

Coho Salmon Relocations and Redd Surveys in the Elwha River 2011-2021:

Summary Report



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Executive Summary

The recolonization of historically accessible habitats in the Elwha River by coho salmon is an important component of restoring Elwha fish populations. In an effort to accelerate recolonization of newly accessible habitats following dam removals on the Elwha River, a total of 3,162 surplus adult coho salmon were relocated from lower river hatcheries to main stem and tributary habitats in the middle Elwha River in seven of eleven years between 2011 and 2021. Tributary spawning ground surveys showed that initially the number of redds observed was correlated with the number of relocated adults and their release location. However, since 2016, adult coho were only relocated in three years of six years and the proportion of untagged coho observed on spawning grounds has dramatically increased.

Observations of live and dead fish on spawning ground surveys suggest that adult spawners were initially primarily relocated hatchery fish. During 2012 and 2013, 94.5% and 96% of the observed live or dead coho were tagged relocated hatchery adults. Later year surveys show an increasing percentage of untagged fish that are likely of natural origin. During 2016, we observed a total of 439 coho on spawning ground surveys. Of those fish 129 (29.5%) were tagged. In 2018, 2019 and 2020 all of the observed fish were untagged. In 2021 we observed a total of 278 adult coho of which 11 (3.9%) were tagged. This result suggests that significant numbers of natural origin fish are now returning to the Elwha and that relocation of hatchery fish to the middle river is not routinely necessary.

Passage issues at both the former Elwha Dam Site and Glines Canyon likely impacted coho recolonization immediately following dam removal. Efforts to improve fish passage at the former dam sites occurred in 2014-2016 and adult coho salmon were observed above Glines Canyon Dam in 2016 for the first time. Spawning ground surveys indicate that coho are utilizing habitats above Glines Canyon Dam in increasing numbers, however coho have not been observed to date in the upper Elwha above the Grand Canyon nor have they been observed in the Geyser Valley in the last three years.

The adult coho relocation program has been successful and has contributed to the establishment of self-sustaining populations of coho salmon production in the middle and upper Elwha. Based on both SONAR estimates and observations on spawning grounds, Natural origin coho numbers are exceeding the modest escapement goals established before dams were removed on the Elwha. Management steps necessary to achieve long term recovery goals and to prevent overfishing of Elwha natural coho need to be developed and implemented by co-managers in the Pacific Fisheries Management Commission (PFMC) process.

Introduction

Two main stem hydroelectric dams were removed on the Elwha River, in Washington State between 2011-2014 to restore salmon populations as authorized in the 1992 Elwha Ecosystem and Fisheries Restoration Act (Public Law 102-495). Elwha Dam and Glines Canyon Dams were constructed at river kilometer (Rkm) 7.8 and 21.7, respectively, without fish passage facilities and the Elwha's salmon populations were relegated to the lower 7.8 km of the lower river. Coho salmon (*Oncorhynchus kisutch*), along with other Elwha salmon populations, declined precipitously following dam construction as access to upriver habitats and habitat forming processes was severed (Pess et al. 2008). These impacts were exacerbated by anthropogenic activities such as channelization, floodplain logging, and intentional removal of large wood (Draut et al. 2011) conducted in the lower river in the mid to later-twentieth century.

To increase fishing opportunity, the Elwha River was heavily outplanted with out-of-basin coho salmon beginning in early 1950's and continuing into the early 1970's (WDFW & WWTIT 1994). Between 1967-1976, the Washington Department of Fish and Wildlife (WDFW) outplanted Dungeness River coho to the Elwha (DOI 1996). In the mid 1970's, a hatchery was built by the Lower Elwha Klallam Tribe (LEKT) in the lower river and harvest supplementation programs were begun using a mixture of Elwha and Dungeness origin stock. However, since 1977, stocks used in the hatchery coho program were largely derived from the river population. The total number of hatchery coho released annually from 1979-2017 is depicted in Appendix 1.

Prior to dam removal, Elwha coho salmon were classified by state and tribal co-managers as primarily a hatchery population characterized as healthy with a terminal run size ranging from 2,000-10,000 fish (WDFW & WWTIT 1994). A pre-dam removal escapement goal of 1,250 hatchery fish and 250 natural spawners was established by co-managers (PNPTC et al. 2005), however quantifying the naturally spawning escapement for Elwha coho salmon has been and continues to be problematic. The historic composition of the population, prior to dam removal and during maximum

hatchery outplanting, had been estimated as 90.5% hatchery origin and 9.5% natural origin (PNPTC et al. 2005). The Elwha population of coho salmon was included within the Puget Sound/Strait of Georgia ESU (Evolutionary Significant Unit) when coho salmon were considered for listing under the Endangered Species Act (ESA) (NOAA 1995). The available genetic information indicates that the Elwha coho salmon are regionally more similar to Puget Sound than coastal Washington coho salmon stocks (NOAA 1995; Winans et al. (2008). Winans et al. 2008 genetically characterized Elwha coho with 5 adjacent populations in the Strait of Juan de Fuca region and found that Elwha and Dungeness River populations grouped together.

Strategies for restoring Elwha salmon populations prior to, during and after dam removal are contained in several planning documents. Earlier documents (DOI 1994; DOI 1996) describe several alternatives to meeting the full fish restoration objective as defined in the Elwha Act. These documents also describe the expected (modelled) increases in populations of salmon under the various alternatives. By the removal of Elwha dams, coho salmon are expected to recolonize to at least river kilometer (Rkm) 69.0 and reach a peak production of 35,000 Age 2 recruits and or 12,000⁴ spawners in approximately five life cycles (15-18 years) (DOI 1996).

Specific planning documents for the restoration of Elwha salmon are defined in Ward et al. (2008), NOAA (2012) and Peters et al. (2014). Ward et al. (2008) defines restoration strategies before, during and after dam removal and provides overviews of recovery by stock. This document recognizes that river conditions were expected to be hostile to salmon during the dam-removal period and as a result recommended the maintenance of hatchery programs to support salmon populations during the elevated sediment transport period associated with dam removal.

Following dam removal Ward et al. (2008) called for maintaining (or increasing at higher escapement levels) the on-station releases of 450,000 (up to 750,000) 1+ smolts and implementing a variety of supplementation methods including off-station egg

⁴The reduction in estimates from Age-2 recruits to spawners assumes a total harvest rate of 65% in all fisheries. That rate reflects average marine harvest rates in the 1990's.

plants, fry, smolt and adult releases. For Elwha coho salmon, the hatchery population was identified as the primary restoration stock and on-station releases of 1+ age smolts (450,000/year) is now the primary release strategy through the conservation and recolonization stages of Elwha restoration (Elwha Hatchery HGMP 2012). It should be noted that actual releases of hatchery produced coho during and immediately after dam removal has ranged from 25,772-506,402 (average 267,663).

Ward et al. (2008) was reviewed by the Hatchery Scientific Review Group (HSRG 2012) and one of their significant recommendations was to emphasize the use of adult outplanting over earlier life history stages (eggs, fry, smolts), because it minimized the potential negative interactions of rearing in the hatchery. Those recommendations were largely adopted in the Biological Opinion (NOAA 2012) adopted for lower river hatcheries. In addition, the Elwha population of coho salmon was thought to be strongly imprinted to the lower river in the vicinity of the LEKT hatchery prior to dam removal (Burke et al. 2008; Geffre et al. 2014). On the Columbia River, hatchery coho salmon had a much reduced stray rate as compared to natural origin fish (Westley et al. 2013). As a result, project partners initiated an adult coho relocation program on the Elwha River beginning in 2011 and continuing through 2021 utilizing surplus fish from the lower river hatcheries.

Dam removal on the Elwha River was initiated in the fall of 2011 and by the spring of 2012, Elwha Dam had been completely removed. Glines Canyon Dam was removed in the fall of 2014; however, fish passage was not immediately restored at either site. Fish passage was impacted by hydraulic conditions associated with remnant dam construction debris at Elwha and by rockfalls within Glines Canyon dating to the construction and operation of the dam. Efforts to ensure fish passage, including additional blasting of rocks and removal of dam debris occurred between 2014-2016 and will be continually evaluated until full fish passage is assured consistent with the goals of the Elwha Act.

Here we provide a summary of adult coho salmon relocations and tributary spawning ground surveys conducted on the Elwha River since 2011. For each year we

describe the number of adult coho salmon relocated and their release locations, the number of surveys conducted and the number of redds enumerated, the location and timing of redd excavations as well as the number of live and dead adult coho observed during redd surveys. We use this information to assess the effectiveness of the program as well as an opportunity to review the overall recovery of Elwha coho salmon in relation to earlier planning documents.

Methods-Adult Relocations

Surplus adult hatchery coho salmon collected at the LEKT and WDFW hatcheries were released at upriver locations in 2011-2021 in seven of eleven years. Surplus coho salmon were defined as those adults not needed to support hatchery release target of 425,000. As a result, the numbers of fish moved varied annually depending upon abundance. In 2013-14, during a year of relatively high abundance we relocated 1050 adults. In contrast, because low numbers of returning coho salmon to the hatcheries in 2015, 2018, 2019, and 2020 no upstream releases were made in those brood years.

Release locations varied over time but were planned to advance the colonization of coho salmon in an upstream direction and in concert with gains in fish passage as the Elwha project progressed (Figure 1). In general, tributary releases were favored over mainstem releases primarily because early mainstem releases produced a higher return rate to the hatcheries (fall back). In 2016 and 2017, mainstem releases were targeted over tributary releases when the decision was made to release adults immediately below the former Glines Canyon Powerhouse site in an attempt to evaluate passage conditions through that site (2016). That release site was also utilized in 2017, primarily in an attempt to advance recolonizing fish to habitats above Glines Canyon in ONP. Initial releases focused only on the two largest middle Elwha tributaries (Little River and Indian Creek) and upstream release site were later added at Madison Creek, Sanders Creek and Griff Creek. Since the inception of the program, project partners have relocated a total of 3,162 coho to upstream habitats in the Elwha River.

Metadata and Tagging

Adult coho salmon for relocation were collected at either the LEKT or WDFW hatcheries located in the lower river at Rkm 1.6 and 5.6, respectively. While the WDFW hatchery is dedicated to Chinook salmon production, coho salmon annually volunteer into the adult trap. We worked with hatchery managers to process and relocate fish from the entirety of the run timing and relocations occurred as early as the last week of September and as late as the third week of December. Relocated fish were primarily in pre-spawning condition and were generally bright to red colored in appearance. Adult coho salmon were collected at each hatchery and processed for transport upstream. For each adult we determined sex, measured fork length, condition, visually assessed fin clips and scanned for the presence of a coded wire tag (CWT). Based on a length frequency analysis of length we determined that fish <60 cm were classified as precocious males or “jacks” (Figure 2). If an adult was either adipose clipped or had a coded wire tag⁵ (CWT) it was determined to be of hatchery origin (HOR). Fish that were neither adipose clipped nor had a CWT were determined to be of natural origin (NOR).

In all years, each fish was tagged with a numbered spaghetti tag (Floy) using colors unique to individual release dates/sites. In 2016 only, relocated adults were also tagged with 12 mm Passive Integrated Transponders (PIT-tags). PIT tags have a unique alpha-numeric code that can be assigned to an individual animal. That individual can be identified if the fish swims through antennae arrays maintained within the Elwha watershed in lower Indian Creek (Rkm 0.5) and Little River (Rkm 0.3).

In some years, a subsample of relocated coho salmon were surgically implanted with coded radio transmitters to assess movements within the watershed and passage conditions at the former dam sites. In 2011-2012, we radio-tagged 49 adults that were released in the mainstem below the highway 101 bridge. In 2012-13, twelve adult coho were tagged and released in Little River. In 2014-15, 5 coho were radio-tagged and

⁵ All hatchery origin coho produced at the LEKT received CWT's or clips prior to being released as age 1+ smolts.

released in the lower Elwha River adjacent to the WDFW hatchery. In 2016-17, 40 adult coho were surgically implanted with radio tags in order to provide specific information on their movement within the watershed and in particular with reference to passage above Glines Canyon. Detailed analysis of the radio telemetry program for coho and other species has been completed (Geffre et al. 2014; Geffre et al. 2017).

Following handling and tagging, fish were placed in transport bags (4-6 fish/ bag) and allowed to recover in clean, oxygenated water. Individual bags were then transferred to a tanker truck for transport to upriver relocations sites. Relocation sites were generally within a 20-30 minute drive of the hatcheries. Release sites were selected near stream crossings to minimize handling stress. Upon reaching a release site, individual bags with fish were transferred to the stream channel and allowed to acclimate for 5-10 minutes prior to release. Adult coho were then simultaneously released (Figure 3) and allowed to distribute volitionally.

Redd Surveys

We initially conducted redd surveys in six tributaries below Glines Canyon (Indian Creek, Little River, Madison Creek, Sanders Creek, Hughes Creek, and Griff Creek). The purpose of these redd surveys was to determine the location and timing of adult coho spawning (Figure 1). The survey effort above Glines Canyon was expanded beginning in 2016, as coho salmon passage to areas above Glines Canyon Dam was improved and new survey reaches were added on Cat, Boulder, Hurricane Creeks. Surveys began in late September to early October in most years and generally ended in late-December to mid-January. Surveys were conducted every 10-14 days where possible. We surveyed the entire extent of the accessible tributary habitat, with the exception of Indian Creek. We were unable to survey the middle 4.0 km of Indian Creek because access was limited (private property) and stream wading was unfavorable. Surveys were conducted when stream visibility was favorable and redds were clearly distinguishable.

Redds were identified as disturbed areas in the stream bed where gravels were overturned to form a definitive depression and tail spill. Each redd was identified with a distinct GPS location and number. They were then marked with a flag that included the redd number for the individual stream, date, surveyor initials and the distance (m) and direction to the redd from the flag (e.g., 1; 11/21/11; CGO and SK; L 2 m). Redds from previous surveys were also recorded in addition to new redds. We also counted live and dead coho salmon. All relocated adult coho were also tagged with colored spaghetti tags (Floy) prior to release. This allowed observers to determine the origin of adult coho between relocated Hatchery Origin Recruits (HOR) and volitionally colonizing Natural Origin Recruits (NOR).

Results

Coho Relocations-Brood Year 2011

In 2011, with Elwha Dam still being removed and impassible, we relocated 515 coho adults to middle River release sites beginning on November 1 and ending on December 6 (Table 1). The first three releases were made immediately downstream of the Highway 101 Bridge crossing on the Elwha River. This site was subsequently abandoned because of the high rate of fall back to downstream hatcheries. A subset of 49 coho salmon were radio tagged prior to their release at the mainstem site. A total of 26 of the 49 (55%) radio tagged fish were subsequently recaptured at downriver hatcheries. As a result, the subsequent seven releases of adults were made into the lower portions of Little River and Indian Creek. The composition of the adult releases was 53% male and 47% female, respectively. Eighty nine percent of the relocated fish were determined to be of hatchery origin and 11% natural origin.

Coho Relocations-Brood Year 2012

In 2012, we relocated 244 coho on four different dates in lower and upper Indian Creek (Table 2). Based on two subsamples of adult coho moved on November 7 and

December 6, we estimated the sex ratio at 50% female and 50% male. The origin of the fish was not determined in 2012, but was likely predominantly hatchery (>85%) based on results in the previous brood year. Of the 12 radio tagged coho released to Little River (Rkm) 1.0, four moved downstream to the lower river. The remaining eight coho stayed in Little River and moved as far upstream as Rkm 4.0 and were presumed to have spawned.

Coho Relocations-Brood Year 2013

In 2013, we relocated 1,050 coho to release sites in Little River and Indian Creek on twelve different dates beginning in early October and ending in mid-December (Table 3). This was by far the highest number of fish released to date in the program. Of these, the majority of adults (595/1,050; 56%) were released to Indian Creek and the remaining 455 (44%) adults were released to Little River. The sex ratio of relocated coho was 44% female and 56% male. Ninety-two percent of the relocated fish were determined to be of hatchery origin and 8% natural origin. Of the fish released, 28 were recovered at downstream hatchery facilities suggesting a low rate of downstream fall back. No radio tags were released associated with this brood year's relocation efforts.

Coho Relocations-Brood Year 2014

In 2014, we tagged and released 124 coho salmon on two separate dates, both in upper Indian Creek (Table 4) at Rkm 4.9. The first release occurred on October 20 and the last on December 15. The sex ratio of the released coho was less balanced than in other years (70% female and 30% male) and reflected the low numbers of fish available for relocation in this brood year. Of the relocated fish we determined that 107 (86%) were hatchery origin as indicated by coded-wire tag and clipped adipose fin, while 17 (14%) were of natural origin. In addition, we also relocated 11 Bull trout from the LEKT hatchery to lower Indian Creek as required in the Elwha Project Biological Opinion. The bull trout were sub adults and ranged in size from 23-36 cm.

Coho Relocations-Brood Year 2015

In 2015, no coho salmon were relocated from downstream hatcheries in the Elwha River. This was due to the record low coho salmon returns during 2015 in many watersheds coast wide. In the Elwha River in 2015, only 26 adults returned to the LEKT hatchery.

Coho Relocations-Brood Year 2016

In 2016, a total of 663 coho were released on seven dates at six locations including Indian Creek (upper and lower), Madison Creek, Sanders Creek, Griff Creek and in the mainstem just below the entrance to Glines Canyon (Table 5). Indian Creek received the most adults (327) representing nearly half the adults relocated in 2016-17. The Glines Canyon location was selected in an attempt to assess the ability of Elwha coho salmon to ascend through Glines Canyon and the former dam site. Of the coho released, a total of 355 (54%) were females and 86% of the total were determined to be hatchery origin. In addition to the coho salmon, 11 chum salmon were also relocated to lower Indian Creek from the WDFW hatchery. This represents the first attempt to relocate chum salmon to areas above the former Elwha Dam site.

In 2016, project partners inserted PIT tags into 329 relocated adult coho to further assess their migratory behavior after release. Two permanent PIT antenna arrays are maintained in lower Indian Creek and Little River and we used these sites to assess the number of fish moving across the antennas and their direction of passage. We found that the majority (73%) of coho released into lower Indian Creek moved in an upstream direction (Table 8). Of the 67 PIT-tagged coho released into upper Indian Creek, only 1 (1.4%) moved downstream across the antenna array. Adult coho salmon relocated to the small tributaries (Griff, Madison, Sanders) were detected at the Little or Indian antennas approximately 15% of the time and the majority of fish appeared to stay in and spawn near their release sites (Table 6). For the releases made in the

mainstem below Glines Canyon, we detected a total of 22 of the 210 (10.4%) adults released at the antenna sites. However, we were unable to make any mainstem detections since there were no mainstem antenna sites.

Of the 210 adult coho released immediately below Glines Canyon, we radio tagged 40 (19%) in order to further assess passage through the Glines Canyon area. Of those fish, only 1 ascended above Glines Canyon Dam, but later fell back in the vicinity of the Boulder Garden. Eighteen (45%) of the radio tagged adults fell back to the lower river. The remaining fish were relocated at various locations downstream of their release site including 22 (55%) in the middle river. Sixteen of the middle river fish were located in association with middle river tributaries.

Coho Relocations-Brood Year 2017

In 2017, a total of 409 adult coho were relocated on 6 days to 6 separate locations, including Indian Creek (upper and lower), Madison Creek, and in the mainstem just below the entrance to Glines Canyon (Table 6). The Glines Canyon site received the most adults (218) representing just over half the adults relocated in 2017-18. The Glines Canyon location was selected for release in an attempt to advance recolonization of Elwha coho in the upper watershed as well as to assess the ability of Elwha coho salmon to ascend through Glines Canyon and the former dam site. Coho were released beginning on October 5th and the last release was completed on November 30th. Of the coho released, a total of 262 (64%) were females and 79% of the total were determined to be of hatchery origin. This represents the highest percentage of relocated NOR coho since initiation of the program in 2011.

Coho Relocations-Brood Year 2018, 2019 & 2020

Because of low returns to the LEKT hatchery no relocations of adult coho were made in these years. As a result all coho redds observed in those years are the product of natural origin spawners only.

Coho Relocations-Brood Year 2021

In 2021, a total of 164 coho salmon were relocated on four dates in November of 2021 to release sites in upper and lower Indian Creek (Table 7). Of the coho released, 90 (55%) were females, 67 (41%) were males and 7 (4%) were jacks. There was no determination of the origin (HOR/NOR) for these releases.

Redd Enumeration-Brood Year 2011

In 2011, project partners conducted 70 redd surveys beginning in the third week in November and continuing through the end of December. We enumerated a total of 109 coho salmon redds across a total of 57.9 km of stream (Table 9). Of the 109 redds, most were observed in Little River (58) and Indian Creek (43). The remaining redds were found in the Sanders Creek side channel (2), Madison Creek (1), Madison Creek SC (3), SC 26 (1), and in the main-stem Elwha River (1) approximately 200 m below the highway 101 bridge. The greatest spatial extent of spawning occurred in the Little River and Indian Creek. The first redd was counted on November 18 and the last on December 27. Overall, redd counts peaked in middle December (Figure 5), although the timing was slightly different in Little River where counts peaked in November and the middle of December (Figure 5).

We also enumerated live and dead coho. We counted 23 live males, 32 females, and 3 jacks, and we counted 2 dead males and 8 dead females. Live and dead coho were only found in Little River (58) and Indian Creek (8). Through observation and carcass retrieval we were able to recover 22 Floy tags, including 14 in Little River and 8 in Indian Creek. In Indian Creek two Floy tags that were found on December 20 were from coho released in the main-stem Elwha River on November 1. Of the Floy tags recovered in Little River, one was from a coho released in Little River on November 8 and one on November 22, while 3 were released in Little River on November 29. The other three Floy tags recovered in Little River were from the main-stem release site in November. Although the overall fallback rate from mainstem releases was high, the

tributary tag recoveries indicate that some adult coho moved from the main-stem Elwha River release site upstream into Little River and Indian Creek.

Redd Enumeration-Brood Year 2012

In 2012, project partners conducted 94 redd surveys from mid- October to mid-January (Table 10). High flows and poor visibility precluded surveys in some weeks, particularly in November and December. Overall, observer's enumerated 44 coho salmon redds across 56.1 km of stream, with the greatest number of surveys and length of stream being surveyed in Indian Creek (22.5 km of stream) and Little River (11.6 km).

The majority of the 44 redds counted during our surveys were observed in Indian Creek (36) with the remaining redds found in Little River. Temporally, most redds were constructed from November 4 to December 10. That peak was followed by a lull in spawning activity, and another peak of redds in early and middle January. There was little difference in the timing of redd construction among Indian Creek and Little River, although the peak of redd construction was broader in Indian Creek. We presume the latter pattern was related to the fact that more coho salmon were released and over a longer period of time in Indian Creek compared to Little River. However, part of the pattern was also related to the survey conditions, as we likely missed several redds in Little River that were spawned during prolonged high flows.

We counted eight live males, nine females, and one jack. Seventeen of 18 (94%) live coho salmon observed had a visible Floy tag indicating fish of relocated hatchery origin. We also counted two dead males, nine dead females, and one dead jack. Live and dead coho were only found in Little River and Indian Creek. The carcasses were in various states of decomposition and floy tags were not found on any dead fish, presumably because most of the carcass had been consumed by animals and birds.

Eleven relocated coho were radio-tagged and released into lower Little River (Rkm 1.0) in 2012-2013. Three of the eleven (27%) coho salmon moved downstream and were relocated near the LEKT hatchery where they were originally captured and tagged. The remaining eight coho salmon were relocated upstream or downstream from their

release location and presumably spawned. Three of the fish moved upstream in the vicinity of Rkm 4 on the Little River. We had far fewer fall backs this year because fish were released mostly into clear water tributaries, as evidenced by the fact that we only recovered seven floy tagged coho at the LEKT hatchery.

Redd Enumeration-Brood Year 2013

In 2013, project partners conducted 81 redd surveys from mid-October to mid-January. We enumerated 296 coho salmon redds. The majority of redds counted were observed in Little River (160) and Indian Creek (126) (Table 11). A single coho salmon redd was confirmed in Hughes Creek, which represents the initial observation of coho salmon naturally recolonizing that stream. In addition to coho salmon redds, we observed redds that appeared to be excavated by bull trout in Little River, Indian Creek, Hughes Creek, Griff Creek, and potentially Madison Creek.

In 2014 we assessed redd survey precision by conducting repeat surveys on three different occasions with multiple observers on Little River, Indian Creek and Madison Creek. The survey results were within one redd on Little River and Indian Creek and were equivalent on Madison Creek. The difference in survey results was that one observer determined a redd while the other determined a test-dig (McMillan et al. 2014).

Temporally, most redds were constructed from the third week in November through the third week in December in 2013, which was also consistent with what was observed in 2011/2012 and 2012/2013 (Figure 4). The distribution was bimodal in 2013, with two peaks occurring in the last week of November and another in the third week of December. The range of spawn timing was similar among Little River and Indian Creek, but Little River had a much sharper peak in spawning activity during the last week of November (Figure 4). We presume the latter pattern was related to the fact that more coho salmon were released and over a longer period-of-time in Indian Creek compared to Little River, which had its greatest releases of coho salmon in the two weeks prior (Table 3).

We counted 280 total live and dead coho salmon, with almost equal representation among males and females, though far more live fish were observed than dead. Among streams, we counted 110 live and 26 dead salmon in Little River, 103 live and 21 dead salmon in Indian Creek, 16 live and 3 dead salmon in Madison Creek, and 1 live and 1 dead salmon in Hughes Creek. Nearly all the live and dead coho salmon we observed had floy tags (96%), including 122 of 124 (98%) fish in Little River, 131 of 136 (96%) fish in Indian Creek, 17 of 18 (94%) fish in Madison Creek.

Redd Enumeration-Brood Year 2014

In 2014, project partners conducted 56 redd surveys beginning in the last week of October ranging to the last week in December (Table 12). We enumerated 39 coho salmon redds with the majority of redds observed in Indian Creek (30 redds), which was the only relocation site. This suggests that relocation effectively increased the number of adult coho salmon spawners relative to streams that did not receive relocated adult coho. We also counted five redds in Little River and 2 redds in Hughes Creek, and those fish were presumed to be natural colonizers because all fish that were observed did not have floy tags. In addition to coho salmon redds, we also observed redds that appeared to be excavated by bull trout in Hughes Creek, Little River and Griff Creek.

Temporally, spawning ranged from the last week in October/first week in November until the first week in December (Figure 4). The temporal distribution of redds in Indian Creek and Little River was bi-modal, with distinct peaks in mid-November and then again during the first week of December. Across years, the time at which 50% of the redds were counted in 2014 was the same as we observed in 2013. In contrast, the time at which 50% of the redds were counted in 2014 was a week later than in 2012, and two weeks earlier than in 2011.

Spatially, most redds were enumerated in upper Indian Creek near the upper release site. All redds observed in Little River were found in the lower 1.2 km (Figure 4). In 2014, we counted a total of 74 live adult coho salmon and 5 dead (post spawn) adult

coho salmon. Of these, 69 of the live adult coho salmon were observed in Indian Creek. Only 2 adults were observed in Little River and 3 in Hughes Creek, all without Floy tags.

Redd Enumeration-Brood Year 2015

In 2015, project partners conducted 42 redd surveys beginning in the first week of October and ending in the third week in January (Table 13). We enumerated a total of 6 coho salmon redds across 43.2 km of stream, with the greatest number of surveys and length of stream being surveyed in Indian Creek (6.0 km of stream) and Little River (4.4 km of stream). Redds were only observed in Sanders Creek (2), Hughes Creek (3) and upper Indian Creek (1). Only one live coho was observed in the entire season at upper Indian Creek. New surveys were conducted by ONP crews in the mainstem above Glines (Mills/Cat Creek), Rica Canyon, and Geyser Valley. However, no redds or live/dead coho were observed. There were so few redds that we did not attempt to describe either temporal or spatial relationships in this brood year.

Redd Enumeration-Brood Year 2016

In 2016, project partners conducted 71 redd surveys beginning in the 3rd week of October and ending in the 3rd week in January (Table 14). We enumerated 266 coho salmon redds across 46.5 km of stream, with the greatest number of surveys and length of stream being surveyed in Indian Creek (8.8 km) and Hughes Creek (9 km). Redds were widely distributed and observed in Indian Creek (82), Little River (21), Madison Creek (28), Sanders Creek (43), Griff Creek (37), Hughes Creek (41), Cat Creek (1), Boulder Creek (7) and the Brannon SC (6). A mixture of tagged and untagged fish were observed in all the tributaries. We observed a much lower proportion of tagged coho in this brood year (129/439) and untagged coho were observed in almost all survey locations. The observation of coho salmon spawning in Boulder and Cat Creeks were the first documented coho usage above Glines Canyon Dam since dam removal began in

2011. However, very few other areas above Glines were surveyed. Thus, it is unclear how many adult coho migrated to habitats upstream of Glines Canyon.

Eleven chum salmon were also relocated to Indian Creek (Rkm 1.0) in 2016-17. We were not able to identify any chum redds from this release. However, two chum passed the Indian Creek antenna array in an upstream direction. A single chum carcass was later identified in a late December coho survey in upper Indian Creek.

Redd Enumeration-Brood Year 2017

Survey efforts in 2017-18, were impacted by nearly continuous high water which made access difficult, if not impossible in the larger tributaries. We conducted a total of 33 redd surveys beginning in the 3rd week of October and ending in the 3rd week in January (Table 15). We enumerated 120 coho salmon redds across 23.0 km of stream, with the greatest number of surveys occurring on small tributaries in the middle Elwha (Griff, Hughes, Madison Creeks). Redds were observed in all middle Elwha tributaries, with the highest densities occurring in Madison and Hughes Creeks. Of significance was the observation of spawning coho in lower Falls Creek, a tributary to Lake Sutherland. LEKT obtained a video clip taken by a citizen that clearly depicted multiple coho spawning coho in Falls Creek during December. These fish appeared to be a mixture of tagged and untagged coho and tagged coho were from adult relocations conducted to Indian Creek in November. Only limited surveys occurred above Glines Canyon in Cat, Boulder and Hurricane Creeks. No redds were observed in Cat and Boulder, however a single survey of Hurricane Creek yielded 12 redds. Unfortunately no adult fish were encountered above Glines Canyon during 2017-18 surveys and thus the origin of the any coho redds observed is unknown.

Redd Enumeration-Brood Year 2018

In 2018 project partners conducted 29 separate surveys. Because of high flows and poor visibility all surveys were conducted in tributaries. A total of 53 coho redds and 22 live or dead fish were observed by surveyors. Because of low returns to the LEKT

hatchery, no adult coho were relocated in 2018-2019. As a result none of the observed fish were tagged and are assumed to be of natural origin. The most redds were observed in middle Elwha tributaries including Griff (7), Hughes (26) and Indian (9). Significantly, 7 coho redds were observed in Hurricane Creek which flows across the former Mills reservoir surface (Table 16). This observation represents the furthest upstream distribution of coho spawning to date.

Redd Enumeration-Brood Year 2019

In 2019-2020 project partners conducted 41 surveys that covered a total of 31.5 miles of streams. The majority of the surveys occurred in tributaries with the exception of two mainstem survey of the former Mills reservoir and Geyser Valley in mid-December. For the second consecutive year, no adult coho were relocated from lower river hatcheries because of low returns and all observed coho are assumed to be of natural origin. A total of 189 redds were observed and the spatial distribution of redds was the greatest observed since the initiation of the project (Table 17). The most coho redds were again located in middle river tributaries including Griff (26), Hughes (46) and Indian (27). However, significant numbers of redds were also observed above Glines Canyon including Boulder (37), Hurricane (9) and in the mainstem (17 on Mills/3 Geyser Valley).

Redd Enumeration-Brood Year 2020

In 2020 project partners conducted 51 separate surveys, the majority of which occurred in tributaries because of high flows and poor visibility in the mainstem. A total of 234 coho redds and 270 live or dead fish were observed by surveyors (Table 18). Because of low returns to the LEKT hatchery, no adult coho were relocated in 2018-2019 and all observations of coho were of volitional origin. Redds were observed in all middle and upper tributaries surveyed with the highest number in Indian (79), Hughes (78), Little (41), Hurricane (27) and Griff Creeks (24).

Redd Enumeration-Brood Year 2021

In 2021 project partners conducted 54 separate surveys. Because of high flows and poor visibility almost all of the surveys were conducted in tributaries. A total of 157 (90 females/67 males) adult coho were relocated from the LEKT hatchery to release locations in upper and lower Indian Creek. A total of 346 coho redds and 278 live or dead fish were observed by surveyors (Table 19). Of the adult observations, a total of 11 coho were determined to be tagged and all recoveries were in Indian Creek.

Discussion

A program of adult coho relocations using surplus hatchery coho salmon has been conducted on the Elwha River from 2011 to 2021, with adult coho being moved in 7 of 11 years. The program was initiated primarily to accelerate recolonization of habitats in the middle Elwha and secondarily as an opportunity to assess passage conditions at two former dam sites. At the initiation of dam removal, the Elwha population of coho salmon was predominantly hatchery origin fish (>90%) and this population has historically expressed a strong fidelity to the lower Elwha River (Burke et al. 2008; Geffre et al. 2014) where on-station releases of coho salmon had occurred for over four decades. The coho relocation program was initiated in 2011 prior to the removal of dams and it was anticipated that relocated adults would spawn in middle river habitats and eventually establish natural origin populations that would complete their life histories and return when dam removal and fish passage was accomplished.

From 2011-2021, we relocated a total of 3,162 adult coho salmon to both tributary and mainstem release sites. Initial releases in 2011 occurred in the mainstem Elwha just below the Highway 101 crossing. These early releases resulted in a high rate of fallback (>50%) to the lower river. For subsequent releases, tributary sites were preferentially selected because of the observed lower fallback rate. The high rate of fallback was likely related to the physical characteristics of the release site the coho were initially released: a high gradient riffle where the river was actively incising through the Aldwell reservoir delta.

We conducted systematic spawning ground surveys in tributaries of the Elwha and attempted to determine the origin of adult coho (hatchery versus natural) during the period. In general, relocated adult coho showed a high degree of fidelity to tributary release sites and spawning was documented in every tributary in which adult coho were released. The total number of redds observed was initially highly correlated to the total number of adults relocated to tributaries (Figure 5). For the relocation period, Indian Creek had the most number of redds observed, followed by Little River, Madison, Hughes, Griff Creeks (Figure 6). In recent years, coho have expanded to habitats above Glines Canyon and have spawned in significant numbers in Cat, Boulder and Hurricane Creeks. This has occurred without relocating any adult coho in three out of four the last return years.

Through the 2014 brood year, relocated adults from the downstream hatcheries dominated the observations of live/dead coho in spawning ground surveys. In 2012 and 2013, >95% of the coho adults observed on spawning ground surveys were tagged (McMillan et al. 2015). In contrast, during 2016, the highest numbers of untagged adult coho were observed during spawning ground surveys. The first natural recolonizing coho was documented in 2013 at Hughes Creek and in subsequent years an increasing number of coho observed on spawning ground surveys have been untagged (Figure 7). In addition we have also measured an increase in the percentage of natural origin coho that we have relocated from the lower river hatcheries (Figure 8). These observations suggests that natural production of coho is occurring in the Elwha River and adults are returning to the river (Liermann et al. 2016).

Smolt monitoring conducted by LEKT documented natural origin smolts from Little River and Indian Creek beginning in the spring of 2013 (McHenry et al 2014). Those smolts were the progeny of adults relocated in the fall of 2011. Liermann et al. (2016) found that the relocation of adult coho to two Elwha tributaries (Indian Creek and Little River) resulted in fry and smolt densities that were comparable to other coho streams. They also noted significant differences in life history trajectories with Indian Creek producing 4-5 times as many smolts as Little River. In contrast, Little River had a

higher number of coho parr emigrating out of the watershed as compared to Indian Creek. In summary, this information shows that tributary habitats provided critical habitat for coho salmon and allowed the species opportunity to colonize habitats above the dams during a period of high instability in the mainstem during dam removal.

The number of returning adults was low in both 2014 and 2015. In 2015, only 26 adults returned to the LEKT hatchery. This was the result of the impacts of elevated ocean temperatures and disruption in large scale food chain processes. An anomalously warm water mass began to form in the Gulf of Alaska during autumn 2013 and was named “The Blob” (Bond et al. 2015). This warm water mass spread across the entire North Pacific by summer 2014 raising coastal sea surface temperatures with an 80 m thick mixed layer with 2-3°C anomalies. Ecologically the blob is thought to have resulted in an invasion of tropical/subtropical species, as well as altering planktonic food chains for salmon. Returns of coho salmon in 2015 were at 25 year lows in the Columbia River and along much of the west coast.

(www.nwfsc.noaa.gov/research/divisions/fe/estuarine/ceip/b-latest-updates.cfm).

We used the relocation of adult coho opportunistically to evaluate fish passage through both former dam sites⁶. Hydraulic conditions through both Elwha Dam and Glines Canyon were initially problematic for fish passage. Although Elwha Dam was removed in the spring of 2012, the lower 10-15’ of the base of the dam had not been removed, nor had the caisson, a sheet pile plug built in front of the reconstructed Elwha Dam after its initial failure in 1912 (Reineking 1913). These features were later exposed by erosion following dam removal. Additionally, remnant boulders from dam construction blasting plugged the narrowest portion of the canyon creating hydraulic jumps that created passage issues for some species (McMillan et al. 2014). Glines Canyon Dam was removed during the fall of 2014; however, fish passage was not immediately secured as portions of the canyon wall collapsed into the throat of the since dam construction occurred and these large boulders created large vertical jumps.

⁶ For more rigorous multi-species assessments of Elwha fish passage see Geffre et al. 2014 and Geffre et al. 2017.

Efforts to mitigate these passage issues have occurred included the selective blasting of boulders at both sites. These efforts appear to be mostly successful. The former Elwha dam site is passible for Chinook salmon, coho salmon, chum salmon, pink salmon steelhead, and bull trout (Geffre et al. 2017; McHenry et al. 2017; McMillan et al. 2017). Glines Canyon dam is currently considered passible for Chinook salmon, coho salmon, sockeye salmon, steelhead and bull trout (Geffre et al. 2017; McHenry et al. 2017; McMillan et al. 2017). Continued monitoring is recommended as hydraulic conditions at both sites may change over time.

At the time of dam removal, the Elwha coho population was mostly composed of hatchery origin fish. The hatchery population was founded in the 1970's primarily from Elwha coho salmon with imports from other watersheds (Dungeness, Satsop, Green) in some years. However, it is not known how those imports affected run timing or other characteristics. The population has been in the hatchery for over four decades and it is possible that this has resulted in earlier run timing through the selection of earlier timed matings (Flagg et al. 2000). As coho salmon recovery progresses on the Elwha, it is feasible that spawn timing will change as the proportion of natural origin fish increases. This should be closely monitored as early spawn timing results in earlier emergence and potentially a higher proportion of outmigrating parr.

Adult coho relocations occurred in six of the last nine years on the Elwha River. Our goal was to reestablish self-sustaining populations within the watershed in spatial patterns similar to the historic population prior to dam removal. This goal has been achieved and as a result it is likely no longer necessary to conduct relocations in the middle Elwha. Current estimates of the historic range of coho salmon to include the mainstem Elwha upstream to Carlson Canyon (Rkm 69) as well as all the larger low-gradient tributaries of the upper Elwha (Long, Hayes, Godkin) (DOI 1996). At this time, NOR coho salmon have been established in all of the Elwha watershed through the Geyser Valley (Rkm 29.2). Based upon snorkel and electrofishing surveys conducted in the upper Elwha in the summers of 2018 and 2019, no juvenile coho salmon have been

observed upstream of the Grand Canyon of the Elwha (Rkm 36.2) (Olympic National Park, Unpublished Data)

In the foreseeable future, on station releases of yearling coho salmon will continue at the LEKT hatchery (Ward et al. 2008). Specific viable salmonid population (VSP) (McElheny 2000) recovery goals have been developed for coho salmon in the period following dam removal (Ward et al 2008). This includes an abundance target of 3,000 NOR adults by 2024 and spatial distribution to Rkm 60.0. Nearly a decade into Elwha restoration, the natural origin coho salmon spawning aggregate is clearly growing and has now far exceeded the original goal of 250 natural spawners, based only on SONAR counts in the last three years (Denton et al. 2022). Steps should be taken within management forums to manage the Elwha River and intercepting fisheries to achieve the NOR goals as described and transition the hatchery population to secondary management status. Alternatively, the hatchery and natural goals could be combined into a single escapement objective (1,250 hatchery returns + 3,000 natural spawners = 4,250 Elwha Coho total) for the river if out-planting of adult hatchery coho is still considered a viable option for supplementing the natural spawning aggregate. In order to meet the spatial spawning distribution goal in the upper watershed managers have two choices: 1) relocate surplus hatchery fish to the headwaters, or 2) wait for recolonization to occur from the expanding population of natural origin fish. While wild coho salmon are known to stray at moderate rates (<10%) (Pess et al. 2014), hatchery coho appear to stray at much lower rates. Westley et al. (2013) found that hatchery coho populations only strayed at a rate of 0.5%. If this rate is similar on the Elwha then the overall recovery of naturally produced coho is likely to be protracted over what was predicted (15-18 years) during project planning (DOI 1994; DOI 1996).

While the ability of salmonids to recolonize a watershed following extirpation events is broadly recognized (Perrier et al. 2009; Pess et al. 2014), there is relatively little known about utilizing hatchery populations of adult salmon to reestablish natural, self-sustaining populations from watersheds that have suffered extirpation events. Spring Chinook salmon were relocated from a hatchery to Shitike Creek, Oregon 15

years following a dam removal and a significant portion of juveniles captured the following spring were from that transfer (Baumsteiger et al. 2008). Most of the published literature involves outplanting of hatchery derived juveniles. In New Zealand, populations of Chinook salmon from a founding hatchery population in Northern California were introduced into multiple watersheds and quickly adapted local characteristics (Kinnison et al. 2002). On the Yakima River, Washington, age 1+ hatchery smolts were outplanted over a 10-20 year period in an effort to reestablish coho populations (Bosche et al. 2007). Those efforts have been successful and the program has resulted in an increase in spawning adults and increased spatial distribution (Bosche et al. 2007).

On the Elwha, project managers may consider relocating coho salmon to the upper watershed particularly if monitoring continues to indicate that coho salmon have not volitionally colonized these habitats. The success of such relocations in the middle Elwha (Liermann et al. 2017) shows this is a viable technique though logistically difficult in the upper Elwha. Such relocations are consistent with the Biological Opinion for Elwha hatchery operations (NOAA 2012).

In 2016 adult coho were first documented upstream of the Glines Canyon site. Small numbers of coho were observed spawning in Cat, Boulder and Hurricane Creeks. Following that spawning event, high densities of juvenile coho salmon were documented not only in those tributaries but in nearby side channels of the mainstem (NOAA/LEKT unpublished data). On the Cedar River, Washington after fish passage was restored above an impassible dam, juvenile coho dispersed up to 6.3 km following initial recolonization by adults (Anderson et al. 2012). Local populations established by relatively small numbers of adults could adapt to conditions in the upper watershed and would be more likely to return to these natal habitats as natural origin spawners.

There are other challenges for project managers associated with recovering coho salmon in the Elwha. While specific VSP criteria were established for coho salmon, there were not tied to specific recovery stages as has been done for Elwha Chinook and steelhead. Peters et al. (2014) used VSP parameters to define recovery guidelines for

Chinook salmon and steelhead populations in the Elwha. They defined four specific stages of Elwha recovery tied temporally to dam removal including 1) stock preservation, 2) recolonization, 3) local adaptation, and 4) viable natural populations. Ideally these should be developed for all Elwha stocks with coho as the highest remaining priority (followed by pink and chum salmon). Without such goals it is not clear how and when hatchery coho production will be scaled back or when and where adult outplanting will be completed or terminated. Ward et al. 2008 only states that the hatchery program will be phased out in response to increases in natural origin spawners.

Fundamental to any Pacific salmon monitoring program is the ability to estimate adult abundance, one of the pillars of VSP. Prior to dam removal, adult coho abundance was estimated by totaling in-river sport and commercial catch combined with hatchery rack returns. This method was adequate for a hatchery dominated population with only five miles of accessible river habitat. With dams removed, coho now have potential access to over 70 miles of habitat, much of it difficult to access in the wilderness of ONP. Visual estimation techniques (spawning ground surveys) can be used in clear-water tributaries in the middle Elwha; however, access makes such surveys problematic in the upper watershed. Additionally, mainstem surveys are problematic because of flow, turbidity and access. As a result no spawning ground estimate of abundance has ever been made for Elwha coho.

Other adult enumeration techniques including a weir (Anderson et al. 2015) and a fish wheel (LEKT Natural Resources, Unpublished Data) have previously been tested and determined to be ineffective on the Elwha. Mark-recapture methods using relocated coho in the middle Elwha is another possible enumeration technique. However, expanding this method watershed wide presents formidable challenges. Another mark-recapture technique that should be explored is transgenerational DNA (Rawding et al. 2014). In this technique DNA is collected in a two stage mark-recapture experiment: initially from adults and then from subsequent juveniles typically outgoing smolts at traps. A parentage analysis is used from the DNA results and the population

can be estimated using modelling techniques (Whitmore 2016). We note that much of the infrastructure necessary to conducting an evaluation of this technique is already in place (spawning ground surveys/smolt trapping).

A well designed test fishery combined with a mark-recapture study could also provide information on run-size. In combination with the pre-season forecast, the test fishery catch per unit effort could be used to assess whether actual returns were consistent with the forecast. Initial models could be developed from tribal catch data obtained from net fisheries prior to dam removal, when total run-sizes were fairly well understood. While not as accurate as a weir or SONAR system, the test fishery would provide defensible run-size information. Additionally, a test fishery would be less expensive than other options and have the added benefit of beginning to restore fishing opportunity for the Elwha Tribe. Effort models have been successfully applied in the Dungeness River coho fishery to update run-size in-season (PNPTC et al. 2003).

The best enumeration method is the SONAR acoustic camera, which has been successfully used to estimate steelhead and Chinook escapement in the Elwha since 2010 (Denton et al. 2017). Operating instream infrastructure during a variety of river conditions and determining the species composition are challenges that the SONAR project has overcome to provide precise estimates of steelhead and Chinook abundance. The same challenges exist for enumerating coho except they would be greatly exacerbated as the coho migration period (fall) coincides with the largest flows of the year and is also concurrent with chum salmon. In 2019-21, LEKT obtained resources to perform a pilot project using the existing Elwha SONAR infrastructure and Denton et al. (2020) has been able to generate escapement estimates in those years.

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Table 1. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2011-12. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Recaps	RadioTags	Total
11/1/2011	Mainstem 101 Bridge	2	53	21	34	0	15	55
11/8/2011	Mainstem 101 Bridge	-	-	8	4	0	17	12
11/15/2011	Mainstem 101 Bridge	2	28	15	15	0	17	30
11/22/2011	Indian Creek	9	53	20	42	0	0	62
11/22/2011	Mainstem 101 Bridge	4	36	31	9	0	0	40
11/29/2011	Lower Little River	12	43	23	22	0	0	55
11/29/2011	Mainstem 101 Bridge	14	92	50	56	0	0	106
11/29/2011	Indian Creek	4	50	25	29	0	0	54
12/6/2011	Mainstem 101 Bridge	7	53	28	32	0	0	60
12/6/2011	Indian Creek	4	47	21	30	0	0	51
	Totals	58	457	242	273	0	49	515
	Percentage	0.11	0.89	0.47	0.53			

Table 2. The date, location, and sex ratio of adult coho salmon relocated during 2012-13. ND = No data collected. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Recaps	RadioTags	Total
11/7/2012	Upper Indian Creek	ND	ND	26	15	0	0	51
11/12/2012	Upper Indian Creek	ND	ND	ND	ND	0	0	47
11/12/2012	Middle Indian Creek	ND	ND	ND	ND	0	0	64
12/6/2012	Little River (DNR)	ND	ND	20	24	0	12	62
12/19/2012	Indian Creek	ND	ND	ND	ND	0	0	20
	Totals			56	39	0	12	244
	Percentage (%)			59%	41%			

Table 3. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2013-14. Recaptures are returns to lower river hatcheries. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Recaps	RadioTags	Total
10/2/2013	Upper Indian Creek	1	68	39	30	1	0	69
10/7/2013	Upper Indian Creek	-	-	-	-	0	0	69
10/9/2013	Little River (DNR)	-	-	-	-	1	0	35
10/9/2013	Little River (DNR)	1	50	19	32	2	0	51
10/23/2013	Little River (DNR)	3	38	22	19	1	0	41
10/23/2013	Upper Indian Creek	4	101	41	64	1	0	105
10/30/2013	Indian Creek	9	72	52	29	1	0	81
11/6/2013	Lower Indian Creek	3	87	49	41	3	0	90
11/13/2013	Little River	5	97	27	75	6	0	102
11/20/2013	Little River	5	60	32	33	3	0	65
11/21/2013	Little River	5	66	42	29	2	0	71
11/25/2013	Indian Creek	2	66	20	48	1	0	68
12/4/2013	Lower Indian Creek	24	61	39	46	6	0	85
12/11/2013	Little	5	75	17	53	0	0	80
12/12/2013	Indian Creek	7	31	10	28	0	0	38
	Totals	74	872	409	527	28	0	1050
	Percentage	0.08	0.92	0.44	0.46	0.027		

Table 4. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2014-15. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Total
10/20/2014	Upper Indian Creek	15	85	73	27	100
11/7/2014	Upper Indian Creek	2	22	11	13	24
	Totals	17	107	84	40	124
	Percentage	0.14	0.86	0.70	0.30	

Table 5. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2016-17. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Recaps	RadioTags	Total
9/29/2016	Upper Indian Creek	4	39	23	20	0	0	43
10/4/2016	DNR Bridge Indian Creek	9	98	50	57	0	0	107
10/12/2016	DNR Bridge Indian Creek	35	32	33	34	0	0	67
10/12/2016	Lower Indian Creek	13	43	39	17	0	0	56
10/20/2016	Madison Creek	1	24	15	10	1	0	25
10/20/2016	Griff Creek	2	26	13	15	1	5	28
10/20/2016	Below Glines	4	46	27	23	0	18	50
10/27/2016	Below Glines	0	102	56	46	8	17	102
11/3/2016	Sanders Creek	4	63	33	34	9	0	67
11/17/2016	Below Glines	3	61	36	24	9	0	64
11/17/2016	Lower Indian Creek	17	37	30	24	1	0	54
	Totals	92	571	355	304	29	40	663
	Percentage	0.14	0.86	0.53	0.45	.04	0.06	

Table 6. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2017-18. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Date	Location	NOR	HOR	Females	Males	Recaps	Tag Color	Total
10/5/2017	Glines Powerhouse	5	40	23	22		Red	45
10/12/2017	Glines Powerhouse	5	37	29	13		Neon Orange	42
10/24/2017	Glines Powerhouse	23	108	85	46		Green	131
11/2/2017	Upper Indian Creek	11	33	24	20		Yellow	44
11/20/2017	Lower Indian Creek	11	42	38	15		Red	53
11/30/2017	Madison Creek	11	34	32	13		Light Orange	45
11/30/2017	Upper Indian Creek	17	32	31	18		Light Orange	49
	Totals	83	326	262	147			409
	Percentage	0.20	0.80	0.64	0.36			

Table 7. The date, location, origin (NOR=Natural Origin Recruits/HOR=Hatchery Origin Recruits), and sex ratios of adult coho salmon relocated during 2021-2022. NOR/HOR not determined.

Date	Location	NOR	HOR	Females	Males	Jacks	Total
10/29/21	Lower Indian Creek			24	11	5	40
11/9/21	Lower Indian Creek			10	4	2	16
11/19/21	Upper Indian Creek			21	32	0	53
11/19/21	Lower Indian Creek			35	20	0	55
	<i>Totals</i>			90	67	7	164
	<i>Percentage</i>						

Table 8. Summary of 2016-17 PIT-tagged adult coho salmon by release site and subsequent detections (relocations) at fixed antenna sites in Little River and Indian Creek. Note that in some circumstances the numbers of NOR/HOR and male/females does not equal the total released because of missing data.

Release Date	Location	Number	Indian Detections	Little Detections	Total Detections (%)	Comments
Oct-16	Lower Indian	56	35	2	37 (66%)	Predominately Upstream
Oct-12	Upper Indian	67	1	0	1 (1.4%)	Stayed in Indian
Oct-20	Madison Creek	26	1	3	4 (15.3%)	Stayed in Madison
Oct-20	Griff Creek	28	0	0	0 (0%)	Stayed in Griff
Oct-27	Below Glines	54	2	3	5 (9.2%)	Unknown
Nov-3	Below Glines	102	5	7	12 (11.7%)	Unknown
Nov-7	Sanders	67	9	1	10 (14.9%)	Stayed in Sanders
Nov-11	Lower Indian	64	51	2	53 (77.9%)	Predominately Upstream
Nov-11	Below Glines	54	2	3	5 (8.0%)	Unknown

Table 9. Description of 2011-12 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, number of floy tags observed. SC = sidechannel.

Site	Reach	Length (km)		# Surveys	Redds	# floy
		Reach	Total			
			survey			
Little River						
	Lower	0.0 - 0.9	5.4	6	34	11
	Upper	0.9 - 2.6	1.7	1	24	3
Indian Creek						
	Lower	0.5 - 1.2	2.8	4	15	0
	Middle	0.5 - 2.4	5.7	3	17	2
	Middle Upper	3.7 - 7.2	3.5	3	8	3
	Upper	7.2 - 7.9	1.4	2	3	3
Madison Creek	All	0.1 - 0.3	1.2	6	1	0
Madison SC	All	0.0 - 0.4	2.0	5	3	0
Sanders Creek	All	0.0 - 0.7	4.3	6	0	0
Sanders SC	All	0.0 - 0.4	0.8	4	2	0
Hughes Creek	Lower	0.0 - 0.6	3.6	6	0	0
Griff Creek	Lower	0.0 - 0.6	3.6	6	0	0
Mainstem Elwha	Middle Elwha	0.0 - 8.5	8.5	1	1	0
SC 26	All	0.0 - 0.5	2.0	4	1	0
SC 27	All	0.0 - 0.8	3.2	4	0	0
SC 28	All	0.0 - 0.2	0.8	4	0	0
SC 29	All	0.0 - 0.7	2.1	3	0	0
Brannon SC	All	0.0 - 2.5	5.0	2	0	0
Total			57.6	70	109	22

Table 10. Description of 2012-2013 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed. SC = sidechannel

Site	Reach	Length (km)		# Surveys	Redds	# fish/#floy
		Reach	Total survey			
Little River	LR 1	0.0 - 0.9	7.2	8	6	4/3
	LR 2	0.9 - 5.3	4.4	1	2	0
Indian Creek	IC 1	0.0 - 0.3	2.4	8	2	0
	IC 2	0.5 - 2.4	11.4	6	16	14/14
	IC 3	3.7 - 7.5	0	0	0	0
	IC 4	6.4 - 7.5	6.6	6	18	0
	IC 5	7.5 - 8.2	2.1	3	0	0
Madison Creek	All	0.1 - 0.3	2.4	12	0	0
Madison SC	All	0.0 - 0.4	4.8	12	0	0
Sanders Creek	All	0.0 - 0.6	6.0	10	0	0
Hughes Creek	Lower	0.0 - 0.4	2.4	6	0	0
Griff Creek	Lower	0.0 - 0.4	4.0	10	0	0
SC 26	All	0.0 - 0.2	1.2	6	0	0
SC 27	All	0.0 - 0.2	1.2	6	0	0
Total			56.1	94	44	18/17 (94.5%)

Table 11. Description of 2013-2014 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, and number of redds counted.

Site	Reach	Length (km)		# Surveys	Redds	# fish/#floy
		Reach	Total survey			
Little River	LR 1	0.0 - 0.9	10.8	12	133	122/120
	LR 2	0.9 - 5.3	4.2	1	27	2/2
Indian Creek	IC 1	0.0 - 0.3	3.6	12	18	27/25
	IC 2	0.5 - 2.4	13.9	12	62	86/83
	IC 3	3.7 - 7.5	0	0	0	0
	IC 4	6.4 - 7.5	13.2	12	46	23/23
	IC 5	7.5 - 8.2	0.5	1	0	0
Madison Creek	All	0.1 - 0.4	2.4	8	9	18/17
Sanders Creek	All	0.0 - 0.6	4.8	8	0	0
Hughes Creek	Lower	0.0 - 0.9	6.3	7	1	2/0
Griff Creek	Lower	0.0 - 0.4	3.2	8	0	0
Total			62.9	81	296	280/270 (96.4%)

Table 12. Description of 2014-2015 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, and number of redds counted.

Site	Reach	Length (km)		# Surveys	Redds	# fish
		Reach	Total survey			
Little River	LR 1	0.0 - 0.9	4.5	5	6	2
	LR 2	0.9 - 5.3	0	0	0	0
Indian Creek	IC 1	0.0 - 1.5	4.5	3	1	0
	IC 2	1.5 - 3.4	5.8	2	6	11
	IC 3	4.3 - 7.5	6.4	2	2	0
	IC 4	6.4 - 7.5	5.5	5	15	56
	IC 5	7.5 - 8.2	2.1	3	6	2
Madison Creek	All	0.0 - 0.4	3.6	9	0	0
Sanders Creek	All	0.0 - 0.6	5.4	9	0	0
Hughes Creek	Lower	0.0 - 0.9	8.8	9	2	3
Griff Creek	Lower	0.0 - 0.4	3.6	9	1	0
Total			50.2	56	39	74

Table 13. Description of 2015-2016 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, and number of redds counted..

Site	Reach	Length (km)		# Surveys	Redds	# fish
		Reach	Total survey			
Little River	LR 1	0.0 - 0.9	3.6	4	0	0
	LR 2	0.9 - 5.3	4.4	1	0	0
Indian Creek	IC 1	0.0 - 1.5	6.0	4	0	0
	IC 2	1.5 - 3.4	5.7	3	0	0
	IC 3	4.3 - 7.5	0	0		
	IC 4	6.4 - 7.5	0	0		
	IC 5	7.5 - 8.2	2.8	4	1	1
Madison Creek	All	0.0 - 0.25	1.0	4	0	0
Sanders Creek	All	0.0 - 0.6	3.0	5	2	0
Hughes Creek	Lower	0.0 - 0.9	3.6	9	3	0
Griff Creek	Lower	0.0 - 0.4	1.6	4	0	0
Cat Creek	Lower	0.0-1.5	1.5	1	0	0
Mainstem	Mills	21.6-25.6	4.0	1	0	0
	Rica	25.6-28.0	2.4	1	0	0
	Geyser	28.0-31.6	3.6	1	0	0
Total			43.2	42	6	1

Table 14. Description of 2016-2017 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed. SC = sidechannel.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	6.0	4	21	2/0
Indian Creek	IC 1	0.0 - 1.5	4.5	3	38	55/1
	IC 4	6.4 - 7.5	3.6	4	44	106/44
	IC 5	7.5 - 8.2	0.7	1	0	0/0
Madison Creek	All	0.0 - 0.4	4.4	11	28	78/18
Sanders Creek	All	0.0 - 0.6	6.6	11	43	77/36
Hughes Creek	Lower	0.0 - 0.9	9.9	11	41	32/1
Griff Creek	Lower	0.0 - 0.4	4.4	11	37	81/27
Cat Creek	Lower	0.0 - 1.0	6.0	6	1	0/0
Boulder Creek	Lower	0.0 - 0.3	2.4	8	7	7/1
Brannon SC	All	0.0 - 1.6	1.6	1	6	1/1
Total			49.9	71	266	439/129 (29.5%)

Table 15. Description of 2017-2018 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	1.5	1	3	0/0
Indian Creek	IC 1	0.0 - 1.5	1.5	1	7	1/0
	IC 4	6.4 - 7.5	2.2	2	5	4/0
	IC 5	7.5 - 8.2	0.0	0	0	0/0
Madison Creek	All	0.0 - 0.4	2.4	6	37	31/6
Sanders Creek ⁷	All	0.0 - 0.6	1.8	3	0	6/0
Hughes Creek	Lower	0.0 - 0.9	5.4	6	42	13/1
Griff Creek	Lower	0.0 - 0.4	2.4	6	12	5/0
Cat Creek	Lower	0.0 - 1.0	3.0	3	0	0/0
Boulder Creek	Lower	0.0 - 0.3	1.2	4	0	0/0
Hurricane Creek	All	0.0 - 1.6	1.6	1	14	0/0
Total			23.0	33	120	60/7 (11.6%)

⁷ A major side-channel of the Elwha River avulsed into Sanders Creek during November of 2017.

Table 16. Description of 2018-2019 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	4.5	3	4	0/0
Indian Creek	IC 1	0.0 - 1.5	1.5	1	7	1/0
	IC 4	6.4 - 7.5	1.8	2	0	0/0
	IC 5	7.5 - 8.2	1.4	2	2	0/0
Madison Creek	All	0.0 - 0.4	2.0	5	1	1/0
Hughes Creek	Lower	0.0 - 0.9	4.5	5	25	8/2
Griff Creek	Lower	0.0 - 0.4	2.0	5	7	9/0
Cat Creek	Lower	0.0 - 1.0	2.0	2	0	0/0
Boulder Creek	Lower	0.0 - 0.3	0.6	2	0	0/0
Hurricane Creek	All	0.0 - 1.6	3.2	2	7	3/0
Total			23.5	29	53	22/0 (0.0%)

Table 17. Description of 2019-2020 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	1.5	1	0	0/0
Indian Creek	IC 1	0.0 - 1.5	4.5	3	25	6/0
	IC 4	6.4 - 7.5	1.8	2	0	0/0
	IC 5	7.5 - 8.2	1.4	2	2	0/0
Madison Creek	All	0.0 - 0.4	2.4	6	3	0/0
Hughes Creek	Lower	0.0 - 0.9	5.4	6	46	7/0
Griff Creek	Lower	0.0 - 0.4	2.4	6	26	2/0
Middle Mainstem	Spot			1	16	1/0
Cat Creek	Lower	0.0 - 1.0	4.0	4	5	0/0
Boulder Creek	Lower	0.0 - 0.3	1.2	4	37	3/0
Hurricane Creek	All	0.0 - 1.6	6.4	4	9	0/0
Mills Reservoir					17	13/0
Long Creek	Lower	0.0 – 0.5	0.5	1	0	0/0
Geyser Valley	All			1	3	0/0
Total			31.5	41	189	32/0 (0.0%)

Table 18. Description of 2020-2021 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	1.5	6	41	3/0
Indian Creek	IC 1	0.0 - 1.5	3.0	2	12	26/0
	IC 4	6.4 - 7.5	4.4	4	27	101/0
	IC 5	7.5 - 8.2	0.7	1	40	54/0
Madison Creek	All	0.0 - 0.4	1.6	4	31	54/0
Hughes Creek	Lower	0.0 - 0.9	3.6	4	78	25/0
Griff Creek	Lower	0.0 - 0.4	2.4	6	24	25/0
Griff Jr.	Lower	0.0 - 0.3	0.9	3	2	1/0
Middle Mainstem	Spot			1	2	1/0
Cat Creek	Lower	0.0 - 1.0	6.0	6	2	2/0
Boulder Creek	Lower	0.0 - 0.3	1.8	6	4	0/0
Hurricane Creek	All	0.0 - 1.6	9.6	6	27	4/0
SC Near Griff	All	0.0 - 0.3	0.3	7	0	7/0
SC Near Elwha CG	All	0.0 - 0.4	0.4	1	2	0/0
Long Creek	Lower	0.0 – 0.5	0.5	1	0	0/0
Geyser Valley	All			1	0	0/0
Total				51	277	270/0 (0.0%)

Table 19. Description of 2021-2022 survey locations including site, reach, river kilometer and cumulative length of stream surveyed, number of surveys conducted, number of redds counted, and number of floy tags observed. GW = Ground Water.

Site	Reach	Length (km)		# Surveys	Redds	# fish/floy
		Reach	Total survey			
Little River	LR 1	0.0 – 1.5	1.5	6	33	9/0
Indian Creek	IC 1	0.0 - 1.5	6.0	4	47	17/5
	IC 4	6.4 - 7.5	5.5	5	14	10/4
	IC 5	7.5 - 8.2	1.4	2	18	10/2
Aldwell GW Trib.	All	0.0 – 0.4	0.4	1	3	3/0
Madison Creek	All	0.0 - 0.4	2.4	6	31	104/0
Hughes Creek	Lower	0.0 - 0.9	5.4	5	87	55/0
Griff Creek	Lower	0.0 - 0.4	2.4	5	26	0/0
Griff Jr. Creek	Lower	0.0 - 0.5	2.5	5	21	67/0
Middle Mainstem	Spot			1	4	0/0
Cat Creek	Lower	0.0 - 1.0	4.0	4	1	0/0
Boulder Creek	Lower	0.0 - 0.3	1.5	5	2	0/0
Hurricane Creek	All	0.0 - 1.6	4.8	3	25	3/0
SC Near Griff	All	0.0 - 0.3	0.3	1	0	0/0
SC Near Elwha CG	All	0.0 - 0.4	0.4	1	3	0/0
Total			38.5	54	346	278/11 (3.9%)

Figure 1. Map of Elwha River basin depicting adult coho salmon release locations and tributary spawning ground survey reaches from 2011-2017.

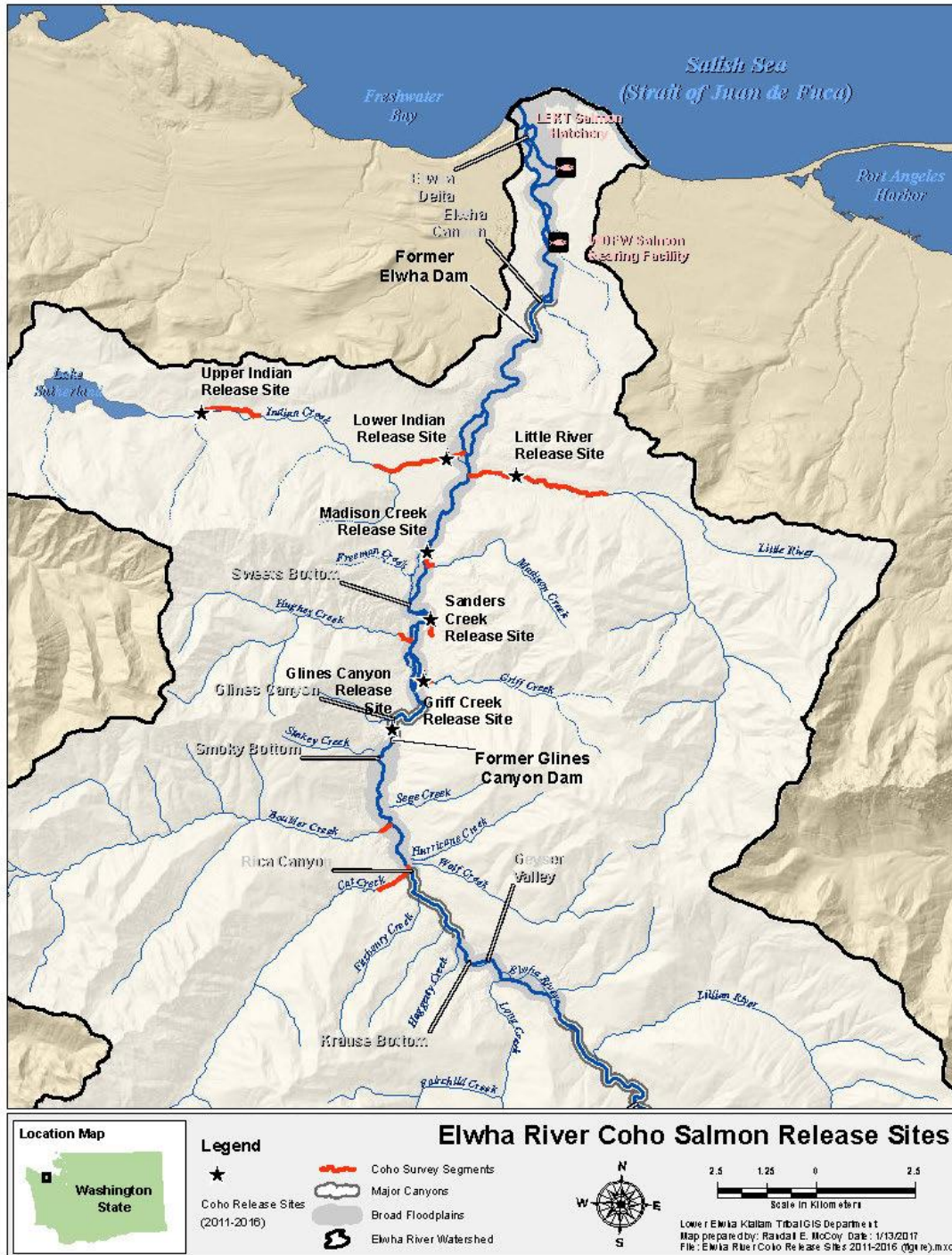


Figure 2. Histogram of adult coho length by sex for 2016 relocations.

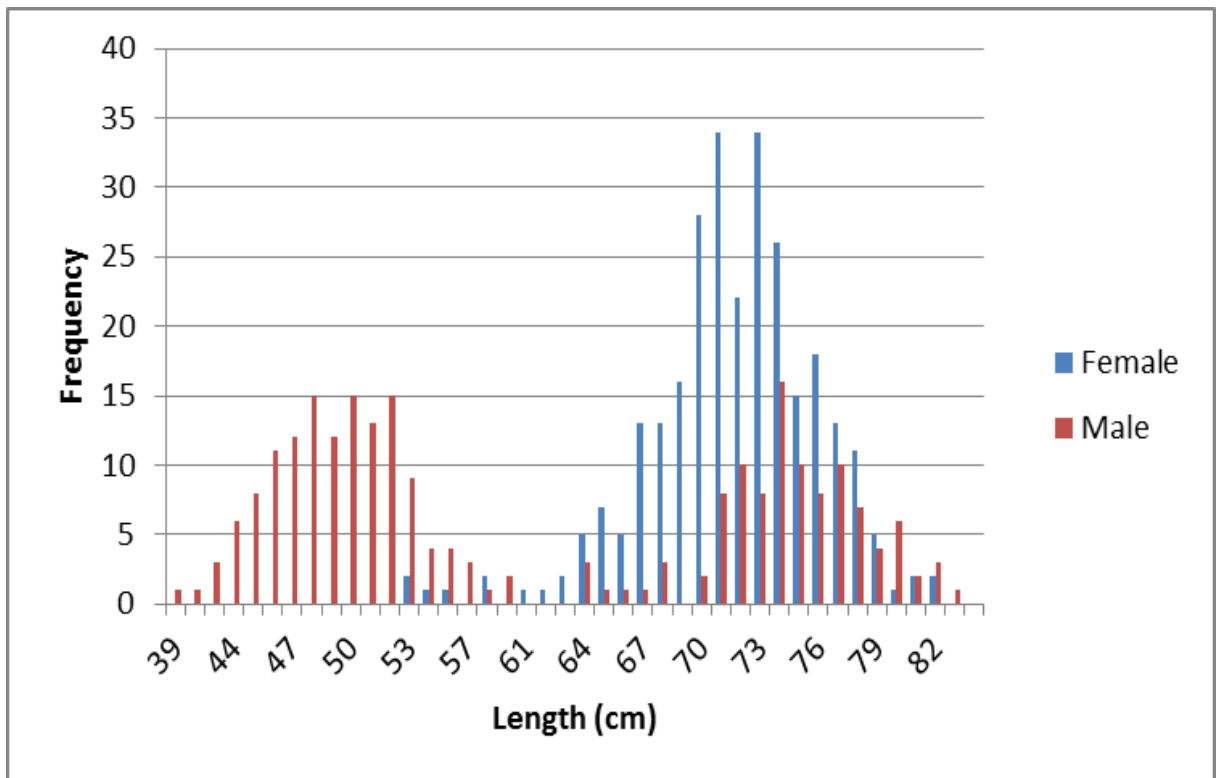
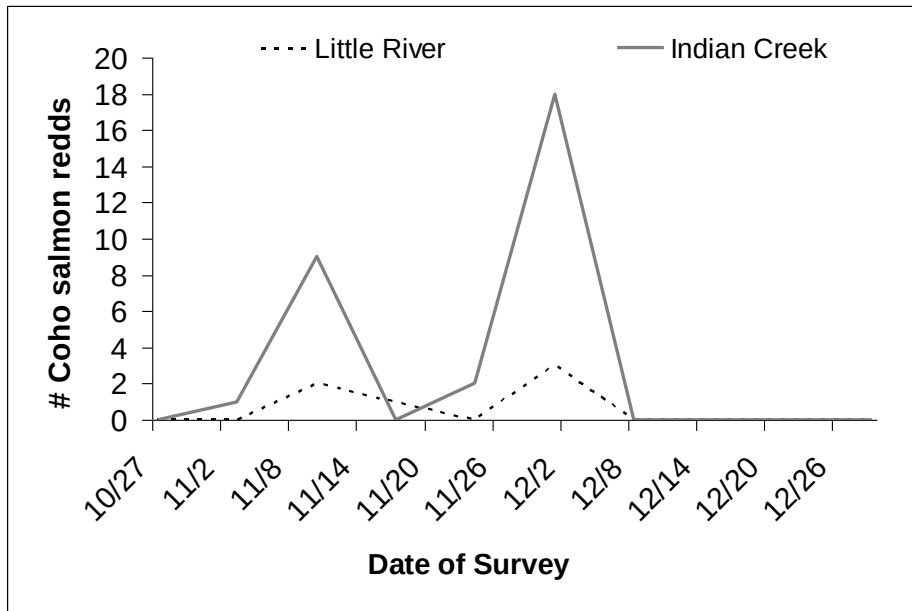


Figure 3. Coho relocation to upper Indian Creek, fall 2013 (top). Tagged coho recovering following release at Glines Powerhouse, fall 2017 (bottom).



Figure 4. Spawn timing of adult coho salmon as depicted by (a.) redds by survey week in Little River and Indian Creek for 2014 and (b.) cumulative distribution of redds by year for all sites for surveys from 2011-2014. Horizontal line in (b.) depicts point at which 50% of redds were counted.

a.



b.

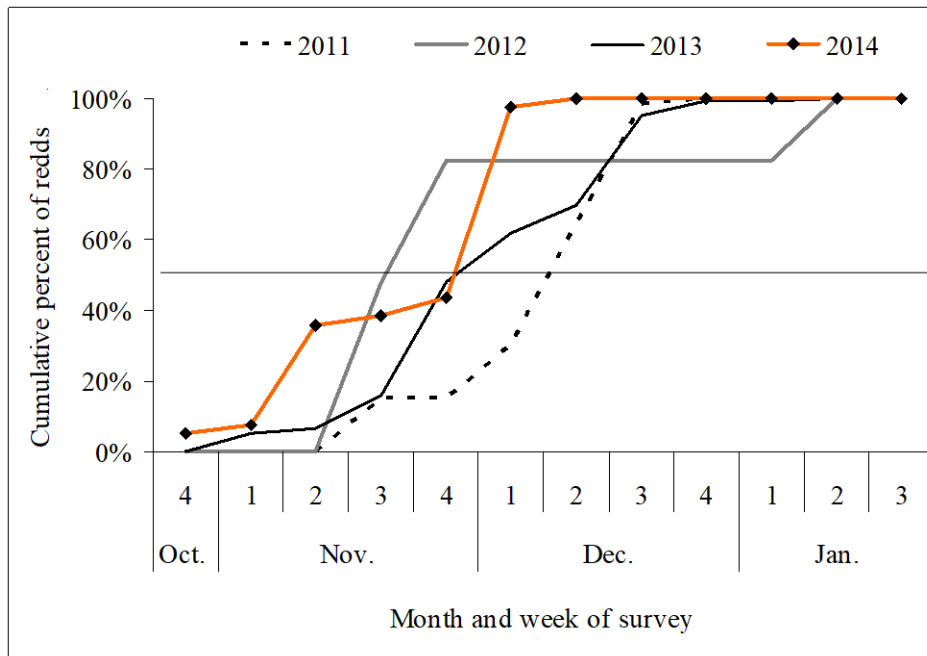


Figure 5. Relationship between number of relocated coho and total number of redds observed for the Elwha River, 2011-2021.

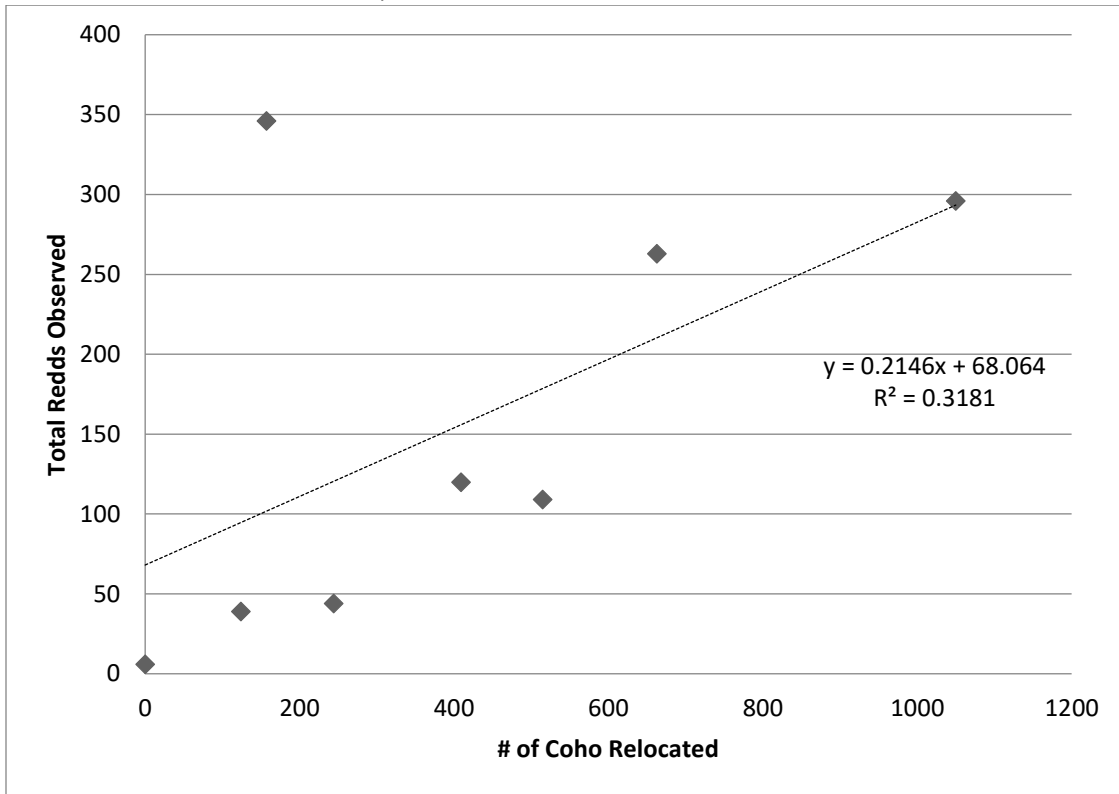


Figure 6. Number of coho salmon redds observed in Elwha River tributaries (2011-2022). Number of adults relocated is depicted by year.

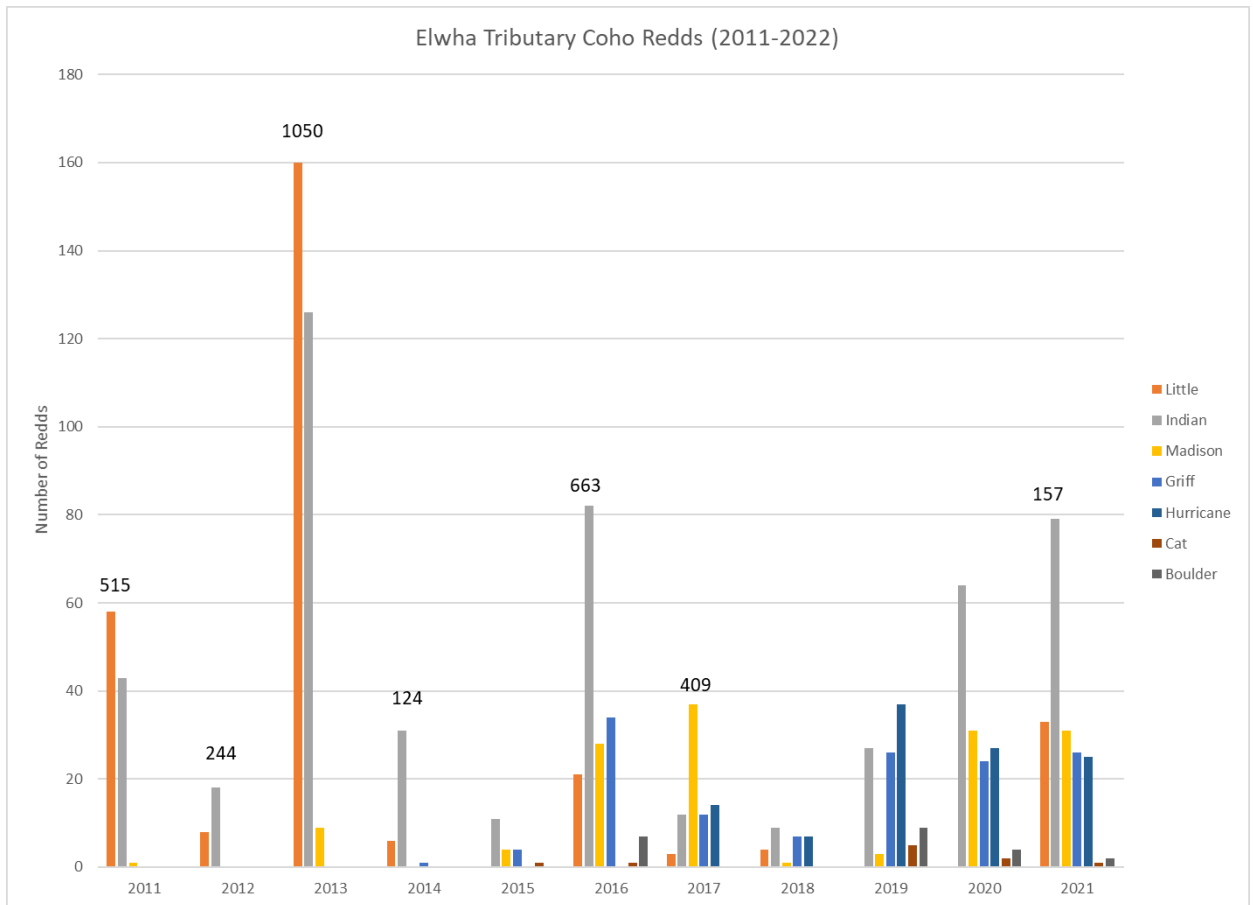


Figure 7. Ratio of tagged coho salmon observed on Elwha spawning ground surveys, 2011-2017. Number above bars is the total number of coho salmon relocated.

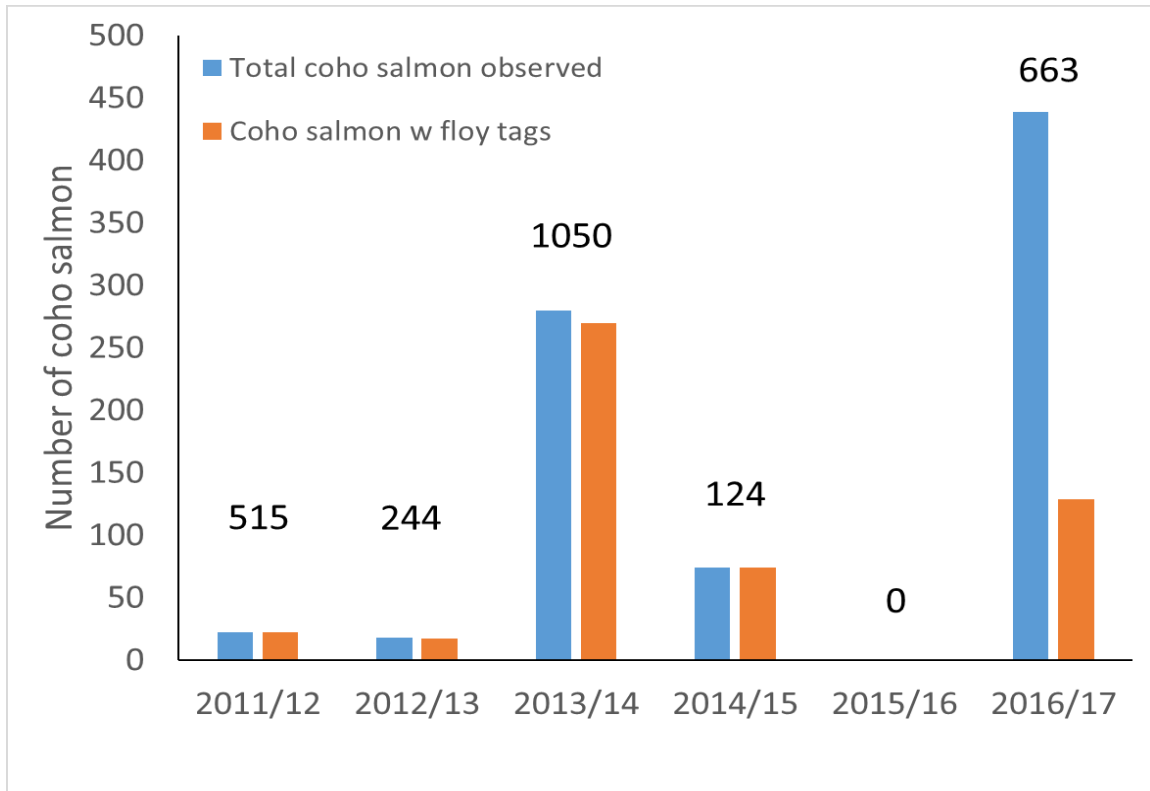
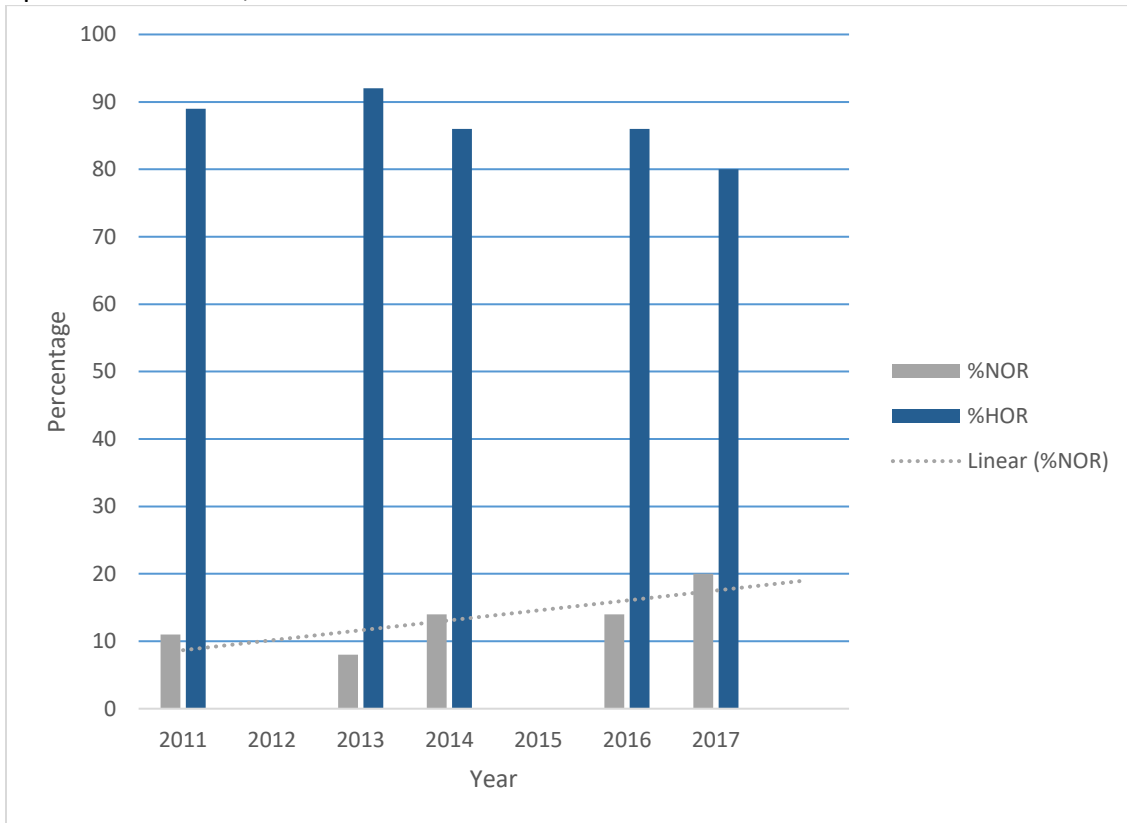


Figure 8. Proportion of natural/hatchery origin coho relocated from Elwha hatcheries to upstream habitats, 2011-2017.



Appendix 1. Hatchery coho smolt releases from Lower Elwha Klallam Tribal facility, 1979-2019.

1979	240,250	2018	365,519
1980	570,000	2019	334,160
1981	879,332	2020	351,781
1982	1,240,055	2021	418,638
1983	1,122,706		
1984	1,226,357		
1985	1,957,814		
1986	1,593,100		
1987	1,025,900		
1988	394,206		
1989	413,479		
1990	995,204		
1991	888,185		
1992	775,621		
1993	760,000		
1994	707,718		
1995	801,000		
1996	722,221		
1997	644,227		
1998	867,379		
1999	645,643		
2000	684,856		
2001	480,632		
2002	662,231		
2003	724,594		
2004	661,700		
2005	175,380		
2006	643,122		
2007	410,866		
2008	323,813		
2009	444,514		
2010	218,720		
2011	506,402		
2012	444,275		

2013	221,729		
2014	77,327		
2015	294,612		
2016	139,178		
2017	25,772		