Evaluation of a Resistance Board Weir in the White Salmon River For Capture of Lower Columbia River Fall Chinook Salmon (*Oncorhynchus tshawytscha*) for Transport during the Year of Condit Dam Removal

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COLUMBIA RIVER FISHERIES PROGRAM OFFICE
VANCOUVER, WASHINGTON

A Conservation Measure in Preparation for Condit Dam Removal

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Summary

In September 1999, a Settlement Agreement was signed by PacifiCorp and State, Federal, Tribal and non-governmental organizations to remove Condit Dam and reopen the upper White Salmon River to fish passage. One of the key conservation measures proposed by PacifiCorp and the Federal Energy Regulatory Commission (FERC) is the capture of adult Lower Columbia River (LCR) fall Chinook salmon (*Oncorhynchus tshawytscha*) before Condit Dam is removed (projected Oct. 2010) and rearing their progeny for release back into the White Salmon River after the removal process is complete (NMFS 2006). The breaching of Condit Dam and draining of Northwestern Lake is expected to temporarily eliminate anadromous spawning in the lower river by inundating the spawning area with reservoir sediments (NMFS 2006). In the spring 2008, a decision was made by the White Salmon Working Group (U.S. Fish and Wildlife Service, Yakama Nation, Washington Department of Fish and Wildlife, NOAA-Fisheries, PacifiCorp and U.S. Geological Survey-Biological Resources Division) to perform adult lower Columbia River (LCR) fall Chinook salmon outplanting upstream of Condit Dam during the year of dam removal in lieu of adult collection and subsequent hatchery propagation. This study builds on results and recommendations presented in Engle and Skalicky (2009) that assessed several capture methods targeting LCR fall Chinook salmon for outplanting above Condit Dam in fall 2008.

A total of 688 LCR fall Chinook salmon (404 hatchery origin and 284 natural origin) were enumerated in the fall of 2009 in the lower White Salmon River at river mile 1.1 using a resistance board weir combined with a video passage system (VPS) and the White Salmon Ponds, a dormant brood stock collection facility owned by the U.S. Fish and Wildlife Service. A total of 46 hatchery origin and 36 natural origin LCR fall Chinook salmon were captured in the White Salmon Ponds over 10 days of non-consecutive operation during the 2009 study period (August 25 through October 9, 2009). Enumeration and capture of steelhead (*O. mykiss*), coho salmon (*O. kisutch*), spring Chinook salmon, upriver bright fall Chinook salmon and one pink salmon (*O. gorbuscha*) occurred over the study period. An estimated escapement of LCR fall Chinook salmon in the White Salmon River for 2009 above river mile 1.1 ranged between 725 – 777 using catch-per-unit effort and an area-under-the-curve estimation, respectively. A qualitative effort on how the resistance board weir may impede or affect migrating salmonids using a dual frequency identification sonar, or DIDSON, was attempted and yielded results that suggest a future, quantitative effort could be successful.

The White Salmon Ponds combined with a resistance board weir are a feasible, recommended tool for capture LCR fall Chinook salmon during the year of Condit Dam removal. An additional seining effort in the lower White Salmon River similar to, but less intensive as conducted in 2008 (Engle and Skalicky 2009), as well as earlier weir placement, closed sport fishing access in the White Salmon River above river mile 1.0, and relocation or surplusing of non-target adult salmonids are also recommended during the year of Condit Dam removal.

Acknowledgements

The authors would like to acknowledge Shawna Castle, Brian Davis, Ken Lujan, Marci Koski, Ryan Koch, Steve Haeseker, David Hand, Maureen Kavanagh, Doug Olson, Courtney Newlon and Ken Gates of the U.S. Fish and Wildlife Service. Frank Shrier and Todd Olson of PacifiCorp, Mark Doulos, Chris Hankin, Casey Risley and Scott Zirjacks of Spring Creek National Fish Hatchery for the coordination, assistance and operation of the White Salmon Ponds. Rich Turner and Scott Carlon of NOAA Fisheries provided installation and permitting assistance. Washington Department of Fish and Wildlife Fisheries Biologists Jim Byrne, Josh Holowatz, Julie Grobelny, Scott Nelson, Shane Hawkins and Lisa Brown provided invaluable knowledge and expertise in permitting, installation, operation and removal of the resistance board weir. Additional assistance during installation and removal was provided by Teresa Fish and Jessica Fischer of U.S. Geological Survey-Biological Resources Division and staff from the Confederated Tribes of the Warm Spring Reservation of Oregon.

This project was supported by funding from PacifiCorp and the U.S. Fish and Wildlife Service, with coordination and assistance from Washington Department of Fish and Wildlife, the Yakama-Klickitat Fisheries Program, NOAA-Fisheries, the U.S. Forest Service and the U.S. Geological Survey – Biological Resources Division who participate in discussions of the White Salmon Working Group.

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Introduction

In 2008, a management decision was made by the White Salmon Working Group (WSWG) which is comprised of staff from the U.S. Fish and Wildlife Service, Yakama Nation, Washington Department of Fish and Wildlife, NOAA-Fisheries, PacifiCorp and U.S. Geological Survey, to perform adult fall Chinook salmon outplanting upstream of Condit Dam during the year of dam removal (projected Oct. 2010) in lieu of adult collection and subsequent propagation. This is a conservation measure to mitigate for the impacts of sediment released downstream on the spawning population of Endangered Species Act-Listed Lower Columbia River (LCR) fall Chinook salmon. To this end, a feasibility study was conducted by the U.S. Fish and Wildlife Service during the fall of 2008 to test several different adult fall Chinook salmon capture methods in the lower White Salmon River (Engle and Skalicky 2009). A total of 99 hatchery origin LCR fall Chinook salmon and 64 natural origin LCR fall Chinook salmon were captured, mainly through active seining, in the lower White Salmon River. Gillnetting and the non-traditional operation of the White Salmon Ponds, a dormant Spring Creek National Fish Hatchery (NFH) rearing and brood stock collection facility, were also assessed for capture of LCR fall Chinook salmon with little success.

After completion of the fall 2008 feasibility study, three management options were proposed to the WSWG to successfully meet the goal of capturing, transporting and reintroducing 500 natural origin LCR fall Chinook salmon upstream of Condit Dam during the year of dam removal (Engle and Skalicky 2009);

Option 1 – Use of seines for capture.

Option 2 – Use of seines and the White Salmon Ponds (with weir).

Option 3 – Use of seines, the White Salmon Ponds (with weir) and hatchery origin fish.

This study addresses the feasibility of Options 2 and 3 proposed to the WSWG (Engle and Skalicky 2009). More specifically, our objective was to determine the feasibility and capture efficiency of a weir at the White Salmon Ponds for capture of LCR fall Chinook salmon. If effective in fish capture, this method may be used during the year of Condit Dam removal.

In addition, the WSWG expressed concerns regarding fish behavior at the weir relative to fish passage and the potential monitoring and evaluation of White Salmon River fish populations after removal of Condit Dam. To address these concerns the U.S. Fish and Wildlife Service provided in-kind assistance to:

- Determine the overall escapement of LCR fall Chinook salmon to the weir.
- Document fish passage and escapement using video technology.
- Explore how the weir may impede or affect migrating salmonids.

This project is a cooperative effort between the members of the WSWG for collection and transportation of adult LCR fall Chinook salmon during the year of Condit Dam removal and utilizes standard hatchery and fish research protocols for those actions. This study addresses the Reasonable and Prudent Measures, Terms and Conditions #2 in the NMFS (2006) Biological Opinion,

"*Minimize direct take of listed species during adult salvage operation by following standard hatchery protocols for collecting, holding, and spawning brood stock*".

When designing this study we also considered the Reasonable and Prudent Measures, Terms and Conditions #5 in the USFWS (2002) Biological Option,

"Develop and implement a bull trout protection plan…. that addresses handling and relocation protocols in the event bull trout are trapped and collected during the fish salvage efforts."

Methods

Collection Facility Description

The White Salmon Ponds were constructed in the early 1950's on the White Salmon River at river mile 1.4 and consists of two adjacent 12 x 220 x 5 ft raceway ponds (Figure 1A). The facility was built as a brood stock collection site for Spring Creek NFH and used annually up until the early 1970's and sporadically thereafter to either collect adult LCR fall Chinook salmon or acclimate juvenile salmon prior to release into the White Salmon River. The ponds were last used for juvenile releases in 2002 because the water intake does not meet NOAA Fisheries criteria for incidental take of listed salmonids. Monthly discharge in the White Salmon River during September averages 670 cubic feet per second (cfs). Approximately 3.3 cfs can be diverted through the water intake for operation of the ponds (Northwest Environmental Services 2007) and to attract returning LCR fall Chinook to enter the ladder. In 2008, the ponds were operated without the traditional adult picket weir in place, in an attempt to lure and volitionally capture LCR fall Chinook salmon in the ponds. This method was met with little success (Engle and Skalicky 2009).

Traditionally, capture of adult LCR fall Chinook salmon occurred by installing a 120 ft picket weir across the river near the entrance to the White Salmon Ponds (Figure 1B and 1C). Returning adults would encounter the weir and navigate into the ponds through a number of ladder steps in the river-side pond and eventually into a holding area in the hill-side pond. The original picket weir used for these operations is in disrepair. An Alaskan Resistance Board Weir (Stewart 2002) was constructed and installed by Washington Department of Fish and Wildlife (WDFW) and the WSWG to direct LCR fall Chinook salmon into the ponds.

Figure 1. (A) Aerial photograph of White Salmon Ponds, a historical brood stock collection facility operated by Spring Creek National Fish Hatchery located at river mile 1.4 on the White Salmon River. (B, C) Pictures of Spring Creek NFH staff constructing the historical picket weir that would block upstream migration of Lower Columbia River Fall Chinook salmon adults for redirection in the White Salmon Ponds. Returning adults were trapped and collected to supply the annual production of Spring Creek NFH production through the late 1970's, and intermittently thereafter. Adult collections have not occurred at the site since the early 1990's. Photos courtesy of PacifiCorp.

Resistance Board Weir - Fabrication, Deployment and Disassembly

A temporary Alaskan Resistance Board Weir (Stewart 2002) was installed over two days in August 2009 adjacent to the White Salmon Ponds. WDFW staff constructed the weir on-site and used methods detailed in Stewart (2003) for installation. Two abbreviated flow operations from Condit Dam were requested by the U.S. Fish and Wildlife Service and provided by PacifiCorp. The flow requests allowed for installation of the weir on August 18th and again on August 20th.

On August 18th WDFW and the representatives from the WSWG installed 8 foot sections of 4 inch profile angle iron (Figure 2A), 2 eyebolts at each side of the river (Figure 2C and 2D), and a 3/8 inch steel cable across the 120 feet wetted width of the river. Water depth at the riffle directly upstream of the ponds was approximately 3 feet and flows were reduced from 671 to 265 cfs over a 45 minute period and maintained at that level for 3 hours, then increased to 377 cfs for another 2.5 hours. The angle iron, eyebolts and cable were placed along an existing concrete sill that traverses the White Salmon River adjacent to the ponds (Figure 2B). Angle iron pieces 8 feet in length with an attached eyelet in the middle and two 3/8 inch holes drilled approximately 1.5 feet from either end were attached to the concrete sill in succession across the wetted width of the river. At each point of attachment on the sill a bracket with an eyelet was also attached so that each eyelet was approximately 4 feet apart. The 3/8 inch holes were used as anchor sites in the existing concrete sill and a cordless rotary hammer drill equipped with a 42 inch long, 3/8 inch diameter bit were used for drilling holes. Eyebolts installed at both ends of the wetted width and in-line with the angle iron were 12 inches long and 1 inch in diameter. The 3/8 inch steel cable was run through the angle iron eyelets, anchored at each end of the river to the eyebolts, tightened with an adjustable turnbuckle and fastened with cable clamps.

During the second flow request on August 20th, the weir panels were affixed to the cable and connected across the wetted width of the river using methods similar to Stewart (2002). Water depth at the riffle site upstream of the ponds was approximately 4 feet and flows were reduced from 627 cfs to 409 cfs over a 45 minute period and sustained that level for 3 hours. After installation, several panels near the thalweg of the river were weighted down to allow fish passage prior to sampling that began on August 25th, 2009. Figure 3 outlines some of the construction and installation of the White Salmon River Resistance Board Weir.

Disassembly of the resistance board weir occurred on October 13th with a flow operation requested by the U.S. Fish and Wildlife Service that reduced the flow from 616 cfs to 455 cfs over a 30 minute period. The weir was disassembled and removed for storage. Removal of the weir was conducted in approximately 3.5 hours by a crew of 12 from the USFWS, WDFW, the WSWG and biologists from the Confederated Tribes of the Warms Springs Reservation of Oregon.

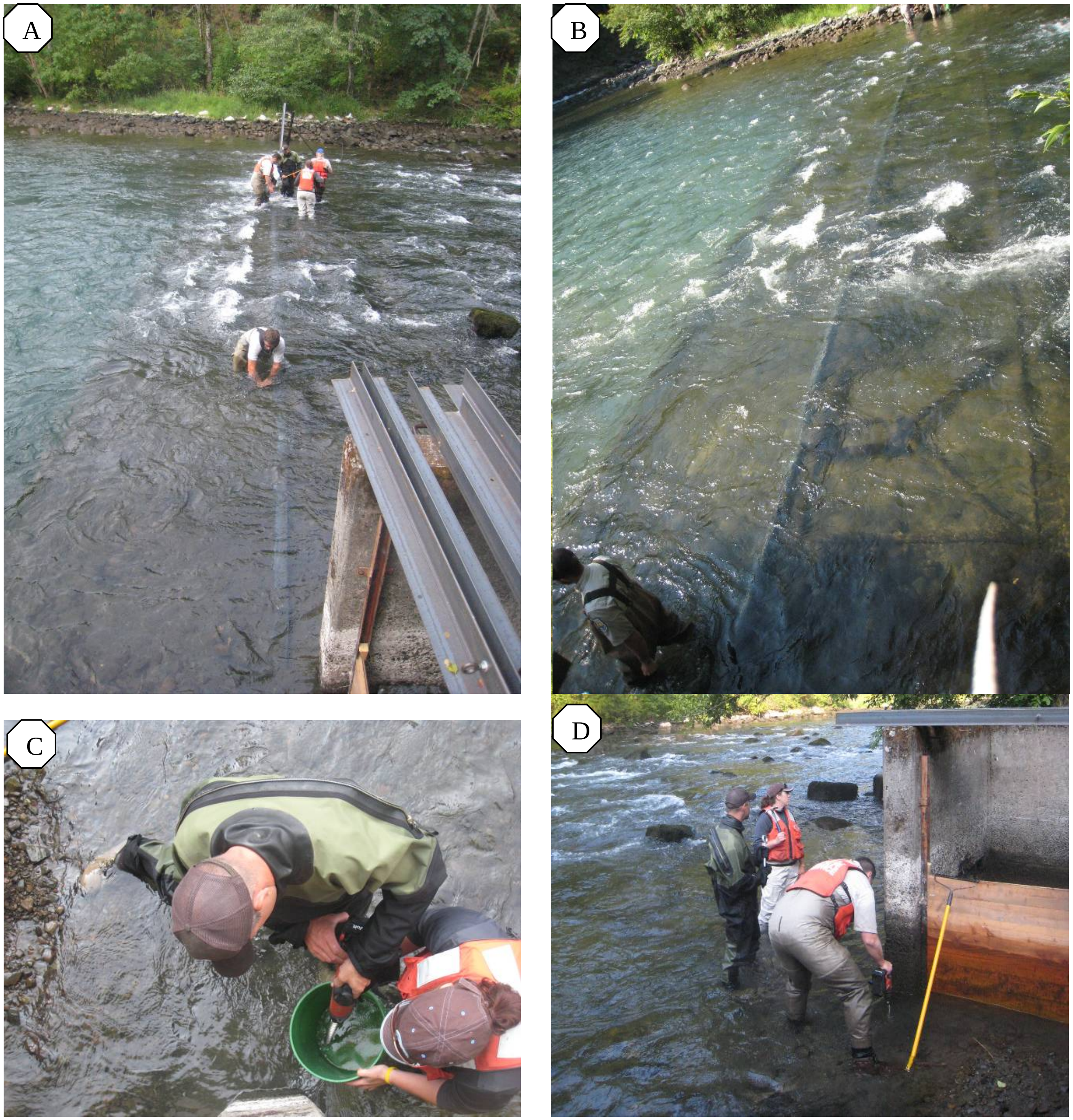

Figure 2. Pictures of White Salmon Working Group members installing the 4 inch angle iron and drilling into the concrete sill at the White Salmon Ponds at river mile 1.4. (A) Angle iron was installed to shield the cable that holds the resistance board weir in place and extended the entire wetted width of the White Salmon River on the existing concrete sill. (B) Angle iron was placed immediately behind the submerged pieces of the historical White Salmon Weir. (C, D) U.S. Fish and Wildlife Service personnel drilling in concrete for installation of eyebolts to hold the submerged cabling.

Figure 3. Installation of resistance board weir panels adjacent to the White Salmon Ponds at river mile 1.4 on August 20th, 2009. Prefabricated panels were floated in the river (A) pulled by rope into position for attachment (B) and a connecting pipe (C) was threaded between two panels by personnel positioned at the end of the weir (D) and connected throughout the length of the panel (E). On August 20th, the installation of panels required 14 people and was completed in approximately 3.5 hours and included installation of a video passage system.

Capture Feasibility of the White Salmon Ponds

The White Salmon Ponds were operated by providing approximately 6.0 cfs of attractant flow from the upstream intake to water-up the ponds. Adult salmonids migrating upstream entered the ponds through a series of ladder steps and eventually entered a secure collection area (Figure 4). The collection ponds were operated twice weekly starting on September 1st, and 10 separate occasions in total, to capture LCR fall Chinook salmon throughout the adult migration in 2009 (Table 1). All captured adult LCR fall Chinook salmon were enumerated by origin (hatchery or natural) based on adipose fin absence or presence and by sex. Spring Chinook salmon, LCR fall Chinook salmon, and Upriver Bright fall Chinook salmon (URB) were differentiated according to run timing and visual identification.

For captured LCR fall Chinook salmon, an individually numbered floy-tag was inserted adjacent to the dorsal fin, in the white muscle tissue for use in deriving population estimates and to determine residence time prior to spawning mortality. Due to the reliable operation of a video passage system these floy tags were not needed to calculate reliable population estimates. Captured LCR fall Chinook salmon were held for tagging within a 150 gallon tub and anesthetized using low voltage DC current (i.e. electro-anesthesia). Within seconds of reducing the voltage, fish recovered from electro-anesthetic and were released directly upstream of the weir in a slow velocity section of the river. Captures of coho salmon, steelhead, and upriver bright fall Chinook salmon were enumerated by origin (hatchery or natural) and released upstream of the weir. Precautions were in place for the potential collection of ESA-listed bull trout (Engle and Skalicky 2009) but none were encountered. To aid in downstream passage over the weir, several resistance boards were not engaged in the thalweg of the river and sandbags were placed on the associated weir panels (Figure 5). This occurred after the first two weeks of operation and provided approximately 3 inches of flow over the top of the weir to aid downstream passage. Initially, an effort to count fish moving downstream over the weir was attempted by sinking panels for approximately 30 minutes while positioning staff to count passage. This was shortly abandoned after staff noticed fish attempting downstream passage during off-peak movement hours and during the night.

Video Passage Enumeration

A video passage system, modified from a design used in Alaska for escapement estimation of sockeye salmon adults (Gates et al. 2004), was used to enumerate movements around the weir when ponds were closed to collection. The video passage system (VPS) consists of two primary components; an underwater passage chute to allow fish to volitionally bypass the weir and a video box that housed an underwater camera and two 20 watt halogen underwater landscape lights. The lights illuminated the passage chute 24 hours a day and were directed towards the rear of the video box to create indirect lighting. Figure 6 provides images of the video system as well its placement in relation to the ponds and the weir. A Sanyo DSR-300 or DSR-3000 digital video recorder (DVR) with motion detection software was mounted in a secure box on top of the pond wall and set to record fish movement through the passage chute. The DVRs monitoring of fish passage using event-triggered video technology similar to a design used in monitoring fish wheel catch in Alaska (Daum 2005). The DVRs were switched twice weekly, archived to DVD, and reviewed by staff for species identification, size (jack < 60 cm, adult > 60 cm), origin based on adipose fin presence (wild) or absence (hatchery), sex (male, female, unknown), migration (upstream, no movement, or downstream) and time of passage (hour:minute).

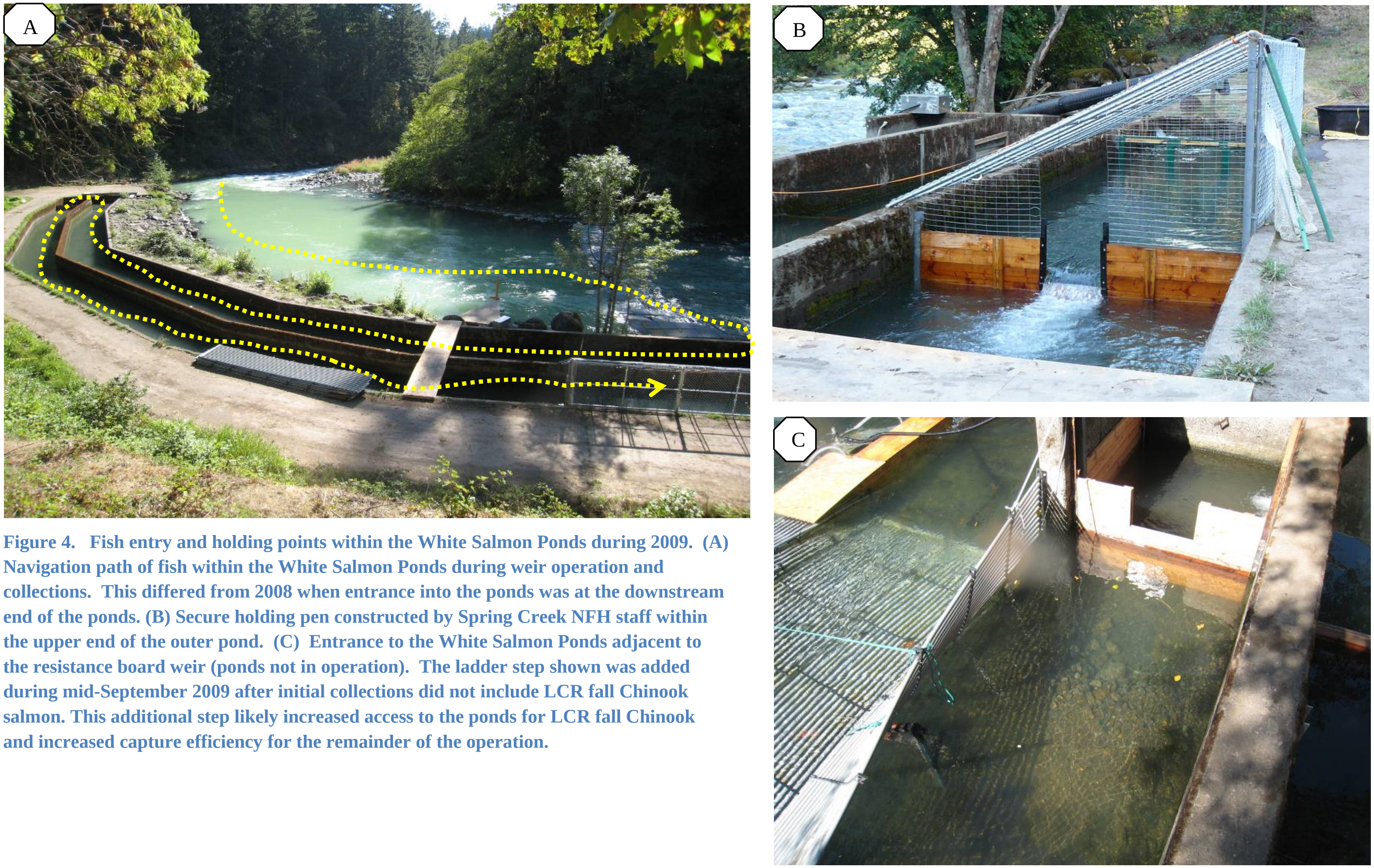

Figure 4. Fish entry and holding points within the White Salmon Ponds during 2009. (A) Navigation path of fish within the White Salmon Ponds during weir operation and collections. This differed from 2008 when entrance into the ponds was at the downstream end of the ponds. (B) Secure holding pen constructed by Spring Creek NFH staff within the upper end of the outer pond. (C) Entrance to the White Salmon Ponds adjacent to the resistance board weir (ponds not in operation). The ladder step shown was added during mid-September 2009 after initial collections did not include LCR fall Chinook salmon. This additional step likely increased access to the ponds for LCR fall Chinook and increased capture efficiency for the remainder of the operation.

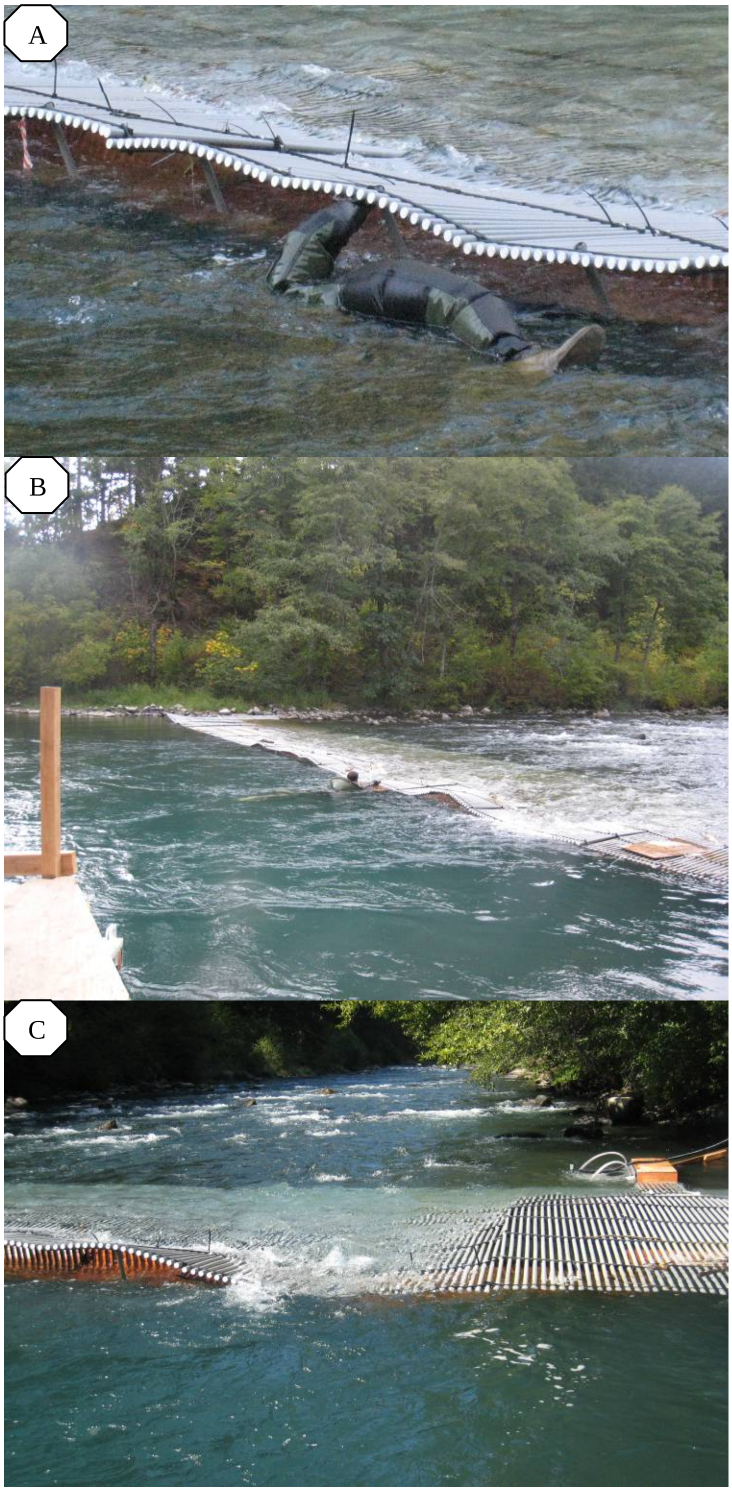

Figure 5. Photographs of the resistance board weir in the White Salmon River operated at the White Salmon Ponds during 2009. (A) A snorkeler checks for carcasses under the weir panels. The resistance boards are engaged and elevate the weir to not allow downstream passage over the weir. (B, C) Changes made during operation of the weir to allow downstream passage. Several resistance boards were not engaged, particularly in areas of high current where fish were observed attempting to move downstream by U.S. Fish and Wildlife Service staff. The depth of the channel near the downstream edge of the weir, and the configuration of the underwater concrete sill, likely helped limit jump attempts by migrating fall Chinook salmon.

Table 1. Method of sampling conducted at the White Salmon Ponds in combination with the resistance board weir during 2009. Start and end times, as well as duration (hours), is provided. Two video failures that occurred during 2009 are identified.

Sampling Category	Start	End	Duration (hours:minutes)
Video Passage	8/25/09 12:11	8/28/09 9:11	69:00
Video Failure[1]	8/28/09 9:11	8/29/09 16:37	31:26
Video Passage	8/29/09 16:37	9/1/09 12:00	67:23
Collection Ponds	9/1/09 12:00	9/2/09 12:00	24:00
Video Passage	9/2/09 12:00	9/3/09 10:38	22:38
Collection Ponds	9/3/09 10:38	9/4/09 10:14	23:36
Video Passage	9/4/09 10:14	9/8/09 11:41	97:27
Collection Ponds	9/8/09 11:41	9/9/09 9:19	21:38
Video Passage	9/9/09 9:19	9/10/09 10:35	25:16
Collection Ponds	9/10/09 10:35	9/11/09 9:44	23:09
Video Passage	9/11/09 9:44	9/14/09 10:59	73:15
Collection Ponds	9/14/09 10:59	9/15/09 8:20	21:21
Video Passage	9/15/09 8:20	9/16/09 9:40	25:20
Collection Ponds	9/16/09 9:40	9/17/09 8:30	22:50
Video Passage	9/17/09 8:30	9/21/09 16:45	104:15
Collection Ponds	9/21/09 16:45	9/22/09 8:30	15:45
Video Passage	9/22/09 8:30	9/23/09 15:30	31:00
Collection Ponds	9/23/09 15:30	9/24/09 9:00	17:30
Video Passage	9/24/09 9:00	9/28/09 14:15	101:15
Collection Ponds	9/28/09 14:15	9/29/09 8:30	18:15
Video Passage	9/29/09 8:30	9/30/09 14:30	30:00
Collection Ponds	9/30/09 14:30	10/1/09 10:00	19:30
Video Passage	10/1/09 10:00	10/2/09 19:11	33:11
Video Failure[2]	10/2/09 19:11	10/6/09 14:57	91:46
Video Passage	10/6/09 14:57	10/9/09 10:55	67:58

[1] A passing rainstorm activated a ground fault circuit interrupter that supplied power the video system.
[2] The memory in the digital video recorder was filled to capacity. Rather than overwrite data, the system stopped archiving video.

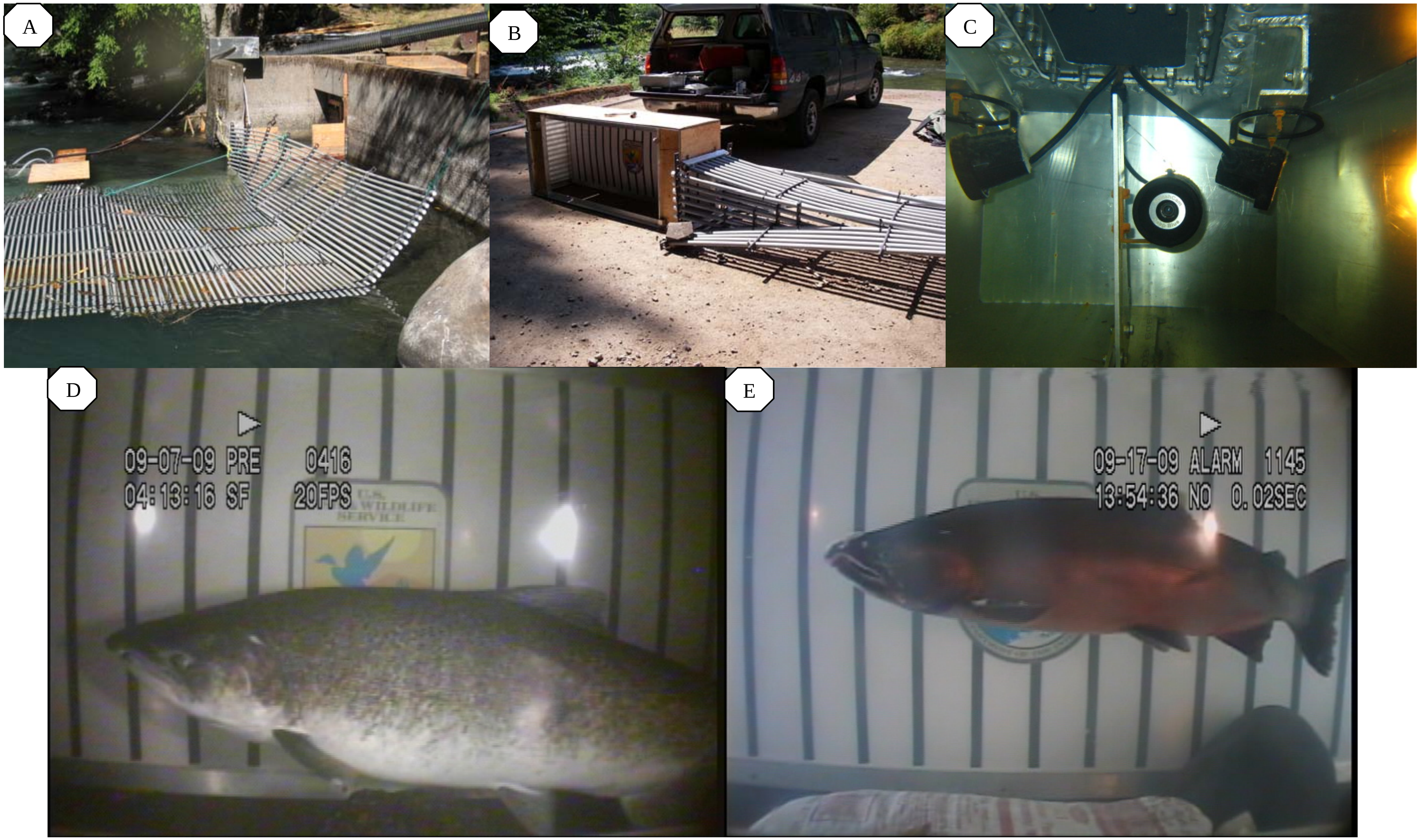

Figure 6. Images of the video passage system (VPS) used by U.S. Fish and Wildlife Service staff during White Salmon Ponds and weir operation during 2009. (A) The VPS is in the left side of the photo approximately 8 feet from the opening of the White Salmon Ponds. (B) A single, 4 ft wide panel was modified to allow for entrance of migrating fish into the passage chute video system once attached into the weir. A steel sawhorse was placed under the modified panel to improve navigation of migrating salmonids to the passage chute opening. (C) An interior photo of the camera and lighting within the video box showing indirect lighting of the system of the page chute. The camera and lights were placed in a water-filled, water-tight trapezoidal aluminum box with a safety glass window that attached to the passage chute shown in picture B. This design was provided by USFWS staff in the Kenai Fish and Wildlife Field Office (Ken Gates, USFWS, personal communication.) (D) Nighttime video capture of a lower Columbia River fall Chinook salmon. The date and time stamp of the video image is visible. (E) Daytime video capture of a coho salmon. The time and date stamp are visible, as is a sandbag placed in the chute to direct fish into the field-of-view.

Escapement Estimation

Point estimates of the escapement above the weir are considered a complete census with the exception of two periods during which the video system failed (Table 1). To account for the unknown escapement during the periods of video failure, we used a catch-per-unit-effort (CPUE) method and the area-under-the-curve (AUC) method to estimate the total abundance of fish above the weir.

The catch-per-unit-effort escapement estimate was calculated as

$$Escapement\ above\ weir = \frac{Catch}{Effort} \times Study\ Duration$$

Catch includes all fish captured in the collection ponds and fish recorded as upstream migrants using the video passage system. Using trapezoidal approximation, the area-under-the-curve escapement estimate was calculated as

$$AUC = \sum_{i=2}^{n} (t_i - t_{i-1}) \frac{(x_i + x_{i-1})}{2}$$

where t_i is the day and x_i is the number of salmon observed for the i^{th} survey (Hilborn et al. 1999). For this approximation to be successful the first and last counts of fish need to be zero. If these counts are not zero, as in situations where partial season escapement estimates are required, additional calculations described in Hilborn et al. (1999) may be conducted to obtain the AUC for the first and last sample periods. In this study, depending on the species escapement being estimated, the first and last periods were not always zero. However, because our study encompassed the entire season of interest (i.e., no partial season escapement estimates were required) and considering the small numbers of fish present at the first and last periods; we opted to not expand our escapement estimates using these additional calculations.

Coded Wire Tag Sampling and Age Composition

Adult salmonid carcasses (from natural and weir-induced mortalities) were collected from the weir and examined for coded wire tags (CWTs) during the course of the study. Also, scales were collected and fork length (cm) recorded from carcasses that were not in extreme decay. Carcass sampling coincided with operation of the ponds and switching of DVRs, usually between 3 to 5 occasions per week. Coded wire tags were removed, read, and investigated on the Regional Mark Processing Center website (http://www.rmpc.org/) to identify age and origin. Scales were heat pressed into acetate stock and read by two independent observers for age determination if a CWT was not presence. A single discrepancy in age determination was concluded by a third observer. When external tags were encountered on a carcass, they were read and reported to the tagging agency.

Fish Behavior in Relation to the Weir

Concerns were voiced by members of the White Salmon River Working group regarding how the White Salmon weir may impede or otherwise affect migrating salmon including LCR fall Chinook, steelhead and coho as they attempt to migrate upstream past the weir or enter the collection ponds. To address this issue, we tested the feasibility of using a dual frequency identification sonar (DIDSON) to evaluate salmonid behavior below the weir. This assessment was exploratory in nature and only coincided with a small portion of the adult migration period.

The DIDSON acoustic camera is a sophisticated scientific echosounder that was originally developed for military purposes by the University of Washington's Applied Physics Lab in Seattle, WA (Belcher et al. 2001). The DIDSON uses multiple high frequency beams with a unique acoustic lens system that focuses the beams and creates high resolution acoustic video images. The acoustic beam is divided into 96 beams with a combined view spanning 29 degrees. The DIDSON's unique configuration makes it well suited for behavioral and quantitative assessments of salmonids (Boswel et al. 2008; Homes et al. 2006; Tiffan et al. 2004).

In early September 2009, we fabricated a 9 foot wood scaffolding for mounting an adjustable DIDSON deployment bracket (Figure 7) which the DIDSON camera is mounted to. The bracket can be adjusted for depth, rotational angle and vertical pitch. The bracket and camera were approximately 9 feet from shore and 18 feet downstream of the weir with a camera depth of approximately 5 feet. We used a standard unibody DIDSON which can operate in either high (1.8MHz) or low frequency (1.1MHz) modes. We used the 1.8MHz mode to generate the highest quality images and to accommodate the shorter range of our targets. Operating at this mode the camera can effectively image out approximatly 45 feet but we chose to image out 21 feet which is 30 feet from the opposite shore. At this point, the riverbed rises becoming relatively shallow and the number of salmonids present past 30 feet was minimal in our test recordings and field observations. The scaffolding was required to place the camera in the best possible location for imaging fish with respect to the channel configuration below the weir. The cameras beams must be unobstructed and image the portion of channel that most of the fish are using.

The DIDSON camera was deployed perpendicular to the current facing the opposite shoreline (Figure 6). A laptop computer was used to autonomously record acoustic video during 5 days of monitoring. Separate files were collected for successive hours and each file was assessed individually. Fish smaller than approximately 30 cm were not enumerated due to the presence of rainbow trout and mountain whitefish. In addition, discrimination between individual species was not possible; therefore all fish greater than 30 cm were assessed as salmonids. For each hour, the average number of salmonids present was visually enumerated. Each file was reviewed at a rate of 5 times that of real-time. For each file, 10 random video segments were reviewed and average salmonid density calculated. It was not possible to enumerate the number of fish passing through the acoustic array. In our initial attempts to do so, we observed the same fish or groups of fish recirculation between the acoustic array and weir. In addition to hourly fish densities, we noted anecdotal information regarding fish behavior in relation to the weir.

Figure 7. Scaffolding fabricated below the White Salmon River weir with the deployment bracket and DIDSON camera attached. The shaded triangle depicts the area being imaged by the DIDSON camera. The scaffolding was located approximately 18 feet downstream of the weir.

Results

Collection and Capture Feasibility of the White Salmon Ponds

A total of 688 LCR fall Chinook salmon (404 hatchery origin and 284 natural origin, Table 2) were identified moving upstream through the VPS or directly captured in the ponds (Table 3). Pond captures of LCR fall Chinook potentially improved after September 9th when an additional step was placed in the entrance to the White Salmon Ponds (Figure 4).

In addition to adult LCR fall Chinook salmon, other adult salmonids were captured in the ponds or detected moving upstream through the VPS. Adult summer steelhead of both hatchery and natural origin were numerous at 228 and 63, respectively. Smaller numbers of natural origin coho salmon (69) and upriver bright fall Chinook salmon (53) were observed and were more numerous than their corresponding hatchery counterparts (13 coho salmon and 29 upriver bright fall Chinook salmon). A total of 82 spring Chinook salmon were identified during the study and all were of hatchery origin. One male pink salmon was also enumerated moving upstream and then downstream in the VPS on September 15th.

Video Passage Enumeration and Escapement Estimation

Peak upstream enumeration of LCR fall Chinook salmon through the VPS occurred during the period encompassing September 9th –15th and peak enumeration of summer steelhead occurred during September 27th-30th (Figure 8). Downstream peak enumeration occurred near the same period for LCR fall Chinook salmon but slightly earlier for summer steelhead (Figure 9). Generally, the number of fish detected moving downstream was considerably less than those moving upstream for all of the adult salmonids that were enumerated during the operation of the VPS. For LCR fall Chinook, 688 detections of adults moving upstream occurred within the VPS with only 65 detections of downstream movements for a proportion of downstream to upstream detections of 0.094. Of the other adult salmonid species that were enumerated in the VPS, steelhead had the highest proportion of downstream detections compared to upstream detections (0.202 or 59 to 291, respectively). Upstream passage detections of LCR fall Chinook salmon was highest between 15:00 to 18:00 hours and summer steelhead highest in early morning (06:00 - 08:00) and early evening (14:00 - 16:00). Figures 10 and 11 identify peak counts of upstream and downstream diel migrations of adult salmonids in the White Salmon River during VPS operations.

Based on the two estimation methods of CPUE and AUC without a defined endpoint, we estimate a total of 725 - 777 LCR fall Chinook salmon escaped to the weir in 2009 (Table 4). Adult hatchery origin escapement was estimated to be between 408 – 456 and natural origin escapement was estimated to be between 317 - 321. Summer steelhead were the second most abundant fish during the study period with an escapement estimated to be between 294 - 329 with the majority being from hatchery origin (229 - 257).

Table 2. Adult salmonids enumerated through the video passage system and White Salmon Ponds during 2009 on the White Salmon River. Days of White Salmon Ponds operation are **highlighted**. Pond collections totals are provided in parentheses. Total number of coho salmon (COHO), Lower Columbia River fall Chinook salmon (FCS), spring Chinook salmon (SCS), summer steelhead (SST) and upriver bright fall Chinook salmon (URB) by origin are provided. One pink salmon was also detected on September 15th.

		Natural Origin (Adipose Present)					Hatchery Origin (Adipose Clipped)				
DATE	Day of year	COHO	FCS	SCS	SST	URB	COHO	FCS	SCS	SST	URB
8/25/2009	237								7		
8/26/2009	238								8	1	
8/27/2009	239							2	9	1	
8/28/2009	240								2		
8/29/2009	241							5			
8/30/2009	242							21	5	1	
8/31/2009	243		1					8	2	1	
9/1/2009	244							5(1)	1	2	
9/2/2009	245	1			1			2	10	4	
9/3/2009	246		1(1)						7	2	
9/4/2009	247		1						3		
9/5/2009	248		1					2	4	3	
9/6/2009	249				1			8	5	4	
9/7/2009	250	1	5		2			11	1	9	
9/8/2009	251				2(2)			6		8(6)	
9/9/2009	252		5		1			28		6	
9/10/2009	253				1(1)			8(5)		7(3)	
9/11/2009	254	1			1			6	1	3	
9/12/2009	255	5	4		1		2	15		9	
9/13/2009	256	1	38		3			37	6	4	
9/14/2009	257	2(1)	14 (6)		3			20(11)	9(3)	11(7)	2(1)
9/15/2009	258	1	27		3	6	1	41		7	5
9/16/2009	259		6(4)		2			14(7)		5(1)	1(1)
9/17/2009	260	2	10			2	1	19		4	3
9/18/2009	261	2	4			1		6	2	8	
9/19/2009	262	1	15			2		28		8	1
9/20/2009	263	4	11		2	5		17		8	
9/21/2009	264		4(2)		4(1)		2(1)	16(5)		2	
9/22/2009	265	1	21		1	1	2	17		9	1
9/23/2009	266		13(9)		1	1		20(13)		7(1)	
9/24/2009	267		1					3		2	
9/25/2009	268	1	5		3		1			7	
9/26/2009	269		2		2	8		8		26	2
9/27/2009	270	4	22		6	4		12		14	
9/28/2009	271	7(5)	17(13)		10(2)	4(2)		8(4)		18(2)	2(2)
9/29/2009	272	4	8		2	3	1	1		6	2
9/30/2009	273	1	4(1)		4	1		1		11(2)	
10/1/2009	274	5	10		3			2		3	2
10/2/2009	275	3	22		2	2		3		1	3
10/6/2009	279	3	1			1					
10/7/2009	280	6	6			4		1			
10/8/2009	281	8	1		1	6	2	2		4	2
10/9/2009	282	5	4		1	2	1	1		2	3
	Totals	69(6)	284(36)	0	63(6)	53(2)	13(1)	404(46)	82(3)	228(22)	29(4)

Table 3. Adult salmonid captures at the White Salmon Ponds during 2009. The ponds were operated on 10 occasions, each approximately 24 hours in duration, during late August and September 2009. Dates of Operation for the White Salmon Ponds and the video passage system are provided in Table 1.

Species	Natural Origin (Adipose Present)	Hatchery Origin (Adipose Clipped)
Coho salmon	6	1
Steelhead	6	22
Lower Columbia River fall Chinook salmon	36	46
Upriver bright fall Chinook salmon	2	4
Spring Chinook salmon	0	3

Table 4. Escapement estimates of adult salmonids the White Salmon River weir (river mile 1.1) during 2009. Dates of operation for the White Salmon Ponds and the video passage system are provided in Table 1. Estimates were calculated for coho salmon (COHO), Lower Columbia River fall Chinook salmon (FCS), spring Chinook salmon (SCS), summer steelhead (SST) and upriver bright fall Chinook salmon (URB).

	Natural Origin (Adipose Present)					Hatchery Origin (Adipose Clipped)					All fish				
Type of Estimate	COHO	FCS	SCS	SST	URB	COHO	FCS	SCS	SST	URB	COHO	FCS	SCS	SST	URB
Point Estimate	69	284	0	63	53	13	404	82	228	29	82	688	82	291	82
Catch Per Unit Effort (CPUE)	78	321	0	71	60	15	456	93	257	33	93	777	93	329	93
Area Under the Curve (Without Endpoint)	76	317	0	66	57	13	408	79	229	32	88	725	79	294	89

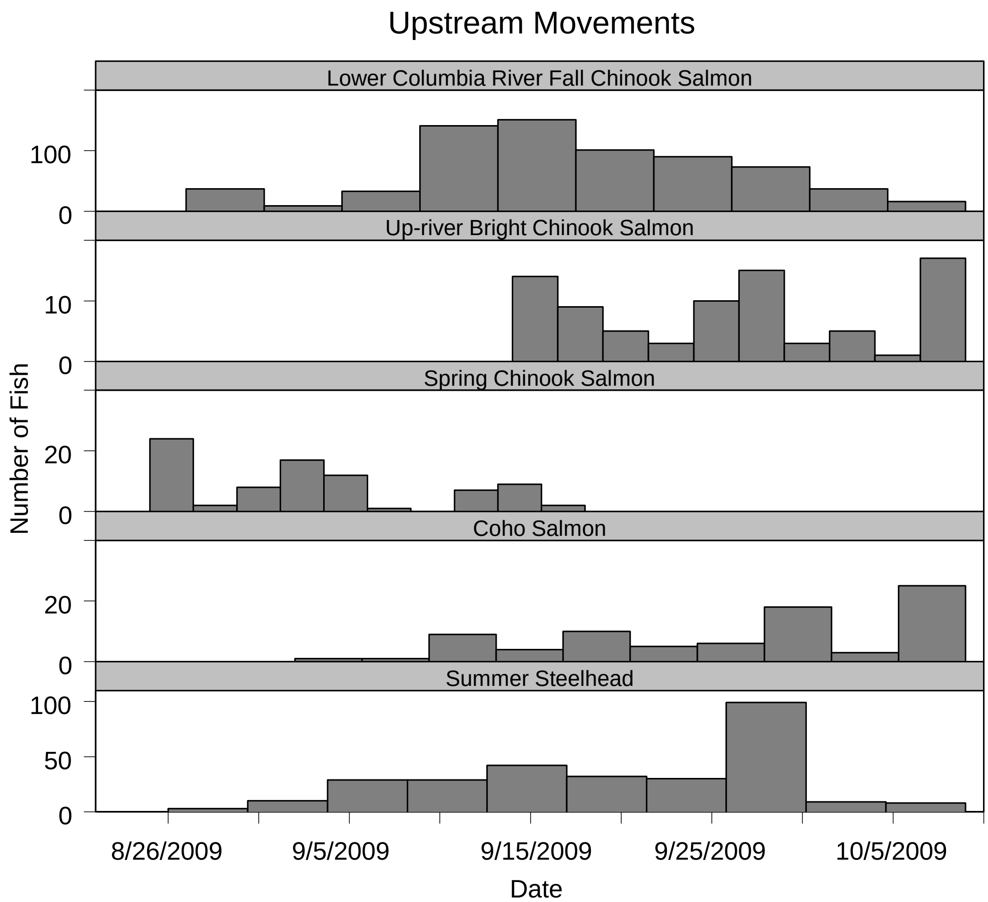

Figure 8. Upstream migration of adult salmonids by date at the White Salmon River weir (RM 1.4) during 2009. A fish was considered an upstream migrant if it was observed traveling upstream through the video passage system or was captured in the collection ponds. Dates of Operation for the video passage system are provided in Table 1.

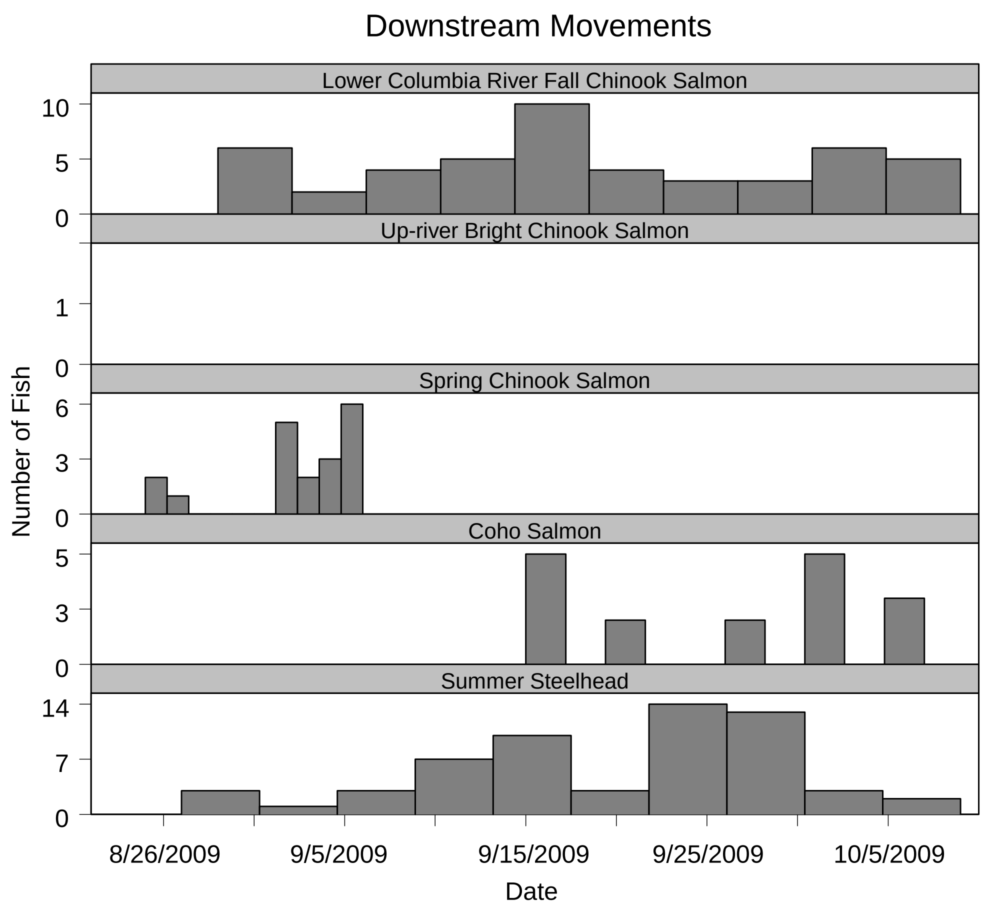

Figure 9. Downstream migration of adult salmonids by date through the video passage system in the White Salmon River weir (RM 1.4) during 2009. Dates of Operation for the video passage system are provided in Table 1.

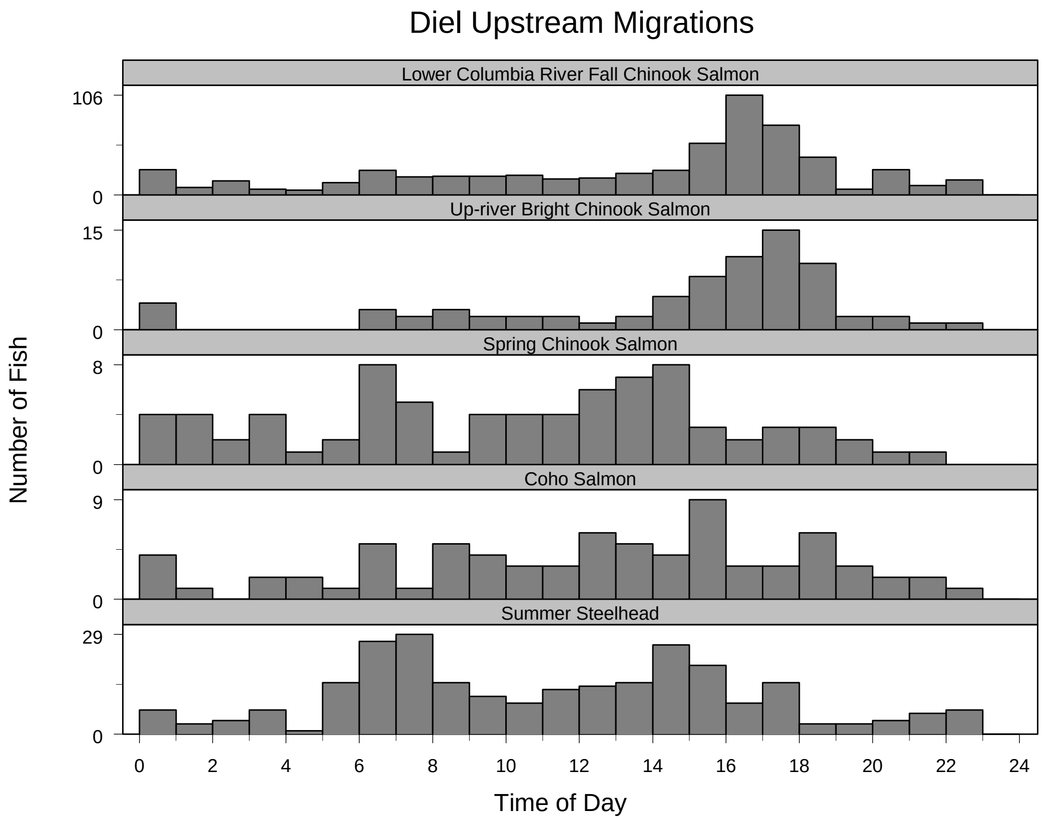

Figure 10. Diel upstream migration of adult salmonids through the video passage system in the White Salmon River weir (RM 1.4) during 2009. Dates of Operation for the video passage system are provided in Table 1.

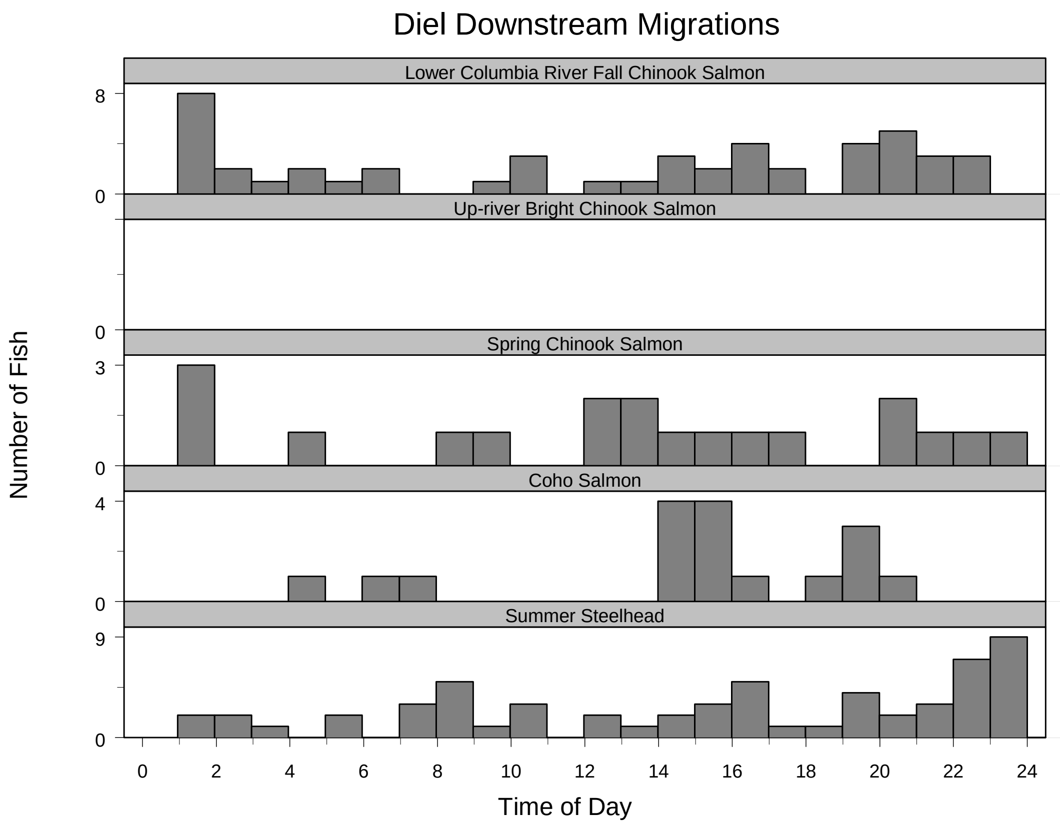

Figure 11. Diel downstream migration of adult salmonids through the video passage system in the White Salmon River weir (RM 1.4) during 2009. Dates of Operation for the video passage system are provided in Table 1.

Coded Wire Tag Sampling and Age Composition

A total of 110 spring Chinook salmon carcasses were examined for coded wire tags (CWT) and 16 CWTs were recovered (Table 5). with 7 randomly selected for biosample information (i.e., scales and length). For LCR fall Chinook salmon 100% of the natural origin and 50% of the hatchery origin adults were biosampled and all were examined for CWTs. A total of 46 natural origin and 27 hatchery origin LCR Chinook salmon adults were biosampled and only one hatchery origin adult had a CWT (Table 5). One coho salmon, one summer steelhead and one mountain whitefish were also biosampled (Appendix A).

Table 5. Coded wire tag (CWT) recoveries from the operation of the White Salmon River weir during 2009. Species information is abbreviated (SCS = spring Chinook salmon, FCS = Lower Columbia River fall Chinook salmon) and length information is in centimeters. Data provided by the Regional Mark Information System (RMIS). All hatchery programs are located in Washington unless otherwise stated.

Date	Species	Sex	Length	CWT	Hatchery Program	Release Year	Brood Year
9/1/2009	SCS	U	62	052965	LTL WHITE SALMON NFH	2008	2006
9/1/2009	SCS	U	U	052975	LTL WHITE SALMON NFH	2008	2006
9/1/2009	SCS	U	U	052598	LTL WHITE SALMON NFH	2007	2005
9/2/2009	FCS	U	U	050686	SPRING CR NFH	2008	2007
9/3/2009	SCS	M	59	105581	CLEARWATER HATCHERY, IDAHO	2008	2007
9/3/2009	SCS	M	52	052965	LTL WHITE SALMON NFH	2008	2006
9/3/2009	SCS	M	54	052975	LTL WHITE SALMON NFH	2008	2006
9/3/2009	SCS	M	53	053091	WARM SPRINGS NFH, OREGON	2006	2005
9/4/2009	SCS	M	57	052975	LTL WHITE SALMON NFH	2008	2006
9/4/2009	SCS	M	53	052975	LTL WHITE SALMON NFH	2008	2006
9/4/2009	SCS	M	U	052975	LTL WHITE SALMON NFH	2008	2006
9/6/2009	SCS	F	61	052965	LTL WHITE SALMON NFH	2008	2006
9/6/2009	SCS	M	59	052965	LTL WHITE SALMON NFH	2008	2006
9/6/2009	SCS	M	60	052965	LTL WHITE SALMON NFH	2008	2006
9/6/2009	SCS	M	55	052975	LTL WHITE SALMON NFH	2008	2006
9/14/2009	SCS	M	59	052965	LTL WHITE SALMON NFH	2008	2006
9/16/2009*	SCS	U	51	094622	ROUND BUTTE STATE HATCHERY, OREGON	2008	2006

* Also present was a gray floy tag from the Oregon Department of Fish and Wildlife, Dalles Office

Fish Behavior in Relation to the Weir

We collected a total 66 hours (33 daylight, 33 nighttime) of acoustic video on September 10th, 11th, 15th 16th and 17th (Table 6). Daylight and nighttime was differentiated according to the official daylight hours for White Salmon, WA. A discernable diel pattern of fish densities occurred throughout the monitoring period. Average hourly salmonid densities during the day were 4.1 times higher than densities at night. The highest density observed during the day was 13.2 salmonids/hour and occurred at 1300 hours. Conversely, the highest hourly density at night was 2.8 salmonids/hour (Figure 12). The overall pattern is best depicted in a 24 hour time series collected on September 16th (Figure 13).

On September 15, during a period when the video passage system was in operation (i.e., weir passage allowed) and the ponds were closed, the highest daytime densities were between 8 and 9 salmonids/hour. This occurred for three consecutive hours followed by a marked decline in densities. Two hours after that peak the video camera in the weir recorded a season high of 40 salmonids passing through the weir between 1600 and 1700 hours. This was also followed by a sharp decline in weir passage (Figure 14). The densities observed below the weir appear to be supported by video counts, as well as the subsequent drop in densities and weir counts.

Table 6. Average hourly densities of salmonids present within the DIDSON's acoustic array.

File, Date_Hour	Hourly Density	File, Date_Hour	Hourly Density
2009-09-10_1500_HF.ddf	0.8	2009-09-16_0100_HF.ddf	0.1
2009-09-10_1600_HF.ddf	2.5	2009-09-16_0200_HF.ddf	2.8
2009-09-10_1700_HF.ddf	2.8	2009-09-16_0300_HF.ddf	2.5
2009-09-10_1800_HF.ddf	1.8	2009-09-16_0400_HF.ddf	0.4
2009-09-10_1900_HF.ddf	1.6	2009-09-16_0500_HF.ddf	0.4
2009-09-10_2000_HF.ddf	1.4	2009-09-16_0600_HF.ddf	2.2
2009-09-10_2100_HF.ddf	0.7	2009-09-16_0700_HF.ddf	3.3
2009-09-10_2200_HF.ddf	0.3	2009-09-16_0800_HF.ddf	4.4
2009-09-10_2300_HF.ddf	0.8	2009-09-16_0900_HF.ddf	7.8
2009-09-11_0000_HF.ddf	0.7	2009-09-16_1000_HF.ddf	9.2
2009-09-11_0100_HF.ddf	0.5	2009-09-16_1100_HF.ddf	11.3
2009-09-11_0200_HF.ddf	1.1	2009-09-16_1200_HF.ddf	11.3
2009-09-11_0300_HF.ddf	1.1	2009-09-16_1300_HF.ddf	13.2
2009-09-11_0400_HF.ddf	1.0	2009-09-16_1400_HF.ddf	9.5
2009-09-11_0500_HF.ddf	2.1	2009-09-16_1500_HF.ddf	5.1
2009-09-11_0600_HF.ddf	2.1	2009-09-16_1600_HF.ddf	2.8
2009-09-11_0700_HF.ddf	3.4	2009-09-16_1700_HF.ddf	2.0
2009-09-11_0800_HF.ddf	3.9	2009-09-16_1800_HF.ddf	1.1
2009-09-15_1000_HF.ddf	4.1	2009-09-16_1900_HF.ddf	0.5
2009-09-15_1100_HF.ddf	4.1	2009-09-16_2000_HF.ddf	0.1
2009-09-15_1200_HF.ddf	5.5	2009-09-16_2100_HF.ddf	0.3
2009-09-15_1300_HF.ddf	8.4	2009-09-16_2200_HF.ddf	1.3
2009-09-15_1400_HF.ddf	8.6	2009-09-16_2300_HF.ddf	1.0
2009-09-15_1500_HF.ddf	8.7	2009-09-17_0000_HF.ddf	1.5
2009-09-15_1600_HF.ddf	4.5	2009-09-17_0100_HF.ddf	1.2
2009-09-15_1700_HF.ddf	1.4	2009-09-17_0200_HF.ddf	1.3
2009-09-15_1800_HF.ddf	0.8	2009-09-17_0300_HF.ddf	0.6
2009-09-15_1900_HF.ddf	1.4	2009-09-17_0400_HF.ddf	0.6
2009-09-15_2000_HF.ddf	1.1	2009-09-17_0500_HF.ddf	1.2
2009-09-15_2100_HF.ddf	0.8	2009-09-17_0600_HF.ddf	1.3
2009-09-15_2200_HF.ddf	0.8	2009-09-17_0700_HF.ddf	2.0
2009-09-15_2300_HF.ddf	2.0	2009-09-17_0800_HF.ddf	2.4
2009-09-16_0000_HF.ddf	2.0	2009-09-17_0900_HF.ddf	2.1

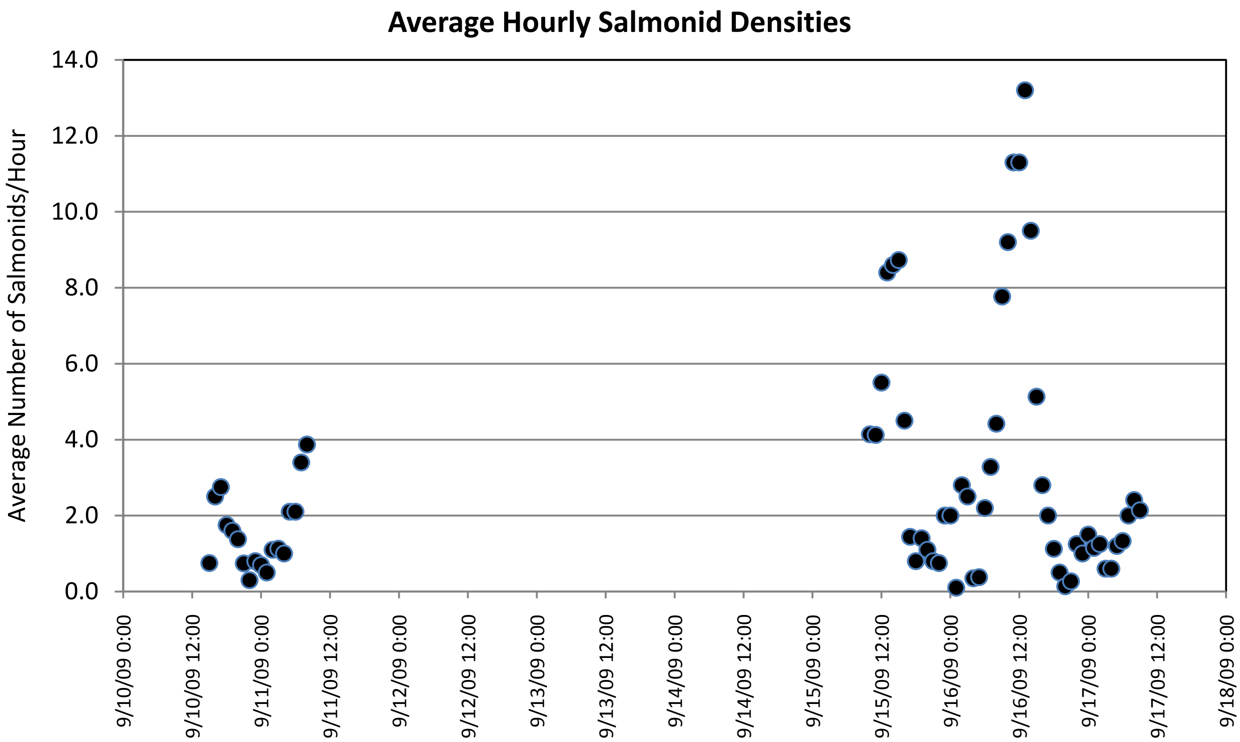

Figure 12. Average hourly salmonid densities for the 66 hours of data acoustic data collected.

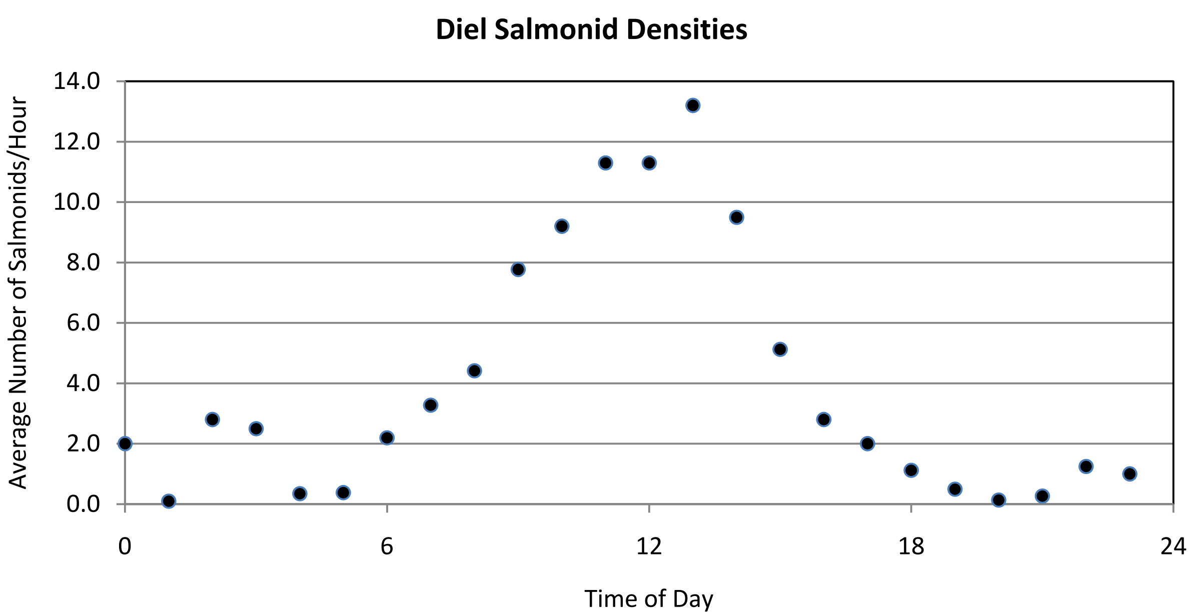

Figure 13. Average hourly salmonid densities for a 24 hour time series on September 16th 2009.

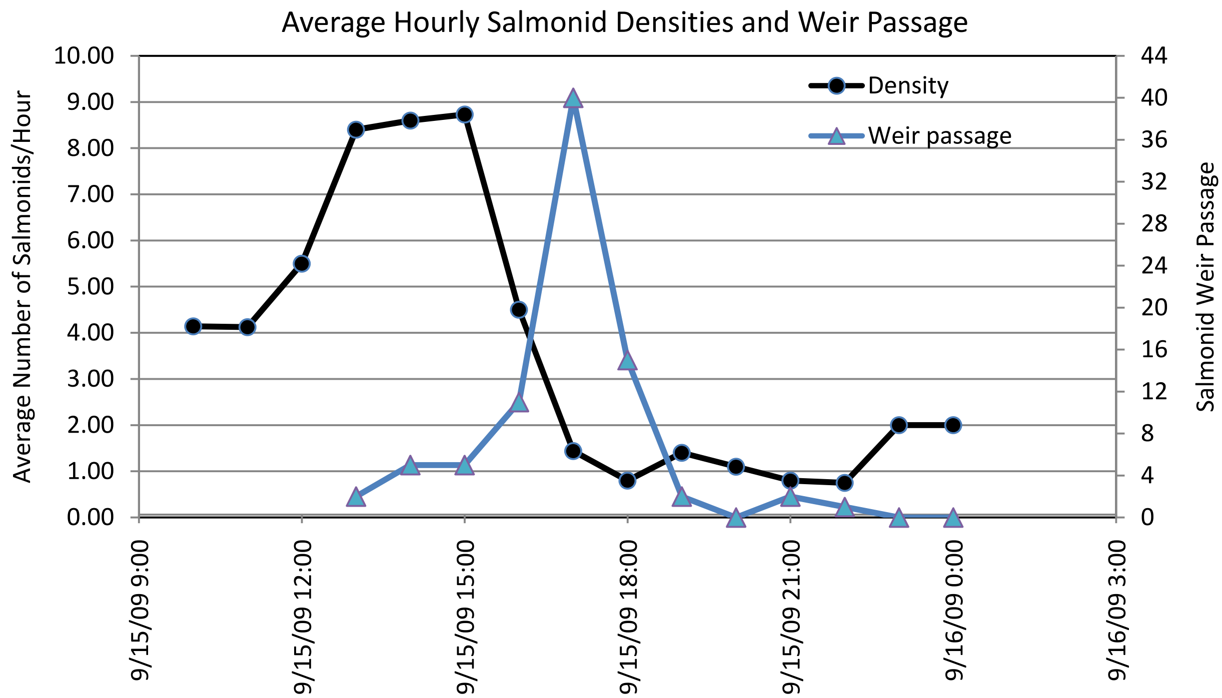

Figure 14. Comparison of average hourly salmonid densities (left y-axis) observed below the weir with the DIDSON camera and hourly video counts of salmonids passing through the weir (right y-axis).

Discussion and Recommendations

Collection and Capture Feasibility of the White Salmon Ponds

Overall, we found the use of a resistance board weir combined with the operation of the White Salmon Ponds a feasible tool for collection of adult LCR fall Chinook salmon. During the year of Condit Dam removal we would expect similar results. Daily captures of adult salmonids during pond operation seemed comparable to the number and species composition of adults passing through the VPS at the time (Table 2). Additionally, even though the White Salmon Ponds have not been operated extensively for adult salmonid collection since the 1970's, the existing ponds combined with the resistance board weir and minor pond restoration was adequate for this short-term operation.

During the early period of this study, we did observe limited mortality of adult salmonids on the weir, which presumably had passed upstream through the VPS and were attempting downstream passage over the top of the weir (Table 7). A portion of these mortalities could have been associated with catch-and-release practices from sport angling in the area. We base this assumption on the number of natural origin recoveries, presence of fishing tackle on the weir, and comparison to natural and hatchery origin numbers of adult salmonids passing through the VPS. Mortalities could have also occurred due to the higher velocities immediately upstream of the weir and inability of fish to pass over the weir when the resistance boards were engaged.

Visual examination of these early mortalities were deemed “healthy” by the crew and were likely not post-spawn adults.

Table 7. Mortalities associated with the operation of the White Salmon River weir and collection ponds during 2009. Direct observation of mortalities was not observed but these fish were separated from post-spawn carcass recoveries due to healthy appearance, initial operation of the weir with all the resistance boards activated, or circumstances of recovery.

Species	Hatchery Origin (Adipose Present)	Natural Origin (Adipose clipped)
Coho salmon	0	1
Steelhead	0	3
Lower Columbia River fall Chinook salmon	1	3
Mountain Whitefish	0	2
*Oncorhynchus mykiss** (juvenile)	0	1

*Observed ahead of the secure collection area in the White Salmon Ponds, suggesting the morality occurred from the water intake.

Most spring Chinook salmon carcasses we encountered were post-spawn, near death, or in a state of advanced decay. After providing better access to downstream passage over the weir, we observed adult LCR fall Chinook salmon and steelhead moving downstream with little effort. We also noted two occasions where adults jumped onto the weir and passed upstream. This occurred in conjunction with increased streamflow from Condit Dam, which typically occurred around 17:00 hours and lasted for a short duration. The mass and force of this increased flow further submerged the weir below normal operating levels and provided salmonids with easier access over the top of the weir.

Video Passage Enumeration and Escapement Estimation

The enumeration of LCR fall Chinook salmon through the VPS, plus the total number of LCR fall Chinook salmon captured in the White Salmon Ponds approached the target number of adults that can be supported by the spawning habitat upstream of Condit Dam (500-600 per discussions within the WSWG). Additionally, our CPUE and AUC escapement estimates are in excess of this target number. Both the enumeration of LCR fall Chinook salmon within the VPS and the escapement estimates may be slightly inflated because downstream passage was not strictly controlled and enumerated. Both the weir and VPS allowed downstream passage, hence double counting adults could have occurred with adults salmonids allowed to move both upstream and downstream on a number of occasions. We believe double counting did occur but not at a significant scale to introduce substantial bias in our estimates.

During the video review we observed individual fish, identified by scale loss patterns or distinct physical injuries that appeared to move upstream on several occasions without an accompanying downstream detection through the VPS. These fish may have passed downstream over the top of the weir and were only detected moving upstream through the VPS. We also noted floy-tagged adult LCR fall Chinook salmon moving upstream through the VPS; an indication that these fish were captured and handled during pond collections. This was expected as a number of fish we captured in the ponds moved downstream over the weir immediately after being released. Also, one hatchery origin LCR fall Chinook jack that was tagged and handled at the collection ponds was recaptured at Spring Creek NFH. This suggests some fidelity of Spring Creek NFH adults back to the hatchery after entry into the White Salmon River. This was somewhat expected considering that Engle et al. (2006) had previously documented movements of hatchery origin LCR fall Chinook salmon from Spring Creek NFH to the White Salmon River with some fish ultimately returning to the hatchery.

Fish Behavior in Relation to the Weir

The DIDSON camera is an excellent tool for quantitative assessments (Boswell et al. 2008). In addition, and unlike most traditional echosounders, the video images lend themselves to unique behavioral observations. In assessing salmonid densities we also observed several noteworthy behaviors. While densities were low during the nighttime, most of the salmonids observed at night appeared to in a relative state of torpor as compared to observed daytime activity levels. They were low in the water column and close to the river bottom. Movements were minimal and they primarily stayed in the same position. Conversely, fish observed during the day were higher in the water column and actively moving through and within the acoustic array, both upstream and downstream. Some defensive behaviors we also observed throughout a 24 hr period. Fish that were holding would actively chase other fish away that were migrating into the array. This behavior was less evident during the night.

We did not quantify upstream movement but did observe some patterns in upstream movement. Qualitatively, we observed more fish moving upstream during both dawn and dusk rather than holding in the array. The most distinct behavioral observation was from smaller fish (< 30 cm total length). During the day, they were almost always present and at times more numerous than larger salmonids (> 30 cm total length). Conversely, at night smaller fish were almost never present. Observations by snorkelers indicated that most of these fish were rainbow trout and mountain whitefish.

The objective of our acoustic work was to test the feasibility of the DIDSON camera to qualitatively assess salmonid behavior with respect to potential migration/barrier effects of the weir. As our efforts only covered a short period of the adult migration period and the results were not quantitative in nature we cannot make a definitive statement. It would appear however that large numbers of fish do hold below the weir. Large numbers were present when both the weir was open for passage and when the ponds were open for collection. It is possible that without the weir in place, fish would also hold in this location as the large concrete sill under the weir is undercut and creates a velocity shelter. Additionally, to definitely make a statement about the weir we would need similar data collected without the weir in place.

Our assessment of hourly fish densities is informative but a more quantifiable approach would involve an assessment of salmonids migrating into the pool below the weir. This could be done by locating the DIDSON just above the downstream riffle so that quantitative hourly counts could be made and compared to upstream weir passage and pond counts. In addition, collecting data throughout the entire LCR fall Chinook run would be ideal. With this approach it would be possible to statistically assess the effects of the weir and differentiate the effects of pond collections vs. upstream passage through the VPS.

Recommendations

After completion of this study, and in conjunction with the findings and recommendations of the U.S. Fish and Wildlife Service's fall 2008 feasibility study (Engle and Skalicky 2009), we recommend the following specific conservation actions are taken.

1. We recommend two methods be employed to capture LCR fall Chinook salmon: a) resistance board weir operated in conjunction with the White Salmon Ponds and b) intermittent seining effort in the lower White Salmon River between river miles 0.6 to 1.1. This recommendation is based on the success of both methods during 2008 and 2009 feasibility studies and an interest in representing both spatial and temporal components of the LCR fall Chinook salmon run. Using these two methods should also increase the overall number of natural origin LCR fall Chinook salmon available for transport upstream of Condit Dam.

2. We recommend installation of the resistance board weir earlier than mid-August to create an upstream migration block to adult salmonids. This would reduce the number of incidental mortalities of non-target adult salmonids affected by sediment flows from dam removal. Downstream passage over the weir will be provided for adult salmonids located between the weir and Condit Dam (river mile 3.3). We suggest the weir be installed in May to exclude spring Chinook salmon use above the White Salmon Ponds. This may not be possible due to discharge and logistical constraints associated with a dam operation request during the year of removal. Depending on discharge and run-off during the year of removal, weir placement could likely occur without a dam operation request in July after outmigration of salmonid smolts.

3. We recommend closure of sport fishing from Condit Dam to a point 150 yards downstream of the weir (river mile 1.0), as well as upstream of Condit Dam once transportation of LCR fall Chinook salmon begins. Without allowing upstream passage, the weir should concentrate fish immediately downstream and may increase their vulnerability to capture. Additionally, harvest or incidental catch and release of adult LCR fall Chinook salmon that have been transported upstream of Condit Dam may impact their ability to successfully reproduce.

4. Based on the number of LCR fall Chinook salmon captures in the year of removal, we recommend the use of a sliding scale to determine the number of hatchery fish that will be transported upstream of Condit Dam. Information on run timing between hatchery origin and natural origin adults in the White Salmon River during 2009 suggests a slight difference (approximately 1 week) in peak run timing that should be considered in development of the sliding scale. Historic contribution of hatchery adults in the spawning population, age composition and sex ratio should also be considered. This scale should be developed with input from the technical expertise of the WSWG parties.

5. Based on the numbers of incidental adult salmonids species (coho salmon, steelhead, upriver bright fall Chinook salmon) counted and captured during the 2009 feasibility study, we recommend the WSWG parties discuss, develop and implement an incidental species transport or surplusing program that accounts for both the capture of natural and hatchery origin adult salmonids. Transport and relocation of these incidental captures would provide fisherman an additional opportunity for harvest, as well as reduce the mortality of natural origin adults at the time of dam removal. Based on captures of incidental species in 2009, and recommendation 2 (i.e., no upstream passage beyond the weir and to Condit Dam in the year of dam removal), these adults may be captured repeatedly by seining or operation of the ponds. Transport and relocation of these captures to an area that would provide opportunity for sport and tribal harvest, and continuation of their migration to the upper Columbia Basin would be beneficial. Based on conversations within the WSWG, Drano Lake may be suitable for immediate release of these captures with minimal temperature acclimation and maximum opportunity for fisheries and continuation of migration.

Literature Cited

Belcher, E. O., Matsuyama, B., and Trimble, G. m. 2001. Object identification with acoustic lenses, In Proceedings of Oceans 2001 Conference, 5-8 November, Honolulu, Hawaii, pp. 6-11. Marine Technical Society/IEEE.

Boswell, K. M., M. P. Wilson, J. J. Cowan Jr., 2008. A Semiautomated Approach to Estimating Fish Size, Abundance, and Behavior from Dual-Frequency Identification Sonar (DIDSON) Data. North American Journal of Fisheries Management Volume 28, Issue 3

Daum, D. W. 2005. Monitoring fish wheel catch using event-triggered video technology. North American Journal of Fisheries Management 25:322–328.

Engle, R., D. Olson, L. Marchant and M. Ahrens. 2006. Assessments to determine the effect of current and alternate ladder operations on brood stock collection and behavior of hatchery fall Chinook salmon at Spring Creek National Fish Hatchery during 2003-2005. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, Washington. http://www.fws.gov/columbiariver/publications/SC_ladder_ops_brood_stock_2004-05%20Final.pdf

Engle, R. and J. Skalicky. 2009. Capture, transportation and reintroduction of lower Columbia River Fall Chinook salmon into the upper White Salmon River – A conservation measure in preparation for Condit Dam Removal. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, Washington. http://www.fws.gov/columbiariver/publications/Final_Report_Capture_Transport_and_Reintroduction_3_13_2009.pdf

Gates, K.S., J.B. Laker and M.A. Price. 2004. Estimation of adult sockeye salmon escapement into Little River Lake using a flexible picket weir and a remote video recorder. Kodiak National Wildlife Refuge, Alaska, 2001-2003. U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Office, Alaska Fisheries Technical Report Number 68, Kenai, Alaska. http://alaska.fws.gov/fisheries/fish/Technical_Reports/t_2004_68.pdf

Hilborn, R., B. G. Bue, and S. Sharr. 1999. Estimating spawning escapements from periodic counts: a comparison of methods. Canadian Journal of Fisheries and Aquatic Sciences 56:888-896.

Holmes, J. A., G. M. Cronkite, H. J. Enzenhofer, and T. J. Mulligan. 2006. Accuracy and precision of fish-count data from a ''dual-frequency identification sonar'' (DIDSON) imaging system. ICES Journal of Marine Science 63:543–555.

National Marine Fisheries Service. 2006. Biological Opinion for ESA Section 7 Consultation for the Condit Hydroelectric Project (FERC No. 2342) NOAA Fisheries Consultation No. 2002/00977. National Marine Fisheries Service, Northwest Region, Seattle, Washington. October 12.

Northwest Environmental Services. 2007. Preliminary Design Study – Fish Screening and Related Improvements for Big White Pond Facility on the White Salmon River. Oregon City, Oregon.

Stewart, R. 2002. Resistance board weir panel construction manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A02-21, Fairbanks, Alaska.

Stewart, R. 2003. Techniques for installing a resistance board fish weir. Alaska Department of Fish and Game, Division of Commercial Fisheries, Arctic-Yukon-Kuskokwim Region, Regional Information Report No. 3A03-26, Fairbanks, Alaska.

Tiffan, K. F., D. W. Rondorf, and J. J. Skalicky. 2004. Imaging fall Chinook salmon redds in the Columbia River with a dual-frequency identification sonar. North American Journal of Fisheries Management 24:1421–1426.

U.S. Fish and Wildlife Service (USFWS). 2002. Endangered Species Act Consultation on Bull Trout (*Salvelinus confluentus*) for the Condit Hydroelectric Project (P-2342). USFWS, Western Washington Office, Lacey Washington. September 6.

Appendix A. Collected biosampling information from adult carcass recoveries from the White Salmon Weir and in the area upstream to Condit Dam at river mile 3.3. Species abbreviations are used for summer steelhead (SST), coho salmon (COS) , spring Chinook salmon (SCS), fall Chinook salmon (FCS) and upriver bright (URB).

Date	Card #	Scale #	Sex	Adipose Marked	Species	Length (cm)	Age (From Scales)	Comments
8-Sep-09	1	1	Unknown	No	SST	38	3	
9-Sep-09	1	2	Female	No	COS	57	3	
14-Sep-09	1	3	Male	Yes	SCS	59	3	
14-Sep-09	1	4	Female	No	SCS	53	3	
14-Sep-09	1	5	Male	No	SCS	63	3	
14-Sep-09	1	6	Male	Yes	FCS	58	3	
14-Sep-09	1	7	Male	No	SST	59	4	
14-Sep-09	1	8	Female	No	SST	58	4	
14-Sep-09	1	9	Female	No	SST	63	3	
14-Sep-09	1	10	Male	No	FCS	114	4	
17-Sep-09	1	11	Male	Yes	SCS	55	3	
17-Sep-09	1	12	Male	Yes	SCS	54	3	
17-Sep-09	1	13	Male	Yes	SCS	56	3	
17-Sep-09	1	14	Male	Yes	FCS	58	2	
17-Sep-09	1	15	Male	No	FCS	106	4	
17-Sep-09	1	16	Male	Yes	FCS	65	2	
18-Sep-09	1	17	Male	Yes	FCS	65	3	
18-Sep-09	1	18	Male	No	FCS	54.5	3	
18-Sep-09	1	19	Male	No	FCS	40.5	2	
21-Sep-09	1	20	Male	Yes	SCS	55	2	
18-Sep-09	2	1	Male	Yes	FCS	53	2	
18-Sep-09	2	2	Male	No	FCS	55	2	
23-Sep-09	2	3	Male	No	FCS	94	3	
23-Sep-09	2	4	Male	Yes	FCS	61	2	
24-Sep-09	2	5	Male	Yes	FCS	73		Floy #10092
24-Sep-09	2	6	Male	Yes	FCS	75	3	
25-Sep-09	2	7	Male	Yes	FCS	79	3	
28-Sep-09	2	8	Female	No	FCS	96	4	
28-Sep-09	2	9	Female	No	FCS	98	4	Grey Floy #25504
28-Sep-09	2	10	Female	No	FCS	90	4	
28-Sep-09	2	11	Male	No	FCS	86	4	
28-Sep-09	2	12	Male	Yes	FCS	66	2	
28-Sep-09	2	13	Male	Yes	FCS	62	2	
28-Sep-09	2	14	Female	No	Whitefish	45		
29-Sep-09	2	15	Female	Yes	FCS	87	4	
29-Sep-09	2	16	Male	Yes	FCS	65	2	

Date	Card #	Scale #	Sex	Adipose Marked	Species	Length (cm)	Age (From Scales)	Comments
30-Sep-09	2	17	Female	No	FCS	90	4	
30-Sep-09	2	18	Male	Yes	FCS	63	2	
1-Oct-09	2	19	Female	Yes	FCS	99	4	
1-Oct-09	2	20	Female	No	FCS	101	4	
3-Oct-09	3	1	Female	No	FCS	89	4	
3-Oct-09	3	2	Female	No	FCS	96	4	
3-Oct-09	3	3	Male	Yes	FCS	66	2	
3-Oct-09	3	4	Female	No	FCS	90	4	
3-Oct-09	3	5	Male	No	FCS	100	4	
3-Oct-09	3	6	Male	Yes	FCS	63		Blue Floy #28
3-Oct-09	3	7	Female	No	FCS	92	4	
3-Oct-09	3	8	Male	No	FCS	95	3	Grey Floy #72
3-Oct-09	3	9	Male	No	FCS	63	3	Blue Floy #'s 49, 50
3-Oct-09	3	10	Female	No	FCS	100	4	
5-Oct-09	4	1	Male	No	FCS	54		
5-Oct-09	4	2	Female	No	FCS	102	4	
5-Oct-09	4	3	Female	No	FCS	100		No scales
5-Oct-09	4	4	Female	No	FCS	93	3	Bad scales
5-Oct-09	4	5	Female	Yes	FCS	80	3	
5-Oct-09	4	6	Female	Yes	FCS	89	3	
5-Oct-09	4	7	Female	No	FCS	95		
5-Oct-09	4	8	Male	Yes	FCS	70	3	
5-Oct-09	4	9	Female	Yes	FCS	82	4	
5-Oct-09	4	10	Female	Yes	FCS	85	3	
5-Oct-09	4	11	Female	No	FCS	96	4	
5-Oct-09	4	12	Male	No	FCS	100	4	
5-Oct-09	4	13	Female	Yes	FCS	86	3	
5-Oct-09	4	14	Male	No	FCS	49	2	
5-Oct-09	4	15	Female	Yes	FCS	85		
5-Oct-09	4	16	Male	No	FCS	93	3	
13-Oct-09	5	1	Male	No	FCS	48	2	
13-Oct-09	5	2	Female	Yes	FCS	42	3	
13-Oct-09	5	3	Female	No	FCS	87		
13-Oct-09	5	4	Male	Yes	FCS	58	2	
13-Oct-09	5	5	Female	No	FCS	86	3	Blue Floy #14
13-Oct-09	5	6	Female	No	FCS	92	3	
13-Oct-09	5	7	Female	Yes	FCS	76	3	
13-Oct-09	5	8	Female	No	FCS	84	4	Blue Floy #83
13-Oct-09	5	9	Female	No	FCS	95	4	
13-Oct-09	5	10	Female	No	FCS	92	4	

Date	Card #	Scale #	Sex	Adipose Marked	Species	Length (cm)	Age (From Scales)	Comments
13-Oct-09	5	11	Female	No	FCS	96		
13-Oct-09	5	12	Female	No	FCS	94	4	
13-Oct-09	5	13	Unknown	No	Whitefish	42	6	Whitefish
15-Oct-09	6	1	Female	No	FCS	79	3	Carcass Survey
15-Oct-09	6	2	Female	No	FCS	92	4	Carcass Survey
15-Oct-09	6	3	Female	No	FCS	94	4	Carcass Survey
15-Oct-09	6	4	Female	No	FCS	93	4	Carcass Survey
15-Oct-09	6	5	Female	No	FCS	95	4	Carcass Survey
15-Oct-09	6	6	Female	No	FCS	88	3	Carcass Survey
15-Oct-09	6	7	Female	No	FCS	94	4	Carcass Survey
15-Oct-09	6	8	Female	No	FCS	82	4	Carcass Survey