

**McCloud River Winter Run Chinook Salmon  
Reintroduction, Implementation, and Monitoring:  
Report on Field Operations 2024**



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*Cover photo: Crew member removing a dead egg from a remote site incubator at AhDiNa  
campground*

This report covers the third year of winter-run chinook salmon reintroduction in the McCloud River, and the first year of Pacific States Marine Fisheries Commissions involvement on the project. The work described in this annualized report is funded by Assembly bill 211 Section 2a's general fund for protecting salmon. In addition to Section 3a's California Emergency Relief fund for improving drought resiliency on state owned land. Actions and efforts described in this report were fulfilled through a collaborative effort with California Department of Fish and Wildlife (CDFW), Pacific States Marine Fisheries Commission (PSMFC), University of California Davis (UCD), Center for Watershed Science (CWS), the Winnemem Wintu Tribe (WWT), University of California Santa Cruz (UCSC), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Fish and Wildlife Service (USFWS). The funding source is derived from a CDFW contract: McCloud River Winter Run Chinook Salmon Reintroduction Implementation and Monitoring (Grant Agreement Number – Q2396062) with PSMFC.

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## SUMMARY

The McCloud winter-run Chinook salmon (*Oncorhynchus tshawytscha*) (WRCS) reintroduction project is essentially broken into a binary phase design. Phase one involved rearing WRCS eggs in a remote site incubator (RSI) at the AhDiNa campground near McCloud, California. From July 12<sup>th</sup> through September 26<sup>th</sup>, the PSMFC crew camped at AhDiNa to protect eggs from predation, remove dead eggs to prevent harmful ectoparasites or bacteria, and ensure proper water and oxygen flow. Eggs were delivered via helicopter from Livingston Stone National Fish Hatchery (LSNFH) on the following dates: July 12<sup>th</sup>, July 26<sup>th</sup>, and August 16<sup>th</sup>. The PSMFC-maintained RSI received 20,100 eggs, while an additional 42,188 eggs were delivered to a "Nur Nature Base" system operated by UCD and WWT, at the same campground. Phase two focused on a cooperative effort between PSMFC staff and WWT to trap WRCS out-migrating 20.65 miles downstream from their hatching and fry release point on the McCloud River. Fish were transported to the Sacramento River below Keswick Dam, in Redding to live out their anadromous lifecycle. Two different trapping systems were implemented on the lower McCloud River: a Rotary Screw Trap (RST) and an Incline Plane Trap (coined the "FrySCOOPER") with a V-shaped row of steel weir panels to funnel juvenile chinook salmon into the trap. Both traps were maintained and checked seven days per week. A total of 4,617 WRCS were caught in the traps and transported to the boat ramp where they were released in the Sacramento River. Everyday PSMFC crews checked in with, and transported any fish caught at the Juvenile Salmon Collection System (JSCS), an in-lake trap, operated by the Department of Water Resources (DWR). Traps were maintained and operational from August 27<sup>th</sup> through November 19<sup>th</sup>. Our monitoring efforts aimed to provide objective evidence on the McCloud River system's capacity to support the rearing of both egg and juvenile Chinook salmon fry.

## INTRODUCTION

The Sacramento River is the largest river in California; its watershed occupies 17% of the state's total land area (Golet 2003). These waters are home to 125 different fish species, found across various locations and seasons (Wang 1986). This includes four distinct Evolutionarily Significant Units (ESUs) or runs of Chinook salmon: Winter, Spring, Fall, and Late Fall, classified by the timing of their freshwater migration upriver. The Sacramento River is home to the only winter-run Chinook salmon (WRCS) population in the world (US NMFS, 2019). Chinook salmon rarely migrate further south than the Central Valley Watershed and its tributaries because they depend on cold, oxygenated freshwater for reproduction. Though adult chinook salmon can withstand warmer water conditions than juveniles, water temperatures exceeding 13 to 15.5° Celsius between arrival and spawning can have a direct impact on offspring size, number, and overall fertility of eggs (Windell et al, 2017).

The upper reaches of the Sacramento River are home to the first National Fish Hatchery: Baird Station. It was constructed in 1872 on the McCloud River to bring east coast fish to California to help support a growing population (NOAA 2021). In return, hundreds of millions of Chinook salmon eggs were sent to the east coast to stock rivers and streams throughout the United States and around the world. It was operated by the U.S. Fish Commission and chief Conchoolooloo of the McCloud Wintu tribe. The Winnimem Wintu tribe referred to the salmon as "nur". In July of 1881, egg collection on 6,000 WRCS could occur in a single day. In 1878, 200,000 spring-run Chinook salmon were processed from August 27<sup>th</sup> to October 5<sup>th</sup>, the McCloud River was saturated with spawning salmon (Yoshiyama 2001). Baird Station was abandoned in 1937 due to the construction of Shasta Dam and now lies as a submerged relic

beneath Shasta Lake. Shasta Dam underwent construction for seven years from 1938 until its completion in 1945, standing 602 feet above the outflow of the Sacramento River (USBR 2022).

Under the Central Valley Project, every major waterway (American River, Feather River, Mokelumne River) feeding the Central California drainage were dammed. This resulted in an estimated 1,057 miles (or 48%) of viable Chinook salmon habitat in the Central Valley watershed being unreachable (Yoshiyama 2001) (Figure 1). This action prevented WRCS from reaching their historical spawning grounds in the Southern Cascade Mountains in the headwaters of the Sacramento, McCloud, and Pit rivers (NMFS 2021). Salmon populations that once drove up into cold, oxygenated headwaters, were now forced to spawn in a less suitable habitat on the valley floor. Following this wave of watershed manipulation, Chinook salmon populations on the Sacramento River have declined precipitously, by more than 75 percent since the 1950's (Yoshiyama et al. 1998). Monitoring Central Valley Chinook salmon runs began in the mid 1900's following years of declining population sizes and the construction of Shasta Dam.

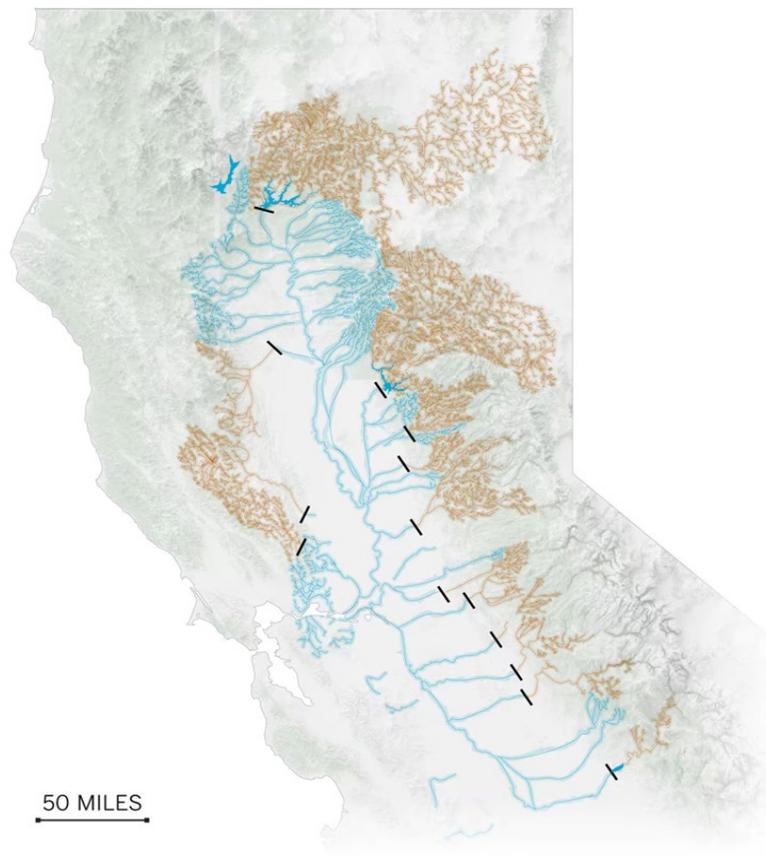


Figure 1. Damming across the Central Valley watershed, brown coloration represents historical salmon habitat that is now unreachable, black lines represent constructed dams, and blue lines represent rivers accessible to anadromous salmon populations. (Outdoor Project 2016).

WRCS escapement estimates began being tracked by CDFW in 1969, in just over 20 years, population sizes plummeted from 53,000 adults to just 144 in 1991 (Azat 2024). This rapid decline landed WRCS on the list of threatened species in 1989. It was apparent that water temperatures on the valley floor were exceeding the survivability threshold for eggs and juveniles. In 1992, the Bureau of Reclamation was required to build a “Temperature Control Device” that would allow us to control the depth of which we pulled water from Lake Shasta. This gave the USBR the ability to manipulate the water temperatures of the upper Sacramento

River (CDFW 2018). Despite these changes by the USBR, populations to this day have dwindled and even in the best return years, we're lucky to get a fraction of the run size we once saw in the early 1900's. This has led to the species being listed as an Endangered species in 1994 and then reaffirmed in 2005 and 2016 (Endangered and Threatened Species, 2016).

WRCS are faced with tremendous adversity in both their upstream and downstream journeys. Historically, WRCS were the first run in the river each season and before the implementation of the "Temperature Control Device", endured the warmest seasonal river temperatures at its most vulnerable stage (eggs). WRCS begin their journey into a brackish water system in the San Francisco Bay around December. The peak spawn time for adult WRCS is between May and August in the upper reaches of the Sacramento River (CDFW 2018). Typically, WRCS average a 90-day incubation from once eggs are laid till alevins emerge, usually late August to late November. Alevins are also called sac fry due to a ventrally attached yolk sac derived from the egg they once resided in. At this stage of life, fish are very limited in mobility, they do not feed and rely on the nourishment from the yolk sac to give them a better chance of survival before they emerge from the gravel (NPS 2019). Juvenile chinook don't possess many defensible mechanisms other than their ability to swim away in a burst of speed, this greatly impacts their susceptibility to predation (Taylor and McPhail 1985). Alevins slowly absorb their yolk sac for roughly another month, once the yolk sac is fully absorbed, it's crucial fish are released into the river as they must begin feeding.

In 2014 and 2015, Temperature Dependent Mortality (TDM) accounted for approximately 95% of the WRCS egg population, when water temperatures exceeded the 56°F threshold (CDFW 2018). The "Temperature Control Device" aids our ability to supply cool water to the Upper Sacramento River despite hot summer temperatures in Northern California. However, in extreme drought events when Shasta Lake water levels drop, our ability to pull cold water from a greater depth in the lake is hindered. Other runs are not abstained from these issues, WRCS, due to the run and emergence time were just the first to be hit to this degree.

This tragedy forged a whole new way of thinking: if we can't bring colder water to the fish, how can we bring fish to colder water? The 1,057 river miles of historical salmon habitat in the Central Valley River system that is currently unreachable has now come back into question. Above Lake Shasta, historically, salmon could be found in three main river systems: McCloud River, Pit River, and Upper Sacramento River. In 2014, the USBR completed a survey of aerial imagery to identify habitat type, water temperature, and flows to quantify areas that meet the reproductive suitability index for Chinook salmon (created by Batelle's Pacific Northwest National Laboratory Marine Sciences Lab in 2010). They found that the Upper Sacramento and McCloud Rivers could support a population of 2,163 spawning females (USBR 2014). The McCloud River is known for its glacial hue, largely a result of the glacial fed mud creek tributary. This turbidity can be both advantageous and disadvantageous to juvenile chinook populations. NTU levels ranging from 10-80+ NTU's (Nephelometric Turbidity Units) can have a deleterious effect on juvenile chinook populations (Gregory 1992). In some years, NTU levels above 70 on the McCloud River aren't uncommon.

In addition to turbidity and water temperature, another vital factor to juvenile salmonid survival is dissolved oxygen levels. Dissolved oxygen readings are typically taken from a portion of the water column. This is helpful when pertaining to emerging fry, but for alevins or eggs still in the gravel this can be misleading. Typically, chinook eggs sit in the top 4 inches of gravel, at this depth dissolved oxygen levels are believed to be 3 mg/L (Milligrams per Liter) lower than the dissolved oxygen level in the overlying water column (ODEQ 1995). The average embryo in

the soil will begin to show symptoms of oxygen deprivation distress at levels lower than 6.5 mg/L in the gravel. Levels lower than 5 mg/L have proven to have a great impact on the rate of embryonic development, hatch timing, and overall survival of chinook salmon (Bjornn & Reiser 1991).

While they do require different spawning conditions three different species of salmonid already spawn on the McCloud River: Kokanee (landlocked Sockeye salmon) (*Oncorhynchus nerka*), Brown Trout (*Salmo Trutta*), and Rainbow Trout (*Oncorhynchus mykiss*). All three species share similar life cycles, they feed in the lake Shasta ecosystem, supporting larger growth rates with greater and more consistent access to food than that found in the river. They also utilize the McCloud River system when it comes time to spawn. Browns spawn from April to June, rainbows spawn anywhere from April to October, and Kokanee spawn between September and November. They travel up the river system looking for ideal substrate, colder water temperatures, and higher dissolved oxygen levels (Hayes 1987).

In 2022, a pilot project began on the McCloud River, planting 80,000 WRCS eggs just below McCloud Reservoir. The project closely monitored egg survival and trapped out-migrating fry to better understand migration patterns. This study aimed to assess the effectiveness of rearing juvenile Chinook on the McCloud River and to determine if water conditions could still support WRCS after an 80-year absence. Since then, similar projects have started on the Feather River, Yuba River, and American River to explore volitional passage to former anadromous barriers.

## **METHODS**

### **Remote Site Incubation Methods**

The incubation site was located 22 miles upstream from Lake Shasta at AhDiNa Campground, on the McCloud River. Two different incubation styles were implemented on site. The first Remote Site Incubator (RSI) was the PSMFC operated Heath Tray system, a common practice used at most California Fish hatcheries (Figure 2). The Heath Trays utilize a gravity fed water supply line to circulate freshwater in the RSI. WRCS eggs were flown in via helicopter from Livingston Stone National Fish Hatchery on three separate dates: July 12<sup>th</sup>, July 26<sup>th</sup>, and August 16<sup>th</sup>. The PSMFC-maintained RSI received 20,100 eyed eggs (approximately 60 days old), while an additional 42,188 eyed eggs were delivered to a "Nur Nature Base" system operated by UCD and WWT, at the same campground.

From July 12th through September 26th, the PSMFC crew camped at AhDiNa to protect eggs from predation, remove dead eggs to prevent harmful ectoparasites or bacteria, and ensure proper water and oxygen flow (Figure 3). Water lines were checked to ensure that proper water circulation flowed through the Heath trays. Heath trays are an incredibly water efficient RSI, they can rear up to 80,000 eggs on just five GPM (Gallons Per Minute). Approximately five gallons of water per minute was circulated through each stack. Each stack holds eight incubation trays, and each tray holds five to 10 thousand eggs. Each tray of eggs was checked once daily to remove any dead or dying eggs from the collective group and recorded. Several other metrics were recorded including dissolved oxygen levels (mg/L- Milligrams Per Liter), water temperature (Degrees), turbidity levels (NTU- Nephelometric Turbidity Units), and flow (GPM).



Figure 2. Hatch tray system used to hold eggs up at AhDiNa Campground operated by PSMFC



Figure 3. One dead egg latching onto and jeopardizing the health and safety of three live eggs



Figure 4. Circular tank, holding the remaining Chinook, with a belt feeder installed atop it.

Roughly 10-14 days after the eggs' arrival at AhDiNa the first alevins began to hatch. Following the hatching of eggs, alevins were held for roughly one month until they were buttoned up (a term used for describing a juvenile chinook that's absorbed its yolk sac). At this time, alevins become mobile and begin searching for food. Fry were released from AhDiNa campground on August 26<sup>th</sup>, 2024, and September 26<sup>th</sup>, 2024, to begin their journey down the McCloud River. Two different release tactics were implemented on the McCloud River. The first release was on the night of August 26<sup>th</sup>, as soon as fry buttoned up, 7,297 WRCS were released at the campground. The second release was postponed due to the relocation of our IPT down river, fish were transferred into a circular holding tank and held for 16 days until the trap was ready. An automatic belt feeder was installed atop the tank to ensure fish were being fed an adequate amount of food each day (Figure 4). One night an animal ravaged the feeder whilst snapping the standpipe in the tank releasing 2,898 fish prematurely. From there on out all feeding was done manually until the release of the remaining 9,103 fish on September 26<sup>th</sup>.

### **Trap Operation Methods**

While the fry began to develop up at AhDiNa campground, 20.65 miles downstream two different trapping methods underwent installation. Two different trapping systems were implemented on the lower McCloud River: a Rotary Screw Trap (RST) and an Incline Plane Trap (coined the "FrySCOOPER") with a V-shaped row of steel weir panels to funnel juvenile chinook salmon into the trap. Both traps were maintained and checked seven days per week. A total of 4,581 WRCS were caught in the traps and transported to the boat ramp where they were released in the Sacramento River. Everyday PSMFC crews check in with, and transport any fish caught at the Juvenile Salmon Collection System (JSCS), an in-lake trap two miles downstream, operated by the DWR (Figure 5). Traps were maintained and operational from August 27th through November 19th. Our monitoring efforts aimed to provide objective evidence on the McCloud River system's capacity to support the rearing of both egg and juvenile Chinook salmon fry.

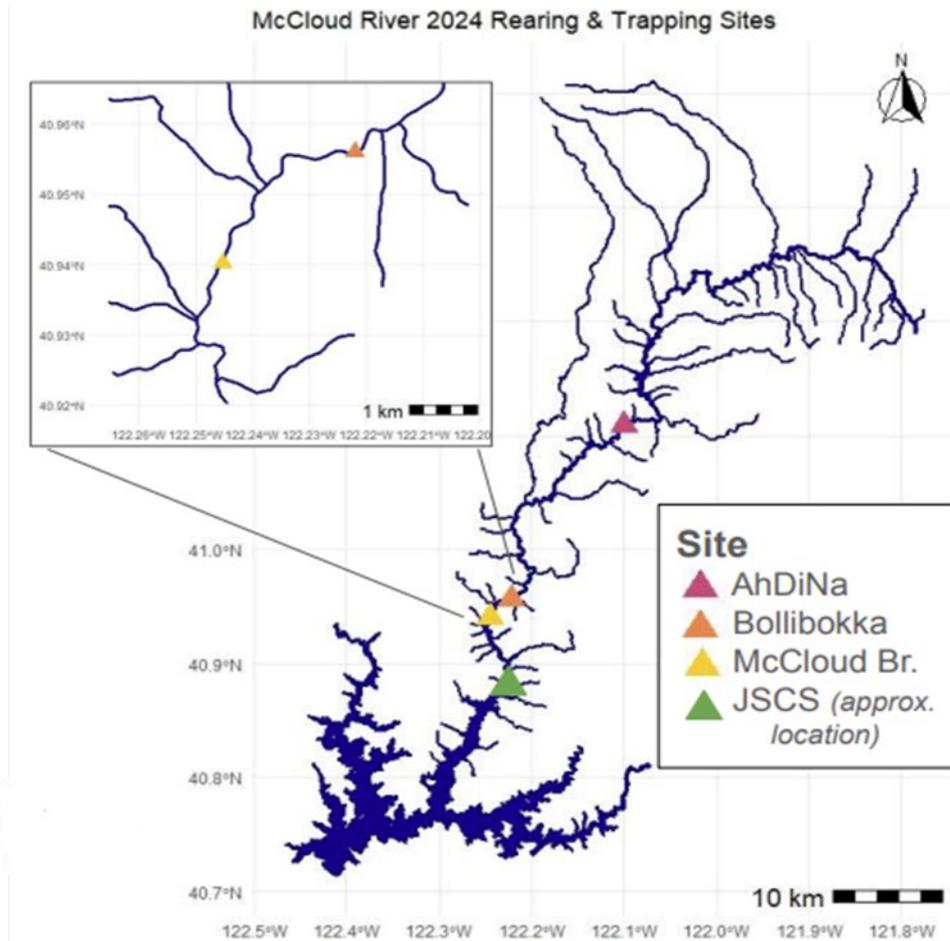


Figure 5. A map displaying the location of the three different traps used on the McCloud River arm in relation to the rearing site.

The PSMFC crew and the WWT worked every day of the week to ensure the weir and trap were both cleared of debris and fish weren't sitting in the trap for extended periods of time putting their safety at risk. Once one trap was checked, crews would travel ~ 1.5 miles to the second trap to clean and check it for fish. When the weir panels were covered in vegetative debris, water flow through the panels decreased and velocity spiked inside of the IPT (observed from 0.8 to 5.5 Feet Per Second (FPS). Young salmon roughly 50 mm in length, have a sustained swimming speed of 1.2 FPS (Fangue et al. 2021). When exposed to flows greater than the sustained swim speed for long periods of time can be fatal for juvenile WRCS. Throughout the season different strategies were implemented to mitigate high velocities within the trap, such as placing willow (Figure 6).



Figure 6. The use of sandbar willow to mitigate high velocities in the IPT

The WWT deployed an evening crew that was able to ensure that debris was cleaned off the weir multiple times a day. This allowed more water to pass through the weir panels and reduce the sweeping velocity by carrying water across the panels and into the trap. Once traps were in place efficiency trials were carried out by a NOAA crew to test the capture efficiency of our trap. Any time the trap was modified a new trial was run to figure out how efficient our trap configuration was at capturing out-migrating chinook. A known number of fry were released at night with an identifiable mark whether it be a Bismark Brown (BB) dye and/or an Upper Caudal (UC) clip to help us differentiate between efficiency trial fish and those migrating down river from the incubation site. You then take the number of fish captured and divide it by the total number of fish released and it gives you an idea of how efficient your trap is. Fry released at night vs the day can see upwards of a 25%-30% better survival rate (Grant County Public Utility District 2019).

The RST did not endure these same adversities that the IPT did. The RST traps fish within two to three feet of the surface of the water and did not have the same weir funneling a vast majority of the river into it. During September and October, fall leaf litter began to accumulate in the water column. We installed a debris boom, and the WWT diverged into an evening crew so that the trap could be cleaned constantly. Fish were extracted from the trap daily, identified, and sorted according to species.

Chinook salmon were set aside for further processing, counted, and placed in a live car in the river until crews completed trap maintenance. By group consensus, all parties involved in the McCloud River project are working to minimize fish handling on WRCS. The UCD research team created a hands-off fish measuring device called the "Fish Viewer." It was agreed by the Co-Managers that McCloud crews would process every other fish, up to 15 WRCS per day. For other species, the WWT conducted gastric lavages to assess the predation rate of bass on out-migrating Chinook salmon. All other bycatches were identified, measured, and released behind the trap.

### **Transportation Methods**



Figure 7. Fish held in a cooler acclimating until they are ready for release.

After processing the WRCS captured in the traps, fish were placed in Engel coolers for transport preparation (Figure 7). The coolers were equipped with bubblers to reoxygenate the water and soaked in the river for an hour to cool the water. While the fish were safely kept in a live pen in the river, the trap was cleaned, and necessary modifications were made. The water temperature was recorded before transport, and then again once we reached the release site. The PSMFC crew coordinated daily with the JSCS crew to pick up fish caught in the downstream trap, which were then transported with the fish we collected. Fish were driven in passenger vehicles for an hour to Posse Grounds boat ramp in Redding, California. Upon arrival, the water temperature of the Sacramento River was checked to ensure proper acclimation, following the standard practice of a 3.6°F change per hour (Poletto 2017). Once the water temperature in the transport cooler and release site was within two degrees Fahrenheit of each other, the fish were

released near cover into the Sacramento River. Fish were released and injured fish were observed for a short while to record any further mortality.

## RESULTS

### Remote Site Incubation Data

The PSMFC crew was slated to rear 40,000 WRCS eggs up at AhDiNa campground for the 2024 season. Due to the poor return of adult WRCS, half of the egg allotment was reallocated to prioritize more fish for the Sacramento River instead of the McCloud. A PSMFC crew was responsible for the rearing of 20,100 eggs. Due to the delay in transferring fish from trays to a circular tank, 135 Chinook salmon died from emaciation, as their yolk sacs were fully absorbed, and they needed to feed. In total 638 eggs and alevins died before release. A total mortality rate of 3.17% for the 2024 season. Typically, hatcheries sport anywhere from four to ten percent mortality from egg to buttoned up alevin (Gallinat 2024). This year reflected the highest egg to fry survival out of the three years WRCS eggs have been transported up to the McCloud (Table 1).

Table 1. McCloud egg mortality over the three years of operation.

Year	Eggs Delivered	Count of Dead Eggs	Egg Mortality Rate
2022	40,000	4,710	11.78%
2023	40,000	15,200	38.00%
2024	20,100	638	3.17%

Throughout the crew’s 12-week occupation at AhDiNa, water temperatures fluctuated from 32°F degrees to 58°F. The average temperature at the rearing site was 52.13°F with a median of 51.62°F. The Diurnal temperature cycles on the McCloud River swing on average 5.1°F throughout the day during our sampling period. Throughout our 12-week egg incubation and juvenile rearing period, flows were consistently between 300-400 CFS. Dissolved oxygen levels at the incubation site swung between 10.02 and 25.75 mg/L. The average dissolved oxygen level at AhDiNa campground was 11.12mg/L Crews also recorded daily turbidity levels (NTU) in the McCloud River. From July through August, while eggs were in the water the turbidity conditions at AhDiNa campground ranged from 2.1-12.9 NTU’s.

### Trapping Data

River conditions on the McCloud varied throughout the trapping season, ranging from 330 to 1,650 CFS (Figure 8). Flow in the IPT was managed to avoid speeds higher than the swimming capacity of juvenile Chinook (1.2 FPS), as higher flows led to mortality. Throughout the season, 339 Chinook were counted as dead, likely due to high velocities, with three days accounting for 48.6% of the total mortality. Initially, the trap site just north of the McCloud Bridge had issues. Despite releasing 7,297 WRCS from AhDiNa on August 26, the IPT caught only 3 live fish and 60 dead. The PSMFC crew replaced the RST with the IPT to assess its efficiency in capturing out-migrating Chinook. After an efficiency trial, the RST caught 0 of 99 fish, resulting in a 0% capture rate. The IPT and weir were then relocated downstream, closer to the lake arm.

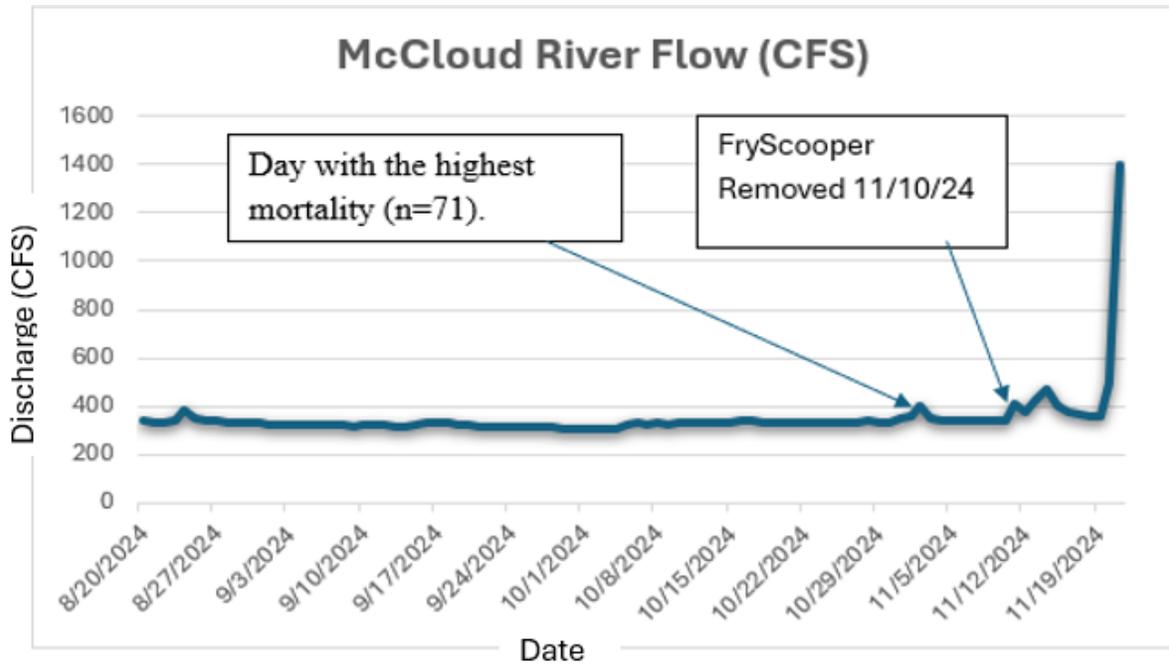


Figure 8. Flow in cubic feet per second on the McCloud River System above Lake Shasta from August 20<sup>th</sup>, 2024, through November 20<sup>th</sup>, 2024 (CDEC gage MSS).

Three separate efficiency trials ensued following the relocation of the IPT downstream. Efficiency trials ranged from 22.50% all the way up to 75% (Table 2). Efficiency trial fish were found in the trap for up to three days following the release. As the season progressed, the average size of the WRCS being captured trended in an increasing direction. This was reflected in the fish used for trap efficiencies as well, fish used in efficiency trials ranged from 31.8 mm to as high as 49.5 mm by the end of the trapping season (Figure 9). Another key factor that can impact trap efficiency is predation in the reach of river where your trap is located.

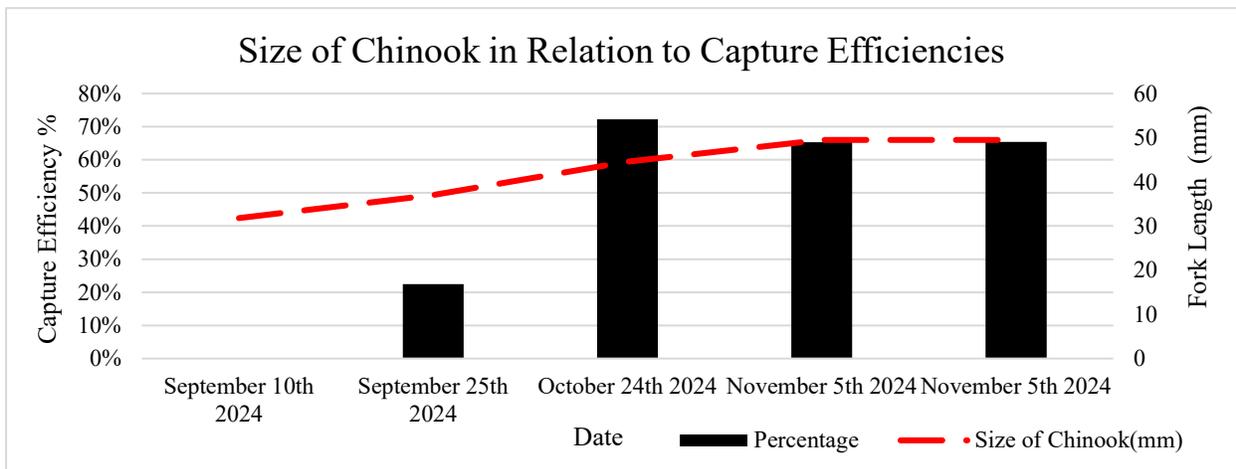


Figure 9. The FryScoopers capture efficiency throughout the trapping season with the blue bars representing capture efficiency. In relation to the orange line tracking size of chinook used in efficiency trial.

Table 2. Efficiency trial results from the RST and IPT throughout the 2024 season. The orange rows represent an efficiency trial performed when 30 feet of weir panels were removed to alleviate velocity in the FrySCOOPER.

Date	Trap Type	Individuals Released	Individuals Caught	Percentage	Type of Mark
September 10th 2024	RST	98	0	0%	BB/UC
September 25th 2024	Fry Scooper	200	45	22.50%	BB/UC
October 24th 2024	Fry Scooper	400	301	75.25%	BB/UC
November 5th 2024	RST	202	7	3.47%	BB Only
November 5th 2024	Fry Scooper	202	139	68.81%	BB Only
November 5th 2024	Fry Scooper	104	67	64.42%	BB/UC

Three different species of bass can be found in the Lower McCloud River: spotted bass (*Micropterus punctulatus*), Largemouth bass (*Micropterus salmoides*), and Smallmouth bass (*Micropterus dolomieu*). The WWT performed gut checks on any captured bass species (n=21) in the traps to determine whether they recently preyed on Chinook salmon fry. They found that 14.2% of the time Chinook salmon were found in their stomach contents. Chinook fry was only found in the stomach contents of spotted bass. Only 3 spotted bass were captured passed October 28<sup>th</sup>, when daily river temperatures were down to nearly 43° Fahrenheit. Spotted bass are believed to have a thermal survivability threshold at 6° Celsius (42.8° Fahrenheit) (Cherry et al. 1977). This evidence suggests spotted bass, one of the most common predators of WRCS fry on the McCloud River, begins to out-migrate the river system as early as mid-October. This statement is supported by our trial efficiency results in mid to late October, showing a capture rate as high as 75%, suggesting predation in this reach of the river had a minimal impact on out-migrating chinook during this time of year.

Between the RST and IPT, a total of 11 different bycatch species represented by a 6 letter species code (Table 3), were captured in addition to our target species (Figure 10). Rainbow trout made up most of the catch representing 39.2% of our overall bycatch. The average rainbow trout that was caught was roughly 167 mm (Figure 11). Brown trout were also caught throughout the season though much less frequently as they made up just 7.7% of our non-target catch. Most of the trout were either young of the year or adults utilizing the McCloud River to spawn as represented by fork lengths distribution below.

Table 3. This table represents the species codes associated with the common names of fish found in the McCloud in-river traps.

Species Code	Common Name
BLUEGI	Bluegill
BROTRO	Brown Trout
LARBAS	Largemouth Bass
RAITRO	Rainbow Trout
RIFSCU	Riffle Sculpin
RIVLAM	River Lamprey
SACPIK	Sacramento Pikeminnow
SACSUC	Sacramento Sucker
SMABAS	Smallmouth Bass
SOCSAL	Sockeye Salmon (Kokanee)
SPOBAS	Spotted Bass

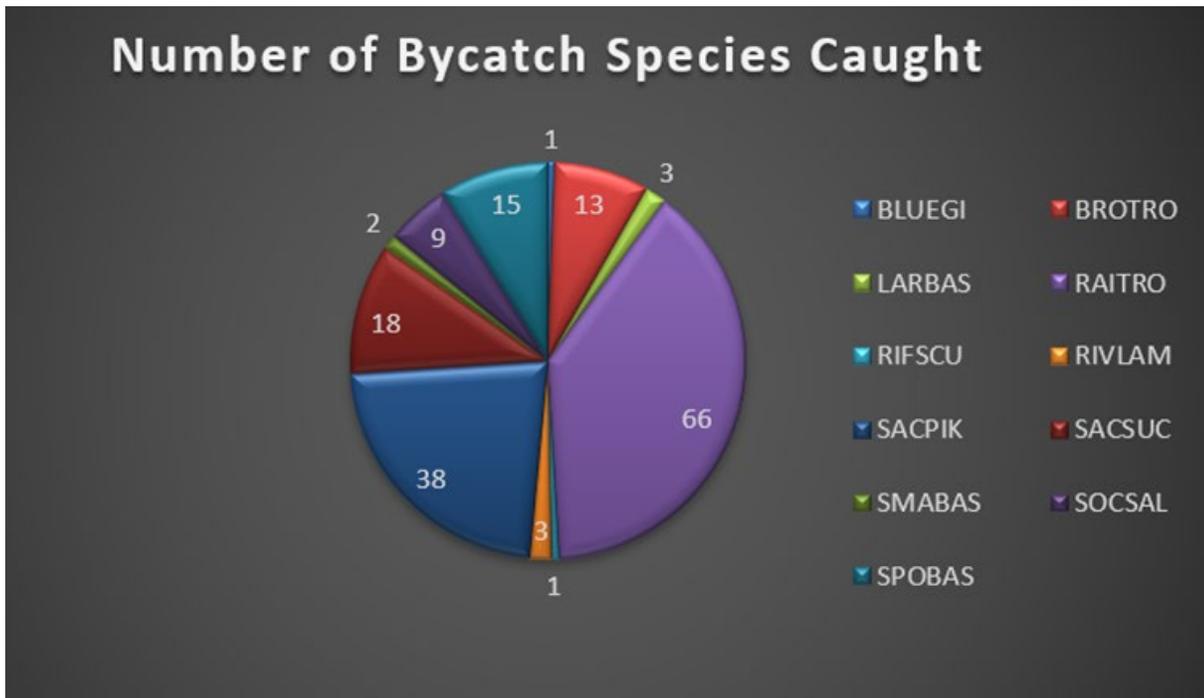


Figure 10. Represents the various number of non-target fish caught in traps on the McCloud River in the 2024 trapping season.

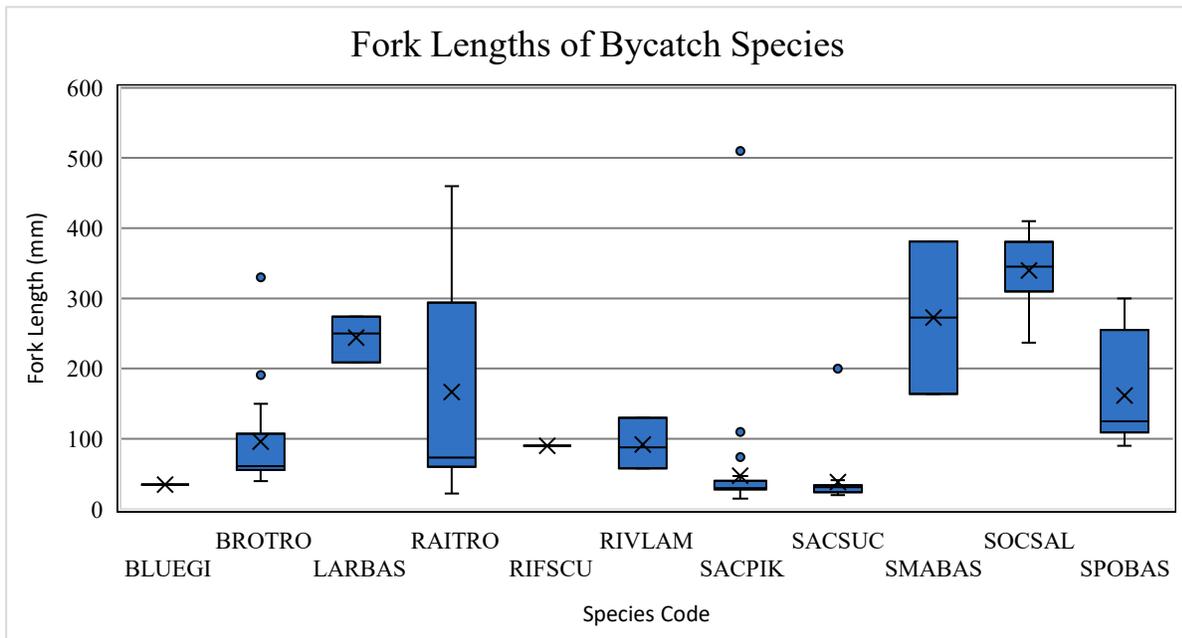


Figure 11. Bycatch species recovered from in-river traps (RST & IPT). The dots are representative of an outlier, that is a data point outside the interquartile range and represents data that's found outside the typical distribution or 1.5 times the upper quartile, the solid black line represents the median while the "X" represents the mean.

### Fryscoper Catch

The IPT fished from August 27<sup>th</sup> through November 11<sup>th</sup>. Though it was not truly effective until its complete relocation on September 21<sup>st</sup>. In total, the trap caught 4,123 chinook which accounted for 89.3% of our total WRCS catch in 2024. It's worth noting that both Heath tray releases occurred when trap efficiency was 0% and 22.5% respectively. These capture efficiencies resulted in our two lowest efficiencies of the season. The heath tray releases accounted for 20,000 of the 62,000 fish being reared at AhDiNa campground. This resulted in low recovery percentages for fish out-migrating earlier in the trapping season. The IPT proved its ability to catch chinook efficiently, but trap modifications were required to ensure safe recapture of WRCS. Throughout the season, high in-trap velocities were a constant challenge. As a result, 99.4% of the total Chinook mortality (337 out of 339) from in-river traps occurred in the IPT. Only two dead fish were from the RST.

### Rotary Screw Trap Catch

The RST fished from August 27<sup>th</sup> through November 19<sup>th</sup>. The RST demonstrated the ability to remain operable in high flow conditions. With that reason alone it was able to fish for a total of 84 days this trapping season, compared to the IPT only fishing 68 days. In totality, the RST captured 494 WRCS which represents 10.7% of our total chinook catch for the 2024 season despite operating 16 more days than the IPT. Despite seasonal high debris load and strong flow conditions, the RST only resulted in two chinook mortalities throughout the season.

### Chinook Size Distribution

Out of the 4,617 WRCS trapped in the 2024 season, 600 fish were processed in the fish viewer, and size in millimeters (mm) was determined. WRCS caught in the RST and IPT this year varied from 20.96 – 71.68 mm in length (Figure 12). The average individual WRCS caught this year was 35.96 mm. The differentiation between the three years of trapping on the McCloud

River (2022-2024), shows a broader size distribution in this year's data set compared to previous years (Figure 13). This is represented by the standard deviation taken from all three data sets, in 2022 it was 6.23, 2023 was 6.52, and lastly 2024 was 7.44. This higher standard deviation resembles the degree of variation between sampled individuals.

Distribution of Nur Size Across Field Season  
Starting second week of September

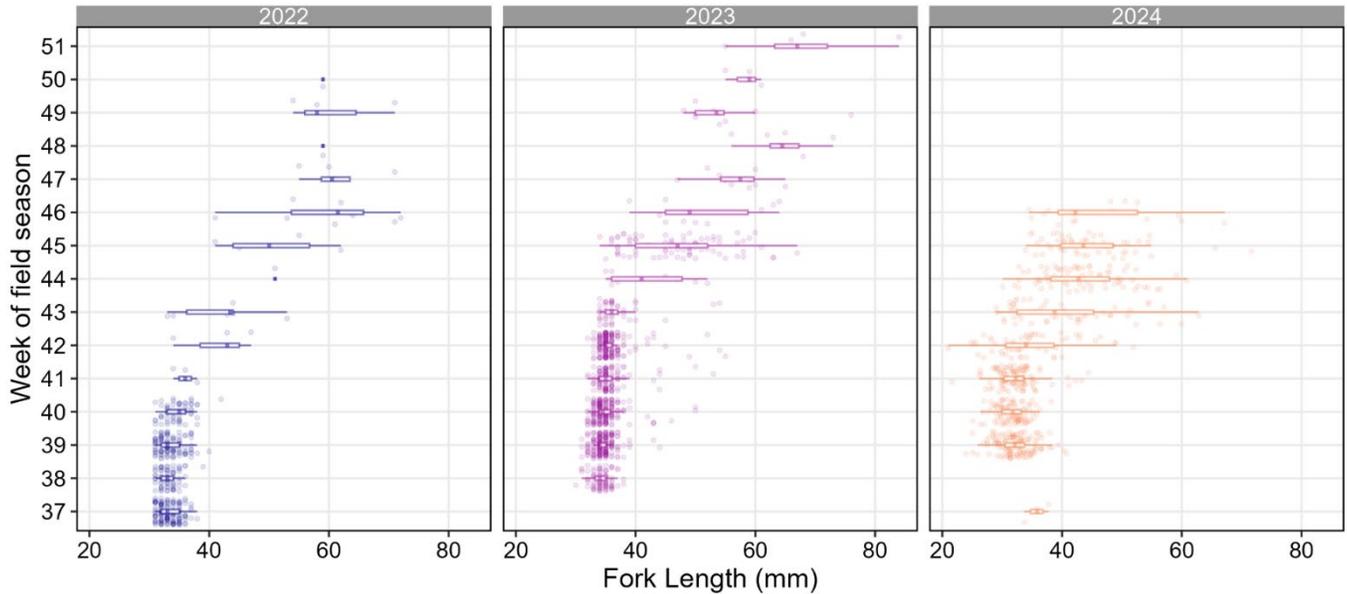


Figure 12. Weekly size distribution of chinook salmon caught in traps as the trapping season progressed contrasted with years 2022-2024. Each point represents an individual's size in mm. The rectangular box represents 50% of the most common sample size, the wicks off the box plot represent your outside 25% of samples on either side of the mean. Any point below or above the end of the wick represents an outlier data point.

Distribution of Nur Fork Lengths  
Across 2022-2024 trapping seasons

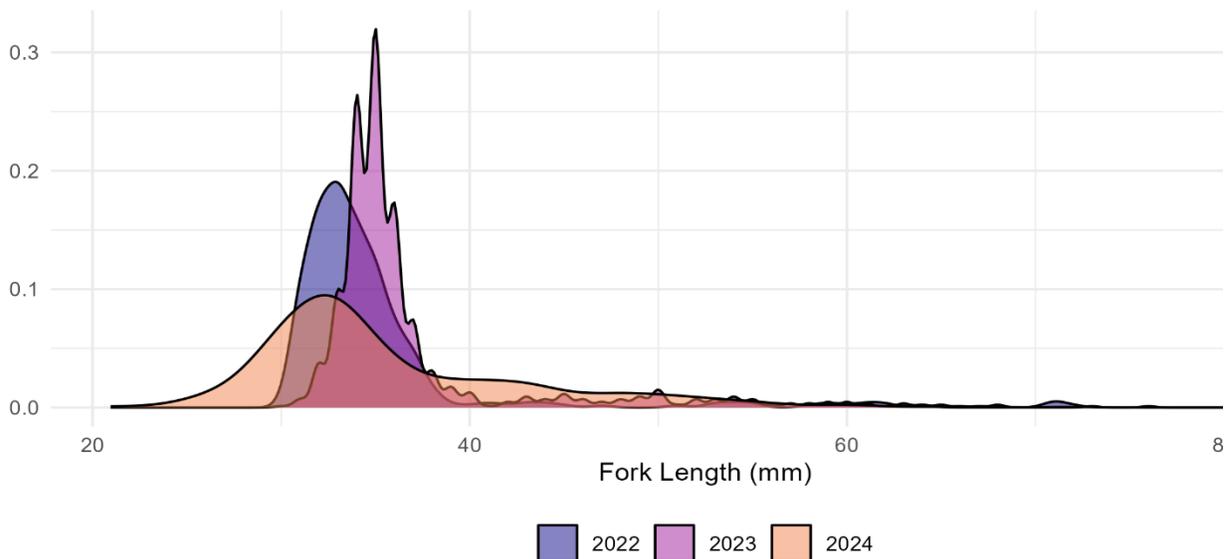


Figure 13. Distribution of WRCS or “Nur” fork lengths acrossed trapping seasons from the UCD Center for Watershed Sciences.

### Transportation Data

Fish are transported from McCloud Bridge Campground to Posse Grounds boat ramp in Redding, California. Throughout the trapping season the PSMFC crew transported 4,581 Chinook salmon. Out of the 4,617 transported 10 fish did not survive transportation, with one of those being a fish from the in-lake trap (JSCS). This data suggests that we had a 99.8% survival rate in fish that were transported throughout the 2024 season. One of those fish was a 140 mm yearling Chinook salmon, that was safely transported to the release site. Throughout most of the trapping season water temperatures at the trapping site and release site remained within several degrees. Later into November, McCloud River temperatures began to drop while Sacramento River temperatures at the release site remained stagnant. Despite a longer acclimation period, just one chinook died in transport to the release site in the month of November. Overall temperature on the McCloud River swung between highs of 58.6 degrees to lows of 37.4 throughout the duration of our trapping season (Figure 14) (CDWR 2024). A much greater fluctuation of seasonal water temperatures than that of the Sacramento River at the release site.

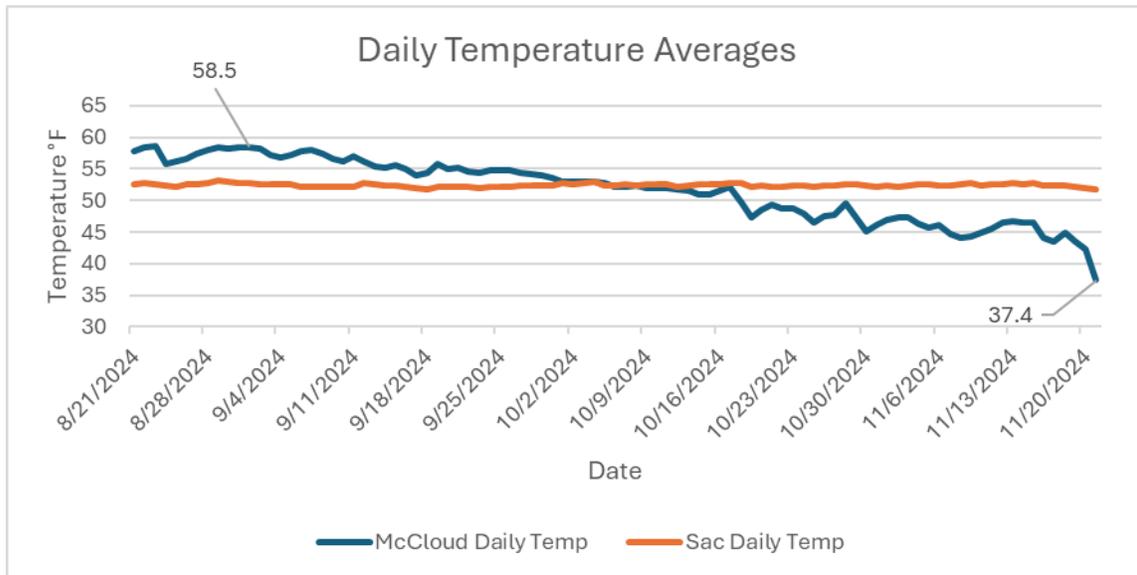


Figure 14. Daily average water temperature of the McCloud River above Lake Shasta and at the mainstem Sacramento River (SAC gauge) (CDEC, 2024).

### DISCUSSION

The McCloud River Winter Run Chinook Salmon Reintroduction, Implementation, and Monitoring project seeks to evaluate the system's capacity to support and sustain a reintroduced WRCS population through comprehensive research and data collection. The PSMFC crews collected field data and observations to obtain objective evidence to best aid a struggling fish population. The co-managers can utilize this data to dictate the direction WRCS conservation goes. This project was made possible in large part by CDFW who supplied the funding for the data collection.

Since the project's inception, an environment has been established to foster the development of innovative tools to advance salmon conservation and reintroduction. Various methods of remote site incubation have been tested, providing tangible evidence of their efficacy

and performance on the McCloud system. The IPT, built from scratch, achieved trap efficiency as high as 72%. While this type of trap has been used in previous monitoring efforts, it was specifically designed for the McCloud River and performed exceptionally well in areas where IPTs on other rivers have faced challenges, such as high debris load.

Our final efficiency trial was held with 30 feet of river unobstructed. This proved to have a minimal effect on our overall capture efficiency despite removing weir panels, as we found its capture efficiency to be ~71%. Furthermore, fish released further upriver proved to have a higher capture efficiency than fish released just upstream from our trap. Out-migrating Chinook tend to select a migratory corridor when moving down stream before holding in cover for the day (Rosario et al 2013). Juvenile Chinook are not equally distributed in a watershed while they out-migrate but instead select for these migratory corridors where they can out-migrate the system impinged. There were also several other culminating factors that worked in our favor resulting in such high capture efficiencies, like increasing fish size, outmigration of predator species in the McCloud River system, and increased turbidity.

In addition to larger, tangible debris within the McCloud River system, there are heavy amounts of microscopic, suspended debris throughout the water column. This generates the glacial hue that the McCloud River is known for. While eggs were in the water the turbidity conditions ranged from 2.1-12.9 NTU's. Later into the season turbidity levels rose to 66.4 NTU's, which worked to the advantage of out-migrating WRCS. Most Piscivorous fish, bird, and mammal species are reliant on visuals to detect prey. This has an impact on the physiology and behavior of juvenile chinook. More fish tend to be more dispersed in the water column instead of displaying cover seeking tactics which promotes an overall quicker migration rate (Gregory 1998). This aided fish working through the river system, more specifically our second release group (released September 26<sup>th</sup>).

Just a couple of river miles upstream of our rearing site at AhDiNa campground sits lake McCloud. While the lake and its earthen dam provide flood control and water accessibility throughout the year. It is important to note its impact on the WRCS population. Despite obtaining optimal water conditions (high dissolved oxygen levels, cold water, etc.) for juvenile WRCS rearing, the Lake McCloud dam does play a pivotal role in the future of WRCS reintroductions to the McCloud River system. The hydroelectric dam was built in 1965 and since then few adaptations have been made to improve both its operation/efficiency as well as improve the water quality that is released into the lower McCloud River. The dam doesn't utilize a Temperature Control Device. Water is pulled from the upper half of the water column. Despite having access to much colder water at greater depths in the lake. Colder water is also synonymous with higher dissolved oxygen levels. Both key factors in the Chinook Salmon reproductive suitability index. Modifications to the dam can influence greater success for a reintroduced WRCS population.

The McCloud River system offers a steady supply of invertebrates, prey that many juvenile salmonids seek out. This was represented in our fork length distribution chart for trout, we found most trout were categorized into two groups: young of the year, or adults running up the river to spawn. Most adult trout caught in the trap, just by visually assessing their body condition, could be categorized as a pre-spawn or post-spawn individual. We couldn't capture a true representation of the adult fish caught in the trap due to their ability to swim freely in and out of the trap. Both trout and bass species were observed doing this behavior while smaller fish were trapped inside due to high velocities pushing them back into the back of the FrySCOOPER.

This most likely led to an unknown number of predatory events as both species are known to predate juvenile chinook.

It is well known that IPTs struggle with high debris loads and fluctuating water velocities. The team found ways to mitigate high velocities and provide refuge areas for fish in harsh conditions. One strategy implemented in the IPT was the use of sandbar willow, which plays a crucial role in juvenile WRCS survival in floodplains. Sandbar willow provides habitat and predator protection while reducing the energetic cost of fish maintaining position in the river. Even with water velocities reaching 2.9 FPS, juvenile fish swimming velocity was only 1.14 FPS when using sandbar willow (Fangue et al. 2021). This concept was applied in the IPT to create refugia for trapped fish (Figure 5). Additionally, metal plates forming a channel system and a grid pattern made of cinderblocks helped reduce flow inside the trap to safer levels for the fish ( $n < 0.5$  FPS).

A major benefit of the partnership with WWT is the incorporation of Traditional Ecological Knowledge (TEK) into the trap configuration. Rather than designing refugia for fish within the IPT, the approach leveraged natural habitat used by fish within the river system. Numerous new projects aimed at increasing rearing habitat for juvenile WRCS have focused on planting willows along riverbanks to combat erosion and provide critical habitat for the species.

Other monitoring efforts depending on the objective, use RST's, which better manage debris load and high velocities. However, RST's host on average a three to five percent capture efficiency. Our project's trapping objective is less focused on monitoring and more focused on capture. In addition, UCD has developed a hands-off fish measuring device in hopes to decrease fish stress through processing. All contributing agencies push the group to reject complacency and continue to find new ways of thinking about salmon reintroduction.

This was PSMFC's first year contributing to the McCloud River salmon monitoring project, and there was a significant learning curve in joining a project that was already in its third year of fish releases. Despite the challenges of rearing and trapping juvenile salmonids, the PSMFC crew achieved the lowest egg-to-fry mortality rate in a three-year span that is the McCloud project at 3.17%. This year also produced the highest capture efficiency of any trap on the McCloud River (72%) over the three years of trapping efforts. However, the trapping season was cut short by an early atmospheric river in November, which dropped 12 inches of rain in a three-day period. This caused the McCloud River to swell to 4,800 CFS, which is 12 times the flow levels observed throughout the season. All gear was removed before the storm arrived, effectively ending the trapping season.

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## **ABBREVIATIONS**

(BB) Bismark Brown dye  
(CDEC) California Data Exchange Center  
(CDFW) California Department of Fish and Wildlife  
(CFS) Cubic Feet per Second  
(CWS) Center for Watershed Science  
(DWR) Department of Water Resources  
(ESU) Evolutionary Significant Units  
(FPS) Feet Per Second  
(GPM) Gallons Per Minute  
(IPT) Incline Plane Trap  
(JSCS) Juvenile Salmon Collection System  
(LSNFH) Livingston Stone National Fish Hatchery  
(mm) Millimeters  
(NMFS) National Marine Fisheries Service  
(NOAA) National Oceanic Atmospheric Administration  
(NPS) National Park Service  
(NTU) Nephelometric Turbidity Units  
(PSMFC) Pacific States Marine Fisheries Commission  
(RSI) Remote Site Incubator  
(TEK) Traditional Ecological Knowledge  
(UC) Upper Caudal clip  
(UCD) University of California Davis  
(UCSC) University of Santa Cruz  
(USBR) United States Bureau of Reclamation  
(USFWS) United States Fish and Wildlife Service  
(WRCS) Winter Run Chinook Salmon  
(WWT) Winnimem Wintu Tribe

## **LITERATURE CITED**

- Azat, J. 2023. GrandTab 2024.05.20 California Central Valley Chinook Escapement Database Report. California Department of Fish and Wildlife. Available from <https://www.calfish.org/ProgramsData/Species/CDFWANadromousResourceAssessment.aspx>
- Ball, M. 2016. Outdoor Project. Examining The Sacramento Watershed: The Water <https://www.outdoorproject.com/articles/examining-sacramento-watershed-water>
- Bjornn, T. and D. Reiser. 1991. Habitat requirements of salmonids in streams. In Meehan, W. ed., Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitat. American Fisheries Society Special Publication 19. pp. 83-138.

- California Department of Fish and Wildlife. 2018. Winter-run Chinook Salmon. <https://wildlife.ca.gov/Conservation/Fishes/Chinook-Salmon/Winter-run>
- CDWR, 2024. California Data Exchange Center, Gage Located Upstream of the Highway 44 Bridge. <https://cdec.water.ca.gov/dynamicapp>.
- CDWR, 2024. California Data Exchange Center (CDEC), McCloud River Above Shasta Lake (MSS). <https://cdec.water.ca.gov/dynamicapp/QueryDaily?s=MSS>
- Cherry, D.S., Dickenson, K.L., & Cairns, J. 1977. Preferred, Avoided, and Lethal Temperatures of Fish During Rising Temperature Conditions.
- Del Rosario, R.B., Y.J. Redler, K. Newman, P.L. Brandes, T. Sommer, K. Reece, & R. Vincik. 2013. Migration patterns of juvenile winter-run sized Chinook salmon (*Oncorhynchus tshawytscha*) through the Sacramento-San Joaquin delta. *San Francisco Estuary & Watershed Science*: 11 (1) (<https://escholarship.org/uc/item/36d88128>)
- Endangered and Threatened Species; 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon, 81 F.R. 33468-33469 (proposed May 26, 2016).
- Fangue, N.A., Cocherell, D.E., Mauduit, F. *et al.* 2021. Juvenile Chinook salmon use of sandbar willows in a large-scale, simulated riparian floodplain: microhabitat and energetics. *Environ Biol Fish* **104**, 867–879. <https://doi.org/10.1007/s10641-021-01119-2>
- Gallinat, M.P. & Kiefel, D.E. 2024, August. Washington Department of Fish and Wildlife: Spring Chinook Salmon Hatchery Mitigation Evaluation for S.E. Washington: 2023 Annual Report.
- Golet, G.H. *et al.* 2003 Using Science to Evaluate Restoration Efforts and Ecosystem Health on the Sacramento River Project, California.
- Grant County Public Utility District. 2019. An Ecological Approach for Optimizing Hatchery Release Timing of Salmon.
- Gregory, R.S. 1992. The influence of ontogeny, perceived risk of predation, and visual ability on the foraging behavior of juvenile chinook salmon. *Theory and Application of Fish Feeding Ecology* 18: 271-284.
- Gregory, R.S., & Levings, C.D. 1998. Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon. *American Fisheries Society* 127:275–285.
- John W. Hayes. 1987. Competition for Spawning Space Between Brown (*Salmo trutta*) and Rainbow Trout (*S. gairdneri*) in a Lake Inlet Tributary, New Zealand. *Canadian Journal of Fisheries and Aquatic Sciences*. **44**(1): 40-47. <https://doi.org/10.1139/f87-005>
- Lo, V. K., Martin, B. T., Danner, E. M., Cocherell, D. E., Cech, Jr, J. J., & Fangue, N. A. (2022). The effect of temperature on specific dynamic action of juvenile fall-run, *Oncorhynchus tshawytscha*. *Conservation Physiology*, *10*(1), coac067. <https://doi.org/10.1093/conphys/coac067>
- 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. 2014. Recovery Plan for The Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the DPS of California Central Valley Steelhead
- National Oceanic and Atmospheric Administration. 2021. Baird Station: The First National Fish Hatchery.

- National Park Service (NPS). 2019. The Salmon Life Cycle  
<https://www.nps.gov/olym/learn/nature/the-salmon-life-cycle.htm>
- Oregon Department of Environmental Quality (ODEQ). 1995. Dissolved Oxygen: 1992-1994 Water quality standards review. Final Issue Paper. 166pp.  
<http://www.fishlib.org/Bibliographies/waterquality.html>
- Poletto JB, Cocherell DE, Baird SE, Nguyen TX, Cabrera-Stagno V, Farrell AP, Fangué NA. Unusual aerobic performance at high temperatures in juvenile Chinook salmon, *Oncorhynchus tshawytscha*. *Conserv Physiol*. 2017 Jan 4;5(1)
- Taylor, E. B., and J. McPhail. 1985. Burst swimming and size-related predation of newly emerged Coho Salmon *Oncorhynchus kisutch*. *Transactions of the American Fisheries Society* 114:546–551.
- United States Bureau of Reclamation. 2022. Shasta Dam Construction.  
<https://www.usbr.gov/mp/mpr-news/docs/factsheets/shasta-dam.pdf>
- United States Bureau of Reclamation. 2014. Habitat Assessment Final Report: Shasta Dam Fish Passage Evaluation
- US NMFS (2019). United States. National Marine Fisheries Service. Biological Opinion on Long Term Operation of the Central Valley Project and the State Water Project.
- Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin Estuary and adjacent waters, California: a guide to the early life histories. Technical Report 9 (FS/B10-4ATR 86-9). Berkeley Digital Library Project, Berkeley, CA.
- Windell, Sean et al. 2017. Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) across the life cycle”, 2017, <http://doi.org/10.7289/V5/TM-SWFSC-586>
- Yoshiyama, Ronald M. and Fisher, Frank W. 2001. 'Long Time Past: Baird Station and the McCloud Wintu', *Fisheries*, 26: 3, 6 — 22
- Yoshiyama, R.M., Gerstung, E.R., Fisher, F.W., Moyle, P.B. 2001. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California 179:71-101
- 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.
- 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/sfew.2018v16iss3art2.