

DATA SUMMARY REPORT

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Project: Evaluation of the Mud Mountain Dam Fish Passage Facility: 2023

Introduction

The goal of the Mud Mountain Dam (MMD) Fish Passage Facility (FPF) study was to provide biologists, engineers, resource managers, and regional decision-makers with quantitative measures of the post-construction effectiveness and efficiency of attraction, collection, and upstream passage of adult migrating salmonids at the FPF, which is located approximately five miles downstream of MMD. Radio telemetry (RT) technology was utilized to provide post-construction effectiveness and efficiency evaluation of the FPF (e.g., attraction and collection of upstream migrating salmonids for transport) for adult salmonids. Post-construction data included an evaluation of adult salmon behavior and distribution in the tailrace of the Barrier and FPF Fishway entrance, the collection efficiency of the Fishway itself, and survival rates from collection at the FPF to release at the fish outplant site upstream of MMD. Results from this study will inform managers if the FPF is operating as designed or if any potential changes are needed to improve fish collection and survival.

Researchers from the Pacific Northwest National Laboratory (PNNL) conducted this study. This data summary report covers tagging and release activities, and preliminary behavior, distribution, and collection efficiency estimates from June 22, 2023, through the end of the data collection period on October 16, 2023. The objective of this study was to perform a post-construction assessment at the new FPF. Migrating adult Chinook salmon (natural origin and acclimation pond origin) were tagged with RT and passive integrated transponder (PIT) tags for the purpose of evaluating:

1. Adult salmon behavior (i.e., milling, traversing, direct entrance into the fish ladder) and distribution in the tailrace of the FPF and Barrier.
2. The collection (attraction) efficiency of the Fishway (ladder).
3. Fish passage into and through the FPF and any upstream delays within the Fishway.
4. Survival rates from collection at the FPF to release at the fish outplant site upstream of MMD.
5. Detection rates of tagged fish after release upstream of MMD, including fallback rates from the outplant site to MMD.

For the purposes of this data summary, the objectives will be discussed at a high level, i.e., general trends in the data. Results presented in this data summary report are considered preliminary and subject to change in the final report after further analyses of the data are completed.

Methods

The RT system used for this study enabled the detection of tagged fish from immediately downstream of the FPF and Barrier (in the tailrace), within the FPF Fishway (ladder) (Figure 1), and at three detection sites at or upstream of MMD (Figure 2). The three upstream sites include one at the MMD dam face to monitor the MMD forebay, two at the adult fish release/outplant site, and one at Federation Forest State Park, approximately 17 river kilometers (rkm) upstream of the outplant site. These upstream detection sites at or above MMD were used to evaluate fallback to the MMD forebay, movement around the adult fish outplant site, and movement upstream of the adult fish outplant site (towards spawning grounds). Using RT detections, events for each individual fish were created. Events are sequences of detections that help evaluate whether detections are representative of a fish passing a detection site or a false positive picked up by antennas that generated a fish tag frequency by chance. For this study, events were characterized by 3 detections in 60 seconds on aerial antennas and 2 detections in 120 seconds on underwater antennas. Aerial antennas had a stricter requirement than underwater antennas because they are noisier (i.e., may generate more false positives).

The RT tag signal power was used to identify in which zone a fish was located at a given time if the fish was simultaneously detected on more than one RT site. A percentile threshold for signal power per receiver was built using all detections for all fish per receiver to get a robust look at receiver performance. These percentile thresholds were then applied to the events and any detection having a signal power under the threshold at a given receiver were removed. The threshold chosen for this data summary was 80 (moderate restriction), to minimize noise and the potential for false positives while not being so restrictive that true detections were excluded. Individual fish data was restricted to the release date and time, through the end of the study period.

Adult spring Chinook salmon (natural origin and acclimation pond origin) were run-of-river fish that were greater than 40 centimeters (cm) in length. Fish were captured in the FPF and were lightly anesthetized (i.e., ~30 seconds in anesthesia) using Aqui-S20E (active ingredient: clove oil) for ease of handling during tag insertion. Fish were double tagged with an RT tag (MCFT2-3A series; Lotek Wireless Inc., Newmarket, Ontario, Canada) and a PIT tag. The RT tag was gastric inserted, and the PIT tag was injected into the fish by the pelvic girdle. Prior to gastric insertion, each RT tag had a rubber band placed around it to help prevent regurgitation (Bridger and Booth 2003; Keefer et al. 2004; Thorsteinsson 2002). The tag was coated in glycerin for lubrication and ease of insertion. A rod was used to insert the tag down the pharynx of the fish and into the stomach, and the antenna was routed out through the mouth (Bridger and Booth 2003; McCleave et al. 1978). After tagging, fish were transported and released on the same day at a river access point on Stuck Road (~21.1 river kilometers [rkm] downstream of the FPF; Table 1).

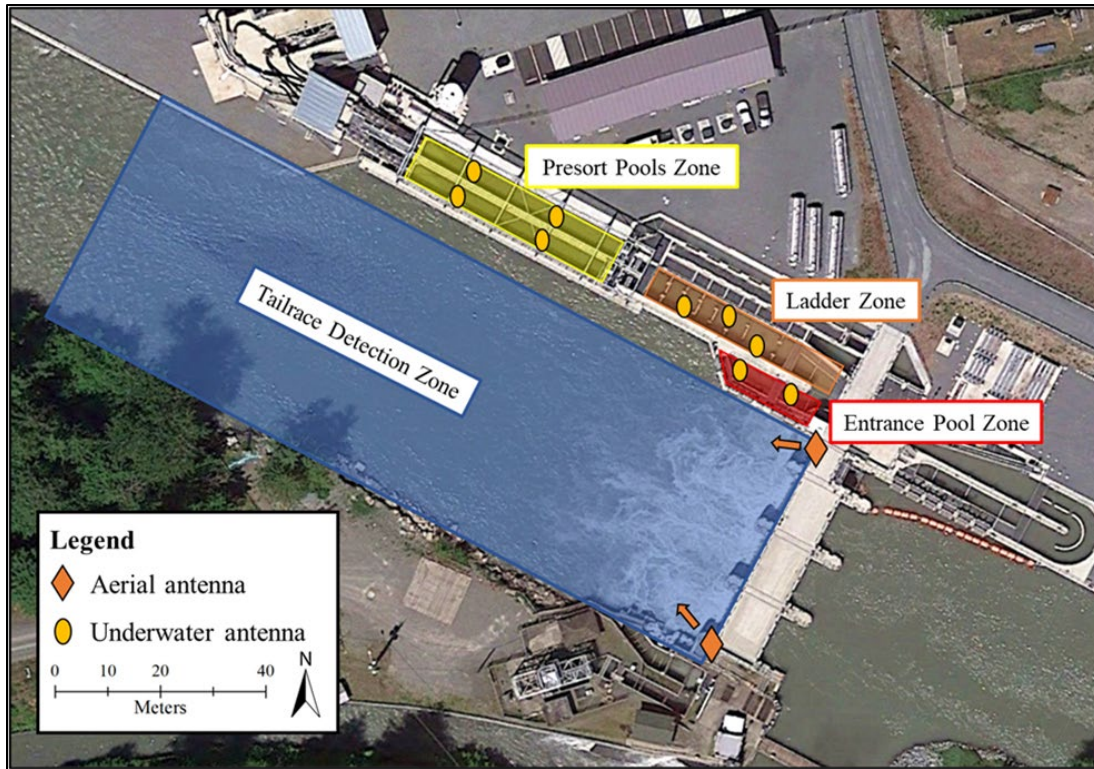


Figure 1. Locations and types (aerial and underwater) of radio telemetry antennas, as well as detection zones at the Mud Mountain Dam Fish Passage Facility and Fish Barrier study area.

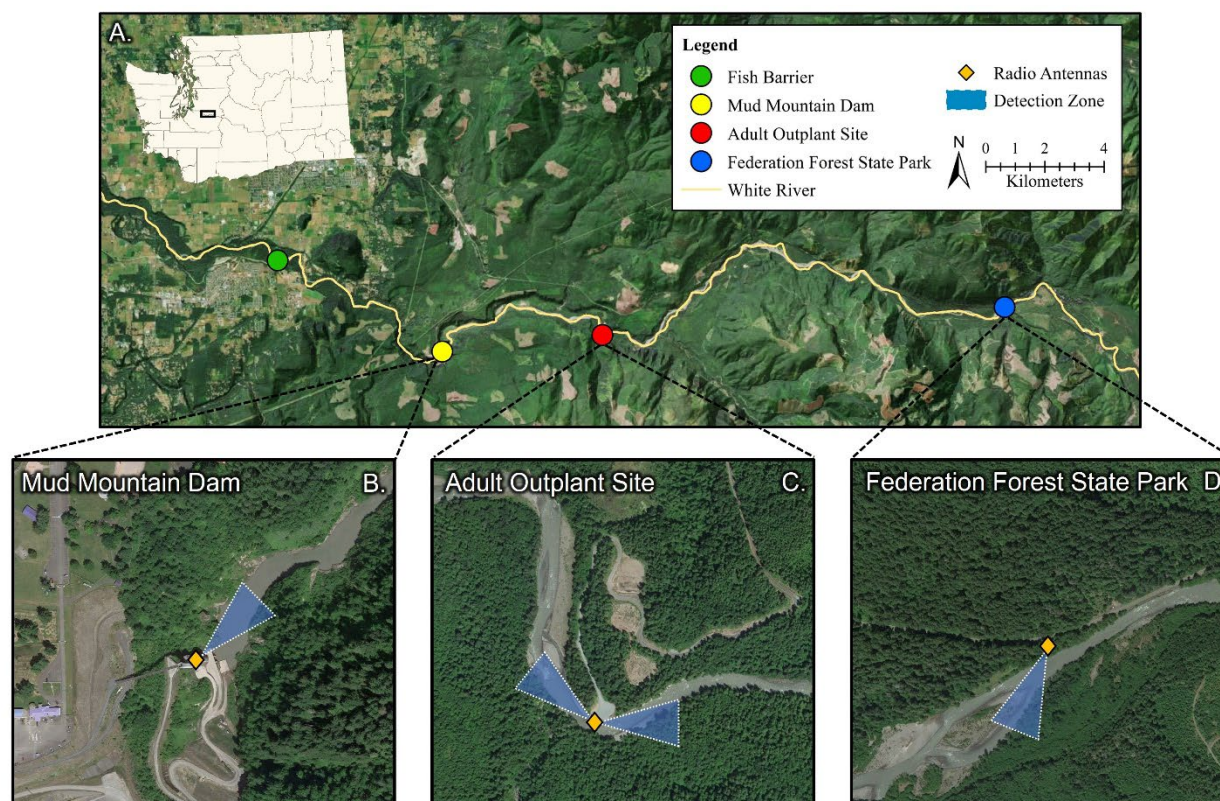


Figure 2. Detection Zones and Antenna Locations for the MMD Dam Face, Adult Fish Outplant, and Upstream Spawning Detection Sites. (A) is a study area overview of the upstream release locations; (B) shows the one antenna location at MMD dam face; (C) shows the two antenna locations at the outplant adult fish release site; and (D) shows the one antenna location at Federation Forest State Park (~17 rkm upstream of the adult fish release site). Orange diamonds indicate approximate placement of aerial antennas, and blue triangles represent detection zones.

Table 1. Sample sizes (n), sexes, and total lengths and weights of Chinook salmon released at the Stuck Rd. location.

| n | | | Total Length (cm) | | Weight (kg) ¹ | |
|-------|------|--------|-------------------|-------|--------------------------|---------|
| Total | Male | Female | Mean | Range | Mean | Range |
| 169 | 128 | 41 | 59.2 | 45-80 | 3.1 | 1.2–7.5 |

¹Weights were estimated using length conversions following methods described in Pahlke (1998) and length-weight conversions following methods described by Jasper and Evenson (2006).

Results

Fish tagging and releases occurred during June 22 through July 21, 2023, when 169 fish were tagged and released (Table 1). Five additional fish were tagged but were not included in the study, as four of them regurgitated their RT tags while in transit to the release location, and one was accidentally released upstream with non-study fish being transported above the dam. The four dropped RT tags were sanitized and reused throughout the remainder of the study. Manual fish sorting by the Tribes continued after our tagging and

release period, and 48 tagged fish were confirmed to be recaptured successfully at the FPF via visual observation (i.e., the RT tag antenna was seen) or by scanning the fish and detecting its PIT tag. A total of 9 fish were reported captured in gill nets near the Stuck Road release site and therefore were excluded from analyses. Using an 80-percentile threshold of RT signal power, the RT system enabled the detection of 77.5% (124 of 160 fish) of the tagged fish in the study area after release. Because the fate of the remaining 36 fish were unknown (i.e., these fish were not detected in the tailrace or FPF), they were also excluded from the analyses.

Behavior and Distribution—This represents the number of times a fish moved into and out of each detection zone. Approximately 7.3% (9 of 124 fish) of fish detected in the Tailrace Zone did not enter the FPF as there were no detections for those 9 fish in the Fish Entrance Pool, Ladder, or Presort Pool zones. Of the 115 fish that entered the FPF, only one fish swam into the FPF entrance one time before exiting back into the tailrace, while the remaining fish moved into and out of each FPF detection zone, overall, nearly all fish (114 of 115 fish) entering the FPF were detected in all zones.

Collection Efficiency—This represents the number of fish collected in the Presort Pool Zone divided by the number of fish detected in the Tailrace Zone. Approximately 92% (114 of 124 fish) of fish detected in the study area were detected in the Presort Pool Zone. Of the remaining 10 fish, 1 entered the Fish Entrance Pool and exited back to the Tailrace Zone, while the other 9 fish were detected in the Tailrace Zone but never entered the FPF and did not have the opportunity to be collected in the presort pools. Preliminary analyses showed fish could freely exit the Presort Pool Zone, as fish were detected moving into and out of that zone multiple times (Figure 3). Of the 114 fish detected in the Presort Pool Zone, 61 (53.5%) were detected moving into and out of that zone at least ~2–32 times. This behavior may indicate that not all fish that entered the Presort Pools were truly collected (i.e., sorted and transported to the upstream release site), if they were able to exit before being moved up the Archimedes Screw Lift.

Delays within the fishway—This represents the number of times fish entered the Fish Entrance Pool and Ladder zones before the final entrance in the Presort Pool Zone. The number of times fish moved into and out of these zones varied. For fish that entered the Presort Pool Zone only once (53 fish), the number of times fish entered the Fish Entrance Pool and Ladder zones before collection ranged from 1 to approximately 7 times. Figure 4 illustrates a fish that entered all zones of the fishway once, moving through the fishway linearly, and was subsequently collected. For fish that entered the Presort Pool Zone more than once (61 fish), the number of times fish entered the Fish Entrance Pool and Ladder zones before collection ranged from approximately 2–37 times. The amount of time for these delays varied from a day to a few weeks. For example, one fish was delayed over two weeks after its first attempt into the FPF, where it was detected moving between the Ladder and Presort-Pool zones 6 times before it was collected (Figure 5).

Recapture, Upstream Movement and Fallback- Recaptures were confirmed through detection at the outplant site. Of the 114 fish detected in the Presort Pool zones, 111 (97 %) were also detected at the outplant site and were confirmed recaptures. A total of 61 (55 %) of recaptured fish were detected ~17 rkm upstream at Federation Forest State Park. Mean travel time from the release site upstream to Federation Forest State Park was 438.8 hours or 18.2 days. Notably, five recaptured fish fell back after release and were detected downstream at the MMD detection zone, two of which re-entered the FPF and one was collected for a second time, released, and was detected upstream at Federation Forest State Park. Additionally, one of the five fall back fish was detected at Federation Forest State Park before falling back past the outplant site and downstream to MMD.

Summary

The 2023 FPF post construction evaluation occurred from June 22nd through October 16th, 2023. A total of 169 adult Chinook salmon were tagged and released between June 22– July 21, 2023. Thereafter, RT technology installed at and within the Barrier and FPF, and at or above MMD, was utilized to detect upstream migrating and out-planted tagged fish. Of the 169 fish tagged, 124 were detected in the tailrace, 115 entered the FPF, and 111 were collected, transported, and released at the outplant site. Of the 115 fish entering the FPF, 62 (54%) entered and exited the FPF multiple times. It was also found that fish could freely exit the Presort Pools, as ~54% of fish entered this zone more than once. Taken together, this indicates that most fish exhibited milling behaviors. They did not immediately enter the FPF and move up the ladder into the pre-sort pools in one attempt. Fish were often moving into and out of the FPF entrance and up and down the ladder prior to—and after—entrance into the presort pools. Greater than 50% of all fish captured and released at the upstream outplant site above MMD continued upstream past Federation Forest State Park, while only 4.5% of captured and out-planted fish fell back to MMD.

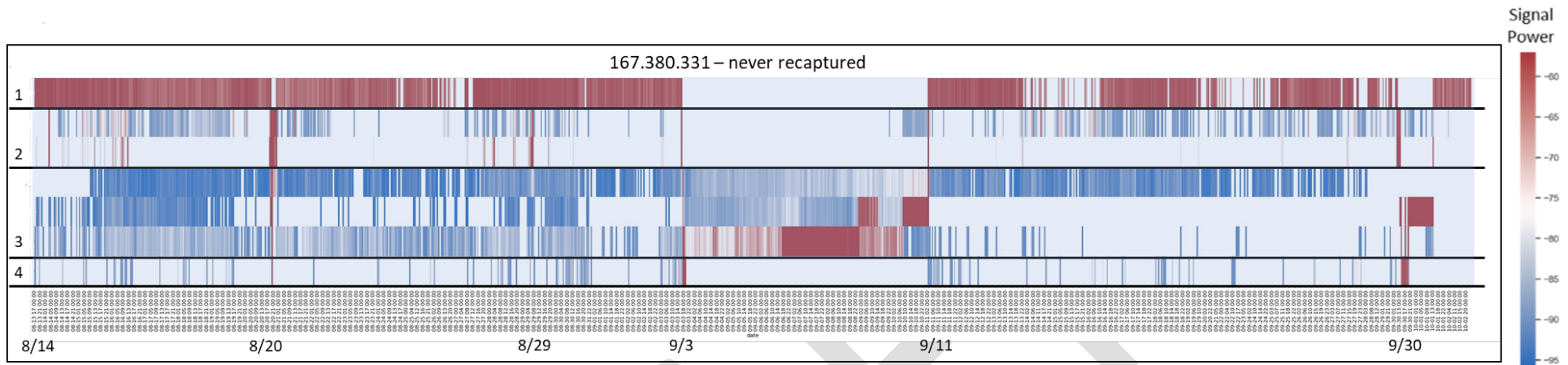


Figure 3. Heat map of the event history for fish 167.380.331, which was never confirmed as recaptured. This fish had experienced several delays in the FPF, notably in the Ladder, and it entered and exited the Presort Pool Zone several times. To follow fish movement, dark red designates a strong signal power strength and is a positive indicator of fish presence, and blue is a weaker signal power where fish may be in the area but not next to an antenna in that zone. The numbers on the y-axis denote the detection zones (1 = Tailrace; 2 = Fish Entrance Pool; 3 = Ladder; 4 = Presort Pool) and on the x-axis is the date and time stamp. Key dates are enlarged to show the initial detection in the Tailrace Zone (8/14), Fish Entrance Pool Zone (8/14), Ladder and Presort Pool zones (8/20). This fish entered the Fish Entrance Pool and Ladder zones 5 times and spent several days in the Ladder before exiting back into the Tailrace Zone. The fish did enter the Presort Pool zones on 9/30, but again escaped back to the Tailrace, and was not detected again by any site after 10/2.

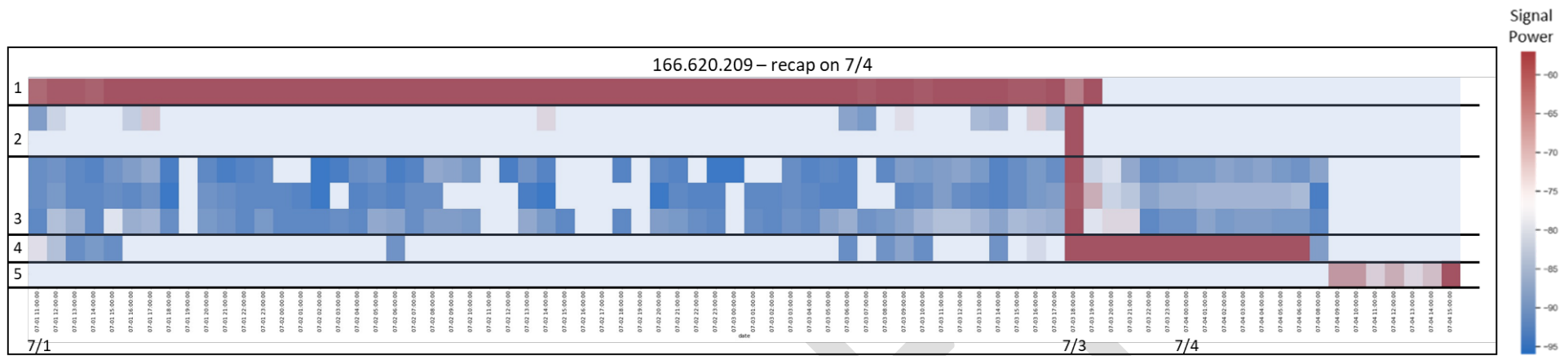


Figure 4. Heat map of the event history for fish 166.620.209, confirmed to be recaptured on 7/4. This fish experienced no delays within the FPF, with only one entrance each into the Fish Entrance Pool, Ladder, and Presort Pool zones. To follow fish movement, dark red designates a strong signal power and is a positive indicator of fish presence, and blue is a weaker signal power where fish may be in the area but not by an antenna in that zone. The numbers on the y-axis denote the detection zones (1 = Tailrace; 2 = Fish Entrance Pool; 3 = Ladder; 4 = Presort Pool; 5 = Outplant Site) and on the x-axis is the date and time stamp. Key dates are enlarged to show the initial detection in the Tailrace Zone (7/1), and initial and final detections in the Fish Entrance Pool, Ladder, and Presort Pool (7/3 and 7/4). The fish was released at the Outplant Site on 7/4; however, it was never detected upstream at Federation Forest State Park.

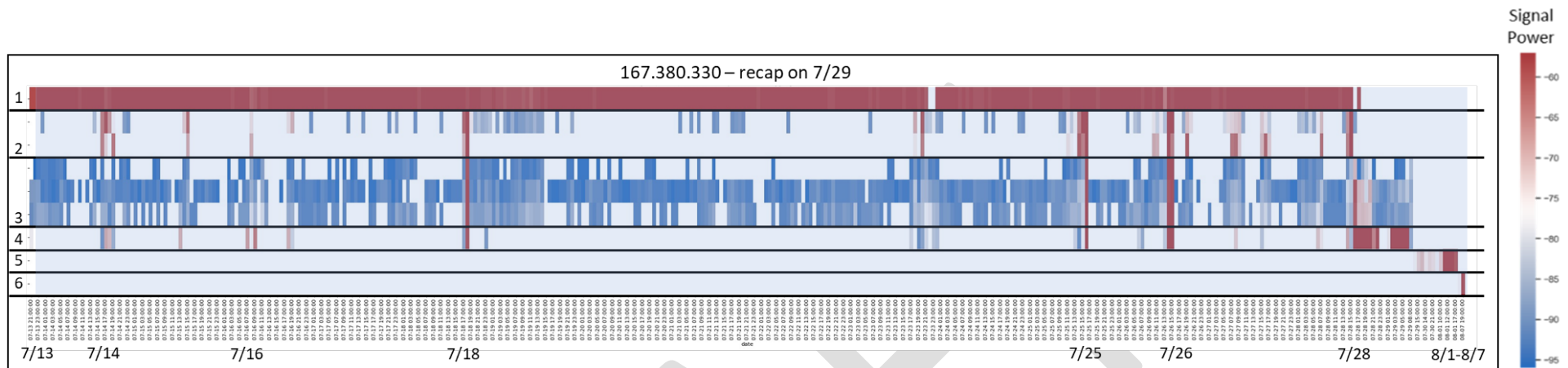


Figure 5. Heat map of the event history for fish 167.380.330, confirmed to be recaptured on 7/29. This fish experienced delays in the FPF and entered the Presort Pool Zone several times. To follow fish movement, dark red designates a strong signal power and is a positive indicator of fish presence, and blue is a weaker signal power where fish may be in the area but not by an antenna in that zone. The numbers on the y-axis denote the detection zones (1 = Tailrace; 2 = Fish Entrance Pool; 3 = Ladder; 4 = Presort Pool; 5 = Outplant Site; 6 = Federation Forest State Park) and on the x-axis is the date and time stamp. Key dates are enlarged to show the initial detection in the Tailrace Zone (7/13), initial detections and movements into and out of the Fish Entrance Pool and Ladder zones (7/14), and final detections in the Fish Entrance Pool, Ladder, and Presort Pool zones (7/28). This fish was released at the Outplant Site on 7/29, where it presumably recovered before leaving the zone on 8/1. The fish ultimately successfully traveled upstream to Federation Forest State Park, where it was detected on 8/7.

References

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