Elwha River Salmonid Assessment: Adult Weir Project

2012 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 2012, which was the third summer/fall season and the second winter/spring season for the floating weir on the Elwha River, a 59.4 meter wide resistance board floating fish weir and multiple fish traps were operated at river kilometer 5.9 (river mile 3.7). Biological information was obtained from all salmon, trout, and char species collected at the weir. The weir was fished for a total of 140 days in 2012: 59 days in the winter/spring from February 16 to April15, and 81 days in the summer/fall from August 2 to October 21. A total of 370 salmonids were collected (upstream and downstream) in 2012, representing seven different salmonid species: 174 (47%) Chinook salmon, 76 (20.5%) pink salmon *O. gorbuscha*, 45 (12.1%) steelhead (20 in winter and 25 in summer), 35 (9.4%) coho salmon *O. kisutch*, 33 (8.9%) bull trout *Salvelinus confluentus*, 4 (1%) sockeye salmon *O. nerka*, and 3 (0.9%) chum salmon *O. keta*. For all salmonids except Chinook salmon carcasses, the weir collected a greater number of fish in 2012 than the average of the previous two years (2010 and 2011). A total of 79 (45.4% of all) Chinook salmon captured at the weir in 2012 were held for brood stock purposes.

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Introduction

Two hydroelectric dams on the Elwha River in Washington State have blocked access to the majority of the Elwha 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 created 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 created the Lake Mills reservoir. Although there are other factors affecting Elwha River salmonid populations, the dams are a primary cause of the decline of the Elwha fish runs. For almost 100 years, anadromous salmonid species have been restricted to the lower 7.9 km of habitat in the Elwha River below Elwha Dam. 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 ecosystem (NPS 1995).

The Elwha River watershed encompasses 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 cubic feet per second (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 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 “salmon and trout spawning, core rearing, and migration” habitat 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 *Oncorhynchus tshawytscha* and Puget Sound steelhead trout *O. mykiss* 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.

Salmonid stocks in the Elwha River are severely depleted. Pess et al. (2008) estimated 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 to be 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 in the Elwha.

A resistance board floating weir is an innovative tool for capturing fish and describing biological characteristics of the fish species present. 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 and largest in Puget Sound.

The floating weir provides information on three of the four parameters for evaluating Viable Salmon Population (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. The 2012 field season was the third year for the Elwha Weir Project, which was planned for the period before, during and after dam removal on the Elwha River.

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.

Objectives

The main objectives for the Elwha Weir Project for 2012 were:

(1) Install and operate an adult salmon trap (floating weir) during the winter/spring (March-May) 2012 season and summer/fall (July-October) 2012 trapping seasons,
(2) Enumerate and collect biological information from adult salmon, steelhead trout and char captured during the trapping seasons specified in Task 1, and
(3) Collect adult salmon for brood stock purposes (as requested by fisheries managers) during the trapping seasons specified in Task 1.

The weir project 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 the Washington Department of Fish and Wildlife.

Methods

Description of Study Site

The Elwha River is located in the northwest corner of Washington State and drains from the Olympic Mountains north 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.

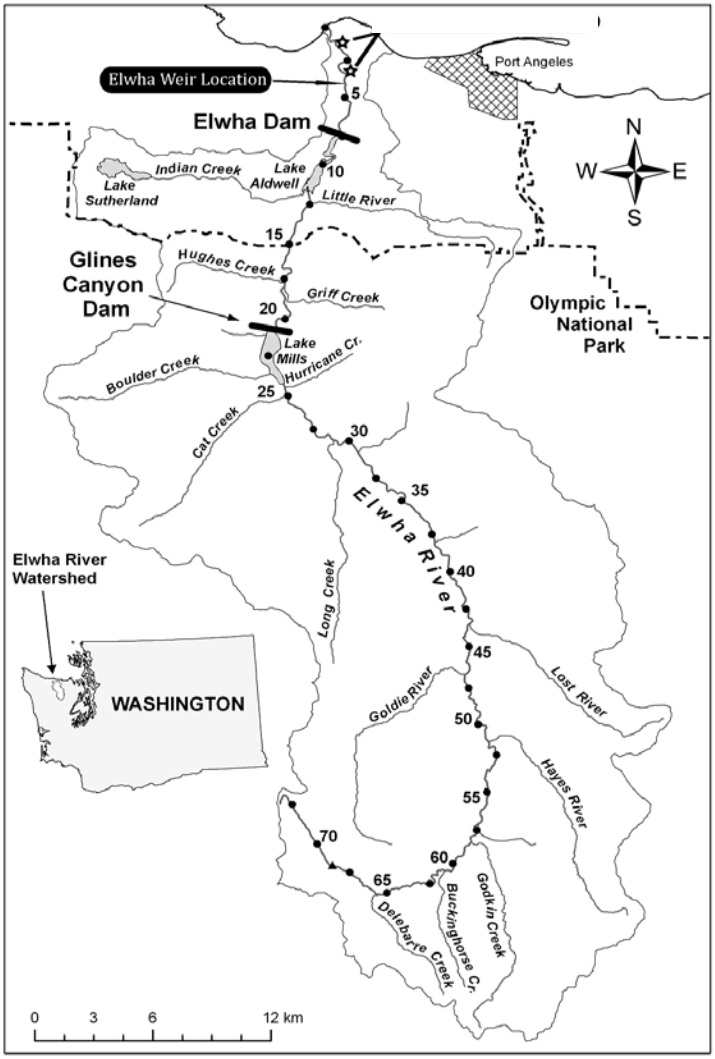

Figure 1 The Elwha River watershed in northwestern Washington. Map shows location of the Elwha floating weir at river kilometer 5.9 (river mile 3.7). River distances are in 2.5-mile increments (black dots). (Figure prepared by Jeff Duda, U.S. Geological Survey.)

U.S. Geological Survey records from 1897 to 2007 show 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 high flow in late winter to early summer ranges from 37.1 to 62.9 cms (1,310-2,220 cfs). Mean low flow in late summer is 22.1 cms (780 cfs).

Weir Operation

A resistance board floating fish weir was located on 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 0.91 meters (m) wide and 6.1 m long. Weir panels were made of schedule 40 polyvinyl chloride (PVC) pipe. The panels were attached to a 7.6 cm wide steel substrate rail. Resistance boards, made of 5.1 cm foam insulation sandwiched between two 46x91 cm pieces of 0.95 cm high molecular weight polyvinyl chloride, 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 (i.e., on river left and river right), with two or three traps in the upstream direction and one trap in the downstream direction. Curtains, made of 2.5 cm high density polyethylene (HDPE) pipe and chlorinated polyvinyl chloride (CPVC) spacers, were installed between the traps and river banks. Total project width (weir, traps, bi-pods, and HDPE curtains) was approximately 59.4 m (Figure 2).

Figure 2. Floating weir on the Elwha River on the Olympic Peninsula in Washington State in 2012.

Fish Collection

For clarity, the term “captured” shall denote fish caught in the upstream direction, while the term “recovered” shall denote fish intercepted in the downstream direction, such as fish netted off the weir, carcasses that have floated onto the weir, live, post-spawned senescing fish or fish caught in the downstream traps. Live fish recovered in the downstream direction are denoted as “recovered live.” Subsequently, the term “collected” shall denote fish handled at the weir regardless of direction. This is especially important when talking about Chinook salmon that were recovered moving in the downstream direction, which may have moved upstream past the

weir site before the weir was fish tight (i.e., fish that migrated upstream before August 2, 2012), or were passed upstream of the weir and subsequently returned to the weir at a later date, such as fish that were Floy tagged (e.g. coho salmon). As such, they are considered part of the population for each salmonid species collected at the floating weir in the Elwha River.

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

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 (adipose clip), fin condition, scale samples, and DNA samples. Spawning condition was recorded as direction of travel (upstream or downstream) and condition (live or carcass/dead).

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 3-4 minutes. Following data collection, fish were either held as brood stock or placed back into the river in the same direction they were traveling when 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. When possible, fin condition (adipose and dorsal fin morphology) was also noted on fish which appeared to be of hatchery origin. Pictures were generally taken of fish having unique features.

Scale samples were handled according to WDFW protocols (L. Campbell, WDFW, personal communication). Age determination was made by WDFW personnel by counting annuli on 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 (i.e., steelhead trout, bull trout, and cutthroat trout) ages (Burgner 1991).

During the 2012 summer/fall season, coho and chum salmon migrating upstream as pre-spawners were tagged with orange, numbered Floy® tags, manufactured by Floy Tag & Manufacturing, Inc. (Seattle, WA). Chinook were PIT tagged to aid in identification when fish were held for the captive brood stock program (operated at the WDFW rearing channel). Steelhead and sockeye were also tagged with pink and green colored Floy tags, respectively.

Coded wire tags were recovered from fish carcasses that were scanned by WDFW personnel during sampling at the WDFW Elwha Rearing Channel. Snouts were removed, frozen, and then transported to the WDFW CWT lab for tag removal and decoding. Fish rearing and release

information associated with each CWT code was obtained from the Regional Mark Information System Database (http://www.rmpc.org/).

Figure 3. Bull Trout in fish cradle at the floating weir on the Elwha River in 2012. A total of 33 bull trout were collected during the 2012 summer/fall season on the Elwha.

Figure 4. Typical Steelhead captured in early August in 2012 at the floating weir on the Elwha River. Fish are lifted from a cradle to obtain tag information.

Results and Discussion

Objective 1. *Install and operate an adult salmon trap (floating weir) during the winter/spring (March-May) 2012 season and summer/fall (July-October) 2012 trapping seasons.*

This was the second winter/spring season for weir operations on the Elwha River. The weir was installed for the 2012 winter/spring season on February 8, 2012, and was "fish-tight" (i.e., when the weir first began to collect data) on February 16. The weir was disabled several times during the 2012 winter/spring season due to the use of explosives during the removal of Glines Dam, which released large amounts of woody and fine sediment debris flowing downstream into the lower river (Figure 5). The 2012 winter/spring trapping season ended on April 15, when the snowpack in the Olympic Mountains began to melt, causing flows in the Elwha River to exceed the capacity of the weir (~2,700 cfs). It is believed that the weir was probably removed prior to the end of the wild winter steelhead migration in the Elwha (Figure 6). The trapping configuration during the 2012 winter season used two traps: one upstream trap and one downstream trap (Figure 7).

A new technique was used in 2012 to maximize data collection during the summer/fall season. The weir panels were left in the river between seasons (i.e., April 16 and August 1, 2012) – only the traps and curtains were removed – minimizing installation time for summer/fall operations, resulting in a longer trapping season. Weir panels were in the Elwha River for a total of 257 continuous days (8 months, 13 days).

This was the third summer season for weir operations on the Elwha River. The traps and related equipment were re-installed on August 2, 2012. It is believed that the weir was installed after the early portion of the Chinook salmon migration occurred in the Elwha (Figure 6). The weir was removed on October 21, ending the 2012 summer/fall season. Weir components were stored at the WDFW Rearing Channel and the substrate rail remained in the river.

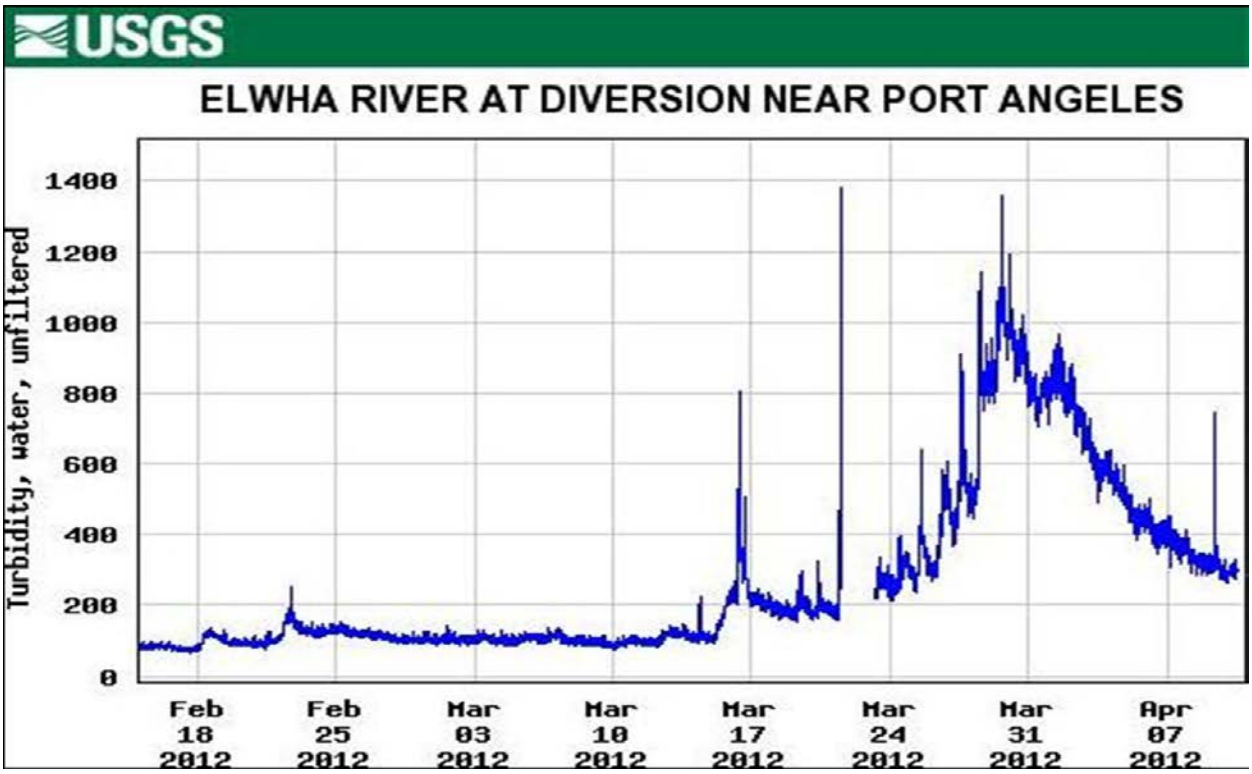

Figure 5. Turbidity levels in the Elwha River during the 2012 winter/spring season. Turbidity levels fluctuated with blasting at Glines Dam. The weir operated from February 16 to April 15, 2012.

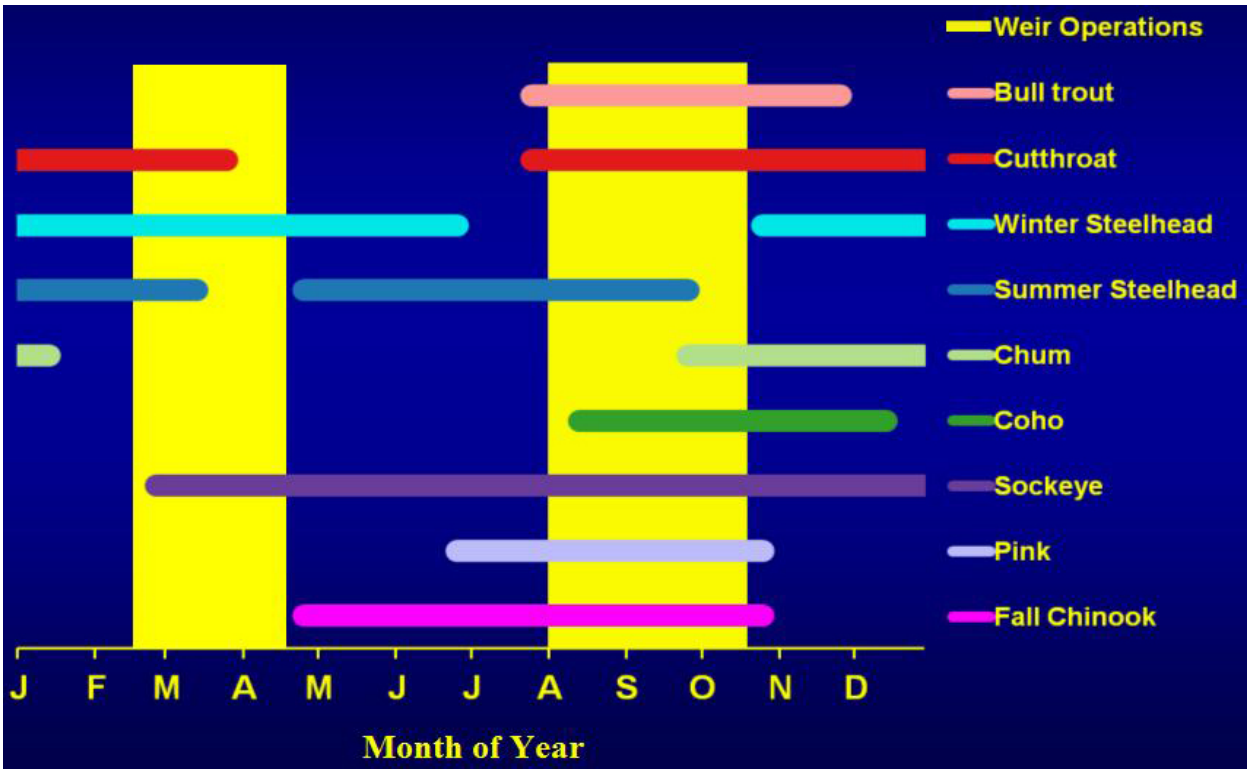

Figure 6. Presence of salmonids (immigration and spawning) by species in the Elwha River and the period of weir operation in 2012. Yellow shaded areas represent the period of weir operation.

Figure 7. The floating weir fishing at 2,520 cfs during the 2012 winter/spring trapping season on the Elwha River. One upstream trap and one downstream trap on river left (west bank) were used.

Figure 8. The floating weir in September during the 2012 summer/fall trapping season on the Elwha River. Two upstream traps and two downstream traps were used on river left and river right, respectively.

Objective 2. *Enumerate and collect biological information from adult salmon, steelhead trout and char captured during the trapping seasons specified in Task 1.*

A total of 370 salmonids were collected during the 2012 winter/spring and summer/fall seasons. During the winter season, 20 adult steelhead (8 males, 12 females) were collected (Table 1). Of the 20 steelhead captured, 18 (90%) had intact adipose fins and two (10%) had clipped adipose fins. No PIT tags or other tags were detected. Scale samples collected from all 20 steelhead are presented in Table 2. One female steelhead (age 4, 65 cm) was a repeat spawner.

Table 1. Total number and fork length of steelhead collected at the Elwha floating weir during the 2012 winter/spring season. 'n' is sample size.

Condition	Male Fork length (cm)				Female Fork length (cm)				Total
	n	Range	Mean	Median	n	Range	Mean	Median	
Pre-spawn (up trap)	7	64-80	72.7	74.0	10	61-78	68.5	66.0	17
Post-spawn (down)	1	-	60.0	-	1	-	61.0	-	2
Carcasses (down)	0	-	-	-	1	-	61.0	-	1
Total	8	-	-	-	12	-	-	-	20

Table 2. Age-length structure of steelhead by origin and sex collected at the Elwha floating weir during the 2012 winter/spring season. 'n' is sample size. 'R' indicates regenerated (unreadable) scales.

Steelhead		Male	Female	Total
Age	Statistic	Fork length (cm)	Fork length (cm)	
Age 1.1	N	1	2	3
	Mean	60.0	61.0	-
	Median	-	61.0	-
Age 2.1	N	5	4	9
	Mean	71.0	65.5	-
	Median	71.0	65.0	-
Age 2.2*	N	1	5	6
	Mean	74.0	72.4	-
	Median	-	74.0	-
Age 3.1	N	1	0	1
	Mean	80.0	-	-
	Median	-	-	-
Age R.1	N	0	1	1
	Mean	-	61.0	-
	Median	-	-	-
Total	N	8	12	20

*Includes one female repeat spawner.

Of the 20 steelhead collected, 10 were Floy tagged and released by WDFW into Little River (Figure 9), four were radio tagged by LEKT, and transported and released by WDFW into Little

River, three were provided to LEKT for brood stock purposes, two hatchery-origin steelhead were sacrificed per funding agreement, and one carcass was recovered in the downstream trap.

Figure 9. A steelhead captured at the floating weir on the Elwha River in April 2012 released in Little River. Of the 20 steelhead collected at the weir in winter/spring, 14 were released in Little River.

During the 2012 summer/fall trapping season, a total of 350 salmonids were collected at the weir between August 2 and October 21 (Table 3). The majority (77.5%) of all unique, individual fish were collected during a six week period between September 3 and October 14. Catch in the upstream direction was greatest (66.7%) between August 27 and September 30. Recovery in the downstream direction was greatest (79.2%) between September 17 and October 14, 2012. Age-length structure of all fish (upstream, downstream, live, carcass, male and female) by species collected at the Elwha floating weir in 2012 are presented in Table 5.

Chinook Salmon

Almost half (49.6%) of the fish collected at the weir in 2012 were Chinook salmon. Of the 174 Chinook collected, 55.7% (n=97) were recovered post-spawned (as carcasses or as live fish) in the downstream direction, and 44.3% (n=77) were captured as live, pre-spawn fish in the upstream trap (Table 4). Twelve of the Chinook recovered in the downstream direction were recovered live, four of which were held for brood stock. There were no unspawned Chinook salmon carcasses recovered at the weir. Of the 174 Chinook collected, 78.2% (n=136) were males and 21.8% (n=38) were females. A total of 79 (45.4%) of all Chinook salmon collected at the weir in 2012 (n=61 males and n=18 females) were held for brood stock purposes. These

catch totals compare to a total Chinook salmon escapement of 2,638 estimated by Denton and Liermann (2013) using multi-beam SONAR technology.

Scale samples were collected from 99.4% (n=173) of the Chinook salmon collected at the floating weir on the Elwha River in 2012, 91.3% (n=158) of which were readable scales. Scale age data indicated that Chinook return to the Elwha River to spawn at 2 to 5 years of age (Table 5). Scale age data was consistent with CWT data and otolith data, with respect to brood year.

Scale age data indicated that 89.7% (n=70) of the returning hatchery-origin Chinook salmon were released by the WDFW Rearing Channel as sub-yearlings, while 10.3% (n=8) were released as yearlings [see Note below]. Of the 70 Chinook salmon released as sub-yearlings that returned to the Elwha to spawn in 2012 and were captured at the weir, 82.9% (n=58) were male and 17.1% (n=12) were female. Of the Chinook eight yearling releases that were captured, seven (87.8%) were males and one was female.

Note: 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 2011, 11,957,720 hatchery-reared juvenile Chinook were released from the WDFW Rearing Channel: 10,905,524 sub-yearlings (89.7%) and 1,247,020 yearlings (10.3%) (www.rmpc.org; WDFW).

Table 3. Salmonids captured at the Elwha floating weir during the 2012 summer/fall season by direction of travel, species, life stage, by week.

Species Captured	Week of												Total
Upstream	July 30	Aug 6	Aug 13	Aug 20	Aug 27	Sept 3	Sept 10	Sept 17	Sept 24	Oct 1	Oct 8	Oct 15	
Bull trout	3	13	9	-	3	-	-	-	1	-	-	-	**29**
Chinook, brood stock	1	3	1	2	10	31	14	9	3	1	-	-	**75**
Chinook, non-brood	-	-	-	-	1	-	-	1	-	-	-	-	**2**
Steelhead, transport to Little River	-	2	1	-	-	-	1	-	-	-	-	-	**4**
Steelhead, hatchery; Nutrient enrichment	-	2	-	2	-	-	-	-	1	-	-	-	**5**
Pink	-	1	1	1	-	-	1	1	-	-	-	-	**5**
Sockeye	-	1	-	1	-	-	1	-	-	-	-	-	**3**
Coho	-	-	-	-	1	-	1	8	12	5	1	-	**28**
Chum	-	-	-	-	1	-	-	-	1	-	-	-	**2**
Upstream Total	**4**	**22**	**12**	**6**	**16**	**31**	**18**	**19**	**18**	**6**	**1**	**0**	**153**
Downstream													
Steelhead, live	2	1	-	-	1	-	-	2	-	1	-	-	**7**
Steelhead, carcass	-	3	1	2	1	1	-	-	-	1	-	-	**9**
Chinook, carcass	-	-	-	1	1	4	9	21	15	19	15	-	**85**
Chinook, live, brood stock	-	-	-	1	1	-	-	1	1	-	-	-	**4**
Chinook, live, non-brood	-	-	-	-	-	-	-	3	-	4	1	-	**8**
Bull trout	-	-	-	1	-	1	-	-	-	-	2	-	**4**
Chum	-	-	-	1	-	-	-	-	-	-	-	-	**1**
Pink, carcass	-	-	-	-	1	1	2	22	23	5	1	-	**55**
Pink, live	-	-	-	-	1	1	3	10	-	1	-	-	**16**
Coho, live	-	-	-	-	-	-	-	1	-	1	2	-	**4**
Coho, carcass	-	-	-	-	-	-	-	-	-	-	3	-	**3**
Sockeye, post-spawn	-	-	-	-	-	-	-	-	-	1	-	-	**1**
Downstream Total	**2**	**4**	**1**	**6**	**6**	**9**	**14**	**60**	**39**	**33**	**24**	**0**	**197**
Total catch at weir	**6**	**26**	**13**	**12**	**22**	**39**	**32**	**79**	**57**	**39**	**25**	**0**	**350**

Table 4. Total catch of salmon, trout, and char collected at the floating weir in the upstream and downstream directions in the Elwha River in 2012. "Up" fish were captured migrating in the upstream direction. "Down" fish were recovered in the downstream direction. Data are organized by species and sex. "-" indicates no fish.

Species / Sex	Total Captured	Male		Female		Subtotal		Percent (%)	
		Up	Down	Up	Down	Up	Down	Up	Down
Chinook salmon	174	59	77	18	20	77	97	44.3	55.7
Pink salmon	76	1	27	4	44	5	71	6.6	93.4
Coho salmon	35	7	1	21	6	28	7	80.0	20.0
Bull trout	33	17	1	12	3	29	4	85.6	14.4
Steelhead trout	25	2	6	8	9	10	15	40.0	60.0
Sockeye salmon	4	2	1	1	-	3	1	75.0	25.0
Chum salmon	3	2	1	-	-	2	1	66.7	33.3
Total	350	90	114	64	82	154	196	-	-

Table 5. Age-length structure of all fish collected by species during the 2012 summer/fall season at the floating weir on the Elwha River. Brood year by age is in parentheses. 'n' is sample size.

Age	Statistic	Bull trout	Chinook	Chum	Coho	Pink	Steelhead	Sockeye
Age 2 (2010)	N	-	8	-	1	72	1	-
	Mean	-	40.6	-	69.0	49.7	53.0	-
	SD	-	7.2	-	-	5.2	-	-
Age 3 (2009)	N	3	101	2	32	-	3	-
	Mean	37.7	69.3	67.5	66.3	-	69.3	-
	SD	2.5	6.3	6.4	5.6	-	0.6	-
Age 4 (2008)	N	4	45	1	-	-	8	2
	Mean	43.0	87.7	79	-	-	68.3	53.5
	SD	2.9	6.3	-	-	-	4.5	4.9
Age 5 (2007)	N	10	4	-	-	-	8	2
	Mean	49.3	94.5	-	-	-	72.6	61.5
	SD	4.1	5.8	-	-	-	7.9	3.5
Age 6 (2006)	N	2	-	-	-	-	-	-
	Mean	51.0	-	-	-	-	-	-
	SD	4.2	-	-	-	-	-	-
Age 7 (2005)	N	1	-	-	-	-	-	-
	Mean	56.0	-	-	-	-	-	-
	SD	-	-	-	-	-	-	-
Data n/a	N	13	16	0	2	4	5*	0
Total	N	33	174	3	35	76	25	4

*Four of the five steelhead with unreadable (n/a, regenerated) scales were ocean age 2.

The majority (72.8%) of male Chinook collected at the weir in 2012 returned to spawn at age 3. The remaining male Chinook were ages 2 (6.4%), 4 (18.4%) and 5 (2.4%). The majority (66.7%) of female Chinook salmon collected at the weir in 2012 returned to spawn at age 4 (Figure 10). The remaining female Chinook were age 3 (30.3%) and 5 (3.0%). There were no age 2 females.

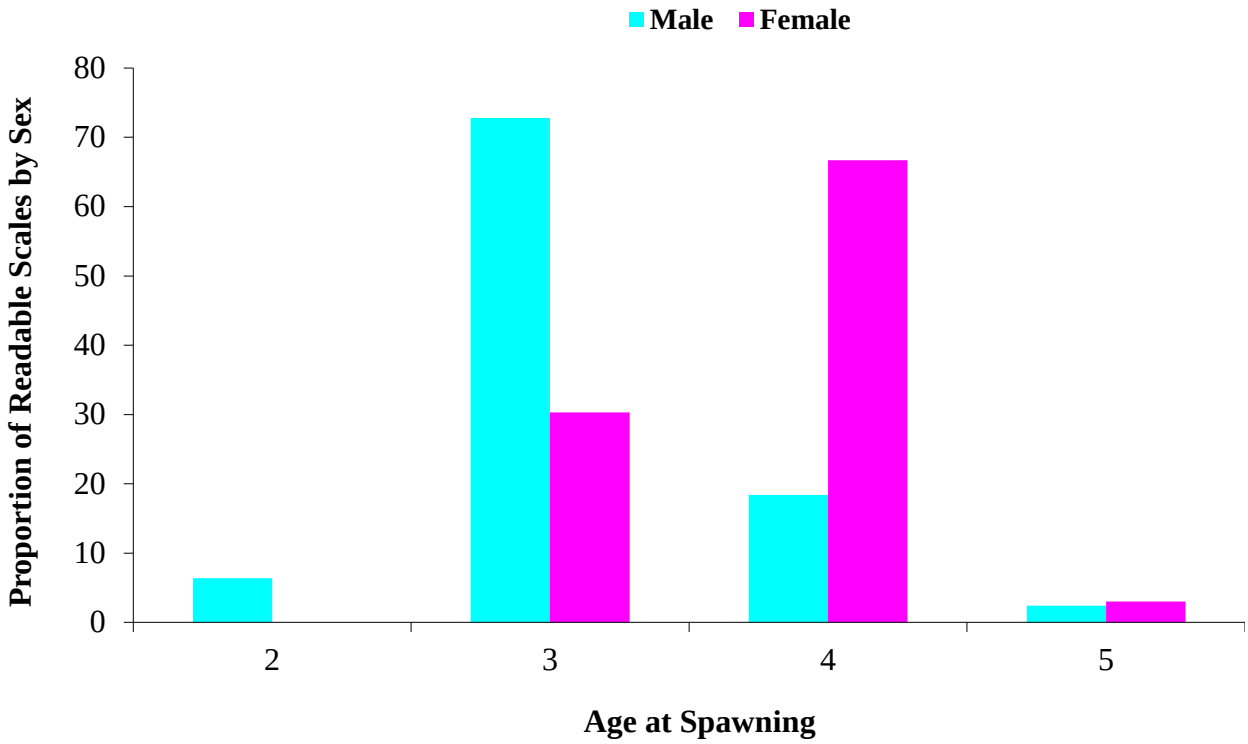

Figure 10. Percent of Chinook salmon by age class for male and female fish collected at the floating weir on the Elwha River in 2012. No age 2 females were captured.

Overall mean fork length of female Chinook salmon was significantly greater than that of male Chinook (n=158, *t*-test, $p<0.00015$), a result largely explained by the observation that 67.7% of females returned to spawn at age 4, while 72.8% of the males returned to spawn at age 3. Mean fork length of female Chinook salmon was 78.9 cm (n=38, range=57-98 cm, SD=10.2) and mean fork length of male Chinook was 71.7 cm (n=136, range=31-100 cm, SD=13.4).

Mean fork length for age 3 Chinook females was 67.2 cm (n=10, SD=5.9), 85.4 cm at age 4 (n=22, SD=4.7), and one 98 cm age 5 female. Mean fork length for age 2 Chinook males was 40.6 cm (n=8, SD=7.2), 69.7 cm at age 3 (n=91, SD=6.5), 89.8 cm at age 4 (n=23, SD=7.0), and 93.3 cm at age 5 (n=3, SD=6.5). For age 3 and 4 Chinook salmon, the mean fork length of males was greater than that of females. The difference in mean fork length between male and female Chinook salmon at age 3 was 2.2 cm, which doubled to 4.4 cm at age 4.

Fork length of Chinook salmon increased with age for both sexes, but the rate of increase in fork length declined with age (Table 6). Male fork length increased in size by 71.7% (29.1 cm) between ages 2 and 3, 28.8% (20.1 cm) between ages 3 and 4, and 3.9% (3.5 cm) between ages 4 and 5. Female fork length increased in size by 27.1% (18.2 cm) between ages 3 and 4.

Based on scale age data, eight male Chinook salmon "jacks" (age 2 males) were collected at the weir in 2012. Jacks ranged in fork length from 31 cm to 50 cm (mean=40.6 cm, median=41.0 cm, SD=7.2 cm). The two smallest (31 and 33 cm, age 2.2) of the eight Chinook jacks collected were released as yearlings from brood year 2009. One jack (scale age 2.1) had a CWT, indicating that it was released as a sub-yearling from the WDFW Elwha Rearing Channel in 2010.

Eight coded wire tags were obtained from 4.6% of the 174 Chinook salmon (7 males, 1 female) captured at the floating weir on the Elwha River in 2012. All eight CWT Chinook captured were originally released from the WDFW Elwha Rearing Channel: Two (25%) age 4 fish from brood year 2008 released in 2010, five (62.5%) age 3 fish from brood year 2009 released in 2011, and one (12.5%) age 2 fish from brood year 2010 released in 2012.

Out of the 107 Chinook salmon otoliths collected from carcasses at the weir and broodstock spawned at the WDFW Elwha Rearing Channel, 88 (82%) were marked indicating hatchery origin and 19 (18%) were unmarked.

Note: Otoliths are the only way to assign origin (hatchery or natural) to the majority of Chinook salmon in the Elwha River. Most (about 90%) of the hatchery-origin Chinook that are released into the Elwha River (about 2.5 million annually) are otolith-marked and released as sub-yearlings from the WDFW Elwha Rearing Channel. A small portion (about 10%) of Elwha-origin hatchery releases are tagged with CWT and released as yearlings: approximately 200,000 from WDFW Elwha Rearing Channel and 200,000 from WDFW Morse Creek Rearing Pond (Elwha stock) annually.

Table 6. Age-length structure of Chinook salmon by sex collected at the Elwha floating weir on the Elwha River in 2012. Brood year by age is in parentheses. 'n' is sample size.

Chinook salmon Age	Statistic	Mean Male Length (cm)	Mean Female Length (cm)	Total N	Percent of Age Class*
Age 2 (2010)	n	8	-	8	5.1
	Mean	40.6	-	-	-
	SD	7.2	-	-	-
Age 3 (2009)	n	91	10	101	63.9
	Mean	69.5	67.0	-	-
	SD	6.3	5.9	-	-
Age 4 (2008)	n	23	22	45	28.5
	Mean	89.8	85.4	-	-
	SD	7.0	4.7	-	-
Age 5 (2007)	n	3	1	4	2.5
	Mean	93.3	98.0	-	-
	SD	6.5	-	-	-
n/a	n	11	5	16	-
Total	N	136	38	174	-

* Relative to total of 158 readable scales.

Non-Chinook Species

In addition to the 174 Chinook salmon captured, there were six other species of salmonids collected during the 2012 summer/fall season at the floating weir on the Elwha River: 76 pink salmon *O. gorbuscha*, 35 coho salmon *O. kisutch*, 33 bull trout *Salvelinus confluentus*, 25 summer-run or early winter-run steelhead *O. mykiss*, 4 sockeye salmon *O. nerka*, and 3 chum salmon *O. keta* (Table 5).

A total of 76 pink salmon were collected at the floating weir on the Elwha River during the 2012 summer/fall season: 55 (72.4%) were post-spawned carcasses and 21 (27.6%) were live. Sixteen (76.2%) of pinks were recovered live in the downstream direction (15 on the weir and 1 in the down trap), and five (23.8%) were caught live in the upstream trap. No unspawned pink salmon carcasses were collected at the weir.

Of the 76 pink salmon collected, 63.2% (n=48) were female and 36.8% (n=28) were male. Female pinks ranged from 42 to 56 cm in fork length and male pinks ranged from 38-67 cm in fork length (Table 7). Scale samples were collected from 100% (n=76) of the pink salmon captured at the floating weir on the Elwha River in 2012, 94.7% (n=72) of which were readable. All pink salmon collected were 2 years of age.

Table 7. Age-length structure of pink salmon by sex collected at the Elwha floating weir in 2012. Brood year by age is in parentheses. 'n' is sample size.

Pink salmon Age	Statistic	Male Length (cm)	Female Length (cm)	Total
Age 2 (2010)	n	28	48	76
	Mean	53.6	47.3	-
	SD	6.0	2.9	-
Total	N	28	48	76

A total of 35 coho salmon were captured at the floating weir on the Elwha River during the 2012 summer/fall season. Eight (22.9%) of the 35 coho salmon collected had clipped adipose fins, indicating they were of hatchery origin. Of the 35 coho salmon collected, 77% (n=27) were females and 23% (n=8) were males. Scale samples were collected from 100% (n=35) of the coho salmon collected at the floating weir on the Elwha River in 2012, 94.3% (n=33) of which were readable. Two female coho scales were not readable. Thirty-two of the 33 coho were 3 years of age and ranged in fork length from 56 to 79 cm (Table 8). The remaining coho was a female age 2. Mean female coho age 3, fork length was 65.9 cm (n=range 56-79 cm, SD=5.85) and mean male coho fork length was 67.8 cm (range 60-73 cm, SD=4.89).

Table 8. Age-length structure of age 3 coho salmon by sex collected at the Elwha floating weir in 2012. Brood year by age is in parentheses. 'n' is sample size

Coho salmon Age	Statistic	Male Length (cm)	Female Length (cm)	Total
Age 3 (2009)	n	8	24	32
	Mean	67.8	65.9	-
	SD	4.9	5.8	-
Total	N	8	24	32

Floy® tags with colored, uniquely numbered tags were attached to 23 of the 28 (75.0%) pre-spawning coho salmon collected at the floating weir on the Elwha River in 2012. The coho tagged with Floy tags were captured in the upstream traps and were in pre-spawn condition. Of the 23 coho tagged, 43.5% (n=10) were recovered live or as carcasses at the weir in the downstream direction. All (100%) of the Floy-tagged coho recovered at the weir were female. Most (70%, n=7) of the Floy-tagged females recovered at the weir were of hatchery-origin and 30% (n=3) were wild. On average, Floy-tagged females spent 11 days upstream of the weir in 2012 (n=10, range=5-24 days, SD=5.5)

A total of 33 bull trout were collected at the floating weir on the Elwha River during the 2012 summer/fall season. Almost 40% (n=13, 38.2%) of the bull trout were collected in a one week period between August 6-12, and almost two-thirds (n=22, 64.7%) were collected during the two week period between August 6-19, 2012 (Table 3). Of the 33 bull trout collected in 2012, 52.9% (n=18) were male and 47.1% (n=15) were female.

Bull trout collected at the weir during in 2012 ranged in fork length from 35 to 58 cm. Mean fork length of male bull trout was 48.5 cm (n=18, range=40-56 cm, SD=4.4). There was a greater range in fork length of female bull trout (range=35-58 cm) and mean of 45.6 cm (n=15, SD=6.2).

Scale samples were obtained from 100% (n=32, one female was a recapture) of bull trout collected at the floating weir on the Elwha River in 2012, 61.8% (n=21) of which were readable. Based on scale data, bull trout collected at the weir were 3 to 7 years old: almost half (47.6%) were 5-years old (Table 9).

Table 9. Total age, sex and mean fork length and age class by percent of bull trout collected at the floating weir during the 2012 summer/fall season on the Elwha River. 'n' is sample size.

Total Age	Brood Year	Mean Male n	Mean Male Length (cm)	Mean Female n	Mean Female Length (cm)	Total N	Percent of Age Class*
3	2008	1	40.0	2	37.7	3	19.1
4	2007	2	43.0	2	43.0	4	19.1
5	2006	8	50.0	2	52.0	10	47.6
6	2005	1	48.0	1	54.0	2	9.5
7	2004	1	56.0	-	-	1	4.8
n/a	-	5	-	8	-	13	-
Total	-	18	-	15	-	33	-

*Relative to a total of 21 readable scales.

Three electronic tags were detected in bull trout collected at the weir in 2012: two PIT tags and one radio tag. The bull trout with the radio tag was a 7-year old male (56 cm), tagged by Olympic National Park (ONP) biologists.

A total of 25 steelhead trout were captured at the floating weir on the Elwha River during the 2012 summer/fall season. As a comparison, 20 steelhead were collected at the weir during the 2012 winter/spring season. Six (24.0%) of the 25 steelhead captured during the 2012 summer/fall season had clipped adipose fins, indicating they were of hatchery origin. Summer steelhead ages ranged from 2 to 5 years of age (Table 10).

Of the 25 steelhead collected, 68.0% (n=17) were female and 32.0% (n=8) were male. Summer steelhead ranged in fork length from 53 to 82 cm (Table 10). Mean female steelhead fork length was 68.8 cm (n=range 53-82 cm, SD=7.3) and mean male steelhead length was 69.5 cm (range 58-80 cm, SD=6.1).

Scale samples from 100% (n=25) of the steelhead collected at the floating weir on the Elwha River during the 2012 summer/fall season, 80.0% (n=20) of which were readable. Based on scale age data, steelhead collected at the weir were between 2 and 5 years old: one (5.0%) 2-year old, three (15.0%) 3-year olds, eight (40.0%) 4-year olds, and eight (40.0%) 5-year olds.

Colored, uniquely numbered Floy® tags were attached to 5 of the 10 (50.0%) pre-spawning steelhead captured at the floating weir on the Elwha River in the upstream traps in 2012. No steelhead Floy tags were recovered.

Table 10. Total age, fork lengths and sex of steelhead trout collected at the floating weir on the Elwha River during the 2012 summer/fall season. The notation "R" indicates unreadable (regenerated) scales.

European Age	Brood Year	Male		Female		Total N	Percent of Age Class*
		n	Lengths (cm)	n	Lengths (cm)		
1.1	2010	-	-	1	53	1	5.0
1.2	2009	2	69, 70	1	69	3	15.0
2.2	2008	3	69, 70, 73	5	61, 62, 68, 71, 72	8	40.0
2.3	2007	1	80	3	76, 80, 82	4	20.0
3.2	2007	1	67	2	65, 70	3	15.0
4.1	2007	-	-	1	61	1	5.0
R.2	-	-	-	4	65, 71, 71, 73	4	-
R.R	-	1	58	-	-	1	-
Total	-	8	-	17	-	25	-

*Relative to a total of 20 readable scales. Four of the five steelhead with unreadable (regenerated) scales were ocean age 2.

Four sockeye salmon were captured at the floating weir on the Elwha River during the 2012 summer/fall season. All of the sockeye were collected live: three in the upstream direction and one in the downstream direction. Of the four sockeye salmon collected, three were males and one was female. The sockeye ranged in fork length from 50 to 64 cm. Mean male sockeye fork length was 57.7 cm (n=range 50-64 cm, SD=7.0) and the female sockeye was 59 cm.

Scale samples were taken from 100% (n=4) of the sockeye collected at the floating weir on the Elwha River during the 2012 summer/fall season. Based on scale age data, sockeye collected at the weir were age 4 (n=2, 50%) or age 5 (n=2, 50%).

Three 3 chum salmon were collected at the floating weir on the Elwha River during the 2012 summer/fall season. All chum were collected live: two were captured in the upstream direction and one was recovered live in the downstream direction. All three of the chum salmon collected were males. Mean fork length of male chum was 71.3 cm (n=range 63-79 cm, SD=8.0).

Objective 3. *Collect adult salmon for brood stock purposes (as requested by fisheries managers) during the trapping seasons specified in Task 1.*

The collection of brood stock increased in 2012 compared to previous years. A total of 79 (45.4%) out of the 174 Chinook salmon collected at the floating weir on the Elwha River in 2012 were held for brood stock purposes. Of the 79 Chinook salmon collected for brood stock, 61 (77.2%) were male and 18 (22.8%) were female.

Multiple-Year Data Comparison: 2010, 2011 and 2012

The floating weir on the Elwha River fished for a total of 140 days in 2012: 59 days during the winter/spring season and 81 days during the summer/fall season. The increasing amount of time that the weir fished each year is presented in Figure 11. The weir was installed on September 8 in 2010 and August 18 in 2011. The weir was installed 37 days earlier in 2012 than in the first year of operation (2010) and 16 days earlier than in 2011.

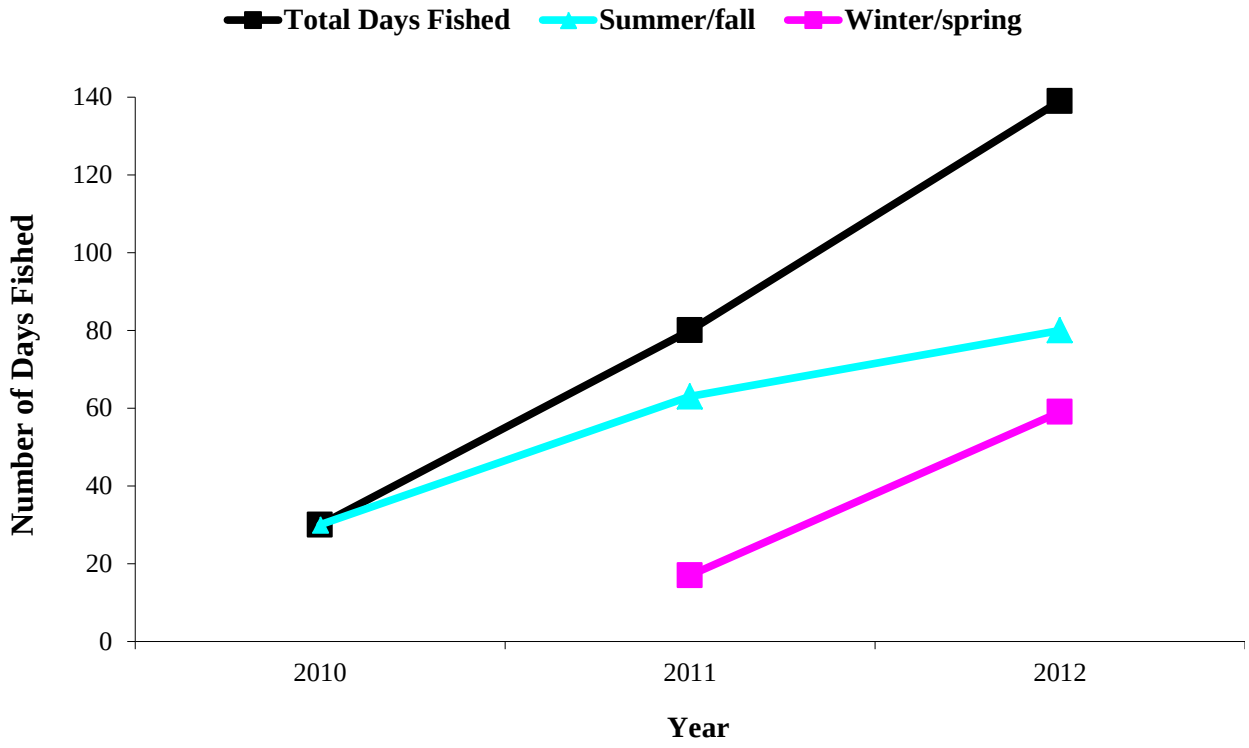

Figure 11. Number of days fished with the floating weir on the Elwha River by year and by season. Total number of days fished is the sum of days fished during the summer/fall and winter/spring seasons.

The weir collected a greater number of all salmonid species in the Elwha River in 2012 than the average of the previous two years (Table 11), except for Chinook salmon carcasses (Mayer et al. 2011, Mayer and Zimmerman 2012). Most of the salmonid species (88.0%, 309/351) were collected after August 18, the installation date of the weir in 2011. Of the 42 salmonids collected before August 18, 2012, 54.8% (n=23) were bull trout and 26.2% (n=11) were steelhead. The greatest increases were in the number of coho salmon (1,750%, n=35), bull trout (971%, n=33) and steelhead (450%, n=45), compared to the 2010-2011 average (n = 2, 4 and 10, respectively). The total Chinook salmon catch decreased 61.3% (n=174) in 2012, compared to the previous two-year average of 450, due to a decrease in recovery of Chinook carcasses at the weir.

The number of live Chinook salmon collected in both the upstream and downstream directions and the number of Chinook salmon brood stock provided by the floating weir on the Elwha River have increased in each of the three years of weir operation (Figure 12). The number of live Chinook salmon collected at the weir increased from 13 (10 males and 3 females) in 2010 to 77

(59 males and 18 females) in 2012. The number of Chinook brood stock provided by the weir increased from seven (1 male and 6 females) in 2010 to 79 (61 males and 18 females) in 2012.

There was a significant decrease (449%, n=84) in the number of Chinook salmon carcasses recovered at the weir in 2012 (Figure 13), that was probably related to the removal of the Elwha Dam, which had created a closed population in the 1.9 km between the dam site and the weir.

Table 11. Total catch of all salmonid species at the floating weir on the Elwha River by year, including collection in both the upstream and downstream direction. The percent change in catch is rounded to the nearest whole number.

Species	2010	2011	2012	Total	Percent Change 2012 vs. 2010/2011*	Percent of All Fish Caught
Chinook salmon	461	438	174	1,073	-61	71.1
Pink salmon	12	184	76	272	n/a	18.0
Steelhead	6	14	45	65	+450	4.3
Bull trout	4	3	33	40	+943	2.5
Coho salmon	3	1	35	39	+1750	2.6
Sockeye salmon	4	6	4	14	-20	0.9
Chum salmon	1	1	3	5	+300	0.3
Total	491	647	370	1,508	-	100%

*Average fish count caught by species at the weir in 2010 and 2011. Pink salmon ran in both odd and even years.

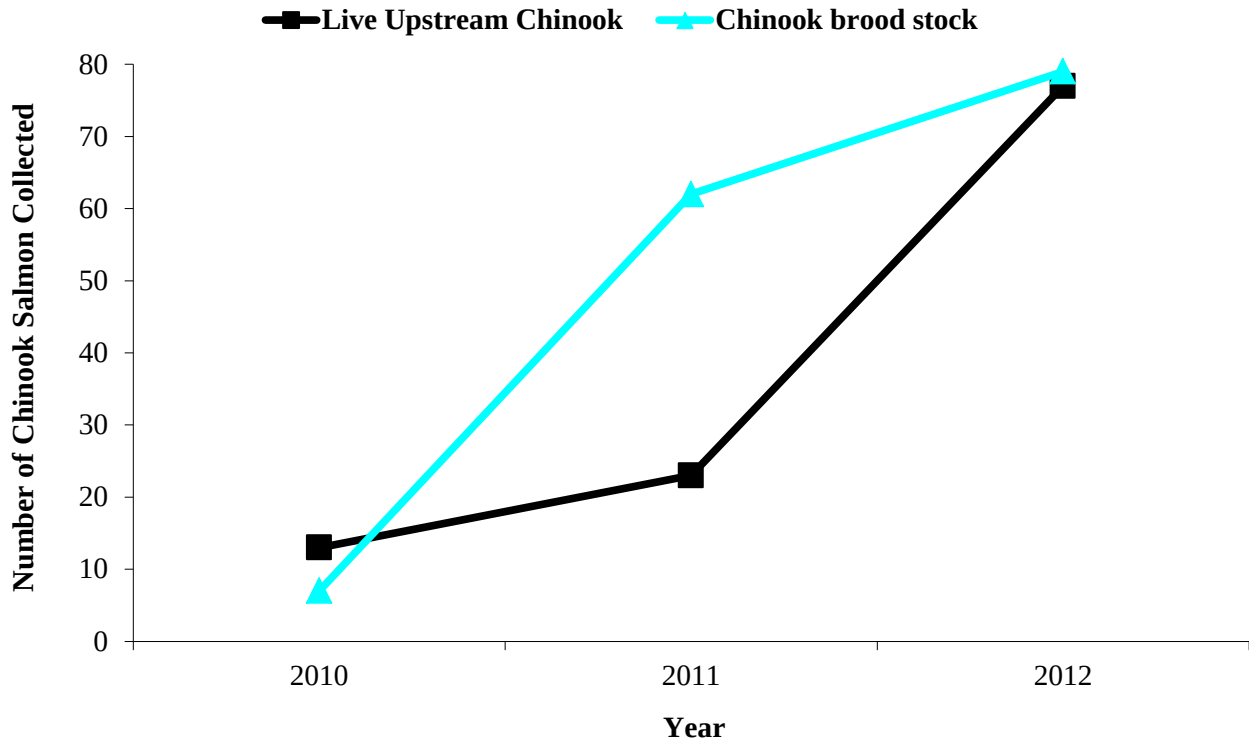

Figure 12. Number of live Chinook salmon collected and number of Chinook salmon brood stock provided by the floating weir on the Elwha River by year.

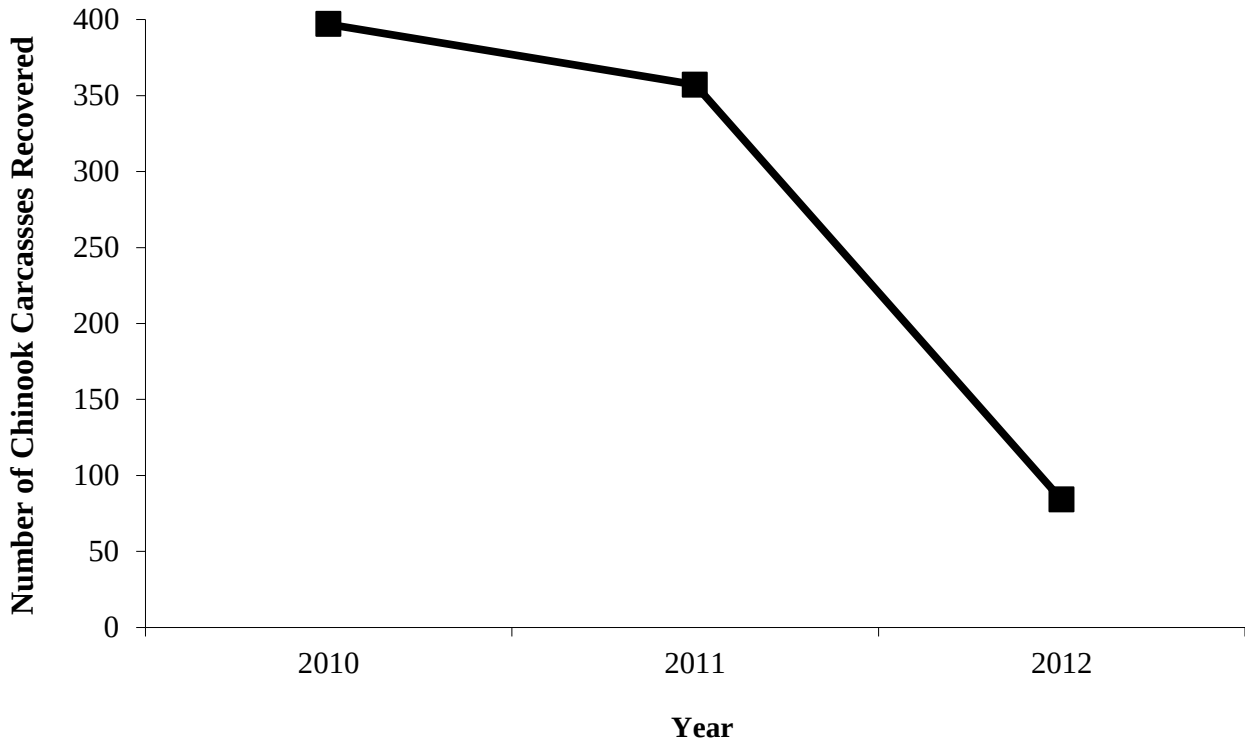

Figure 13. Number of Chinook salmon carcasses recovered at the floating weir on the Elwha River by year.

A total of 1,073 Chinook salmon have been collected at the floating weir on the Elwha River over the past three years. From 2010 to 2012, males comprised 66.8% (n=717) of the Chinook salmon spawning population collected at the floating weir in the Elwha River and females comprised 33.2%, based on scale age data. Over the past three years, readable scales have been available from 89.9 % of all Chinook salmon collected at the floating weir on the Elwha River.

The age structure of male Chinook salmon collected at the floating weir on the Elwha River is presented in Figure 14. The greatest change in male age-at-spawning occurred in males that were 3 years of age. Over the past three years, from 2010 to 2012, males at 2 years of age comprised 15.9% of the male Chinook spawning population, age 3 males 55.0%, age 4 males 21.1%, and age 5 males 8.1%, based on scale data.

The age structure of female Chinook salmon age-at-spawning collected at the floating weir on the Elwha River is presented in Figure 15. The greatest change in female age-at-spawning occurred in females that were 5 years of age. Over the past three years, from 2010 to 2012, females at 3 years of age comprised 16.9% of the female Chinook spawning population, age 4 females 40.3%, and age 5 females 42.7%, based on scale data. There were no age 2 females in any year studied.

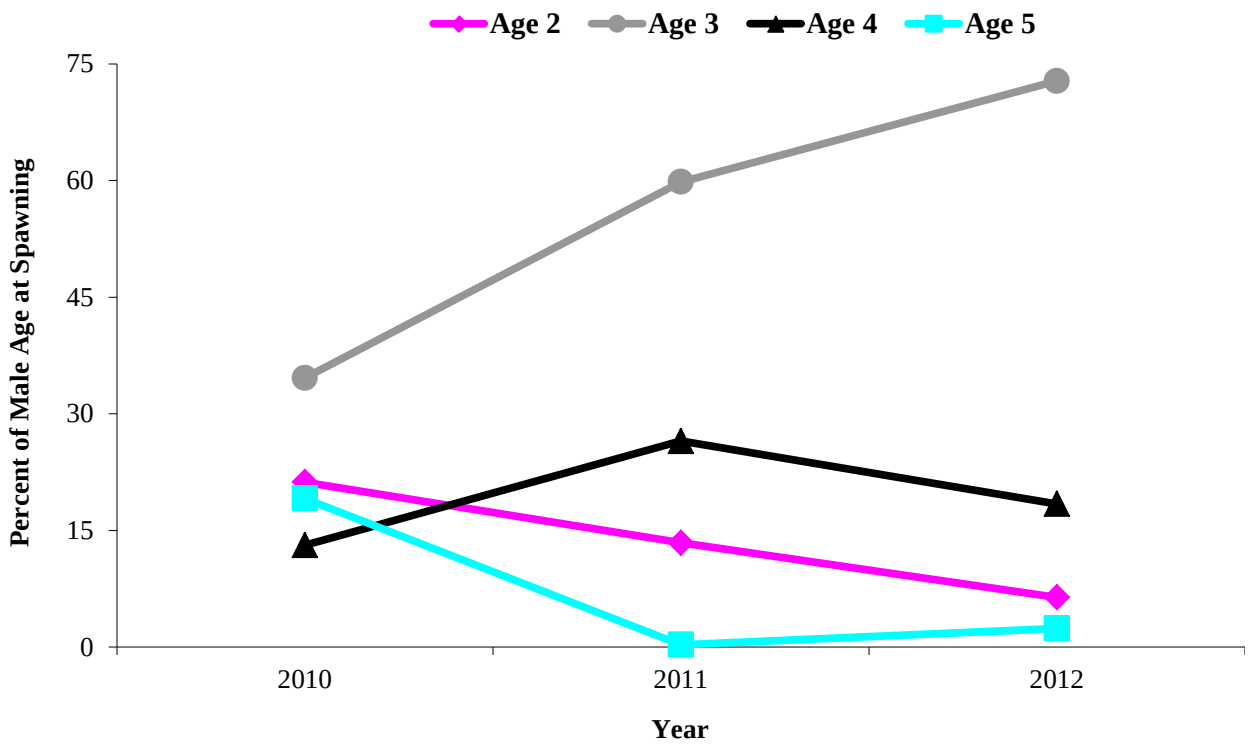

Figure 14. Change in male Chinook salmon age at spawning collected at the floating weir on the Elwha River between 2010 and 2012, based on scale data.

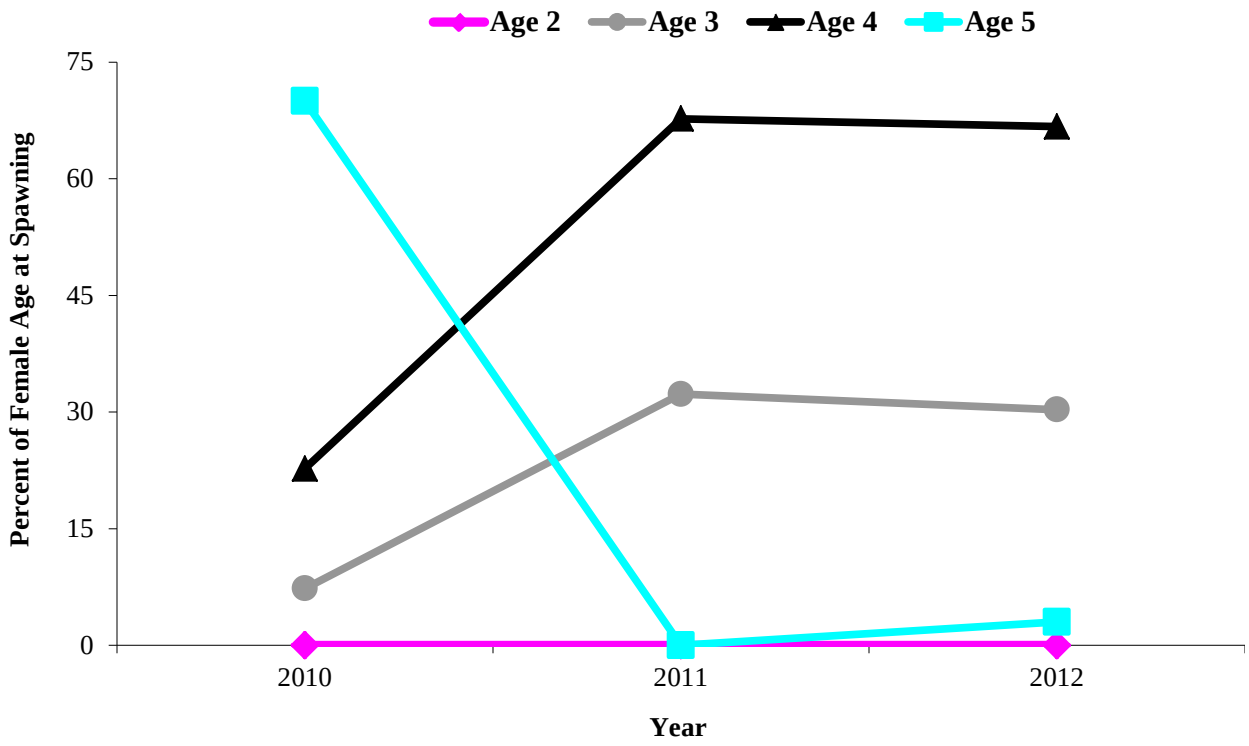

Figure 15. Change in female Chinook salmon age at spawning collected at the floating weir on the Elwha River between 2010 and 2012, based on scale data. There were no age 2 females.

Pink salmon captured at the floating weir on the Elwha River in 2012 were part of an even-year run. The odd-year cycle is the primary life history of pink salmon in the Elwha (Ward et al. 2008). However, the collection of pink salmon at the weir in both 2010 and 2012 documents that pinks spawn in even-years in the Elwha River. Twelve pink salmon were collected in 2010, 184 in 2011, and 76 in 2012. The proportion of male to female pink salmon for the past three years is presented in Figure 16. The sex ratio for all three years combined was about even: 51.5% (n=140) male and 48.5% (n=132) female. However, the majority of pink salmon collected at the floating weir on the Elwha River in even years were female (66.7% in 2010 and 63.7% in 2012), while males represented the majority of males collected (58.7%) in 2011, the first odd year of weir operation.

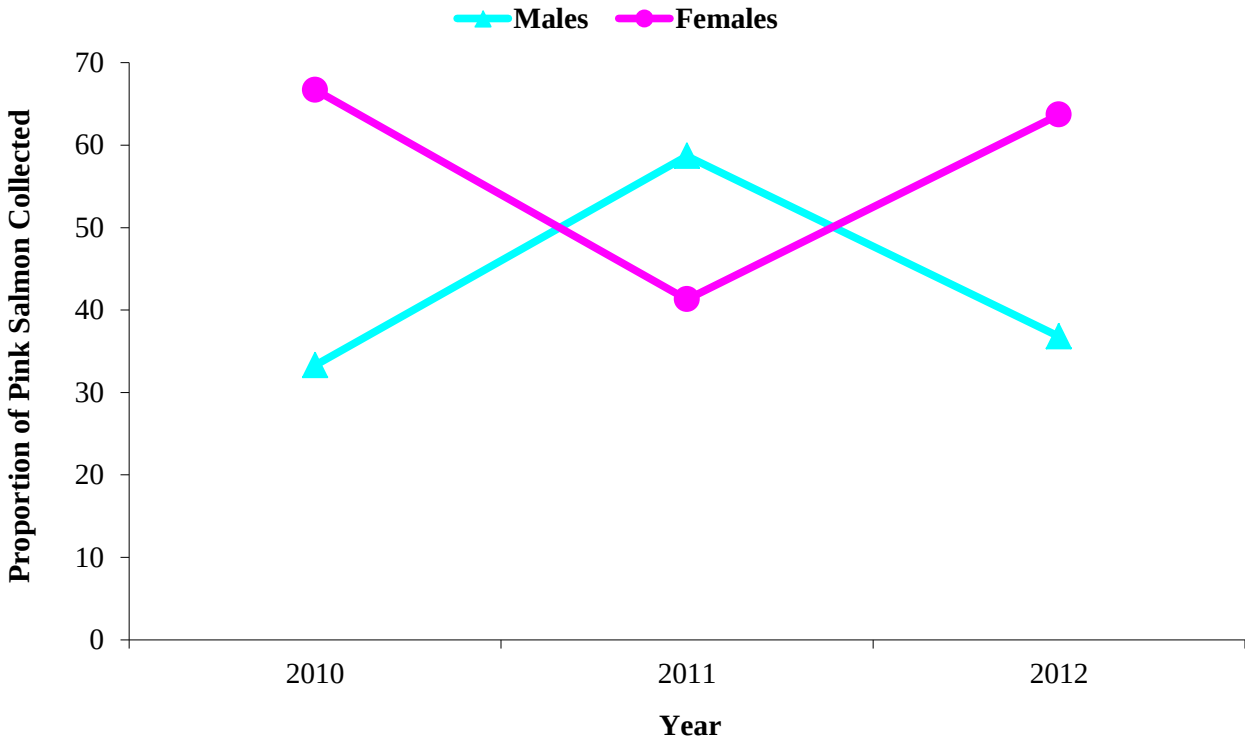

Figure 16. Proportion of male and female pink salmon collected at the floating weir on the Elwha River in 2010, 2011 and 2012. Twelve pink salmon were collected in 2010, 184 in 2011, and 76 in 2012.

Mean fork length of male pink salmon collected at the floating weir on the Elwha River increased in 2011 and 2012, compared to 2010.

Mean fork length of female pink salmon collected at the floating weir on the Elwha River was similar in even years (2010 and 2012), compared to the odd-year (2011) studied.

Table 12. Mean fork length and standard deviation (SD) of pink salmon captured at the Elwha floating weir in 2012 by sex and by year. 'n' is sample size.

Pink salmon fork length Sex	Statistic	2010	2011	2012	Total
Male	n	4	108	28	140
	Mean	47.5	54.1	53.6	-
	SD	3.3	4.2	6.0	-
Female	n	8	76	48	132
	Mean	46.9	50.7	47.3	-
	SD	2.7	3.5	2.9	-
Total	N	12	184	76	272

The relatively high number of bull trout captured at the floating weir on the Elwha River in 2012 may be related to the earlier installation of the weir on August 2 for the summer/fall season, than in previous years (August 18 in 2011 and September 8 in 2010). The majority (70.6%, n=24) of bull trout collected in 2012 were captured live in the upstream direction between August 2 and August 18 (i.e., August 18 was the Julian date when the weir was installed in 2011). This may indicate an early August spawning run timing of bull trout in the Elwha River.

Accomplishments of the Elwha Weir Project: 2010 to 2012

The major accomplishments of the Elwha Weir Project from 2010 to 2012 are as follows:

- Finalized design and construction of a 59.4 m floating weir and fish trapping structure.
- Collaborated with USGS, NOAA, USFWS, Olympic National Park, and LEKT to help staff weir installation, operation and removal.
- Proof of concept: installed and operated a resistance board floating weir for the purpose of enumerating and collecting biological data from salmonids in the Elwha River.
- Developed protocols to operate the weir during the summer/fall and winter/spring seasons.
- Increased the time the weir operated in the 2012 winter/spring season to 59 days and the summer/fall season to 81 days.
- Increased the collection of a greater number of live fish for all salmonid species in 2012.
- Collected abundance and biological data from salmon, trout and char in 2010, 2011 and 2012.
- Collected 33 bull trout in 2012, the majority of which were captured in early August, coinciding with the earlier installation of the weir for the 2012 summer/fall season.
- Data collected were placed into electronic databases. Data were analyzed and results summarized in the 2010, 2011 and 2012 Annual Reports for the Elwha Weir Project (Mayer et al. 2011, Mayer and Zimmerman 2012).

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