Elwha River Salmonid Assessment: Adult Weir Project

2010 ANNUAL REPORT

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Elwha Weir Project 2010 Annual Report

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and

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Executive Summary

Removal of the Elwha Dam and Glines Canyon Dam on the Elwha River is scheduled to begin in fall of 2011. Enumerating returns of adult salmon and steelhead trout in the Elwha River is necessary to assess fish responses to dam removal and to adaptively manage the recovery of salmonid populations. The main goal of the Elwha weir project is to evaluate trends in abundance and diversity of Chinook salmon *Oncorhynchus tshawytscha* and steelhead trout *O. mykiss* in the Elwha before, during and after dam removal. In 2010, a 59.4 meter resistance board floating fish weir was installed and operated at river kilometer 5.9 (river mile 3.7). Biological information was collected from all salmon, trout, and char species captured at the weir, which was fished between September 9 and October 9, 2010. Over this 30-day period, 461 Chinook salmon, 12 pink salmon *O. gorbuscha*, 6 steelhead, 4 sockeye salmon *O. nerka*, 4 bull trout *Salvelinus confluentus*, 3 coho salmon *O. kisutch*, 1 chum salmon *O. keta*, and 1 coastal cutthroat trout *O. clarki clarki* were captured. All eight species were captured within the first two weeks of weir operation. The majority (70.0%) of the female Chinook salmon captured were 5 years of age, whereas the majority (78.3%) of males were 2, 3, and 4 years of age at spawning. Scale age data indicated that most (98.3%) of the spawning Chinook salmon migrated to the ocean as sub-yearlings. Mean fork length of male Chinook salmon (73.5 cm fork length, FL) was less than female Chinook salmon (88.6 cm FL). However, males were longer than females within the same age class. Coded wire tags were recovered from 12 Chinook salmon. Nine of the CWT recoveries were releases from the WDFW Elwha Rearing Channel, and three were released out of the basin. Escapement estimates of Chinook salmon in the Elwha River in 2010 were not derived because the weir was installed toward the end of the Chinook salmon spawning season. Weir operation was delayed until early September due to high summer flows which prevented the installation of the substrate rail. In 2011, weir operation is planned between February and October. The addition of a mark-recapture study for Chinook and the combination of weir and SONAR technology for winter steelhead trout should result in abundance estimates for these species in 2011.

Table of Contents

Introduction

Two hydroelectric dams on the Elwha River in Washington State currently block access to the majority of the watershed, adversely affecting the river ecosystem and the native anadromous fisheries because neither dam was built with fish passage facilities. The lowest dam, the Elwha Dam, 7.9 kilometers (km) from the mouth of the river, was built in 1913 and formed the Lake Aldwell reservoir. The Elwha Dam has prevented anadromous salmon and trout from using 130 km of main stem and tributary habitat (NPS 2005). The Glines Canyon Dam, at river kilometer (rkm) 21, was built in 1927 and formed the Lake Mills reservoir. Even though there are other factors affecting Elwha River salmonid populations, the dams are a primary cause of the decline of fish runs. For almost 100 years, anadromous salmonid species have been restricted to the lower 7.9 km of spawning and rearing habitat in the Elwha River. Prior to dam construction, an estimated 392,000 fish returned annually to the river to spawn compared to annual returns of less than 3,000 naturally-spawning fish by the late 20th century (NPS 2005). The loss of fish from 93% of the Elwha River has resulted in severe impacts to the entire river ecosystem (NPS 1995).

The Elwha River watershed encompasses about 831 square kilometers (km^2), 83% (691 km^2) of which are protected within the Olympic National Park (Ward et al. 2008). The river has a north-south orientation, flowing north into the Strait of Juan de Fuca. Annual precipitation in the Elwha River basin ranges from 220 inches in its upper reaches to 35 inches near its mouth (NPS 2005). River discharge is influenced by winter storms, spring snowmelt, and base flow conditions during summer and fall. Mean annual discharge is approximately 1,500 cfs at the McDonald Bridge stream gage (USGS gage #12045500, rkm 13.8) and 1,650 cfs at the river mouth (NPS 2005). Mean winter flow is about 2,000 cubic feet per second (cfs) and mean summer flows is about 600 cfs (EDPU 2005). The Elwha River and its tributaries are classified by the Washington Department of Ecology as a "salmon and trout spawning, core rearing, and migration" area, signifying "extraordinary" quality (NPS 2005).

Ten stocks of anadromous salmon and trout are either present or known to have been present in the Elwha River before the dams were built: Spring- and summer/fall-run Chinook salmon *Oncorhynchus tshawytscha*, chum *O. keta*, coho *O. kisutch*, pink *O. gorbuscha*, sockeye *O. nerka*, summer- and winter-run steelhead trout *O. mykiss*, bull trout *Salvelinus confluentus*, and cutthroat trout *O. clarki clarki* (NPS 2005, Ward et al. 2008).

Currently, salmonid stocks in the Elwha River are severely depleted (Ward et al. 2008). Almost all Chinook, coho, and steelhead in the Elwha are hatchery produced, and the native stocks are declining (EWIR 2010). The current estimated numbers of adult salmonid returns to the Elwha River (Pess et al. 2008) are as follows:

- 3,000 Summer/Fall Chinook (Spring Chinook returns are unknown)
- 1,800 Winter Steelhead and less than 100 Summer Steelhead
- 150 pink
- 2,900 coho
- 1,000 chum
- 0-50 Sockeye (considered to be extirpated)

Puget Sound Chinook salmon *Oncorhynchus tshawytscha* and Puget Sound steelhead trout *O. mykiss* in the Elwha River are listed as threatened under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NPS 2005). Bull trout *Salvelinus confluentus* are listed as threatened by the U.S. Fish and Wildlife Service.

Removal of the two hydroelectric dams on the Elwha River will be among the largest river restoration projects in the United States and represents a unique opportunity to assess recovery of fish populations at the watershed scale. Dam removal is currently planned to begin in the fall of 2011. The impending nature of this unprecedented restoration has intensified the need for monitoring of salmon abundance and productivity (Ward et al. 2008). Enumerating adult returns to the Elwha River is necessary to assess the effectiveness of dam removal and to adaptively manage the recovery of salmonid populations.

At present, abundance estimates are derived for just two of the eight salmonid species occurring in the Elwha River: Chinook salmon and pink salmon. Chinook salmon abundance estimates are based on redd counts, brood stock collection, and natural pre-spawning and post-spawning mortalities. Pink salmon abundance estimates are derived from peak spawner counts. Neither of these methods provides a means of assessing estimate bias or precision, both of which are necessary for evaluating species responses to dam removal. Redd surveys have been conducted by the LEKT for winter steelhead in the lower Elwha River since 2005 (M. McHenry, LEKT, personal communication). However, the methodology to analyze these data has not been finalized and escapement estimates have not been calculated for winter steelhead. Surveys for chum and coho have been complicated by high flows, low visibility, and unsafe river conditions during the fall and winter months when these species are spawning in the river.

A resistance board floating weir is an innovative tool for capturing fish and describing biological characteristics of each species captured. In combination with a mark-recapture study design, the weir can establish unbiased abundance estimates of known precision for each species. Operation of a floating weir was only recently considered for the Elwha River based on success of this particular design in other Washington watersheds, as well as in Alaska and California (Mayer et al. 2010). This is the first resistance board weir on the Olympic Peninsula and among the first in Puget Sound. The weir is a multi-agency effort, which includes the Lower Elwha Klallam Tribe, National Oceanic and Atmospheric Administration, Olympic National Park, U.S. Fish and Wildlife Service, U.S. Geological Survey, and Washington Department of Fish and Wildlife.

Weir operations depend on seasonal flow conditions and other logistical constraints. Data collected from captured adult salmon and steelhead trout will be used (along with other metrics) to derive Viable Salmonid Population (VSP) metrics recommended by NOAA Fisheries (McElhany et al. 2000). This project will provide information on three of the four parameters considered when evaluating VSP status: Abundance, productivity (population growth rate), and diversity (McElhany et al 2000). For example, tissue samples collected from fish captured at the weir will contribute to regional efforts to describe the population structure of steelhead and bull trout, as well as local efforts to determine the origin (natural or hatchery) of Chinook salmon and steelhead spawning in the Elwha River. (The fourth parameter used to evaluate population status, spatial structure, is not part of this project.) The floating weir will also function as a brood stock collection point in order to preserve salmon runs during dam removal.

Objectives

The primary goal of this project is to estimate abundance and describe life history characteristics of Chinook salmon and steelhead trout in the Elwha River. This project will also provide biological data on all salmon, trout, and char returning to the Elwha River to spawn. These goals will be accomplished using a resistance board floating fish weir in combination with a mark-recapture study design and other available tools for enumerating fish abundance (e.g., SONAR) in the future. The 2010 field season was the first year for this project which is planned for the duration of time before, during, and following dam removal.

The objectives of the Elwha weir project for 2010 were:

(1) Install and operate a floating weir on the Elwha River below the Elwha dam near river kilometer 5.9 (river mile 3.7),
(2) Enumerate catch of salmon, trout, and char by species,
(3) Estimate species-specific escapement above the weir, and
(4) Recommend future approaches for making species-specific escapement estimates above and below the weir on the Elwha River.

Methods

Description of Study Site

The Elwha River is located in the northwest corner of Washington State and drains from the Olympic Mountains into the Strait of Juan de Fuca (Figure 1). The Elwha River watershed includes a 72.4 km main river channel and approximately 113 km of tributaries.

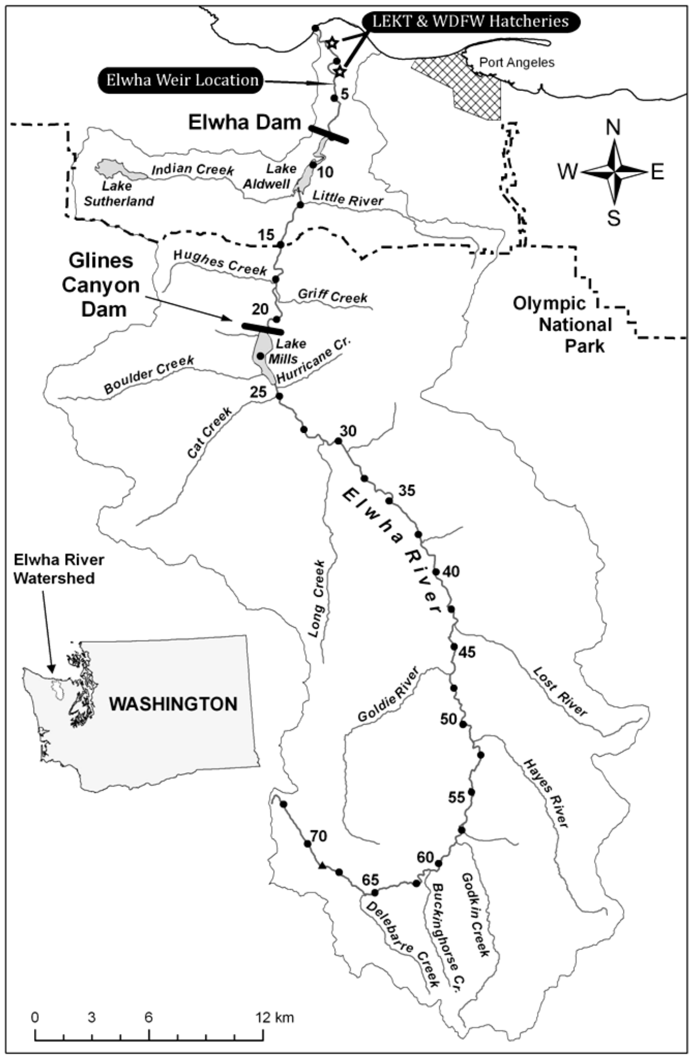

Figure 1. The Elwha River watershed in northwestern Washington. Map shows location of the Elwha floating weir at river kilometer 5.9 (river mile 3.7). River distances are in 2.5-mile increments (black dots). (Figure prepared by Jeff Duda, United States Geological Survey.)

United States Geological Survey records from 1897 to 2007 indicate that the Elwha River has a mean annual flow of 42.7 cubic meters per second (cms, 1,509 cubic feet per second (cfs), USGS gage #12045500, Elwha River at McDonald Bridge, rkm 13.8). Mean low flow in late summer is 22.1 cms (780 cfs). Mean high flow in late winter to early summer ranges from 37.1 to 62.9 cms (1,310 to 2,220 cfs).

Weir Operation

A resistance board floating fish weir was located in the Elwha River near rkm 5.9 (river mile [rm] 3.7) to capture adult salmonids. The weir was designed to divert fish into one of several traps for data collection. The weir was 48.5 meter (m) wide and 6.1 m long. Weir panels were made of schedule 40 polyvinyl chloride (PVC) pipe. The panels were attached at their base to a 3" steel substrate rail. Resistance boards, made of 2" foam insulation sandwiched between two, 18x36" pieces of 3/8" marine-grade plywood, were attached to the downstream (i.e., floating) end of each panel. The weir included four 1.8 m x 1.2 m x 1.1 m aluminum adult salmonid traps. Traps were located on both sides of the weir, with three traps in the upstream direction and one trap in the downstream direction. Curtains, made of 1" high density polyethylene (HDPE) pipe and CPVC spacers, were installed between the traps and the river bank. Total project width (weir, traps, bi-pods, and HDPE curtains) was approximately 59.4 m (Figure 2).

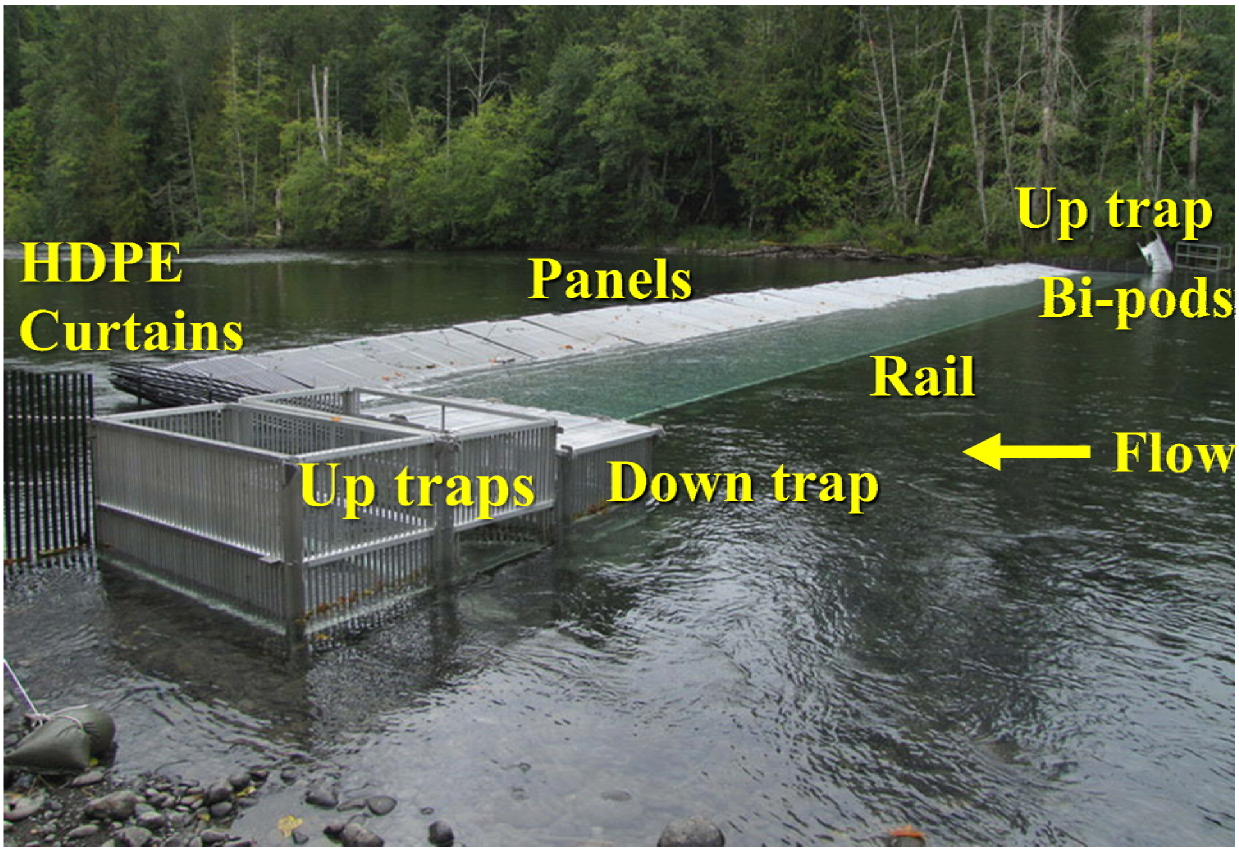

Figure 2. Floating weir in the Elwha River on the Olympic Peninsula in Washington State.

Fish Collection

When in operation, the weir was fished 24 hours a day and was checked once or more daily, depending on stream flow, debris, and number of fish present. Live fish migrating upstream were captured in one of three up traps. Live fish migrating downstream were captured in the downstream trap and several were netted above the weir. Carcasses (post-spawners, i.e., senescing or dead fish) were generally collected after drifting downstream onto the weir panels.

Biological data collected from adult salmonids included species, sex, spawn condition, fork length (FL), presence of coded-wire tag, presence of PIT tag, fin mark (ad clip), scale samples, and DNA samples. Lengths were estimated for fish that were missing heads and/or tails prior to capture at the weir, but were not included in the length analyses. Box plots were generated using the program R, a software environment for statistics and graphics (RDCT, 2010). Spawn condition was recorded as direction of travel (up or down) and condition (live or carcass).

Fish were handled using a cradle that was partially submerged in the river, which hung on the inside of the trap, to keep fish wet and oxygenated (Figure 3, Larson 1995). Data collection from live fish generally took about 3-4 minutes. Following data collection, fish were placed back into the river in the same direction that they were moving when they were captured.

All fish were scanned for the presence of coded wire tags (CWT) using a wand detector manufactured by Northwest Marine Technology, Inc. (Shaw Island, WA) and passive integrated transponder (PIT) tags using a detector manufactured by Biomark, Inc. (Boise, ID) (Figure 4). Scale samples were obtained from the left or right rear quadrant of the fish between the lateral line and the dorsal and the adipose fin using surgical hemostats. DNA samples were obtained with a hole punch or fin clip (generally from the opercle or dorsal fin), stored in ethyl alcohol, and archived in individually marked vials. Fin condition (adipose and dorsal fin morphology) was also noted on fish which appeared to be of hatchery origin, when possible. Pictures were generally taken of fish having unique features.

Salmonids migrating upstream as pre-spawners were tagged with colored, uniquely numbered Floy® tags, manufactured by Floy Tag & Manufacturing, Inc. (Seattle, WA). Floy® tag numbers were recorded when fish were marked and when marked fish were recovered.

Scale samples were handled according to WDFW protocols (L. Campbell, WDFW, personal communication). Age determination was made by WDFW personnel by counting annuli from the scales (Koo 1963). The Gilbert-Rich method was used to notate salmon (Chinook, pink, sockeye, coho and chum salmon) ages and the European method was used to notate trout and char (steelhead, bull trout, and cutthroat trout) ages (Burgner 1991).

Coded wire tags were recovered from fish carcasses. Snouts were removed, frozen, and transported to the WDFW CWT lab for tag removal and decoding. Release information associated with each CWT code was obtained from the Regional Mark Information System Database (http://www.rmpc.org/).

Figure 3. Chinook salmon in fish cradle at the floating weir in the Elwha River (2010).

Figure 4. Female Chinook salmon captured at the floating weir in the Elwha River is scanned for PIT tags and coded wire tags. Fish are lifted from a cradle in order to obtain tag information.

Results and Discussion

Objective 1. Install and operate a floating weir on the Elwha River below the Elwha dam near river kilometer 5.9 (river mile 3.7).

The 2010 season was the first season that the floating weir was operated on the Elwha River. Operation of the floating weir in the Elwha River in 2010 was planned for mid-July to mid-October. Due to high summer flows, the weir was not installed until late August, which was later than originally intended, as flows of 500 cfs are required for safe and efficient installation of the substrate rail. Therefore, the weir was installed after the majority of the Chinook migration occurred (Figure 5, NPS 2005). Rail installation was started on August 30 and completed on August 31 (Appendix A). Panel, trap, bi-pod, curtain installation, and final site preparations were completed on September 8. The weir was fish-tight and began fishing on September 9, 2010.

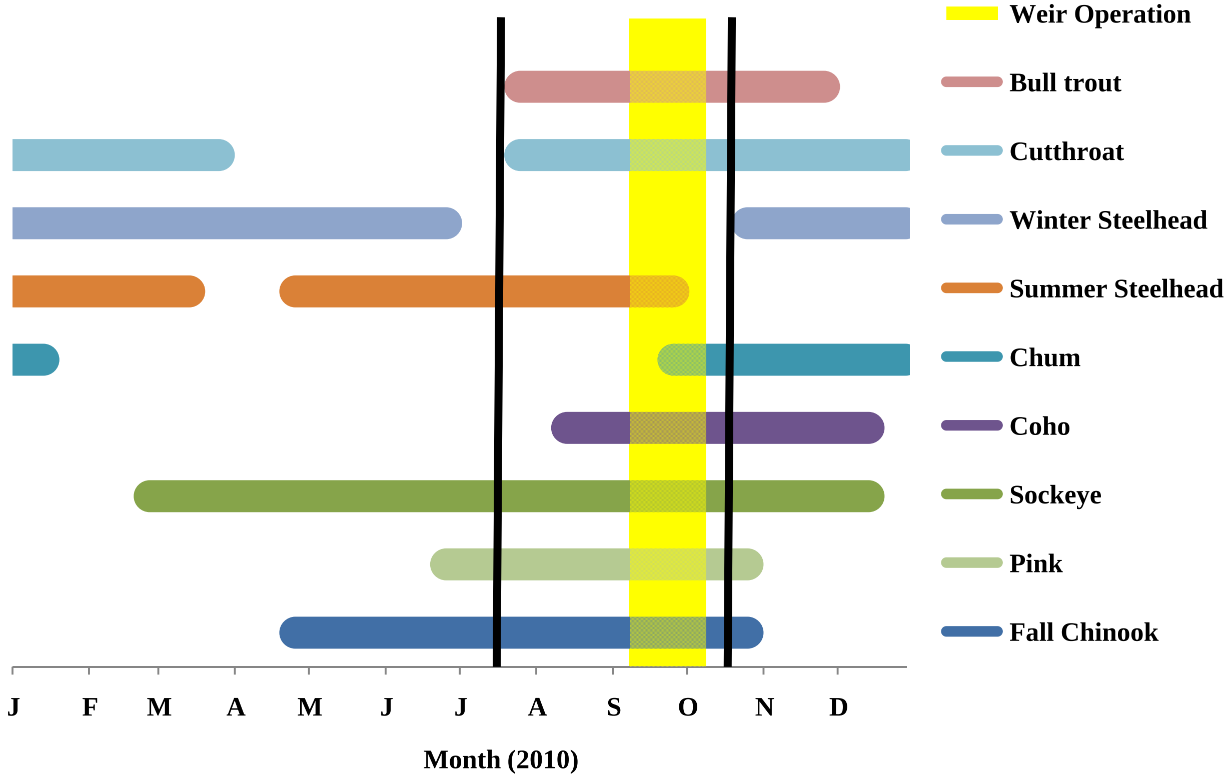

Figure 5. Presence of salmonid species (immigration and spawning) in the Elwha River and period of weir operation in 2010. Black bars represent the planned time frame for weir operation. (Species presence information provided by NPS (2005), edited by Randy Cooper, WDFW.)

The floating weir was operated for 30 days between September 9 and October 9 in 2010. Structural designs for the weir were planned for flows up to 2,000 cfs. On September 26, 2010, the Elwha River reached 2,160 cfs and the weir continued to operate as designed (Figure 6). A high water event on October 9 reached 6,710 cfs and interrupted trapping operations. At this time, operation of the weir ended in order to protect the weir and trap equipment. Weir panels, traps, bi-pods, and HDPE curtains were removed on October 9-12, 2010 and placed in storage at the WDFW Rearing Channel. The substrate rail remained in the river for the 2011 field season.

Figure 6. The floating weir operating at 2,190 cubic feet per second in the Elwha River on September 26, 2010 (USGS gage #12045500).

Objective 2. Enumerate catch of salmon, trout, and char by species.

A total of 492 salmonids were captured during the 30-day trapping season in 2010 (Table 1). Although 8 species of salmonids were captured within the first two weeks of weir operation, the catch was dominated by Chinook salmon (Appendix B). Daily catch was greater in the downstream direction than in the upstream direction (Figure 7). This difference likely occurred because the weir was installed after a majority of Chinook salmon migrated upstream to spawn (Figure 5). Chinook have been observed migrating to the base of the Elwha Dam and then falling back downstream to spawn (P. Crain, Olympic National Park, personal communication). The majority of Chinook captured in the floating weir were in a post-spawning condition (i.e., carcasses or senescing fish). The largest daily catches occurred in the downstream direction and appeared to be associated with river flows (Figure 7). There was a one-day capture delay between upward trending water on September 25 and peak daily catch on September 26, 2010.

Table 1. Total catch of salmon, trout, and char captured at the floating weir in the upstream and downstream direction in the Elwha River in 2010. “Up” fish were captured migrating in the upstream direction. “Down” fish were captured migrating in the downstream direction. Data are organized by species and sex. “-” indicates no fish.

Species / Sex	Total	Male		Female		Undetermined		Subtotal	
	Captured	Up	Down	Up	Down	Up	Down	Up	Down
Chinook salmon	461	12	271	5	168	-	5	17	444
Pink salmon	12	3	1	1	7	-	-	4	8
Steelhead trout	6	1	-	3	2	-	-	4	2
Sockeye salmon	4	1	3	-	-	-	-	1	3
Bull trout	4	1	1	-	1	-	1	2	2
Coho salmon	3	-	1	1	1	-	-	1	2
Chum salmon	1	-	-	1	-	-	-	1	-
Cutthroat trout	1	1	-	-	-	-	-	1	-
Total	492	19	277	11	179	-	6	31	461

Several of the species captured at the floating weir represent stocks at low abundance levels and whose life history strategies are not completely understood: Pink salmon are considered to be at critical levels in the Elwha River; Summer and winter steelhead are considered be at critically low abundance levels; Sockeye salmon native to the Elwha River are considered to be extirpated; and the status of sea-run cutthroat trout in the Elwha River is unknown (Ward et al. 2008).

The 12 pink salmon captured at the weir in the Elwha River in 2010 were an even-year run. The odd-year cycle is primary life history of pink salmon in the Elwha (Wart et al. 2008). Historically, observations of even-year run pink salmon in the Elwha were minimal, but have increased in number in recent years (M. McHenry, LEKT, personal communication). However, the capture of pink salmon at the weir in 2010 provides evidence that even-year pinks spawn in the Elwha River. Trends in the abundance of even-year pinks will be evaluated after additional years of weir operation.

The run timing of the steelhead captured at the weir is uncertain because the weir was operating after the known presence of summer steelhead but before the known presence of winter steelhead in the Elwha (Figure 5). If it is assumed that steelhead spawning in the Elwha is limited to the February to June time period, then these steelhead undergo a substantial period of freshwater maturation prior to spawning. In addition, the presence of bull trout and cutthroat trout in the lower river may indicate the expression of an anadromous life history for these species in the Elwha River (Ward et al. 2008).

The origin of the sockeye captured at the weir in September and October in 2010 is unknown. Tissue samples collected from these fish will be used to assign origin once an appropriate genetic baseline has been developed for sockeye populations in Puget Sound, coastal Washington, and British Columbia. The closest wild population of sockeye on the Olympic Peninsula are Lake Ozette sockeye; However, the Lake Ozette population generally spawn between April and June (P. Crain, NPS, personal communication).

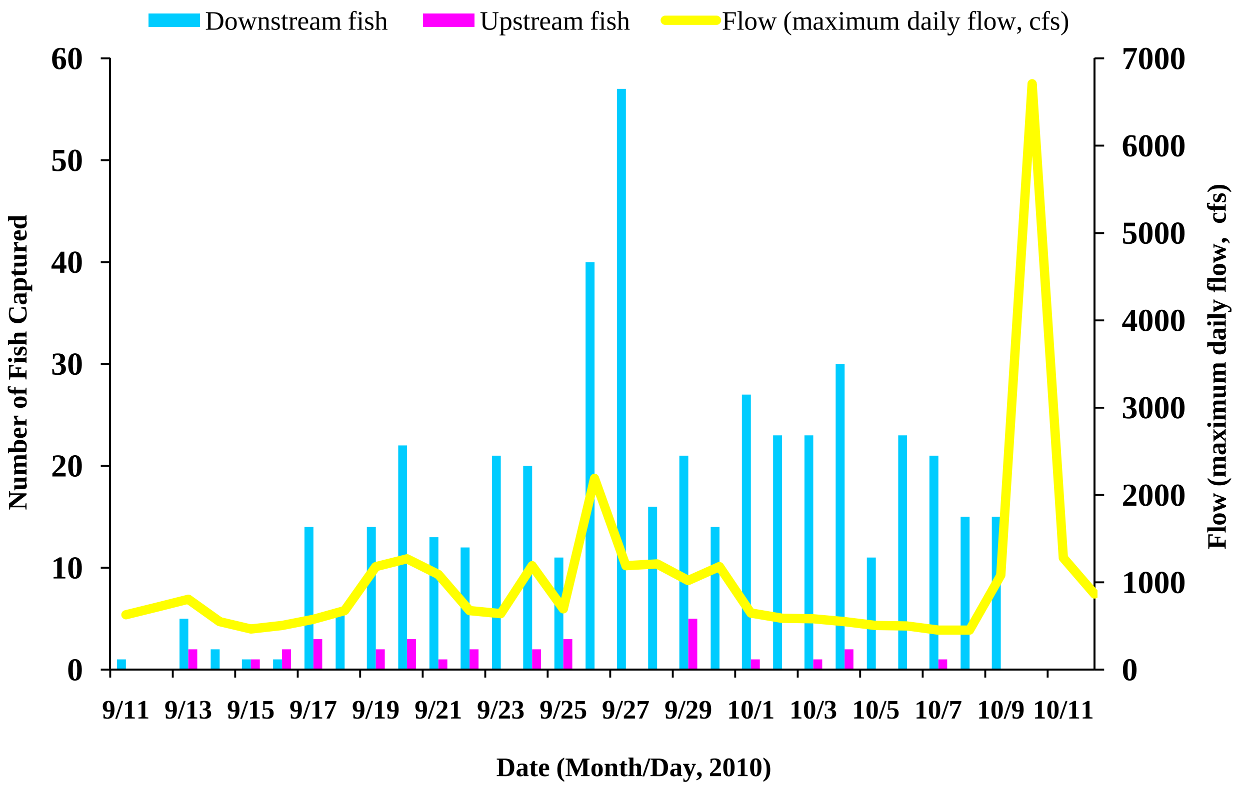

Figure 7. Daily catch of salmon, trout, and char in the floating weir in the Elwha River in 2010. Weir operations were discontinued for the season on October 10, 2010 (USGS gage #12045500).

Chinook salmon

We captured 461 Chinook salmon at the floating weir in the Elwha River in 2010. The majority (92.2%) of these fish were captured as post-spawners. Of the captured fish, 62.1% were male and 37.9% were female.

We collected scale samples from 99.3% (458/461) of the Chinook salmon captured at the weir in the Elwha River in 2010. Three fish were too decomposed to obtain scale samples. Scale age data indicated that Chinook salmon return to the Elwha River at a total age of 2 to 5 years (Table 2). Scale age data also indicated that 98.3% (395/402 readable scales) of the returning Chinook salmon emigrated as sub-yearlings. The high proportion of sub-yearling emigrants was consistent with juvenile Chinook composition of LEKT smolt trap catches and WDFW hatchery releases. A smolt trap is operated in the lower Elwha River by the Lower Elwha Klallam Tribe and catches predominantly sub-yearling Chinook (M. McHenry, Lower Elwha Klallam Tribe, personal communication). The Elwha River is currently the largest producer of hatchery Chinook salmon and steelhead in the Strait of Juan de Fuca (NPS 2005). Releases of hatchery reared Chinook from the WDFW Rearing Channel are predominantly sub-yearling fish: Between 2006 and 2009, 9,271,696 hatchery-reared juvenile Chinook were released from the WDFW Rearing Channel (www.rmpc.org): 8,438,400 sub-yearlings (91.0%) and 833,296 yearlings (9.0%).

Table 2. Age composition by sex of Chinook salmon captured at the floating weir in the Elwha River in 2010. Five fish were too decomposed (senesced), missing heads or tails and internal organs to make a sex determination. "-" indicates no fish.

Total	Female		Male		Total	
Age	Number	Percent	Number	Percent	Number	Percent
2	0	0	60	21.2	60	13.0
3	11	6.4	98	34.6	109	23.6
4	34	19.6	37	13.1	71	15.4
5	105	60.7	54	19.1	159	34.5
No scales	3	1.7	0	0	3	0.7
Senesced	-	-	-	-	5	1.1
Not read	20	11.6	34	12.0	54	11.7
Total	173	100.0	283	100.0	461	100.0

The majority (70.0%) of female Chinook salmon captured at the weir in 2010 returned to spawn at age 5 (Figure 8). The remaining female Chinook captured were age 3 (7.3%) or age 4 (22.7%). No age 2 females were captured. Almost forty percent (39.3%) of the males captured at the weir in 2010 returned to spawn at age 3. The rest of the male Chinook captured were age 2 (24.1%), age 4 (14.9%) or age 5 (21.7%).

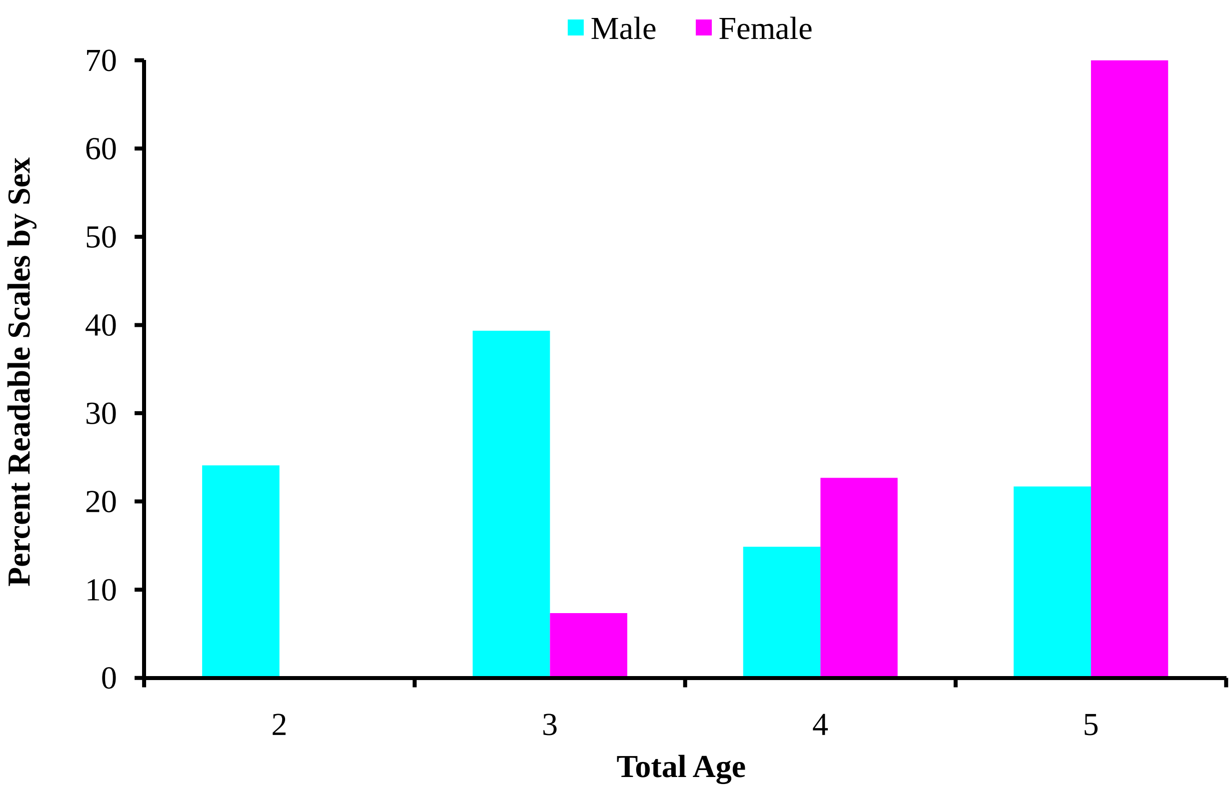

Figure 8. Percent of Chinook salmon by age class for male and female fish captured at the floating weir in the Elwha River in 2010. No age 2 females were captured.

Fork length of Chinook salmon increased with age for both sexes, and the rate of increase in fork length declined with age (Table 3). Mean fork length for all Chinook (males and females) was 47.3 cm at age 2, 73.5 cm at age 3, 88.9 cm at age 4, and 95.8 cm at age 5. Mean length of male Chinook (73.5 cm) was shorter than female Chinook (88.6 cm, $t = 7.8$, df = 377, $p < 0.001$), a result largely explained by the observation that age at spawning for males was more evenly distributed across all age classes than females and there were no age 2 females were captured at the weir in 2010 (Figure 9). At any given age, the mean fork length of male Chinook salmon was greater than that of females, with the greatest difference occurring at age 5 (Figure 8). The difference in fork length between male and female Chinook salmon was 2.2 cm (3.0 %) at age 3, 2.6 cm (2.9 %) at age 4, and 7.5 cm (7.5 %) at age 5.

Nine male Chinook salmon captured at the weir in the Elwha River in 2010 were less than 40 cm. Median fork length of the nine small (< 40 cm) males captured was 32.0 cm (range = 21-39 cm). Based on CWT and scale age data, two of the small males were released as yearlings in 2010 from the WDFW Rearing Channel.

Table 3. Mean fork lengths of 334 spawning Chinook salmon captured at the weir in the Elwha River in 2010. Lengths are given in centimeters by total age and sex. Table does not include 82 fish with estimated fork lengths or 45 fish with unreadable scales.

Total age	Length measurement	Female	Male	Total
2	Sample size (n)	0	60	60
	Average (Avg, cm)	-	47.3	47.3
	Std. Dev. (SD, cm)	-	7.9	7.9
3	n	11	92	103
	Avg	71.5	73.7	73.5
	SD	6.3	5.8	5.8
4	n	22	33	55
	Avg	87.4	90.0	88.9
	SD	6.9	7.4	7.3
5	n	73	43	116
	Avg	93.1	100.6	95.8
	SD	5.5	7.2	7.1

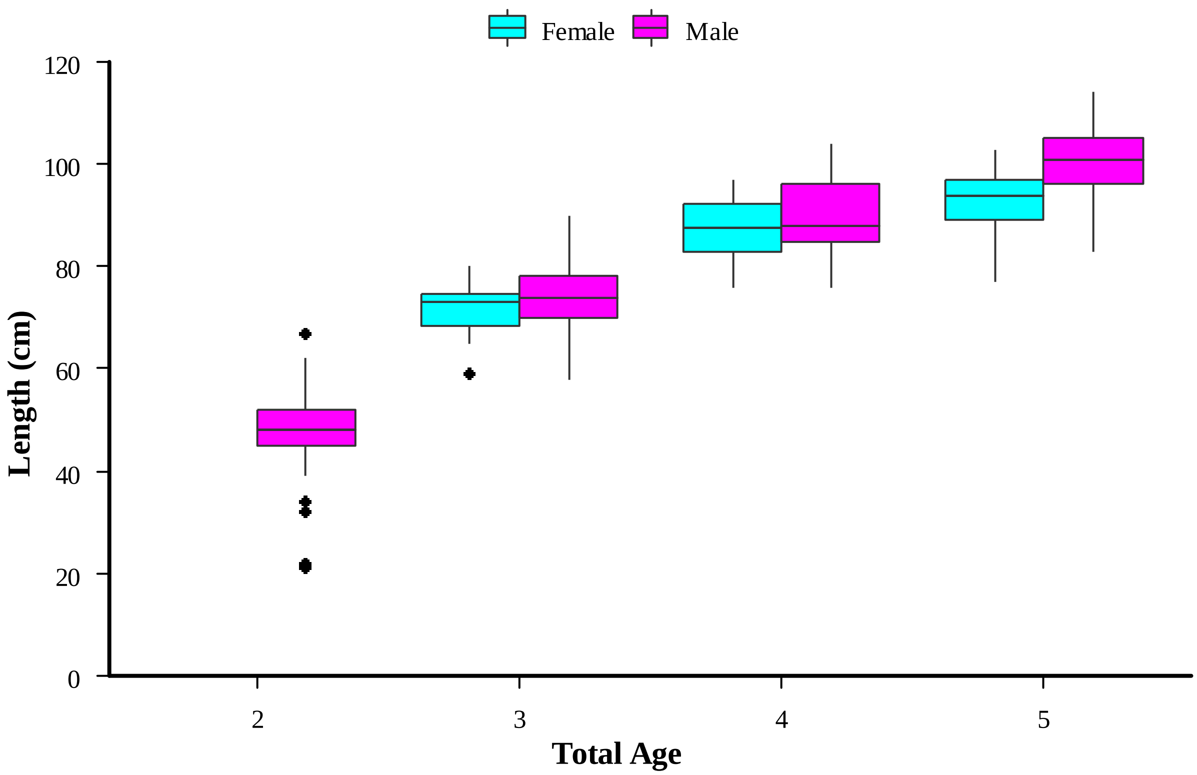

Figure 9. Fork lengths by age and sex of Chinook salmon captured at the weir in the Elwha River in 2010. Lengths are in centimeters. Pink boxes represent male fork lengths. Aqua boxes represent female fork lengths. The colored boxes represent the middle 50% of the data. Vertical lines indicate the upper and lower 25% of the data. The line within each box represents the median. "♦" indicates outliers. No age 2 females were captured.

Of the 461 adult Chinook salmon captured at the floating weir in the Elwha River in 2010, coded wire tags were detected in 12 fish (Table 4): 9 were released from the WDFW's Elwha Rearing Channel, and one each was released from the Grey Wolf River (Dungeness River, CWT Code 210641), the George Adams Hatchery (Purdy Creek, Snohomish River, CWT Code 634270), and the Dryden Pond Hatchery (Wenatchee River, CWT Code 635097). No PIT tags were detected in Chinook salmon at the weir in 2010.

Seven females captured in the floating weir were taken to the WDFW Rearing Channel for hatchery brood stock. In addition, one male, which was captured at the weir and marked with a Floy® tag, was collected upstream of the weir by WDFW hatchery staff for use as brood stock.

Table 4. Coded-wire tags recovered by WDFW from Chinook salmon in the Elwha River in 2010. Age at spawning was calculated by brood year. Release information for CWT codes was from the Regional Mark Information System Database.

CWT	Recovery Location				Brood	Release	Release	Age at
Code	Weir	Surveys	Hatchery	Total	year	year	Location	Spawning
633370	6	2	13	21	2005	2006	Elwha River	5
633373	1	-	2	3	2005	2007	Elwha River	5
633879	1	1	17	19	2006	2008	Elwha River	4
634786	1	-	1	2	2008	2010	Elwha River	2
210641	1	-	-	1	2005	2006	Gray Wolf River	5
634270	1	-	-	1	2007	2008	Purdy Creek	3
635097	1	-	-	1	2008	2010	Wenatchee River	2
210719	-	-	1	1	2006	2008	Dungeness River	4
210774	-	-	1	1	2007	2008	Gray Wolf River	3
Total	12	3	35	50	-	-	-	-

As of January 31, 2011, otolith results were not available from Chinook salmon in the Elwha River. Otoliths are the only way to assign an origin (hatchery or natural) to the majority of Chinook. A small portion of Elwha-origin hatchery releases are tagged with CWT and released as yearlings: 200K from WDFW Elwha Rearing Channel and 200K from WDFW Morse Creek Rearing Ponds. The majority of Elwha origin hatchery releases (~2.5 million annually) are otolith-marked and released as sub-yearlings from the WDFW Elwha Rearing Channel. In 2010, otoliths were recovered from Chinook carcasses on the weir, during spawner ground surveys conducted by WDFW regional staff, and during brood stock collection by WDFW Hatchery staff. Analysis of these otoliths is currently underway at the WDFW otolith lab.

Other salmonid species

There were seven other (i.e., non-Chinook) species of salmonids captured at the floating weir in the Elwha River in 2010: 12 even-year pink salmon *O. gorbuscha*, 6 summer-run or early winter-run steelhead *O. mykiss*, 4 sockeye salmon *O. nerka*, 4 bull trout *Salvelinus confluentus*, 3 coho salmon *O. kisutch*, 1 chum salmon *O. keta*, and 1 sea-run coastal cutthroat trout *O. clarki clarki* (Table 5). While the majority of Chinook captured at the floating weir were carcasses, two-thirds (67.7%) of the non-Chinook species were live when captured at the weir in 2010.

The sample size of salmonids other than Chinook salmon was not large enough to statistically summarize age or length data. Pink salmon were all 2 years of age with lengths between 42 and 50-cm FL (Table 6). Steelhead trout were 1 to 4 years of age with lengths between 52 and 70-cm FL (Table 7). One of the steelhead captured was a repeat spawner. Sockeye salmon were 4 and 5 years of age with lengths between 46 and 68-cm FL (Table 8). Bull trout were 3 and 4 years of age with lengths between 42 and 55-cm FL (Table 9). Coho salmon were 2 or 3 years of age with lengths between 33 and 68-cm FL (Table 10). One chum salmon (female, 65-cm FL, age 4) and one sea-run cutthroat trout (male, 38-cm FL, age 3) were also captured.

Table 5. Condition of the 492 fish captured at the weir in the Elwha River in 2010 by species.

Species	Carcass	Live	Total
Chinook salmon	392	69	461
Pink salmon	6	6	12
Steelhead trout	2	4	6
Sockeye salmon	2	2	4
Bull trout	-	4	4
Coho salmon	-	3	3
Chum salmon	-	1	1
Cutthroat trout	-	1	1
Total	402	90	492

Three of the six steelhead (five females and one male) captured at the floating weir in 2010 had clipped adipose fins (i.e., of hatchery origin). Three steelhead had intact adipose fins, indicating that they were of natural origin. Two of the three coho salmon captured were marked or tagged, indicating a hatchery origin. One coho was adipose clipped, and one coho had a coded-wire tag: The CWT coho was released from the Port Gamble Bay S'Klallam sea pens (Big Quilcene River stock, CWT Code 210834). No PIT tags were detected in non-Chinook species of salmonids.

Table 6. Total age, fork length, and sex of pink salmon captured at the floating weir in the Elwha River in 2010.

Total Age	Brood Year	Female		Male	
		n	Length (cm)	n	Length (cm)
2	2008	7	42, 44, 46, 48, 48, 49, 50	3	43, 50, 50
Unreadable	-	1	48	1	47

Table 7. Total age, fork length, and sex of steelhead trout captured at the floating weir in the Elwha River in 2010. The notation "R" indicates that freshwater age was unreadable. The notation "S" indicates that the fish was a repeat spawner.

European Age	Brood Year	Female		Male	
		n	Length (cm)	n	Length (cm)
1.2	2007	2	67, 70	-	-
2.2	2006	1	68	-	-
3.1	2006	-	-	1	55
R.2	-	1	66	-	-
R.S	-	1	52	-	-

Table 8. Total age, fork length, and sex of sockeye salmon captured at the floating weir in the Elwha River in 2010.

Total Age	Brood Year	Female		Male	
		n	Length (cm)	n	Length (cm)
4	2006	-	-	3	46, 53, 68
5	2005	-	-	1	65

Table 9. Total age, fork length and sex of bull trout captured at the floating weir in the Elwha River in 2010.

Total Age	Brood Year	Female n	Length (cm)	Male n	Length (cm)	Unknown n	Length (cm)
3	2007	-	-	1	42	-	-
4	2006	-	-	1	48	-	-
Unreadable	-	1	55	-	-	-	-
Unreadable	-	-	-	-	-	1	46

Table 10. Total age, fork length, and sex of coho salmon captured at the floating weir in the Elwha River in 2010.

Total Age	Brood Year	Female		Male	
		n	Length (cm)	n	Length (cm)
2	2008	-	-	1	33
3	2007	1	68	-	-
Unreadable	-	1	67	-	-

Objective 3. Estimate species-specific escapement above the weir.

Operation of the floating weir in the Elwha River in 2010 was scheduled for mid-July to mid-October, which would have encompassed almost all of the Chinook spawning season (Figure 5). However, installation of the weir was delayed due to high flows. Therefore, a substantial portion of the Chinook run had occurred prior to installation and the number of fish handled was less than the total number of fish migrating above the weir in 2010.

Twenty-two fish captured at the floating weir in the Elwha River in 2010 were tagged with colored, uniquely numbered Floy® tags, as part of the mark-recapture study (Table 11). Of the 22 fish tagged, seven were recovered at the weir in the downstream direction: 5 Chinook (0-10 days above the weir) and 2 pink salmon (4-7 days above the weir).

An estimate of Chinook salmon escapement above the weir was anticipated to result from the data collected in 2010, by enumerating the total number of Chinook migrating in both the upstream and downstream direction. Weir efficiency was to be calculated from the recovery of marked and unmarked fish captured in the downstream direction: The ratio of marked to unmarked fish is used to expand the number of Chinook captured to the total abundance for Chinook salmon that passed above the weir (see Objective 4). However, because of the shortened trapping season in 2010, both the tagging and recapture of Floy® tags was limited. Therefore, an estimate of Chinook escapement could not be developed for the 2010 season. In future years, we expect that a mark-recapture study design will be used to derive abundance estimates for Chinook salmon, as well as pink and sockeye salmon during the July to October time period.

Table 11. Number of Floy® tags inserted, recovered and days spent above the weir by species for 22 fish captured, tagged and released at the weir in the Elwha River in 2010.

Species	Number Inserted	Number Recovered	Days Above Weir
Chinook salmon	11	7	0, 2, 5, 10, 10
pink salmon	5	2	4, 7
steelhead trout	3	0	-
sockeye salmon	1	0	-
coho salmon	1	0	-
chum salmon	1	0	-
Total	22	9	0-10

Objective 4. Recommend future approaches for making species-specific escapement estimates above and below the weir on the Elwha River.

In order to derive species-specific escapement estimates for salmonids in the Elwha River, the fish enumerated at the floating weir must be expanded with a statistical abundance estimator. Based on flow conditions, we anticipate that weir efficiency (i.e., capture rate) will be high during Chinook immigration and spawning (May – October), but lower during winter steelhead immigration and spawning (November – July, Figure 5). Efficiency will likely differ among species and years, and will need to be estimated for each species in each season. Due to the dramatically different flow regimes between the Chinook and winter steelhead trapping periods, the approaches for abundance estimation for these species are described separately.

The abundance of Chinook salmon will be estimated using a mark-recapture study design and a Chapman-Peterson abundance estimator (Seber 1981). The same approach will be used to estimate abundance of pink and sockeye salmon, if recapture rates are high enough for these species. The Chapman-Peterson estimator requires that a portion of the population is sampled, marked, and released (n_1) during the tagging event(s). This sample is then expanded to a population abundance estimate ($\hat{N}$) based on the number of fish (n_2) and the number of marks (m_2) in the recovery event(s). The recovery sample (n_2) must include marked (m_2) fish and may include unmarked fish.

Equation 1:

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)}$$

An unbiased Peterson mark-recapture estimator requires that the collected data meet the following assumptions: (1) geographic and demographic closure (i.e., a closed population), (2) complete mixing of tagged and untagged fish, (3) no effect of tagging on fish behavior or catch rates, (4) no tags are lost, and (5) all tags will be detected. Efforts will be made to minimize, test, and account for violation of these assumptions. During the tagging events at the floating weir, maiden-caught fish in pre-spawning condition will be identified to species and sex, measured, and tagged with a Floy® tag prior to release upstream. Floy® tags will be recovered from carcasses on the weir, and above and below the weir during WDFW spawning surveys. The location and date of tag recovery will be recorded, as well as the species, sex, tag number, and otolith vial number from individual carcasses. Upon recovery, individual Floy® tag codes will be recorded to track the fish back to the date of release from the weir. Pooling of tagging and recovery data should improve precision of the estimate, but will result in a biased estimate if recovery rates differ between strata (Schwarz and Taylor 1998). Therefore, tagging and recovery data will initially be stratified by time (statistical week), recovery location (weir, WDFW surveys above and below the weir), and sex. Strata will be pooled if a Goodness-of-Fit test (*G* test, Sokal and Rohlf 1981) indicates no difference among strata. We anticipate that tagged fish will be recovered from surveys above and below the weir and that a total abundance estimate for the watershed will be possible. If no tagged fish are recovered from below the weir, then we will use the spawner to redd ratio above the weir to expand the redd count from below the weir. Redd information is collected by WDFW staff during weekly surveys.

Two approaches will be used to estimate winter steelhead abundance. The first approach is the mark-recapture estimator as described for Chinook salmon above. The tagging events will occur in the upstream traps at the floating weir with maiden-caught fish in pre-spawn condition. The recovery samples will be steelhead caught in the downstream traps as kelts or pre-spawners. We do not expect to handle many steelhead carcasses. Because the weir is expected to fish intermittently during the winter steelhead spawning season, tagging and recovery events will not be consistent for the entire run. Therefore, a stratified estimate will be required to produce an unbiased estimate from the mark-recapture steelhead data (Schwarz and Taylor 1998).

The second approach to estimating winter steelhead abundance will be to combine weir and SONAR monitoring data. NOAA will be installing a DIDSON SONAR array in the Elwha River at the weir site in early 2011. The location selected for the SONAR track and mount system is about 20 meters upstream of the current location of the weir substrate rail on the right (east) bank. Whereas the floating weir is expected to operate up to flows of 2,000 cfs, the SONAR will allow collection of continuous fish passage data over a wider range of flows (e.g., up to about 7,000 cfs, Keith Denton, NOAA, personal communication). An estimate of steelhead abundance can be obtained by combining SONAR measurements with weir species composition information and weir count data. However, this estimate may be a lower bound estimate if the floating weir and the SONAR are both non-operational for extended periods of time.

Abundance estimates for all species will be partitioned into natural- and hatchery-origin fish, when possible. Currently, hatchery production in the Elwha occurs for Chinook, chum, and coho salmon, and winter steelhead (native) and winter steelhead (Chambers Creek stock). Hatchery-origin fish can be distinguished from natural-origin fish based on marks, tags, or otolith data (for salmonids), with the exception of chum salmon, which are not currently marked (Table 12).

Table 12. Mark or tag identification of hatchery salmonids released in the Elwha River based on current marking strategies. Release sites are either the Washington Department of Fish and Wildlife Rearing Channel or the Lower Elwha Klallam Tribe hatchery.

Release Site	Species	Life Stage	Mark Type(s)
WDFW	Chinook	Sub-yearling	Otolith
WDFW	Chinook	Yearling	CWT
LEKT	Steelhead (Native)	Yearling	CWT
LEKT	Steelhead (Chambers)	Yearling	Ad clip
LEKT	Coho	Yearling	Ad clip, CWT, Ad clip/CWT
LEKT	Chum	Sub-yearling	n/a

Chinook salmon abundance will be partitioned into hatchery- and natural-origin based on recovery of coded-wire tags and otolith markings, when possible. The presence of coded-wire tags are detected by scanning fish caught at the weir; tag codes are obtained from carcass recoveries. In 2011, otoliths will also be collected from Chinook carcasses that wash onto the floating weir. In past years, approximately 300 otoliths have been collected each year by WDFW staff. Weir operation is expected to increase the number of otoliths collected in the Elwha River. Steelhead abundance will be partitioned into native (Elwha River) hatchery steelhead, Chambers Creek hatchery steelhead, and natural-origin steelhead, based on a combination of coded wire tag detections and fin condition (i.e., adipose fin clip or dorsal fin morphology) of the steelhead captured at the floating weir.

Accomplishments of the Elwha Weir Project in 2010

The major accomplishments of the Elwha floating weir project in 2010:

- Hired a biologist and a technician, and established a field office in Port Angeles, near the Elwha River.

- Finalized design and construction of a 159' floating weir, which was part of a 195' in-river, fish trapping structure.

- Acquired all necessary permits, as well as site access and preparation.

- Installed and operated a resistance board floating weir for the purpose of enumerating salmonids in the Elwha River.

- Collaborated with USGS, NOAA (Northwest Fisheries Science Center), USFWS, Olympic National Park, and LEKT to staff weir operation.

- Collected abundance and biological data from salmon, trout and char at the floating weir.

- The data collected in 2010 were placed into an electronic database. Collected data were analyzed and the results summarized in the first (2010) Annual Report for the Elwha weir project.

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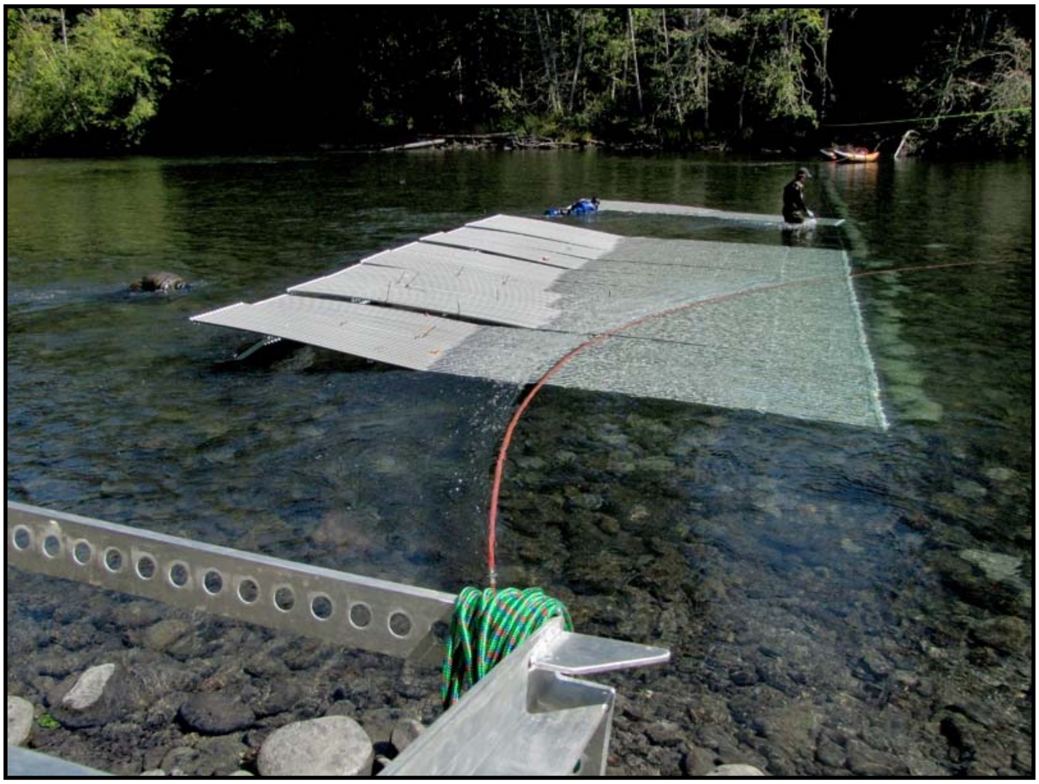
Appendix A

Rail set line used during installation of the floating weir in the Elwha River (2010).

Equipment used in-river during installation of the floating weir in the Elwha River (2010).

Driving pins during installation of the floating weir in the Elwha River (2010).

First two panels used during installation of the floating weir in the Elwha River (2010).


Adding panels during installation of the floating weir in the Elwha River (2010).


Adjusting panels during installation of the floating weir in the Elwha River (2010).

Appendix B

Chinook salmon swimming under the floating weir in the Elwha River (2010).

Male Chinook salmon captured at the floating weir in the Elwha River (2010).

Female Chinook salmon captured at the floating weir in the Elwha River (2010).

Pink salmon captured at the floating weir in the Elwha River (2010).

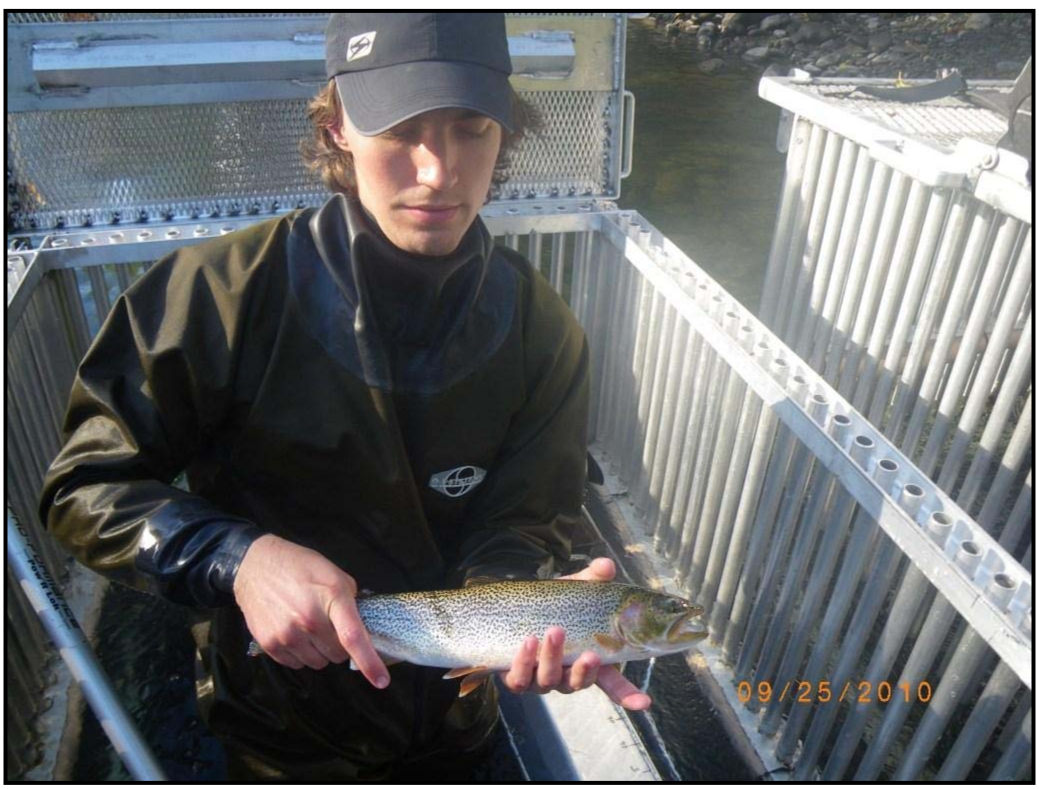
Steelhead trout captured at the floating weir in the Elwha River (2010).

Sockeye salmon captured at the weir in the Elwha River (2010).

Coho salmon captured at the floating weir in the Elwha River (2010).


Bull trout captured at the floating weir in the Elwha River (2010).

Chum salmon captured at the floating weir in the Elwha River (2010).



Cutthroat trout (sea-run) captured at the floating weir in the Elwha River (2010).