The Resources Agency
California Department of Fish and Wildlife

LOWER MAIN STEM EEL RIVER and VAN DUZEN RIVER CHINOOK SALMON SONAR MONITORING PROJECT

SONAR ESTIMATION OF CALIFORNIA COASTAL (CC) CHINOOK SALMON (*Oncorhynchus tshawytscha*) ABUNDANCE IN THE LOWER MAIN STEM EEL AND VAN DUZEN RIVERS, HUMBOLDT COUNTY, CALIFORNIA 2024-2025

FINAL REPORT

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April 15, 2026

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Abstract

The California Department of Fish and Wildlife (CDFW) in partnership with Pacific States Marine Fisheries Commission (PSMFC), National Oceanic and Atmospheric Administration (NOAA) Fisheries West Coast Region, and Pacific Gas & Electric (PG&E), operated two Adaptive Resolution Imaging Sonar (ARIS) 'cameras' to enumerate adult and jack Chinook Salmon escapement into the lower Main Stem Eel River above the confluence with the South Fork Eel River and in the lower Van Duzen River during the fall and winter of 2024-2025. This was the seventh year of the Main Stem Eel River and third year for Van Duzen River sonar monitoring project, and the primary intent was to estimate the returns of adult California Coastal (CC) Chinook Salmon (*Oncorhynchus tshawytscha*) and if possible, estimate returns of adult Northern California (NC) steelhead (*O. mykiss*) and Coho Salmon (*O. kisutch*).

We estimate the abundance of Chinook Salmon returning to the Main Stem Eel River above the confluence of the South Fork Eel River from October 15, 2024 through December 18, 2024, equaled 9,594 fish (95% CI 8,240 – 10,948; with a coefficient of variation (CV) of 8.2%). Project staff were able to separate most of the Chinook Salmon run into size classes of adult Chinook Salmon with a fork length equal to or greater than 62 cm and jack Chinook Salmon between 41 cm and 61 cm. Project staff measured the fork length of 2,800 Chinook Salmon from camera imagery and 2,040 or 72.8% were adult Chinook Salmon and 760 or 27.2% were jack Chinook Salmon. Camera imagery from the first 20 minutes of each hour was analyzed for net upstream fish migration and then expanded to hourly counts and daily counts. The estimated percent salmonid species (Chinook Salmon, steelhead, and Coho Salmon) composition of daily fish counts to identify the total number of upstream migrating salmonids per species. Additionally, fish migration was estimated for periods of time when the camera was not in operation. Daily movement of fish during the Chinook Salmon run at the Main Stem Eel River sonar site ranged from 0 to 2,712 and averaged 49 fish per day. The peaks of migration occurred on November 2 (N = 2,712 fish), November 3 (N = 1,062 fish), November 14 (N = 1,449 fish), and November 15 (N = 984 fish), which accounts for 64.7% of total Chinook Salmon abundance estimate. These peaks aligned with the arrival of the first two significant rain events of the season. During the Chinook Salmon run on the Eel River there were a total of 1,121 hours sampled, accounting for 72.4 % of the total potential sampling time (October 15 – December 18).

We estimate the abundance of adult and jack salmon (Chinook and Coho salmon) returning to the Van Duzen River from November 1, 2024 through December 18, 2024 equaled 2,397 fish (95% CI 2,183 – 2,611; with a coefficient of variation (CV) of 7.9%). Of this total, we estimate the abundance of Chinook Salmon to be 2,00 fish. Camera imagery from the first 20 minutes of each hour was analyzed for net upstream fish migration and then expanded to hourly counts and daily counts. Daily movement of fish during the Chinook Salmon run at the Van Duzen River sonar site (November 1 through December 18, 2024) ranged from 0 to 378 and averaged 57 fish per day. The peaks of migration occurred on November 2 (N = 246 fish), November 14 (N = 255 fish),

November 15 (N = 378 fish), and November 16 (N = 120), which accounts for 41.6% of the total abundance. This peak also aligned with the arrival of the first two significant rain events and rises in hydrograph of the season. During the Chinook Salmon run on the Van Duzen River there were a total of 574 hours sampled, accounting for 49.83 % of the total potential sampling time (November 1 – December 18). Fish migration was estimated for periods of time when the camera was not in operation. Based on sonar fish counts and accompanying spawning ground surveys, we estimate the return of adult and jack Coho Salmon to the Van Duzen River to be between 350 – 500 fish.

It was also the project's objective to enumerate the winter-run steelhead population on the Main Stem Eel River. However, high streamflow conditions prevented camera deployment during significant portions of the winter-run. The camera operated and collected data for 35 days: January 10, 2025 – January 31, 2025, and from February 27, 2025 – March 12, 2025. During these time frames it is estimated that 3,729 winter-run steelhead migrated past the sonar camera. Camera imagery from the first 20 minutes of each hour was analyzed for net upstream fish migration and then expanded to hourly counts and daily counts. Daily movement of fish ranged from 18 to 549 and averaged 104 fish per day during recording. The peaks of migration occurred on January 11 (N = 243), February 28 (N = 231), and March 1 (N = 549). During this period (December 18 – March 31), there were a total of 814 hours sampled, out of 2,472 total possible hours (32.9%).

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Introduction

Once supporting thousands of California Native Tribe members with sustenance and cultural resources and subsequently robust commercial and sport salmon fisheries, the Eel River, known as Wiya't, Taanchow, and ch'idiyu to the region's tribes has a legacy of wild salmon and steelhead abundance. Estimates of over a half a million Chinook and Coho salmon combined were harvested per year at the turn of the 19th century (Moyle et al. 2017). Historic runs of Chinook Salmon probably ranged between 100,000 fish during low return years and peak years approach 800,000 (Yoshiyama and Moyle 2010). These historic run-sizes dropped significantly by mid-1900s as the CDFW Fish and Wildlife Plan (1965) estimated Chinook Salmon spawning escapement of 26,000 fish (Main Stem Eel River upstream of the SF Eel). More recently, Chinook Salmon runs have crashed to far less than 5% of the historical abundance of fish remaining. Similar dramatic declines have been observed with steelhead. Yoshiyama and Moyle (2010) estimated historical numbers of likely 100,000-150,000 adults per year (winter and summer runs combined), declining to an estimated spawning escapement of 38,000 fish by the 1960s (CDFW 1965) and subsequently recent year's estimates of mainly less than 10,000 fish.

As a result of these significant declines, the California Coastal (CC) Chinook Salmon Evolutionarily Significant Unit (ESU) was first listed as a federally threatened species under the Endangered Species Act (ESA) in 1999, and subsequent status reviews reaffirmed the threatened status (Good et al. 2005; Williams et al. 2011; Seghesio et al. 2016, & NOAA 2024). This ESU of Chinook Salmon has a geographic range which extends from rivers and streams south of the Klamath River in northern Humboldt County to and including the Russian River in Sonoma County. As California's third largest watershed, the Eel River is the largest contributor to the CC Chinook Salmon ESU and is crucial for viability of the species (NMFS 2016).

Due to its overall large size, remote geography, limited access, flashy hydrology, and high turbidities, monitoring the returning CC Chinook Salmon populations in the Main Stem Eel River has been difficult, and most previous studies are limited in their scope and duration. Two data sources – i.e., the fish counts at Van Arsdale Fish Station (at Cape Horn Dam) and spawner surveys in the upper Main Stem Eel River (below Cape Horn Dam) and in Tomki Creek - are among the best available long-running data sets, but they have significant limitations (Yoshiyama & Moyle 2010). The Van Arsdale Fish Station (VAFS) has fish counts from 1933 to present; however, major modifications to the fish ladder and provisions to provide attraction flows did not occur until 1987, thus limiting the accuracy of prior years' data. Furthermore, approximately 90% of the watershed is located downstream of Cape Horn Dam and counts at VAFS represent a small and highly variable portion of the run (Berg Associates 2002). Spawning access to VAFS and other headwater habitats (especially during the early part of the fall rainy season and Chinook migration) in the Eel River Basin is influenced by water released from Scott Dam and natural rainfall and river flow.

While collecting valuable fisheries information for the upper Main Stem, the VAFS and on-going upper Eel River carcass surveys do not provide evidence for the status of the basin-wide salmonid escapement. Accordingly, the National Oceanic and Atmospheric Administration (NOAA) Fisheries status review (2005) for West Coast salmon and steelhead noted, "These data are not especially suited to rigorous analysis of population status for a number of reasons, and sophisticated analyses were not pursued." The lack of monitoring data and a comprehensive monitoring plan for California Coastal (CC) Chinook Salmon have made it difficult to establish population status and trend, and the development of direct fishery assessment and abundance-based fishery management (O'Farrell et al. 2012). Subsequently, the 2016 NOAA Fisheries status review (Seghesio et al. 2016) recommended the need for monitoring specifically in the Eel River watershed, "CC Chinook salmon monitoring in the Eel River should be the top monitoring priority for that ESU". To address these issues, the California Department of Fish and Wildlife (CDFW) developed a strategic monitoring approach and plan for near-future and longer-term implementation, which included recommendations for deploying **D**ual-frequency **ID**entification **SON**ar (DIDSON) technology in the Eel River to monitor CC Chinook Salmon populations (Lacy et al. 2016).

The underwater camera's sonar technology transmits and receives sound pulses that allow it to identify objects in underwater habitats, such as rivers. Considering the effectiveness to monitor salmon escapement in nearby northern California rivers (e.g. Mad River and Redwood Creek), CDFW believed DIDSON cameras could also be well suited to the highly variable discharge and water turbidity that characterize the Eel River during the period of salmon and steelhead migration. CDFW and partners initiated a pilot study in the fall of 2018, operating a DIDSON camera to collect fish migration run timing data and enumerate salmon and steelhead escapement into the lower Main Stem Eel River, approximately 4 miles above the confluence with the South Fork Eel River (SF Eel River). Based on the success of the pilot study, the project has seasonally operated for a total of seven monitoring seasons (2018 – 2025). In fall of 2023 and spring of 2024, NOAA Fisheries West Coast Region and PG&E provided funding for the acquisition of two of the newer, updated sonar camera model: the **A**daptive **R**esolution **I**maging **S**onar (ARIS) Explorer 1200, the next generation of DIDSON technology. The ARIS has a fully adjustable focal range and can produce images of superior resolution and clarity due to its use of higher operating frequencies and narrower beam spacing. It also has improved data review software. Collectively, the ARIS technology allows for greater accuracy in determining population estimates and run composition.

In the fall of 2022, NOAA Fisheries West Coast Region provided separate funding to initiate a pilot-project study in the lower Van Duzen River, which has now successfully concluded its third season. The goal of this study is to monitor the timing of fish passage and enumerate the Chinook Salmon run into the Van Duzen River. While the sonar station has been relocated during the different project years due to changing river and bed and bank conditions, it has always operated in the lower river, and it is unlikely that spawning occurs downstream of the station locations.

Including the CDFW sonar cameras, a network of sonar stations has been established in the Eel River watershed: California Trout operates a sonar camera in the lower South Fork Eel (since the fall of 2018); and Round Valley Indian Tribes (in partnership with Applied River Sciences) operates cameras in the lower Middle Fork Eel River near Dos Rios (est. fall of 2021) and most recently (fall of 2024) in the upper Main Stem Eel River just upstream the confluence with Outlet Creek (Figure 1). Collectively, the sonar monitoring network and collaboration of data sharing between the organizations provides a robust understanding of adult movement, and a more complete Chinook Salmon abundance estimate for the entire watershed.

Study Area

The Eel River is located in northern California approximately 200 miles north of San Francisco, drains into the Pacific Ocean just south of the city of Eureka, Humboldt County. It is the third largest river in California with a drainage basin of 3,684 square miles (CDFW 1995), and a discharge of 5.4 million-acre feet (CDFW 1995). The Eel River watershed is comprised of the Main Stem Eel, North Fork Eel (283 sq. mi.), Middle Fork Eel (753 sq. mi.), SF Eel (690 sq. mi.), and the Van Duzen (428 sq. mi.) rivers. The Eel River is approximately 197 miles in length with 832 tributaries – totaling 3,526 miles of blue line stream according to the USGS 7.5" maps. The Main Stem Eel River has its headwaters in Lake County near Bald Mountain, flowing south to Lake Pillsbury, then 12 miles west to Van Arsdale Reservoir, and then northwest approximately 157 miles to the Pacific Ocean. Elevations on the Main Stem range from sea level at the mouth to over 6,700 feet at the headwaters. The Main Stem Eel River sonar site is located at RM 44 and the project area covers the Main Stem Eel River (including the North and Middle Forks) from its headwaters downstream to near its confluence with the SF Eel River (Figure 1).

The Van Duzen River is a major tributary of the lower Eel River, and the watershed is located primarily in Humboldt County with a small portion of its headwaters in Trinity County. The river is approximately 63 miles in length and is one of the few remaining un-dammed rivers in California. Elevations range in its headwaters from near 6,000 feet to about 60 feet at its confluence with the Eel River. The Van Duzen River and its tributaries contain about 153 miles of accessible stream miles for anadromous fish. The Van Duzen River sonar site project area includes its mainstem and all its significant tributaries from its headwaters downstream to near its confluence with the Eel River.

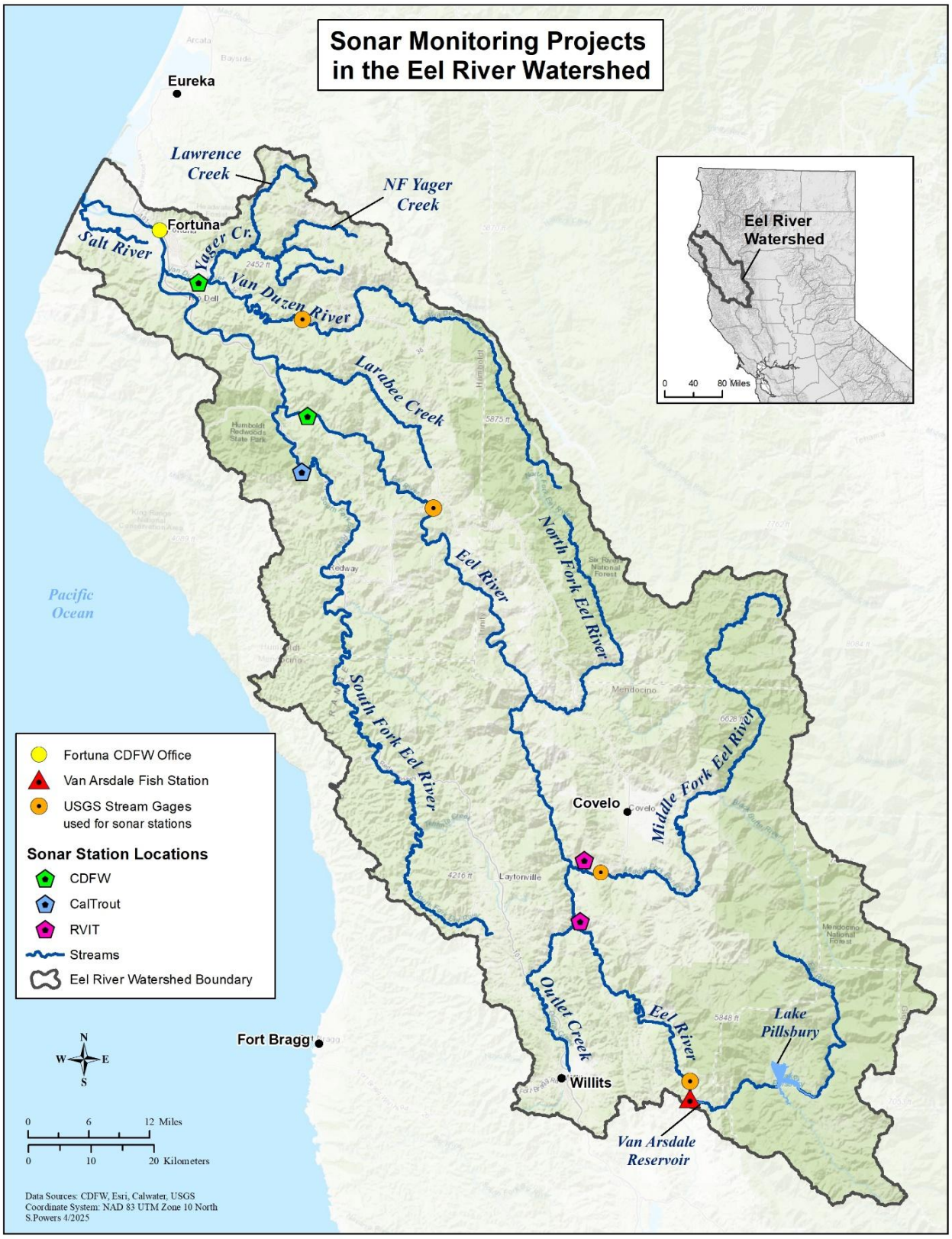

Figure 1. The Eel River watershed and location of the CDFW Main Stem Eel River and Van Duzen River sonar monitoring stations, additional sonar stations, and important features within the Eel River watershed.

Methods and Materials

Sonar Camera and Site Selection

CDFW's Coastal Watershed Planning and Assessment Program (CWPAP) in conjunction with PSMFC operated *Sound Metrics* ARIS 1200 model units in the lower Main Stem Eel River and lower Van Duzen River. This season is the first in which an ARIS unit was used in place of a DIDSON on the Van Duzen River and the second on the Main Stem Eel River. The ARIS 1200 model can capture images from the camera extending outwards to an 80-meter distance.

The Main Stem Eel River sonar site is at River Mile (RM) 44, approximately 4 miles upstream of its confluence with the SF Eel River behind a locked gate on Humboldt Redwood Company Property (HRC) (Figure 1). Site selection for the Main Stem site began with examining USGS topographical maps and utilizing Google Earth to view the lower Main Stem Eel River within a reasonable distance from the CDFW Fortuna field office. It became apparent that selecting a sonar camera station would be constrained to a few potential river sites accessed from the lower seven miles of Dyerville Loop Road, which roughly follows a portion of the Main Stem Eel River from the rural settlement area of McCann downstream to the confluence with the SF Eel River. In February of 2018, CDFW and Trout Unlimited staff conducted a reconnaissance-level raft floating trip on the Eel River from the McCann Bridge (RM 48) downstream to the SF Eel River (RM 40) to determine the best potential location for the sonar station.

Ideally, a sonar site contains the following criteria: 1) a uniform stream bottom profile that offers adequate esonification as described by Maxwell (2007) (i.e. uniform topography without large pits, boulders, or other structures that create blind spots); 2) a longitudinal profile that is characteristic of swift, laminar flow where fish 'milling' behavior is minimized (Pipal et al. 2012); and 3) safe, secure site for the camera and associated equipment to occupy. Project staff found a location that fit this description: the site is situated in a confined, swiftly flowing run unit with a uniform channel bottom, just downstream of a large pool and riffle unit. No significant tributaries are located downstream of the site to the confluence with the SF Eel River, and it is unlikely that salmonids would spawn in this section of the river considering the habitat conditions in high velocity flows during the fall and winter months. All project years have occurred at this location. The USGS Fort Seward Gage (#11475000) is the nearest stream gage, located approximately 23 miles upstream of this project site, and provides important real-time stream flow data and stream water temperatures.

A similar process was performed for determining the pilot year (fall/winter 2022) Van Duzen River site: due diligence with mapping software, determining a location with a proper river configuration/profile by boat floating the Van Duzen River from just upstream of Yager Creek downstream to its confluence with the Eel River, and coordination with landowners to determine the security of the site. The lower Van Duzen River, like the lower Main Stem Eel River, has limited access points and multiple stream channel configurations. Nonetheless, project staff identified

a site at RM 3.8 that fit enough of the criteria to function adequately as a pilot-year sonar site for the fall Chinook Salmon run. The river channel at the selected site underwent significant reconfiguration over the course of the pilot season; the stream channel widened considerably, transforming the run into a wide riffle unable to be effectively esonified. For the 2023 season, the site moved approximately 800 feet upstream from the original pilot site. This is where the camera also operated at the beginning of the 2024/25 season; however, an unusually large, early season rain event beginning on November 19, 2024 produced extremely high stream flow conditions that washed away acres of land at the camera site. Thereafter, the site was no longer suitable or accessible for camera operations, and the project lead worked with the current landowner and an upstream landowner to find a new, secure location for the sonar station that provided the desired specifications listed above. Camera operations resumed on December 3, 2024 at the new site, located upstream at approximately RM 5 and just downstream of the Yager Creek confluence with the Van Duzen River. The USGS Bridgeville Gage (11478500) is located approximately 18 miles upstream of the sonar site, providing important real-time stream flow data.

Sonar Installation and Operations

The sonar camera sites are located at remote locations on large river bars without access to any structure or power source. As in the case of previous project years, the Main Stem site utilized a cargo trailer with attachable solar panels (on top of trailer) to house a laptop, portable hard drive, sonar equipment, and batteries needed to provide the external power source for camera operations. Trout Unlimited (North Bay and Redwood Empire chapters) purchased and outfitted the trailer with the necessary equipment (including solar panels and lithium-ion batteries). Humboldt Redwood Company (HRC) provided access and maintenance of the gravel bar road as well as locking gate security to the site. The Van Duzen River site utilizes a similar set-up, a cargo trailer equipped with solar panels and lithium-ion batteries to house and power all sonar related equipment. NOAA West Coast Fisheries provided funding for the trailer and Trout Unlimited helped outfit the trailer for the project needs.

On October 15, 2024, prior to the onset of the first significant rainfall of the season, CDFW project lead, PSMFC field lead, and scientific aids with assistance from AmeriCorps Watershed Stewards Project (WSP) corpsmembers transported the cargo trailer, the ARIS 1200 camera, laptop, hard drives, and associated equipment to the Main Stem Eel River site. After the solar panels were connected and sonar equipment was powered up, staff-initiated testing and recording of sonar imagery. A similar process was performed for the Van Duzen site on November 1, 2024, with project staff (now including PSMFC field technician and scientific aids) installing the ARIS 1200 camera.

At both sites, staff installed weir panel approximately one meter (m) downstream of the camera and extended almost one meter past the lens to prevent fish from passing the sonar undetected by swimming behind or too close to the camera (ARIS window start range was set at 0.7m). The

cameras are housed in aluminum lock boxes attached to H-frame stands and stabilized with rebar driven into the river bottom and lashed to the stand with 1 cm nylon rope. Cameras are secured to the gravel bar using Earth Anchor duckbills, steel cable, and locks.

Project staff checked the cameras daily to ensure the quality of recorded sonar imagery and if necessary, repositioned it in response to changes in flow and channel width. The pitch of the camera is manually adjusted to properly esonify the water column (Holmes et al. 2006). During storm events, project staff often make multiple trips per day to the field site(s), adjusting the stand location, weir panels, and camera pitch for data quality purposes. If flows exceed 7,500 cfs and approximately 800-1,000 cfs at the Main Stem and Van Duzen sites, respectively, project staff remove the stands and cameras from the rivers to prevent damage or loss of equipment. The cargo trailer housing the power source, ARIS top-box, and computer are also vulnerable at higher flows, requiring additional precautionary measures. If stream flows are predicted to reach 10,000 cfs or higher at the Main Stem Eel River site then project staff move the trailer to a higher terrace. If flows are predicted to exceed 25,000 cfs then all equipment is transported back to the CDFW Fortuna office. During non-operating periods project staff utilize the opportunity to rinse and clean the camera to prevent silt and algal accumulation, which diminishes video quality.

Data Recording and Processing

The sonar camera continuously records data files, 24 hours a day, seven days a week. All recorded data files are arranged in 20-minute incremental files starting on the hour and stored on a 2-terabyte external hard drive. Project staff would copy data at the site on a weekly basis to an additional hard drive that would be brought back to the CDFW Fortuna office for processing. The data processing (manually counting and measuring fish greater than 39 cm in total length) occurs on desktop computers using Sound Metrics ARIScope and ARISFish proprietary software to review ARIS data files. Adjusting software settings provides proper contrast and resolution allowing one to distinguish between fish, debris, and potentially other animals (Figure 2). Unprocessed data files are played back 4 to 12 times faster than recorded speed to more easily detect fish presence/movement. Daily fish movement counts are entered into individual Excel Spreadsheets that separates the following: date recorded, date reviewed, camera window length, reviewer, stream flow (cfs recorded at the sonar site's corresponding USGS gage) 20 minute per hour counts of upstream and downstream fish movements, net hourly fish movements, fish size and general comments (e.g. quality of the video, additional animals observed, etc.). Daily fish movement refers to the sum of net hourly fish movements.

To separate adults from jack (precocious males) salmon, project staff estimates sizes of individual fish in camera footage using the measure tool in the ARIS review software. At minimum, we measure the first 10 individuals (>39 cm TL) that passed through the window for each hour to the nearest centimeter (cm) and recorded lengths are placed in either the adult (≥ 62 cm) or jack (39 – 61 cm) category for further comparison. A preliminary total length cutoff of 62 cm is used to separate adult Chinook Salmon from jacks based on analysis of Chinook age and size arrivals at

VAFS (A. Andrews personal communication 2025). Jacks are presumed to be two-year old returning fish and adults are three-year old or greater.

Reviewing data files is time consuming and a lengthy process; therefore, sub-sampling is commonly used to reduce workload and produce a reliable estimate of abundance (Maxwell 2007). We use a non-replicated systematic sample of the first 20 minutes of each hour to enumerate fish and generate fish passage estimates (Metheny et al. 2016; Sparkman et al. 2017). Net movement is determined for each 20-minute file and defined as the sum of positive upstream movements and negative downstream movements. To estimate abundance of Chinook Salmon the project uses the net movement of all fish observed for the 20-minute subsample expanded to the hour. Daily counts are simply the sum of net hourly counts. To properly assess error arising from using a 20-mintute subsample to represent hourly fish passage, we use the V5 variance estimator and determined 95% confidence intervals for the total yearly passage (Xie and Martins 2014; Metheny et al. 2016; Sparkman et al. 2017). The V5 estimator is used to account for missed sampling time and the nonlinear patterns of anadromous fish movement, which can increase the variance estimate (Reynolds et al. 2006). The estimator looks at the passage rate before any given hour and after any given hour to best represent the migration pattern and account for temporal autocorrelation. Studies comparing different sampling methods have shown that systematically sampled, non-replicated data has the highest precision and accuracy (Holmes et al. 2006; Xie and Martins 2014).

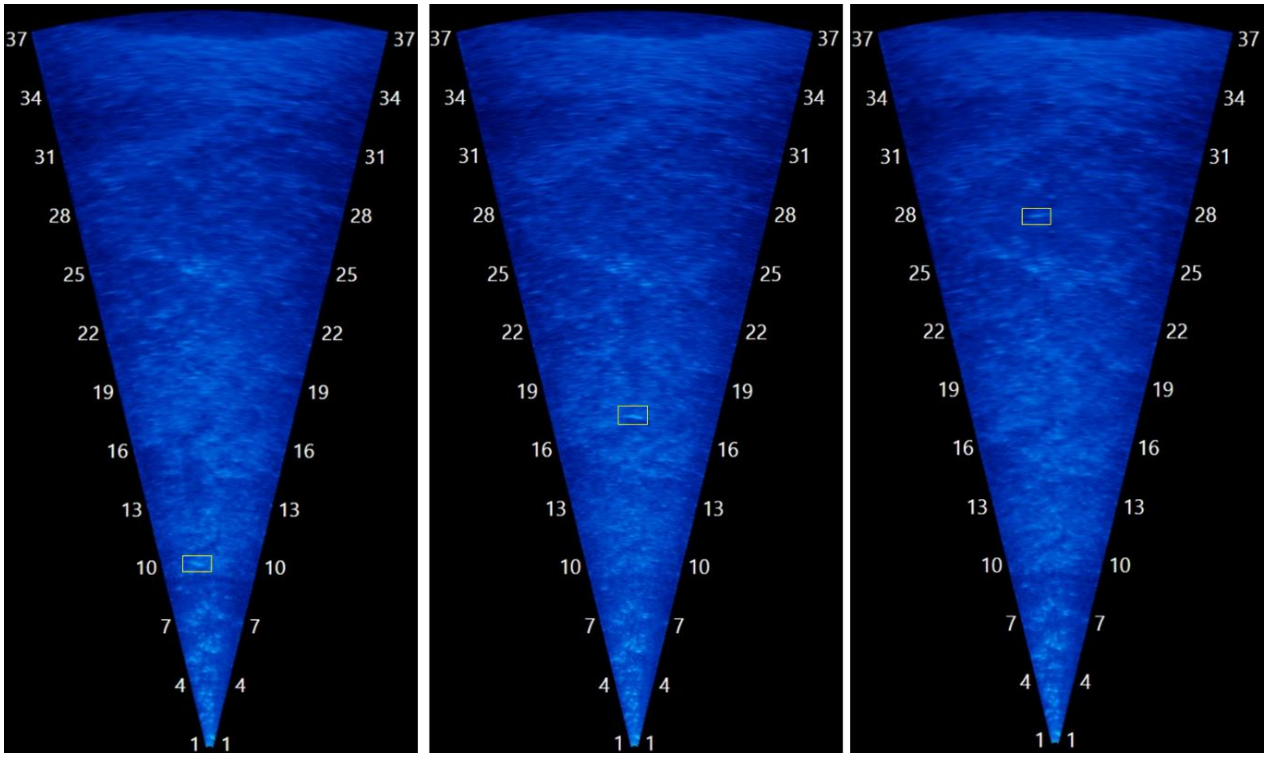

Figure 2. Side by side comparison of still-frame ARIS imagery featuring presumed adult Chinook Salmon, at various distances from the camera. The yellow box outlines where a fish is located. This recording was taken at the Main Stem Eel River sonar site in the fall of 2023.

Data Quality Assurance

Multiple reviewers are utilized throughout the project season to process the large amount of video data collected. Any bias in reviewers' counts or in recorded fish lengths could affect the resulting population estimates. To ensure the quality of data and accuracy while enumerating fish movement, a significant portion of data files are reviewed multiple times. The correlation of counts from independent reviewers watching the same video is examined to determine repeatability of the estimation process. If there is significant disagreement in counts, files would be reviewed an additional time. On high passage days (greater than 100 fish/day for Main Stem Eel and greater than 50 fish/day for Van Duzen), a portion of the data is reviewed by multiple staff members and independent counts are averaged. While the ARIS camera's advanced technology aids review of data files recorded during high stream flow events, particularly challenging data files (due to the river's high sediment load creating background noise), are also reviewed independently by a second reviewer to assure the accuracy of the final fish count. We also compared fish lengths taken from the same video by independent reviewers to assess repeatability of the software's length measuring process. Project leads have multiple years' experience reviewing sonar data from the Main Stem Eel River sonar monitoring project and performed extensive Quality Assurance (QA) and Quality Control (QC) allowing for both consistent and accurate counts.

Estimating Missed Hours

There are several methods to account for passage estimates when the sonar is non-operational due to high stream flows or other technical/software issues. The most common method, when there are missing hours on a given day, is to calculate an average value for each missed hour using previous and post day counts for that same hour. When the camera is out for multiple days, the days preceding and following are used to average missing values. In past years, these calculations were done by hand because camera operations were relatively uninterrupted during the Chinook run.

This year, to account for missing days and hours during the extended periods of non-operation in late November and late December, we utilized the impute TS R-package to fill in missing values (na). The impute TS package offers multiple state of the art imputation algorithm implementations along with plotting functions for time series missing data statistics (Moritz and Beielstein 2017). The moving average function na_ma (x,k=144/168,weighting="simple"), where na represents a missed hour, and k = the number of inputs before and after a certain value that are used to calculate that missing value. In this case, the values represent 20-minute reviews/samples. We set k to 144 (hours before and after missed value) for the Main Stem Eel and 168 for the Van Duzen River. We believe this method helps provide a reasonable and accurate estimate.

Species Apportionment

Salmonid species cannot typically be differentiated by sonar imagery alone; however, seasonal, single-run rivers more easily lend themselves to species apportionment efforts. Distinct, temporal migration patterns have been observed in the Eel River for Chinook Salmon, Coho Salmon (*Oncorhynchus kisutch*) and steelhead (Yoshiyama et al. 2010). Chinook Salmon begin to move from the ocean into the river's estuary in September and hold in the lower reaches until rainfall and increases in discharge allow for passage through shallow riffles. Annually, a small number of adult steelhead have been observed migrating with the initiation of the fall-run Chinook Salmon (Halligan 1997, 1998). Evidence of this continues to the present as prior to increases in the hydrograph adult steelhead are observed in the late summer/early fall holding with Chinook Salmon in the lower river.

Species assignment for this monitoring year was based on the following methods: taking into account the typical run timing of each species, tangle netting efforts conducted at and/or in the vicinity of Main Stem Eel River sonar site, seasonally overlapping adult salmon spawning ground surveys performed in upper Eel River tributaries, Van Duzen River tributaries and in the SF Eel River tributaries, and real-time and historical observations at the VAFS on the upper Main Stem Eel River.

Chinook Salmon and Steelhead Run Timing

It is estimated that a large majority of the Chinook Salmon run was completed by December 18, 2024. This is primarily based on three indicators: the VAFS observed its last Chinook Salmon ascending the ladder the week of December 22 (two adults); Garcia and Associates/Kleinfelder weekly spawner surveys detected no new Chinook Salmon redds after December 19 in the upper Eel River below Van Arsdale and the tributaries of Tomki Creek, Longbranch Creek, and String Creek (A. Anderson, PG & E Personal Communication 2025); and no Chinook Salmon were caught or observed during a December 12, 2024 tangle netting effort at the Main Stem Eel sonar site.

Some overlap occurs between the end of the Chinook Salmon run and the beginning of the steelhead run. VAFS observed their first steelhead arrival on Friday December 6, and steelhead observations continued to rise throughout the month (A. Anderson, personal communication 2024). Moreover, the December 12 tangle netting effort caught several adult steelhead, indicating their presence in the lower river. Considering the VAFS observations, tangle netting results, and additional steelhead sightings during spawning ground surveys, staff concluded that the steelhead run began earlier than previous project years. In the absence of a conclusive method to discern the two species in sonar footage review during run timing overlap, project staff postulated December 18, 2024, as the date to separate the Chinook Salmon run from the winter-run steelhead.

Coho Salmon Run Timing

While a significant Southern Oregon / Northern California Coast (SONCC) ESU Coho Salmon run persists in the SF Eel River, typically arriving in mid-to-late December and continuing till mid to late February, recent detections of adult Coho Salmon in the Main Stem Eel River have been limited to a small number of adult fish in the Outlet Creek watershed (Yoshiyama 2010), a few observations at the VAFS, and Matt Horne saw a spawning pair in Short Creek (MF Eel River) in 2015 (Matt Horne, RVIT Fisheries Program, Personal Communication March, 2025). Most recently, CDFW performed juvenile fish mask and snorkel surveys in the Outlet Creek watershed during the summer of 2025. Crews identified only a very small number of juvenile Coho Salmon. The limited number of juveniles detected contrasted with the robust numbers of adult Coho Salmon observed during 2024/25 adult spawning ground surveys in the SF Eel and Van Duzen rivers; therefore, it seems likely that only a very small run of Coho Salmon (less than 50 adults) continues to persist in the Main Stem Eel River via the Outlet Creek watershed and do not statistically effect the Main Stem Chinook Salmon abundance estimate.

Additional Fish Species

The Eel River supports additional fish species that are likely to be discernable in sonar footage review, primarily Sacramento Pikeminnow (*Ptychocheilus grandis*), Sacramento Sucker (*Catostomus occidentalis*) and Green Sturgeon (*Acipenser medirostris*). Sacramento Pikeminnow, and to a lesser extent, Sacramento Sucker in their adult phase can be large enough (>39 cm) to potentially be counted as salmonids passing the camera; however, their migration patterns are generally different enough from salmonids that they are not likely passing the camera during salmonid migration season in large numbers. Tangle netting efforts this year did show the presence of some of these fish during the Chinook and Steelhead runs on the Main Stem Eel, but they were rarely longer than 39 cm. As noted in Harvey & Nakamoto (1999) adult Sacramento Pikeminnow upstream movement is generally muted during the winter months with higher flows and colder water temperatures within the Main Stem Eel River. Harvey and Nakamoto findings are further supported by similar observations through the six years of conducting this monitoring project – both in data review and biological surveys. Project staff have documented limited adult Sacramento Pikeminnow movement during most of the time frame the sonar camera is deployed. It appears that upstream movement of large, adult Pikeminnow (potentially of steelhead-size) commences when the colder, Eel River stream temperatures increase to above 15^{o}C and flows are on a continually descending pattern. These conditions usually do not occur until the winter steelhead run nears its end in April.

Data Review Techniques and Field Speciation Methods

Staff utilize data review methods and techniques described in Sparkman and Holt (2020), which provides the reviewer insights to possibly discriminate other fish species from Chinook Salmon and steelhead movement. For example, Sacramento Suckers almost always exhibit schooling behavior, move slowly through the sonar field, and are smaller in body length (rarely >40 cm)

and body height. Distinguishing non-salmonid species is also aided by experienced, knowledgeable staff performing QA/QC of data files containing difficult to decipher fish species

Project staff also employs speciation efforts in the field when species overlap may occur. Mask and snorkel dive surveys are effective during low stream flow periods to document the presence of salmonid species and/or non-salmonids near the sonar site area. Project staff conducted mask and snorkel surveys on October 30, 2024 and November 8, 2024 (Table 1) in the run unit where the Eel River camera operates and in the large pool unit upstream of the camera site. During these surveys, divers spread out across the width of the river and floated downstream in a parallel line, working to keep pace with each other throughout the survey to ensure complete coverage of the channel.

The 2024-25 season was the first in which tangle nets were used to capture fish on the Main Stem Eel River. CDFW Arcata staff, who had over a year's experience performing tangle netting surveys on the Mad River, assisted and helped train project staff on various methodologies. The tangle net was approximately 30 m long and 4 m deep with a 10 cm mesh of 6# monofilament. Tangle netting efforts utilized two techniques: drift netting and fixed net sets. Drift netting was performed with a motorized boat to deploy the net and occurred within 1.5 km of the sonar site. The fixed net method was done by setting the net immediately upstream of the sonar site. Tangle netting was performed on 5 separate occasions between November 5, 2024 and January 29, 2025 with the nets safely and effectively capturing a variety of fish species (Table 1)

Table 1. Number of fish observed/captured by date, method and species during 2024-25 field speciation surveys on the Main Stem Eel River. Fish fork-lengths noted in ().

Date	Flow (cfs) @Fort Seward	Method	Chinook	Steelhead	Sacramento Pikeminnow	Sacramento Sucker
10/30/2024	73.1	Mask and Snorkel	1 (70 cm)	0	25 (ave. size 25-30 cm)	0
11/5/2024	118	Drift and fixed net				1 (32 cm)
11/8/2024	118	Mask and snorkel	0	0	7 (size range 35-40cm); 70 (size range 15-20 cm)	0
11/15/2024	744	Fixed net	1 (85 cm)	0	1 (40cm)	9 (size range 37-46 cm)
12/12/2024	2,790	Drift and Fixed net		1 (80 cm)	2 (43 & 46 cm)	2 (45 & 40 cm)
01/24/2025	1,500	Fixed	0	0	0	0
1/29/2025	1,160	Drift net	0	4 (61, 60, 59, & 65 cm)	0	8 (size range 35-38 cm)

The Van Duzen River sonar site is located downstream of its confluence with Yager Creek whose tributaries provide spawning habitat for Chinook and Coho Salmon; therefore, adult spawning ground surveys are an effective method for determining run-timing of each species. Citizen scientist, Eric Stockwell performs spawner surveys in these tributaries throughout the Chinook and Coho Salmon migration period and provides timely communication with the project lead concerning the timing of species migration and fish and redd counts. Project staff occasionally accompanies Eric on these surveys for project-related data collection purposes. These surveys also offer the opportunity to discuss protocols and share information between CDFW and local citizen scientists. Project staff completed three spawner surveys in the Yager Creek watershed with Stockwell and observed abundant numbers of Coho Salmon and their redds (Table 2).

Table 2. 2024-25 Adult spawning ground survey results conducted by CDFW and E. Stockwell in Lawrence Creek tributaries: *Booths Run Shaw Creek, and Fish Creek. M= males; F= females; Unk= unknown*

Stream	Date	Live Coho	Live Chinook	Redds	Carcasses
Booths Run	12/19/2024	101 (49 M, 26F, 5 Jacks, 21 Unk)	0 (0M, 0F, 0 Jacks)	30	2
Shaw Creek	1/15/2025	39 (9M, 25F, 3 Jacks, 2 Unk)	28 (8M, 17F, 3 Jacks)	39	15
Fish Creek	1/9/2025	65 2 jacks	0	28	6

Late Summer/Early Fall Lower Eel River Surveys

As mentioned previously, Chinook Salmon begin to enter the Eel River early to mid-September and generally hold in several locations (staging areas) in the lower river until suitable flows (generally greater than 250 cfs at the USGS Scotia gage) are encountered coupled with a combination of other environmental factors which encourage upstream movement. CDFW and local citizen scientists Eric Stockwell and David Sopjes have conducted kayak and stand-up paddleboard excursions in the lower Eel River to observe species present, the timing of their arrival, approximate expansion of fish numbers as they continue to arrive, and their appearance/condition. These surveys usually begin in mid-September and continue to the onset of continuous higher river flows, which leads to dispersal of the fish. The citizen scientists incorporate recreational drone flights to capture fish images and further the accuracy of their counts from systematic review of drone imagery footage. These surveys provide important information regarding where salmon hold on a yearly basis, the habitat conditions, and water quality (YSI digital water quality meter measurements and CDFW deployment of stream temperature loggers).

Annually, project staff coordinate with Stockwell and Sopjes to accompany them on a portion of their surveys as well as perform surveys independently of the citizen scientists. These paddle surveys typically begin near the Fortuna River Lodge (RM 9) and float downstream approximately

two miles (near the Fernbridge) attempting to identify fish to species, condition, and approximate numbers. In addition to seasonally increasing numbers of adult and jack Chinook Salmon, surveyors observation usually include the following: several dozen adult steelhead, hundreds of half-pounder steelhead, hundreds to low thousands of Sacramento Pikeminnow consisting of some large, adult-sized fish but predominantly between 10-30 cm, several Striped Bass (*Morone saxatilis*), small schools of American Shad (*Alosa sapidissima*), and varying numbers (estimating between 3 and 18) adult Green Sturgeon (CDFW and E. Stockwell, personal communication 2023 and 2024).

Results

Field Operations

Sonar monitoring of adult Chinook Salmon migration was implemented on the Main Stem Eel and VDR and winter-run steelhead migration was monitored on only the Main Stem Eel River site. It is feasible to operate the Main Stem site at flows up to 7,500 cfs and VDR up to 1,000 cfs, and during flows exceeding these threshold cameras are removed for equipment and staff safety. The project attempts to maximize the total hours/days of sonar data collection for Chinook Salmon migration from the onset of fall migration flows to December 18, 2024 and steelhead migration from December 19, 2024 to early April 2025.

Main Stem Eel River Site – Fall-run Chinook Salmon Operations

The Main Stem Eel River camera was deployed in the fall of 2024 on October 15 in advance of increased flow to document any fish movement. A slight rise in the hydrograph in late October initiated Chinook Salmon movement as a couple of hundred adults and jacks passed the camera. The first significant precipitation event within the Eel River watershed occurred the week of November 1, with flows rising from approximately 89 cfs to 200 cfs at the USGS Fort Seward gage (Figure 3).

Unlike previous project years, several significant late autumn storms (Table 3) in the Eel River watershed caused a higher proportion of interruptions to camera operations at the Main Stem Eel River site during the mid to late portion of the adult Chinook Salmon run. Accordingly, the camera operated continuously throughout mid-October and the first half of November until a seasonally early, large atmospheric river event beginning on November 19 caused flows to peak at 108,000 cfs on November 22 (Figure 3). This forced the removal of the Main Stem camera from November 19 till November 30. Camera operations resumed on November 30 and continued uninterrupted until December 12 when another large rain event commenced bringing prolonged high stream flows and inoperable conditions until early January.

Table 3. Monthly precipitation totals with % historical average in parentheses () measured at NOAA stations in Humboldt and Mendocino Counties October 1, 2024– April 30, 2025. Main Stem Eel River watershed stations: Fort Seward, Covelo, and Willits. Van Duzen River watershed station: Bridgeville.

Monthly Precipitation Totals and % of Historical Average (in)				
Month	**Main Stem Eel River Watershed**			**Van Duzen River Watershed**
	Fort Seward (in)	**Covelo (in)**	**Willits (in)**	**Bridgeville (in)**
October	0.88 (24%)	0.79 (30%)	0.35 (11%)	1.08 (25%)
November	16.82 (227%)	14.73 (213%)	16.14 (197%)	20.96 (211%)
December	13.25 (137%)	13.84 (176%)	13.98 (159%)	15.68 (136%)
January	1.94 (18%)	1.78 (21%)	1.16 (12%)	Camera Out
February	13.66 (172%)	13.29 (208%)	13.74 (184%)	
March	7.4 (116%)	5.88 (97%)	7.73 (108%)	
April	2.33 (71%)	2.72 (114%)	2.79 (90%)	
TOTAL (in)	56.3	53.0	56.6	37.72

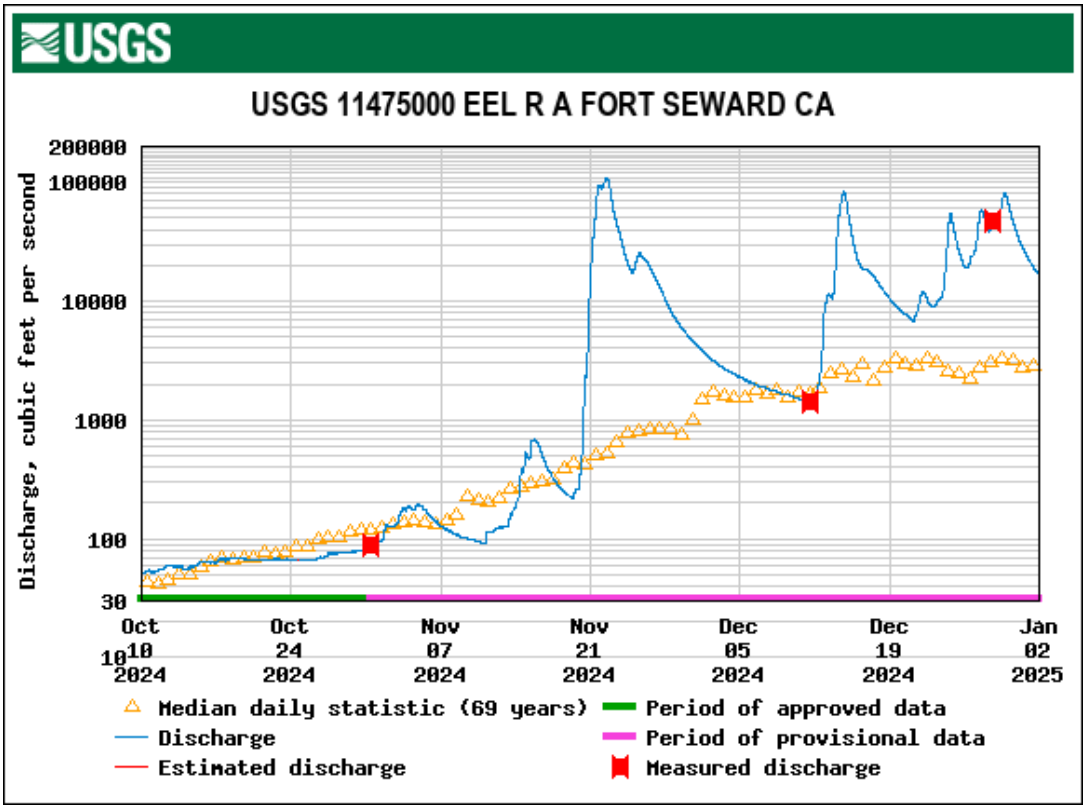

Figure 3. Estimated daily streamflow (cfs) and historical median daily statistic measured from the USGS gauging station at Fort Seward, Humboldt County. Time period covers the Main Stem Eel River fall-run of adult Chinook Salmon.

During the project's estimated adult Chinook Salmon migration period from October 15 till December 18, the sonar camera recorded 1,121 hours, accounting for 72.4% of the total potential sampling frame for the Chinook Salmon fall-run (Table 4). This was below the project's 7-year average, 87.1%, of percent sampled during the yearly Chinook Salmon run.

Table 4. Percent of time sampled and time missed due to high streamflow and other factors for all project years 2018-2024 during the fall-run Chinook Salmon, Main Stem Eel River, Humboldt County, CA.

Summary of Main Stem Eel River Sonar Operations during adult Chinook Salmon Migration Season.				
Project year and timing of fall-run Chinook Salmon migration	**Sampled Total %**	**Sampled # Hours**	**Not Sampled Total %**	**Not Sampled # Hours**
2024 Oct 15 – Dec 18	72%	1121	28%	427
2023 Sept 25 – Dec 20	94%	1852	6%	116
2022 Nov 1 – Dec 22	90%	1115	10%	119
2021 Oct 20 - Dec 23	76%	1176	24%	371
2020 Nov 12 – Dec 31	98%	1162	2%	23
2019 Nov 25 – Dec 31	91%	799	9%	78
2018 Nov 15 – Dec 31	88%	1,058	11%	108
7 – Year Average	*87.1%*	*1,183*	*12.9%*	*177*

Van Duzen River Site – Fall-run Chinook Salmon

While the Main Stem Eel River experienced seasonally near normal stream flow conditions during the 2024 early to mid-autumn period, the Van Duzen River experienced prolonged low flow conditions – less than 10 cfs measured at the USGS Bridgeville gauge for most of September and October (Figure 4). Therefore, Van Duzen camera operations did not commence until the first seasonal rise in stream flow (above 50 cfs at the Bridgeville USGS gauge) beginning on November 1. The Van Duzen ARIS operated almost continuously until November 19, when it was removed due to rising high stream flows.

A seasonally unusual atmospheric rain event caused flows to peak on November 22 at 27,700 cfs (Bridgeville gauge) and remained elevated through the end of the month (Figure 4). The extremely high flows, washed away acres of land in the lower river, including vehicle access to the sonar site. The high flows reshaped the river, and the site was no longer usable as a sonar station. The project lead worked with the current site landowner and an upstream landowner to establish a new sonar station location, which was approximately 1.2 miles upstream of the former site. The camera was reinstalled on December 3 and recorded until the large earthquake on December 5, 2024 caused a brief pause in the recording. The camera was removed on December 12 and was out for the rest of the Chinook Salmon monitoring season due to high flows. The prolonged high flows and logistics of coordinating a new sonar site resulted in a less than 50% sample rate during the Chinook Salmon run on the Van Duzen River (Table 5).

Table 5. Percent monthly time sampled, and time missed due to fluctuating streamflow and other factors during 2024-2025 season, Van Duzen River, Humboldt County, CA.

Summary of Van Duzen River Sonar Operations during adult Chinook Salmon Migration Season							
Sampling Month	**Total % Sampled**	**Hours Not Sampled High flow**	**% Not Sampled Due to High flow**	**Hours Not Sampled Low flow**	**% Not Sampled Due to Low Flow**	**Hours Not Sampled for Other Factors**	**% Not Sampled for Other Factors**
Nov. 1st- 30th	55%	277	38%	0	0%	16	7%
Dec. 1st - 18th	41%	224	52%	0	0%	29	7%
2024 Total	48%	501	45%	0	0%	45	7%
3-year project ave.	*67.1%*	*326.6*	*27.2%*	*25.3*	*3.6%*	*44.3*	*4.6%*

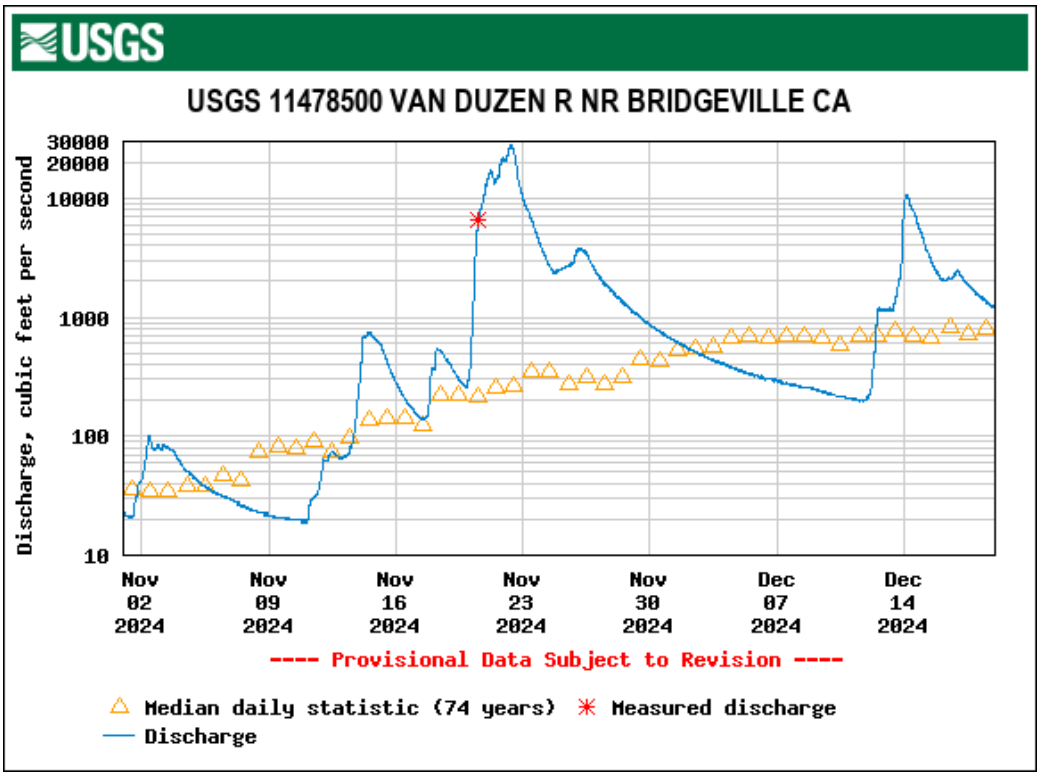

Figure 4. Estimated daily streamflow (cfs) and historical median daily statistic measured from the USGS gauging station at Bridgeville, Humboldt County, CA. Time period covers the potential Van Duzen River fall-run of adult Chinook Salmon. Flows were too low for fish passage until Nov 6, 2023.

Main Stem Eel River Site – Winter-run Steelhead

Based on several tangle netting efforts conducted at the sonar site and the timing of the initial and final steelhead observations at the VAFS, the estimated run period for winter steelhead in the Main Stem Eel River was mid-to late December to early April, 2024. However, prolonged high

stream flow conditions exceeded the flow threshold for operating the sonar camera for significant portions of the winter steelhead run. Estimated mean daily flows as measure at the USGS Fort Seward gage averaged 14,753 cfs during this period (Figure 5); therefore, camera operations were limited from January 10 until January 31 and February 27 until March 12. From December 19, 2024 to April 7, 2025 there were 2,472 potential hours to record data, and of these, the project sampled 814 hours, comprising 32.9% of this sampling time frame.

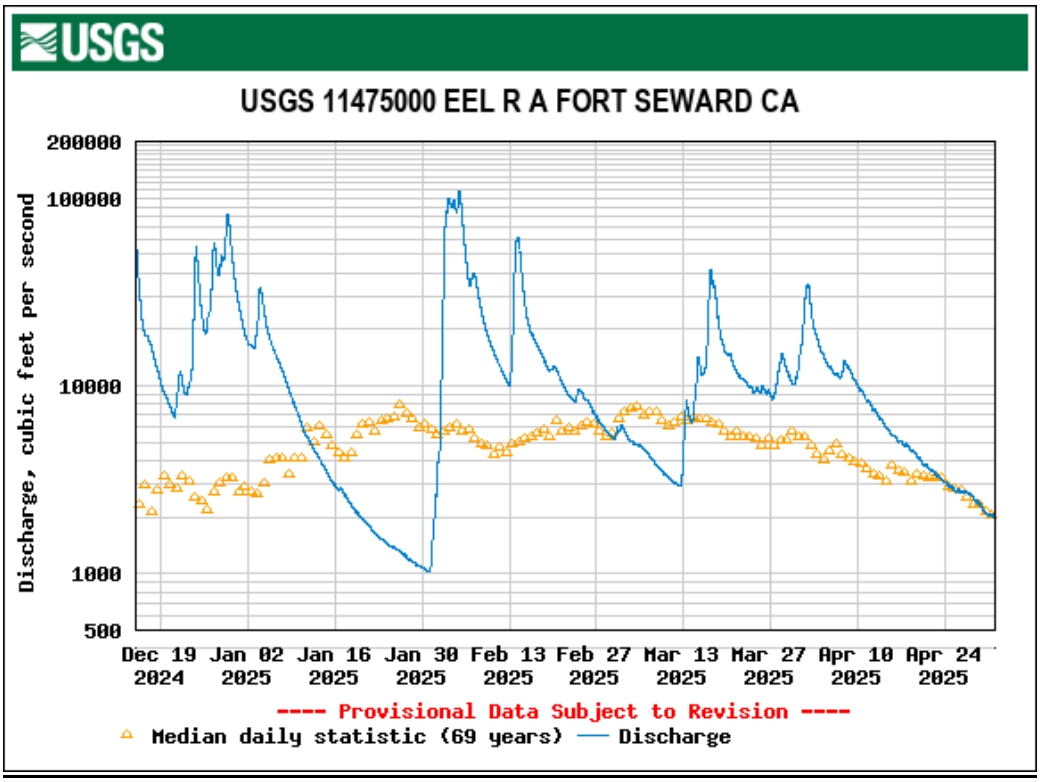

Figure 5. Estimated daily streamflow (cfs) and historical median statistic measured from the USGS gauging station at Fort Seward, Humboldt County, CA. Time period covers the typical migration period of Main Stem Eel River winter-run steelhead.

Daily Passage Rates of Chinook Salmon

With the deployment of the sonar camera in mid-October, staff observed some very low numbers of salmon/steelhead fish passage during the first week of operations. Higher numbers of jacks and adults began passing the camera on October 28 and continued through the rest of October with an average of 104 fish per day (October 28 through October 31) (Figure 6). The Eel River watershed received its first significant rainfall of the season in the first week of November. The precipitation subsequently increased the hydrograph allowed the several thousand fish holding in the lower reaches of the Eel River to begin migrating through formerly impassible riffles and access the Van Duzen River (RM 13) and the confluence of the Main Stem and South Fork Eel River(s) (RM 40.5).

Daily movement of fish during the fall Chinook Salmon run at the Main Stem Eel River sonar site (October 15 through December 18, 2024) ranged from 0 to 2,712 and averaged 148 fish per day (Figure 6). The peak of migration occurred October 29 through November 21: a total of 9,003 fish, accounting for 94% of the total run. Peak fish passage days were observed on November 2 (N = 2,712 fish), November 3 (N = 1,062 fish), November 14 (N = 1,449 fish) and November 15 (N = 984 fish), coinciding with the first two significant precipitation events of the season within the watershed. The 2,712 fish counted on November 2 was the highest single day passage in the history of the project. As explained in the Methods and Materials section (p.14), to account for missing days and hours during the extended periods of non-operation in late November and mid-December, we utilized the impute TS R-package to fill in missing values (na). Those missing values are outlined in black in Figures 6 and 7 and are included in the total abundance estimate described in the Chinook Salmon Abundance Estimates (p. 25).

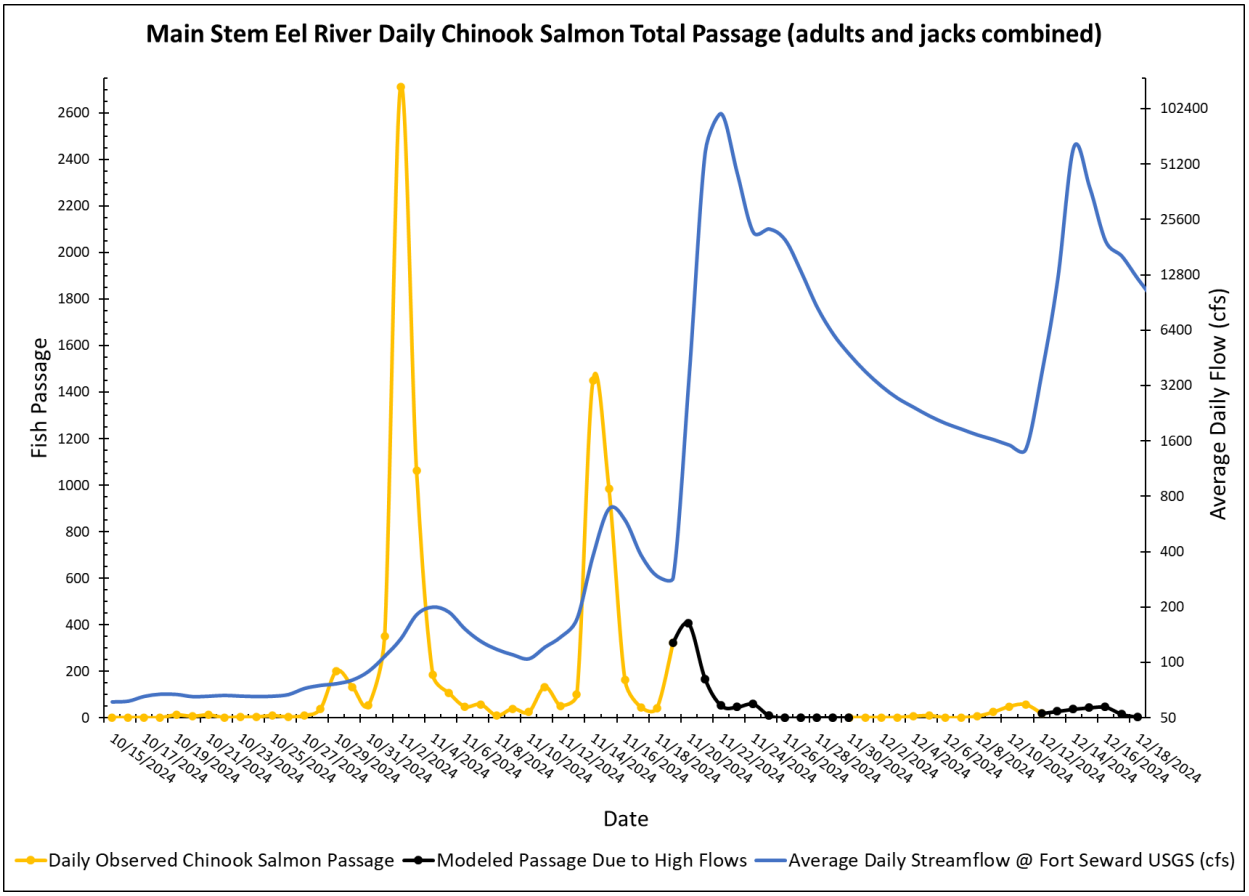

Figure 6. Streamflow (cfs) measured from the USGS gauging station at Fort Seward and the daily expanded Chinook Salmon (adults and jacks) movements from October 15 – December 18, 2024 at the Main Stem Eel River sonar site, Humboldt County, CA.

Daily movement of fish during the Chinook Salmon run at the Van Duzen River sonar site (November 1 through December 12, 2024) ranged from 0 to 378 and averaged 50 fish per day (Figure 7). The peaks of migration occurred on November 2 (N = 246 fish), November 14 (N = 255 fish), November 15 (N = 378 fish), and November 19 (N = 201 fish), which accounts for 45.1% of

the total abundance. These peaks also aligned with the arrival of the first two significant precipitation events and rises in hydrograph of the season (Figure 7).

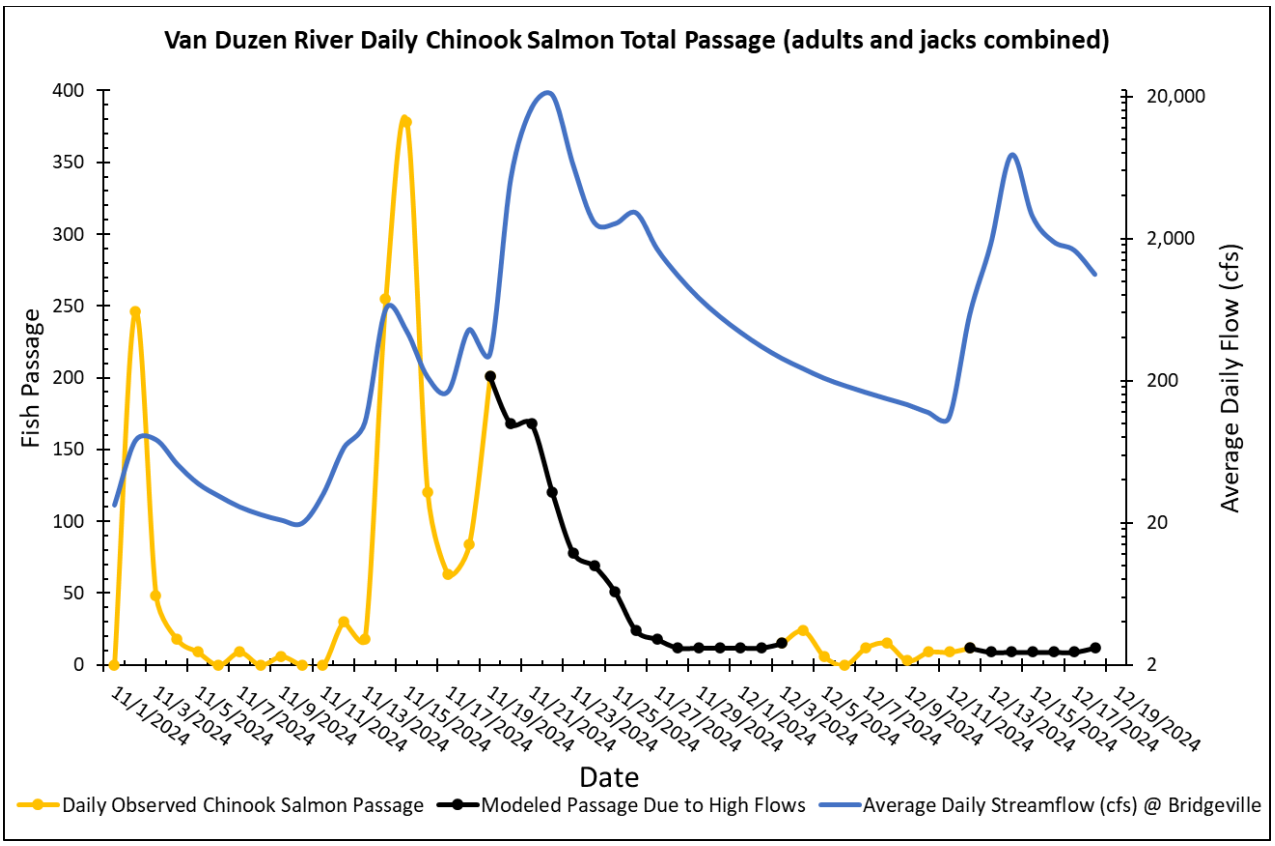

Figure 7. Streamflow (cfs) measured from the USGS gauging station at Bridgeville and the daily expanded Chinook Salmon (adults and jacks) movements from November 1 – December 18, 2024 at the Van Duzen River sonar site, Humboldt County, CA.

Chinook Salmon Abundance Estimates: Main Stem Eel and Van Duzen Rivers

We estimate the abundance of Chinook Salmon returning to the Main Stem Eel River above the confluence of the South Fork Eel River from October 15, 2024 through December 20, 2024, equaled 9,594 fish (95% CI 8,240 – 10,948; with a coefficient of variation (CV) of 8.2%). Project staff measured the fork length of 2,800 Chinook Salmon from camera imagery and 2,040 or 72.8% were adult Chinook Salmon and 760 or 27.2% were jack Chinook Salmon. This ratio is similar to the observed ratio of 81% adult and 19% jack Chinook Salmon recorded at the VAFS in 2024/25 using the same size criteria (A. Andrews, PG&E, personal communication 2025).

We estimate the abundance of salmon (Chinook and Coho Salmon) returning to the Van Duzen River from November 1, 2024 through December 18, 2024 equaled 2,397 fish (95% CI 2,183 – 2,611; with a coefficient of variation (CV) of 7.9%). The high stream flows present in mid-December provided suitable conditions to encourage Coho Salmon to swim up the Van Duzen River to access their spawning grounds; therefore, the later part of the Chinook Salmon run

experienced some overlap with the beginning of the Coho Salmon run. Camera operations captured the initiation of the Coho Salmon run, and they composed a portion of the 2,397 fish estimate. Based on sonar camera operations, species run-timing, and adult spawner ground surveys conducted within Van Duzen River tributaries, we estimate the Van Duzen River Chinook Salmon run to be 2,000 fish.

Coho Salmon Abundance Estimates: Van Duzen River

In previous decades, Coho Salmon occupancy in the Van Duzen River has been limited; they were considered nearly extirpated from the basin in the early 2000s with multiple years of no observations. A few spawning adult sightings in the Lawrence Creek watershed (Fish Creek) resumed in the winter of 2010, and overall sightings increased slightly in the following years. Current Coho Salmon distribution continues to be mostly limited to the Yager Creek watershed and specifically the Lawrence Creek drainage (Figure 1); therefore, adult spawning ground surveys are an effective means of understanding the run size of returning Coho Salmon in the Van Duzen River watershed. The 2022/23 and 2023/24 adult spawning ground surveys indicated Coho Salmon occupied approximately 3.5 miles of stream habitat with low spawning densities, suggesting approximately 6.5 redds per stream mile (CDFW 2023 & 2024 and E. Stockwell personal communication 2023 & 2024). However, the 2024/25 Coho Salmon run in the Yager Creek watershed (as well as in the SF Eel River) experienced a significant increase in occupied habitat, number of redds, and live fish observed (E. Stockwell and CDFW). The spawner survey efforts in Lawrence Creek watershed provided run-timing information and numbers of returning adult Coho Salmon. Using this data, we estimate the 2024-25 Van Duzen River Coho Salmon run to be approximately 350 - 500 fish.

Fish Measurements

On the Main Stem Eel River, fish lengths estimated using ARISFish or ARISScope software measuring tools ranged from 39 cm to 110 cm. The average adult Chinook Salmon length was 78.12 cm and the average jack Chinook Salmon length was 51.91 cm. The highest number of fish measured were in the 68-79 cm category (169 individuals) and the second highest number of fish measured in the 80-85 cm category (166 individuals) (Figure 8).

On the Van Duzen River, fish lengths estimated using ARISFish or ARISScope software measuring tools ranged from 39 cm to 113 cm. The average adult Chinook Salmon length was 77.24 cm and the average jack Chinook Salmon length was 50.83 cm. The highest number of fish measured were in the 68-73 cm category (58 individuals) and the second highest number of fish measured in the 62-67 cm category (53 individuals) (Figure 9).

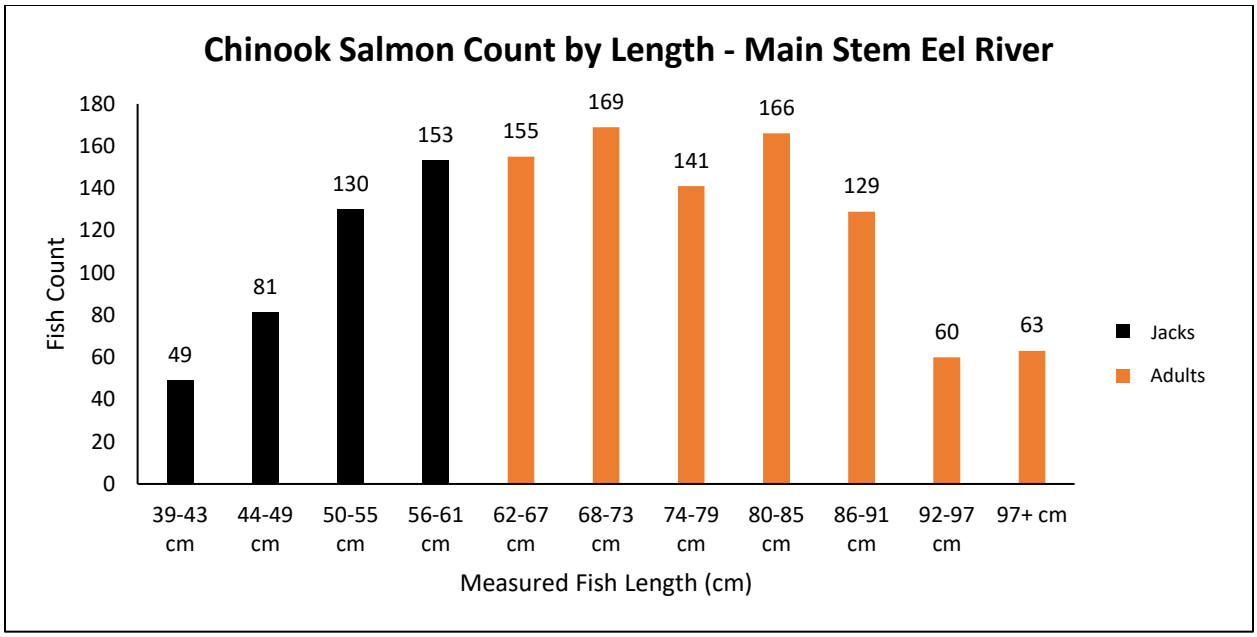

Figure 8. Estimated Chinook Salmon lengths (cm) using Sound Metrics ARIScope and ARISFish proprietary on the Main Stem Eel River, Humboldt County, CA. Chinook Salmon between 39 cm and 61 cm are identified as jacks and Chinook Salmon ≥ 62 cm are identified as adults. Total number (N) of fish measured = 1,296 from October 15 through December 18, 2024

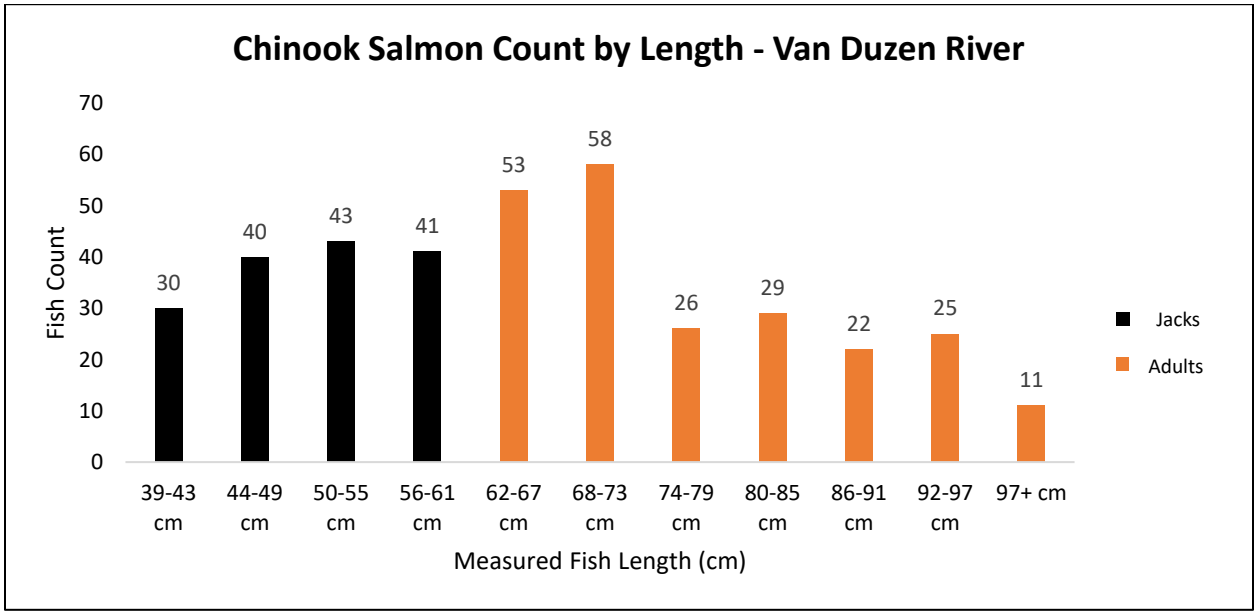

Figure 9. Estimated fish lengths (cm) using Sound Metrics ARIScope and ARISFish proprietary for data files recorded on the Van Duzen River, Humboldt County, CA. Chinook Salmon between 39 cm and 61 cm are identified as jacks and ≥ 62 cm are identified as adults. Total number (N) of fish measured = 378 from November 1 through December 18, 2024.

With the addition of the ARIS 1200 model cameras the past two years, project staff has been able to collect more accurate size data on migrating Chinook Salmon due to the improved image quality in a variety of flows when compared to the DIDSON model cameras. This current year saw

an increase in the average adult Chinook Salmon length in both the Main Stem Eel and Van Duzen River. Fish, on average, were five and half cm larger (Figure 10). While it is currently a small sample size, moving forward it could be interesting to track future size trends.

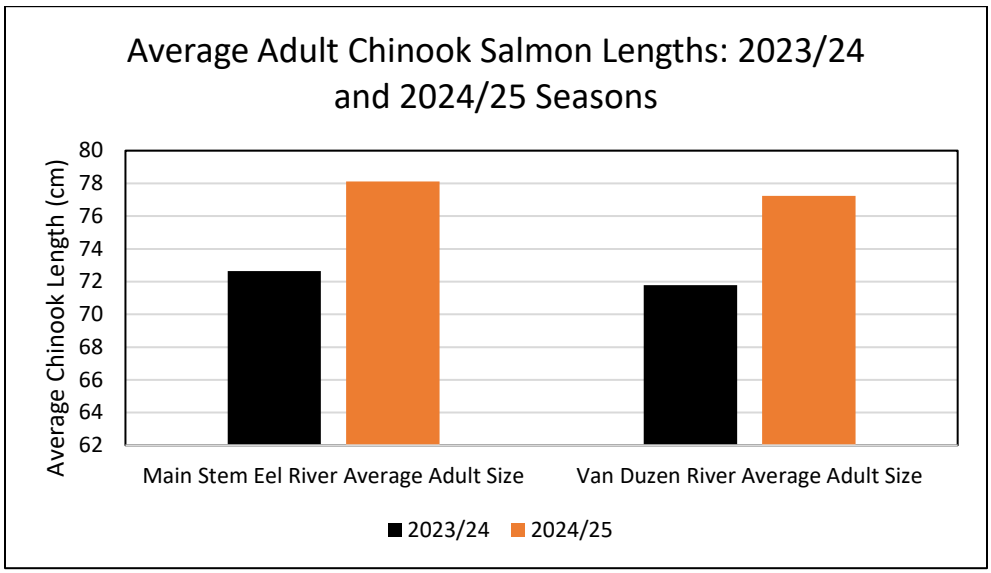

Figure 10. Average adult Chinook Salmon lengths (cm) during 2023/24 and 2024/25 seasons using Sound Metrics ARIScope and ARISFish proprietary for data files recorded on the Main Stem Eel River & Van Duzen River, Humboldt County, CA.

Main Stem Eel River Winter Steelhead Daily Passage and Counts

Daily movement of fish during the estimated winter-run steelhead period (December 19 to March 31, 2025) ranged from 18 to 549 and averaged 103 fish per day during camera operations. There were two particularly large pulses of steelhead passage counts: 1) early to mid-January (peaking January 11, N = 243 fish) and 2) the first week of March (peaking March 1, N = 549 fish) (Figure 11). Both pulses were observed on the descending limb of the hydrograph. The March 1 total of 549 fish was the highest single day count of steelhead during the seven years of the project. High streamflow conditions prevented sonar camera operation and data collection for lengthy periods of the winter-run steelhead: December 19 through January 10, January 31 through February 27, and March 12 through the end of the run, which typically ceases in early April.

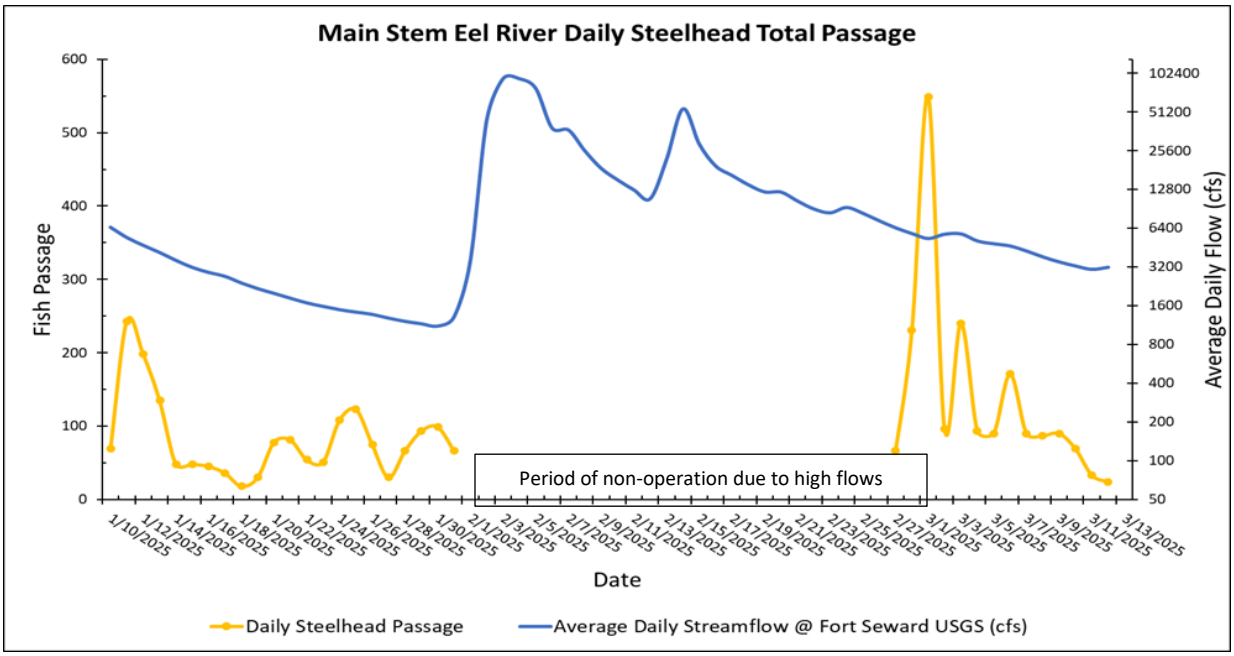

Figure 11. Main Stem Eel River sonar site daily expanded steelhead passage, Jan. 10, 2025 to March 13,2025, and streamflow (cfs) measured from the USGS gauging station at Fort Seward, Humboldt County.

The project began tracking winter-run steelhead passage on the Mainstem Eel River on January 10, 2025. Prior to this date, prolonged high stream flows prevented camera operations from December 12 through January 9, thus preventing data collection during the beginning portion of the steelhead run. As noted previously, camera operations during the winter steelhead run consisted of two periods: January 10 to January 31; and February 27 to March 12. The 35 days of operation represent approximately 1/3 of the typical winter-run migration period. The expanded estimate of net upstream movement of steelhead during these 35 days of camera operations is 3,723 fish. This expanded estimate was derived from net movement of all steelhead observed for the 20-minute subsample expanded to the hour during those 35 days of operations. While somewhat limited in scope, 3,723 fish represent high steelhead passage totals, and this year would have likely surpassed all previous project year's steelhead counts if camera operations/data collection could have occurred more throughout the steelhead season.

Downstream Steelhead Migration

Steelhead are considered iteroparous, meaning they can undertake multiple rounds of spawning migration and reproduction throughout their lives. Behavior from downstream-migrating steelhead (or kelts) can impact population estimates when not properly accounted for (Pipal et al. 2010). Because of the limited camera operations during typical downstream steelhead movement, project staff observed a minimal number of presumed kelts this year, and we believe kelts had an insignificant impact on the overall steelhead count.

Discussion

CDFW identified DIDSON technology as a non-intrusive survey method for meeting the adult count station requirements of a life-cycle monitoring station as outlined in Fish Bulletin 180 (Adams et al. 2011). The Main Stem and Van Duzen River Sonar Monitoring Project aim to produce relevant and comprehensive data for management of the Eel River Chinook Salmon population, which is a significant component of the overall CC Chinook Salmon ESU. Since the project's inception in the fall of 2018, it has successfully allowed for a more accurate estimate of the CC Chinook Salmon run in the Main Stem Eel River (upstream of the SF Eel River) and since 2022 in the Van Duzen River. The sonar capably detected fish movement 24 hours per day in variable stream flows; thereby providing counts used to estimate the CC Chinook Salmon run abundance.

2024-25 Chinook Salmon Abundance Estimates and Previous Project Years Summation

The 2024-25 project estimated 9,594 (CV = 8.2%) Chinook Salmon migrated past the sonar camera on the Main Stem Eel River and approximately 2,000 Chinook Salmon on the Van Duzen River. The first four years of the project witnessed slightly increasing yearly counts, each abundance estimate increasing by about 5% each year. The 2022-23 and 2023-24 project years showed dramatic increases in abundance, with the 2022-23 project year nearly doubling the previous year's estimate, followed closely by 2023-24 season (Figure 12). The 2024-25 season far surpassed any previous run and the almost linear increase in yearly escapement estimates during the project's seven years of operation are indicating improving population numbers. While recent years have shown promising trends, it is important to note that seven years is a relatively short time span for the analysis of a Chinook Salmon population, and abundance estimates are still falling short of the NMFS spawner abundance target for delisting of 10,600 adult Chinook Salmon for the Main Stem Eel River (NMFS 2016).

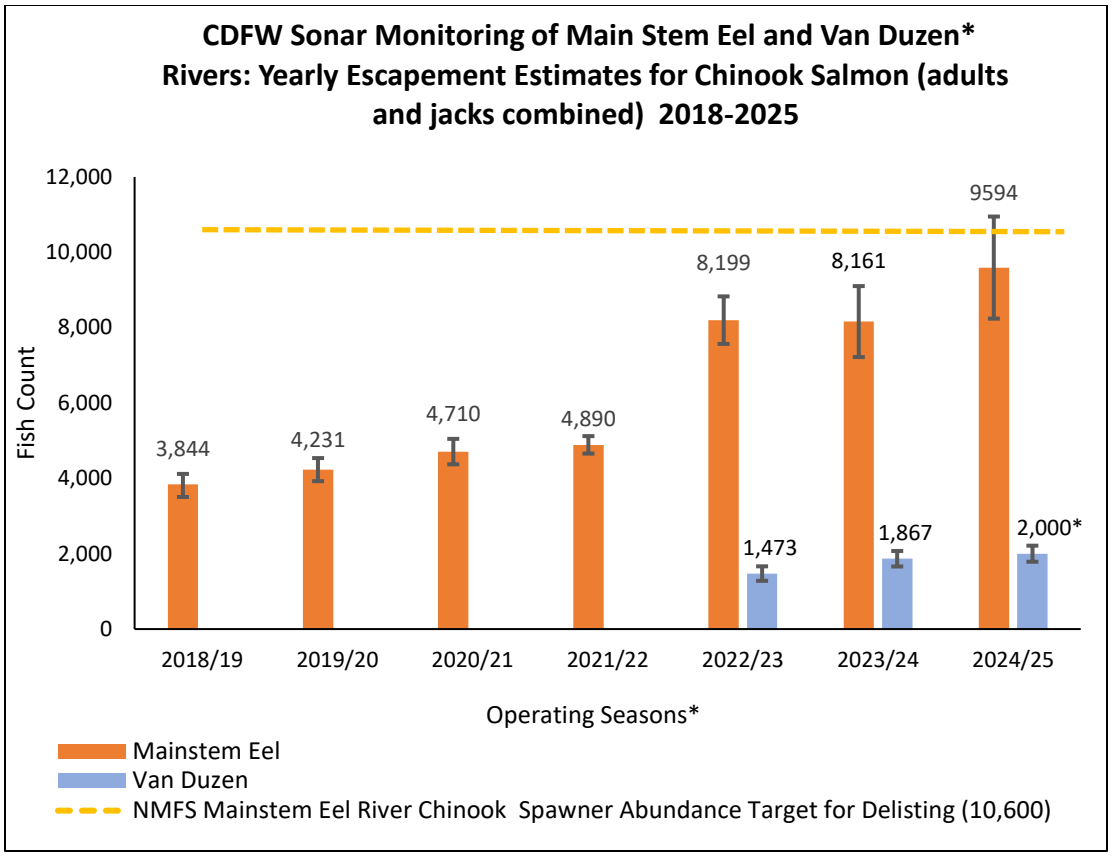

Figure 12. Lower Main Stem Eel River abundance estimates for Chinook Salmon for seven seasons of sonar operations: 2018-19 through 2024-2025 (spring). * Van Duzen River sonar operations began in the fall of 2022. NMFS Main Stem Eel River Spawner Abundance Target for Delisting derived from the NMFS Coastal Multispecies Recovery Plan (NOAA 2016)

Sonar Station Abundance Estimates vs VAFS Counts

As noted previously, the other long-standing data source for the Main Stem Eel River is the adult/jack fish counts at the VAFS. CDFW records of ladder counts of combined adult and jack Chinook Salmon from 1986/87 to present range from 0 (1990/91) to 3,471 (2012/13), with a yearly average of 587 Chinook Salmon. The counts at VAFS are subject to high interannual variation, most likely due to stream flow conditions where lower stream flows hinder Chinook Salmon migration to the upper portions of the river and disproportionally affecting VAFS counts. Since the sonar project's inception during the fall of 2018, VAFS counts have been a small fraction, usually less than 5% than those estimated passing at the sonar camera station (Figure 13). For example, the 2022/23 and 2023/24 project years had an average yearly run estimate of 8,180 Chinook Salmon (jacks and adults) while average yearly tallies at VAFS were 266 (about 3% of the sonar abundance estimates). This year, VAFS counts were up to 9.3% of the sonar abundance estimate. The higher percentage can likely be attributed to the high stream flows experienced during the peak of the run in November, which allowed these fish to move freely throughout the watershed, including accessing the upper watershed above the VAFS.

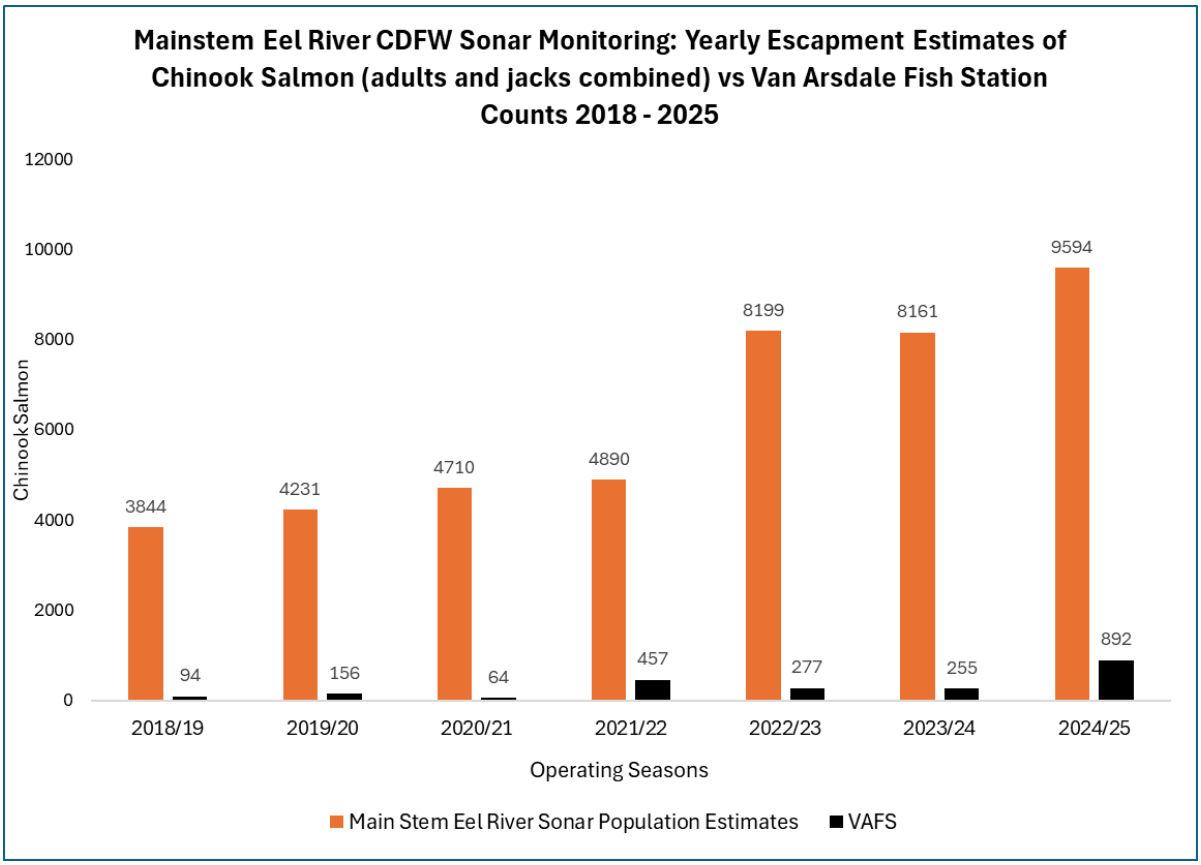

Figure 13. CDFW lower Main Stem Eel River yearly sonar escapement estimates of Chinook Salmon vs Van Arsdale Fish Station (VAFS) counts during the project years 2018-2025.

This project year's consistent, early fall rainfall initiated what is considered a seasonally appropriate upstream migration period for Chinook Salmon (Halligan 1997,1998; and Moyle 2017) from the lower holding areas near the estuary to potential spawning grounds in various locations in the watershed. Conversely, the lack of or delay of seasonal rainfall experienced during the first couple years of the project (2018, 2019, and 2020) hindered the timing of their migration (Table 6), and in some instances, Chinook Salmon spawned in the lower river, downstream of the Main Stem sonar site and SF Eel River. Timely rainfall patterns and amounts can lead to broader geographic and temporal spawning distributions. This, in turn, may improve overall odds of success of egg to fry production and lead to more life history diversity.

Table 6. Julian week fish passage counts of Chinook Salmon at the Main Stem Eel River sonar site during all project years. Totals do not include missing data during non-operation.

Julian Week	2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024	2024-2025
10/1-10/7						24	
10/8-10/14						0	
10/15-10/21				63		240	33
10/22-10/28				2227		195	66
10/29-11/4				599	1866	690	4686
11/5-11/11				172	3762	5064	585
11/12-11/18			915	165	186	750	2841
11/19-11/25	1509	11	1443	387	264	573	1053
11/26-12/2	585	1593	87	312	723	141	-6
12/3-12/9	603	1076	6	423	660	285	45
12/10-12/16	273	588	312	329	276	27	273
12/17-12/23*	378	660	1197	214	114	117	18
12/24-12/31*	300	291	750	63	174	411	0
Total	3648	4219	4710	4954	8025	8517	9594

**Final two weeks in December includes steelhead counts in addition to Chinook Salmon counts*

Eel River Basin Chinook Salmon Population Estimates

Qualitative estimates of the Eel River Basin Chinook Salmon population were unavailable prior to the establishment of sonar cameras stations in the Main Stem Eel River (CDFW), Van Duzen River (CDFW) and SF Eel River (CalTrout), the MF Eel and upper Main Stem Eel River (Round Valley Indian Tribes, RVIT). Monitoring these major sub-basins supports an overall Eel River population estimate. The combined results of Main Stem Eel River, Van Duzen River and SF Eel River sonar monitoring (Table 7) indicate the 2024-25 fall-run Chinook Salmon abundance estimate of the Eel River Basin is approximately 17,000 – 19,500 adult and jack Chinook Salmon (Davis and Kajtaniak 2026 and Metheny 2026). It is an increase from the 2023-24 estimate of approximately 15,500 - 17,500 adults and jacks combined (Kajtaniak, Nordstrom, and Davis 2025 and Metheny and Shaffer 2024). These estimates do not include Chinook Salmon that migrated and spawned in the lower Eel River, Larabee Creek, and SF Eel River and tributaries (such as Bull Creek) downstream of its Myers Flat sonar station location. However, Chinook Salmon spawning in these areas are likely a relatively minor component of the overall Eel River Basin population.

Table 7 displays a summary of monitoring data for each of the sonar camera stations operating in the major branches of the Eel River. California Trout (SF Eel) and Round Valley Indian Tribes (MF Eel and Upper Main Stem Eel) produce annual reports detailing their operations and a more thorough discussion of their results.

Table 7. All available years of sonar stations Eel River Chinook Salmon population estimates (adult and jacks combined) and expanded steelhead counts. South Fork Eel River 2018-19 and 2019-20 species apportionment has changed since previous reports to reflect improved species assignment model (M. Metheny pers. comm. 2026). Recovery Target(s) are from NOAA-NMFS species recovery plans. The "*" indicates that this Van Duzen River population threshold includes the Lower Eel River and Larabee Creek. The "**" notes that prolonged high flow conditions in the MF Eel hindered efforts to enumerate both salmon and steelhead numbers (RVIT 2024).

Main Stem Eel River	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**NOAA Recovery Target**
Chinook Salmon	3,648	4,219	4,710	4,953	8,199	8,161	9,594	10,600
Steelhead	1,395	4,032	2,632	2,933	396	1,476	3,729	22,100
% of steelhead season monitored	40%	82%	85%	82%	32%	13%	32.9%	
Van Duzen River	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Recover Target**
Chinook Salmon	No sonar operations				1,473	1,867	2,000	2,900*
Coho Salmon							350-500	7,900
South Fork Eel River	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Recovery Target**
Chinook Salmon	2,284	1,223	No sonar operations		3,929	6,065	6,438	7,300
Coho Salmon	810	276			101	1,243	877	9,600
Steelhead	6,100	3,125			1,064	4,041	1,640	19,000
Middle Fork Eel River	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24****	**2024-25**	**Recovery Target**
Chinook Salmon	No sonar operations			552	447	252	859	NA
Steelhead				1,767	339	N/A	324	9,400
Upper Main Stem Eel River	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**2024-25**	**Recovery Target**
Chinook Salmon	No sonar operations						949	NA
Steelhead							117	NA
Eel River Basin					**2022 -23**	**2023 - 24**	**2024-25**	
Chinook Salmon	Basin estimates not available prior years				13,000 - 15,000	15,500 - 17,500	17,500 - 19,500	

Winter-Run Steelhead Counts

This Sonar Monitoring Project also aims to record and present data for management of Eel River steelhead, a significant contributor to the NC Steelhead DPS. Typically, most of the winter-run

steelhead run on the Main Stem Eel River occurs during the winter season from late December to late March. As the winter season progresses, the daily streamflow increases significantly and is generally maintained throughout the season. Overlapping with the winter-run steelhead run, these higher flow conditions hinder continuous deployment of the camera and create gaps in data collection (Figure 11 and Table 8). High stream flows were present through most of the winter 2024/25 and camera operations were limited to approximately 1/3 or the winter steelhead run. Nonetheless, data captured indicated a potentially strong run of steelhead with an expanded count of 3,729 steelhead during 35 days of operations. The entire run is likely significantly higher than this number of fish and shows a notable rebound from historically low counts in 2022/23.

Four of the seven project years have experienced this extreme interannual variability in precipitation and high flows throughout much of the winter steelhead season limiting camera operations and data collection. Alternatively, the winters of 2019/20, 2021/22 and 2021/22 were drought years, and the associated lower than normal stream flows provided the opportunity for longer periods of camera operations/data collection. Notably, the 2021/2022 winter received very little precipitation from February to mid-April, and the dry stretch and abnormally low flows seemed to have delayed some fish movement. Camera operations ceased prior to a late rain event that anecdotally noted upstream migration of steelhead that had been holding in the lower river. These extensive annual flow variations represent the importance of continuous, multiple years of sonar data collection to provide potential future trend analysis of steelhead runs in the Eel River basin, including aiding the ability to help correct fish passage estimates during periods/years when staff cannot operate the camera due to high stream flows.

Table 8. CDFW Main Stem Eel River sonar site winter-run steelhead counts (expanded) vs percent (%) hours of active camera operations during the assumed winter-run migration period. Expanded counts only represent when camera was in operation (non-operations generally due to excessive stream flow).

CDFW Sonar Monitoring Project Years	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25
Steelhead Counts (expanded)	1,395	4,032	2,632	2,933	396	1,476	3,729
% time of active camera operations	40%	82.2%	85%	82.2%	31.9%	12.5%	32.9%

Summer-Run Steelhead

The Eel River is currently the southernmost river with summer-run steelhead in North America (Jones, 1992). Summer run steelhead enter the river (freshwater) sexually immature and migrate upstream from late March to early June depending on flow conditions. Currently, there are two locations in the Eel Basin where summer-run individuals are routinely observed: the Van Duzen and Middle Fork (MF) Eel rivers with the MF Eel being the far more robust of the two (Kannry et

al. 2020). CDFW has monitored adult summer steelhead abundance in the MF Eel through annual direct observation census of all summer holding habitat since 1966. The result of this census is an index of adult abundance with a mean size of 770 individuals per year (Harris, 2019).

This project previously investigated the possibility of collecting summer steelhead run data during the spring of 2020 by operating a DIDSON camera continuously till the end of May (Kajtaniak & Roberts 2021), and again with an ARIS camera operating throughout April into early May in 2024. During data file review of April and early May files from both project years, staff observed some fish that were presumed to be summer steelhead due to their large size (greater than 55 cm) and swimming motion. However, some portion of adult Sacramento Pikeminnow also begin their migration from the lower river to upstream reaches to feed and/or spawn during this time period (Harvey and Nakamoto 1999, Georgakakos 2020). Large, adult Sacramento Pikeminnow can be of similar size to steelhead and subsequently are very difficult to impossible to distinguish from steelhead during data file review. We experienced similar results during both project years: high fish passage days, and the inability to accurately identify the fish to species. Therefore, project staff believe it is difficult to accurately assign fish species < 55 cm and subsequently produce summer steelhead data for population estimates via the sonar camera.

Green Sturgeon Observations

Green Sturgeon (*Acipenser medirostris*) are found in coastal waters and rivers of North America where they feed in marine and estuarine environments and spawn in a few select rivers (Adams et al. 2002; Moyle 2002). Being one of the larger rivers in the state, it was believed the Eel River historically maintained an important spawning run of Green Sturgeon, although inferences about population size are impossible because of lack of historical data (Adams et al. 2002). After the 1964 flood Moyle et al. (1992) considered the spawning run of Green Sturgeon on the Eel to be extirpated. However, outmigrant trapping studies documented juvenile green sturgeon nearly 100 km upstream on the Main Stem Eel River twelve years after the flood (Puckett 1976), and periodic observations of Green Sturgeon by fisherman and boaters indicated a run persisted on the Eel River. Stillwater Sciences and the Wiyot Tribe (2017) conducted a three-year study between 2014-2016 and concluded, “while the size of the spawning run in the Eel River basin and the degree of spawning success remain unknown, the Eel River can be added to the official list of spawning rivers used by green sturgeon, along with the Klamath, Rogue, and Sacramento rivers.” In recent years, CDFW and Stockwell and Sopjes (Pers. Comm. 2020, 2021, 2022, 2023, & 2024) have reported yearly, late summer observations of adult Green Sturgeon in the lower Eel River (below the confluence with Van Duzen River), including most recently seven to nine Green Sturgeon in September of 2023 and three in October of 2024.

The 2024-2025 project year observed eight potential Green Sturgeon observations at the Main Stem Eel River sonar site while performing review of March sonar files (Table 9). The project identifies Green Sturgeon to be any fish that has a total length greater than 100 cm measured using the measuring tool on Sound Metrics ARIScope and ARISFish proprietary software while

performing data review of the steelhead run files. Of these seven to eight observations, one was of a fish just above the project's minimum size determination for Green Sturgeon and several files had a similar-sized looking fish on the same day; therefore, we believe a minimum of five and a maximum of eight individual green sturgeon were observed (Table 9). These fish were seen moving past the camera during flows of 3,000-5,000 cfs.

Table 9. Green Sturgeon Observations (N = 8) from the Main Stem Eel River sonar site from March 5 through March 10, Humboldt County, CA. Multiple observations were too close to the camera to get an accurate total length, but all were estimated to be over 110 cm.

Date Observed	Flow @ Ft Seward (cfs)	Hour Observed	Length of Fish (cm)	Fish Movement Direction
3/5/2025	4760	1100	101	Upstream
3/5/2025	4760	2300	122	Upstream
3/7/2025	4460	1420	133	Upstream
3/8/2025	4040	1100	110+	Upstream
3/8/2025	4040	2000	110+	Upstream
3/8/2025	4040	2100	110+	Upstream
3/10/2025	3370	1800	129	Downstream
3/10/2025	3370	2000	110+	Upstream

The five to eight individual sturgeon identified this year via the sonar station were the second highest number during the project's seven years of operation. However, it is important to note that camera operations are somewhat limited during the Green Sturgeon spawning migration period, approximately February through June, and the project is only reviewing a sub-sample of all data files. Additional sturgeon movement/passage are likely occurring; therefore, project data is not being reported as population estimates but camera operations are still a valuable tool in tracking this rare species. Table 10 displays all project year's observations of Green Sturgeon at the Main Stem Eel River sonar site.

Table 10. CDFW Main Stem Eel River sonar site Green Sturgeon observations by project year.

Project Year	Total Sturgeon Observed	Date of observation; Number of sturgeon denoted in (); and direction of movement (upstream↑) or (downstream↓)
2024-2025	8	3/5/25 (2) ↑; 3/7/25(1) ↑; 3/8/25 (3) ↑; 3/10/25 (1) ↑ (1) ↓
2023-2024	9	4/10/24 (1) ↑; 4/15/24 (1) ↑; 4/17/24 (1) ↑; 4/28/24 (1) ↑; 4/29/24 (1) ↓ (1) ↑; 4/30/24 (1) ↑ (1) ↓; 5/1/24 (1) ↑
2021-22	7	2/2/22 (1) ↓; 3/6/22 (1) ↑; 3/11/22 (1) ↑; 3/12/22 (2) milling; 3/13 - 3/23 (2 fish observed milling on an almost nightly basis)
2019-20	1	3/16/20 (1) ↑

Acknowledgements

2024/25 project funding was provided by the U.S. Fish and Wildlife's Sport Fish Restoration Program, CDFW Pacific Coastal Salmon Recovery Fund with additional funding from PG&E for the crew lead (PSMFC fisheries biologist) position, purchase of an ARIS camera, and project vehicle. NOAA Fisheries West Coast Region supplied the funding for an ARIS camera purchase for the Van Duzen River monitoring site. We are very grateful for our project partners: Pacific States Marine Fisheries Commission, who hired a fishery biologist to run field operations and lead data review; PG&E and NOAA Fisheries West Coast Region for project funding and support; Trout Unlimited for previous equipment purchases and technical support; private landowners Mat Nyberg, David Noble, and Humboldt Redwood Company (Keith Lackey and Mike Miles) for un-limited access to the sonar site locations and additional security measures. PSMFC project members, Dominick Davis, fisheries biologist, Louis Salas, fish tech, and Stan Allen, Project Manager; NOAA Fisheries West Coast Region, Joshua Fuller; PG&E Fisheries Biologist, Andrew Anderson; TU/California Trout project member, Charlie Schneider. An enormous thanks to CDFW field staff for daily operations and data review: Quinn Dudley and Elise Chester; CDFW Allan Renger, Chris Loomis and Seth Ricker for report editing and project support. AmeriCorps Watershed Steward Project Corpmembers: Stella Baumstone and Liam Hay. Eric Stockwell and David Sopjes for the timely updates of fish counts in the lower river, sharing their pertinent spawner survey information, and amazing photos. California Conservation Corps, Brian Starks, for lending their portable generator and additional equipment. Last, but certainly not least, collaborating with the amazing folks in the Eel River Watershed Sonar Monitoring Network: Matt Metheny, California Trout; Wyatt Smith and Matt Horne RVIT; and Erin Suenaga and Scott McBain, Applied River Sciences.

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Photo Appendix

Date and Description

1. 11.10.2022. Aerial view of Main Stem Eel River Sonar Site, looking downstream. Photo Credit, David Sopjes
2. 11.10.2022. Aerial view of Main Stem Eel River sonar site, looking upstream. Photo Credit, David Sopjes
3. 10.31.2024. First attempt at speciation via tangle netting at the Main Stem Eel River site with the assistance of CDFW colleagues from the Arcata office (89.2 cfs at USGS Fort Seward gaging station).
4. 11.15.2024. CDFW environmental scientist David Kajtaniak with tangle netted Chinook Salmon at Main Stem Eel River sonar site. Measured and released (646 cfs at USGS Fort Seward gaging station).
5. 11.15.2024 Main Stem Eel River with deployed tangle net and recently captured Sacramento Pikeminnow.
6. 11.15.2024. A family of three otters observed porpoising in front to the Van Duzen River camera (380 cfs at USGS Bridgeville gaging station)
7. 11.15.2024. Screenshot of Van Duzen River ARIS footage displaying family of otters pictured in previous photo (photo 6).
8. 11.17.2024. Original Van Duzen River sonar site
9. 11.21.2024. The aftermath of a massive storm event that destroyed road access to the Van Duzen River ARIS site. (3820 cfs USGS Bridgeville gage).
10. 12.7.2024. The new Van Duzen River ARIS site.
11. 12.12.2024. Environmental scientists David Kajtaniak and Braden Herman with an 80cm steelhead captured near the main stem Eel River site while tangle netting (2,790 cfs at Ft. Seward gage).
12. 12.12.2024. CDFW scientists using a jet boat in a drift setup during a tangle netting attempt near the Main Stem Eel River sonar site.
13. 12.19.2024. A male coho salmon attempts to jump an 8 foot waterfall on Booths Run, tributary to Lawrence Creek. Observed during an adult spawning ground survey with Eric Stockwell.
14. 01.24.2025. CDFW and PSMFC biologists begin a tangle netting attempt near the Main Stem Eel River sonar site (1450 cfs at USGS Fort Seward gaging station).
15. 2.05.2025. Inoperable conditions at the Main Stem Eel River sonar site. Arrow indicates normal trailer location (76,000 cfs at USGS Fort Seward gaging station).
16. Aerial view of Van Duzen River sonar site, red box is approximate location of sonar unit. Photo Credit, David Sopjes.
17. 02.27.2025. Main Stem Eel River ARIS site
18. Cargo trailer with mounted soalar panels.
19. Equipment setup inside cargo trailer.
20. 04/15/2024. Screenshot of Main Stem Eel River ARIS footage of a Green Sturgeon (in red box) - 160 cm total fish length.

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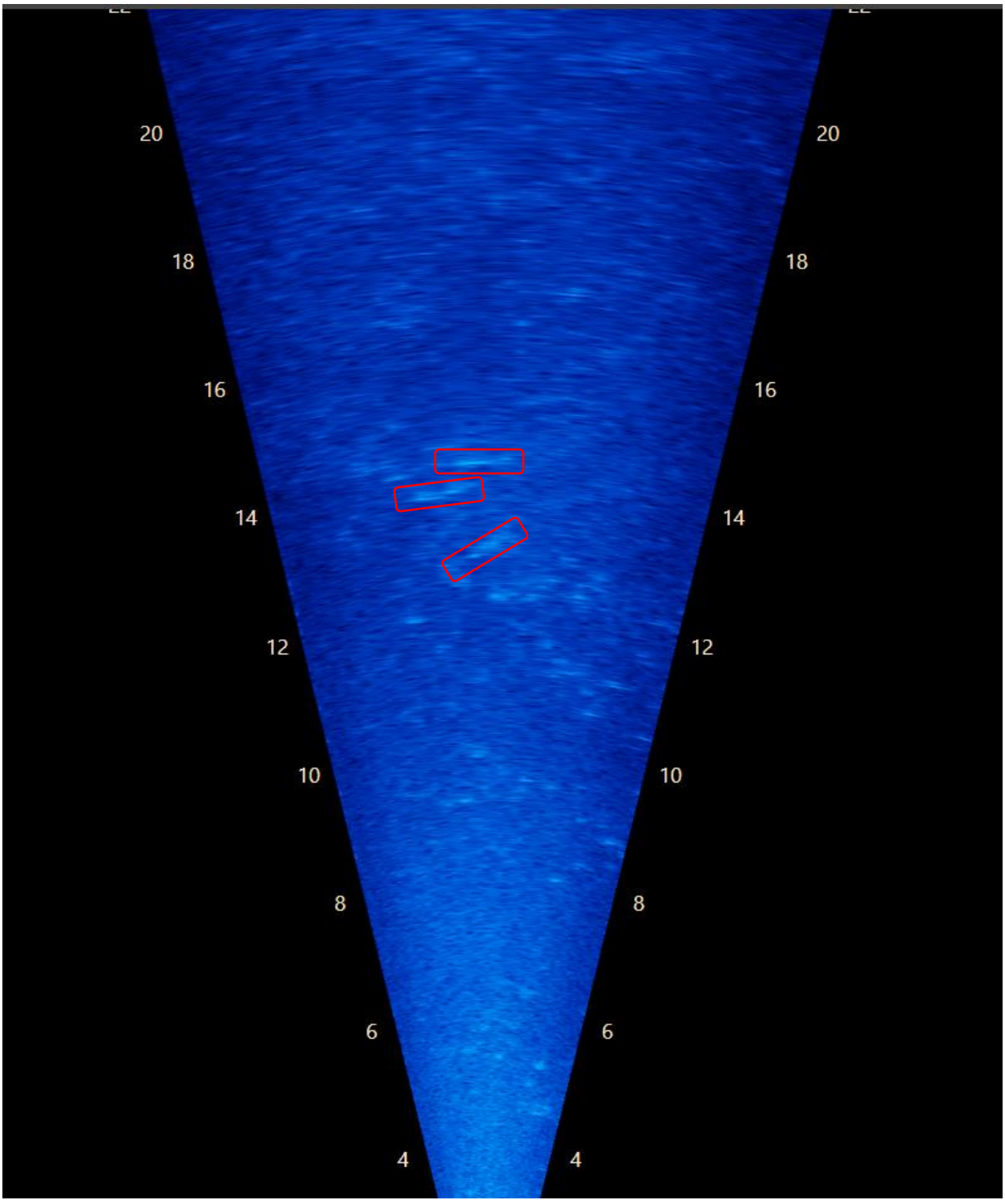

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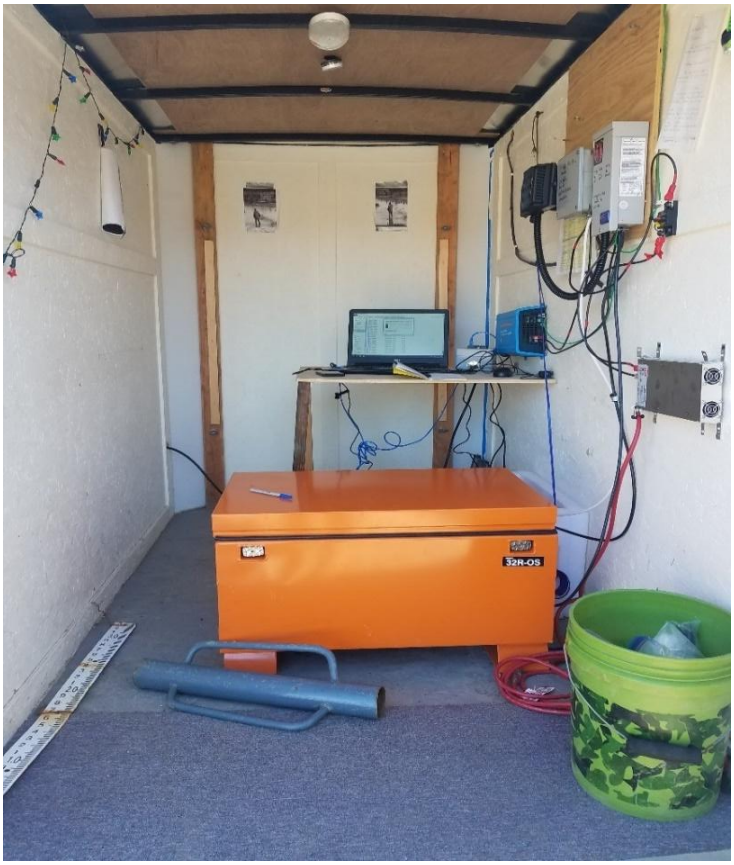
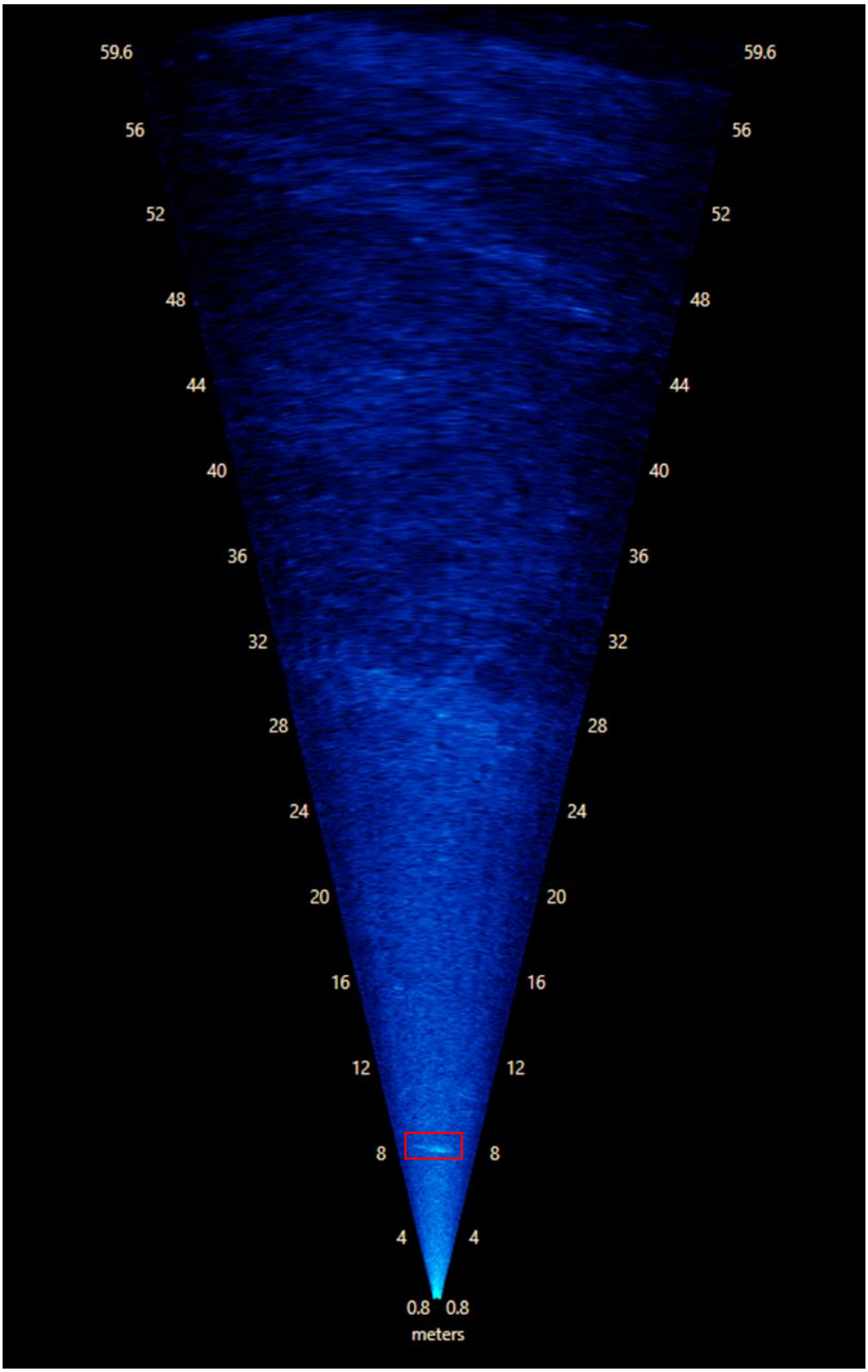


19.) Equipment setup inside cargo trailer.



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