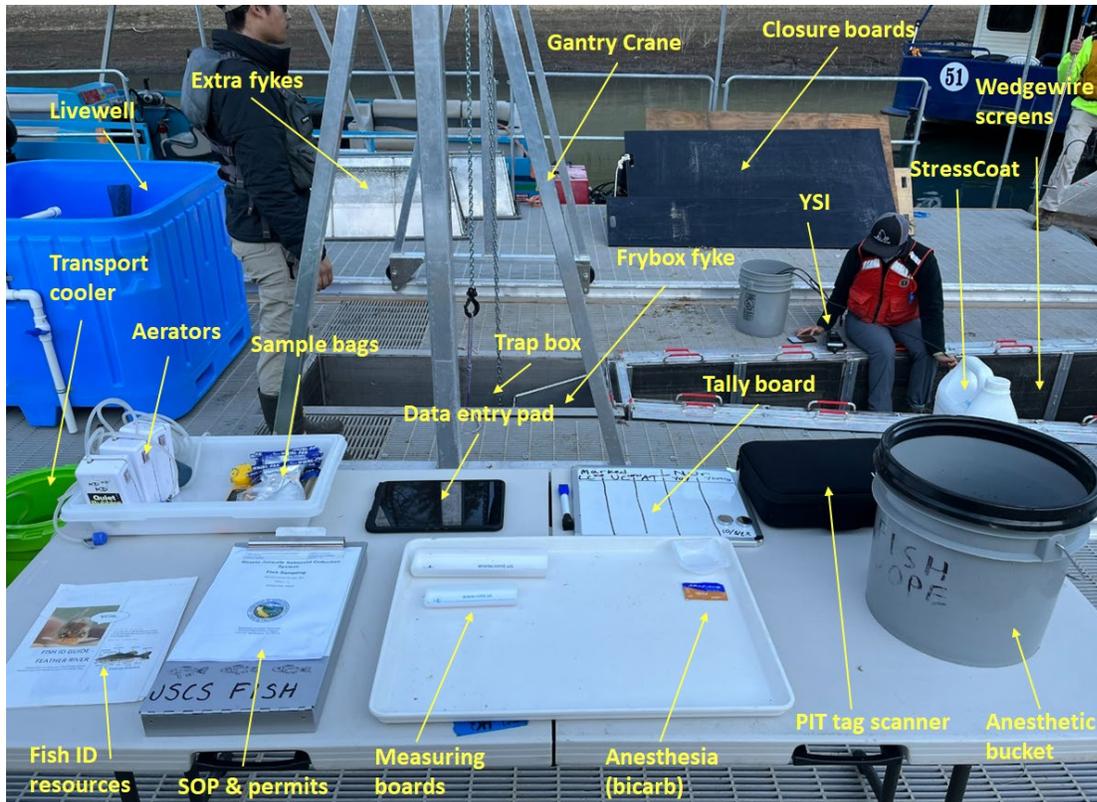


Figure 4.6-3. Fish sampling station set up on JSCS platform

Although the JSCS Scientific Collection Permit included permissions to take morphometric measurements as well as scale and tissue samples from salmon, JSCS crews only took fork length measurements during the 2023 field season. The Winnemem Wintu Tribe recommended against unnecessary handling and sampling of Nur, and DWR determined that the information about origin, age, and fitness that could be gathered by weight, scale, and tissue samples were not required to answer the priority research questions outlined in Section 2.2 Internal Planning Documents. Additionally, conditions on the floating trap platform proved too unstable to take accurate weight measurements, and most salmon were too small (<50 mm FL) to safely take scale or tissue samples from.

All live salmon were placed in transport containers and driven to shore by boat for transfer to CDFW at 1:30 PM daily, after which CDFW and the Winnemem Wintu Tribe relocated the salmon for release into the Sacramento River below Keswick Dam. Any mortalities were labeled and stored in labeled sample bags according to the Mortality Kit protocol provided by NOAA and UC Davis and submitted to CDFW concurrently.

Target predators including trout and bass species captured in the JSCS were measured and PIT tagged (if FL >75 mm) to monitor whether these fish were recaptured (i.e., found a way to pass upstream of the JSCS structure).

Starting on October 16, 2023, black bass caught in the JSCS were transferred to the custody of the Winnemem Wintu Tribe for stomach contents sampling. The Winnemem Wintu Tribe checked bass

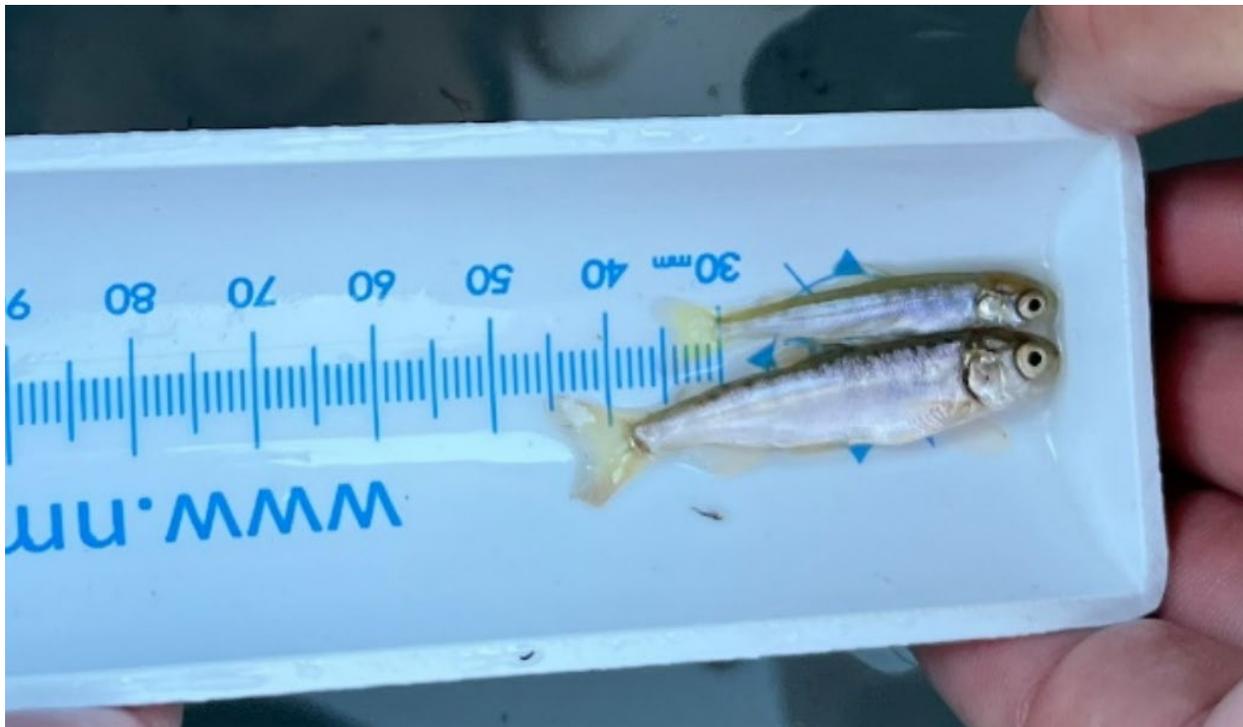
stomachs for juvenile salmon; the carcasses were identified and counted and, when intact, measured and held according to the Mortality Kit protocol.

#### 4.6b: Efficiency Trials

DWR conducted weekly mark-recapture trap efficiency trials to determine capture probability (**Table 4.6-1**). For each efficiency release, 300 juvenile winter-run Chinook Salmon (“efficiency fish”) were dual marked with Bismark brown Y dye and a caudal fin clip (Figure 4.7-4). The dual mark method with caudal fin clip was selected over a dual mark with Visual Implant Elastomer due to the limits of equipment availability, staff training, and average fish size (<45 mm FL). The marking occurred on Tuesdays, fish were allowed to recover overnight, and the fish were transported and released for mark-recapture trials on Wednesdays.

**Table 4.6-1:** Schedule of weekly efficiency trials for 2023 field season

	9/27	10/4	10/11	10/18	10/25	11/1	11/8
Fish Released	300	299	299	0	0	299	300



**Figure 4.6-4.** Unmarked Nur (above) with dual-marked efficiency fish (below) on measuring board

The efficiency releases were conducted according to the DWR Shasta Juvenile Salmonid Collection System: Fish Sampling Standard Operating Procedures (2023). Efficiency fish were transported by truck from Livingston Stone National Fish Hatchery to the McCloud Bridge Campground. The release location was approximately 0.5 mi (0.8 km) and two habitat units (riffle and glide leading into reservoir pool) upstream of the JSCS (**Figure 4.1-1**). At Site 1, the release location was directly behind the CDFW fish trap. The transport container was tempered with river water until temperatures were within 0.5 °C of

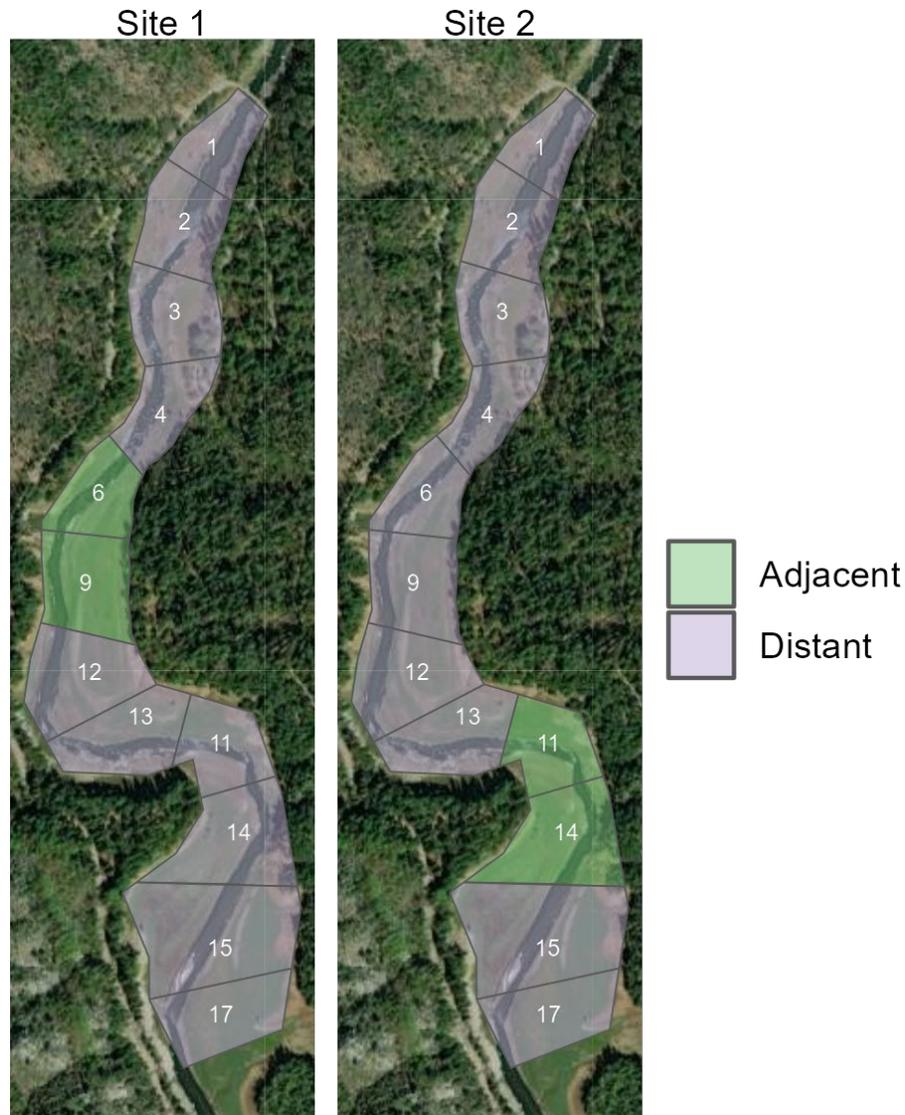
each other, at which point the fish were transferred to a holding pen in the river to acclimate. At dusk, the fish were released by a crew of two wading across the river and tipping the pen at regular intervals to evenly distribute the release across the channel and discourage schooling. The release site was then monitored for 30 minutes to observe any increase in predator activity. Most efficiency fish were recaptured within 24 hours of release. It is assumed that fish not recaptured did not survive.

#### 4.6c: Hook and Line Sampling

Weekly hook and line sampling provided additional information about the predator assemblage around the JSCS structure. Hook and line surveys were performed two days a week to evaluate relative species abundance, potential predation risk, and patterns in spatial and temporal habitat use through the analysis of Catch Per Unit Effort (CPUE). Hook-and-line surveys were implemented before and after the installation of the JSCS.

Sampling was conducted within 16 total areas, consisting of eight control and eight treatment areas. Test areas were located within the anticipated JSCS zone of influence, under 500 meters upstream and downstream from the trap location. Control areas were located both 500 meters upstream and downstream of the zone of influence. Each zone was approximately 250 meters long as measured from the river center (**Figure 4.6-5, Figure 4.6-6**). The footprint of the project was planned to move within the sampling season based on depths and water levels. For each planned move, four treatment zones (2 upstream and 2 downstream) were identified within the anticipated JSCS zone of influence and four control zones were identified (2 upstream and 2 downstream) outside of the 500 meter zone of influence. In 2023, the temperature curtain was installed at Site 2 for the entire season. Therefore, for Site 1, no control zones were analyzed below the temperature curtain.

On sampling days (Saturday and Sunday weekly), one control site and one treatment site were based on a randomized schedule depending on trap location. Sampling was conducted for 2 hours within each zone to standardize effort. Each area was fished methodically to cover all habitat features that may hold predatory fish species (JSCS structure elements, woody debris, rocky substrate, drop-offs, points). Anglers used artificial lures ranging in size (2-5 inches in length) to mimic juvenile salmonids. Anglers were allowed to choose their own bait/lure and fishing techniques without standardization. Once a fish was landed, the fish was sampled for morphometrics and tagged with a PIT tag then immediately released into the river.



**Figure 4.6-5.** Map of hook and line sampling treatment (adjacent) and control (distant) zones

#### 4.6d: Traditional Ecological Knowledge, Western Fisheries Science, and Salmon Sampling

Protocols for salmon sampling differ significantly between Winnemem Wintu traditional ecological knowledge and western scientific fisheries methods. Winnemem Wintu traditional ecological knowledge centers relationships with salmon and the maintenance of multispecies kinship networks (McLeod 2001; Zedler and Stevens 2018; Woelfle-Hazard 2022) where western science prioritizes the collection of numeric data to quantify ecological phenomenon (Smith 1990; Scott 1998). This difference became most apparent in divergent approaches to salmon handling: standard scientific methods in western fisheries sampling includes netting the fish, anesthetizing it, sampling it for length and weight, taking scale or genetic samples, and conducting surgery to mark the fish or implant a tag. The Winnemem Wintu Tribe asserts that this kind of handling decreases the wildness of Nur, causes stress to juveniles, and adversely affects the overall fitness of salmon. The Winnemem Wintu Tribe recommended not anesthetizing salmon during the JSCS field season and encouraged DWR to adopt sampling methods that minimized

handling time. In response, DWR changed JSCS sampling protocols to stop anesthetizing fish for handling and reduced the scope of salmon handling to fish identification and fork length measurement only. NOAA and UC Davis are working in collaboration with the Winnemem Wintu Tribe to develop methods for fork length measurement that do not require netting or measuring boards for the 2024 field season.

#### 4.7: Operational Issues

Unforeseen operational issues posed minor and major challenges to the safe and successful completion of the 2023 field season. The boat gates were difficult to open without the pushing force from a moving boat and one of the gates became inoperable due to the attached guidance net forming billows as the water level dropped, causing the gate to lean dramatically. The radios used for communication with CDFW staff did not reach the entire distance from the upstream trapping location to the JSCS, resulting in a lack of communication for part of each day. The gantry crane installed to raise and lower the fry box and fykes in the JSCS fish trap created vibrations and loud noise, which plausibly contributed to increased handling stress. Several instrumentation issues occurred as well throughout the season: several temperature sensors became waterlogged and stopped recording data and the temperature buoys upstream of the JSCS became inaccessible for retrieval by boat when water levels became too shallow. Finally, the Exo sonde collecting continuous water quality data at the trap malfunctioned at the second site and stopped recording data. Considering these issues during planning for the 2024 field season can help ensure safe trap operation and successful data collection.

##### 4.7a: Dropping Water Levels

Two significant operational issues arose as water levels dropped at Site 1. First, the guidance nets formed billows as the force of the water against the impermeable panels bowed the net and panels out to behind the docks. This became noticeable in mid-October when velocities upstream of the JSCS were very high. When this was observed, staff engineers tightened the guidance nets using the attached winches, but this was challenging due to the high forces pushing against the nets and a lack of underwater visibility to assess the positioning of the nets. Over-tightening the nets would have resulted in the chains on the bottom of the nets being lifted off the bottom of the reservoir. If the hydraulic forces on the nets are greater than the force exerted by the weight of the chains on the nets, then the entire guidance net will remain off the bottom and fish may pass beneath the guidance net. Visual observations were made of fish in the billows, but staff were not able to confirm any injuries or mortalities.

Second, the docks on the ends closest to the banks at Site 1 became beached as water levels dropped. This was particularly noticeable for the right-most dock, which was almost entirely out of water by the time the relocation process began. As a result, the relocation took longer than expected as these docks had to be lifted back into the water for transport. This caused some bank disturbance and created some minor tears in the impermeable panels below these docks.

##### 4.7b: Debris

The fyke at the entrance to the fry box was fit with different large fish/predator exclusion devices at different points during the field season, including closely spaced wooden dowels (intended to mimic willows) and vexar netting. In conditions with higher trap velocities and increased debris loads, leaf litter collected at the fyke entrance and contributed to crushing injuries. To mitigate this, DWR increased the

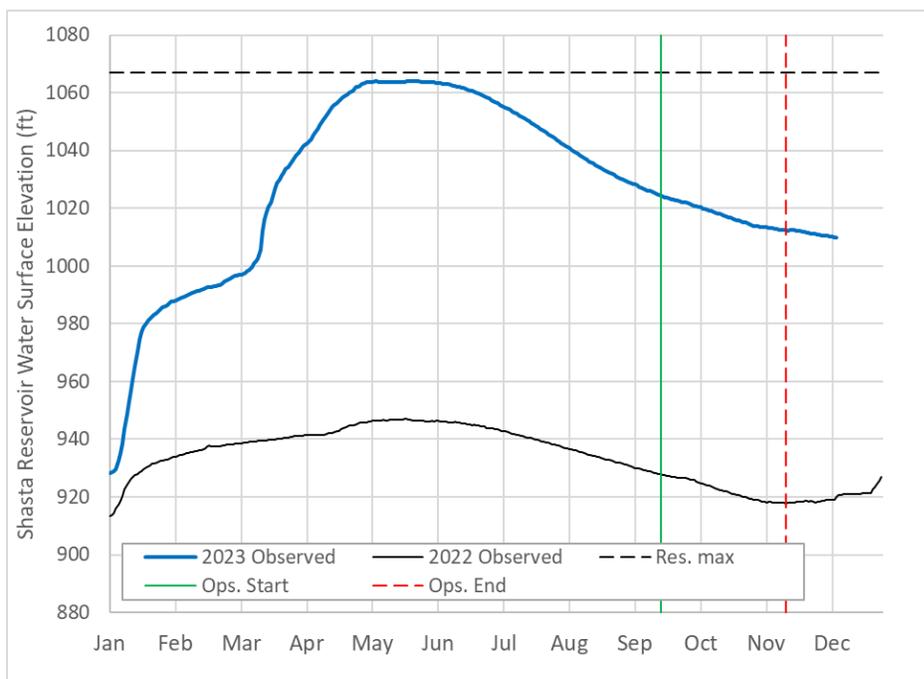
frequency of trap cleaning, and if injury persisted the next day, replaced the exclusion device with a more open configuration (e.g., greater spacing between dowels or a larger size vexar).

## Section 5: Results and Observations

### 5.1: Hydrology and Water Surface Elevation (WSE)

After a particularly dry 2022, the winter of 2023 had above-average precipitation that caused Shasta Reservoir to reach a WSE near its full capacity at 1067 ft (**Figure 5.1-1**). Comparison of WSE in 2022 and 2023 is shown visually in Figure 5.1-1; comparison of important dates related to the JSCS project is presented in tabular form in **Table 5.1-1**. Start and end dates of JSCS 2022 Project operations were the same as for 2023. The difference in WSE at the start of JSCS project operations between 2022 and 2023 was nearly 100 feet (96.6 feet, Table 5-1). Over the JSCS deployment, reservoir WSE decreased approximately 12 feet in 2023 and 10 feet in 2022 (Table 5-1).

For 2023, reservoir WSE and bathymetry data, along with on-site reconnaissance, were used to determine placement of the JSCS structure at 2 locations in the reservoir. During installation at the initial siting location, the reservoir was slightly (1 – 3 feet) deeper than expected, owing to several issues such as unexpected discrepancies between bathymetry data and actual bed locations as well as vertical datum inconsistencies. Prior to the start of the 2023 season, the project team assumed that forecasted reservoir levels were referenced to the NAVD 88 datum, which is the vertical datum used for most modern surveying efforts. However, USBR uses the NGVD 29 vertical datum for reservoir forecasting and real-time data reporting, which is approximately 2-3 feet lower than NAVD 88. For consistency, WSE in all figures in this report are referenced to the NGVD 29 vertical datum. In the future, during on-site reconnaissance, a systematic review and check of actual bed elevation, depths, and WSE compared to existing data sets is recommended.

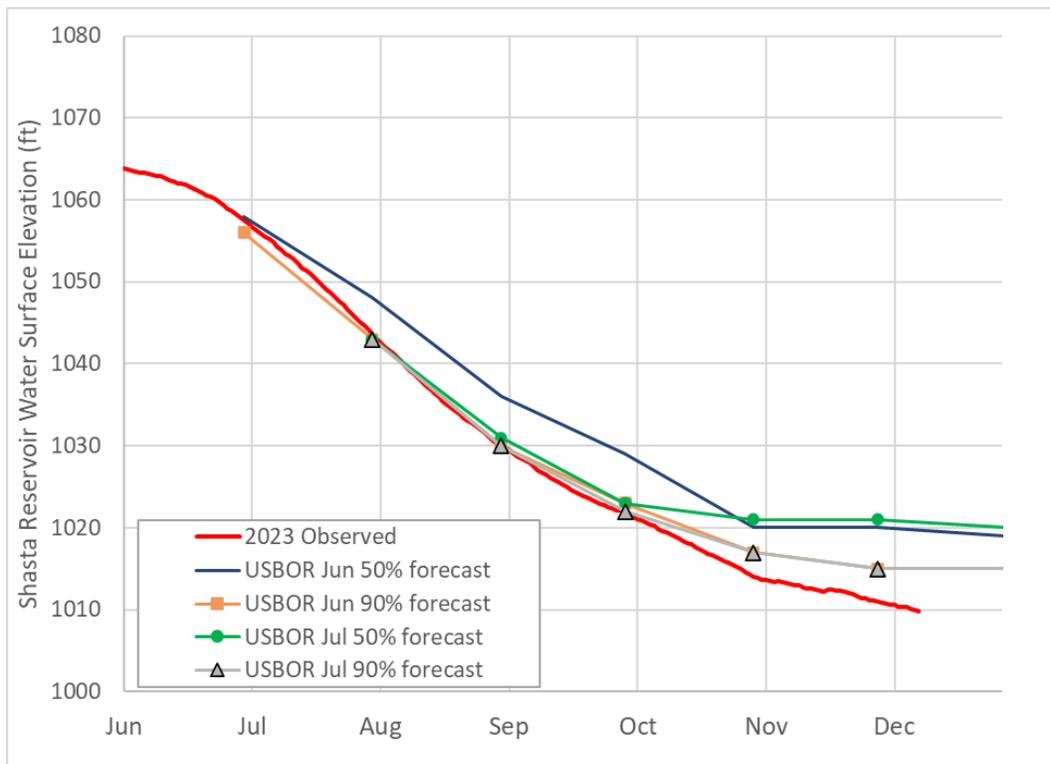


**Figure 5.1-1.** Time series of daily WSE in Shasta Reservoir as reported by USBR (CDEC SHA) for January 1, 2023 – December 10, 2023 and January 1, 2022 – December 31, 2022. Start (September 18, 2023) and end (November 16, 2023) dates of JSCS 2023 Project operations (Ops.) indicated by vertical lines.

**Table 5.1-1.** Comparison of WSE in Shasta Reservoir for 2022 and 2023 at important dates during the project: start of installation; start of operations (end of installation); and end of operations. Change in WSE over operations period computed as difference in WSE from start of operations and end of operations; negative values indicate a decrease in WSE over time.

Project year	Start of installation WSE (ft)	Start of operations WSE (ft)	End of operations WSE (ft)	Change in WSE over operations period (ft)
2022	930.0	927.8	917.9	-9.9
2023	1028.4	1024.4	1012.5	-11.9

June and July forecasts from the USBR were considered during the JSCS siting planning phase because these were the available forecasts in early August 2023. As seen in **Figure 5.1-2** and **Table 5.12**, the July 2023 90% forecast issued by USBR was quite accurate approximately 2 months into the future, until approximately September 30, 2023. As seen in **Table 5.1-2**, reservoir WSE was not well-predicted by the 50% forecasts in 2023. That the 90% forecasts performed better suggests the reservoir was operated as for dry conditions despite the wet winter and the peak reservoir WSE reaching near maximum capacity. The April 90% forecast was relatively accurate during July through September (**Table 5.1-2**) but was not accurate for May and June. For 2023, the July 90% forecast was sufficient for installation of the JSCS at the initial site. Because the forecasts continue to be updated in subsequent months, refinement of expected WSE was done with subsequent forecasts during JSCS deployment.



**Figure 5.1-2.** Retrospective 2023 time series of performance of USBR June and July 2023 forecasts compared to observed data. Observed WSE shown for the period June 1, 2023 – December 10, 2023.

**Table 5.1-2.** Comparison of USBR WSE forecasts in Shasta Reservoir for 2023 by month of issue (columns). Observed WSE is actual WSE on the date shown. Italicized rows indicate range of time during which JSCS was installed and operations began.

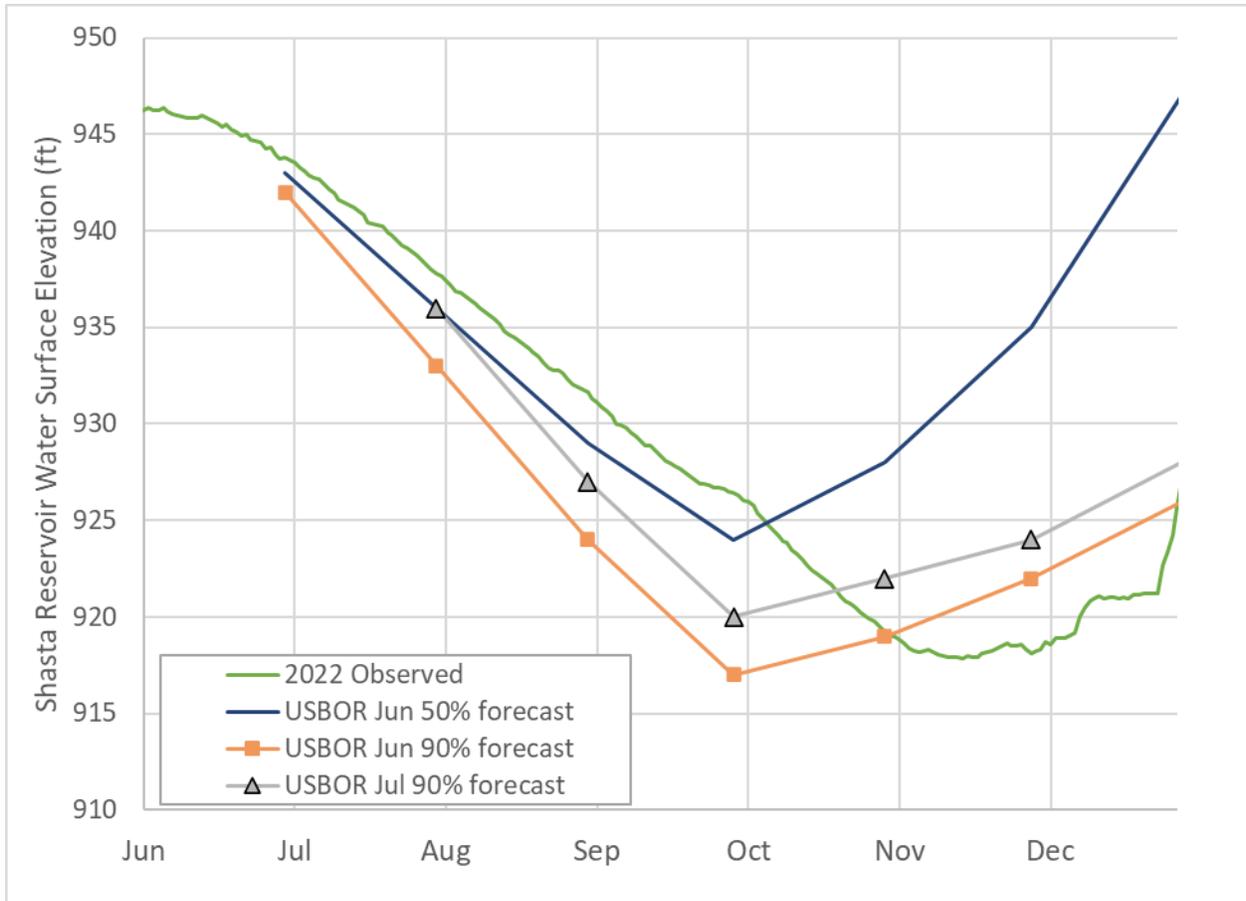
Date	2023 WSE (ft) forecast by month of issue										Observed WSE (ft)	
	Apr 90%	Apr 50%	May 90%	May 50%	Jun 90%	Jun 50%	Jul 90%	Jul 50%	Aug 90%	Aug 50%		
4/30/2023	1061	1061										<b>1062.9</b>
5/31/2023	1060	1062	1061	1062								<b>1063.8</b>
6/30/2023	1055	1053	1054	1056	1056	1058						<b>1057.5</b>
7/31/2023	1043	1039	1042	1045	1043	1048	1043	1043				<b>1043.7</b>
8/31/2023	1030	1026	1027	1032	1030	1036	1030	1031	1028	1028		<b>1029.9</b>
9/30/2023	1021	1018	1020	1023	1023	1029	1022	1023	1020	1020		<b>1021.9</b>
10/31/2023	1016	1011	1014	1015	1017	1020	1017	1021	1013	1017		<b>1014.1</b>
11/30/2023	1015	1013	1014	1016	1015	1020	1015	1021	1011	1017		<b>1011.0</b>
12/31/2023	1017	1018	1015	1020	1015	1019	1015	1020	1011	1016		<b>1012.6</b>

**Table 5.1-2 (continued).** Performance of USBR WSE forecasts in Shasta Reservoir for 2023 by month of issue (columns) as compared to observed WSE on date of forecast. 90% and 50% forecasts explained in text. Italicized rows indicate range of time during which JSCS was installed and operations began.

Date	2023 Predicted – Observed (ft)									
	Apr 90%	Apr 50%	May 90%	May 50%	Jun 90%	Jun 50%	Jul 90%	Jul 50%	Aug 90%	Aug 50%
4/30/2023	-1.9	-1.9								
5/31/2023	-3.8	-1.8	-2.8	-1.8						
6/30/2023	-2.5	-4.5	-3.5	-1.5	-1.5	0.5				
7/31/2023	-0.7	-4.7	-1.7	1.3	-0.7	4.3	-0.7	-0.7		
8/31/2023	0.1	-3.9	-2.9	2.1	0.1	6.1	0.1	1.1	-1.9	-1.9
9/30/2023	-0.9	-3.9	-1.9	1.1	1.1	7.1	0.1	1.1	-1.9	-1.9
10/31/2023	1.9	-3.1	-0.1	0.9	2.9	5.9	2.9	6.9	-1.1	2.9
11/30/2023	4.0	2.0	3.0	5.0	4.0	9.0	4.0	10.0	0.0	6.0
12/31/2023	4.4	5.4	2.4	7.4	2.4	6.4	2.4	7.4	-1.6	3.4

Similar to 2023, June and July forecasts from the USBR were considered during the JSCS siting planning phase because these were the available forecasts in early August 2022. Comparison of USBR forecasts to

actual observations in 2022 are presented in **Figure 5.1-3** and **Table 5.1-3**. In contrast to 2023, the July 2022 forecast issued by USBR was much-less accurate; 2 months into the future the forecast was approximately 7 feet lower than observed (Figure 5.1-3). As seen in Table 5.1-3, the 90% forecast did not perform well for April through June 2022. For 2022, the June 50% forecast was better suited to planning but was still 2 feet lower than observed. A forecasted WSE lower than observed is useful for a conservative estimate but must be used cautiously, particularly when deploying the JSCS in shallower waters. For planning activities that necessarily occur prior to deployment, pairing USBR forecast with observed WSE is essential, along with developing WSE projections that span the range of plausible conditions (i.e., the low and high end of WSE forecasts).

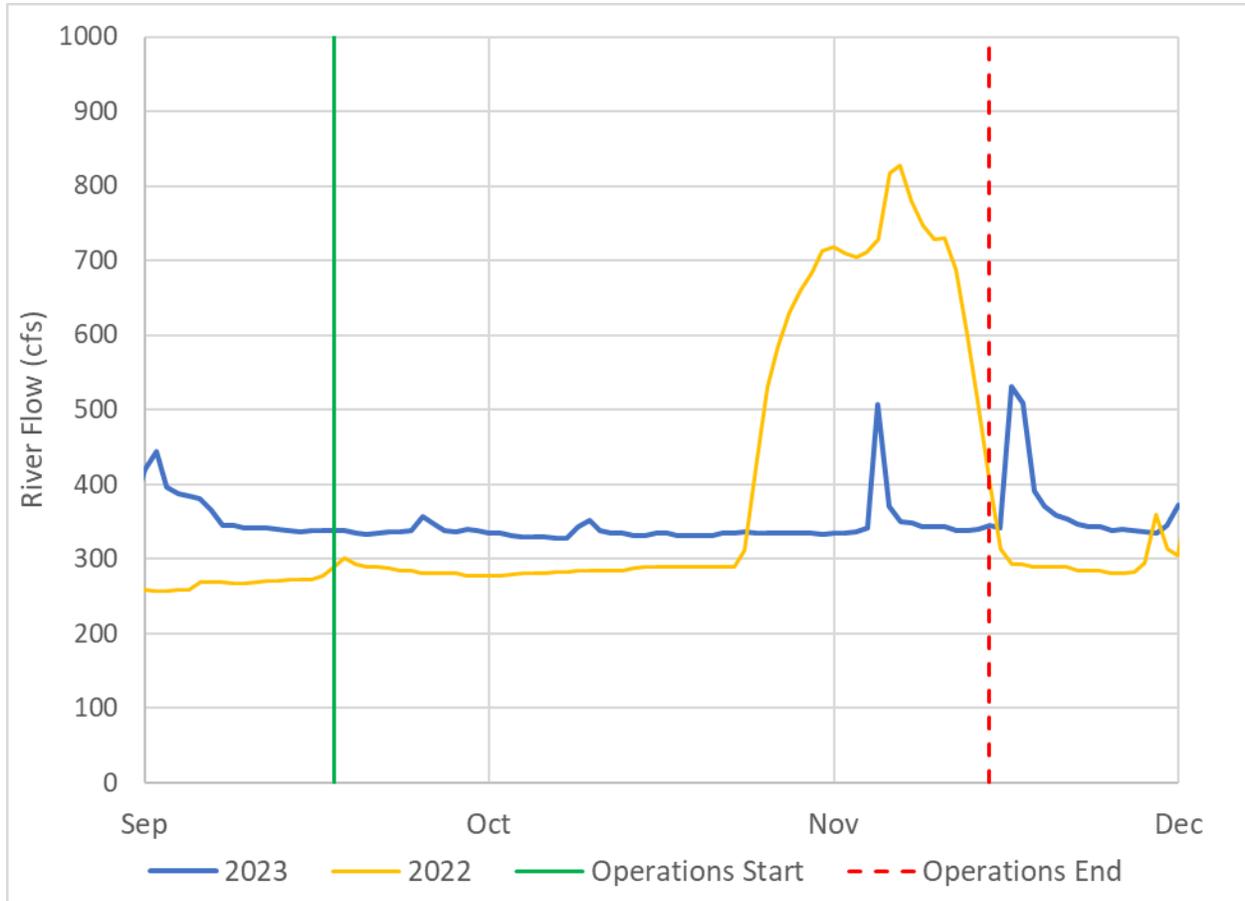


**Figure 5.1-3.** Retrospective 2022 time series of performance of USBR June and July 2022 forecasts compared to observed data. Observed WSE shown for the period June 1, 2022 – December 20, 2022. Note the July 50% forecast was not available.

**Table 5.1-3.** Comparison and performance of USBR WSE forecasts in Shasta Reservoir for 2022 by month of issue (columns). Observed WSE is actual WSE on the date shown. *Italicized rows indicate range of time during which JSCS was installed and operations began. Note fewer 50% forecasts were available in 2022.*

Date	2022 WSE (ft) forecast by month of issue					Observed WSE (ft)	2022 Predicted - Observed				
	Apr 90%	May 90%	Jun 90%	Jun 50%	Jul 90%		Apr 90%	May 90%	Jun 90%	Jun 50%	Jul 90%
4/30/2022	942					<b>945.8</b>	-3.8				
5/31/2022	935	944				<b>946.2</b>	-11.2	-2.2			
6/30/2022	927	937	942	943		<b>943.8</b>	-16.8	-6.8	-1.8	-0.8	
7/31/2022	917	929	933	936	936	<b>937.8</b>	-20.8	-8.8	-4.8	-1.8	-1.8
8/31/2022	906	919	924	929	927	<b>931.6</b>	-25.6	-12.6	-7.6	-2.6	-4.6
9/30/2022	897	912	917	924	920	<b>926.5</b>	-29.5	-14.5	-9.5	-2.5	-6.5
10/31/2022	897	912	919	928	922	<b>919.2</b>	-22.2	-7.2	-0.2	8.8	2.8
11/30/2022	896	911	922	935	924	<b>918.1</b>	-22.1	-7.1	3.9	16.9	5.9
12/31/2022	895	910	926	947	928	<b>927.1</b>	-32.1	-17.1	-1.1	19.9	0.9

During 2023 JSCS operations there was little fluctuation in river inflow (**Figure 5.1-4**) and the average daily inflow was 340 cfs. In contrast, during 2022 JSCS operations, river inflow was relatively constant (average: 285 cfs) until the second half of the deployment when a flow pulse occurred with a peak magnitude of 827 cfs that lasted 23 days (Figure 5.1-4).

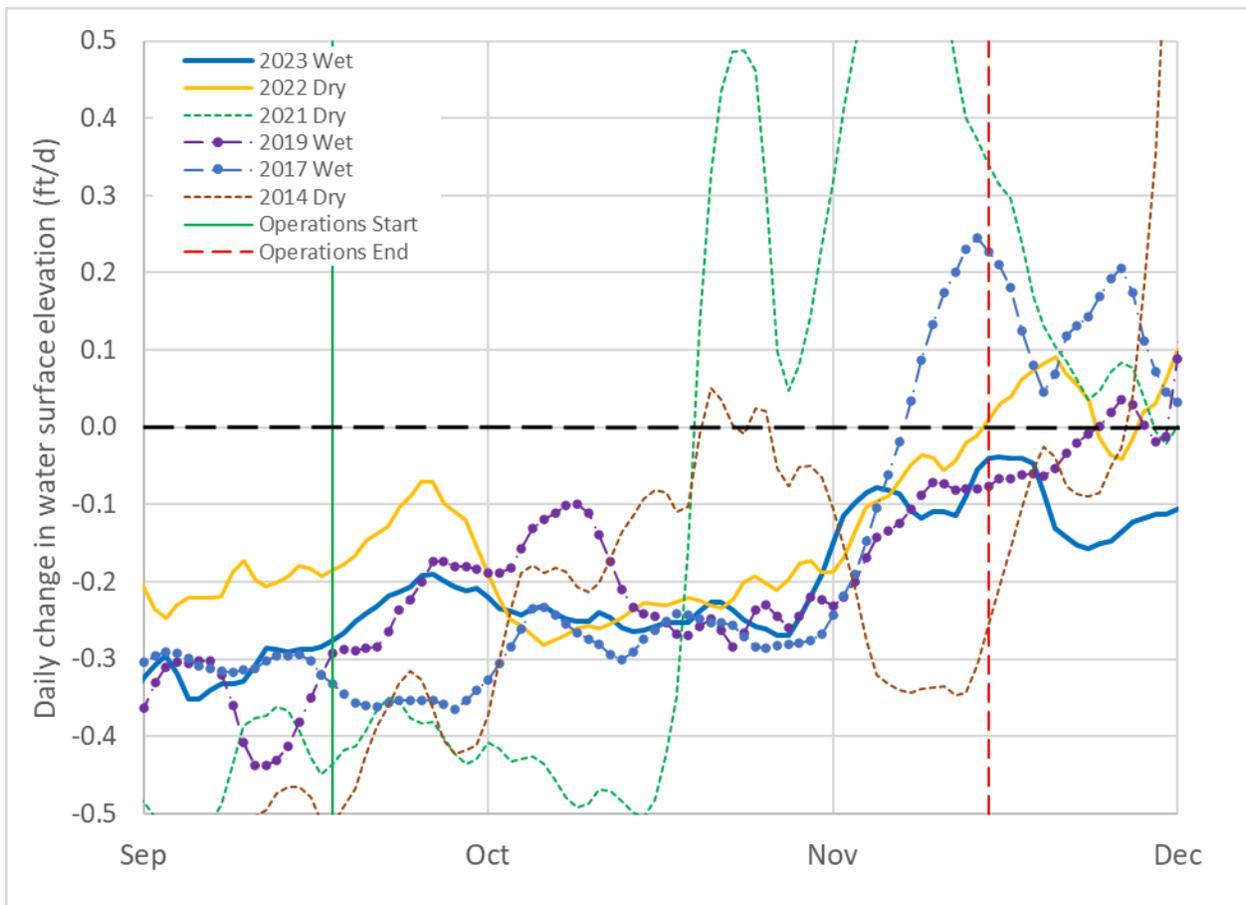


**Figure 5.1-4.** Time series of river flow upstream of JSCS in McCloud River (*Winnemem Waywaket*) as measured at USGS Gage 11368000 (CDEC MSS) for September 1 – December 1 in 2022 and 2023.

Shasta Reservoir WSE changes in response to inflows and outflows. The change in WSE affects JSCS operations by altering water depths and widths at fixed locations and altering the proximity to the river upstream. Typically, the reservoir fills in the winter and spring months in response to precipitation and empties in the summer and fall months in response to human demands for water in a period of little-to-no precipitation. Thus far, JSCS operations have commenced in the fall during the cyclical decrease in WSE. Figure 5.1-5 shows the daily change in WSE computed as the average of the difference in WSE from subsequent day minus previous day, with a 7-day moving average applied to smooth data. The dashed horizontal line at zero differentiates periods for reservoir losing water (rate of change less than 0) from periods for reservoir gaining water (rate of change greater than 0). In 2023, change in WSE was generally negative (i.e., WSE decreasing each day) and the amount of change of WSE decreased over the deployment (Figure 5.1-5), ranging from about -0.4 ft/d on October 8, 2023 to about 0.05 ft/d on November 6, 2023.

Looking ahead to future years of JSCS deployment in Shasta Reservoir, a qualitative comparison of change in reservoir WSE was performed for two reservoir conditions: near-maximum WSE and very-low WSE (Figure 5-7). Years 2017, 2019, and 2023 were hydrologically wet and Shasta reservoir WSE reached near-maximum during the year. Years 2014, 2021, and 2022 were hydrologically dry and are the three years with lowest Shasta reservoir WSE in the period of record. Comparing rates of change in WSE during the fall months when JSCS has been deployed (Figure 5.1-5), large variability is seen but some

general trends are apparent. During September and the first half of October, WSE change was always negative (i.e., reservoir losing water and WSE decreasing over time). For all years considered, the magnitude of WSE change during September to mid-October varied from -0.5 feet per day (ft/d) in 2014 to -0.07 ft/d in 2022. For most years considered, the reservoir WSE rate of change decreases beginning in mid-October. Precipitation in late-fall or early-winter can lead to near-zero, meaning the reservoir is no longer losing water or is gaining water, or even positive daily change in WSE. Given the unpredictability of precipitation during this period, it is difficult to predict when the daily change in WSE will become near-zero or positive, but historical data suggest this may occur by mid-November (Figure 5.1-5). If the amount of WSE increase exceeds the allowable range of the JSCS guidance net, a relocation upstream may be required. Hydrologically dry years (2014, 2021, 2022) have greater variability in daily WSE change than hydrologically wet years (2017, 2019, 2023, Figure 5-7). Thus, consideration of the allowable deployment depths for the JSCS structure, the timing and duration of JSCS deployment, and hydrologic conditions are necessary.



**Figure 5.1-5.** Time series of daily change in WSE in Shasta Reservoir as reported by USBR (CDEC SHA) for September 1, 2023 – December 1, 2023.

In summary, Shasta reservoir WSE is a dominant control on JSCS siting but is inherently difficult to predict. USBR forecasts, specifically those issued in July, offer some understanding of probable conditions but are limited in utility. In future deployments, waiting until the June USBR forecast is issued in late June to initiate siting plans would be more efficient. Siting planning should be finalized with the USBR July forecast and accompanied by a field effort to ground-truth existing bathymetry data. Based on

prior years, the USBR July forecast is issued in late July. Based on 2022 and 2023 data, the USBR July forecast is reasonably predictive for Shasta Reservoir conditions through mid- to late-September. Depending on when the JSCS is installed, historical WSE rate of change data as presented in this report can help understand anticipated changes in WSE during the deployment.

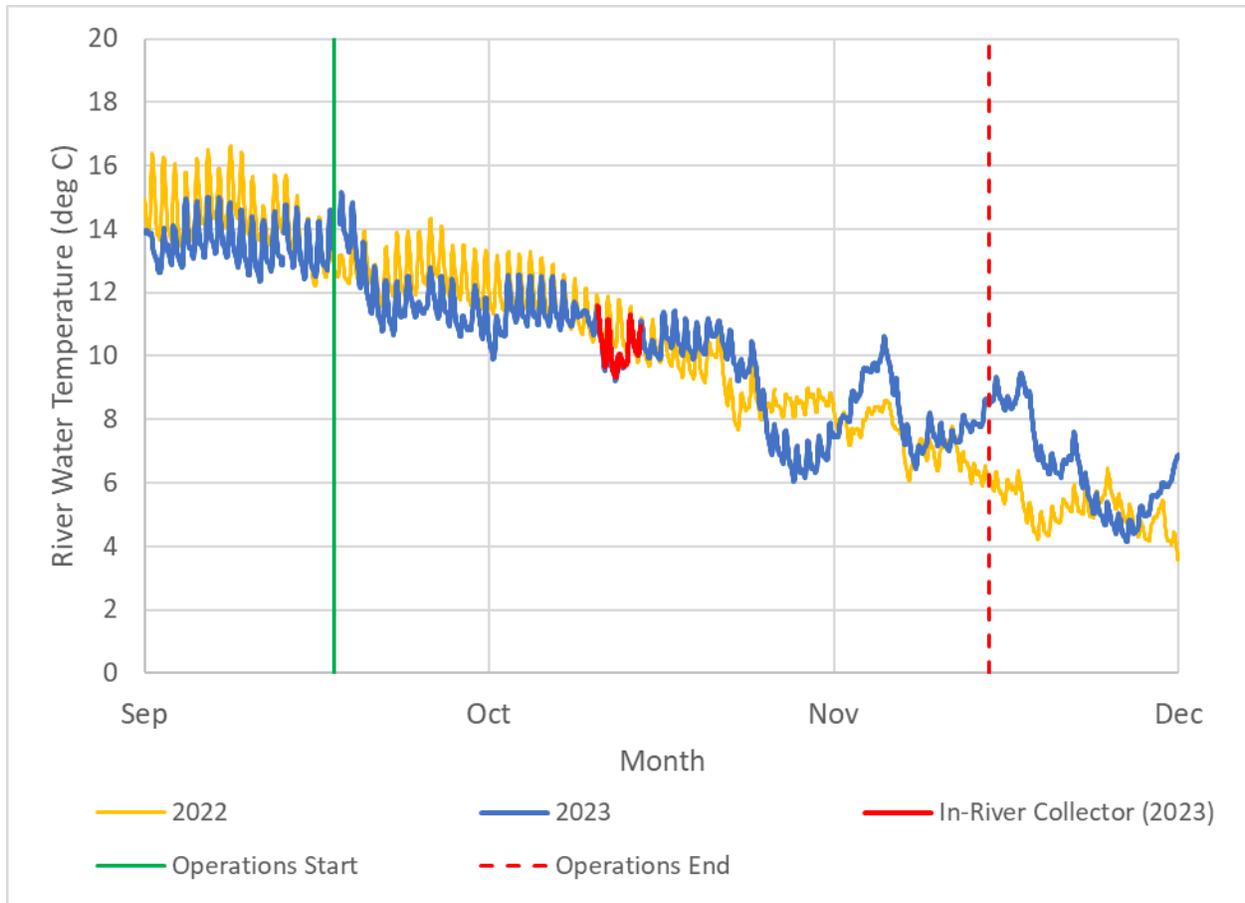
## 5.2: Water Temperatures

Vertical variation in water temperature is a function of depth, time of year, and roughness. In this case, depth is a proxy for location relative to the river-reservoir interface and the presence of JSCS structure elements in the water introduces roughness. The data collected in 2023 show stratified conditions persist throughout the reservoir arm at the deeper locations and that the presence of JSCS structure elements affects the stratification. At both JSCS sites, water temperatures and velocities in the reservoir were stratified prior to guidance net installation and the addition of the guidance net structure reduced this stratification immediately upon installation (**Figure 5.2-5**; see also **Section 5.3a**). Despite the elimination of stratification upstream of the guidance net, downstream of the trap platform remained stratified which gave rise to stratified temperatures within the fry box at Site 1 for the first 10 days of operation (**Figure 5.2-5**). Considering that water depth in the fry box is only 4.5 ft deep, large top-bottom variations in temperature can indicate a limited volume for which any captured fry can find cool temperatures.

In summary, water temperature in the reservoir was affected by the presence of JSCS structure elements. The presence of the temperature curtain in the reservoir was associated with cooler temperatures upstream of the temperature curtain for depths from near surface to mid depth. The temperature curtain thus provides a mechanism to cool the reservoir directly upstream, but may require a longer time period to set up the cooler temperatures depending on where the curtain is located relative to the river. Considering the need to deploy the JSCS at moderately shallow (12 – 20 ft) depths, if the JSCS is installed in September, a temperature curtain could support cooler water temperatures in the fry box during mid-to-late September. Note however that the temperature difference between upstream and downstream of the temperature curtain in 2023 at the depths relevant to the fry box (i.e., S4 and S7 in **Figure 5-15**) took time to develop and was only about 0.5 – 2 °C during September. Note this is a conservative scenario that assumes low inflow conditions from the river upstream and the typical hot air temperature and sunny conditions during September. Alternatively, if deployment is delayed until October, or if an even-shallower (8 – 12 ft) JSCS structure is installed, the temperature curtain would likely not be necessary. Future deployments can use the data and analysis here to improve the JSCS design.

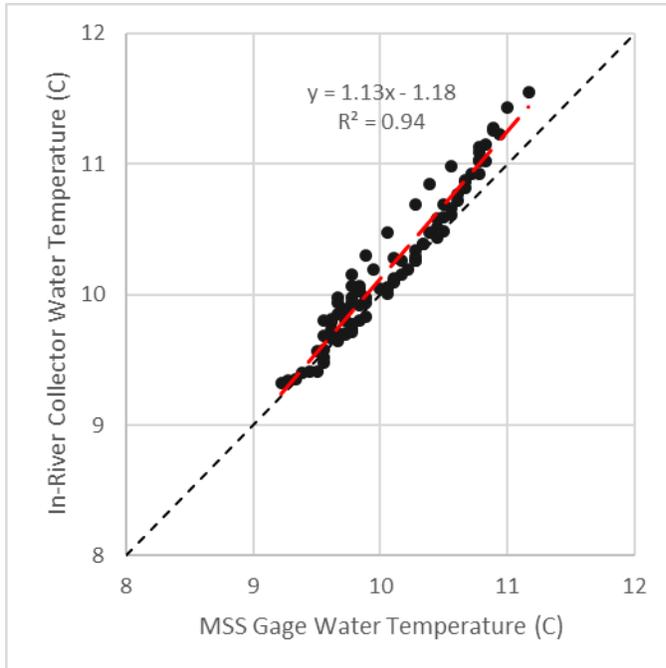
### 5.2a: River Temperatures

During 2023 JSCS operations there was a decreasing trend in river temperature with diurnal variability and minimal variation between 2022 and 2023 JSCS operations (**Figure 5.2-1**). During 2023 operations, the average river temperature over the deployment was 10.0 °C; river temperature at the start and end of operations was 14.0 °C and 8.6 °C, respectively. Similarly, for 2022 JSCS operations, the average river temperature over the deployment was 10.2 °C; river temperature at the start and end of operations was 13.4 °C and 6.1 °C, respectively (**Figure 5.2-1**).



**Figure 5.2-1.** Time series of water temperature in the river upstream of JSCS (McCloud River, *Winnemem Waywaket*) as measured at USGS gage 11368000 (CDEC MSS) for September 1 – December 1 in 2022 and 2023.

Water temperature data were collected at the CDFW in-river salmonid collection system site ('Riverine' in Figure 4.6-1). A short period of data were available to compare with water temperature collected at the MSS gage (**Figure 5.2-2**) from October 11, 2023 until October 15, 2023. These results show that the in-river collector data ranged from exactly equal to McCloud River Above Shasta Lake (MSS) gage data to slightly greater than MSS gage data. Investigating the time series more closely (Figure 5.2-1), the in-river collector temperatures are equal to MSS gage temperatures during the night and are slightly greater than MSS gage temperatures during the day. This comparison shows that MSS gage data are a reasonable surrogate for water temperatures within the river closer to the river-to-reservoir transition. Note these data are from the 2023 location near McCloud Bridge and were collected in mid-October, which is after the highest air temperature of the deployment in September; additional data collection would help understand the relationship when the river-to-reservoir transition is located farther downstream and during periods of warmer air temperatures.

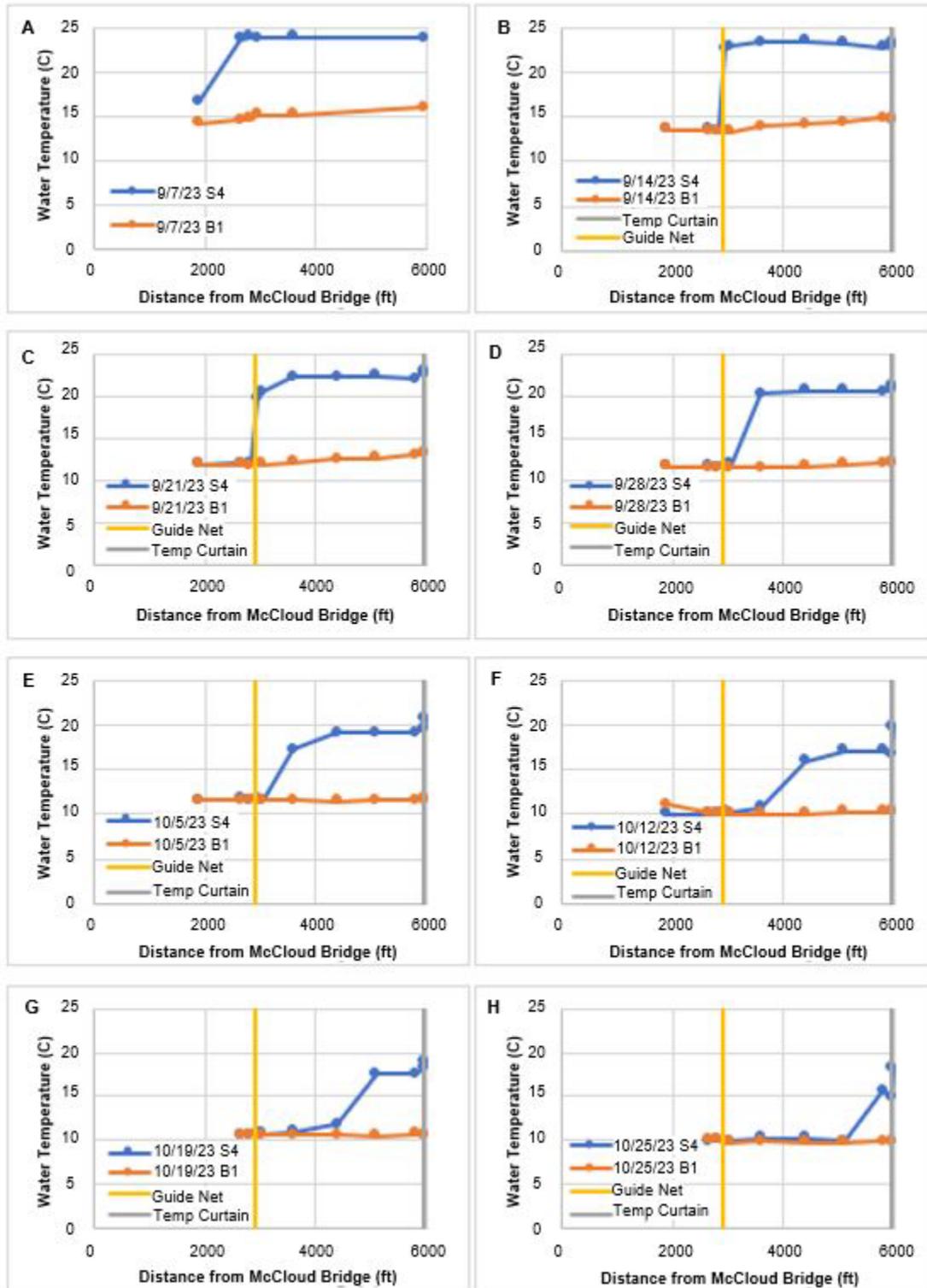


**Figure 5.2-2.** Comparison of in-river water temperatures from October 11 – 15, 2023 at CDFW fish trap versus at MSS Gage further upstream. Short-dashed line is 1:1 line of perfect agreement and Long-dashed red line is best-fit line.

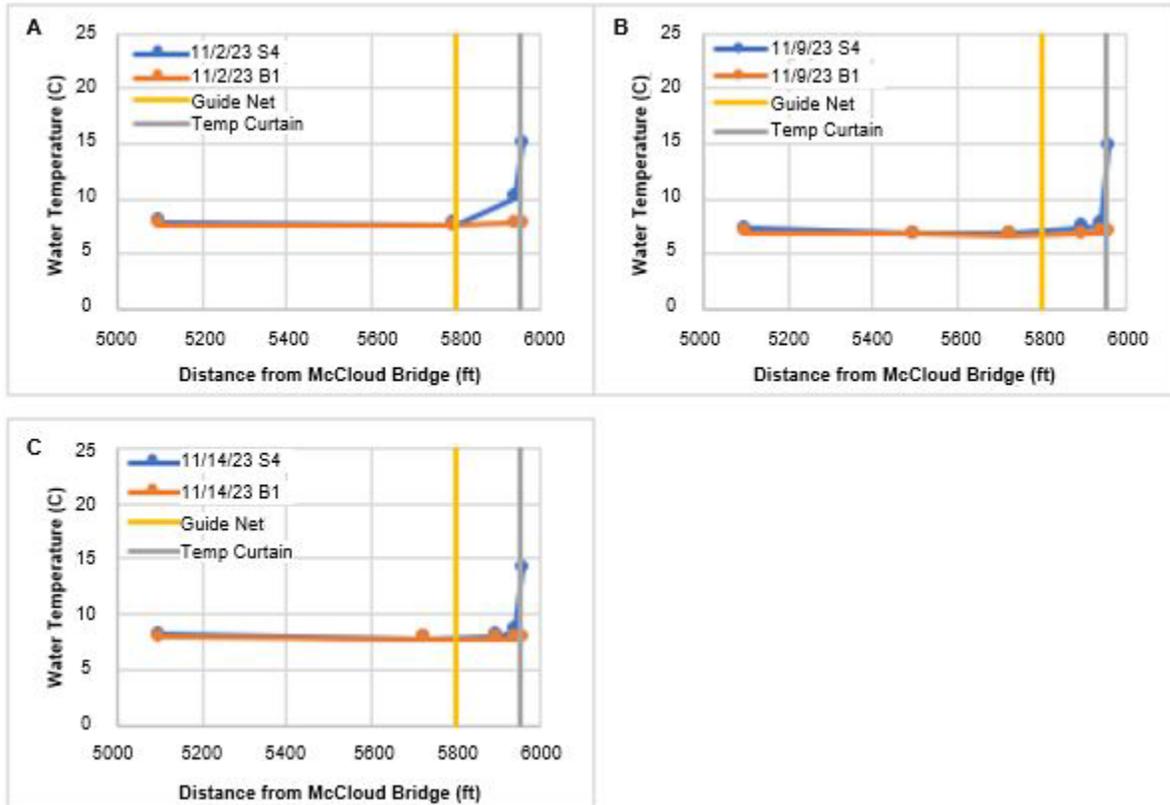
### 5.2b: Longitudinal Profiles of Near-Surface and Near-Bed Water Temperature

At the initial location of the JSCS guidance net (Site 1, approximately 2900 ft downstream of McCloud Bridge), the water temperatures were stratified (i.e., much warmer near the surface and much cooler near the bed) throughout the reservoir reach until the guidance net was installed on September 13, 2023 (**Figure 5.2-3A-B**). Near the river inflow, the degree of stratification was reduced but still present (1900 ft, **Figure 5.2-3A**). One day after the guidance net was installed, the region upstream of the guidance net was well-mixed to the cold riverine temperatures of the river inflow (13.5 °C, **Figure 5.2-3B**; see associated river temperature in **Figure 5.2-1**). It's evident that just downstream of the trap platform, the reservoir remained stratified until a date between September 21 and September 28, 2023 (**Figure 5.2-3C-D**). By September 28, 2023, the reservoir upstream and downstream of the trap platform was well-mixed and temperatures uniformly cold at about 11.5 C (**Figure 5.2-3-D**). Over the subsequent 4 weeks, near-surface temperatures gradually decreased and well-mixed conditions slowly propagated downstream (**Figure 5.2-3F – H**). On the final day of deployment at Site 1, the reservoir was well-mixed to a distance of 5100 feet downstream of McCloud Bridge (**Figure 5.2-3H**).

Conditions at the relocation site (Site 2, approximately 5800 ft downstream of McCloud Bridge) remained stratified throughout the season until the guidance net was installed at Site 2 on November 1, 2023. One day after the guidance net was installed (November 2, 2023), again conditions upstream of the guidance net were well-mixed and cold. Water temperature was weakly stratified between the guidance net and temperature curtain downstream and more-strongly stratified downstream of the temperature curtain (**Figure 5.2-4A**). During the 2 weeks at Site 2, water temperatures became well mixed between the guidance net and temperature curtain and remained stratified downstream of the temperature curtain (**Figure 5.2-4B – C**).



**Figure 5.2-3.** Longitudinal profile of near-surface (S4) and near-bed (B1) water temperatures during JSCS deployment at Site 1. A: September 7, 2023; B: September 14, 2023; C: September 21, 2023; D: September 28, 2023; E: October 5, 2023; F: October 12, 2023; G: October 19, 2023; H: October 25, 2023. Additional information about conditions is presented in **Table 5-6**.



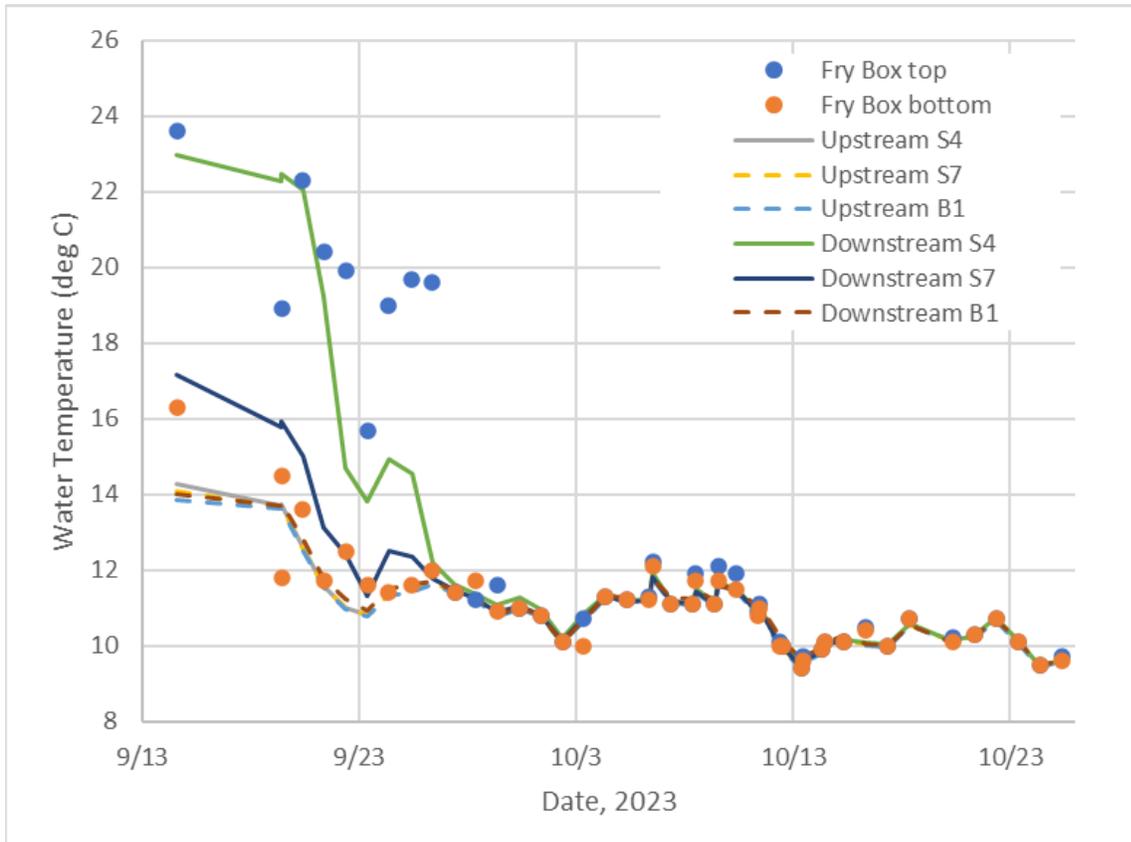
**Figure 5.2-4.** Longitudinal profile of near-surface (S4) and near-bed (B1) water temperatures during JSCS deployment at [Site 2](#). A: November 2, 2023; B: November 9, 2023; C: November 14, 2023. Additional information about conditions is presented in Table 5-6.

### 5.2c: Effects of Guidance Net on Water Temperature

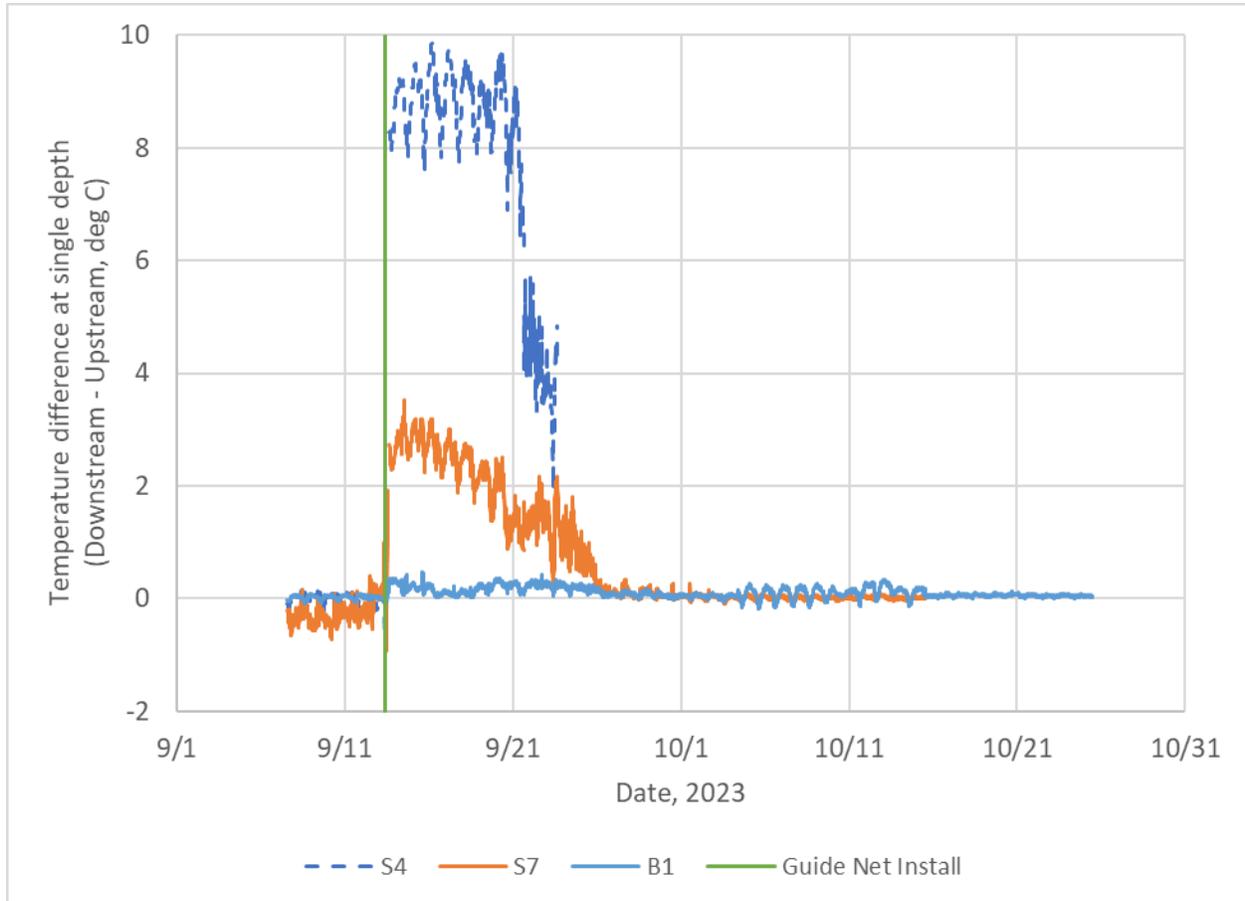
While some of the effects of the JSCS structure elements on water temperature were presented in the previous section, additional comparisons are presented here. For the trap platform at Site 1, a comparison of water temperatures at the surface, mid-depth and near the bed from locations upstream, within, and downstream of the fry box at Site 1 is shown in **Figure 5.2-5**. These data are further summarized to show a comparison of the difference between downstream and upstream water temperatures at discrete depths in **Figure 5.2-6**. The average difference between downstream and upstream at all sensor depths for the period of greatest stratification is shown in **Table 5.2-1**.

Until Sep 27, 2023, near-surface water temperatures in the fry box were substantially higher than those at the bottom of the 4.5-foot water column with the box (Figure 5.2-5), owing to strongly stratified conditions downstream of the trap platform (Figure 5.2-6). During this period (September 14 – 26, 2023), the near-surface region of the fry box was 7.8 °C warmer than that at the near-bed, on average. As seen in Figure 5.2-5, during this stratified period, the temperatures at the top of the fry box most closely followed those at 4 ft depth downstream of the trap platform (Downstream S4, Figure 5.2-5), while those for the bottom of the fry box most closely followed those at 7 ft, depth downstream of the trap platform (Downstream S7, Figure 5.2-5). By September 27, 2023, the temperature difference between upstream and downstream of the trap platform was eliminated (Figures 5.2-5 and 5.2-6) and water temperatures in the fry box and downstream of the trap platform were cold throughout the water column. This elimination of stratification was most likely caused by a combination of decreasing depth in

the reservoir and associated increase in velocity, cooling air temperatures, and operations of the JSCS structure (i.e., deployment of impermeable panels on the guidance net).



**Figure 5.2-5.** Time series of water temperatures from September 13 – October 25, 2023 at 4 feet below water surface (S4), 7 feet below water surface (S7), and 1 foot height above bed (B1) for sensors located upstream, downstream, and within the JSCS Fry Box at Site 1.



**Figure 5.2-6.** Time series of water temperature difference between sensors located upstream and downstream of JSCS trap platform at Site 1, September 13 – October 25, 2023. Differences are presented for each pair of sensors at a fixed depth, computed as downstream minus upstream.

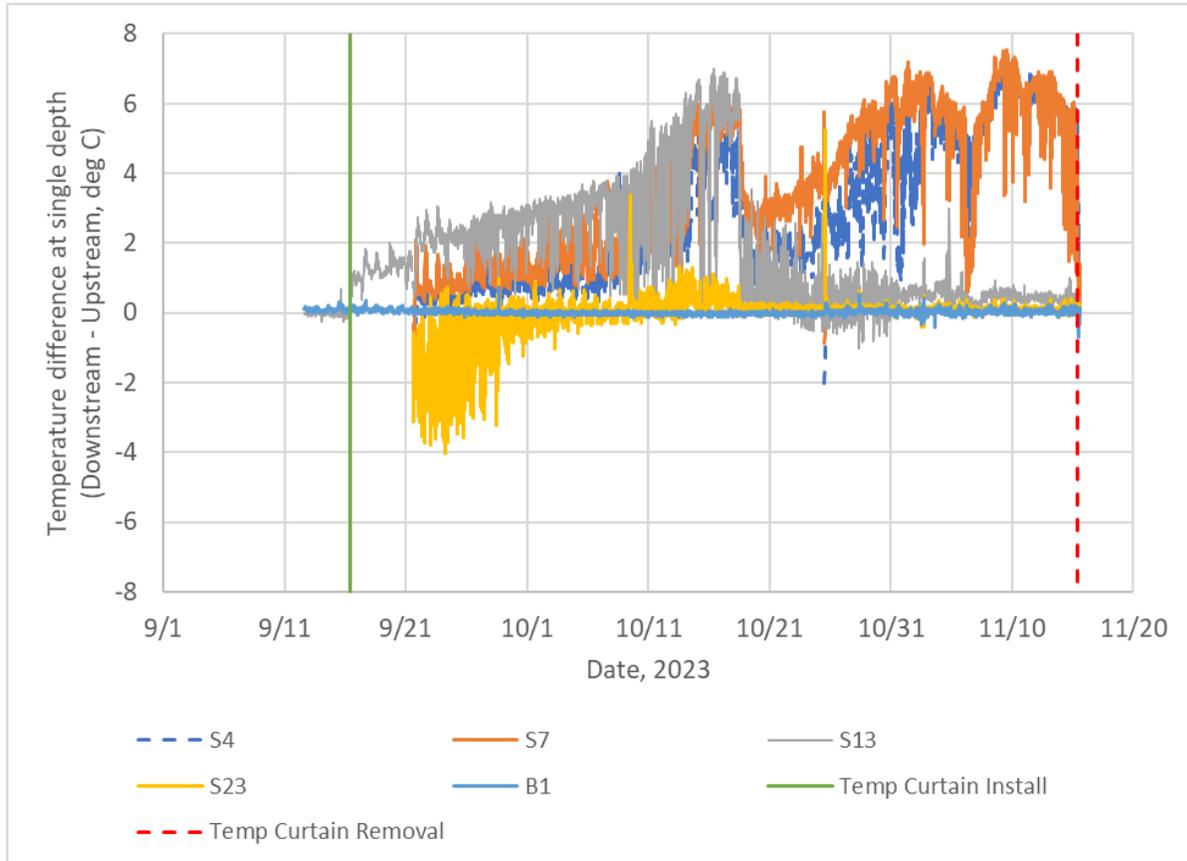
**Table 5.2-1.** Summary of average water temperature difference upstream and downstream of trap platform by depth at Site 1 for September 7 – 23, 2023. Date range is for period of most-stratified conditions (see Figure 5.2-5). Sensors were deployed either relative to water surface (BWS, below water surface) or relative to reservoir bottom (HAB, height above bed). S4-4 feet BWS; S7-7 feet BWS; B1-1 foot HAB.

Sensor Location	Average temperature difference at single depth (Downstream – Upstream, °C)	Start of averaging period	End of averaging period
4 ft BWS	4.9	9/7/2023 14:30	9/23/2023 15:30
7 ft BWS	1.3	9/7/2023 14:30	9/23/2023 15:30
1 ft HAB	0.1	9/7/2023 14:30	9/23/2023 15:30

## 5.2d: Effects of Temperature Curtain on Water Temperatures

In 2023 the temperature curtain was deployed at one location throughout the season, approximately 3000 ft downstream of Site 1 and 150 ft downstream of Site 2. A summary of the difference between downstream and upstream water temperatures at discrete depths in **Figure 5.2-7**. The average difference between downstream and upstream at all sensor depths throughout the entire deployment season is shown in **Table 5.2-2**.

Before the installation of the temperature curtain on September 26, 2023, there were no differences between upstream and downstream of temperature curtain location (Figure 5.2-7). Immediately upon installation, the water temperature at 13 ft below water surface (BWS) started cooling upstream of the curtain. During the period September 21 – October 18, 2023, the sensors at 4, 7, and 13 ft BWS were cooler upstream at an increasing rate until a peak of approximately 5, 6, and 7 °C cooler upstream than downstream at 4, 7, and 13 feet BWS, respectively. During this same time period, temperatures were cooler downstream compared to upstream at 23 ft BWS, and no difference at 1 ft height above bed. The conditions at 23 ft BWS were likely impacted by the deployment depth of the temperature curtain, which was approximately 25 ft, and higher density cold river water likely converged under the temperature curtain and caused an eddy downstream. After October 18, 2023, water temperature differences at 13 ft BWS and 23 ft BWS decreased and remained low throughout the remainder of the deployment, indicating that the middle depths of the reservoir had cooled and were relatively uniform upstream and downstream of the temperature curtain. However, at 4 ft BWS and 7 ft BWS, temperatures remained cooler upstream of the temperature curtain by between 2 and 7 °C (Figure 5.2-7). Averaging over most of the deployment, the water temperatures upstream of the temperature curtain were cooler by 2.8 and 3.6 °C at 4 ft BWS and 7 ft BWS, respectively (Table 5.2-2).



**Figure 5.2-7.** Time series of water temperature difference between sensors located upstream and downstream of JCS temperature curtain. S4-4 feet below water surface; S7-7 feet below water surface; S13-13 feet below water surface; S23-23 feet below water surface; B1-1 foot height above bed.

**Table 5.2-2.** Summary of average water temperature difference upstream and downstream of temperature curtain by depth for September 12 – November 15, 2023. Date range is for most of the deployment. Sensors were deployed either relative to water surface (BWS, below water surface) or relative to reservoir bottom (HAB, height above bed). S4-4 feet BWS; S7-7 feet BWS; S13-13 feet BWS; S23-23 feet BWS; B1-1 foot HAB. Note that the period of record for the sensor at 4 ft BWS begins September 21, 2023.

Sensor Location	Average temperature difference at single depth (Downstream – Upstream, °C)	Start of averaging period	End of averaging period
4 ft BWS	2.8	9/21/2023 14:00	11/15/2023 14:45
7 ft BWS	3.6	9/12/2023 14:30	11/15/2023 14:45
13 ft BWS	1.8	9/12/2023 14:30	11/15/2023 14:45
23 ft BWS	-0.05	9/21/2023 14:00	11/15/2023 14:45
1 ft HAB	0.02	9/12/2023 14:30	11/15/2023 14:45

### 5.3: Velocity

Velocity data presented in this section show the evolution of velocity structure over time and the response of the environment to the presence of JSCS components. The addition of the guidance net made the velocity more uniform over depth but also reduced its streamwise magnitude. A riverine flow structure was evidenced at the end of the Site 1 deployment but at a much shallower depth compared to baseline (pre-deployment) conditions. Upon relocation to Site 2, the velocity structure resembled a quiescent reservoir environment. Velocity structure at the trap entrance was relatively uniform over depth with most flow in the streamwise (longitudinal) component. The velocity magnitude at the trap entrance steadily increased over the period of deployment at Site 1 and high diffusion of velocity was evident between the trap inlet and the fry box, even at the highest velocity magnitudes. While at Site 2, the velocities within the trap did not change appreciably over time and were less than 1 ft/s at the inlet and less than 0.3 ft/s at the fry box. Further comparison of velocity data and JSCS configuration (e.g., number of impermeable panels deployed) with JSCS efficiency study results will provide greater understanding of optimal conditions for collecting juvenile salmon.

#### 5.3a: Cross-sectional velocity from ADCP

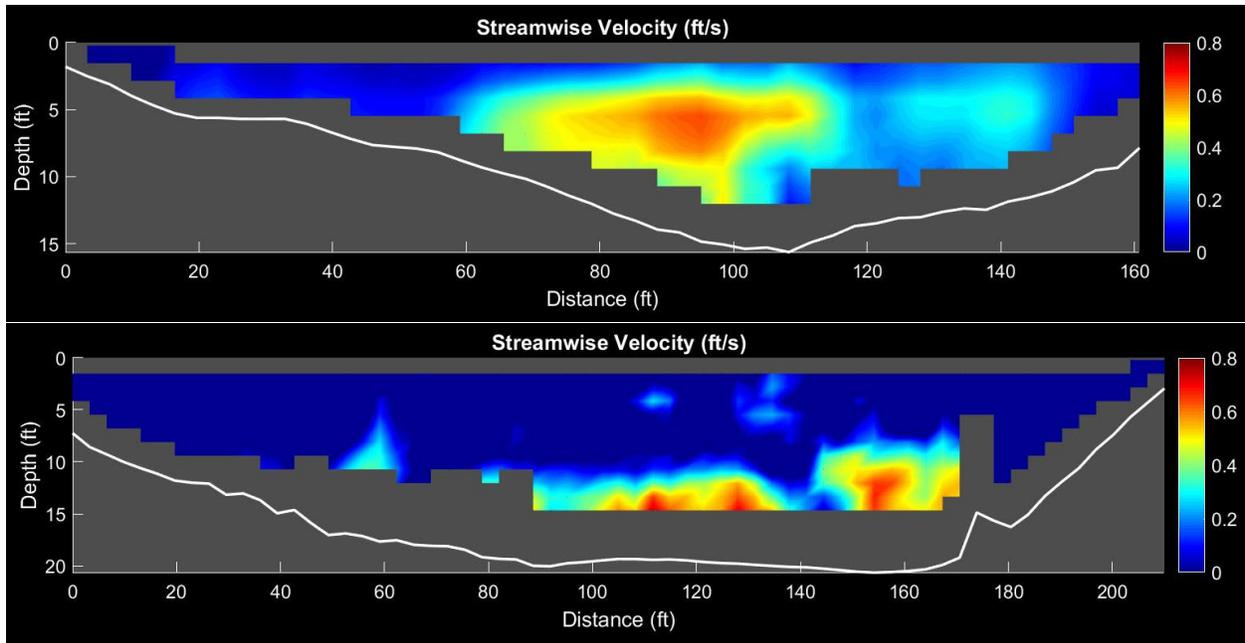
ADCP-derived velocity data were successfully collected on eight separate days during the 2023 deployment (**Table 5.3-1**). Data were collected once at two locations prior to deployment at Site 1, on five separate days (approximately weekly) during deployment at Site 1, and on two separate days (approximately weekly) during deployment at Site 2. While 3-dimensional velocity data were collected, this analysis focuses on one dimension of velocity, the along-channel (streamwise) component. Streamwise velocity data are visualized using contour plots with similar colorbar scales between figures for ease of comparison. ADCP transects are presented in this report from only 2 of the 6 locations to focus on salient results and simplify comparisons across the deployment (**Figure 5.3-1**). Cross-sectional plots are facing downstream with left bank displayed on the left and right bank displayed on the right.

**Table 5.3-1.** Dates, conditions, and water depths at trap for ADCP data shown in Figures 5-18 through 5-25 comparing velocity transects upstream of JSCS trap platform over time.

Date	Condition	Water Depth at Trap (ft)
9/1/23	Baseline conditions prior to deployment at Site 1	n/a
9/21/23	8 days after JSCS installation at Site 1	13
9/28/23	15 days after JSCS installation at Site 1	12
10/5/23	22 days after JSCS installation at Site 1	10
10/12/23	29 days after JSCS installation at Site 1	9
10/19/23	36 days after JSCS installation at Site 1	7
11/3/23	2 days after JSCS installation at Site 2	28
11/9/23	8 days after JSCS installation at Site 2	25

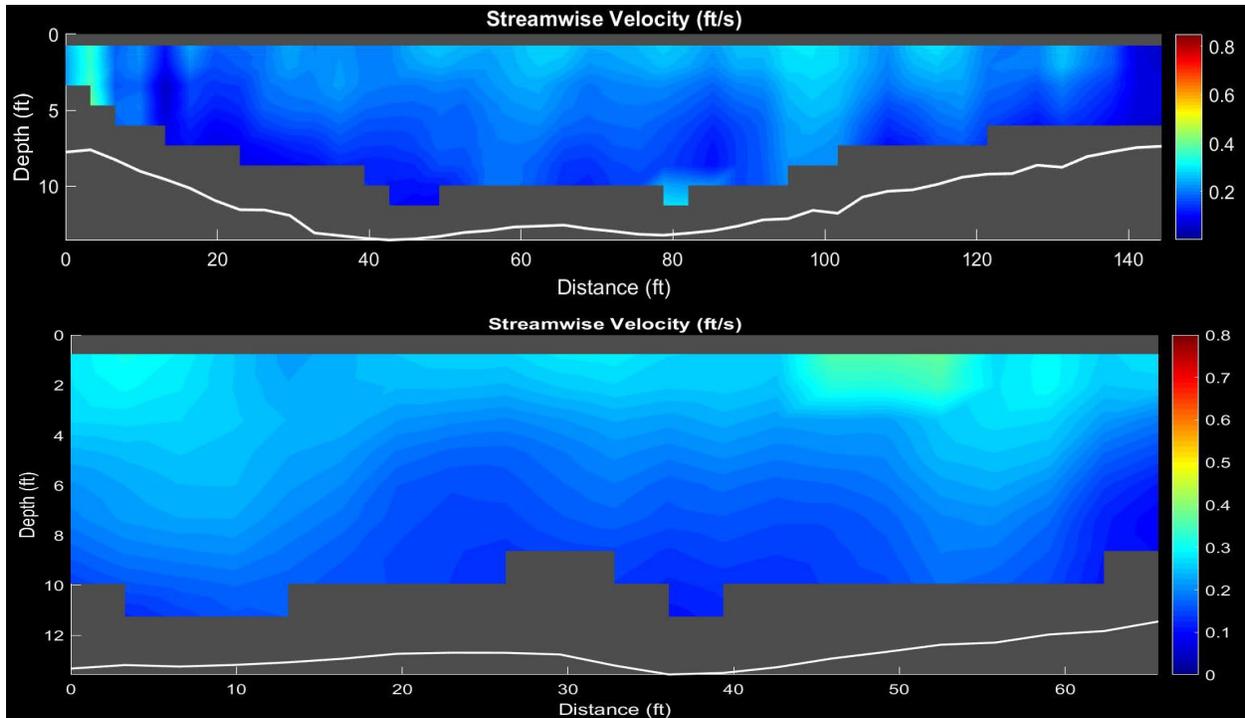


**Figure 5.3-1.** Aerial image of JSCS deployment at Site 1 on September 21, 2023 showing locations of ADCP-derived velocity data collection. XS1 and XS3 are highlighted in green as these were selected for further analysis detailed below.



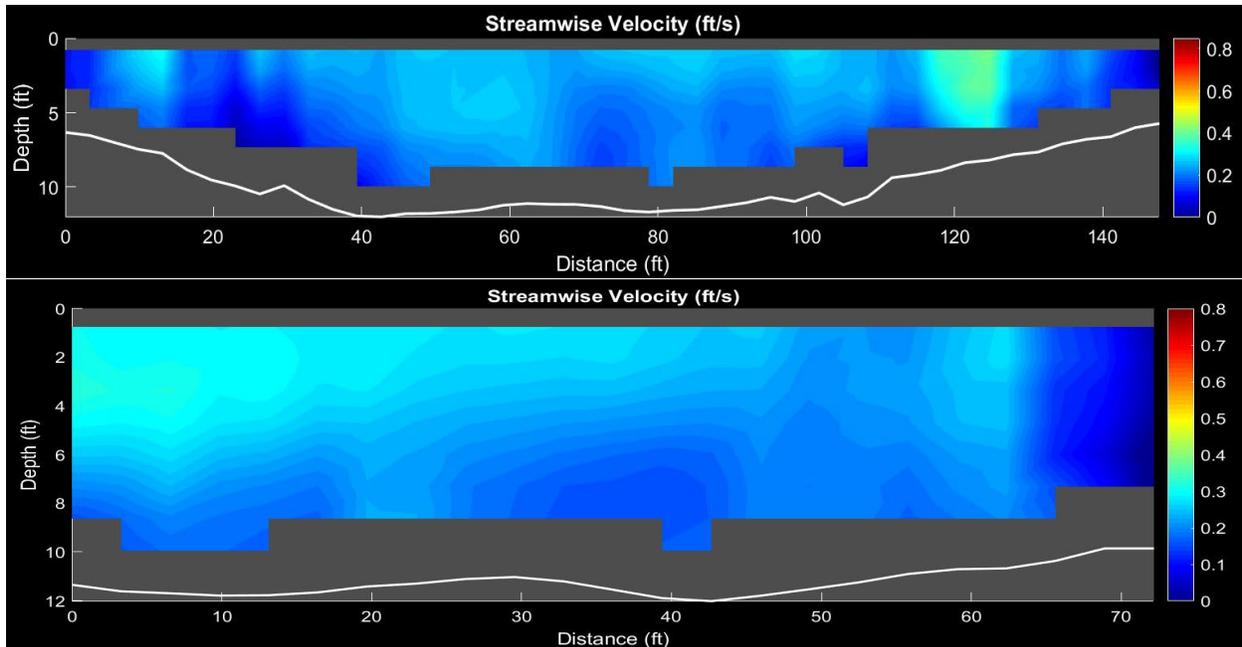
**Figure 5.3-2.** Velocity contour plots collected during baseline survey prior to JSCS deployment on September 1, 2023. Top: velocity at a transect with maximum depth of 15 ft at a location upstream of Site 1. Bottom: velocity at a transect at planned location for Site 1 having a maximum depth of 20 ft. Note that velocities in the top panel are taken from a location farther upstream in a more riverine environment than those in the bottom panel.

Velocity data collected 12 days prior to JSCS installation on September 1, 2023 provide a comparison of velocity conditions at two distances from the river (**Figure 5.3-2**). The shallower location (top, Figure 5.3-2) is nearer to the river with a maximum depth of 15 ft and exhibits higher velocity nearer the water surface. The deeper location (bottom, Figure 5.3-2) is at the planned Site 1 for the JSCS but the water depth was approximately 5 ft deeper than at the start of JSCS operations on September 13, 2023. The velocity structure has some missing data due to near-bed ADCP beam interference, but it can be inferred that the river inflow is confined to the bottom 10 feet of the reservoir and the top 10 feet is very-low velocity. This velocity structure is attributed to stratification of the water column, where the colder denser river water flows below the warmer, less-dense reservoir water. Density stratification inhibits mixing and, in this case, leaves the near-surface quiescent and warm. Given that water depths at the start of JSCS operations were approximately 15 ft, the data shown for the shallower location in Figure 5.3-2 (top) are representative of velocity structure at the start of JSCS operations just prior to guidance net installation.



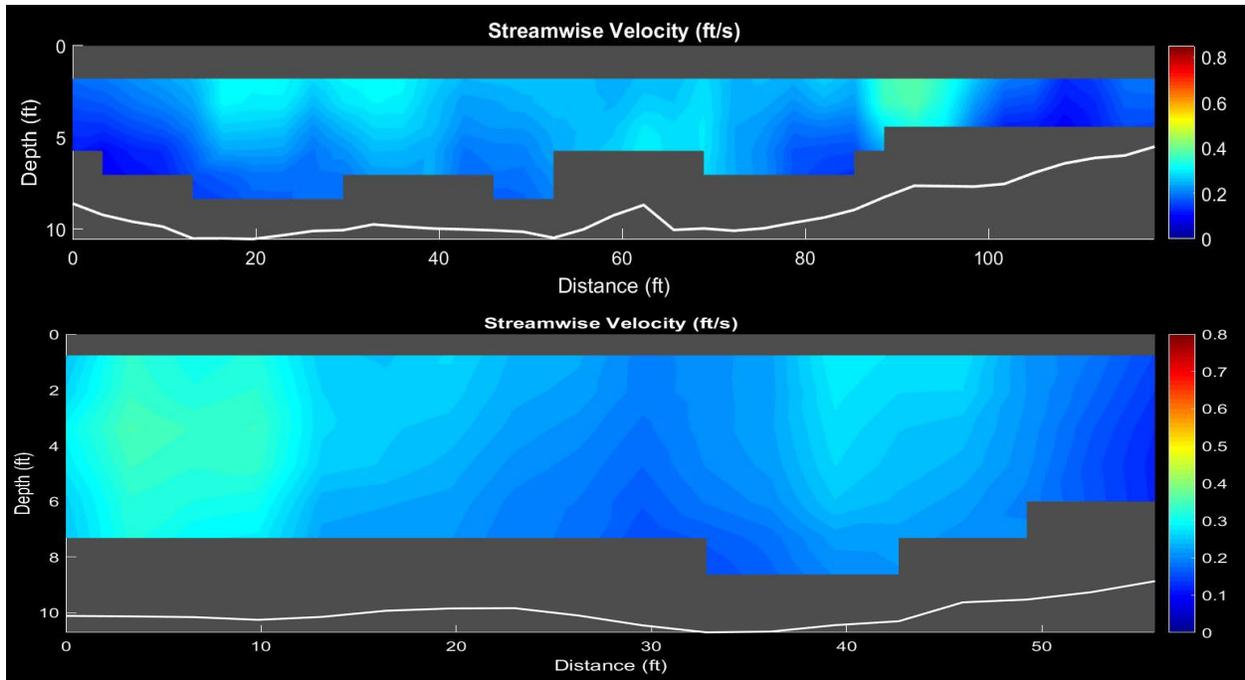
**Figure 5.3-3.** Velocity contour plots collected during JSCS operations at Site 1 on September 21, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 14 ft. Bottom: velocity at a transect 40 ft upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 13 ft.

Velocity data collected 8 days after JSCS installation at Site 1 on September 21, 2023 exhibit relatively well-mixed conditions with little change in velocity magnitude over space (**Figure 5.3-2**). As was demonstrated with the temperature sensor data (Figures 5.2-3B and 5.2-6, the installation of the guidance net provided a mechanism to mix the water column by adding friction, leading to the cooling of near-surface waters and a uniform velocity structure upstream of the guidance net. An along-channel increase in velocity moving from XS1 to XS3 is not evident except for minor localized increases at the surface (Figure 5.3-3). On this date, 7 of the 9 docks had impermeable panels deployed, from approximately transect XS1 to transect XS3 (Figure 5.3-1). Thus transect XS3 is located at the transition from a converging flow zone caused by the constriction of the guidance net plus impermeable panels. The flow at transect XS3 would have encountered a divergence owing to the loss in friction caused by the absence of impermeable panels. This may explain why an increase in velocity at XS3 is not evident in Figure 5.3-3 (bottom).



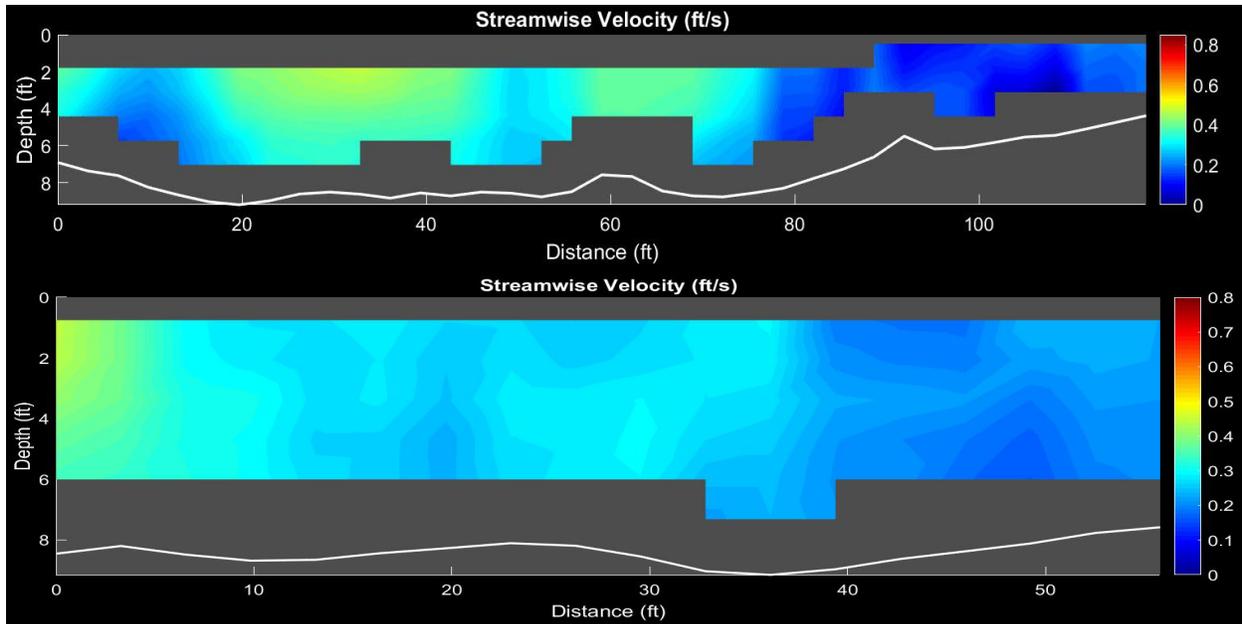
**Figure 5.3-4.** Velocity contour plots collected during JSCS operations at Site 1 on September 28, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 13 ft. Bottom: velocity at a transect 40 feet upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 12 ft.

Velocity data collected 15 days after JSCS installation at Site 1 on September 28, 2023 exhibit relatively well-mixed conditions with a slight increase in velocity magnitude moving downstream (**Figure 5.3-4**). An along-channel increase in velocity moving from XS1 to XS3 is slight (approximately 0.1 ft/s, Figure 5.3-4). On this date, 7 of the 9 docks had impermeable panels deployed, from approximately transect XS1 to transect XS3 (Figure 5.3-1). Thus transect XS3 is located at the transition from a converging flow zone caused by the constriction of the guidance net plus impermeable panels. The flow at transect XS3 would have encountered a divergence owing to the loss in friction caused by the absence of impermeable panels. In contrast with data collected on September 21, 2023, a slight increase in velocity at XS3 is evident in Figure 5.3-4 (bottom), perhaps owing to the interaction between the converging flow caused by the impermeable panels along with decreasing water depths as the river progressed toward this location.



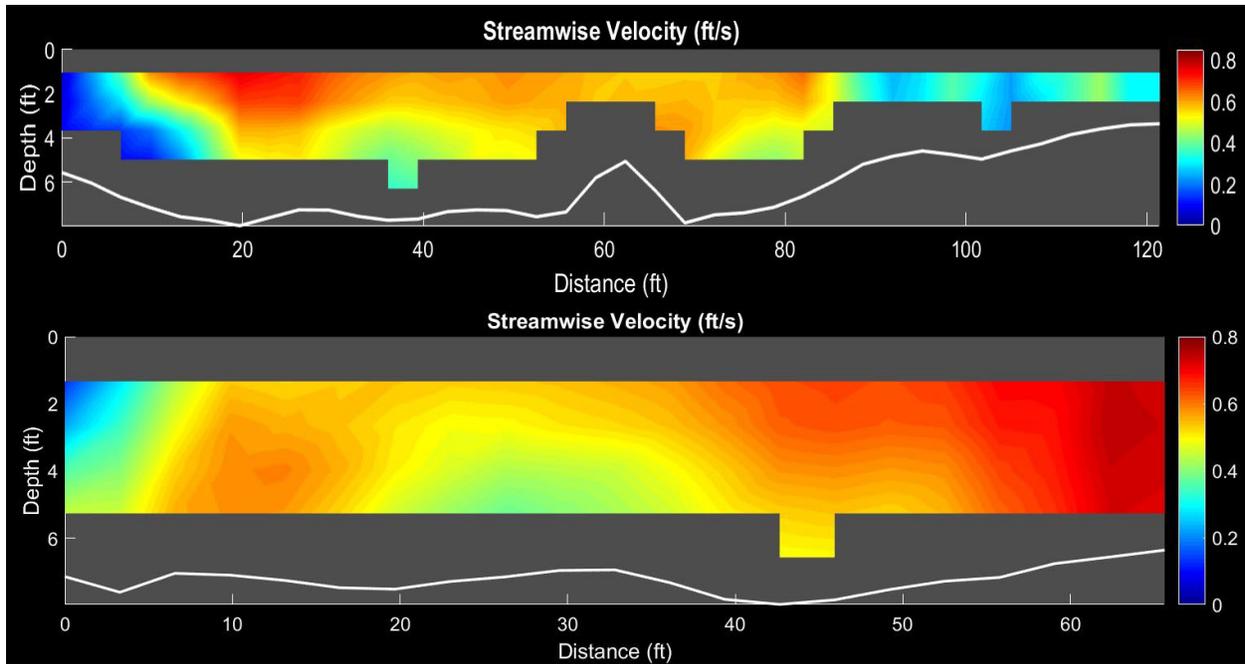
**Figure 5.3-5.** Velocity contour plots collected during JSCS operations at Site 1 on October 5, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 11 ft. Bottom: velocity at a transect 40 feet upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 10.5 ft.

Velocity data collected 22 days after JSCS installation at Site 1 on October 5, 2023 exhibit relatively well-mixed conditions with an increase in velocity magnitude moving downstream (**Figure 5.3-5**). An along-channel increase in velocity moving from XS1 to XS3 is more evident (approximately 0.2 ft/s, Figure 5.3-5). On this date, 9 of the 9 docks had impermeable panels deployed, from approximately transect XS1 to the trap platform (Figure 5.3-1). Thus transect XS3 is located along a converging flow zone caused by the constriction of the guidance net plus impermeable panels. By this date, the river was nearing the Site 1 location.



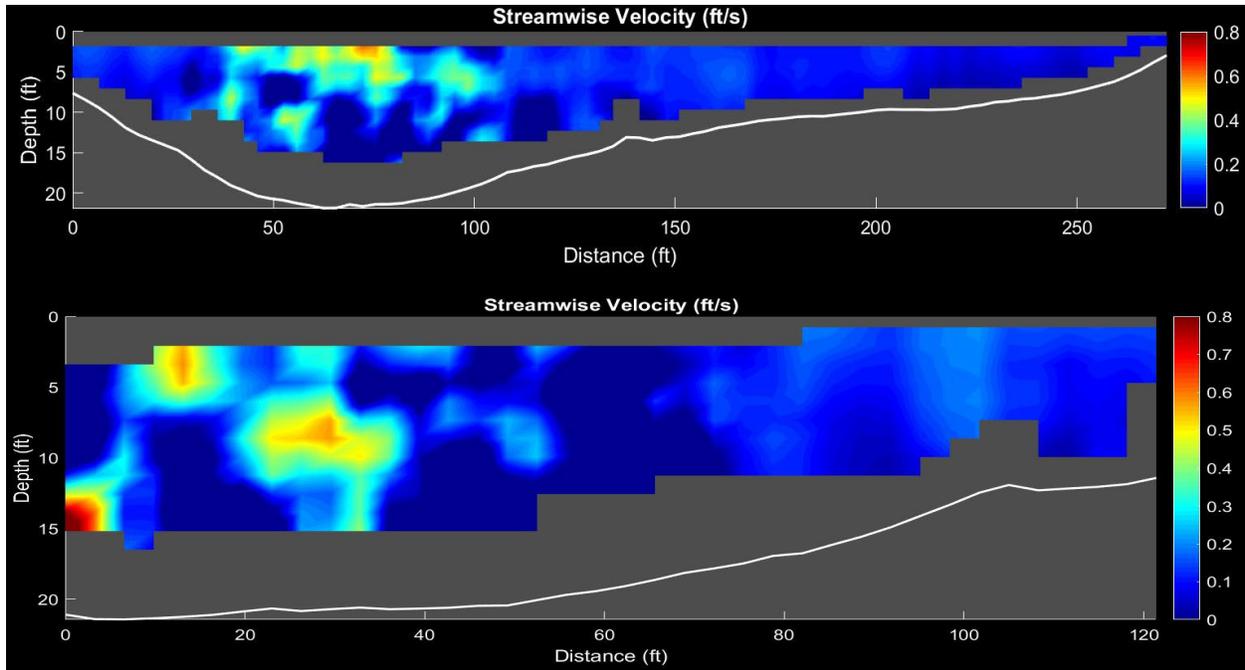
**Figure 5.3-6.** Velocity contour plots collected during JSCS operations at Site 1 on October 12, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 9 ft. Bottom: velocity at a transect 40 feet upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 9 ft.

Velocity data collected 29 days after JSCS installation at Site 1 on October 12, 2023, exhibit a more-riverine structure with mid-channel peak velocities around 0.5 ft/s (**Figure 5.3-6**, top). This velocity structure more closely resembles that seen during baseline conditions (Figure 5.3-1, top) except the velocity magnitude is lower (0.5 ft/s compared to 0.7 ft/s) despite the water depth being shallower (9 ft compared to 15 ft). The lower velocity magnitude on October 12 is likely due to the presence of the guidance net adding friction to the flow. An along-channel increase in velocity moving from XS1 to XS3 is slightly evident (Figure 5.3-6). On this date, 2 of the 9 docks had impermeable panels deployed along the right guidance net between transect XS1 to transect XS3 (Figure 5.3-1). Thus, less flow constriction was present along the channel which may explain why an increase in velocity at XS3 is not evident in Figure 5.3-6 (bottom). By this date, the river was just upstream of the Site 1 location.



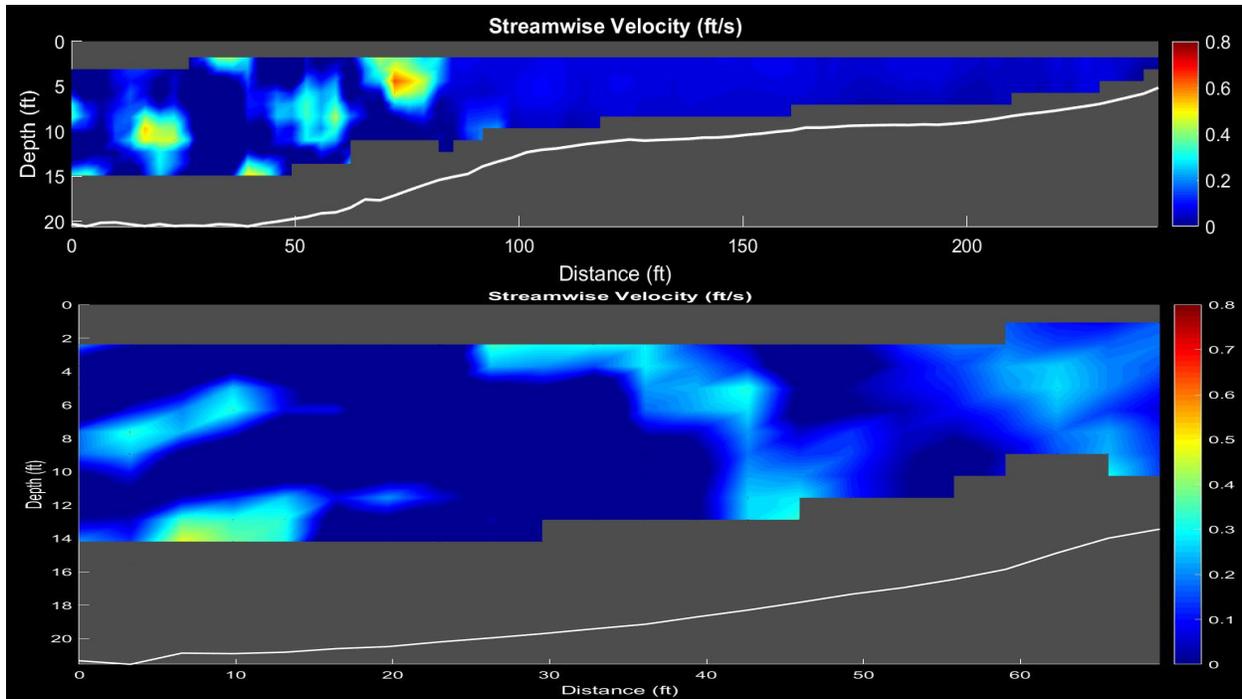
**Figure 5.3-7.** Velocity contour plots collected during JSCS operations at Site 1 on October 19, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 8 ft. Bottom: velocity at a transect 40 feet upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 7.5 ft.

Velocity data collected 36 days after JSCS installation at Site 1 on October 19, 2023 exhibits a riverine structure that more closely resembles baseline near-river conditions with mid-channel peak velocities around 0.8 ft/s (**Figure 5.3-7**). Note that the water depth on October 19 is approximately half as deep compared to baseline data collection on September 1 (7.5 ft compared to 15 ft). As discussed previously, the presence of the guidance net adds friction to the flow, as evidenced by the mixing of the water column upon guidance net installation (Figure 5.3-3). This observation of riverine velocity structure at half the water depth suggests that the friction induced by the guidance net is substantial. An along-channel increase in velocity moving from XS1 to XS3 is not evident (Figure 5.3-7). On this date, 0 of the 9 docks had impermeable panels deployed. Thus, less flow constriction was present along the channel which may explain why an increase in velocity at XS3 is not evident in Figure 5.3-7 (bottom). On this date, the river was at the Site 1 location. This is the last date of ADCP velocity data collection at Site 1.



**Figure 5.3-8.** Velocity contour plots collected during JSCS operations at Site 2 on November 2, 2023. Top: velocity at a transect 100 feet upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 22 ft. Bottom: velocity at a transect 40 ft upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 22 ft.

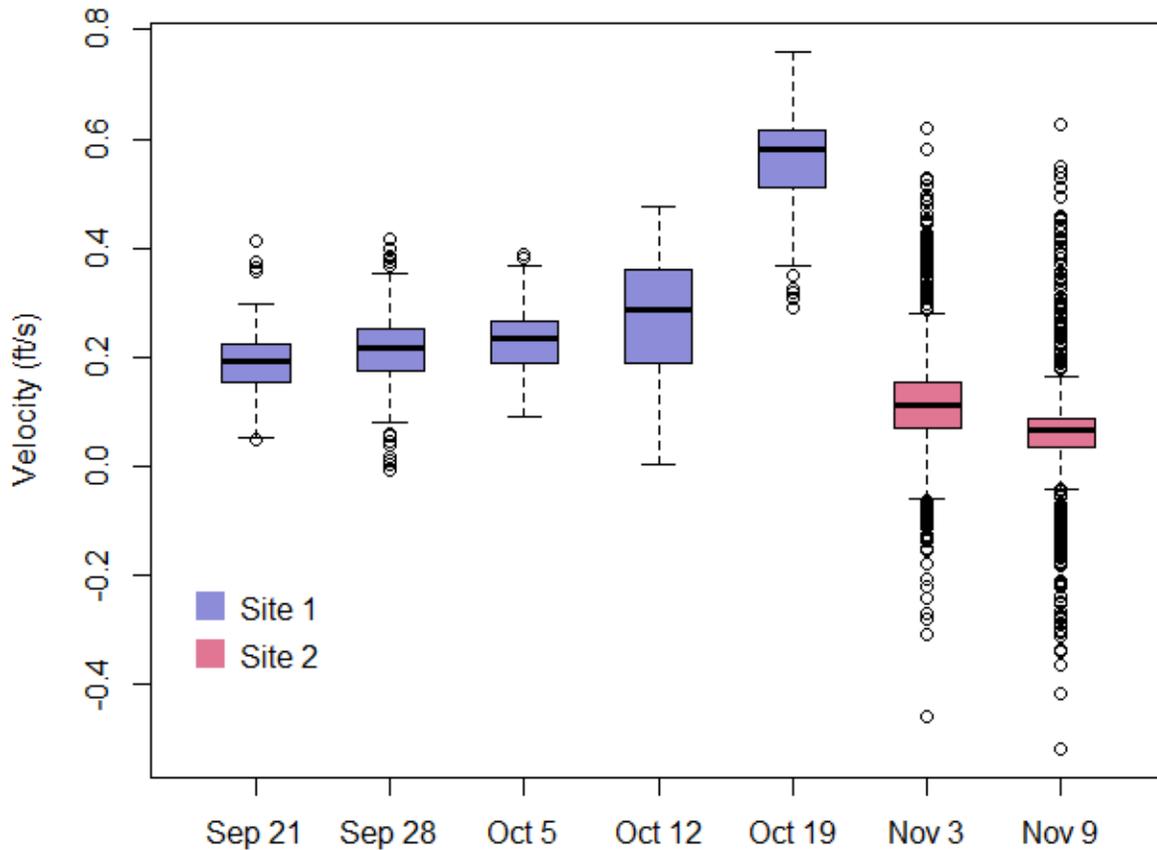
Velocity data collected 2 days after JSCS installation at Site 2 on November 3, 2023 exhibits a reservoir structure with velocities less than 0.2 ft/s (**Figure 5.3-8**). The localized high-velocity regions are likely spurious data points. This velocity structure is typical of an in-reservoir location far downstream of the river inflow. On this date the water depth was approximately 28 ft at the JSCS trap (Table 5.3-1). An along-channel increase in velocity moving from XS1 to XS3 is not evident (Figure 5.3-8). On this date, 7 of the 9 docks had impermeable panels deployed. Despite the presence of these panels, an increase in velocity at XS3 is not evident in Figure 5.3-7 (bottom) owing to the JSCS location far from the river inflow.



**Figure 5.3-9.** Velocity contour plots collected during JSCS operations at Site 2 on November 9, 2023. Top: velocity at a transect 100 ft upstream of the trap opening, near the upstream end of the guidance net (XS1, Figure 5.3-1) with maximum depth of 20 ft. Bottom: velocity at a transect 40 ft upstream of the trap opening, near the trap platform (XS3, Figure 5.3-1) a maximum depth of 21 ft.

Velocity data collected 8 days after JSCS installation at Site 2 on November 9, 2023 exhibits a reservoir structure with velocities less than 0.2 ft/s (**Figure 5.3-9**). The localized high-velocity regions are likely spurious data points. This velocity structure is typical of an in-reservoir location far downstream of the river inflow. On this date the water depth was approximately 25 ft at the JSCS trap (Table 5.3-1). An along-channel increase in velocity moving from XS1 to XS3 is not evident (Figure 5.3-9). On this date, 9 of the 9 docks had impermeable panels deployed. Despite the presence of these panels, an increase in velocity at XS3 is not evident in Figure 5.3-9 (bottom) owing to the location far from the river inflow. This is the last date of ADCP velocity data collection at Site 2.

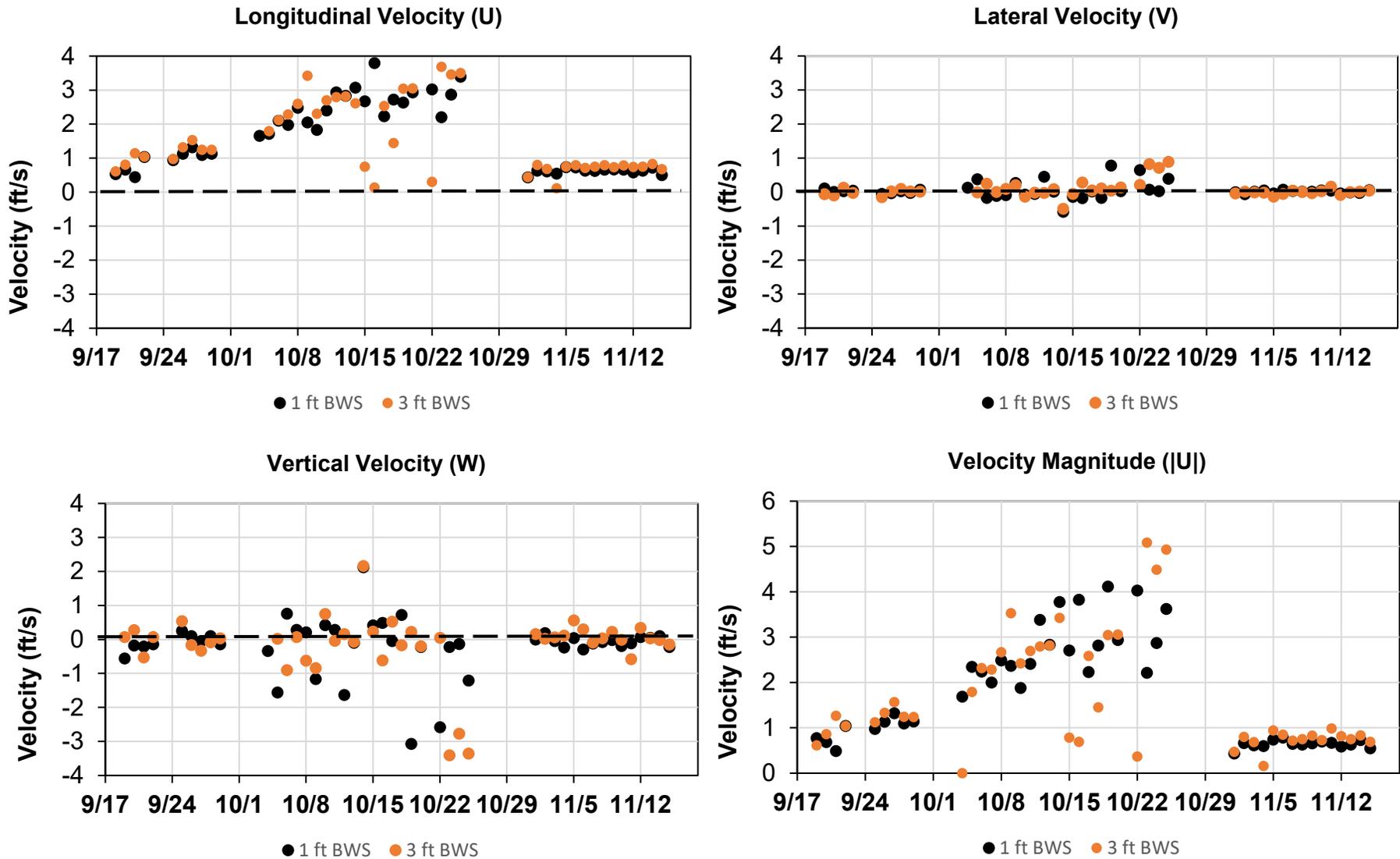
Overall, median cross-sectional velocity values gradually increased from approximately 0.2 to 0.3 ft/s over the first four weeks at Site 1 and increased to a median value of approximately 0.6 ft/s in the final week at Site 1 (**Figure 5.3-10**). Median velocity values at Site 2 were less than 0.2 ft/s both weeks and exhibited a high degree of variability due to the reservoir conditions mentioned above. This variability of low-quality data is illustrated by the large range and number of outliers for data collection at Site 2 (Figure 5.3-10).



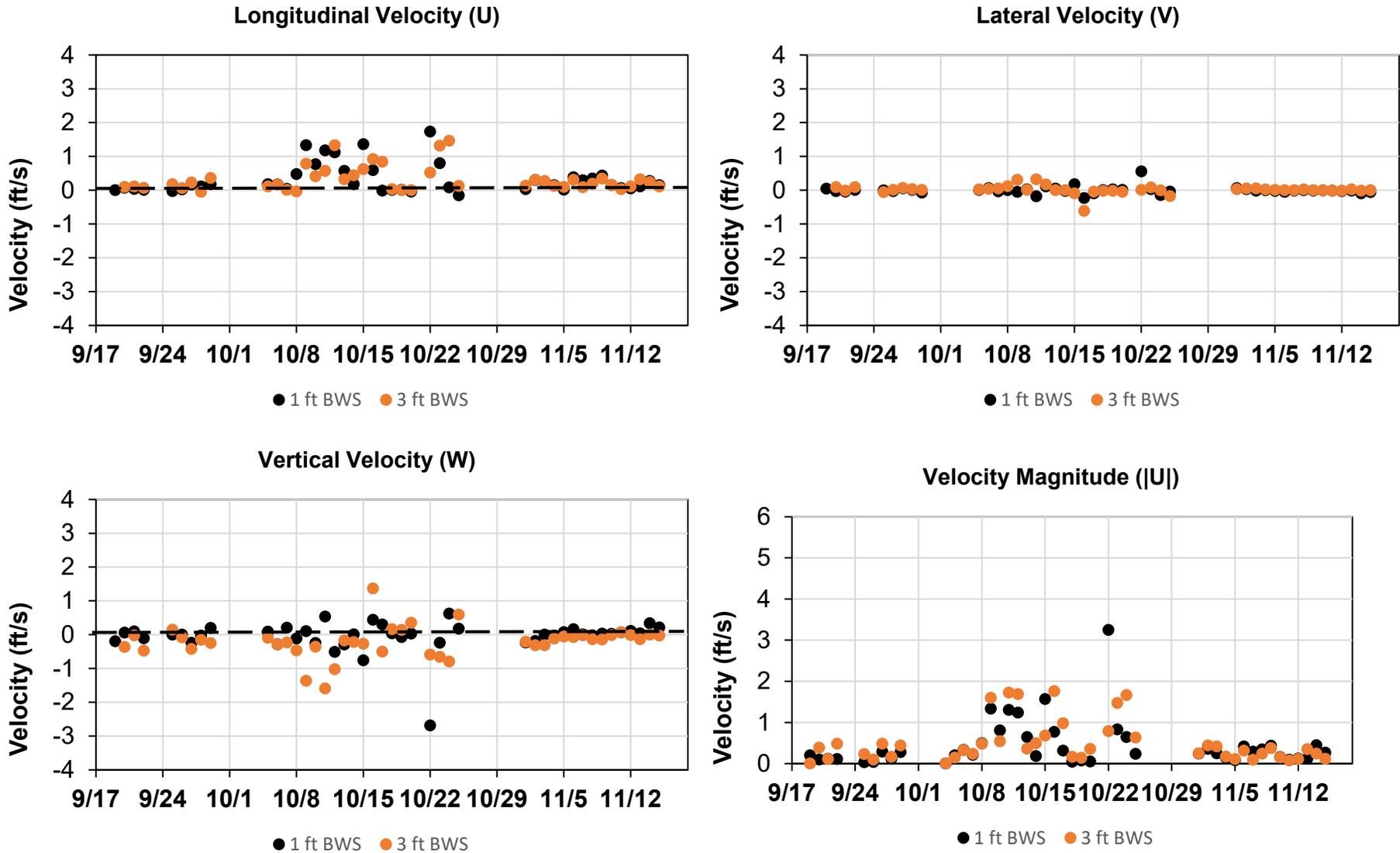
**Figure 5.3-10.** Boxplots illustrating ADCP cross-sectional velocity distributions over the course of the season. Each boxplot represents the distribution of velocity values from XS1 located upstream of the trap. The circles represent outliers that are well outside the interquartile range and represent data that are very high or low compared to the median (solid horizontal line).

### 5.3b: Point Velocity from ADV

ADV-derived velocity data were collected approximately daily at 2 – 4 locations between the upstream end of the trap and the fry box (Figure 4.6-3). Velocity was observed at 2 depths—1 ft and 3 ft below water surface. While 3-dimensional velocity data at multiple locations and depths were collected, this analysis focuses on velocity magnitudes collected at 2 locations (downstream of trap entrance fyke and downstream of fry box fyke, locations B and D in Figure 4.6-3) and 1 depth (3 ft below water surface). This simplifies the analysis and allows for focusing on salient results from the deployment. Velocity magnitudes are presented in a time series with identical y-axis limits for ease of comparison.



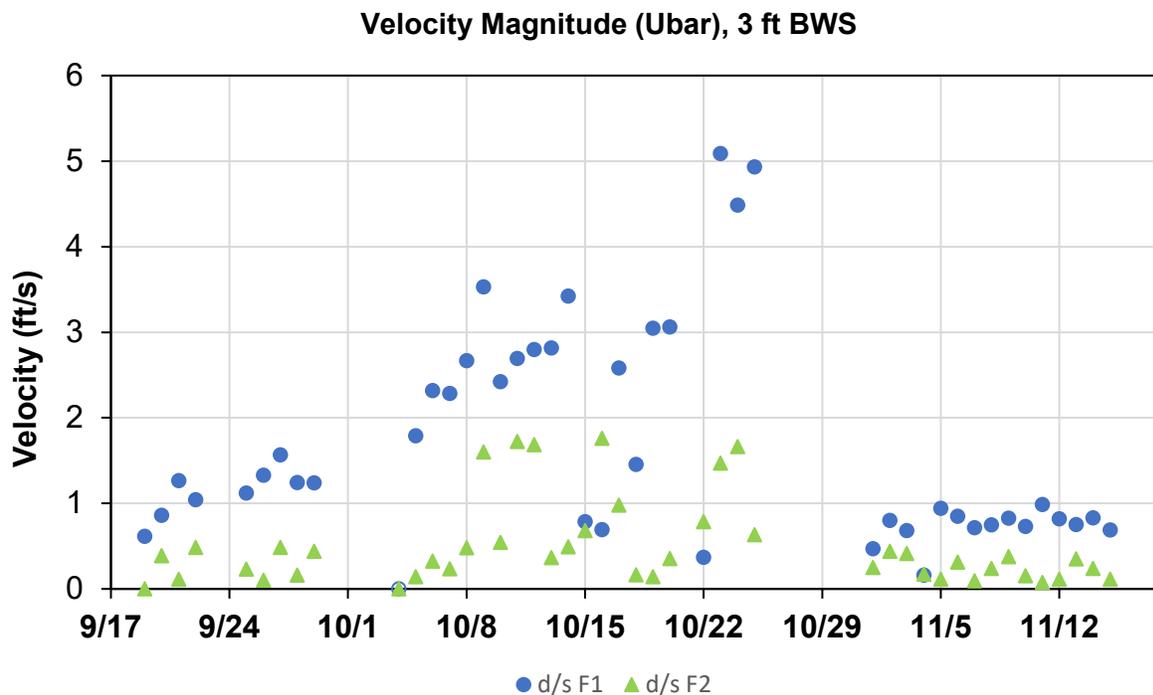
**Figure 5.3-11.** Time series of velocity components measured with an ADV downstream of the trap entrance fyke (location B in Figure 4.6-3) at two depths (1 ft and 3 ft below water surface, BWS). Velocity components U, V, W are measured by the ADV and velocity magnitude  $|U|$  is calculated.



**Figure 5.3-12.** Time series of velocity components measured with an ADV within the Fry Box downstream of the Fry Box fyke (location D in Figure 4.3-6) at two depths (1 ft and 3 ft below water surface, BWS). Velocity components U, V, W are measured by the ADV and velocity magnitude |U| is calculated.

As seen in **Figure 5.3-11**, velocity components and magnitudes just downstream of the trap entrance fyke (location B in **Figure 4.6-3**) vary over time. Comparing the 1 ft and 3 ft depths, there is generally good agreement indicating relatively uniform velocity over depth. Generally, most of the flow is in the along-channel (longitudinal, U) velocity component, except for several days in mid-October when the vertical component (W) was elevated during a period of heavy leaf loading in the system. During the period of operation at Site 1, the velocity magnitude steadily increases to a peak value of 5.1 ft/s on October 23, 2023 (Figure 5.3-11). After relocation to Site 2, velocity magnitude is low and relatively constant around 0.8 ft/s for the remainder of the deployment (Figure 5.3-11).

Contrasting these data with those just downstream of the fry box fyke within the fry box (location D in **Figure 4.6-3**), the velocities are much lower with less variability (**Figure 5.3-12**). Comparing data from the 1 ft and 3 ft depths, there is generally good agreement, indicating relatively uniform velocity over depth. Generally, most of the flow is in the along-channel (longitudinal, U) velocity component, except for several days in mid-October when the vertical component (W) was elevated during a period of heavy leaf loading in the system. During the period of operation at Site 1, the velocity magnitude slightly increases to a peak value of 1.7 ft/s on October 22, 2023 (Figure 5.3-12). After relocation to Site 2, velocity magnitude is low and relatively constant around 0.2 ft/s for the remainder of the deployment (Figure 5.3-12).



**Figure 5.3-13.** Time series of velocity magnitude measured with an ADV at two locations—downstream of trap entrance fyke (d/s F1, location B in Figure 5-17) and downstream of fry box fyke (d/s F2, location D in Figure 5-17) at one depth (3 ft below water surface, BWS).

A direct comparison of velocity magnitude between these two locations at a single depth is presented in **Figure 5.3-13**. This comparison shows how velocity is diffused between the trap entrance and the Fry Box. Even at the highest velocity magnitudes of 5 ft/s, the velocity magnitude inside the fry box was less than 2 ft/s at all times. The decrease in velocity magnitude just downstream of the trap entrance (d/s F1, Figure 5.3-13) in mid-October is likely due to heavy leaf loading which may have deflected flow around

the trap platform, causing it to avoid the trap inlet entirely. The diffusion of velocity indicates that the trap platform design was adequate for reducing velocities within the fry box during periods of high-inlet velocity conditions.

### 5.3c: Summary of velocity data for comparison with JSCS efficiency study

To test the efficiency of the JSCS in collecting juvenile salmon, a total of five releases of marked fish were conducted over the study. For each release, a known number of marked fish were released approximately 0.5 miles (mi) upstream in the evening at 30 minutes after sunset. The number of marked fish captured in the JSCS trap were tallied over the following days. Additional details describing efficiency results are available in **Section 5.6d: Efficiency Trials and Capture Probability**. To support further investigation of those data, a summary of water depth at the trap and ADV-derived velocity magnitudes are presented in **Table 5.3-2**.

**Table 5.3-2.** Summary of water depth and velocity data for JSCS efficiency release dates. For each release date, data from one day after are presented because fish collection for each release began the following day.

Efficiency Release #	Efficiency Release Date	JSCS Site	Water Depth at Trap Entrance (ft)	Velocity Magnitude at Trap Entrance <sup>1</sup> (ft/s)	Velocity Magnitude in Fry Box <sup>2</sup> (ft/s)
1	9/27/2023	1	13	1.3	0.1
2	10/4/2023	1	10	2.1	0.2
3	10/11/2023	1	9	3.1	1.5
4	11/1/2023	2	28	0.7	0.4
5	11/8/2023	2	28	0.7	0.4

TABLE NOTES:

<sup>1</sup> Calculated as the average of the velocity magnitude at 1 ft and 3 ft below water surface at the location downstream of the trap entrance fyke (Location B in Figure 5-17)

<sup>2</sup> Calculated as the average of the velocity magnitude at 1 ft and 3 ft below water surface at the location downstream of the fry box fyke (Location D in Figure 5-17)

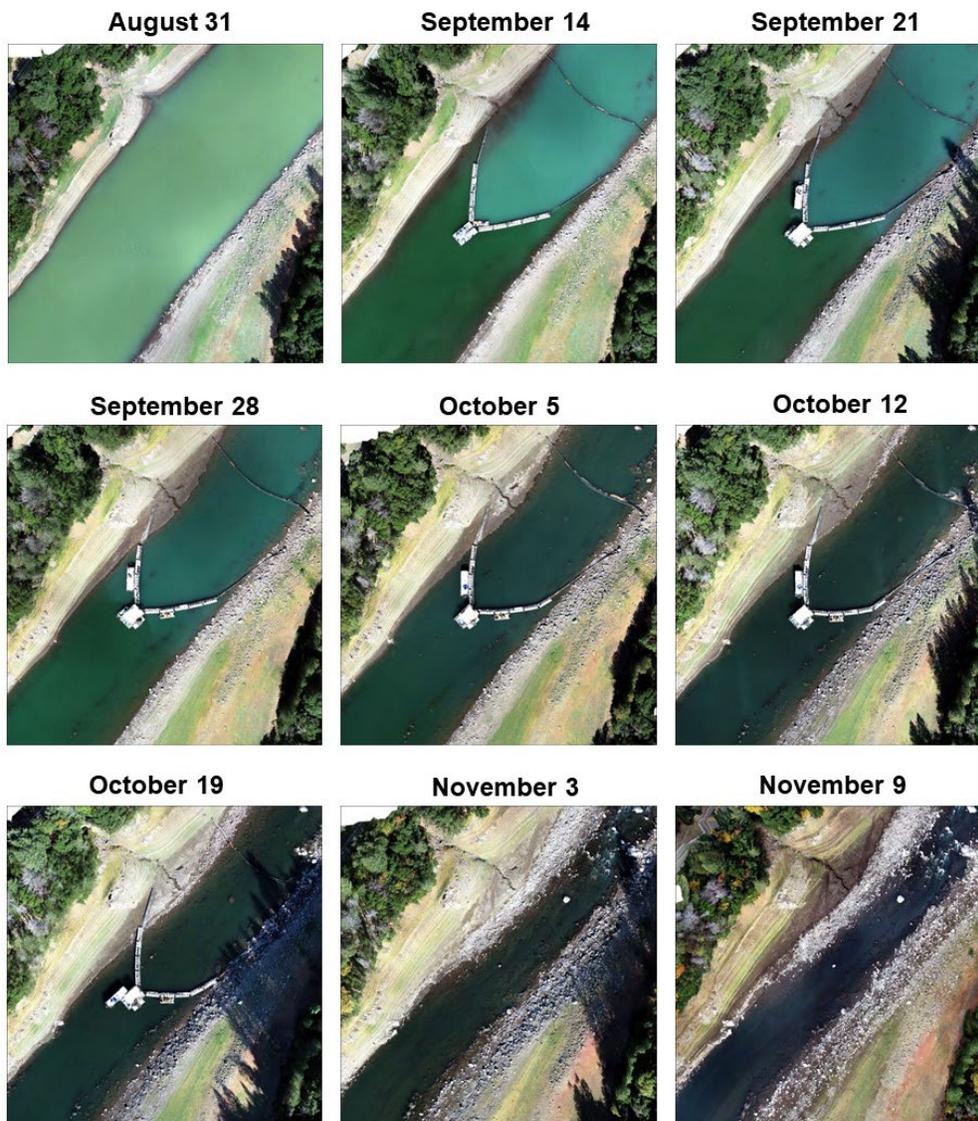
### 5.4: Meteorological Data

Several observations were made from the meteorological data. Air temperature ranged from 39.7 °F to 91.5 °F with an average temperature of 62.5 °F. Air pressure remained fairly constant over the season, ranging from 28.5 to 29.25 inHg. Wind speeds were variable during the season, with sustained winds less than 20 mph and maximum wind gusts of 35 mph. Wind direction was also highly variable but frequently oriented approximately 350° from true north. A total of 2.13 inches of rain fell during the season. No rain was observed until September 25, 2023 and 1.5 of the 2.13 inches of rain came on November 5 – 6, 2023.

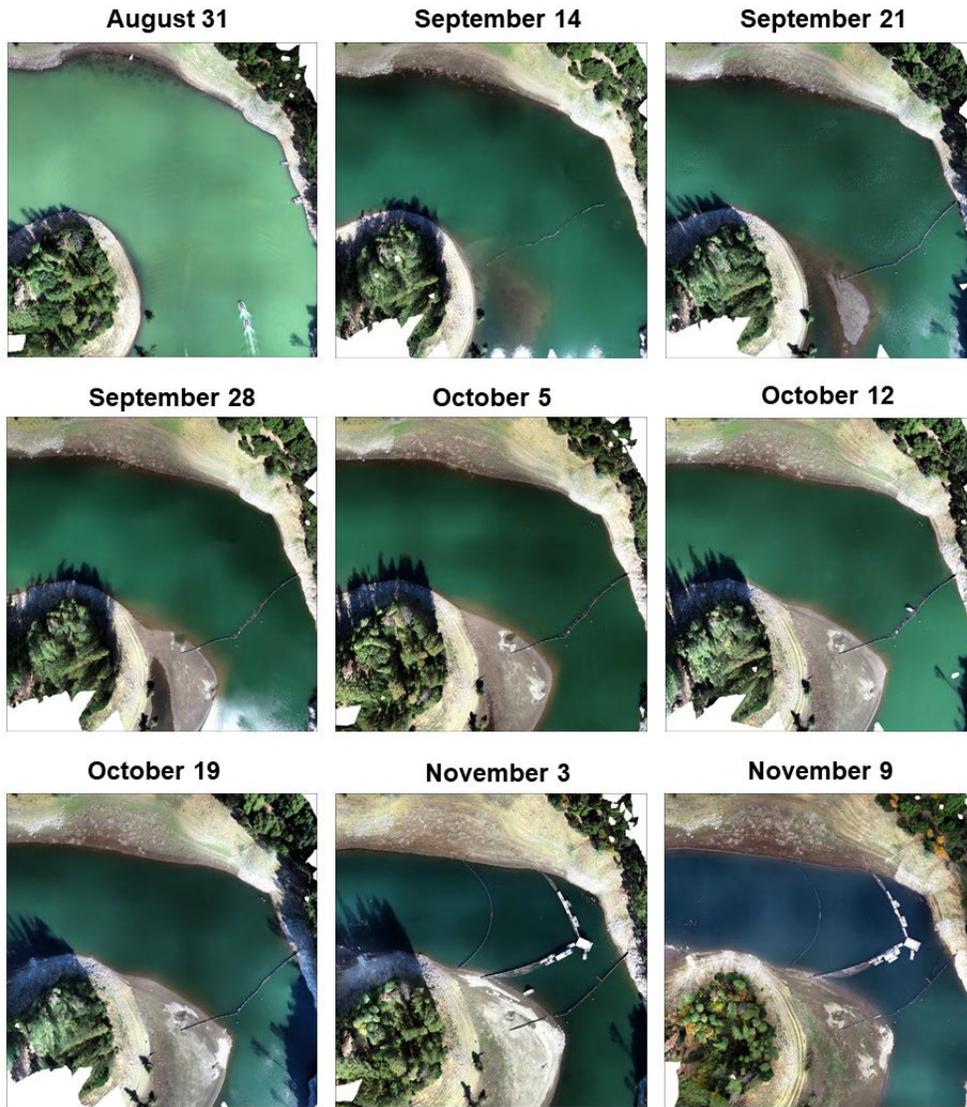
No correlation was identified between meteorological factors and fish catch in the 2023 field season. More robust data from future years of JSCS fish trap operation may help identify any relationships between juvenile Chinook Salmon outmigration from the McCloud River and meteorological phenomena.

### 5.5: Drone Imagery

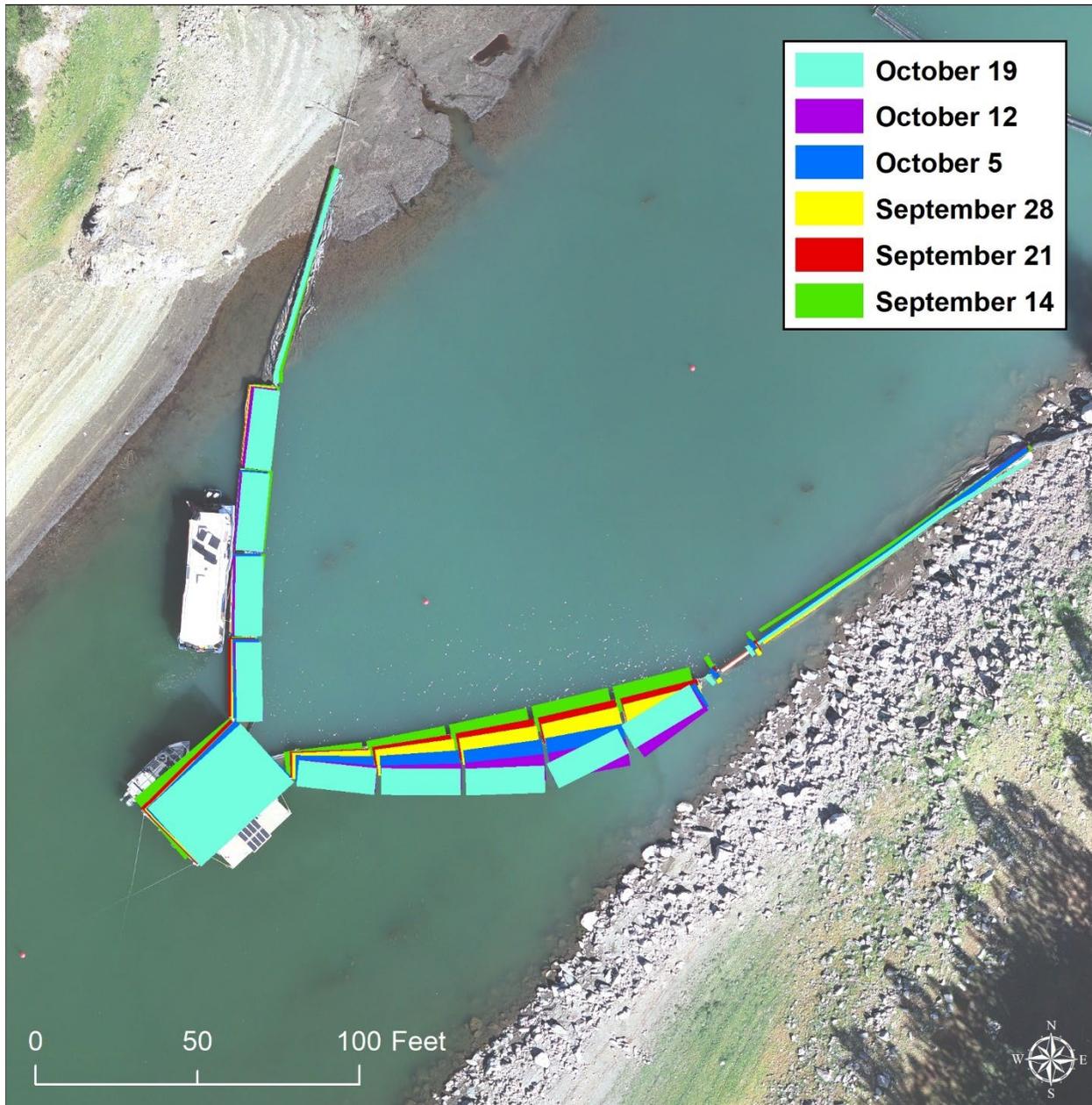
A total of 9 drone flights were conducted over the course of the season. Imagery from these flights show the decrease in WSE over time and how the JSCS shifted as a result (**Figure 5.5-1 and Figure 5.5-2**). At the first site, the JSCS configuration shifted slightly over time due to the changes in water depth and velocity (**Figure 5.5-3**). The JSCS did not noticeably shift at the second site as the water level and velocity did not change significantly while it was located there.



**Figure 5.5-1.** Aerial imagery of JSCS location within McCloud Arm channel at Site 1 August 31 – November 9, 2023.



**Figure 5.5-2.** Aerial imagery of JCS location within McCloud Arm channel at Site 2 August 31 – November 9, 2023.



**Figure 5.5-3.** Shifting of JCS platform and docks over time at Site 1. Background imagery is from September 21, 2023.

### 5.6: Fish Sampling

Fish traps were operated at three locations in the McCloud River during the 2023 field season to capture outmigrating juvenile winter-run Chinook Salmon for relocation and release into the mainstem Sacramento River. An incline plane trap (IPT) and then a rotary screw trap (RST) were operated by CDFW and the Winnemem Wintu Tribe nearly continuously at a fixed location below the McCloud Bridge from September 14 to November 27, 2023 (71 days). The exceptions to the continuous sampling were October 8, November 15, and November 23 – 25. The JCS trap was operated by DWR and the

Winnemem Wintu Tribe continuously from September 20 to October 25, 2023 (35 days) at Site 1 and November 1 – 15 (15 days) at Site 2. The JSCS trap was checked once daily, hook and line sampling was conducted twice weekly, and mark-recapture trap efficiency trials were conducted once weekly.

Over the course of field operations in 2023, the JSCS captured 489 Nur and 349 dual-marked efficiency fish for a combined total of 843 juvenile winter-run Chinook Salmon (**Table 5.6-1**). Nur catch at the JSCS peaked in October (**Fig. 5.6-1**). The JSCS recaptured the greatest proportion of marked efficiency fish in the first and second efficiency trials (43.0% and 51.5% respectively; **Table 5.6-4**).

### 5.6a: Trap Catch

The trap catch analysis excludes marked winter-run Chinook Salmon (efficiency fish), which are considered in **Section 5.6d: Efficiency Trials and Capture Probability**. The available CDFW trap data are included to provide a comparison to the JSCS in total catch, seasonal timing, and species composition. Fork length summaries are only included for the JSCS because fork length data was not available for the CDFW traps at the time of writing this report. In this section, Nur refers to juvenile winter-run Chinook Salmon reared in McCloud River water at Ah Di Na and released into the McCloud River.

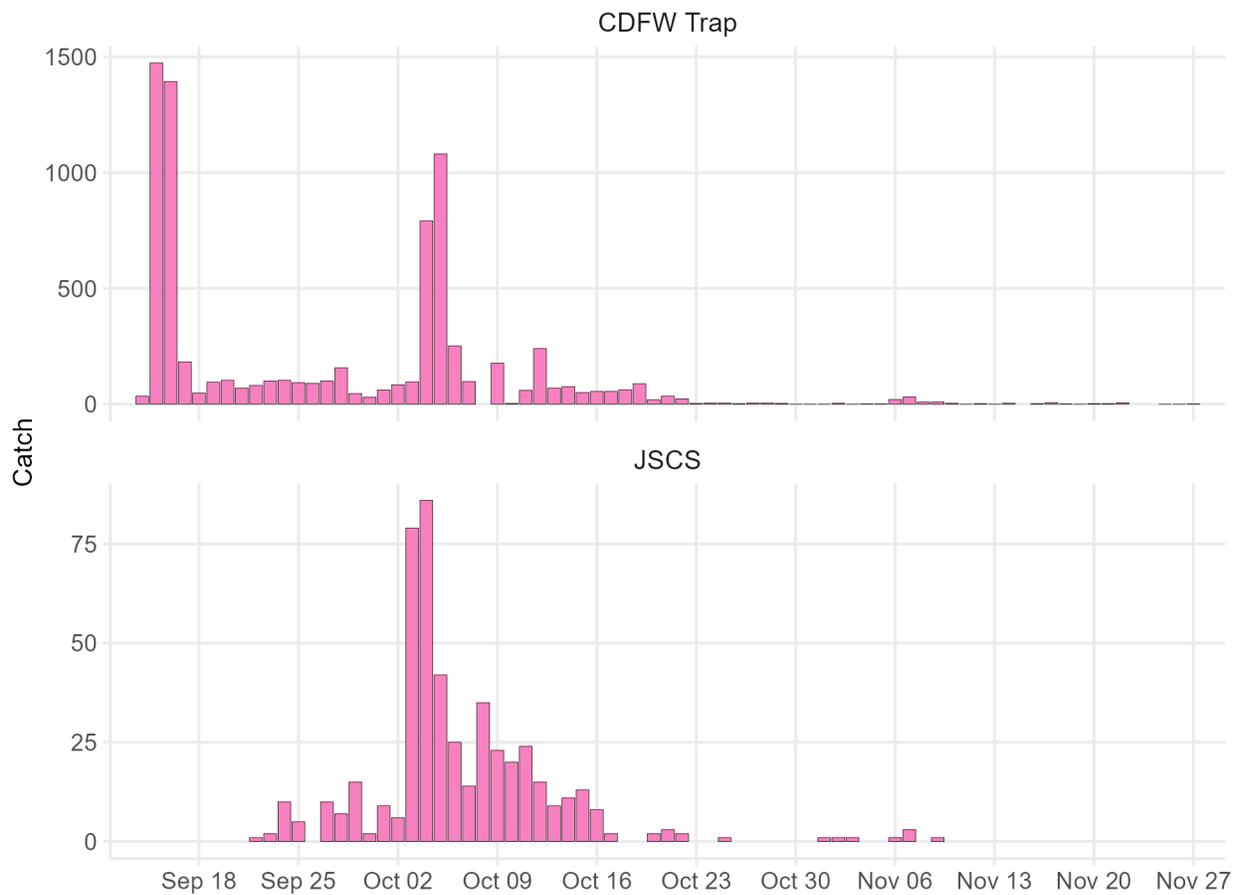
The trap catch analysis focused on water temperature at the bottom of the fry box and water velocity through the trap. Several velocity measurements were taken throughout the entrance fyke and fry box (see **Section 5.3: Velocity** for details). For this analysis, those values were averaged into a single daily velocity value. A number of potential covariates were confounded. Velocity was correlated with water depth at the trap and the number of panels deployed. Thus, velocity was used here as a proxy measure for changes to the JSCS structure. Water temperature was not correlated with velocity, depth, or panels deployed. However, water temperature *was* correlated with day of year and, thus, temperature effects on catch can't be teased apart from non-temperature based seasonal effects.

The CDFW traps installed at the McCloud Bridge (IPT operated September 14 through November 7, 2024; RST operated November 9 through December 18, 2024) caught over 15 times as many Nur as the JSCS (Table 1). This is most likely driven by proximity to the source location for the Nur and the fact that Nur caught in the CDFW traps were not returned to the river to continue outmigration. More predators were caught in the JSCS, which could be related to higher resident predator populations or predators aggregating near the structure provided by the JSCS. Predators were defined as piscivorous species that are likely large enough to not be gape-limited against consuming young-of-year Nur (see Table 5.6-2 for species included).

**Table 5.6-1.** CDFW and JSCS catch by species group.

Species Group	CDFW Traps	JSCS Trap
Nur	7811	489
Predators	365	726
Non-predators	160	95

The JSCS started operating later than the CDFW IPT and missed an early peak in daily catch of Nur in September (**Figure 5.6-1**). Otherwise, both traps generally exhibited a similar pattern in daily catch of Nur, including notable peaks in early October.



**Figure 5.6-1.** Daily Nur catch at the CDFW Trap and JSCS. Note: the y-axis is scaled separately in each panel.

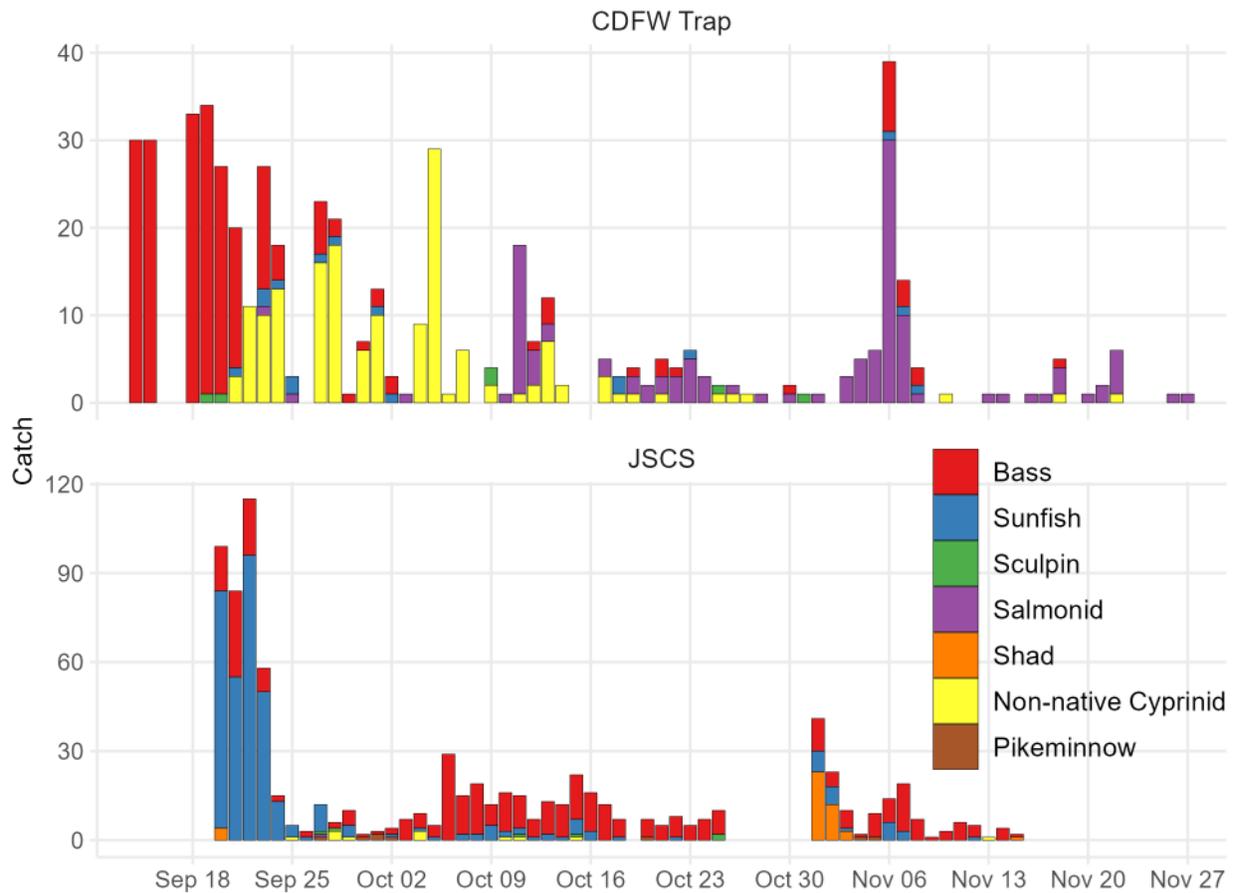
For non-target species, the CDFW traps caught more cyprinids and salmonids whereas the JSCS caught more sunfish, bass, and shad (**Table 5.6-2**). The temporal distribution of non-target catch also differed between the CDFW Trap and JSCS (**Figure 5.6-2**). Most notably, the CDFW trap catch was characterized by an early peak in bass catch, followed by cyprinids, and then salmonids whereas the JSCS exhibited a pronounced early peak comprised of sunfish and bass.

**Table 5.6-2.** CDFW Trap and JSCS non-target catch by species group.

Species Group	Species	Predator	CDFW Trap Catch	JSCS Catch
Bass	Spotted Bass ( <i>Micropterus punctulatus</i> )	Yes	223	338
	Smallmouth Bass ( <i>Micropterus dolomieu</i> )	Yes		24
	Black Bass ( <i>Micropterus</i> spp.)	Yes		22
	Largemouth Bass ( <i>Micropterus salmoides</i> )	Yes		1
Sunfish	White Crappie ( <i>Pomoxis annularis</i> )	Yes		275
	Bluegill ( <i>Lepomis macrochirus</i> )	No	2	33
	Black Crappie ( <i>Pomoxis nigromaculatus</i> )	Yes	7	31
	Green Sunfish ( <i>Lepomis cyanellus</i> )	Yes	7	15

California Department of Water Resources  
 Juvenile Salmonid Collection System: Report on Field Operations 2023

	Sunfish ( <i>Lepomis</i> spp.)	No	8
	Crappie ( <i>Pomoxis</i> spp.)	Yes	3
	Pumpkinseed ( <i>Lepomis gibbosus</i> )	No	1
Sculpin	<i>Cottus</i> sp.	Yes	6
	Prickly Sculpin ( <i>Cottus asper</i> )	Yes	2
	Riffle Sculpin ( <i>Cottus gulosus</i> )	Yes	2
	Brown Trout ( <i>Salmo trutta</i> )	Yes	74
Salmonid	Rainbow Trout ( <i>Oncorhynchus mykiss</i> )	Yes	45
	Kokanee ( <i>Oncorhynchus nerka</i> )	Yes	3
	Threadfin Shad ( <i>Dorosoma petenense</i> )	No	43
Shad	Cyprinid ( <i>Cyprinus</i> spp.)	No	143
	Sucker ( <i>Catostomus</i> spp.)	No	15
Non-native Cyprinid	Channel Catfish ( <i>Ictalurus punctatus</i> )	Yes	1
	Common Carp ( <i>Cyprinus carpio</i> )	Yes	1
	Sacramento Pikeminnow ( <i>Ptychocheilus grandis</i> )	Yes	8



**Figure 5.6-2.** Daily catch of non-target species at the CDFW Trap and JSCS. Note: the y-axis is scaled separately in each panel.

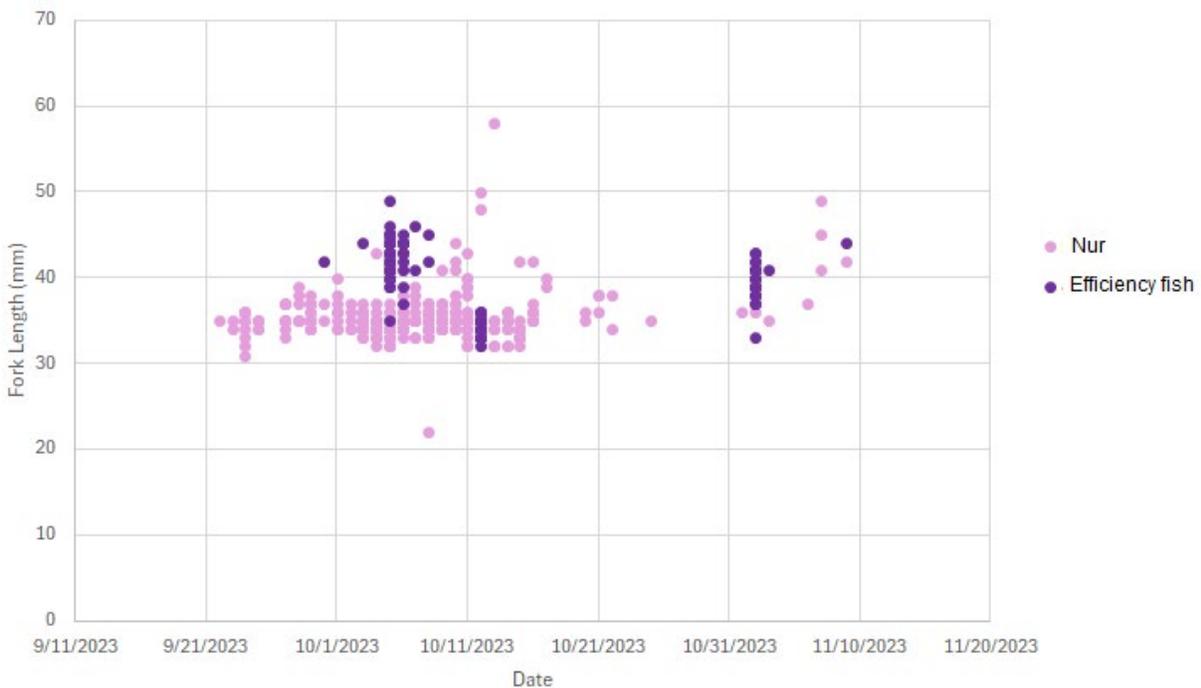
Catch was much higher at Site 1 for Nur and predators, even when accounting for different sampling durations at the two sites (Table 5.6-3). Non-predators were caught in similar numbers at both sites, which was largely driven by Threadfin Shad in the lacustrine environment (Figure 5.6-2).

**Table 5.6-3.** JSCS catch by species group and site.

Species Group	Total		Daily Average	
	Site 1	Site 2	Site 1	Site 2
Nur	481	8	13.4	0.5
Predators	626	100	17.4	6.7
Non-predators	48	47	1.3	3.1

At both sites, staff and crew made visual observations of predators (including adult bass and trout species) in the billows and shadows of the guidance nets. The JSCS did not capture adult fishes and these observations could not be confirmed. However, DWR suspects that predation in and around the guidance nets may affect capture probability. Future adjustments to the design and operation of the guidance nets should keep nets taut to minimize the formation of billows where predators may congregate.

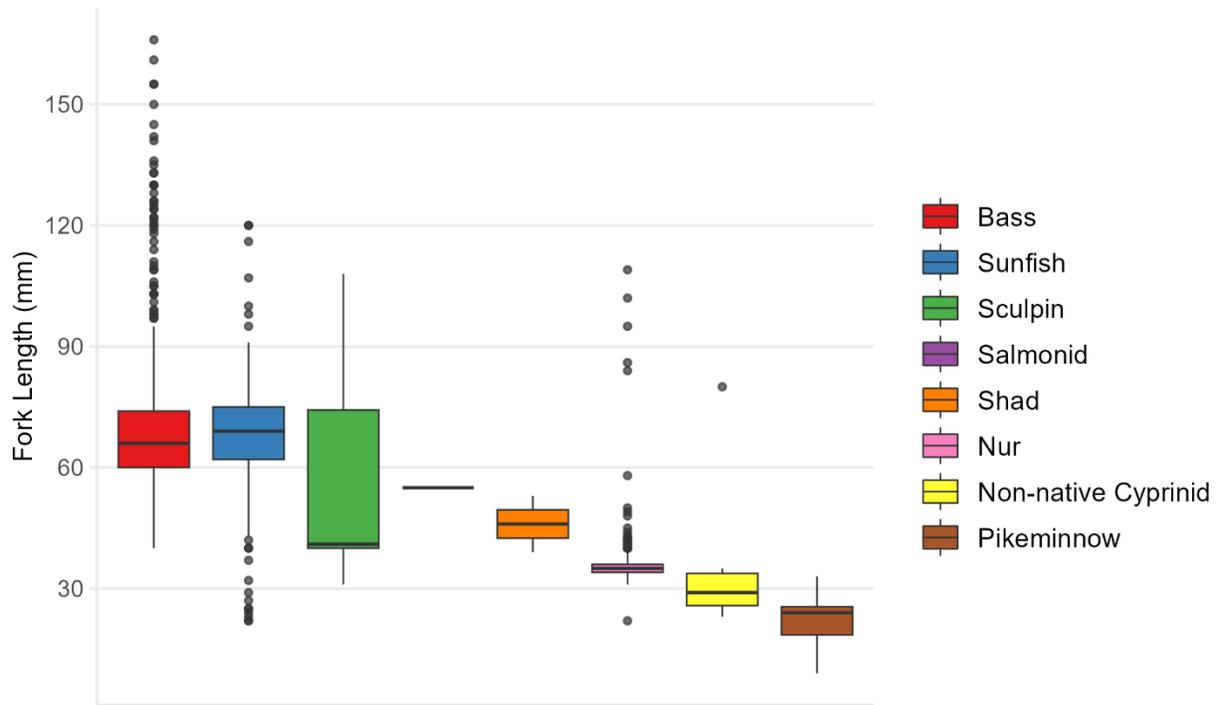
### 5.6b: Fork Length



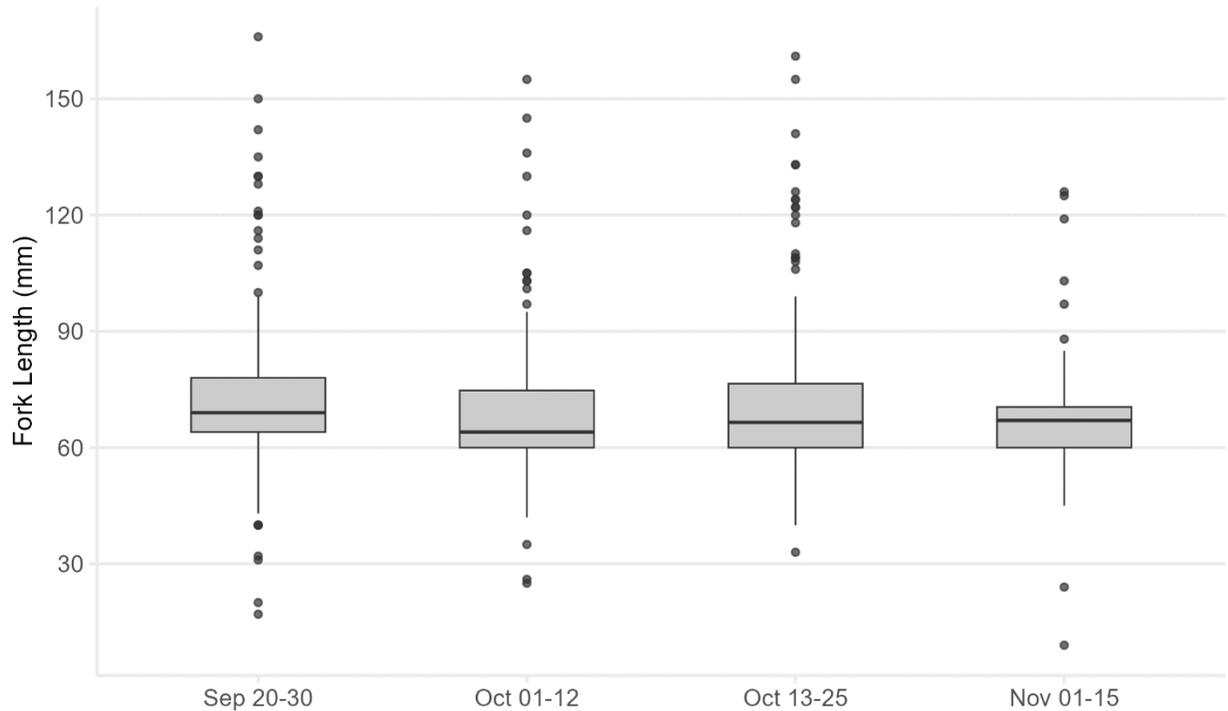
**Figure 5.6-3.** Fork length at date of winter-run Chinook Salmon captured at the JSCS. Each dot represents an individual fork length measurement.

Median fork length (FL) of Nur caught at the JSCS was 35 mm, and the median FL of efficiency fish recaptured at the JSCS was 41 mm (Figure 5.6-3).

PIT tags were detected in five Chinook Salmon with fork lengths >80 mm, which were identified as late fall-run released as part of a NOAA Fisheries/UCSC study. One non-Chinook Salmon salmonid was captured, a 55 mm FL Rainbow Trout. Median fork length of predators across all species groups was 67 mm with a max of 167 mm. The distribution of predator size was similar throughout the trapping season (Figure 5.6-5).



**Figure 5.6-4.** Fork length by species groups caught at the JSCS. In the box plots, the lower and upper bounds represent the 25<sup>th</sup> and 75<sup>th</sup> percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.



**Figure 5.6-5.** Fork length of predators caught at the JCS through the trapping season. The first three periods were conducted at Site 1 and the last was at Site 2. See Table 5.6-2 for the list of species defined as predators. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.

### 5.6c: Correlation

Several key covariates were correlated (**Table 5.6-4**). Fewer impermeable panels were deployed as depths decreased and velocity increased with decreasing depths. Water temperatures dropped throughout the trapping season due to seasonal shifts. The absence of a significant correlation between temperature and velocity led to the selection of those two covariates for subsequent analysis.

**Table 5.6-4.** Correlation matrix for key covariates. Values are Spearman’s rho statistic.

	Day of Year	Temperature	Velocity	Depth	Panels Deployed
Day of Year	1	-0.89***	-0.28	0.19	0.26
Temperature		1	0.26	-0.21	-0.19
Velocity			1	-0.76***	-0.72***
Depth				1	0.70***
Panels Deployed					1

\*  $p < 0.5$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Velocity was a significant predictor of catch for both Nur and predator species (**Table 5.6-5**). The relationship for both groups was non-linear with the highest Nur catch and the lowest predator catch

both occurring when velocity at the trap entrance was about 1.5 fps. For Nur, the peak was largely driven by catching 79 and 86 fish on October 3, 2023 and October 4, 2023 when velocity at the trap entrance was 1.45 and 1.5 fps, respectively, which is considerably higher than the overall daily median of 8 fish. Temperature was a significant predictor of predator catch (Table 5.6-5) with fewer predators caught as temperature decreased. There were no significant effects of velocity and temperature on non-predator catch (Table 5.6-5), but fewer fish were caught in this species group (**Table 5.6-1**), which reduced the power to detect significant effects.

**Table 5.6-5.** Summary output for three generalized additive models that were fitted to JSCS catch for three species groups as a function of velocity and temperature. Cubic regression splines with shrinkage were used to calculate the smooth terms.

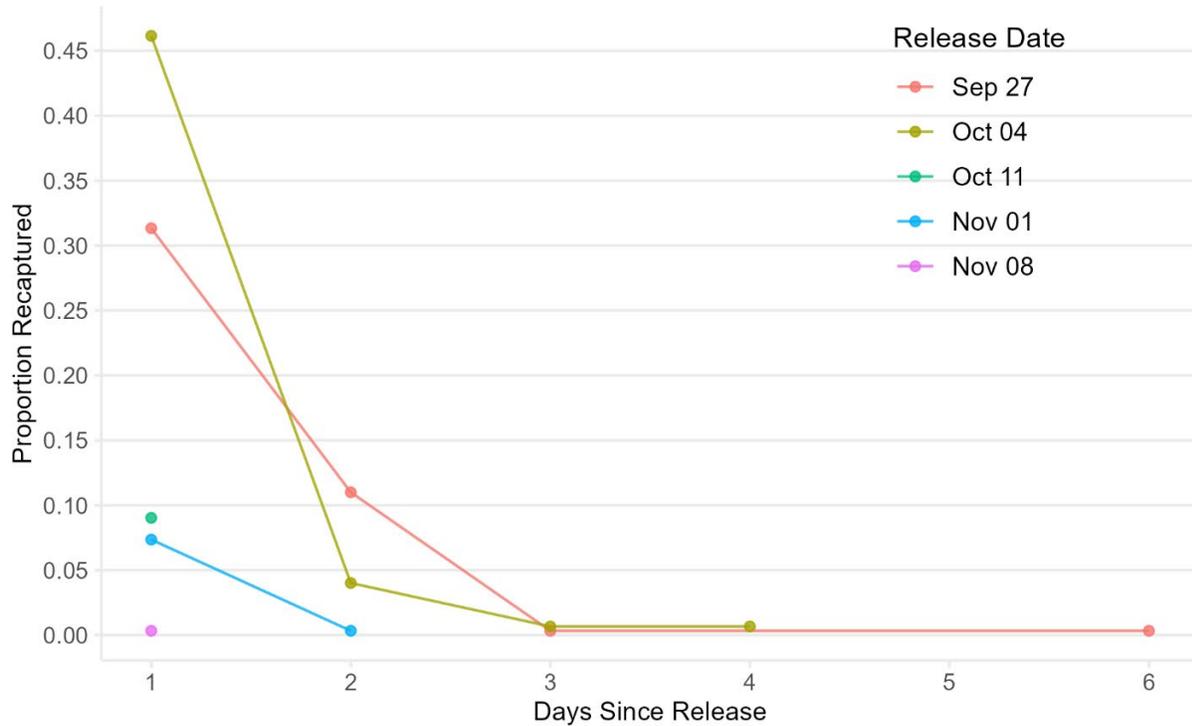
	Adj R <sup>2</sup>	Smooth Term	edf	F	p
Nur	0.60	velocity	5.56	2.40	0.008
		temperature	6.42	1.33	0.118
Predators	0.67	velocity	2.49	1.42	0.003
		temperature	4.80	11.52	<0.001
Non-predators	0.17	velocity	0.81	0.23	0.121
		temperature	4.66	0.54	0.430

#### 5.6d: Efficiency Trials and Capture Probability

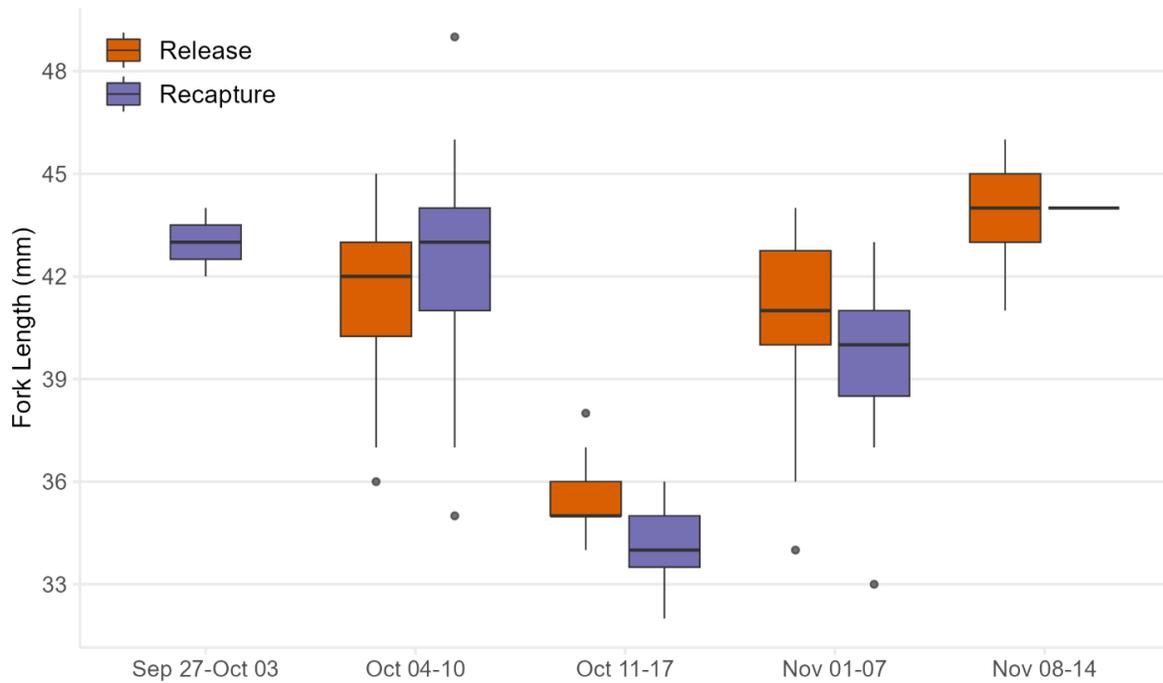
Dual-marked winter-run Chinook Salmon (efficiency fish) were released as part of trap efficiency trials (see **Section 4.6b**: Efficiency Trials). A total of 1497 efficiency fish were released with 334 fish (22%) recaptured at the JSCS (**Table 5.6-6**). 84% of all recaptures occurred 1 day after release and 98% of recaptures occurred within two days of release. Released and recaptured fish generally had similar fork lengths within a release group; fish were smallest in the October 11 release group (**Figure 5.67**). Only 20 marked efficiency fish from upper releases (i.e., above CDFW Trap) were recaptured in the JSCS and are not included in this analysis. In this section we provide descriptive statistics related to release, recapture, and environmental covariates during the release-recapture periods.

**Table 5.6-6.** Releases and recaptures of marked WRCS from trap efficiency trials at the JSCS.

Release Date	Number Released	Number Recaptured	Trap Location
Sep 27	300	129 (43.0%)	Site 1
Oct 4	299	154 (51.5%)	Site 1
Oct 11	299	27 (9.0%)	Site 1
Nov 1	299	23 (7.7%)	Site 2
Nov 8	300	1 (0.3%)	Site 2
<b>Total</b>	<b>1497</b>	<b>334 (22.3%)</b>	



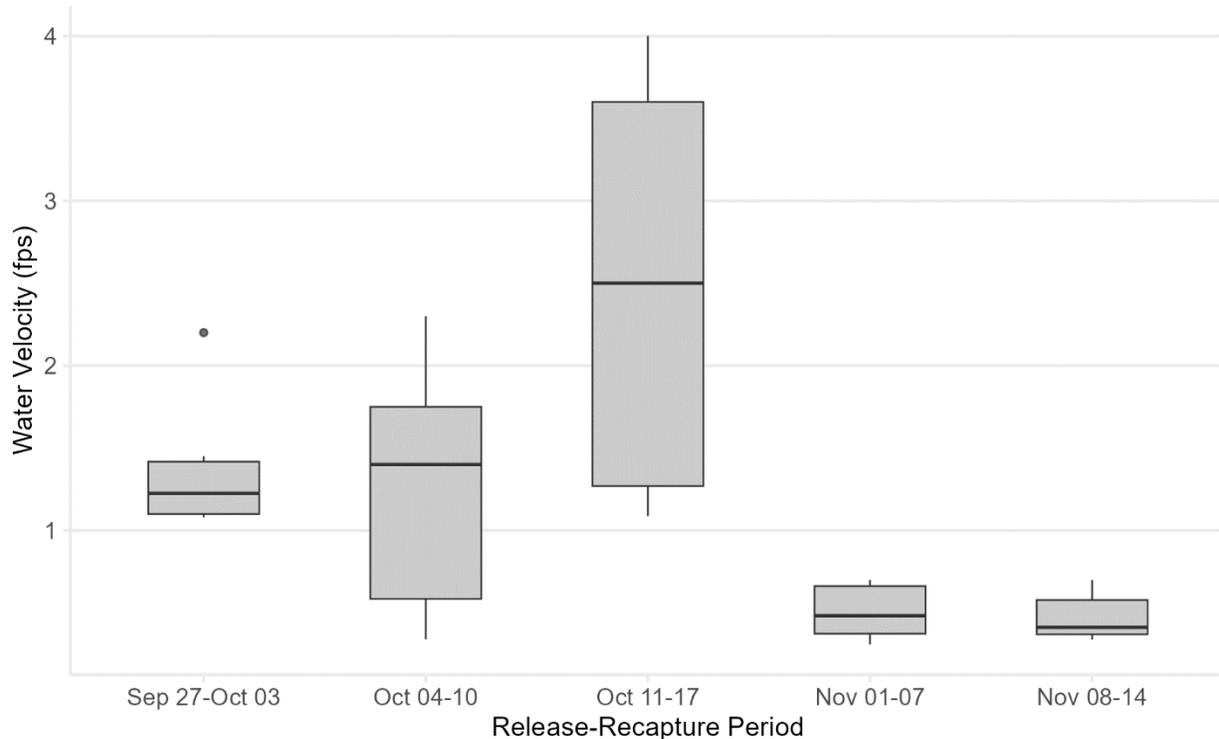
**Figure 5.6-6.** Proportion of marked WRCS recaptured in the days following release from trap efficiency trials at the JSCS.



**Figure 5.6-7.** Fork length of released and recaptured WRCS as part of trap efficiency trials at the JSCS. No fish were measured for the first release. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent

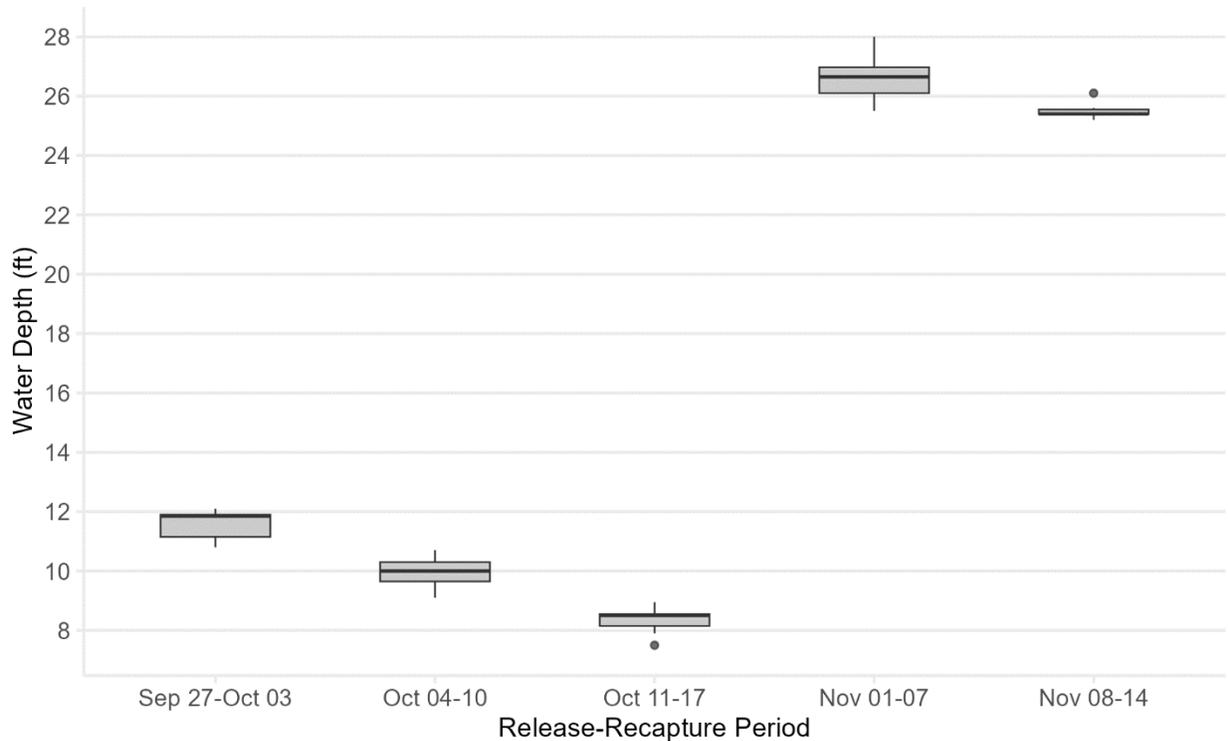
the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.

The highest rates of recapture occurred for the first two releases (**Table 5.6-6**), which were conducted when the JSCS was located at Site 1. The water velocity through the JSCS trap during those two releases (**Figure 5.6-8**) was similar to the ranges of velocities associated with the highest catch of Nur (see Section 5.6a: Trap Catch). There is no significant difference in fork length between released efficiency fish and recaptured efficiency fish, from which it can be inferred that there is no correlation between fork length and capture probability.



**Figure 5.6-8.** Distribution of daily average water velocity through the JSCS trap during the release-recapture periods. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.

The third release was characterized by high water velocities (**Figure 5.6-8**) and shallow depths (**Figure 5.6-9**). The JSCS was not designed to operate at shallow depths and modifications including raising the impermeable panels of the guidance nets were made to the structure to reduce load, which reduced the ability of the JSCS trap to catch fish. Additionally, the right guidance net was raised during the final week at Site 1 to reduce load on the system but inadvertently came off the bottom, which may have allowed for temporary fish passage underneath the net.



**Figure 5.6-9.** Distribution of daily water depth at the JSCS trap during the release-recapture periods. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.

The last two releases were conducted when the JSCS was located at Site 2 (**Table 5.6-6**). Much lower recapture rates were observed at Site 2 than for the first two releases at Site 1, presumably because of changes in conditions between the two sites. However, there was a significantly higher recapture rate for the November 1 release than the November 8 release (**Table 5.6-6**), but not much difference in water velocity (**Figure 5.6-8**) or water depth (**Figure 5.6-9**) for those releases.

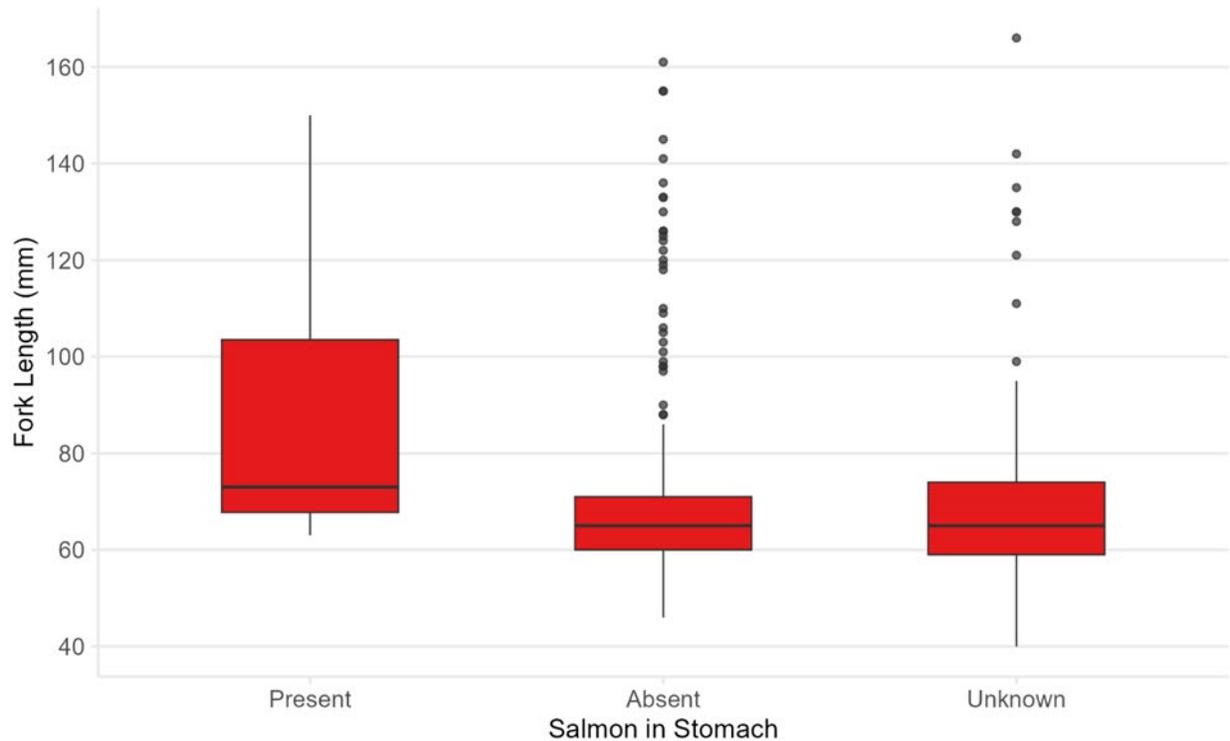
### 5.6e: Bass Stomach Contents

Beginning on October 3, 2023, black bass caught in the JSCS trap were surrendered to the Winnemem Wintu Tribe, euthanized, and examined for the presence of juvenile salmon in their stomachs. Prior to October 3, it is not known how many black bass were sacrificed and checked, but there are two records of Nur in the stomachs of black bass prior to October 3. Fork length was recorded for a subset of the salmon found in the stomach contents of black bass if the carcass was intact.

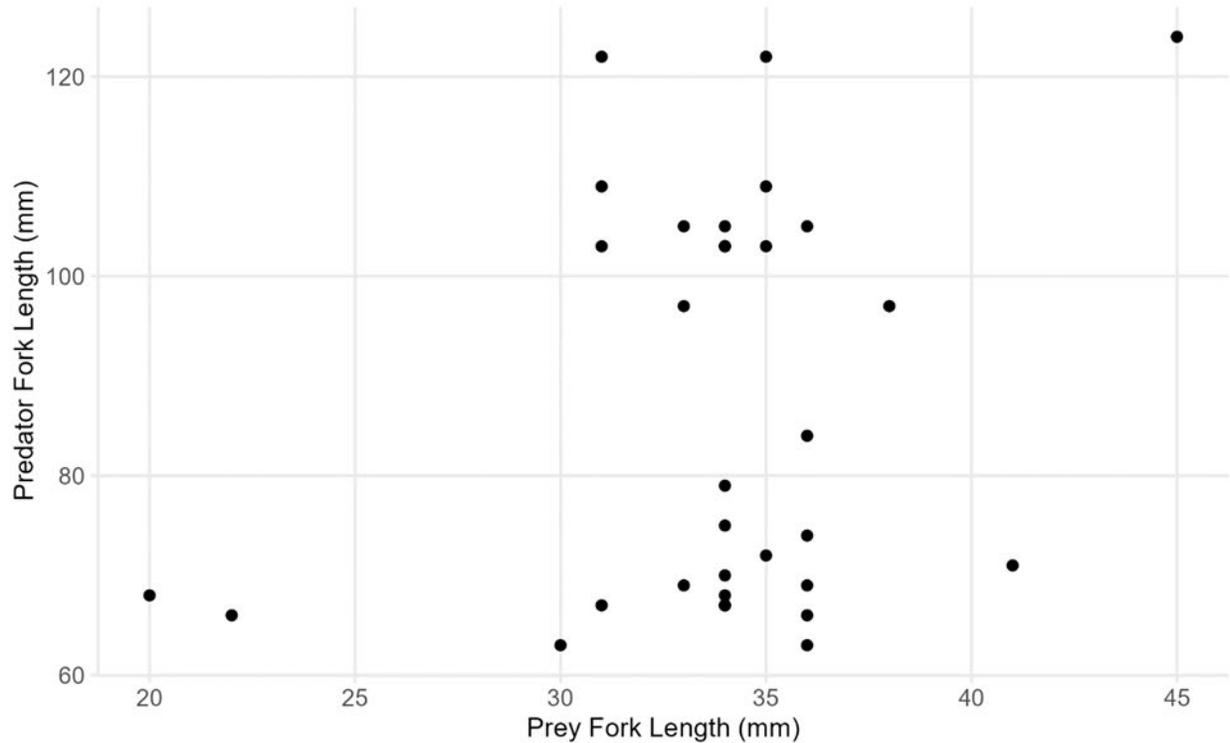
Of the 382 black bass caught in the JSCS trap throughout the season, 299 (78%) were euthanized and examined for the presence of juvenile winter-run Chinook Salmon in their stomach. Due to partial digestion, it was not possible to consistently differentiate between dual-marked efficiency fish and river-reared Nur in the field. The carcasses retrieved from bass stomachs were salvaged and sent to Southwest Fisheries Science Center affiliate researchers at UC Davis, who are conducting genetic analysis to determine parentage and origin (river-reared or hatchery) of predated juvenile salmon. Of the 299 black bass sampled, 32 (11%) were found to have juvenile winter-run Chinook Salmon in their

stomach. Those 32 black bass consumed 56 juvenile salmon; the median was 1 juvenile salmon per bass stomach with a maximum of 12 juvenile salmon observed in a single bass stomach (a 114-mm FL Spotted Bass).

There was a significant difference in bass fork length relative to juvenile salmon consumption ( $F_{2,295} = 5.84, p = 0.003$ ) where black bass with salmon present in their stomachs were larger than those with salmon absent or unknown (**Figure 5.6-10**). There was no relationship between the size of the salmon in the stomach and the size of the black bass predators (**Figure 5.6-11**).



**Figure 5.6-10.** Fork length distribution for black bass caught in the JCS trap relative to the presence of juvenile salmon in the stomach. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.



**Figure 5.6-11.** Relationship between the fork lengths of black bass predators and the juvenile salmon prey found in their stomachs.

### 5.6f: Hook and Line Sampling

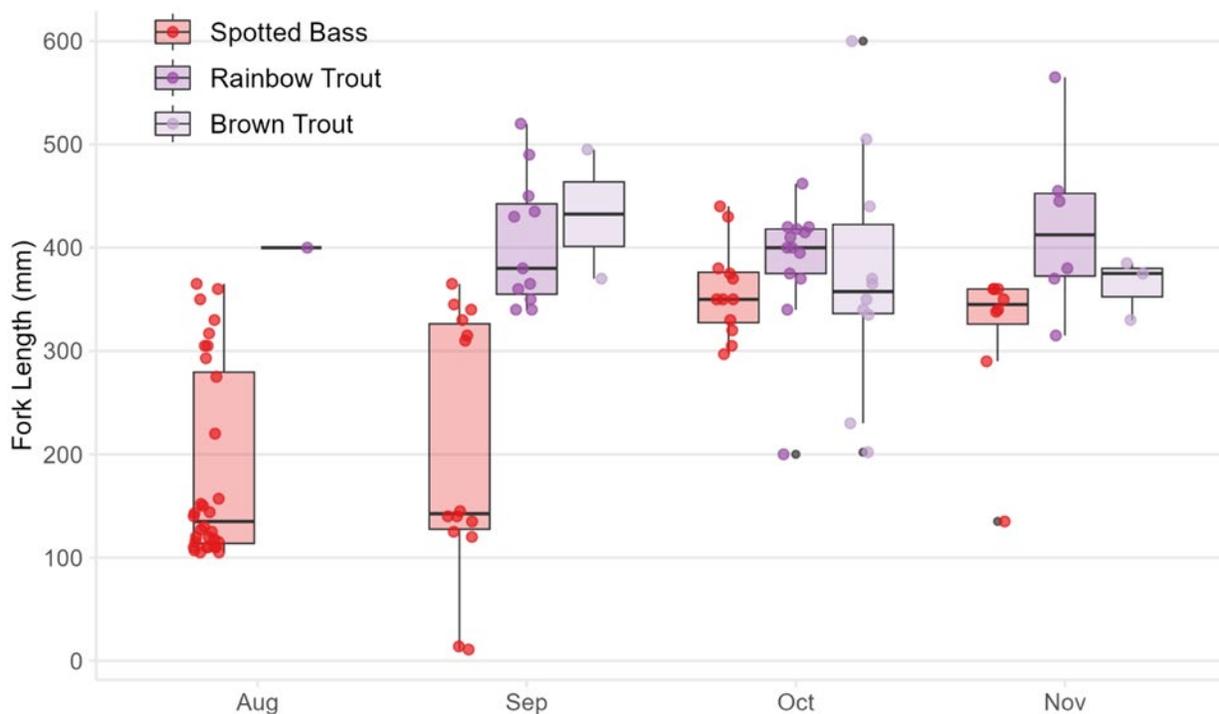
Hook-and-line sampling was conducted to sample the predator community before JSCS installation and during JSCS operation. A subset of captured fish were PIT tagged for a mark-recapture analysis, but none of the tagged fish were recaptured.

A total of 44 hook-and-line surveys were conducted across 20 days for an average of 4.2 hrs/day of sampling. Four days of sampling were conducted in August prior to JSCS construction. Three and nine days of sampling were conducted in September and October, respectively, while the JSCS was located at Site 1. Four days of sampling were conducted in November while the JSCS was located at Site 2.

A total of 114 fish were caught via hook-and-line sampling with Spotted Bass, Rainbow Trout, and Brown Trout representing 97% of all catch (**Table 5.6-7**). PIT tags were inserted into Spotted Bass (30 individuals tagged), Rainbow Trout (18), and Brown Trout (6) across September (24), October (17), and November (13). Fish caught via hook-and-line sampling generally had fork lengths in the 300-500 mm range except for Spotted Bass in August and September (**Figure 5.6-12**).

**Table 5.6-7.** Total catch from hook-and-line sampling by species and month.

Species	Aug	Sep	Oct	Nov	Total
Spotted Bass	32	14	12	8	66
Rainbow Trout	1	11	13	6	31
Brown Trout		2	10	3	15
Channel Catfish	1				1
Sacramento Pikeminnow	1				1
<b>Total</b>	<b>35</b>	<b>27</b>	<b>35</b>	<b>17</b>	<b>114</b>

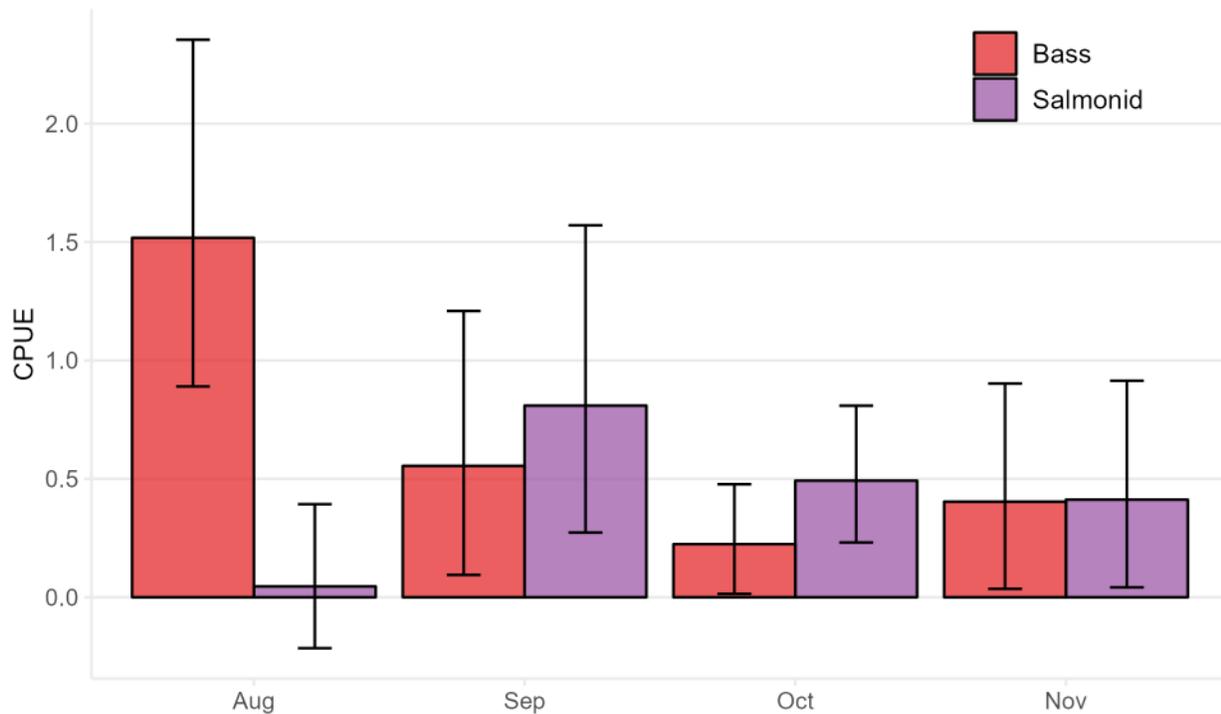


**Figure 5.6-12.** Fork length distribution for species caught by hook-and-line sampling from August to November. Not shown are individual Sacramento Pikeminnow (430 mm) and Channel Catfish (700 mm). Actual measurements are plotted as jittered points on top of the boxplots. In the box plots, the lower and upper bounds represent the 25th and 75th percentiles, respectively, the middle line represents the median, the whiskers represent the range (when no outliers), and points represent outliers that extend beyond 1.5 times the interquartile range.

For CPUE, the sampled species were split into two groups: Bass and Salmonid. Sacramento Pikeminnow and Channel Catfish were excluded because only one individual was caught of each species. Rainbow Trout and Brown Trout were lumped into the Salmonid group to increase statistical power. There was a significant interaction between month and species group on catch per unit effort (CPUE) (**Table 5.6-8**) with the highest CPUE occurring for Bass in August (**Figure 5.6-13**), prior to JSCS construction.

**Table 5.6-8.** ANOVA table for CPUE by month and species group for hook-and-line sampling.

Species	df	Sum of Squares	Mean Square	F	p
Month	3	0.71	0.24	1.27	0.291
Species Group	1	0.10	0.10	0.51	0.475
Month * Species Group	3	3.85	1.28	6.87	<0.001
Residuals	79	14.76	0.19		

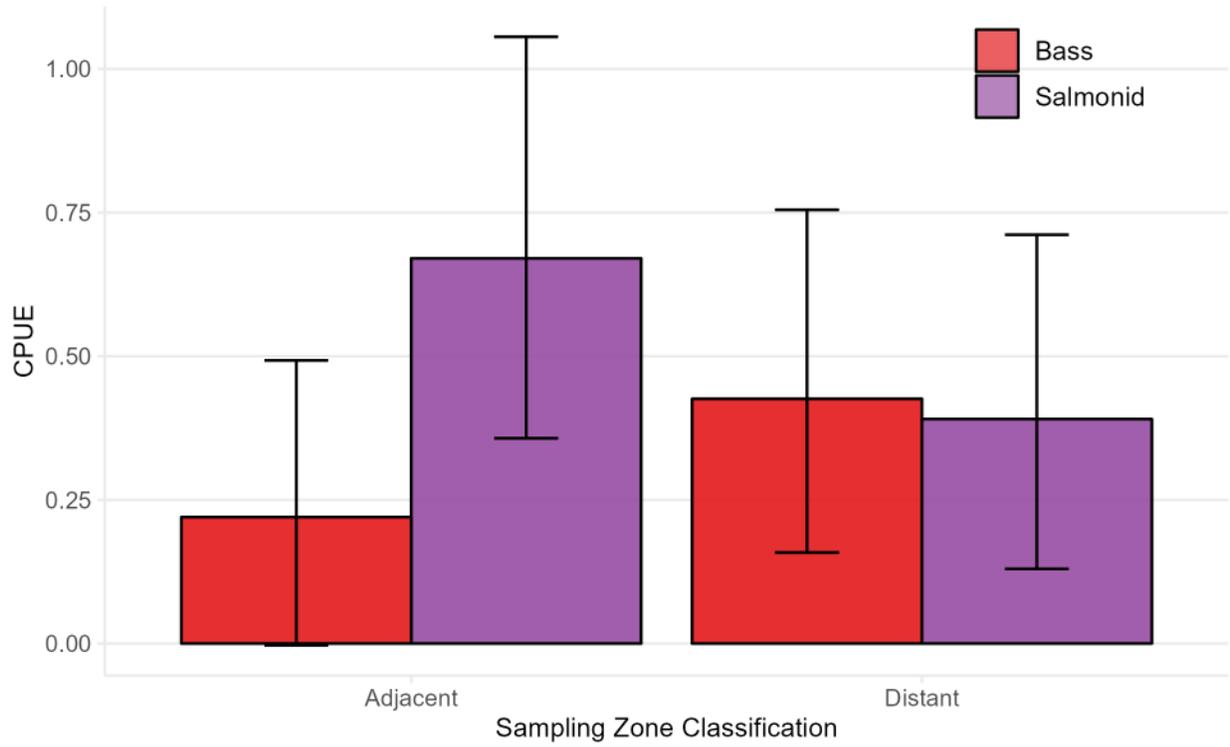


**Figure 5.6-13.** CPUE by month and species group for hook-and-line sampling.

The two sampling zones adjacent to the JSCS at each site were classified as Adjacent and all other zones as Distant. There were no significant effects of sampling zone classification and species group on CPUE (Table 5.6-9; Figure 5.6-14).

**Table 5.6-9.** ANOVA table for CPUE by sampling zone and species group for hook-and-line sampling.

Species	df	Sum of Squares	Mean Square	F	p
Zone	1	0.002	0.001	0.008	0.929
Species Group	1	0.373	0.373	2.027	0.159
Zone * Species Group	1	0.496	0.496	2.700	0.105
Residuals	65	11.95	0.19		



**Figure 5.6-14.** CPUE by sampling zone and species group for hook-and-line sampling.

# Section 6: Conclusions and Recommendations

## Catch and Capture Probability

Over the course of field operations in 2023, the JSCS captured 489 Nur and an additional 349 dual-marked efficiency fish for a combined total of 843 juvenile winter-run Chinook Salmon (**Table 5.6-1**). Nur catch at the JSCS peaked in October catch at the upstream CDFW traps peaked in September (**Fig. 5.6-1**). Trap deployment over a longer period of time in the 2024 field season (i.e., extending field operations through January) will provide a more robust understanding of outmigration timing and distribution as well as trap function in various reservoir conditions (e.g., rising and falling water surface elevation).

The JSCS recaptured the greatest proportion of marked efficiency fish in the first and second efficiency trials, 129 out of 300 (43.0%) and 154 out of 299 (51.5%) respectively; **Table 5.6-4**. Trap efficiency and capture probability may be correlated with environmental conditions in and around the JSCS structure, including depth and velocity. During the two weeks of highest capture rates, reservoir depth at the trap site ranged between 10-12 ft and velocities at the trap entrance ranged between 1.3-2.1 ft/s (**Table 5.3-2**). For the 2024 field season, trap site and operations planning should consider maintaining these parameters to maximize trap efficiency and capture probability.

## Predation

Black bass and sunfish comprised a majority of non-salmonids captured at the JSCS trap in 2023, especially in earlier and warmer months (**Fig. 5.6-2**). Black bass posed a particular concern as predators, and DWR surrendered bass to the Winnemem Wintu Tribe for stomach sampling starting October 3, 2023. Of the 299 black bass sampled, 32 (11%) had winter-run Chinook Salmon present in their stomach (**Section 5.6e**). The number of salmon recovered from a single bass stomach ranged from 0 to 12 carcasses. The total winter-run Chinook Salmon carcasses recovered from black bass stomachs numbered 56, or 6.2% of the total winter-run Chinook Salmon catch. Predation offers one explanation for lower-than-expected catch numbers later in the season, but the observed rates of predation in the trap do not account for low capture probabilities in the 2023 field season. It is possible that predators, habitat characteristics, released winter-run Chinook salmon behavior, potential unintended passage routes through the guidance nets, or other environmental factors upstream of the JSCS had significant effects on capture probability. Further research on predator diets in the vicinity of the JSCS should be conducted to evaluate the impact of predation on capture probability and survival. Further predator-related research might incorporate knowledge of effective seasonal fishing strategies and effective lure types from local knowledge holders in order to maximize predator capture. Local and targeted predator removal may mitigate the impacts of non-native predators on juvenile salmonid survival in the project area. Installation of additional refuge in the trap (e.g., a laundry basket “hotel”) or of olfactory decoys outside the trap may reduce predation within the JSCS trap itself. Additional survey (e.g., snorkel), sampling (e.g., hook and line), and monitoring (e.g., acoustic tags, predation event recorders) efforts focusing on the reservoir stretch upstream of the trap location may offer insight into the predator assemblages and behavior directly upstream of the JSCS, juvenile salmon utilization of refuge habitat

near the JSCS, and juvenile salmon behavior navigating JSCS structure elements. These studies should inform predator management decisions made to support a long-term reintroduction effort.

No PIT tagged resident fish were recaptured over the course of the 2023 field season and resident/migratory fish use of fish passage devices remains unknown. Further research (e.g., acoustic tagging, predation event recording, camera/sonar) is needed to assess resident fish behavior around and navigation of the JSCS structure.

### JSCS Structure Components

The JSCS guidance nets, impermeable panels, and fish trap worked as designed to passively provide significant velocities entering the trap and to diffuse velocity between the trap entrance and the fry box. This passive velocity control funneled fish into the trap without placing stress on juvenile winter-run Chinook Salmon. Even at the highest velocities in the trap (> 5 ft/s), velocities inside the fry box remained below 2 ft/s (**Fig. 5.3-12**). Debris-related impingement and predator exclusion posed challenges to fry box operation during the 2023 field season, and strategic approaches to minimize debris and predators in the fry box should be evaluated. Adjustments to trap structure and operation should also include replacing the chain gantry crane with an electric winch to minimize sound and vibration disturbance.

Both the temperature curtain and the guidance nets had significant cooling effects on upstream water temperatures. The guidance nets were installed with the JSCS fish trap and platform while the temperature curtain was deployed at the most downstream site all season. The presence of the temperature curtain was associated with cooler temperatures upstream of the curtain for depths from near-surface to mid-depth, with deployment resulting in temperature differences of 2.8 °C and 3.6 °C at 4 ft and 7 ft below water respectively (**Table 5.2-2**). The guidance nets also functionally lowered near-surface water temperatures upstream of net deployment by blocking flow and encouraging mixing (**Fig. 5.3-2, Fig. 5.3-3**). During the initial 16 days of the 2023 deployment, during which the air temperatures were highest, the guidance net structure facilitated cooler temperatures upstream; temperature differences (downstream minus upstream) of 4.9 °C and 1.3 °C at 4 ft and 7 ft below water surface, respectively, were observed (**Table 5.2-1**).

### Meteorological Data

Results from the 2023 field operations of the JSCS did not indicate any correlation between juvenile salmon outmigration or behavior and meteorological data (e.g., air temperature, precipitation, or moon phase). More robust trap capture data in the 2024 field season may offer insight as to any relationship between juvenile salmon behavior and meteorological phenomena in the McCloud River.

### Water Surface Elevation and Reservoir Conditions

Reservoir WSE was a dominant factor in determining the siting of the JSCS trap. The monthly USBR reservoir WSE forecasts provided useful information for planning and became more accurate closer to the field season (**Fig. 3.4-1**). Site planning for 2024 should be finalized with the USBR July forecast and accompanied by a field effort to ground-truth existing bathymetry data. Ideally, the selected sites would avoid deployment in river bends to minimize any effects of channel geomorphology on trap efficiency and for overall ease of logistics. If possible, a second site should be approximately 10 ft deeper than the

first site to maintain optimal depth between 8 ft and 20 ft and optimal capture conditions throughout the season.

Dropping reservoir depths and increasing velocities at Site 1 posed a risk to trap operation and fish safety the week of October 20, 2023 (**Section 4.8b, Fig. 5.3-7**). Relocating the JSCS depended on contractor availability, and scheduling conflicts resulted in the JSCS remaining at Site 1 past the ideal conditions for demobilization and reinstallation. The relocation effort took one week from the time fishing stopped at Site 1 until fishing resumed at Site 2. Dependence on external contractors for trap installation, movement, and demobilization reduces the capacity of JSCS trap operators to respond to changing reservoir conditions quickly and with agility. Alternatives to build internal capacity for all elements of trap operation should be considered to reduce the cost and improve the responsiveness of JSCS operation.

### Comparison with Prior Field Season

There were two key differences in JSCS deployment between the 2022 and 2023 field seasons. First, the purpose of the 2022 season was to ensure that structure components (temperature curtain, guidance nets, platform, and docks) could be successfully deployed and the fish trap was neither installed nor operated. The purpose of the 2023 field season, however, was to test the efficacy of the fish trap and begin identifying ideal methods and parameters for JSCS fish trap operations. Second, the JSCS was deployed in a single location with water depths remaining greater than 30 ft for the duration of deployment during the 2022 field season. As a result, surface water temperatures were consistently high (>20° C) and velocities were very low (<0.1 ft/s), which are not ideal conditions for fish trap operation. Based on these observations and significantly higher reservoir levels in 2023, DWR selected an initial location farther upstream near reservoir-riverine interface at the McCloud Bridge and planned to relocate the trap to a secondary location partway through the 2023 season to respond to forecasted decreases in water surface elevation as discussed in **Section 3.1**. JSCS deployment at two sites provided additional data about fish trap function under different reservoir conditions but resulted in a break in trap operation during the relocation. Future siting and deployment planning should seek to strike a balance between maximizing JSCS responsiveness to changing reservoir conditions and minimizing disruption to trap operation. Planning for the 2024 season will build upon lessons learned from the previous two seasons to improve efficiency across the undertaking.

In conclusion, further data collection is needed to support, challenge, or expand upon the preliminary interpretations and recommendations outlined in this report. 2023 was the first season of JSCS fish trap operation in the field and additional data will offer a more robust understanding of the efficacy and impact of, as well as ideal parameters and methods for, JSCS deployment in the McCloud Arm of Shasta Reservoir.

## Section 7: Acknowledgements

The DWR Riverine Stewardship Program would like to acknowledge and thank our project partners for their generosity of time, expertise, and effort to make the 2023 field operations of the JSCS successful.

Chief Caleen Sisk, Marine Sisk, Bekah Olstad, Cassandra Curl, Arron Sisk, and Nina Sisk of the Winnemem Wintu Tribe contributed deep knowledge of the Winnemem Waywaket and of Nur to the JSCS project. Special thanks to Cassandra, Arron, and Nina for their invaluable work in trap operation and fish sampling. The Winnemem Wintu Tribe's tremendous effort to restore salmon to the McCloud River makes this project possible.

Travis Hinkelman, Taylor Spaulding, Matt Silva, and Cameron Reyes of Environmental Science Associates (ESA) all contributed to this report. Many thanks to them and to their colleagues at ESA for their help preparing for this field season, putting in long hours on the river, and analyzing the season's data.

Thanks to Kaitlin Dunham, Kevin Niemela, and the staff at Livingston Stone National Fish Hatchery for assisting with the provision and preparation of juvenile winter-run Chinook Salmon for mark-recapture efficiency trials.

Anne Boyd, Mikayla Debarros, Dennis Cocherell, and Nann Fangué of the UC Davis Fish Conservation Physiology Lab offered training to the DWR RSP crew in fish handling and field methods. Traci Treleaven, JohnFranco Saraceno, Jay Aldrich, JT Casby, Craig Stuart, and Naoaki Ikemiyagi of DWR Division of Integrated Science and Engineering provided their hands-on guidance in preparation for this field season. Scott McReynolds, Justin Call, and Austin Hall from the DWR Northern Region Office also provided us with their technical expertise in the field this season.

Brian Bellgraph (PNNL), Steve Edmondson (NOAA Fisheries), John Hannon (USBR), Jon Mann (CDFW), Mark Miyoshi (WWT), Rene Henery (Trout Unlimited), Stacie Smith (NOAA Fisheries), Steve Thomas (NMFS), and Toby Kock (USGS) all contributed to the design of the JSCS Fish Trap.

Thanks to Mark Gard (CDFW) for extensive bathymetric surveying of the McCloud Arm of Shasta Reservoir and for verifying site bathymetry prior to the 2023 season.

This work was funded through a State Reimbursable Authority Receivable Grant from CDFW (Grant #D2210007/DWR 348002A). Thanks to Jason Roberts for organizing DWR's part in this project and securing funding for this work.

Finally, deep thanks to Matt Johnson (CDFW) and Rachel Johnson (NOAA Fisheries) for their outstanding efforts to coordinate and collaborate on work across agencies to bring the salmon home.

## Section 8: References

- Anderson, G., W. Ellison, and R. Heizer. 1978. Treaty Making and Treaty Rejection by the Federal Government in California, 1850-1852. Publications in Archeology, Ethnology, and History 9. CA: Ballena Press. California State Library.
- Clancey, K., L. Saito, K. Hellmann, C. Svoboda, J. Hannon & R. Beckwith. 2017. Evaluating Head-of-Reservoir Water Temperature for Juvenile Chinook Salmon and Steelhead at Shasta Lake with Modeled Temperature Curtains, *North American Journal of Fisheries Management*, 37:5, 1161-1175, DOI: 10.1080/02755947.2017.1350223.
- Department of Water Resources (DWR). 2023a. Juvenile Salmonid Collection System: Science Plan, Version 2 Prepared by Environmental Science Associates for Department of Water Resources Riverine Stewardship Program. Document D201900930.05.
- Department of Water Resources (DWR). 2023b. Shasta Juvenile Salmonid Collection System: Fish Sampling Standard Operating Procedures. Version 1.2. *In review*.
- Department of Water Resources (DWR). 2023c. DWR-1-SOP-010 Calibration and Maintenance for Multi-Parameter Water Quality Instruments (ProDSS). Version 1.0 *In review*.
- Department of Water Resources (DWR). 2023d. DWR-1-SOP-003 Calibration and Maintenance for Multi-Parameter Water Quality Instruments (EXO). Version 2.1.
- Garibaldi, A. & N. Turner. 2004. Cultural Keystone Species: Implications of Ecological Conservation and Restoration. *Ecology and Society*. 9:3, 1-18. DOI: 10.5751/ES-00669-090301.
- Garret, B. 2010. Drowned Memories: The Submerged Places of the Winnemem Wintu. *Archaeologies* 6:2, 346- 71. DOI: 10.1007/s11759-009-9109-9.
- ICF International. 2016. Battle Creek Winter-Run Chinook Salmon Reintroduction Plan. (ICF 00148.15.) August. Sacramento, CA. Prepared for California Department of Fish and Wildlife. Sacramento, CA.
- Lindley, S. T., R. Schick, B. P. May, J. J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley Basin. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-360.
- Madley, B. 2016. *An American Genocide: The United States and the California Indian Catastrophe, 1846-1873*. New Haven: Yale University Press.
- McLeod, Christopher. 2001. *In the Light of Reverence*. Sacred Land Film Project.
- Moyle, P.B., R. Lusardi, and P. Samuel. 2017. "State of the Salmonids II: Fish in Hot Water." California Trout Inc. San Francisco, CA. Available: <https://caltrout.org/wp-content/uploads/2017/05/SOS-II-Fish-in-Hot-Water-Report.pdf>.

California Department of Water Resources  
Juvenile Salmonid Collection System: Report on Field Operations 2023

Ngo, M. 2009. "Appendix F: Video Interview Transcript 11/ 10/2009 Winnemem Wintu Interview with Tribal Chief and Spiritual Leader, Caleen Sisk." In *Loss of Sacred Spaces: The Winnemem Wintu Struggle Against a Cultural Genocide by California Water Demands*, submitted to California State University Department of Geography. Long Beach, CA.

National Marine Fisheries Service (NMFS). 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. California Central Valley Office. Sacramento, CA. Available: [https://media.fisheries.noaa.gov/dam-migration/central\\_valley\\_salmonids\\_recovery\\_plan-accessible.pdf](https://media.fisheries.noaa.gov/dam-migration/central_valley_salmonids_recovery_plan-accessible.pdf).

National Marine Fisheries Service (NMFS) 2016. California Central Valley Recovery Domain. 5-Year Status Review: Summary and Evaluation of Sacramento River Winter-Run Chinook Salmon ESU.

National Marine Fisheries Service (NMFS) 2021. Species in the Spotlight: Priority Actions 2021-2025 Sacramento Winter-run Chinook Salmon. Available: [https://media.fisheries.noaa.gov/2021-04/SIS%20Action%20Plan%202021\\_SacWinterRunChinook\\_FINAL%20508.pdf](https://media.fisheries.noaa.gov/2021-04/SIS%20Action%20Plan%202021_SacWinterRunChinook_FINAL%20508.pdf).

National Marine Fisheries Service (NMFS). 2023. Survival of Endangered California Winter-Run Chinook Salmon in 2022. West Coast Regional Office. Available: <https://www.fisheries.noaa.gov/west-coast/climate/survival-endangered-california-winter-run-chinook-salmon-2022>.

Pacific Netting Products (PNP). 2023. DWR-JSCS 2023 Fish Trap Shasta. Prepared for Department of Water Resources Riverine Stewardship Program. Sacramento, CA.

Scott, James. 1998. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. CT: Yale University Press.

Sisk, C. 2002. Statement on the Protection of Native American Sacred Places as they are affected by Department of Defense Undertakings, § Committee on Indian Affairs.

Smith, Dottie. 1995. *The History of the Indians of Shasta County*. California State Library. Sacramento, CA.

Smith, Neil. 1990. *Uneven Development: Nature, Capital, and the Production of Space*. GA: University of Georgia Press.

Starr, C. and L. Day. 2020. Juvenile Salmonid Emigration Monitoring in the Lower American River, California January – June 2020. Unpublished report prepared for the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife, Sacramento, California.

U.S. Bureau of Reclamation (USBR), 2014. Shasta Dam Fish Passage Evaluation Habitat Assessment Final Report. Mid-Pacific Region. August 2014. Available: <https://www.usbr.gov/mp/bdo/shasta-dam-fish-pass.html>.

California Department of Water Resources  
Juvenile Salmonid Collection System: Report on Field Operations 2023

- U.S. Bureau of Reclamation (USBR). 2016. Shasta Dam Fish Passage Evaluation Draft Pilot Implementation Plan Final Report. Mid-Pacific Region. December 2016. Available: <https://www.usbr.gov/mp/bdo/shasta-dam-fish-pass.html>.
- U.S. Bureau of Reclamation (USBR) 2023. U.S. Bureau of Reclamation (USBR) operates Shasta Dam and reports observed WSE (retrieved from CDEC: <https://cdec.water.ca.gov/dynamicapp/QueryDaily?s=SHA>).
- U.S. Geological Survey (USGS). 2023a. National Water Information System data available on the World Wide Web—Streamgage 11367800 McCloud River at Ah Di Na, CA. Available: [https://waterdata.usgs.gov/ca/nwis/inventory/?site\\_no=11367800](https://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11367800)
- U.S. Geological Survey (USGS). 2023b. McCloud River Above Shasta Lake. Station ID: MSS. California Data Exchange Center. Available: [https://cdec.water.ca.gov/dynamicapp/staMeta?station\\_id=mss](https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=mss)
- U.S. Geological Survey (USGS). 2020. National Water Information System data available on the World Wide Web—Streamgage 11368000 McCloud River above Shasta Reservoir, CA.
- Winnemem Wintu Tribe (WWT). 2011. *First Contact*. Available: <https://vimeo.com/17282440>.
- Winnemem Wintu Tribe (WWT). 2016. Winnemem Wintu Salmon Restoration Plan McCloud River. Submitted to U.S. Bureau of Reclamation. Available: [https://cawaterlibrary.net/wp-content/uploads/2017/05/shasta\\_winnemem.pdf](https://cawaterlibrary.net/wp-content/uploads/2017/05/shasta_winnemem.pdf).
- Winnemem Wintu Tribe (WWT). 2019. Winnemem Wintu Letter: Scoping Comments. Available: <https://cawaterlibrary.net/document/winnemem-wintu-salmon-restoration-plan-for-the-mccloud-river/>
- Wölfe-Hazard, C. 2019. Fishy Pleasures: Unsettling Fish Hatching and Fish Catching on Pacific Frontiers. *Imaginations*, 10:1, 325–352. DOI: /10.17742/IMAGE.CR.10.1.11
- Wölfe-Hazard, C. 2022. *Underflows: Queer Trans Ecologies and River Justice*. University of Washington Press. Seattle, WA.
- Yoshiyama, R.M and F.W. Fisher. 2001. Long Time Past: Baird Station and the McCloud Wintu. *Fisheries*, 26:3, 6-22.: DOI: 10.1577/1548-8446(2001)0262.0.CO;2.
- Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. *North American Journal of Fisheries Management* 18:487-521. DOI: 10.1577/1548-8675(1998)018%3C0487:HAADOC%3E2.0.CO;2.
- Zedler, J.B., and M.L. Stevens. 2018. Western and Traditional Ecological Knowledge in Ecocultural Restoration. *San Francisco Estuary and Watershed Science*. 16:3. DOI: 10.15447/sfews.2018v16iss3art2.