# Elwha River Salmonid Assessment: Adult Weir Project

## 2011 ANNUAL REPORT

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# Executive Summary

Removal of the Elwha and Glines Canyon Dams in the Elwha River began in September 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* before, during and after dam removal. In 2011, a 59.4 meter resistance board floating fish weir and fish traps were 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. The weir was fished for the winter season (April 27 to May 13, 2011) and the summer/fall season (August 18 to October 20, 2011). The August 2011 weir installation occurred in flows of more than 1,640 cfs. A total of 647 salmonids were captured in 2011: 438 Chinook salmon, 184 pink salmon *O. gorbuscha*, 14 steelhead (12 during the winter and two in the fall), 6 sockeye salmon *O. nerka*, 3 bull trout *Salvelinus confluentus*, 1 coho salmon *O. kisutch*, and 1 chum salmon *O. keta*. Of these, a total of 175 fish were captured for the Washington Department of Fish and Wildlife (WDFW) and Lower Elwha Klallam Tribe (LEKT) brood stock programs: 62 Chinook and 113 pink salmon. The majority (67.7%) of the female Chinook salmon captured in 2011 were 4 years of age. The majority (59.8%) of males were age 3. A combination of scale, otolith, and coded-wire tag data indicated that most (94.1%) of the spawning Chinook salmon were hatchery origin and released from the WDFW Rearing Channel as sub-yearlings. Mean fork length of male Chinook salmon was longer than the females within each age class. Coded wire tags (CWT) were recovered from 21 Chinook salmon. Sixteen of the CWT's were from fish released from the WDFW Rearing Channel. Five CWT's were recovered from fish with origins outside the Elwha basin: Four from the Dungeness River, and one from Grovers Creek, Vancouver Island, British Columbia.

# Table of Contents

## Introduction

For nearly a century, two hydroelectric dams on the Elwha River in Washington State have blocked access to the majority of the watershed, adversely affecting the river ecosystem and native anadromous fisheries because neither dam was built with fish passage facilities. The lower 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. 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 20$^{th}$ century (NPS 2005). The loss of fish from 93% of the Elwha River has resulted in severe impacts to the entire 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 and spring snowmelt. 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). Mean summer (base) flow 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 of "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). Puget Sound Chinook salmon and Puget Sound steelhead trout are listed as threatened under the Endangered Species Act (ESA) by the National Marine Fisheries Service (NPS 2005). Bull trout are listed as threatened by the U.S. Fish and Wildlife Service.

Salmonid stocks in the Elwha River are severely depleted. Native stocks are declining and almost all Chinook, coho, and steelhead in the Elwha are hatchery produced (EWIR 2010). Pess et al. (2008) summarized the current number of adult returns to the Elwha River as follows:

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

Removal of the two hydroelectric dams on the Elwha River is among the largest river restoration projects in United States history and represents a unique opportunity to assess recovery of fish populations at the watershed scale. Dam removal began in September 2011. 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.

Presently, abundance estimates are derived for just two of the eight salmonid species in the Elwha River: Chinook salmon and pink salmon. Chinook salmon abundance estimates are based on redd counts, brood stock collection, and returns to the hatchery. Pink salmon abundance estimates are derived from peak spawner counts. Although spawner surveys are conducted annually for steelhead, a method for estimating steelhead spawner abundance has not been derived. None of the current methods provides a means of assessing estimate bias or precision, both of which are necessary for evaluating species responses to dam removal.

A resistance board floating weir is an innovative tool for capturing fish and describing biological characteristics of 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 and in other states on the west coast (Mayer et al. 2010). This is the first floating weir on the Olympic Peninsula and among the first in Puget Sound.

Data collected at the weir will be used (along with other tools) to derive Viable Salmonid Population (VSP) metrics as defined by NOAA Fisheries (McElhany et al. 2000). This project will contribute information towards the calculation of three of the four parameters considered when evaluating VSP status: Abundance, productivity (population growth rate), and diversity (McElhany et al 2000). The weir will also be used to collect brood stock to preserve salmon runs during dam removal.

*Objectives*

The Elwha Weir Project is planned for a period of time before, during, and following dam removal. The primary goal of the Elwha Weir Project is to enumerate and describe the life history characteristics of Chinook salmon and steelhead trout in the Elwha River. The weir project also provides broodstock during the early phases of restoration and provides biological data on all salmon, trout, and char returning to the Elwha River to spawn. The 2011 field seasons were the second year for this project.

The main objectives of the Elwha Weir Project in 2011 were:

(1) Install and operate a floating weir on the Elwha River below the Elwha dam near river kilometer 7.7 (river mile 3.7),
(2) Enumerate catch and collect biological information from adult salmon, steelhead trout and char by species,
(3) Collect adult salmon (Chinook and pink salmon) for brood stock purposes (as requested by fisheries managers), and
(4) Estimate species-specific escapement above the weir.

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.

This report was prepared to inform fisheries managers, co-managers and interested parties about the operations of the floating weir in the Elwha River operated by WDFW. This is the second annual report for the Elwha Weir Project.

## 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.

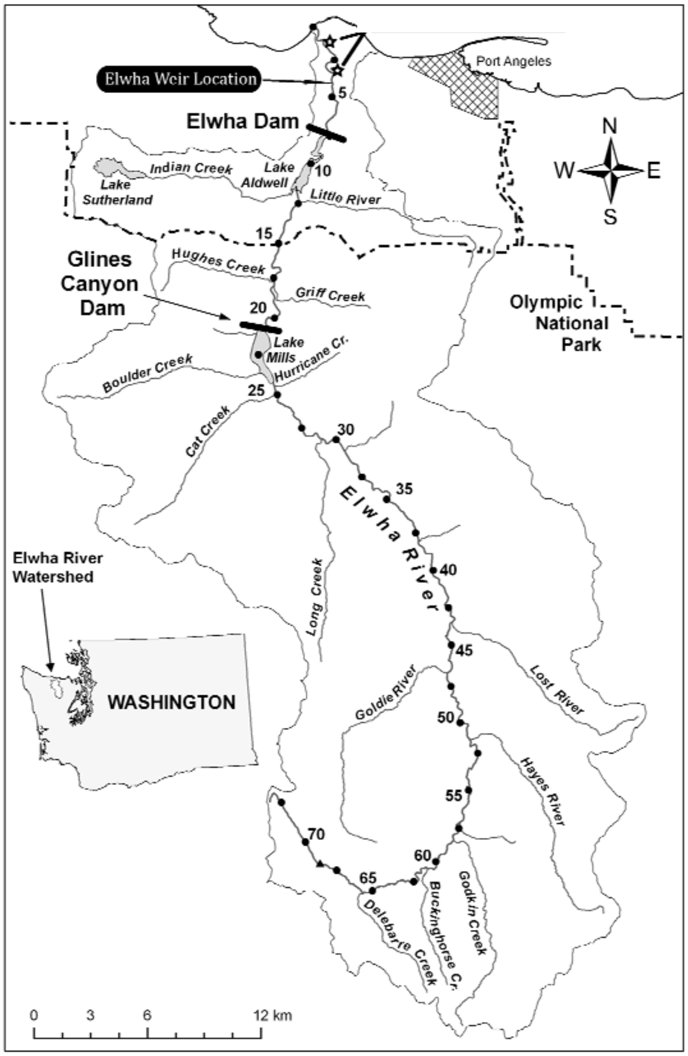


Figure 1. The Elwha River watershed in northwestern Washington. Map shows location of the Elwha floating weir at river kilometer 5.9 (river mile 3.7). River distances are in 2.5-mile increments (black dots). (Figure prepared by Jeff Duda, U.S. Geological Survey.)

U.S. Geological Survey records from 1897 to 2007 show 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, 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 3.7) to capture adult salmonids. The weir was designed to divert fish into one of several traps for data collection. The weir panels were 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 7.6 cm steel substrate rail. Resistance boards, made of 5.1 cm foam insulation sandwiched between two, 46x91 cm pieces of 0.95 cm marine-grade plywood, 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 two traps in the upstream direction and one to two traps in the downstream direction. Curtains, made of 2.5 cm high density polyethylene (HDPE) pipe and CPVC spacers, 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 two up traps. Live fish migrating downstream were captured in two downstream traps and a number of fish were netted from the weir. Carcasses were generally collected after drifting downstream onto the weir panels.

Biological data collected from adult salmonids included species, sex, spawn condition, fork length, presence of coded-wire tags, presence of PIT tags, fin mark (ad clip), scale samples, and DNA samples. Spawn condition was recorded as direction of travel (up or down) and condition (live or carcass). Coded-wire tags and otoliths were collected from each carcass.

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

Age data were validated, in order of certainty, with coded wire tags (CWT), when present in carcasses, otolith samples from carcasses, and scale samples (all fish). All fish were scanned for the presence of CWT using a wand detector manufactured by Northwest Marine Technology, Inc. (Shaw Island, WA) and for passive integrated transponder (PIT) tags using a detector manufactured by Biomark, Inc. (Boise, ID), (Figure 4).

Otoliths were recovered from fish carcasses. Otoliths were removed in the field and transported to the WDFW Otolith Lab. Decoding of thermally marked otoliths provided information on origin (location and brood year) of the hatchery produced fish. Snouts were removed from carcasses with a “positive” electronic CWT scan. Snouts were frozen and transported to the WDFW CWT lab for tag removal and decoding. Release information (location and brood year) associated with each CWT code was obtained from the Regional Mark Information System Database (http://www.rmpc.org/).

Scales were collected from every captured fish except for pink salmon, which were subsampled. Scale samples were taken from the first 30 pink salmon and then a subsample was taken from every fifth pink thereafter (i.e., 35, 40, 45, etc.). Scale samples were handled according to WDFW protocols (L. Campbell, WDFW, personal communication). 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. 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 and bull trout) ages (Burgner 1991).

DNA samples were obtained with a fin clip or hole punch (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 hatchery origin, when possible. Pictures were generally taken of fish having unique features.

Early in the season, the first 11 pink salmon migrating upstream as pre-spawners were tagged with colored, uniquely numbered Floy® tags, manufactured by Floy Tag & Manufacturing, Inc. (Seattle, WA). Selected Chinook were PIT tagged for identification following spawning in the brood stock program operated by WDFW at the rearing channel facility.


Figure 3. Pink salmon with Floy tag in cradle at the floating weir in the Elwha River in 2011.

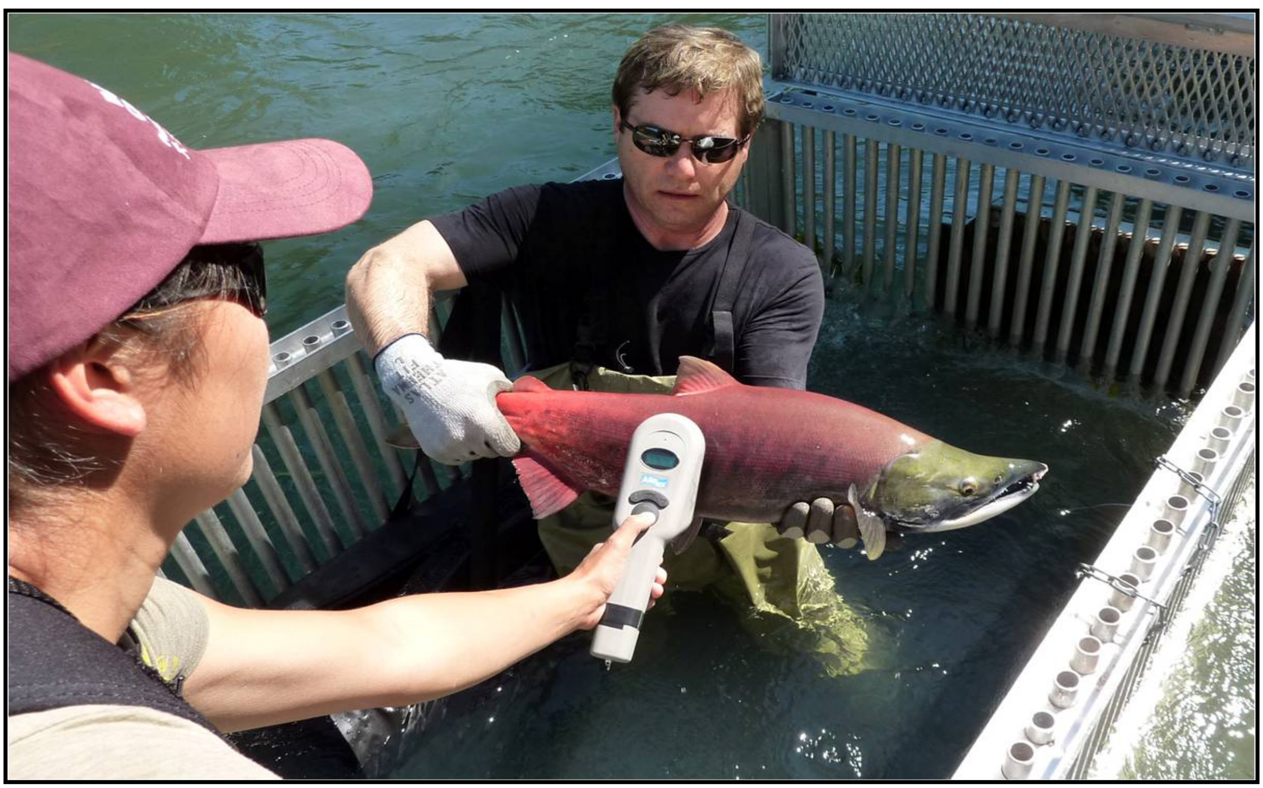

Figure 4. A male Sockeye salmon captured at the weir in the Elwha River in 2011 is scanned for PIT tags and coded wire tags. Fish are lifted from cradle in order to obtain tag information.

## 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 2011 season was the first winter season and second summer/fall season that the floating weir operated in the Elwha River. Due to high winter flows, the weir was installed in late April for the winter steelhead season. The weir panels were installed in a discharge of about 1,600 cfs. Operation of the weir for the winter season occurred between April 27 and May 13, 2011 (16 days). The weir was installed in mid-August for the summer/fall season. Operation of the weir for the summer/fall season occurred between August 18 and October 20, 2011 (63 days).

The weir installation process took 4-6 days from the start of installation to the point where it was "fish tight" (i.e., when the weir is fishing and collecting data). The installation dates were determined by river flows. For example, in 2011, there was a 190% of normal snowpack in the Olympic Mountains which led to higher than average flows in the early summer months. As a result, the weir was likely installed after a portion of the winter steelhead, Chinook and pink salmon moved past the weir site (Figure 5).

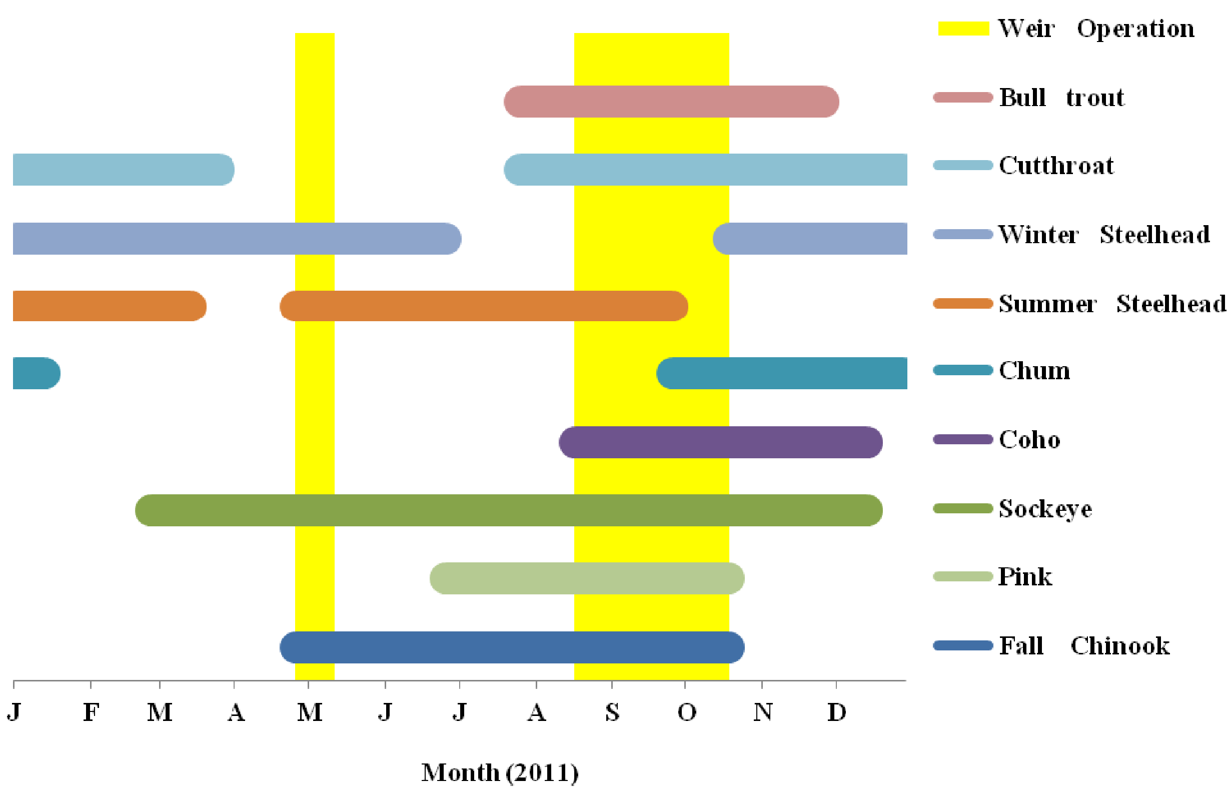


Figure 5. Presence of salmonid species (immigration and spawning) in the Elwha River and the timing of weir operation in 2011. Species presence information provided by NPS (2005) and edited by Randy Cooper, WDFW.

For the winter steelhead season, the weir was installed on April 21 and began fishing on April 27. The weir was removed on May 13, just prior to the snowmelt season (Figure 6). Weir components were stored at the WDFW rearing channel. The substrate rail remained in-river.

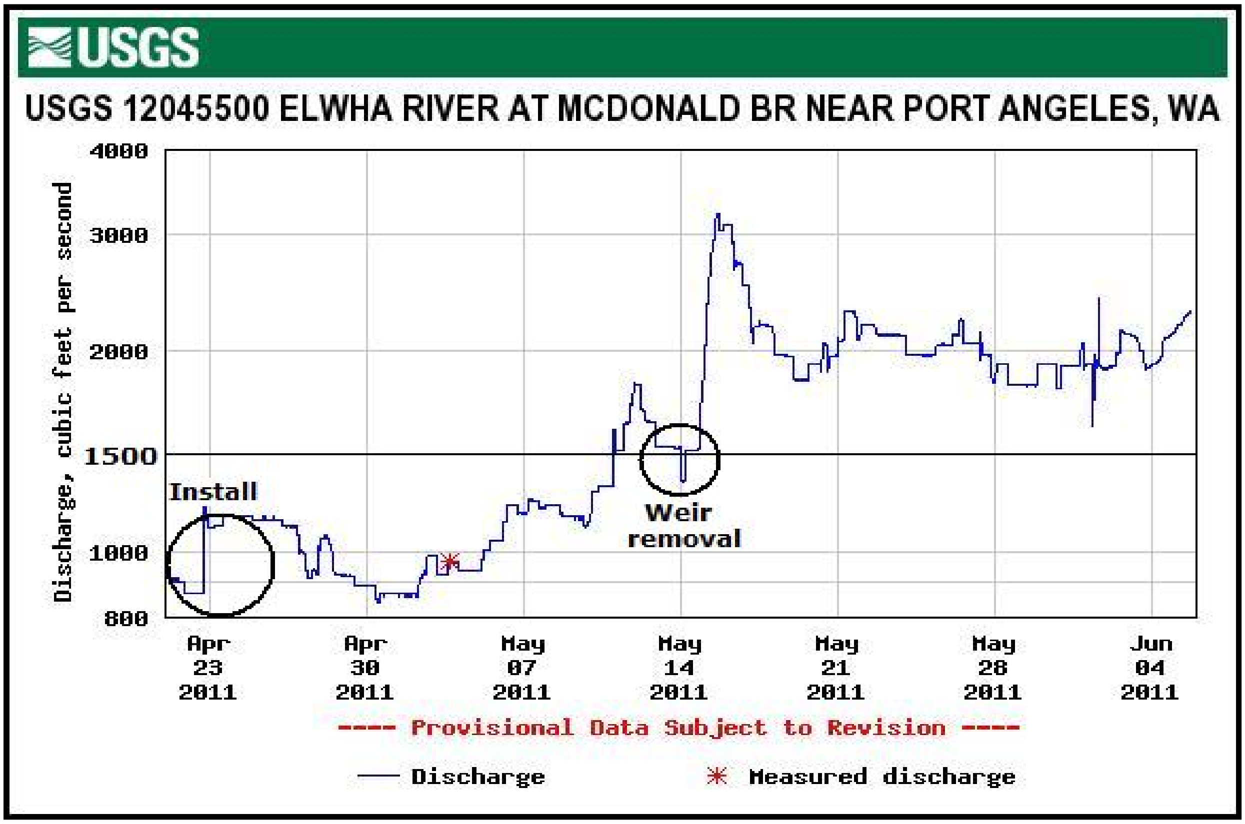


Figure 6. The 2011 winter season operations of the floating weir in the Elwha River. The weir operated between April 27 and May 13, 2011.

The trapping configuration during the 2011 winter season used three traps: One upstream trap and one downstream trap (placed mid-panel below the rail) on river left (west bank), and one upstream trap on river right (east bank) (Figure 7).

For the summer/fall seasons, the weir was installed on August 10, 2011, in flows of more than 1,640 cfs (Figure 8). The weir began fishing on August 18, 2011. The weir was fished for 10 weeks and removed on October 20, 2011, due to the removal of a log boom at the Elwha Dam, which released of hundreds of large logs into the lower Elwha River (Figure 9). Weir components were stored at the WDFW rearing channel. The substrate rail remained in the river.

Figure 7. The winter 2011 trapping configuration used three traps: One upstream trap and one downstream trap on river left (west) bank, and one upstream trap on river right (east) bank.

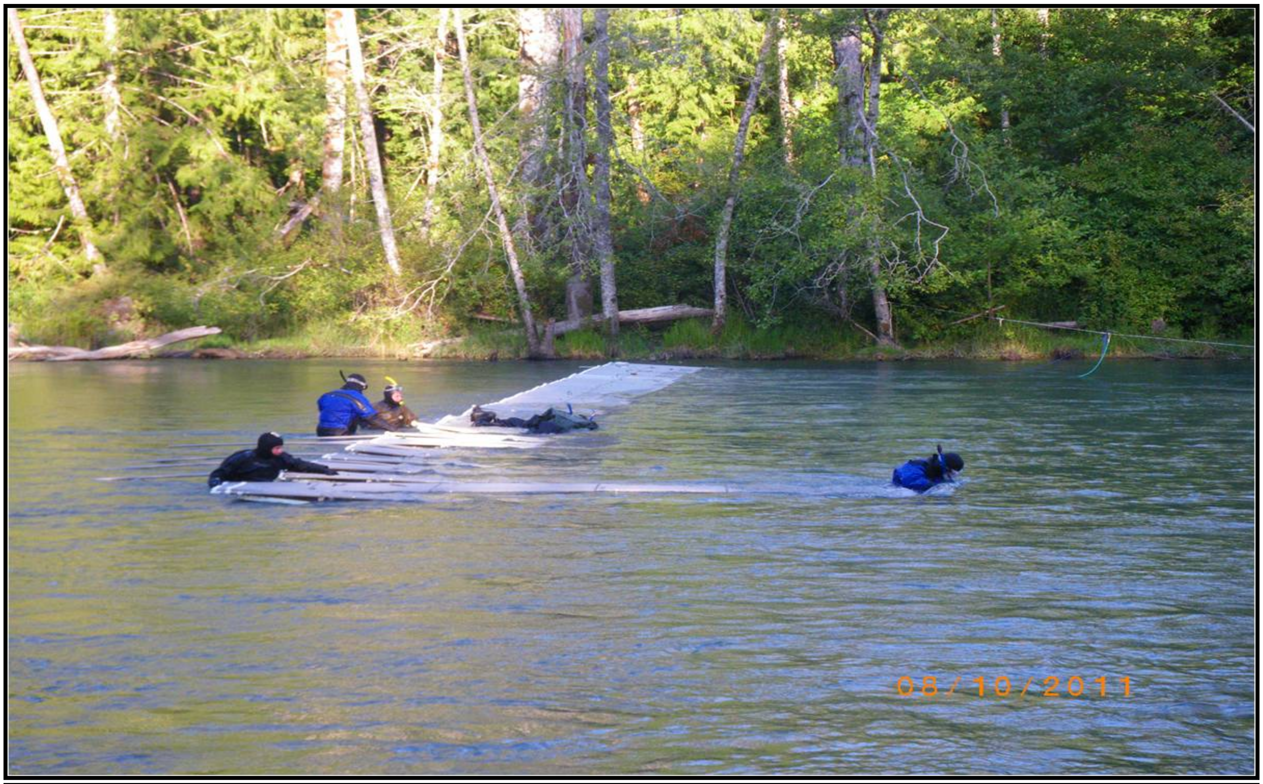


Figure 8. The Elwha floating weir was installed on August 10, 2011, in flows above 1,640 cfs.


Figure 9. Hundreds of large logs at the Elwha Dam were released on October 21, 2011, which headed downstream into the lower Elwha River, in the direction of the weir (2 km downstream). The weir was removed one day prior to protect it from potential damage caused by the release.

*Objective 2. Enumerate catch and collect biological information from adult salmon, trout and char by species.*

A total of 647 salmonids were captured during the two trapping seasons (winter and summer/fall) in 2011: 12 steelhead in the winter and 635 total salmonids in the summer/fall. During the 2011 winter trapping season, 12 adult steelhead (4 males and 8 females) were captured (Table 1). All steelhead captured had intact adipose fins. No coded wire tags were detected, indicating all were likely of natural origin. Steelhead age composition is presented in Table 2. One female (80 cm) winter steelhead was a repeat spawner, with the first spawning in 2010 and the second in 2011.

Table 1. Number and fork length of steelhead captured at the Elwha floating weir during the 2011 winter season. 'n' is sample size.

| Condition | Male | | Female | | Total |
|---|---|---|---|---|---|
| | n | Fork length (cm) | n | Fork length (cm) | |
| Pre-spawn (up) | 1 | 91 | 4 | 67, 74, 76, 80 | 5 |
| Post-spawn (down) | 1 | 71 | 3 | 74, 83, 85 | 4 |
| Carcasses | 2 | 81, 89 | 1 | 64 | 3 |
| Total | 4 | - | 8 | - | 12 |

Table 2. Age and length of male and female steelhead captured at the Elwha floating weir during the 2011 winter season. 'n' is sample size. All steelhead captured during the 2011 winter season were of natural origin.

| Steelhead | | Male | Female | Total |
|---|---|---|---|---|
| Age | Stat. | Fork length (cm) | Fork length (cm) | |
| Age 2.1 | n | 0 | 1 | 1 |
| | Mean | - | 67.0 | - |
| | SD | - | - | - |
| Age 2.2 | n | 2 | 4 | 6 |
| | Mean | 90 | 79 | - |
| | SD | 1.4 | 5.8 | - |
| Age 3.1* | n | 0 | 0 | 0 |
| | Mean | - | - | - |
| | SD | - | - | - |
| Age 3.2 | n | 1 | 1 | 2 |
| | Mean | 81.1 | 80.0 | - |
| | SD | - | - | - |
| Age R.1 | n | 1 | 2 | 3 |
| | Mean | 71.0 | 70.0 | - |
| | SD | - | 8.5 | - |
| Total | N | 4 | 8 | 12 |

*Repeat spawner.

During the 2011 winter season, more than two dozen post-spawning steelhead were observed at the weir. These fish were intentionally passed down during periods of weir modification or when the weir was opened by submerging a panel to allow passage. There were nine days in the winter during which no steelhead were caught.

During the 2011 summer/fall trapping season, 635 adult salmonids were captured at the weir (Table 3) between August 18 and October 20. The majority (68.8%) were captured during a three week period between September 19 and October 9. Daily catch was greater in the downstream direction (as carcasses) than in the upstream direction, which was probably a result of installing the weir after a number of Chinook salmon migrated upstream to spawn.

The majority of Chinook captured in the floating weir were in a post-spawning condition (i.e., carcasses or senescing fish). Of the 438 Chinook captured, 81.5% (357/438) were post-spawned carcasses and 18.5% (81/438) were live pre-spawners. Four point three percent (19/438) of the Chinook captured were caught live in the upstream trap and 14.2% (62/438) were caught live in the downstream direction. There were no unspawned Chinook salmon carcasses. Of the 438 Chinook salmon captured, 84.9% (372/438) were male and 15.1% (66/438) were female (Table 4). The age and length composition of live fish and for carcasses for all species captured is presented in Tables 5 and 6, respectively.

We collected scale samples from all (100.0%) of Chinook salmon captured at the weir in the Elwha River in 2011. Of the 438 Chinook salmon captured at the weir in 2011, coded wire tags were detected in 21 fish. Sixteen of the CWT's were in fish released from the WDFW Elwha Rearing Channel (CWT Codes 631424, 633879, 634267, 634786) and five CWT's were recovered from fish releases outside the Elwha basin, including four from the Grey Wolf River (Dungeness River, CWT Codes 210775, 210846) and one from Grovers Creek, Vancouver Island (British Columbia, CWT Code 635089). No PIT tags were detected in any fish captured at the weir in 2011. Otoliths were collected from a total of 414 Chinook salmon: 358 Chinook carcasses that wash onto the floating weir and an additional 56 Chinook that were captured live at the weir and subsequently used for broodstock. Otolith results were used to assign origin to Chinook salmon with no external mark or tag and to validate scale age results. Otoliths are the only way to assign an origin (hatchery or natural) to the majority of Chinook because subyearling Chinook released from the Elwha Rearing Channel have thermal otolith marks but no external mark indicating hatchery origin (Volk et al., 1990).

Based on otolith results only, 93.2% (386/414) of the Chinook salmon were determined to be of hatchery origin. Eighty five point five percent (354/414) were Elwha origin released as subyearlings, 5.1% (21/414) were of Elwha origin released as yearlings, 1.7% (7/414) were naturally-produced from the Elwha River, 1.2% (5/414) were of hatchery origin outside the Elwha, 6.0% (25/414) were of unknown release strategy (i.e., brood year and hatchery of origin is known, but their release as a yearling or sub-yearling is not known), and 0.5% (2/414) had no otolith marks.

Eighty-four percent (326/386) of the otoliths recovered from known hatchery origin were from male Chinook salmon and 15.6% (60/386) were from female Chinook salmon. Of the males, 1 (0.3%) was from the 2006 brood year, 91 (27.9%) from 2007, 196 (60.1%) from 2008 and 38

(11.7%) were from brood year 2009. Of the otoliths recovered from females, 42 (70.0%) were from the 2007 brood year and 5 (30.0%) were from brood year 2008. In past years, about 300 otoliths have been collected each year by WDFW staff. Weir operation increased otolith collection to 992 samples from the Elwha River in 2011.

Origin and total age (brood year) of Chinook salmon were assigned based on the combination of scale, coded wire tag and otolith data (Table 7). Scale data were available for all Chinook; however, CWT data applied to just a portion of the Chinook, and otolith data applied only to thermally-marked (i.e., hatchery origin) Chinook. Based on the available data, age discrepancies occurred in 15 (3.6%) of the 414 fish recovered with otolith marks, when scale results were different than either the CWT or otolith results. When a discrepancy existed, CWT results were assumed to be the most reliable, followed by otolith results, followed by scale age data.

Age results from live fish (Table 5) and carcasses (Table 6) indicated that Chinook return to the Elwha River at a total age of 2 to 5 years. The majority (67.7%) of female Chinook salmon captured at the weir in 2011 returned to spawn at age 4 (Figure 10). The remaining female Chinook salmon were age 3 (32.3%). No age 2 or age 5 females were captured. The majority (59.8%) of males captured at the weir in 2011 returned to spawn at age 3. The rest of the male Chinook were ages 2 (13.4%), 4 (26.5%) and 5 (0.3%).

Of the Elwha origin hatchery Chinook captured, 93.7% (354/378) were released as sub-yearlings by the WDFW Rearing Channel and 6.3% (24/378) were released as yearlings (Table 7). The subyearling/yearling ratio for hatchery Chinook returns was comparable to the release proportions for these two age classes. Between 2006 and 2010, 10,721,158 hatchery-reared juvenile Chinook were released from the WDFW Rearing Channel (www.rmpc.org, WDFW): 9,668,962 sub-yearlings (90.2%) and 1,046,196 yearlings (9.8%). Of the 354 Chinook salmon released as sub-yearlings and captured at the weir in 2011, 83.3% (295/354) were male and 16.7% (59/354) were female. Of the Chinook yearling releases that were captured, 95.8% (23/24) were male and 4.2% (1/24) were female.

Of the 184 pink salmon captured at the weir, 70.1% (129/184) were live and 29.9% (55/184) were post-spawned carcasses. Thirty-two point six percent (60/184) of the pinks captured were live pre-spawners caught in the upstream trap and 37.5% (69/184) were caught live in the downstream direction. There were no unspawned pink salmon carcasses. Of the 184 pink salmon captured, 58.7% (108) were male and 41.3% (76) were female (Table 4).

Table 3. Total number of salmonids by species captured by week at the Elwha floating weir during the 2011 summer/fall season. Release type indicates whether the fish were released in the direction of travel (river) or retained for broodstock (hatchery).

| Species | Condition | Release Type | Week 1 8/18-21 | Week 2 8/22-28 | Week 3 8/29-9/4 | Week 4 9/5-11 | Week 5 9/12-18 | Week 6 9/19-25 | Week 7 9/26-10/2 | Week 8 10/3-9 | Week 9 10/10-16 | Week 10 10/17-20 | Sub-Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chinook | Live | River | 0 | 0 | 0 | 0 | 0 | 3 | 6 | 8 | 2 | 0 | 19 | 438 |
| | | Hatchery | 0 | 1 | 6 | 2 | 6 | 11 | 26 | 10 | 0 | 0 | 62 | |
| | Carcass | River | 0 | 0 | 0 | 9 | 26 | 60 | 71 | 117 | 61 | 13 | 357 | |
| Pink | Live | River | 1 | 10 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 16 | 184 |
| | | Hatchery | 0 | 0 | 14 | 8 | 18 | 23 | 33 | 17 | 0 | 0 | 113 | |
| | Carcass | River | 0 | 0 | 0 | 1 | 10 | 26 | 12 | 5 | 1 | 0 | 55 | |
| Sockeye | Live | River | 2 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 | 6 |
| | | Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Carcass | River | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | |
| Bull trout | Live | River | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 3 | 3 |
| | | Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Carcass | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Steelhead | Live | River | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| | | Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Carcass | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Coho | Live | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| | | Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Carcass | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Chum | Live | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| | | Hatchery | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Carcass | River | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | |
| Total | - | - | 3 | 13 | 22 | 20 | 61 | 125 | 150 | 162 | 66 | 13 | 635 | 635 |

Table 4. Total catch of salmon, trout, and char captured at the floating weir in the upstream and downstream direction in the Elwha River in 2011. “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 | 438 | 67 | 305 | 1 | 65 | - | - | 68 | 370 |
| Pink salmon | 184 | 42 | 66 | 18 | 58 | - | - | 60 | 124 |
| Sockeye salmon | 6 | 3 | 2 | - | 1 | - | - | 3 | 3 |
| Bull trout | 3 | - | - | - | - | 1 | 2 | 1 | 2 |
| Steelhead trout | 2 | 1 | - | - | 1 | - | - | 1 | 1 |
| Coho salmon | 1 | - | - | - | 1 | - | - | - | 1 |
| Chum salmon | 1 | - | - | - | 1 | - | - | - | 1 |
| Total | 635 | 113 | 373 | 19 | 127 | 1 | 2 | 133 | 502 |

Table 5. Age and length composition of live fish by species captured at the Elwha floating weir in 2011. Brood year for each age is in parentheses. ‘n’ is number of samples. Scale samples were taken from the first 30 pink salmon and then subsampled from every fifth pink thereafter.

| Age | Stat. | Chinook | Pink | Sockeye | Bull trout | Steelhead | Coho | Chum |
|---|---|---|---|---|---|---|---|---|
| Age 2 (2009) | n | 9 | 129 | 0 | 0 | 0 | 1 | 0 |
| | Mean | 43.4 | 53.3 | - | - | - | 64.0 | - |
| | SD | 7.2 | 4.2 | - | - | - | - | - |
| Age 3 (2008) | n | 53 | 0 | 0 | 1 | 1 | 0 | 0 |
| | Mean | 74.8 | - | - | 41.0 | 67.0 | - | - |
| | SD | 6.8 | - | - | - | - | - | - |
| Age 4 (2007) | n | 18 | 0 | 0 | 1 | 1 | 0 | 0 |
| | Mean | 85.1 | - | - | 46.0 | 47.0 | - | - |
| | SD | 7.2 | - | - | - | - | - | - |
| Age 5 (2006) | n | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| | Mean | - | - | 64.7 | - | - | - | - |
| | SD | - | - | 5.9 | - | - | - | - |
| Age 6 (2005) | n | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| | Mean | - | - | 71.0 | 61.0 | - | - | - |
| | SD | - | - | - | - | - | - | - |
| Age 7 (2004) | n | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Mean | - | - | 65.0 | - | - | - | - |
| | SD | - | - | - | - | - | - | - |
| Data n/a | n | 1 | 0 | 0 | 3 | 0 | 0 | 0 |
| Total | N | 81 | 129 | 5 | 6 | 2 | 1 | 0 |

Table 6. Age and length composition of carcasses by species captured at the Elwha floating weir in 2011. Brood year for each age is in parentheses. ‘n’ is sample size.

| Age | Stat. | Chinook | Pink | Sockeye | Bull trout | Steelhead | Coho | Chum |
|---|---|---|---|---|---|---|---|---|
| Age 2 (2009) | n | 38 | 55 | 0 | 0 | 0 | 0 | 0 |
| | Mean | 47.6 | 52.6 | - | - | - | - | - |
| | SD | 5.2 | 4.7 | - | - | - | - | - |
| Age 3 (2008) | n | 188 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mean | 75.9 | - | - | - | - | - | - |
| | SD | 6.5 | - | - | - | - | - | - |
| Age 4 (2007) | n | 128 | 0 | 1 | 0 | 0 | 0 | 1 |
| | Mean | 88.6 | - | 38.0 | - | - | - | 67.0 |
| | SD | 7.1 | - | - | - | - | - | - |
| Age 5 (2006) | n | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Mean | 98.0 | - | - | - | - | - | - |
| | SD | 14.1 | - | - | - | - | - | - |
| Data n/a | n | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | N | 357 | 55 | 1 | 0 | 0 | 0 | 2 |


Figure 10. Percent of Chinook salmon by age class captured at the floating weir in the Elwha River in 2011. No age 2 or age 5 females were captured.

The overall mean fork length of male Chinook (75.7 cm, n = 343) was shorter than female Chinook (81.6 cm, n=65, *t*-test, $p < 0.0015$), a result largely explained by the observation that age at spawning for males was more evenly distributed across four age classes (ages 2-5) than females, especially in the age 2 class where there were 46 males and no females (Figure 10).

Mean fork length for Chinook males was 46.8 cm at age 2, 75.5 cm at age 3, 90.2 cm at age 4, and one fish was 108 cm at age 5. Mean fork length for Chinook females was 74.1 cm at age 3 and 85.1 cm at age 4. No age 2 or age 5 females were captured at the weir in 2011. There was no significant difference in the length of 3 year old males and females. However, mean length of 4-year old males (90.2 cm, n=91) was significantly longer than that of 4-year old females (85.1 cm, n=44; t = 133, $p = 0.00005$).

Fork length of Chinook salmon increased with age for both sexes and the rate of increase in fork length declined with age (Table 7). Males increased in size by 61.3% (28.7 cm) between ages 2 and 3 and 19.5% (14.7 cm) between ages 3 and 4. Females increased in size by 14.8% (11.0 cm) between ages 3 and 4.

Four male Chinook salmon captured at the weir in 2011 were less than 40 cm (30, 35, 37, 38 cm). The smallest female captured was 60 cm. All of the Chinook males less than 40 cm were yearling hatchery releases: Three of the males <40 cm had CWT's confirming their release in the 2009 brood year and one male had no tags.

Age and length composition of pink salmon and sockeye salmon, by origin and sex captured at the floating weir in the Elwha River in 2011 are presented in Tables 8 and 9, respectively. All pink salmon sampled (n=64) were 2 years of age.

Table 7. Origin, age, and length of male and female Chinook salmon captured at the Elwha floating weir in 2011. Brood year for each age is in parentheses. ‘n’ is sample size. Origin was determined using a combination of coded-wire tags, otoliths, and scale results.

| **Chinook** | | Male | | | | | Female | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | Stat. | Natural | Hatchery Sub-yrlg | Hatchery Yearling | Hatchery Strays | Unknown | Natural | Hatchery Sub-yrlg | Hatchery Yearling | Hatchery Strays | Unknown | |
| Age 2 (2009) | n | 0 | 37 | 4 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 47 |
| | Mean | - | 48.2 | 35.0 | 56 | 44.4 | - | - | - | - | - | - |
| | SD | - | 4.5 | 3.6 | n/a | 3.0 | - | - | - | - | - | - |
| Age 3 (2008) | n | 4 | 175 | 15 | 2 | 26 | 1 | 17 | 0 | 0 | 1 | 241 |
| | Mean | 71.8 | 76.6 | 67.7 | 72.0 | 76.2 | 69 | 74.6 | - | - | 71 | - |
| | SD | 6.7 | 6.1 | 8.2 | 7.1 | 6.3 | n/a | 6.2 | - | - | n/a | - |
| Age 4 (2007) | n | 2 | 82 | 4 | 0 | 12 | 1 | 42 | 0 | 2 | 1 | 146 |
| | Mean | 93.5 | 89.7 | 83.0 | - | 93.1 | 87 | 84.8 | - | 72.0 | 81 | - |
| | SD | 12.0 | 6.6 | 6.3 | - | 6.9 | n/a | 6.0 | - | 4.2 | n/a | - |
| Age 5 (2006) | n | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| | Mean | - | 108 | - | - | - | - | - | 88 | - | - | - |
| | SD | - | n/a | - | - | - | - | - | n/a | - | - | - |
| n/a | n | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| Total | N | 6 | 295 | 23 | 3 | 45 | 2 | 59 | 1 | 2 | 2 | 438 |

Table 8. Mark status, age, and length of male and female pink salmon captured at the Elwha floating weir in 2011. Brood year for each age is in parentheses. ‘n’ is sample size.

| **Pink** | | Male | | Female | | Total |
|---|---|---|---|---|---|---|
| Age | Stat. | Unmarked | Ad Clip | Unmarked | Ad Clip | |
| Age 2 (2009) | n | 107 | 1 | 72 | 4 | 184 |
| | Mean | 54.8 | 56 | 50.8 | 49 | 53.1 |
| | SD | 4.2 | n/a | 3.4 | 4.2 | 4.4 |
| Total | N | 107 | 1 | 72 | 4 | 184 |

Table 9. Mark status, age, and length of male and female sockeye salmon captured at the Elwha floating weir in 2011. Brood year for each age is in parentheses. 'n' is sample size.

| **Sockeye** | | Male | | Female | | Total |
|---|---|---|---|---|---|---|
| Age | Stat. | Unmarked | Ad Clip | Unmarked | Ad Clip | |
| Age 4 (2007) | n | 1 | 0 | 0 | 0 | 1 |
| | Mean | 38 | - | - | - | - |
| | SD | n/a | - | - | - | - |
| Age 5 (2006) | n | 2 | 0 | 0 | 0 | 2 |
| | Mean | 68.00 | - | - | - | - |
| | SD | 1.41 | - | - | - | - |
| Age 6 (2005) | n | 1 | 0 | 1 | 0 | 2 |
| | Mean | 71 | - | 58 | - | - |
| | SD | n/a | - | n/a | - | - |
| Age 7 (2004) | n | 1 | 0 | 0 | 0 | 1 |
| | Mean | 65 | - | - | - | - |
| | SD | n/a | - | - | - | - |
| Total | N | 5 | 0 | 1 | 0 | 6 |

The sample size of salmonids other than Chinook, pink and sockeye salmon captured at the weir during the summer/fall season was not large enough to statistically summarize age or length data. The following salmonid species were also captured at the weir in 2011: Three bull trout *Salvelinus confluentus* (sex unknown, 41, 46 and 61 cm, ages 3, 4 and 6, respectively); 2 steelhead trout *Oncorhynchus mykiss* (one hatchery male, adipose clipped, 67 cm, age 3, and one wild female, 47 cm, age 4); 1 coho salmon *O. kisutch* (hatchery female, adipose clipped, 64 cm, age 2); and 1 chum salmon *O. keta* (wild female, 63 cm, age 4).

*Objective 3. Collect adult salmon for brood stock purposes (as requested by fisheries managers).*

A total of 175 fish were captured for WDFW and LEKT brood stock programs: 62 Chinook salmon and 113 pink salmon. Of the 62 Chinook salmon captured for brood stock purposes, 80.6% (50) were male and 19.4% (12) were female. Mean fork length of the male Chinook captured for brood stock was 72.2 cm (SD 11.3), which was shorter than the females at 79.5 cm (SD 4.0). The mean age of males was 3.0 years old (n = 44, SD 0.5) compared to 3.4 years old (n = 12, SD 0.5) for females. One of the males collected for brood stock was from the 2006 brood year, 6 males (12.2%) were from 2007, 38 (77.6%) from 2008, and 5 (10.2%) were from the 2009 brood year.

Of the 113 pink salmon captured for brood stock, 59.3% (67) were male and 40.7% (46) were female. Mean fork length of the male pinks captured for brood stock was 54.9 cm (SD 4.2), which was longer than the females at 51.3 cm (SD 3.6).

*Objective 4. Estimate species-specific escapement above the weir.*

At the request of the fisheries managers, Objective 3 (Collect adult salmon for brood stock purposes) was added to weir operations in 2011. Based on this in-season decision, all live, pre-spawning Chinook and pink salmon captured at the weir in 2011 were transferred to the WDFW Rearing Channel and LEKT broodstock programs, respectively, for spawning. Therefore, no escapement estimates using mark/recapture methodology was possible using the weir in 2011.

Future approaches for deriving species-specific estimates of spawning escapement are being developed in the Elwha Monitoring and Adaptive Management Plan (in development). These approaches will rely heavily on fish captured and released from the weir in future years.

## Accomplishments of the Elwha Weir Project in 2011

The major accomplishments of the Elwha floating weir project in 2011:

- Operated the floating weir during two different trapping seasons: Winter/spring and summer/fall.
- The weir was installed during August of 2011 in flows of greater than 1,640 cfs.
- Weir removal procedures were created which allowed the weir to be removed in 3 hours.
- SONAR was established by NOAA at the weir site.
- Otolith data collected from Chinook salmon in the Elwha River was tripled in 2011, compared to previous years.
- The data collected in 2011 were placed into an electronic database. Data were analyzed and the results summarized in this second annual report for the Elwha weir project.

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