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Age Structure and Hatchery Fraction of Elwha River Chinook Salmon: 2014 Carcass Survey Report

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Executive Summary

Monitoring the recolonization of Pacific salmon and steelhead following the removal of two dams is a critical component of the Elwha Restoration Project. During fall of 2014, we collected adult Chinook salmon (*Oncorhynchus tshawytscha*) carcasses from the Elwha River in order to evaluate the proportion of hatchery fish, the age distribution of returning adults and the ratio of fish that exhibited stream vs ocean type life history strategies. Surveys were conducted from the base of the former Glines Canyon Dam at river km 21.4 downstream to where the river enters into the Strait of Juan de Fuca, including three tributaries. Of the carcasses sampled from the river and its tributaries (N = 302), the majority (88 %) were located upstream of the former Elwha Dam site. We also sampled fish (N = 500) throughout the season at the WDFW hatchery in the lower Elwha River. Carcasses were sampled for physical measurements, hatchery marks, scales and genetics. We sampled 797 non-jack carcasses during the sampling season, representing 18.3 % of the estimated escapement above the Elwha SONAR site. Over 96 % of the fish sampled were marked hatchery fish. Age-4 was the dominant age class (57%), and age-2 fish (jacks) accounted for less than 1% of our total sample. All of the Chinook that migrated to the ocean as two year old juveniles were hatchery origin, and so we did not observe any stream-type life histories among unmarked fish.

Introduction

The Elwha River is the site of the largest dam removal project in Unites States history. The passage of the Elwha River Ecosystem and Fisheries Restoration Act in 1992 authorized the removal of two dams, Elwha Dam and Glines Canyon Dam, from the mainstem Elwha River. The removal of the dams will allow all five species of Pacific salmon plus steelhead trout to recolonize 112 km of habitat in the Olympic National Park that has been blocked since 1913 (Wunderlich et al. 1994). Removal will also facilitate the resumption of anadromous life history strategies in resident cutthroat trout and bull trout populations. The long term goal of the removal project is the recovery of naturally producing self-sustaining runs and reducing reliance on hatchery production (Ward et al. 2008). Dam deconstruction began in September of 2011; demolition of Elwha Dam was completed in March of 2012 and Glines Canyon Dam in late August of 2014.

Compared to the Chinook salmon native population that historically inhabited the Elwha River prior to dam construction, the current population exhibits truncated life history diversity, notably the absence of the early-timed adult returns (Ruckelhaus et al. 2006). In recent decades, Elwha Chinook salmon have largely been supported by hatchery production in the limited habitat below the Elwha Dam. In an effort to preserve the genetic integrity of the Elwha Chinook stock, fishery managers intentionally limited the release of out of basin hatchery fish over the years (Brannon and Hershberger 1984; WDFW and WWTIT 1994). Contemporary genetic analyses confirm that the Elwha stock is unique with respect to Puget Sound and groups much more closely to Chinook salmon from the neighboring Dungeness River than other watersheds in the region (Ruckelshaus 2006).

Guidelines for monitoring the recovery of ESA-listed Chinook salmon and steelhead were laid out in the Elwha Monitoring and Adaptive Management (EMAM) plan for listed species of Chinook salmon and steelhead (Peters et al. 2014). A series of four recovery stages were described including: 1) Preservation, 2) Recolonization, 3) Local Adaptation and 4) Viable Natural Population. Progression through the phases is measured using the Viable Salmon Population (VSP) metrics abundance, productivity, spatial distribution and diversity (McElhany et al. 2000).

Several of these VSP metrics rely on data describing the hatchery mark rates, age structure, and juvenile life-histories of fish returning to the Elwha River watershed. In order to estimate the abundance of natural-origin salmon, one must subtract the proportion of the total return that was produced in hatcheries. Age structure data are required for the cohort analysis needed to evaluate spawner to spawner productivity and smolt-to-adult return rates.

For Chinook salmon, a key diversity metric is the proportion of naturally spawned salmon that adopt stream-type vs. ocean-type life histories. Stream type Chinook have a longer freshwater residency time than ocean-type Chinook salmon, spending an entire year in freshwater prior to seaward migration. Ocean-type Chinook migrate within their first year of life, either as small fry soon after emergence or as larger parr that have spent 1-6 months rearing and growing in freshwater. Within Puget Sound, dam construction has selectively restricted access to the majority of snow melt dominated headwater streams that are typically associated with the stream type life history (Beechie et al. 2006). Currently, the vast majority of natural-origin Elwha Chinook utilize the ocean type life history strategy (McHenry 2015a). It is hypothesized that access to the upper watershed might allow for the stream type life history trait to reemerge (McHenry et al. 2015b).

In response to this need for biological information, we conducted Chinook salmon carcass surveys in the fall of 2014. The primary hatchery marking strategy for Elwha River Chinook salmon are thermal otolith marks induced during hatchery rearing, and so samples must be collected from carcasses. Age structure and juvenile life history data are commonly derived from scales also collected during carcass surveys. Our primary objectives were to:

1) Measure the proportion of hatchery to natural origin Chinook salmon returning to the Elwha River

2) Describe the age structure of hatchery and natural-origin Chinook salmon returning to the Elwha River

3) Assess the relative frequency of stream-type vs. ocean-type juvenile life histories of naturally produced Chinook salmon returning to the Elwha River

We conducted carcass surveys throughout the Elwha River and tributaries downstream of the former Glines Canyon Dam, allowing us to evaluate two spatially explicit hypotheses. First, we predicted that the proportion of hatchery marked fish would decrease with the distance upstream from the WDFW hatchery located at river km 5.6. Second, we predicted that adults adopting stream-type juvenile life histories would tend to be found at more upstream locations nearer cold-water, snowmelt dominated headwaters. We intend these hypotheses as long term guides for our monitoring efforts and expect that the data needed to evaluate them will accumulate in future years. This is particularly true for evaluating the rate of stream type life histories, which may depend on colonizing habitats upstream of the former Glines Canyon Dam site.

This report summarizes the results from the carcass recovery project for the 2014 spawning season.

Methods

Sample collection

We surveyed the mainstem Elwha and tributaries from the former Glines Dam Powerhouse site at river km 21.4 to the confluence of the river with the Strait of Juan de Fuca. Surveys were conducted by foot and inflatable raft. The Elwha River was broken up into 6 sections (Table 1, Figure 1). Each reach was scheduled to be surveyed every 7 to 10 days. Based on redd survey numbers from previous spawning seasons, we felt this sampling structure would allow us to sample most of the available carcasses in each reach throughout the season.

Table 1. Description of Sampling Reaches for the Elwha Chinook Carcass Recovery from August 26 to October 31, 2014.

Reach	Description	River Km		Survey Crew
		Start	End	
1	Former Elwha Dam Site to mouth of River	7.9	0.2	WDFW
2	Gooseneck to former Elwha Dam Site	10.1	7.9	WDFW
3	Highway 101 Bridge to the Gooseneck	12.4	10.1	WDFW
4	Fishermans Corner to Highway 101 Bridge	20.1	12.4	WDFW
5	Altaire Bridge to Fishermans Corner including Hughes Creek	20.1	17.2	ONP, WDFW
6	Glines Dam powerhouse site to Rabbit Hole	21.4	18.2	ONP, WDFW
Tributary	Indian Creek	1.6	0	LEKT
Tributary	Little Creek	1.6	0	LEKT

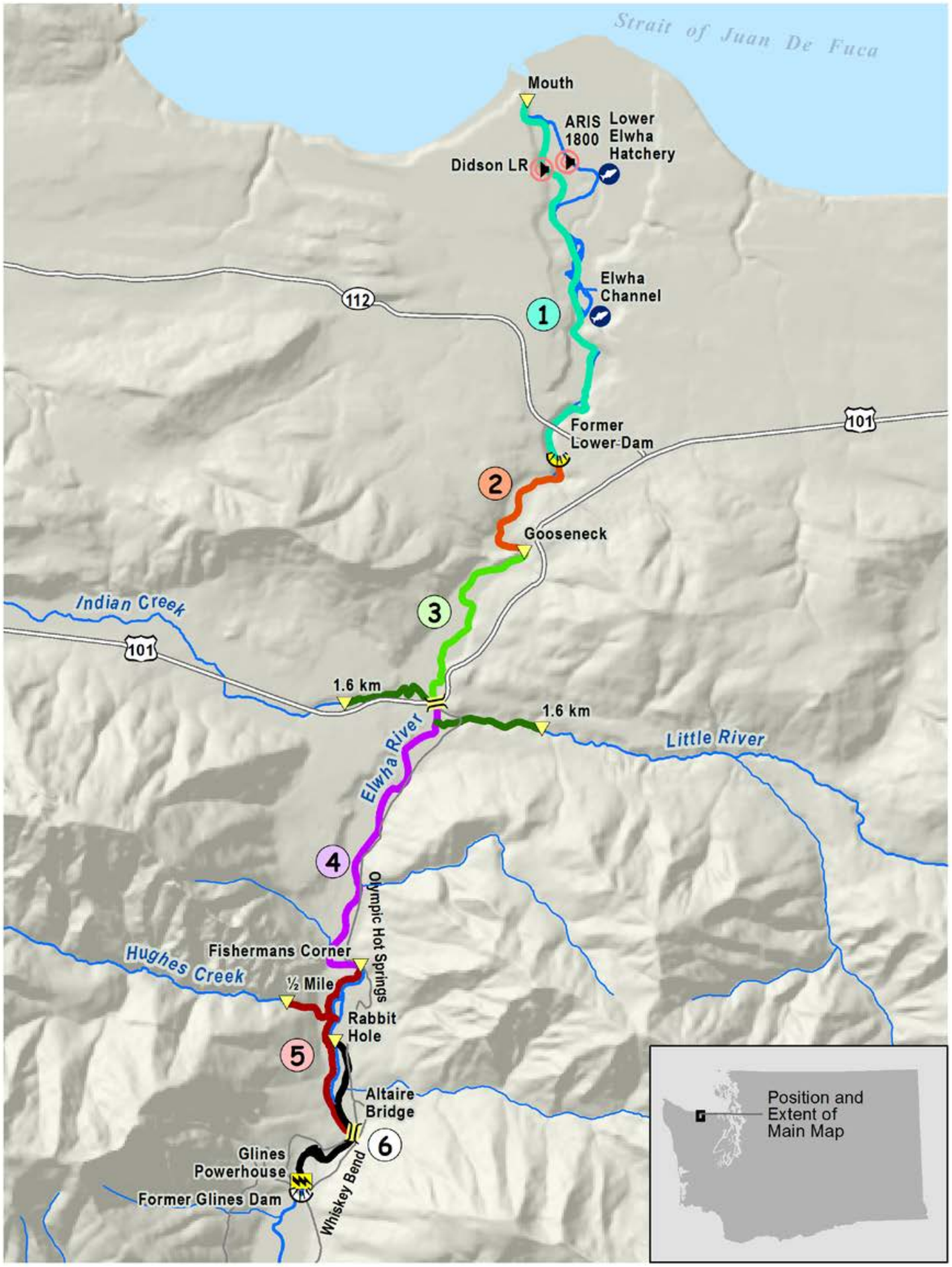

Figure 1. Map of Elwha River with carcass surveys sections for 2014 sampling season.

Chinook salmon carcasses were sampled weekly at the WDFW Elwha Rearing Channel (hereafter WDFW Hatchery) throughout the spawning season. Chinook salmon broodstock spawned at the WDFW hatchery originated from a variety of sources. The primary collection method was by gill net from the Elwha River. Chinook salmon broodstock also included volunteers to the WDFW hatchery trap and volunteers to the LEKT hatchery trap that were subsequently transported to the WDFW adult holding pond. WDFW used PIT tags, inserted upon capture and transfer to the adult holding pond, to identify the original collection method of Chinook salmon spawned at the hatchery. Some broodstock were collected from the river and spawned on site rather than at the hatchery but these were not sampled in our study.

At all locations, carcasses were sampled for fork length, postoribital-hypural (POH) length (length from the posterior margin of the eye orbit to the end of the hypural plate), sex, presence of CWT tag, presence of any adipose marks, otoliths, DNA fin clip and scales. If a CWT was detected, the head was removed and taken to the lower Elwha hatchery freezer for processing after the season. DNA was collected from carcasses that showed more than 50% red coloration in the gills in order to maximize sample quality. DNA samples are currently archived at the WDFW Molecular Genetics Laboratory in Olympia WA but were not analyzed in this study. At the WDFW Rearing Channel, fish were also scanned for a PIT tag to determine their original capture location.

Daily stream discharge and turbidity data were downloaded from the U.S Geological Survey (USGS) Water Data website. Discharge data were reported as cubic feet per second (CFS) and collected at the McDonald Bridge station (site = 12045500). Turbidity was reported in formazin nephelometric units (FNU) from the water diversion immediately upstream from the WDFW Rearing Channel (site = 12046260).

Average daily discharge ranged between 223 and 4550 CFS during the sampling season (Figure 2). Average flow did not exceed 1,000 cfs until October 14 and did not fall below 1,890 cfs after October 20. Turbidity ranged between 4.4 and 1470 FNU and stream visibility was greatly reduced following the increase in flow on September 24, when the river rose from 326 CFS to 999 CFS.

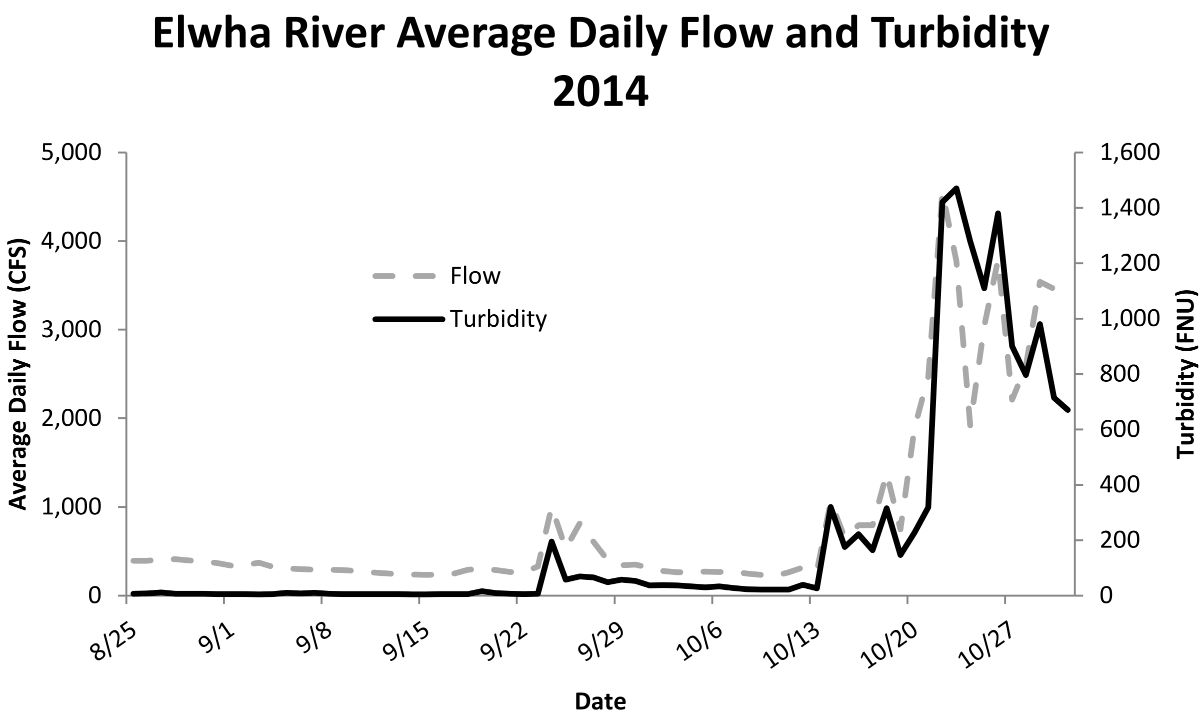

Figure 2. Average daily discharge (CFS) and turbidity (FNU) for the Elwha River, August 25 – October 31, 2014.

Evaluating hatchery mark rates

The primary hatchery marking strategy for brood years of Elwha Chinook salmon expected to return in 2014 was a thermal otolith mark (Table 2). Avoidance of the adipose clip was intended to reduce vulnerability to mark selective fisheries. Most hatchery Chinook salmon are released into the Elwha River as subyearlings, but there is also a smaller yearling release group (Table 2). The yearling, but not subyearling release, receives a CWT mark in addition to the thermal otolith mark.

In some years, equipment malfunctions limited the capacity to induce thermal otolith marks. Thermal otolith marks require sequentially altering water temperature during embryonic development in a prescribed protocol over the course of approximately 1-3 weeks, and specialized chillers are required to accomplish this task. Any hatchery juveniles that were not otolith marked due to chiller malfunctions were selectively placed into the yearling program receiving the CWT mark (Table 2, brood year 2012). For brood year 2010, although all hatchery chinook salmon were otolith marked, chiller malfunctions limited the number of cold water incubations for some fish, resulting in a mark that was less distinctive than desired.

Table 2. Releases of hatchery Chinook in the Elwha River Basin, brood years 2009-2012.

Brood Year	Type	Thermal Otolith	Thermal Otolith + CWT	CWT	AD + CWT + Thermal Otolith	Total
2009	Subyearling	3,039,730	0	0	0	3,039,730
	Yearling	0	200,824	0	0	200,824
2010	Subyearling	1,236,562	0	0	0	1,236,562
	Yearling	0	212,900	0	0	212,900
2011	Subyearling	1,524,769	0	0	0	1,524,769
	Yearling	0	196,575	0	0	196,575
2012	Subyearling	907,387	0	0	251,892	1,159,279
	Yearling	0	0	201,074	0	201,074

Results

Carcass Recoveries

We sampled a total of 802 carcasses throughout the sampling season (Table 3). A total of 302 samples (37.7%) originated from the Elwha River and tributaries. Nearly a third of all carcasses were sampled above the former Elwha dam site. The highest number of samples collected in one week occurred during week of Sept 15-19 (Table 4). The number of carcasses found dropped significantly after the high water on September 24. Length and sex data were recorded for each carcass except for one from Reach 1. Otolith samples were taken from 783 (97.6%) carcasses, scale samples from 779 (97.1%) and DNA fin clips from 556 (69.3%). No carcasses were recovered from Little River in 2014.

Table 3. Total number of Chinook carcasses sampled by survey reach in the Elwha River Watershed 2014.

Reach	Number of Carcasses Sampled	Percent of Total
Reach 1 - Elwha Dam Site to river mouth	36	4.50%
Reach 2 - Gooseneck to former Elwha Dam Site	41	5.10%
Reach 3 - Highway 101 Bridge to Gooseneck	27	3.40%
Reach 4 - Fishermans Corner to Highway 101 Bridge	54	6.70%
Reach 5 - Altaire Bridge to Fishermans Corner plus Hughes (left channel)	40	5.00%
Reach 6 - Glines Powerhouse to Rabbit Hole (right channel)	85	10.60%
Indian Creek	19	2.40%
Little River	0	0.00%
WDFW Hatchery	500	62.30%
Total	**802**	**100%**

Table 4. Number of Chinook carcasses sampled by week for individual reaches during the 2014 season. Zero indicates a survey was completed but no carcasses were sampled. A dash indicates no survey was conducted that week. No surveys were conducted during the week October 27-31 due to lack of visibility.

Week	Reach						Indian Creek	Little River	Hatchery
	1	2	3	4	5	6			
Aug 25-29	0	-	-	-	-	26	-	-	9
Sept 1-5	0	0	0	-	2	-	-	-	34
Sept 8-12	7	-	-	15	6	15	19	-	92
Sept 15-19	0	25	17	-	25	36	-	-	110
Sept 22-26	-	11	8	30	-	-	-	-	105
Sept 29 - Oct 3	13	5	-	6	5	7	-	-	80
Oct 6-10	16	0	2	3	2	1	-	-	70
Oct 13-17	0	0	0	-	0	-	-	-	-
Oct 20-24	-	-	0	0	-	-	-	-	-
Totals	36	41	27	54	40	85	19	0	500

Adult Collection Method Data

Over three quarters (76%) of the samples we collected from the river were recovered during the month of September. Most of the fish sampled at Elwha hatchery were net-collected fish rather than volunteers to either the WDFW or LEKT Hatchery (Table 5). We sampled close to a third of all the net and LEKT fish that came to the hatchery in 2014 and just over 50% of all volunteers to the WDFW Hatchery (Table 6). Chinook salmon gaffed for hatchery broodstock were not sampled this season.

Table 5. Adult collection method summary for Elwha Chinook salmon carcass sampling 2014.

Sample Location	**Collection Method**	**Number of Carcasses Sampled**	**Percent of Total Carcasses Sampled**
Mainstem and Tributaries	Natural Spawners	302	37.7%
	Gaffed	0	0.0%
WDFW Hatchery	Gill Net (N)	305	38.0%
	Lower Elwha Klallam (LEKT)	104	13.0%
	Volunteers (V)	91	11.3%

Table 6. Elwha Chinook salmon broodstock collection summary. Numbers include non-viable females and pond mortalities.

Broodstock collection method	Total Collected	Percent sampled
Gill net	991	30.8%
LEKT Hatchery volunteers	318	32.7%
WDFW Hatchery volunteers	174	52.3%
Gaffed	367	0 %
Total, all sources	1,859	27.0%

Hatchery mark rates

We collected 783 otolith samples over the course of the season. Seven hundred and fourteen (91.2%) of the samples had an otolith mark present. Of the remaining 69 samples, 32 had no otolith mark but did have a CWT present and one fish was ad marked but did not carry an otolith mark or CWT. Thus, 36 fish (4.6%) had no internal (Otolith or CWT) or external hatchery marks (Table 7). Overall, the hatchery mark rate was > 95% and we observed relatively little differences in the mark rates of the different survey reaches and hatchery broodstock sources (Table 7). Only a single reach, reach 3, had a mark rate < 90% (Table 7).

Table 7. Hatchery mark rates of Chinook salmon sampled from the Elwha River 2014 based on thermal otolith, adipose and CWT marks.

	Location	Otolith Mark		All Hatchery Marks	
		N	Percent Marked	N	Percent Marked
Hatchery	Net	304	90.50%	304	97.40%
	LEKT	104	81.70%	104	92.30%
	Volunteer	91	91.20%	91	97.80%
Carcass Survey	Reach 1	20	95.00%	20	100.00%
	Reach 2	41	92.70%	41	92.70%
	Reach 3	27	88.90%	27	88.90%
	Reach 4	54	98.10%	54	98.10%
	Reach 5	40	92.50%	40	92.50%
	Reach 6	85	98.80%	85	98.80%
	Indian Creek	17	94.10%	17	94.10%
	Total	783	91.20%	783	96.20%

CWT Data

We collected CWTs from 62 fish in the Elwha River watershed during fall 2014. All but two of the CWT samples were collected at the WDFW Hatchery. The two snouts from the river were recovered between the former Elwha Dam site and the river mouth. The majority of the CWTs originated from releases into the Elwha River, but some were derived from releases into the neighboring Morse Creek (N = 3) or Dungeness (N= 2) watersheds (Table 8). All of the Elwha released CWTs were from the yearling program (Table 8), as was expected based on the recent CWT marking strategy (Table 2).

Table 8. Chinook Coded Wire Tag (CWT) data for snouts recovered during spawn year 2014.

	Sampling Location	# of Snouts	Brood Year	Release Location
River	Elwha Dam to Mouth	1	2009	Elwha River
		1	2010	Elwha River
Hatchery	Net	11	2009	Elwha River
		17	2010	Elwha River
		1	2010	Morse Creek
		1	2011	Elwha River
		1	2011	Morse Creek
		1	2011	Gray Wolf River
		1	2012	Elwha River
	LEKT	8	2009	Elwha River
		7	2010	Elwha River
		1	2010	Morse Creek
		1	2010	Hurd Creek
		2	2012	Elwha River
	Volunteer	6	2010	Elwha River
		1	2011	Elwha River
		1	2012	Elwha River
	Total	62		

Scale Data

Of the 779 scale samples collected, 738 (94.7%) were successfully aged in the laboratory. Age 4 was the dominate age class in each sampling reach and all collection sources at the hatchery, as over 50% of the entire collection was composed of age-4 Chinook salmon (Table 9). In some reaches, the number of age-3 samples outnumbered age-5, whereas in other reaches, age-5 fish were in greater abundance (Table 4). The highest percentage of age-5 Chinook salmon were collected from the two reaches immediately surrounding the former Elwha Dam site, reaches 5 and 6 (Table 9). We did not find any age 2 Chinook carcasses in the mainstem or tributary surveys, but a small percent (<5%) were collected at the hatchery. Forty-three fish (5.5%) were identified as fish that migrated to the ocean as age 2 (Stream type Chinook, Table 10). All of these stream-type Chinook were hatchery origin. No scale samples were collected from Indian Creek or Little River.

Scale samples from six of the 36 unmarked fish displayed signs of accelerated growth indicative of hatchery rearing. Experienced scale readers from the WDFW lab are certain that these fish, which were all age-4 yearlings, are hatchery origin. These fish (0.77 % of the N = 783 fish evaluated for hatchery marks) either originated from out of basin or a portion of the fish released from brood year 2010 did not receive otolith and or CWT. Prior to release, N = 500 yearlings from BY 2010 were checked for CWT and all were CWT positive. Note that BY 2010 included a portion of fish whose otolith mark was not as distinctive as desired due to chiller malfunctions (see Methods).

Table 9. Chinook carcass age data from scale samples by reach for the Elwha River 2014.

Sample Location	Collection Method	Number of Samples	Total age			
			2	3	4	5
WDFW Hatchery	Net	293	0.30%	20.10%	58.40%	21.20%
	LEKT	95	2.10%	28.40%	54.70%	14.70%
	Volunteer	82	2.40%	35.40%	56.10%	6.10%
Reach 1	Carcass Sample	34	0.00%	8.80%	55.90%	35.30%
Reach 2		40	0.00%	17.50%	50.00%	32.50%
Reach 3		26	0.00%	30.80%	57.70%	11.50%
Reach 4		50	0.00%	24.00%	58.00%	18.00%
Reach 5		39	0.00%	20.50%	69.20%	10.30%
Reach 6		79	0.00%	21.50%	51.90%	26.60%
Indian Creek		0	-	-	-	-
Little Creek		0	-	-	-	-
All Samples		738	0.70%	23.00%	56.90%	19.40%

Table 10. Age at return of hatchery and unmarked subyearling and yearling releases.

Origin	Age at Outmigation	N	Total Age			
			2	3	4	5
Unmarked[1]	Subyearling	27	0	4	22	1
Unmarked[1]	Yearling	0	NA	NA	NA	NA
WDFW Hatchery	Subyearling	668	5	165	378	120
WDFW Hatchery	Yearling	43	0	1	20	22

[1] Excludes N = 6 unmarked fish with scales showing accelerated growth indicative of hatchery rearing.

Length

Postoribital-hypural lengths were taken for all but one carcass from a fish found in Reach 1. We were able to sample 754 carcasses for fork length (94%). All other carcasses we encountered were either too decomposed or torn up from predators to make an accurate measurement. Of the carcasses collected from natural spawners in the river and its tributaries, the average POH length of both males and females was larger below the former Elwha Dam site than above it (Table 11), a difference that was statistically significant based on a *t*-test ($p = 0.029$). At the hatchery, fish netted from the river were larger than either LEKT or volunteer fish, differences that were statistically significant (*t*-test, $p < 0.001$).

Table 11. Chinook average length data by reach for the Elwha River 2014.

		Total Fish Sampled		**POH**	
	Sample Location	**Male**	**Female**	**Male**	**Female**
Below Elwha Dam Site	Hatchery NET	168	137	65.1	71.2
	Hatchery LEKT	56	48	61.4	67.9
	Hatchery Volunteer	50	41	60.2	67.4
	Reach 1	11	24	68.0	70.8
Above Elwha Dam Site	Reach 2	16	25	64.3	71.6
	Reach 3	15	12	66.7	67.6
	Reach 4	25	29	60.8	69.4
	Reach 5	26	14	64.7	70.1
	Reach 6	54	31	66.6	67.4
	Indian Creek	13	6	67.0	74.2
	Above Average	**-**	**-**	65.1	69.5

Sonar Adult Abundance Estimate

Escapement of non-jack Chinook was estimated to be 4,360 fish above the SONAR sites. Fifty percent of the Chinook run had passed the SONAR sites by July 20th. By combining the carcass samples with the SONAR data, we estimate that less than 160 of the returning non-jack adults were natural origin (Table 12). The 2014 return was dominated by age-4 hatchery-origin Chinook salmon that were released in 2011 as subyearlings (Table 12)

Table 12. Estimated age composition of returning adults to the Elwha River 2014, based on age data from scales and SONAR abundance estimates (Denton et al. 2015).

Origin	Juvenile life-history	Age			
		2	3	4	5
Natural	Sub Yearling	NA	24	131	6
	Yearling	NA	0	0	0
Hatchery	Sub Yearling	NA	981	2,248	714
	Yearling	NA	6	119	131

DNA Collection

We collected DNA fin clips from 556 fish this season. These samples are stored for future analysis at the WDFW Molecular Genetics Laboratory.

Discussion

The fall of 2014 was the third spawning season since 1913 that Chinook salmon were able to access the watershed between Glines Dam and the former Elwha Dam (21.7 km to mouth). Biological samples collected from Chinook salmon carcass collections are an important component of monitoring recolonization, permitting an assessment of hatchery fraction, age structure and life history diversity. In previous years (2010 – 2013), most carcass samples were collected from gaffed hatchery broodstock or from carcasses drifting downstream onto the Elwha weir (Anderson et al. 2015). In 2014, we significantly expanded our effort to collect carcasses from naturally spawning fish directly from the spawning grounds, due in part to the termination of the Elwha weir project. This included daily surveys in different sections of the river from the end of August to the end of October.

Sampling conditions during 2014 were very good for the first 29 days of the season. River flows stayed below 415 CFS and turbidity remained low, less than 16 FNU, allowing for good visibility in deep pools most days. On September 24, we experienced a high flow event that increased flows to nearly 1,000 CFS and turbidity to nearly 200 FNU. This change in flow and turbidity significantly limited our ability to locate and sample carcasses. We found that turbidity levels above 6 FNU limited our surveyors' ability to recover carcasses in water deeper than 30 cm. Flows for the remainder of the season never dropped below 1,310 CFS. Turbidity also remained high throughout the rest of the season, never dropping below 21 FNU.

Despite these tough late season sampling conditions, we recovered 302 carcasses between Glines Canyon Dam and the mouth of the river. At the WDFW Hatchery, we successfully sampled 491 (52%) of the 944 spawned fish, with an additional 9 samples from holding pond mortalities. Our total sample of 797 non-jack Chinook, represented 18.3% of the fish that were estimated to have passed the sonar site on the lower river (Denton et al. 2014).

For fish that spawned naturally, we collected carcasses from each target reach except Little River. The absence of carcass samples found in Little River was almost certainly related to the lack of spawning in the tributary. During 2014, newly formed gravel bars at the mouth of Little River limited access to the tributary during the low water conditions that persisted for most of September (McHenry et al. 2015b). Only one redd was observed in Little River during 2014 (McHenry et al. 2015b). The majority of Chinook are believed to have spawned before flows increased in late September.

We found that 3.8% of the adult Chinook salmon sampled from the Elwha River in 2014 were unmarked. This is consistent with results from 2010 – 2013, where the rate of unmarked fish ranged from 3-9%, (Anderson et al. 2015). Returns of Chinook salmon to the Elwha River continue to be dominated by hatchery fish. Currently in the initial Preservation phase of the Elwha Monitoring and Adaptive Management Guidelines, there are no specific objectives for the percent of natural origin spawners (pNOS) to trigger movement to the subsequent Recolonization phase (Peters et al. 2014). The management goal of the Preservation phase is to protect the species from extinction during the period when high sediment load is expected, at times, to be lethal to fish. Transition to the recolonization phase will largely be triggered by abundance and productivity targets, as the spatial distribution trigger ("portion of population accessing above Elwha Dam") has already been met (McHenry et al. 2015b) and there are no diversity triggers (Peters et al. 2014).

Among the N = 27 natural origin fish with readable scale patterns, we did not observe a single stream-type individual (Table 9). This result was perhaps not unexpected given the very low number of natural origin samples and the short time span since removal of Elwha Dam, but nonetheless noteworthy. Chinook salmon age-1+ juvenile outmigrants were observed in the Elwha River, Little River, and Indian Creek during 2014 (McHenry et al. 2015a). Future carcass sampling will determine if recolonization is associated with an increasing proportion of stream-type life histories among returning adults.

We found no support for our two hypotheses regarding the spatial distribution of hatchery mark rates and stream-type life histories. Hatchery mark rates did not decrease in an upstream direction from the WDFW Hatchery. Indeed, some of the highest hatchery mark rates were observed in the reach immediately downstream of Glines Canyon Dam (98.8%) and upstream of the Highway 101 Bridge to Fisherman's corner (98.1%). We did not observe any stream-type life histories among natural origin fish, and thus could not evaluate their spatial distribution. We plan to continue to assess these hypotheses via carcass recovery in future years.

The percentage of age-2 males (jacks) was very low in 2014, less than 1% of our total sample. All of the jacks we sampled were of hatchery origin and migrated as yearlings (Ocean-type Chinook) to the ocean. The percentage of jacks has consistently declined in each of the last five years (Table 13). Given that 2012 was the first year Chinook salmon had access to spawning habitat upstream of the Elwha Dam site, the absence of any natural-origin age-2 jacks indicates that we have not yet observed mature progeny of fish that spawned in newly accessible habitat following dam removal. The number of returning age-2 fish can be an indicator of survival for a given brood, and used to forecast adult returns in future years. If this is the case, the decline in proportion of age-2 jacks (Table 13) may suggest poor recruitment of Elwha Chinook salmon (both hatchery- and natural-origin) in recent cohorts.

Table 13. Age composition from scale samples from Elwha Chinook. 2010-2013: Elwha weir, 2014: carcass + hatchery.

Sampling Year	Number Samples	Age			
		2	3	4	5
2010	401	14.96%	27.68%	17.71%	39.65%
2011	407	11.30%	55.53%	32.92%	0.25%
2012	157	5.10%	63.69%	28.66%	2.55%
2013	413	2.18%	23.24%	71.67%	2.91%
2014	738	0.68%	23.04%	56.91%	19.38%

Age 4 fish were the dominant age class in 2014, representing more than 50% of all carcasses sampled. Nearly 85% of all the unmarked fish were age-4 compared to 57% hatchery subyearlings and 38% of hatchery yearlings (Table 9). Interestingly, we observed greater age class diversity in hatchery fish than natural origin fish, though this result may be due to sampling variance and the much lower number of natural-origin fish (Table 9).

We compared the body size of fish sampled above vs. below the former Elwha Dam site in order to evaluate whether fish passage for Chinook salmon was restricted to larger bodied fish. Larger fish have the capacity for greater swimming speeds, especially burst velocities, than smaller fish (Webb 1995). The results from our samples show that the average size of Chinook above the dam were actually smaller than below the dam by 3 cm for males and 1 cm for females. In addition, the smallest Chinook we sampled all season (fork length 43.5) was found in Reach 4 (Fisherman's to Highway 101), above the dam. It appears smaller Chinook were able to negotiate the former Elwha Dam site and access the upper watershed during the 2014 season.

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