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HOOD RIVER PIT-TAG INTERROGATION SYSTEM EFFICIENCY STUDY

Annual Report of
U.S. Geological Survey Activities

November 2011 – October 2012

April 2013

Hood River PIT-Tag Interrogation System Efficiency Study

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U.S. Geological Survey Activities

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Abstract

We tested an instream Passive Integrated Transponder tag interrogation system (PTIS) at the mouth of the Hood River, Oregon, for a second year (November 2011 – October 2012). The primary goal of the PTIS was to detect adult salmonids tagged with Passive Integrated Transponder (PIT) tags. The PTIS transceiver was a Digital Angel FS1001M running five antennas and supported by solar power. Operation of the system was much improved over the first year of operation when river conditions and equipment issues proved challenging. During the second year of operation, we detected 767 individual fish, including 80 adult steelhead *Oncorhynchus mykiss* and 74 adult Chinook salmon *O. tshawytscha*. Path-detection efficiency was estimated to be 0.77 (SE = 0.04) for adult steelhead and 0.79 (SE = 0.05) for adult Chinook salmon. Site efficiency was estimated to be 0.31 for adult steelhead, and 0.45 for adult Chinook salmon. The PTIS site was registered with the PTAGIS Database as HRM and data was submitted beginning in January 2012. An additional PTIS site was operated at the East Fork Hood River acclimation site to monitor release of steelhead smolts. This site proved very effective during both 2011 and 2012 with detection efficiency of 100%. The second year of operation of the HRM PTIS site demonstrated the potential for a PTIS at this location to provide valuable data to managers of the Hood River. Future operation can likely be improved by addition of an antenna and adoption of new transceiver technology when it becomes available.

Introduction

This report provides information on operation and detection efficiency results from an instream PIT-tag interrogation system (PTIS) at the mouth of the Hood River, OR, (Figure 1), during the period November 2011 to October 2012. The primary purpose of the project was to test the efficacy of the PTIS for providing data on returning adult salmonids as part of the Hood River Production Monitor and Evaluation project (HRPME), and to see if any improvements in performance could be realized compared to the first year of operation. The PTIS was located at the mouth of the Hood River at the downstream end of the west-side jetty, on Port of Hood River property. The work was a cooperative effort between the U.S. Geological Survey-Columbia River Research Laboratory (USGS-CRRL), the Confederated Tribes of Warm Springs (CTWS), and Oregon Department of Fish and Wildlife (ODFW). Funding was provided by Bonneville Power Administration (BPA) under project number 1988-053-03, contract number 54741. Additionally, we report results from a two-antenna interrogation system that HRPME operated in the outflow channel of an acclimation site for hatchery steelhead on the East Fork Hood River.

Because PIT tags are small, relatively inexpensive, carry no internal battery, and last through the lifespan of most fishes, they are commonly used in long-term fish monitoring projects. They have been extensively used in the Columbia River basin to monitor salmonid behavior and survival through life stages and migration routes in the mainstem Columbia River (Skalski et al. 1998; Zabel and Achord 2004). Increasingly, PIT-tag interrogation equipment has been deployed in streams to investigate salmonid behavior (Zydlewski et al. 2001, 2006; Riley et al. 2003; Bond et al. 2007; Martens and Connolly 2010). Most of the interrogation systems deployed and evaluated to date have been in much smaller streams than the mainstem of the Hood River (Zydlewski et al. 2001, 2006; Bond et al. 2007; Horton et al. 2007; Connolly et al. 2008), but researchers are attempting to expand detection abilities to larger streams and rivers that can prove extremely challenging to monitor. The Hood River is about 90-m wide at the site and base flows are generally between 7 and 9 cms, though high flows regularly exceed 280 cms. A detection system in the Klamath River (Beeman et al. 2012), a site similar in size to the Hood River, suffered problems from cables being dislodged and high water that resulted in a detection efficiency estimate for juvenile coho salmon of less than 0.05. Despite the challenges of larger

streams, PTISs in such environments have promise to contribute much valuable data to fisheries management entities.

The PTIS at the mouth of the Hood River was installed in September 2010 (Jezorek and Connolly 2012). The site allowed vehicle access, appeared to have a relatively stable channel structure (though with a mobile cobble and gravel substrate), and was shallow enough to allow personnel to work with large antennas during periods of low flows. Additionally, it was reasoned that the backwater effect from the Columbia River and the width of the Hood River channel would help to buffer water velocities and debris strike velocities during high flow events common to the Hood River.

The transceiver used was a Destron-Fearing 1001M (MUX). This transceiver detects 134.2 kHz full-duplex tags, the standard PIT tag type used in salmonids in the Columbia River basin, and can power up to six antennas. Three solar panels (24V, 180W) were mounted to the roof of an electronics shed facing directly south. The solar panels were connected to a charging circuit that contained two banks of batteries (each bank consisted of two 12V batteries wired in series for 24V) and a switching mechanism to alternately charge one bank of batteries while the other bank was isolated from the charging circuit and powering the MUX.

Operations from September 2010 through October 2011 proved challenging (Jezorek and Connolly 2012). Electromagnetic interference “noise” was problematic. A large flood event destroyed some of the antennas, and due to the high water level of the Bonneville Pool during spring and early summer, much sand was deposited at the site, burying the antennas in up to 50-cm of sand. Despite these challenges, fish were detected, and a second year of operation was agreed upon to further test and improve the system.

Three antenna arrays were operated during the period covered by this report (Figure 2). The upper and middle array each had two antennas (one 12-m and one 6-m) and the lower array had one antenna (12-m). The 12-m antennas were modular (The upper array 12-m antenna was a 2-piece; the middle and lower array 12-m antennas were 4-piece). Because the primary focus of the site at the Hood River mouth was detection of adults, which likely travel close to the

substrate (Hughes 2004; Quinn 2005), the modular antenna design was selected to allow more cross-channel coverage at the cost of some reduced read range compared to shorter antennas. The four-piece modular design allowed construction of 12-m antennas that would conform to the bottom profile in the thalweg area with minimal gaps between antenna and substrate. The use of three arrays was agreed upon to both reduce cable lengths, which would hopefully mitigate some low power and high noise issues, and to increase ability to calculate path efficiency estimates. The arrays were all on the west side of the river, where the thalweg was located. The east bank of the river was a shallow gravel bar at the detector site.

Work Elements from Contract 54741 and progress

F: 157. Collect/Generate/Validate Field and Lab Data

Title: Insure data collection from the system.

Description: USGS will insure that the PTIS is fully functional and is archiving data in the proper format.

Progress:

Personnel from USGS-CRRL visited the site approximately weekly to download files and maintain the site. From 1 November 2011 to 9 October 2012, 767 individual fish were detected, comprised of 307 juvenile Chinook salmon *Oncorhynchus tshawytscha*, 203 juvenile steelhead *O. mykiss*, 80 adult steelhead, 74 adult Chinook salmon (Figures 3 and 4), 16 juvenile coho salmon *O. kisutch*, 7 cutthroat trout *O. clarki*, 3 white sturgeon *Acipenser transmontanus*, 2 adult bull trout *Salvelinus confluentus*, 1 adult coho, and 1 northern pikeminnow *Ptychocheilus oregonensis*. Additionally, at the time of this writing, there were 54 orphan tag codes (no tagging information in the PTAGIS database). Most of the detections occurred during the spring and early summer of 2012 (83% of Chinook salmon and steelhead detections occurred between March 1 and June 30). Between 1 November 2011 and 1 January 2012, only four fish were detected on the system (one adult coho, one adult steelhead, and two juvenile steelhead).

The solar charging system functioned well throughout the period of operation, and a change of batteries was required only once (in late December 2011). We were able to mitigate some of the noise that had plagued us during the 2011 reporting period by replacing standard coaxial cables with twisted-pair coaxial cables.

E: 70. Install Flow Measuring Device

Title: Install a water level logger near the PTIS at the mouth of the Hood River.

Description: USGS will install a water level logger near the PTIS at the mouth of the Hood River.

Progress:

We installed a water level logger (ONSET HOBO Water Level Logger U20-001-04) on 7 February 2012 immediately upstream of antenna 1 (Figure 2). The logger was housed in PVC pipe that was bolted to a boulder on the west bank. Water level measurements were recorded every 15 minutes. These data allowed fish-detection data to be matched more closely with water levels for efficiency calculations.

G: 159. Transfer/Consolidate Regionally Standardized Data

Title: Register the site with PTAGIS and submit data.

Description: The site will be registered with the PTAGIS database so that interrogation data can be submitted. USGS will insure that data collected are submitted to the PTAGIS database. Data will be downloaded, checked, and submitted approximately weekly throughout the project.

Progress:

The site was registered with the PTAGIS database (interrogation site code HRM) and data files were submitted beginning with files from January 2012. Prior to that, the site had undergone many configuration changes and had many operations difficulties, so that the data were not consistent enough for submittal. All data prior to January 2012 were provided to HRPME. During the period covered by this report, USGS personnel visited the site about weekly

to download and check operations. Personnel from HRPME were trained in downloading and data submittal, and they took over these tasks during November 2012.

D: 162. Analyze/Interpret Data

Title: Determine PTIS detection efficiencies.

Description: Determine detection efficiencies of the PTIS at the mouth of the Hood River and the array of detectors at the East Fork Acclimation Site release stream.

Progress:

We calculated path-detection efficiency estimates with detection data from the PTIS at the mouth of the Hood River and site efficiency estimates with detection data from the PTIS and recapture data from points upstream in the subbasin. Path efficiency is the likelihood of detecting a fish traveling a path that takes it over the antennas. Site efficiency is the likelihood of detection of tagged fish that pass the site given that the antennas do not span the width of the river and fish can pass without being subject to detection. Both measures allow comparison of performance in differing years; path efficiency can be used to compare performance at differing water levels. Site efficiency is necessary to generate an estimate of the total number of tagged fish that passed the site.

We used the methods for calculating path efficiency outlined in Connolly et al. (2008). We stratified the efficiency calculations by species (steelhead and Chinook salmon), life stage (adult or juvenile), and water level (high or low; Table 1). Low water was classified as less than 1.06 feet on our water level logger at the site, which corresponded with a Bonneville Pool height of 75.5 feet at the Stevenson, WA, USGS Gage (Station 14128600). Path-detection efficiency estimates varied by species and water level, but were generally good. The path-detection efficiency estimate for upstream moving adult steelhead across all water levels was 0.77 (SE = 0.04; Figure 5), and for upstream moving adult Chinook salmon across all water levels, it was 0.79 (SE = 0.05; Figure 5). These estimates for adults of both species were much improved from the 2011 time period when the adult steelhead estimate was 0.28 (SE = 0.21) and when we were not able to generate an estimate for adult Chinook salmon.

Although adult salmonid monitoring was the main focus of the PTIS at the mouth of the Hood River, we calculated estimates for path-detection efficiency of downstream-migrating juvenile Chinook salmon and juvenile steelhead (Table 1). The path detection-efficiency estimate for juvenile steelhead across all water levels was 0.62 (SE = 0.04), and for juvenile Chinook salmon it was 0.92 (SE = 0.01).

Recapture and creel survey data for adult steelhead and adult Chinook salmon from HRPME during the period covered by this report were provided to allow estimates of site efficiency. Thirty-nine individual PIT-tagged adult steelhead were recaptured upstream of the PTIS. These steelhead were known anadromous adults from interrogations at Bonneville Dam. Twelve of these 39 steelhead were detected at the PTIS, suggesting an adult steelhead site efficiency of about 0.31. Twenty adult spring Chinook salmon were recaptured by HRPME during 2012 in the Hood River watershed. These Chinook salmon had interrogation records at Bonneville Dam confirming that they had returned from out of basin. Nine of these 20 adult Chinook salmon were detected at the PTIS, suggesting site efficiency for adult Chinook salmon of about 0.45. Site efficiencies for adults of both species were higher in 2012 than in the 2011 reporting period (Figure 6).

We used Bonneville Dam and estuary trawl detections of juvenile steelhead that were released from the East Fork Acclimation site to get an estimate of site efficiency for juvenile salmonids. There were 380 juvenile steelhead from the spring 2012 East Fork Acclimation site release that were detected at Bonneville Dam or the estuary trawl through 30 September 2012. Thirteen of these 380 fish were detected at the PIT-tag interrogation site at the mouth of the Hood River, suggesting a juvenile steelhead efficiency slightly higher than 0.03.

An interrogation system of two antennas and two Destron Fearing 2001 transceivers was operated by HRPME personnel at the East Fort Hood River Acclimation site in 2012. During 2011, this site had been a three-array system, with one antenna in each array, and had performed well. One antenna was lost due to ice storm damage during winter 2012, thus only two antennas were available for the 2012 steelhead release. Despite the loss of one antenna, the PTIS in the East Fork Acclimation site outflow channel performed well during the spring 2012 steelhead

smolt release. The PTIS detected 3,309 individual PIT tagged fish leaving the acclimation site. To determine efficiency of this site we used records of PIT-tagged steelhead known to have been placed into the acclimation site. From this tagged group, 424 fish were detected downstream at Bonneville Dam, in the estuary trawl, or at the PIT-tag interrogation site at the mouth through 30 September 2012. All 424 of those fish were detected on the East Fork Acclimation site outflow PTIS, suggesting a detection efficiency of 100% at that site.

H: 132. Produce (Annual) Progress Report

Title: Progress Report for the contract period (Nov 2010 through Oct 2011)

Description: A report will be produced that summarizes the project goal, objectives, hypotheses, completed and uncompleted deliverables, problems encountered, lessons learned, and long-term planning. Included will be reporting of on-the-ground activities and estimates of efficiencies.

Progress:

A report was submitted to BPA in April 2012 and is available online: https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P126054

Discussion

The PTIS performed much better during the 2012 reporting period than in the previous year. We detected many more fish (162 in 2011 period; 767 in the 2012 period), and estimates of both path and site efficiency were much improved. A number of factors contributed to this improved operation. Use of twisted pair coaxial cables for the antennas reduced noise considerably and improved our tag reading ability. We did not experience any flows of the magnitude of the January 2011 flood (about 350 cms), and we did not lose any antennas (only two antennas operated for much of the 2011 period; five antennas operated for the 2012 period). Additionally, the Bonneville Pool level was not as high during the spring and early summer period, and the antennas were not buried by sand deposits. Addition of a third array provided the opportunity to contact additional fish, as well as provide multiple detections of individual fish, which improved path efficiency estimates and reduced variance.

The different site efficiency estimates for adult Chinook salmon and adult steelhead (despite very similar path efficiency estimates), may be due to differing behavior of the two species. Adult salmonids can be expected to capitalize on travel routes that minimize energy expenditure, but different species may use differing routes or depths (Hughes 2004). Because the timing of the peak run for adult steelhead and adult Chinook salmon differed (adult steelhead primarily March and April; adult Chinook primarily May and June), channel changes could have occurred that would have made adult Chinook more likely to travel over the antenna arrays. River discharge differences between the migratory periods may have influenced where in the channel, or depth at which adults of the two species traveled.

The higher path efficiency estimates for juvenile Chinook salmon than for juvenile steelhead may also result from differing behavior between the two species. Juvenile Chinook salmon and juvenile steelhead may migrate at different depths. Passage timing was similar for the two species making it unlikely that changes in the channel or flow dynamics contributed to the species differences. Path efficiency estimates for both species improved in 2012, indicating that the system improvements and better operating conditions did indeed result in more favorable results.

Though path efficiency estimates for juveniles were good, site efficiencies were much lower than those found for adults. Downstream moving juveniles likely travel higher in the water column, where velocities are greater, than upstream migrating adults that seek lesser velocities to conserve energy (Hughes 2004). Even during relatively low water periods, PIT-tagged juveniles could be high enough in the water column to avoid detection at a PTIS in deep water such as at the mouth of the Hood River. Juveniles may be spread horizontally across the river and not pass near the antenna arrays, which only extended across about 20% of the channel. Despite low site efficiencies for juveniles, the juvenile data collected during the 2012 time period indicates that there is high potential for the site to contribute information to juvenile salmonid life-history and survival research in the Hood River subbasin.

Results from the 2012 time period were encouraging for the potential of a PTIS at the mouth of the Hood River to be a useful tool for estimating hatchery adult salmonid returns and to provide additional information on juveniles. Estimates of wild adult salmonids will likely require HRPME to tag an increased number of wild juveniles. The ability to determine site efficiencies and to be confident in those estimates would be enhanced by additional opportunities to recapture or otherwise detect PIT-tagged fish in the Hood River subbasin. A network of sites to recapture or detect PIT-tagged fish will also provide a buffer when the effectiveness of the PTIS at the mouth may be reduced because of high water, antenna damage, or other equipment problems.

Future operation of the PTIS at the mouth of the Hood River will almost certainly encounter challenges associated with such a large river. Site performance could still be much affected by variables such as flooding, antenna damage, channel changes, and Bonneville Pool levels. These variables will likely require evaluation of efficiencies during each year of operation or specific migratory period of interest. This site is currently considered the best location for a large PTIS in the lower Hood River. Alternative site possibilities are constrained by access, dynamic channel structure, and the ability of personnel to effectively work in swift or deep water. As of this writing, there are five antennas in operation at the PTIS at the mouth of the Hood River. The MUX is capable of operating six antennas. Addition of a sixth antenna is recommended to take full advantage of the potential of the system. Future development of transceiver technology may provide a system capable of operating more antennas. Should such a transceiver become available, data from this site would likely benefit by increased stream coverage.

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CTWS helped with site maintenance. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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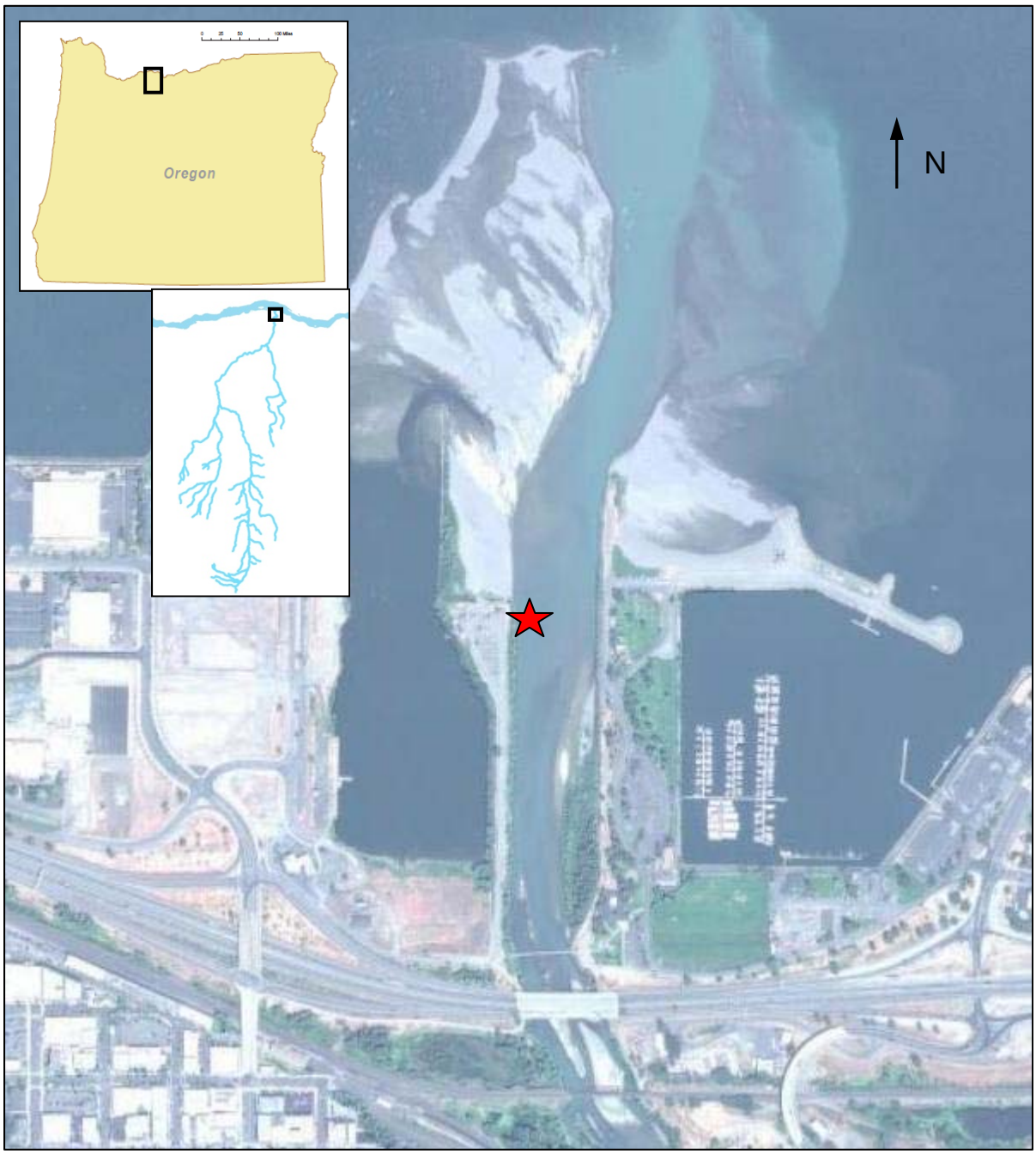

Figure 1. Location of the PIT-tag interrogation system at the mouth of the Hood River, OR.

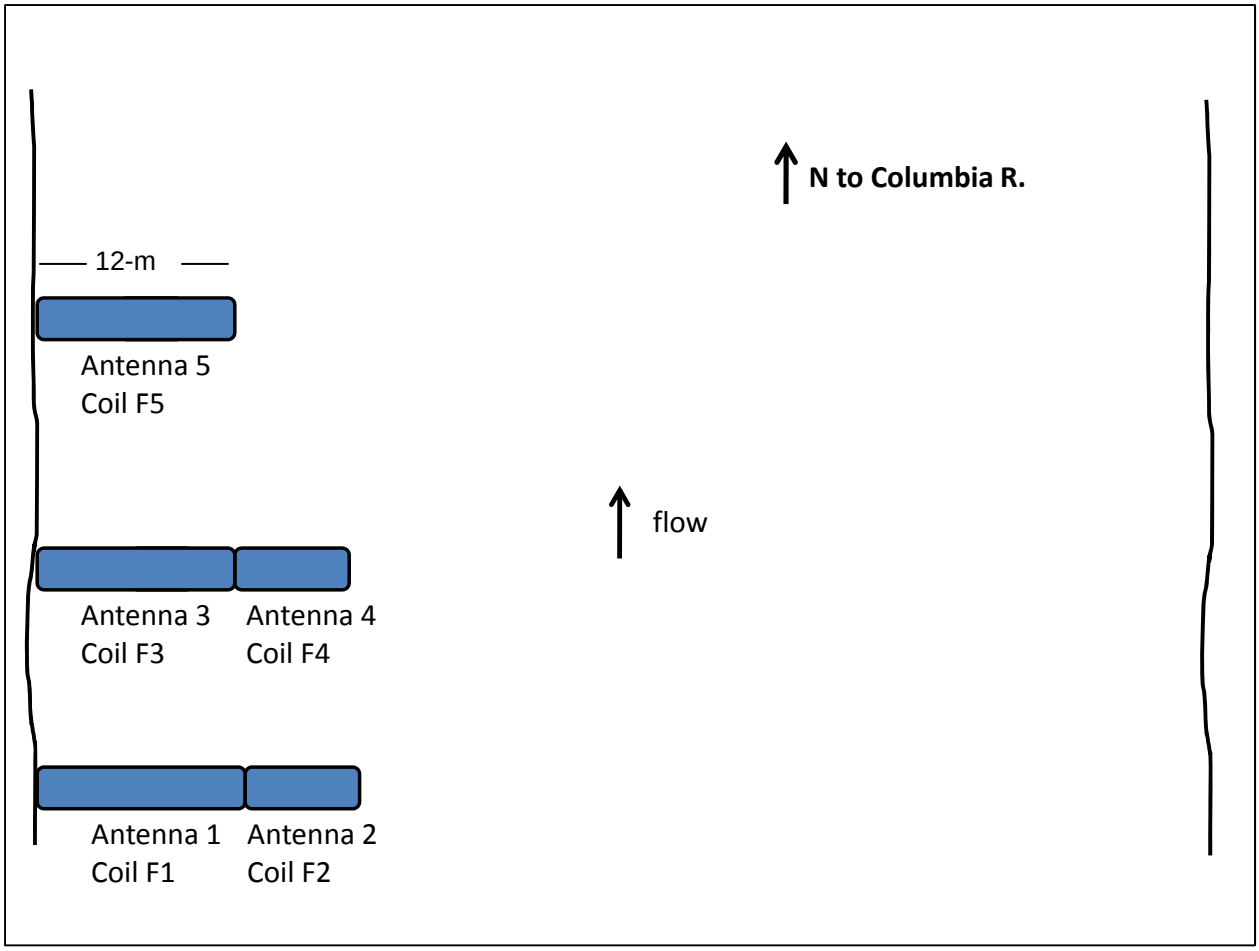

Figure 2. Schematic showing the antenna array configuration for the PIT-tag interrogation system at the mouth of the Hood River, OR. This configuration was in place from November 2011 through October 2012. The site was registered as HRM with the PTAGIS database. Data submitted to PTAGIS begins in January 2012. The distance across the river is about 90 m.

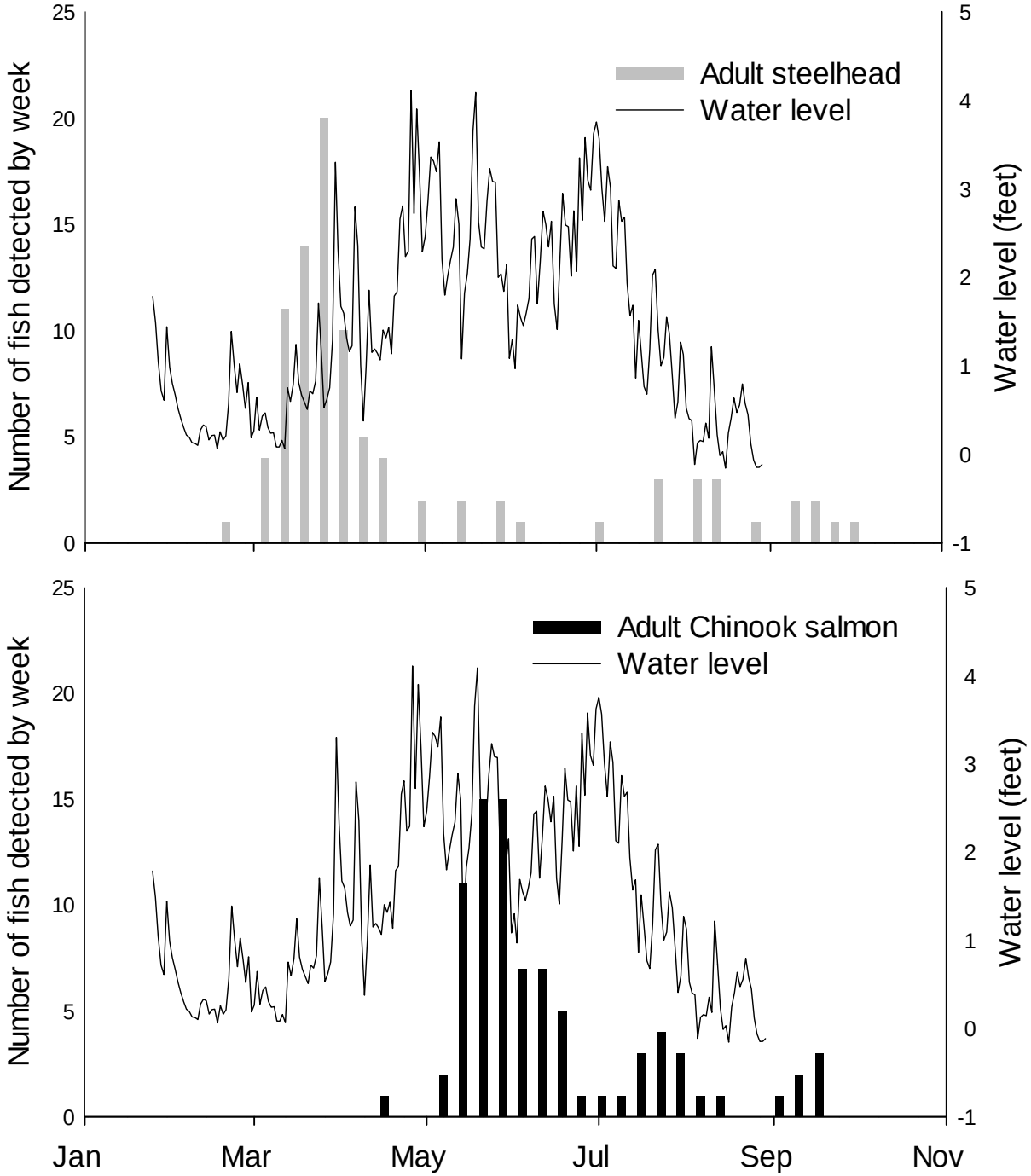

Figure 3. Number of detections per week of PIT-tagged adult steelhead and adult Chinook salmon at the PIT-tag detection system at the mouth of the Hood River, OR, and water level data from a logger at the site. Fish detection data are from 1 January 2012 to 9 October 2012. Between 1 November 2011 and 1 January 2012, there was one additional adult steelhead detected on 23 November 2011.

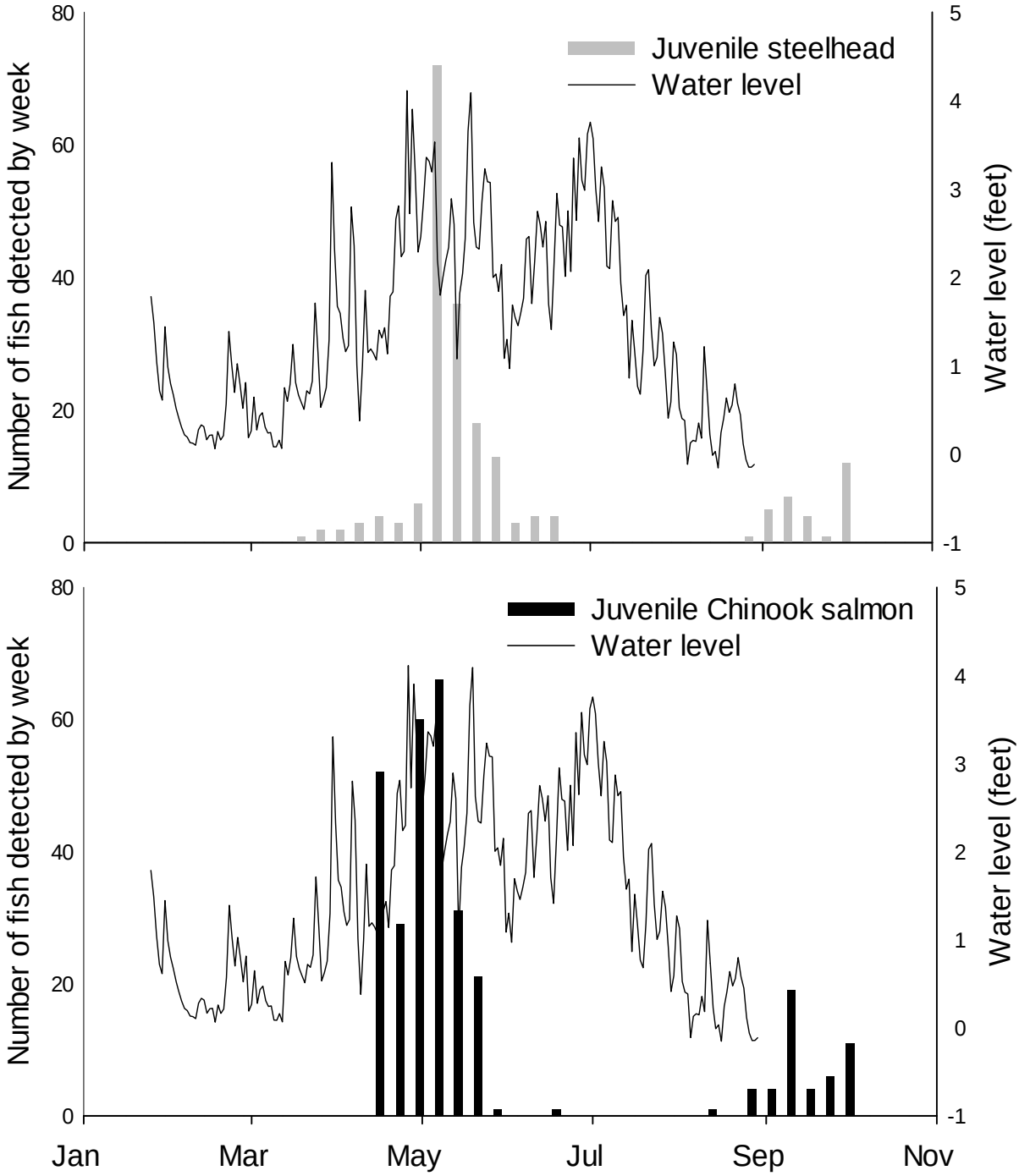

Figure 4. Number of detections per week of PIT-tagged juvenile steelhead and juvenile Chinook salmon at the PIT-tag detection system at the mouth of the Hood River, OR, and water level data from a logger at the site. Fish detection data are from 1 January 2012 to 9 October 2012. Between 1 November 2011 and 1 January 2012, there were two additional juvenile steelhead detected, both on 2 December 2011.

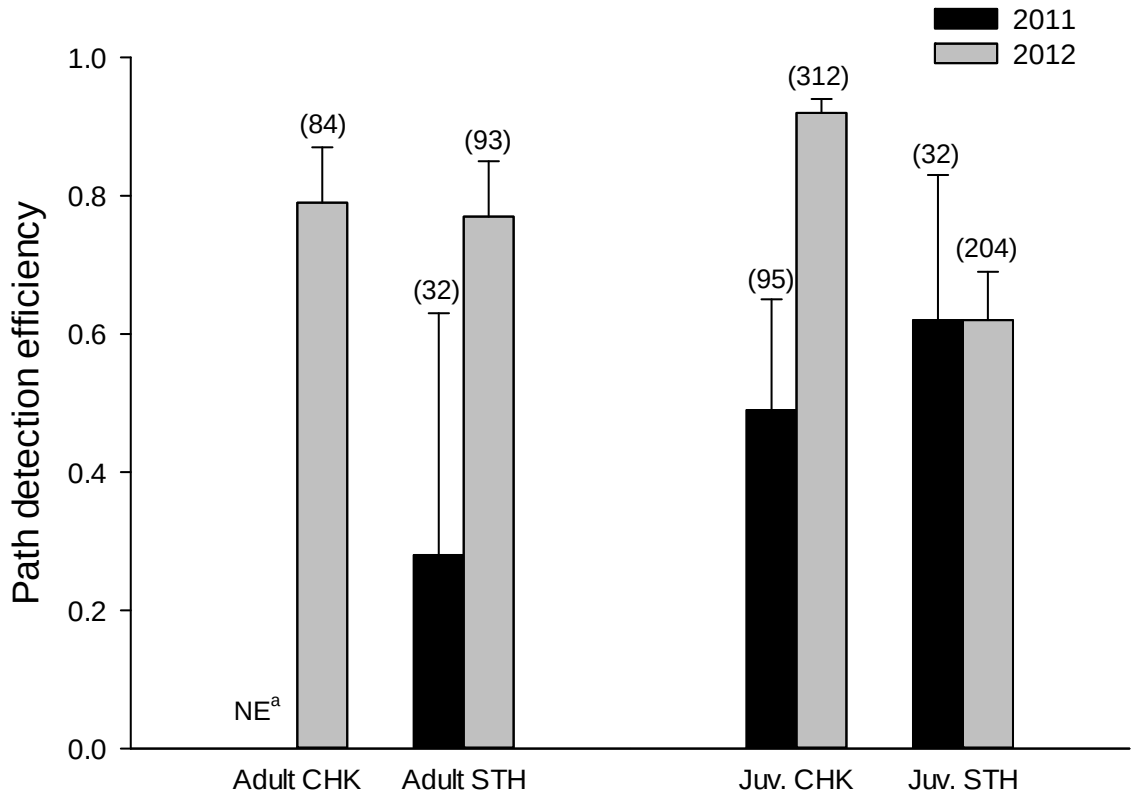

Figure 5. Estimates of path detection efficiencies for adult and juvenile Chinook (CHK) salmon and adult and juvenile steelhead at all water levels at the PIT-tag interrogations system at the mouth of the Hood River, OR. Path detection efficiencies were derived using the methods of Connolly et al. (2008). The 2011 group is from the period 1 November 2010 through 31 October 2011, the 2012 group is from the period 1 November 2011 through 9 October 2012. The error bars represent 95% confidence intervals and the numbers in parenthesis are the number of detection events used to derive the estimate.
[a] NE = No estimate.

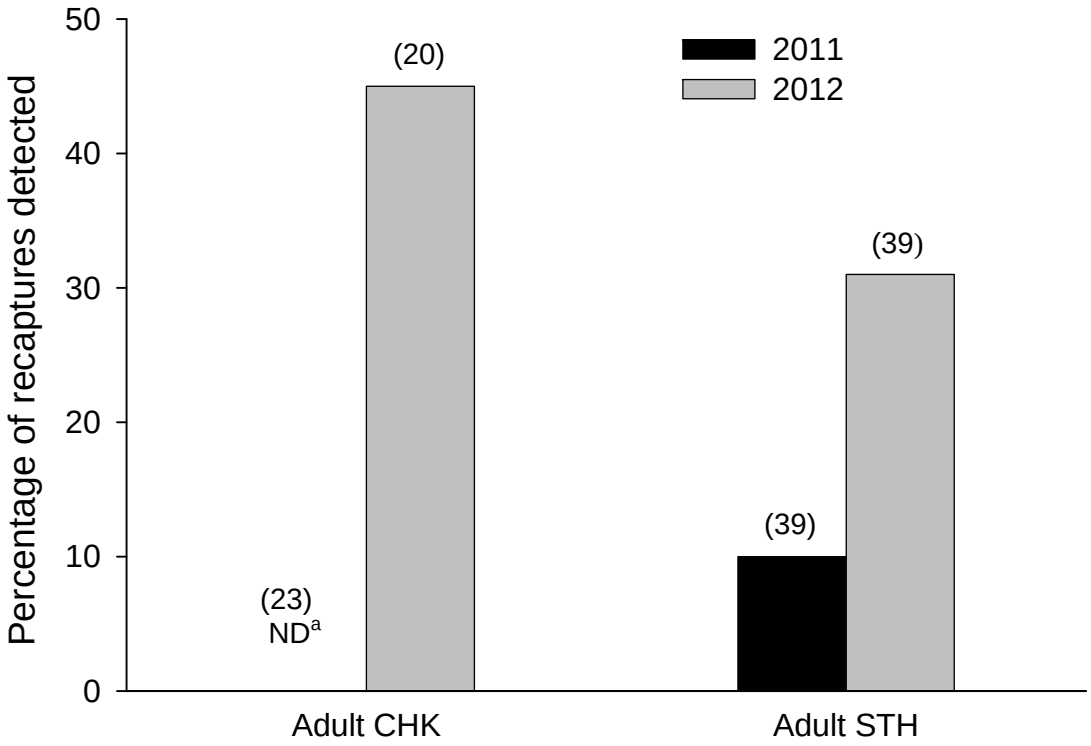

Figure 6. Percentage of adult Chinook (CHK) salmon and adult steelhead (STH) recaptured or otherwise interrogated in the Hood River subbasin that were previously detected at the PIT-tag interrogation system at the mouth of the Hood River, OR. The 2011 group is from the period 1 November 2010 through 31 October 2011, the 2012 group is from the period 1 November 2011 through 9 October 2012. The numbers in parenthesis are the number of PIT-tagged adults recaptured in the Hood River subbasin.
[a] ND = None detected

Table 1. Path detection efficiency estimates at the PIT-tag interrogation system at the mouth of the Hood River, OR, from detection events during the period 1 November 2011 to 9 October 2012. Efficiencies estimates were calculated by the methods outlined in Connolly et al. 2008.

Species	Life stage	Direction	Detection events *N*	Water level	Path detection efficiency	SE	95% CI	CV[a]
Chinook	Adult	Up	15	Low[b]	0.57	0.17	0.24 – 0.83	29.8
Chinook	Adult	Up	69	High	0.83	0.05	0.72 – 0.90	6.0
Chinook	Adult	Up	84	All	0.79	0.05	0.68 – 0.87	6.3
Steelhead	Adult	Up	38	Low	0.83	0.06	0.70 – 0.92	7.2
Steelhead	Adult	Up	55	High	0.72	0.07	0.58 – 0.83	9.7
Steelhead	Adult	Up	93	All	0.77	0.04	0.67 – 0.85	5.2
Chinook	Juvenile	Down	52	Low	0.91	0.03	0.84 – 0.96	3.3
Chinook	Juvenile	Down	260	High	0.92	0.01	0.90 – 0.94	1.1
Chinook	Juvenile	Down	312	All	0.92	0.01	0.90 – 0.94	1.1
Steelhead	Juvenile	Down	47	Low	0.70	0.08	0.53 – 0.83	11.4
Steelhead	Juvenile	Down	157	High	0.59	0.05	0.49 – 0.68	8.4
Steelhead	Juvenile	Down	204	All	0.62	0.04	0.53 – 0.69	6.5

[a] Coefficient of variation = SE/Efficiency estimate × 100.
[b] Low water corresponds to a reading of < 1.06 feet on the water-level logger at the site.