



U.S. Fish and Wildlife Service

Proportion of Hatchery Origin Winter Steelhead and Broodstock Collection in the Elwha River: 2019

Report To: The Lower Elwha Klallam Tribe, Fulfilling LEKT Agreement #: LEKT-FWS-2019-01; FWS Project#: 4837-1336

March 2020

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The Lower Elwha Klallam Tribe

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Abstract

The purposes of this study were to estimate the proportion of hatchery-origin (HOR) winter steelhead spawners (pHOS) and collect broodstock to help the Lower Elwha Tribe (LEKT) hatchery in meeting their egg-take and integrated stock goals. This was a cooperative effort between K. Denton and Associates LLC (KDA), U.S. Fish and Wildlife Service (FWS), and the LEKT. We estimated pHOS for Elwha River winter steelhead and evaluated the current distribution and entry time of HOR and natural-origin (NOR) steelhead in the Elwha River. We sampled 35 sites from river kilometer 0.7 to 25.2 from March 13 to June 24, 2019 (16 weeks) using a tangle net. We calculated pHOS using two methods. First, we calculated the proportion of HOR steelhead caught to the total number of steelhead caught. Second, we attempted to account for spatial differences in HOR and NOR steelhead using catch-per-unit effort. The two pHOS estimates were 0.408 and 0.491, respectively. Differences in temporal and spatial distribution of HOR and NOR steelhead resulted in significant potential bias, resulting in site-specific pHOS estimates ranging from zero to 0.84. This highlights the importance of assessing temporal and spatial variation between the two groups in future assessments. To evaluate the influence of sampling strategy on pHOS estimates, we calculated pHOS based on sampling at groups of sites based on their spatial distribution and for the three months sampling occurred. There was extensive variation in pHOS estimates both spatially and temporally, with pHOS estimate ranging from zero to 0.84. Thus, careful consideration is required to develop an unbiased pHOS estimate for the Elwha River. After assessing potential biases, hatchery-origin steelhead make up between 30 to 40% of the overall spawning population. Through this sampling effort, 40 steelhead, 10 NOR steelhead (4 females, 6 males) and 30 HOR steelhead (17 females, 13 males) were provided to the hatchery for broodstock, representing 69% of the total broodstock and 100% of the NOR steelhead collected in 2019. Based on these data we recommend the following changes to the sampling design. First, additional sampling should occur at the sites downstream of the old mainstem and Hunts Road side channel in the lower river. Second, sampling should continue throughout the river to assess year-to-year variability in the distribution of HOR and NOR steelhead and to better define HOR distribution. Finally, sampling should be initiated no later than early February to avoid issues caused by different entry timing of HOR and NOR steelhead.

Introduction

Hatcheries have played a prominent role in the preservation and subsequent recovery of Pacific salmon (*Oncorhynchus sp.*) and steelhead (*O. mykiss*) following dam removal in the Elwha River (Ward 2008; Peters et al. 2014). Two factors important to consider when hatcheries are used in recovery programs include the proportion of hatchery-origin spawners (pHOS) contributing to natural production and the type of hatchery program used (e.g., Paquet et al. 2011, HSRG 2015). The objective of this project was to provide pHOS estimates for the 2019 return of winter steelhead in the Elwha River. A second objective was to provide broodstock to the Lower Elwha Klallam Tribes (LEKT) hatchery to help maintain the integrated hatchery program.

Although no pHOS criteria currently exists for the Elwha River winter steelhead, managers recognize the importance of monitoring for pHOS even during the early stages of

recovery. In addition, it is recognized that obtaining an unbiased estimate may be difficult because of apparent differences in entry timing and distribution of hatchery-origin (HOR) and natural-origin (NOR) steelhead, which may result in differential catch rates between HOR and NOR fish depending on sampling methodologies. Currently, pHOS estimates for Elwha River winter steelhead are derived from species composition used to develop SONAR population estimates (e.g., Denton et al. 2013-2018). However, these pHOS estimates, which have ranged from 0.25 (2013) to 0.87 (2015) are biased since sampling was designed to estimate overall steelhead abundance, not pHOS (Denton et al. 2013-2018). This potential bias is due to the concentration of sample sites near the LEKT hatchery, with two sites either starting or ending at the hatchery attraction channel, where hatchery fish preferentially home. The hatchery program for winter steelhead on the Elwha River has transitioned from a captive brood program, to an integrated recovery program, and will ultimately be eliminated, once a self-sustaining natural-origin population of steelhead capable of sustaining meaningful harvest is established without continued hatchery support (LEKT and WDFW 2019; LEKT 2012).

The purposes of this study were to estimate the proportion of HOR winter steelhead spawners (pHOS) and collect broodstock to help the Lower Elwha Tribe (LEKT) hatchery in meeting their egg-take and integrated stock goals. This was a cooperative effort between K. Denton and Associates LLC (KDA), U.S. Fish and Wildlife Service (FWS), and the LEKT.

Methods

Field Data Collection

Elwha winter steelhead were sampled using a tangle net at sites throughout the Elwha River to estimate pHOS and to collect broodstock for the LEKT hatchery. Thirty-five different sample sites were sampled during 19 sampling events from March 13 to June 24, 2019 (16 weeks) (Table 1; Figures 1-3). Each site was sampled between one and 15 times during the study. Sampling occurred at sites extending from the lower Elwha River to just upstream of Boulder Creek in the former Lake Mills reservoir (Figure 1 and 2). Broodstock collection occurred only in the lower Elwha River (Figure 1 and 2). The tangle net was approximately 18 m long, 2 m deep, with loosely hung 10 cm stretch mesh composed of very fine twine (#6). We drifted the net through each sample site using a crew of three samplers. Sample sites ranged in length from 44 to 336 m. Sample site length was determined by our ability to fish the site effectively and therefore did not generally start or end at habitat breaks.

Sample sites were spaced as evenly as possible throughout the overall sampling area and segregated into three study reaches, each with different sampling frequencies due to logistical constraints (Figure 1 and 2). The lower Elwha River study reach consisted of 18 study sites and included the area from the mouth to just upstream of the Washington State Department of Fish and Wildlife Hatchery (WDFW) (~ rkm 0.7 – 4.7). The combined length of all of these sites was 1,307 m (~24% of the entire reach). The middle Elwha River reach contained 11 sites (1,143 m combined length, ~13% of the entire reach) and included the area from just upstream of the former Lake Aldwell Reservoir to just downstream of Glines Canyon (~rkm 13.5 – 22.2). The upper Elwha River reach, extending from the former Glines Canyon Dam (~rkm 23.2) upstream

to just upstream of Boulder Creek (~rkm 25.2) contained six sites (807 m combined reach length, ~2% of the entire reach) (Figure 2).

We collected biological data from all captured fish after sampling the entire site, including noting fish origin as hatchery or natural (based on the presence/absence of the adipose fin), sex, and fork length. In addition, scale samples (aging) and fin clips (DNA analysis) were collected and fish were floy tagged to assess recapture rates (if they were not retained for broodstock). Scale and DNA samples were provided to NOAA Fisheries for on-going assessments.

Steelhead caught during these efforts were retained for the broodstock program if they were ripe and ready to spawn, while unripe fish were released to limit the potential mortality prior to spawning. Both HOR and NOR steelhead of both sexes were provided to the hatchery to help ensure selection factors associated with the different sexes were incorporated into the integrated hatchery program. We set the maximum number of NOR steelhead retained for broodstock at 30 fish, to minimize the impacts on colonization of the upper Elwha River watershed. We also attempted to keep the proportion of NOR females included in the brood to a minimum (ideally ~10), since females are the primary mechanism for recolonizing new habitat in the upper Elwha River. The goal was to incorporate fish collected throughout the run to limit potential selection effects. Brood fish were put into a live bag, which was then put into a tote filled with well water from the hatchery. The tote and fish were transported back to the hatchery. Once the fish were delivered to the hatchery, ripe females were sacrificed and spawned immediately. Males were live-spawned as needed and marked with an opercle punch to indicate they had been spawned. Green females and males were placed in the brood pond separated by sex and allowed to mature. Following spawning of the last female, the remaining live males (9) were returned to the river.

Calculating pHOS

We calculated overall basin pHOS using two different methods. The first and the simplest form of pHOS was calculated as:

$$\text{pHOS} = \frac{\#HOS}{\text{Total \# steelhead sampled}} \text{ (Equation 1)}$$

where #HOS, represents the number of HOR spawners sampled.

This assumes that all hatchery fish are 100% marked and that mark identification is 100% accurate. Although we could correct for the mark rate, it was sufficiently high (weighted average for the years in question of 99.05%) that it had little influence on the pHOS estimate (increased pHOS by 0.004, or ~2%) and is therefore not presented.

The pHOS calculation described above, assumes equal catchability of HOR and NOR steelhead, which relies on equal distribution and entry timing of the two groups or sampling effort that results in representative sampling through space and time. The first assumption, is likely false based on past data collections (i.e., Denton et al. 2018, Geffre et al. 2018) and the second assumption requires detailed information regarding entry timing and distribution, which does not exist. In an effort to compensate for biases associated with the likely mismatch between

the temporal and spatial distribution of HOR and NOR steelhead and our sampling, we calculated pHOS using catch-per-unit effort (CPUE) as a correction factor. This is based on the assumption, that CPUE would help account for temporal and spatial variation. We calculated CPUE as the number of fish caught per 100 m sampled at each site during each sampling event. We used this information to calculate relative catch per unit effort for each site and each sampling event throughout the entire sampling period as follows:

$$RCPUE_i = \frac{CPUE_i}{\sum_n^i CPUE} \text{ (Equation 2)}$$

where i represents the different sample sites and each sampling event.

pHOS was calculated using RCPUE to effectively ‘weight’ the pHOS estimates of each sampling event at each site based on catches of HORs and NORs during each sampling event as:

$$pHOS = \sum \frac{\#HOS}{Total \# steelhead sampled} * RCPUE_i \text{ (Equation 3)}$$

RCPUE requires the lengths of each study reach, which we estimated using the measuring tool in ArcGIS Pro (Ver. 2.4.2).

In an effort to assess the impacts of differences in the spatial and temporal variation of HOR and NOR steelhead and our sampling design, we calculated pHOS for six spatially distinct groups and across two temporal scales using equation 1 above. The groups consisted of relatively closely clustered sites in the middle Elwha, upper Elwha, and the following four groups of clustered sites in the lower Elwha River (Figure 3). These lower river groups were the Bluff group, Hunts Rd Channel group, Old Mainstem (OM) group, and the WDFW hatchery outlet group. The two temporal periods examined included the entire sampling period and the month sampling occurred (March – June).

Results

Catch Summary

We sampled 145 fish representing four species and three life history forms of *O. mykiss*. We caught 98 steelhead, 29 bull trout, 16 Chinook salmon, one resident *O. mykiss*, and one putative *O. mykiss/O. clarki* hybrid (Appendix A). Our sampling resulted in 263 drifts, of which 75 resulted in steelhead capture (29%). The proportion of sampling events resulting in steelhead capture was 26% in the lower river and 42% in the middle and upper river combined. We did not recapture any of the 58 tagged steelhead released back into the river during our sampling (40 were taken to the hatchery). Of the 98 steelhead caught 56 were females, 40 were males, with sex not noted for two fish (Table 2). Forty of the 98 steelhead were adipose clipped representing HORs (40.8%).

There were spatial and temporal differences in catch of HOR and NOR steelhead (Figure 4). NOR steelhead were caught throughout the sampling area, while HOR steelhead were only caught in the lower 5 km of river. NOR steelhead were also represented in the catch during the entire sampling period and catch of NOR steelhead peaked in early May. In contrast, fewer HOR steelhead were captured in March and catches peaked in early- to mid-April.

Estimated pHOS

The two pHOS estimates were 0.408 and 0.491 for equations 1 and 2, respectively. Estimates of pHOS also appear to be sensitive to spatial and temporal sampling patterns (Table 3). Estimates of pHOS varied from zero to 0.84 (equation 1), depending on the period or group of sites used to make the estimate. The estimated pHOS from the middle and upper Elwha River were both zero, since no HOR steelhead were caught in those reaches. The pHOS estimates were also sensitive to relatively small changes in spatial scale. For example, the pHOS estimate of the four lower Elwha River groups varied from 0.29 to 0.84 (equation 1). The lowest pHOS estimates occurred at the groups furthest downstream. The greatest pHOS estimate occurred in the OM group, which is closest to the hatchery. Temporal differences also existed in pHOS estimates (Table 3). The pHOS estimates were lowest in March, increased in April, peaked in May and then decreased in June.

Broodstock Collection

Forty of the 98 steelhead caught during this work were provided to the LEKT hatchery for broodstock (Table 4). This included steelhead caught from March 26, 2019 to May 6, 2019. Ten of these fish, six males and four females, were NOR. Thirty of these fish, 13 male and 17 females, were HOR (Table 4). The 40 fish provided to the hatchery represented 68.97% (40 of 58) of the total broodstock collected. The remaining adults (15 females, 3 males, with one of the females from the WDFW hatchery) volunteered into the hatchery.

Discussion

It is apparent from the data that pHOS estimates in the Elwha River are very sensitive to differences in spatial and temporal patterns of HOR and NOR steelhead. Thus, if possible, the sampling strategy must match the spatial and temporal patterns of HOR and NOR steelhead that results in equal probability of catch for both groups to obtain an unbiased pHOS estimate. This will be challenging in the Elwha River due to the concentration of HOR steelhead in the lower River and the fine scale differences in spatial distribution observed in the lower river. The two overall pHOS estimates derived from the data were 0.408 and 0.491. However, these are likely overestimates of pHOS based on the distribution of our sampling sites relative to HOR and NOR steelhead distribution.

Estimating pHOS in the Elwha River requires several basic assumptions. The primary assumption is that the sampling efficiency (i.e., catchability) for HOR and NOR steelhead is similar. However, this assumption encompasses several other assumptions depending on the sampling strategy employed. First, the sampling strategy must encompass the entire run timing or the run timing of the different groups must be similar. Second, one must assume equal distribution of HOR and NOR steelhead throughout the sampling area, which also includes equal relative abundance of HOR and NOR steelhead throughout the sampling area. Violating this

assumption requires that the distribution of sampling effort matches HOR and NOR distribution and/or their relative densities. These assumptions appear to have been violated in the Elwha River and likely resulted in overestimated pHOS. For example, HOR steelhead were concentrated in the lower river, which was sampled with greater effort than areas upstream.

Differences in freshwater entry timing influence pHOS estimates by changing sampling efficiency for each group throughout the sampling period and can easily be compensated for by sampling the entire run. Our sampling started in March, at least one month after steelhead started entering the Elwha River (Denton et al. in prep), because funding was not available until this time. This would not be an issue if the entry timing of HOR and NOR steelhead is the same. However, this does not appear to be the case. The lowest pHOS estimates derived during this project occurred in March (Table 3). Thus, it appears that NOR steelhead enter the river before HOR steelhead. Thus, many NOR steelhead likely passed through our primary sampling locations before we started sampling. This results in reduced capture probability of NORs relative to HOR steelhead, leading to an overestimated pHOS.

Unequal spatial distribution or relative densities of HOR and NOR steelhead will influence sampling efficiency for each group if the sampling locations are not distributed to mirror the distribution or relative abundance of the two groups. HOR steelhead occupy a much smaller portion of the watershed than NOR steelhead. The furthest upstream capture of an HOR steelhead was rkm 5. In contrast, the furthest upstream capture of an NOR steelhead was rkm 25. Thus, HOR steelhead in the Elwha River are concentrated in the lower river, relative to NOR steelhead. The impacts of this difference in distribution among the groups are apparent from the pHOS calculated for the groups of sites based on their spatial distribution. The greatest pHOS estimate came from the group closest to the LEKT hatchery (OM group). The sites within this group also had the greatest impact on the pHOS estimate derived from equation 2 (Table 2). Over 80% of our sampling effort, based on the number of sampling events and length of channel sampled, occurred in the lower river. This effort resulted in just over 80% of the total steelhead catch as well. This concentration of sampling effort in an area where HOR steelhead were concentrated likely resulted in an overestimated pHOS when considering the entire watershed.

It is impossible to estimate how much the pHOS estimates would be overestimated as a result of violating the assumptions described above. The range of pHOS estimates from the group of sites provides some insight into the potential range of the actual pHOS estimate. The most unbiased group would be the Bluffs group (pHOS = 0.29), which was located between the mouth and the Old Mainstem and Hunts Rd Side Channel split (rkm 1.5 – 1.5), since only one redd was observed in or downstream of this group of sites. This suggests that HOR steelhead are likely not congregating here to a greater degree than NOR steelhead. The Hunts Rd Channel group provided the same estimate; however, this site would likely underestimate pHOS. This is based on the apparent concentration of HOR steelhead in the OM group, which would likely result in the most overestimated pHOS estimate. Based on the data and the known assumption violations, the best estimate of pHOS is likely a range from 0.29 to 0.406 (estimate from equation 1).

The Lower Elwha winter steelhead program is designated as an integrated hatchery program, which requires NOR steelhead to be incorporated into the broodstock. Prior to 2019, NOR steelhead have largely come from the captive brood steelhead developed from steelhead eggs mined from the Elwha River prior to dam removal. One NOR male and female steelhead

were incorporated into the program in 2018. The lack of captive brood steelhead, since it terminated on schedule, and the lack of steelhead (HOR and NOR) volunteering into the hatchery led to this effort to maintain the program and its integrated status. The 2019 brood was composed of 58 steelhead. There were 48 HOR steelhead; 18 volunteers into the hatchery and 30 provided by this sampling effort plus 10 NOR steelhead. This resulted in a proportion of hatchery brood composed of natural-origin fish (pNOB) estimate of 0.17 and a proportion of natural influence (PNI) that ranges from 0.26 (pHOS = 0.491) to 0.37 (pHOS = 0.29) depending on the pHOS value used. No PNI objectives are specified for primary populations in the preservation phase (current Elwha steelhead status) or recolonization phase (HSRG 2015). The PNI increase to 0.67 for the local adaptation and fully restored status (HSRG 2015).

Recommendations

Estimating pHOS for winter steelhead in the Elwha River relies on the assumption that HOR and NOR steelhead are likely to be caught relative to their actual abundance. This can be accomplished using two different sampling strategies. One can distribute the sampling sites relative to the relative abundance of HOR and NOR steelhead, or one can sample in areas where only migratory fish will be captured. This sampling effort shows that HOR and NOR steelhead are not equally distributed in the Elwha river.

Based on these data we recommend the following:

- 1) Continue sampling throughout the river to develop a better understanding of the differences in HOR and NOR steelhead distribution and to assess year-to-year variability.
- 2) Add additional sites between the WDFW outlet and HWY 101 to better define the upper extent of HOR steelhead distribution.
- 3) Increase the sampling effort at two to four sites furthest downstream. These sites and/or sites further downstream will predominantly intercept migrating fish based on 2019 steelhead redd distribution (McMillan et al. in prep). Unfortunately, it is unlikely and probably undesirable to capture sufficient steelhead at this location to obtain a pHOS estimate with the desired level of precision. We caution sampling too many fish at these locations due to their proximity to the saltwater, which increases the potential impacts of sampling adults too soon after river entry. In addition, this could result in captures of out-of-basin steelhead that dip into the Elwha River.

Acknowledgements

This report was improved by reviews from Pat DeHaan (FWS), George Pess (NOAA) and John Mahan (LEKT). Kathryn Sutton (FWS), Jeff Johnson (FWS), John Mahan, Steven Lauderback, Keith Lauderback and Larry Henderson (All LEKT) assisted with fieldwork. This project was funded through Hatchery Reform funding, administered by the NWIFC through the LEKT and through population assessment funding administered by the U.S. Fish and Wildlife Service, through the Western Washington Fish and Wildlife Conservation Office. The findings

and conclusions in this report are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service or NOAA Fisheries. Mention of trade names does not imply indorsement by the Federal Government.

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Table 1: Summary of sampling by site (length (m)), reach, date, and week (WK). A one (1) in the table means sampling occurred at this site on this date. Blank cells represent days when no sampling occurred. The two (2) on 4/2/2019 for the LEKT hatchery site, represents a regular sampling day and the incorporation of a dead steelhead found at the outlet of the LEKT hatchery that was included into the pHOS data.

		13-Mar	19-Mar	26-Mar	2-Apr	10-Apr	15-Apr	16-Apr	22-Apr	29-Apr	30-Apr	6-May		21-May	28-May	29-May	3-Jun	11-Jun	18-Jun	24-Jun	
Site	Reach	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 6	WK 7	WK 8	WK 8	WK 9	WK 10	WK 11	WK 12	WK 12	WK 13	WK 14	WK 15	WK 16	# Samples
Below Sisson hole (90)	Lower	1	1	1		1															4
Bottom OM (83)	Lower	1	1	1	1	1	1		1	1		1		1	1		1	1	1	1	15
DS Hunts High Bluff (199)	Lower	1	1	1		1	1		1	1		1		1	1		1	1	1	1	14
HRC 3 (87)	Lower						1		1	1		1		1	1		1	1			8
Hunts Rd Sonar (103)	Lower			1		1	1		1	1		1		1	1		1	1			10
Hunts Rd Start (95)	Lower			1	1	1	1		1	1											6
Hunts Road Upper (86)	Lower			1	1	1	1		1	1		1		1	1		1	1			11
LEKT Hatchery (44)	Lower	1	1	1	2	1	1		1	1		1		1	1		1	1	1	1	16
LEKT Outlet DS (99)	Lower			1	1	1	1		1	1		1		1	1		1	1	1	1	13
LEKT Outlet US (336)	Lower	1	1	1	1	1	1		1	1		1		1	1		1	1	1	1	15
Lower HRC (113)	Lower					1	1		1	1		1		1	1		1	1			9
MS US WDFW outlet (157)	Lower	1	1	1	1	1	1		1	1		1		1	1		1	1	1	1	15
MS US WDFW Outlet TO (127)	Lower						1		1	1		1		1	1		1	1	1	1	10
OMS Sonar (85)	Lower	1	1	1	1	1															5
Sisson hole (119)	Lower	1	1	1	1	1	1		1	1		1		1	1		1	1	1	1	15

		13-Mar	19-Mar	26-Mar	2-Apr	10-Apr	15-Apr	16-Apr	22-Apr	29-Apr	30-Apr	6-May		21-May	28-May	29-May	3-Jun	11-Jun	18-Jun	24-Jun	
Site	Reach	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 6	WK 7	WK 8	WK 8	WK 9	WK 10	WK 11	WK 12	WK 12	WK 13	WK 14	WK 15	WK 16	# Samples
US high bluff (133)	Lower	1	1	1	1	1	1		1	1		1		1	1		1	1	1	1	15
US HRC SONAR 2 (104)	Lower						1							1	1		1	1			5
WDFW outlet (65)	Lower									1		1		1	1		1				5
Bedrock below gage (171)	Middle	1	1	1	1																4
DS Fisherman's Bend 2 (115)	Middle							1			1			1							3
DS Fisherman's Bend 3 (179)	Middle							1			1			1		1					4
DS gauge rip rap run (213)	Middle	1	1	1	1			1													5
DS Hughes (91)	Middle							1													1
DS Sanders 1 (71)	Middle							1													1
Gage Tailout (133)	Middle	1						1													2
Glines Powerhouse (219)	Middle										1					1					2
MS Hughes (151)	Middle							1													1
MS madison (188)	Middle			1	1			1													3
US Sanders (262)	Middle							1													1
Boulder DS (70)	Upper										1										1
Boulder MS (132)	Upper										1										1
Boulder US (229)	Upper										1										1
Glines US (113)	Upper										1					1					2
Windy arm (122)	Upper										1					1					2
Windy arm DS (174)	Upper										1					1					2

Table 2. Catch of hatchery- and natural-origin steelhead by site and site group for all the sites where steelhead were caught. The contribution (value and percent) to the overall pHOS estimate based on relative catch per unit effort (equations 2 and 3) at each sample site where steelhead were caught. The overall pHOS estimate used to calculate the %pHOS column was 0.491.

Site	Group	HOR	NOR	Total	Relative pHOS	%pHOS
DS Hunts High Bluff	Bluff	4	7	11	0.023	4.7
US high bluff	Bluff	1	5	6	0.009	1.8
Lower HRC	Hunts Rd	1	1	2	0.010	2.1
Hunts Rd Sonar	Hunts Rd	0	4	4	0.000	0.0
HRC 3	Hunts Rd	1	0	1	0.013	2.7
Bottom OM	OM	0	2	2	0.000	0.0
LEKT Outlet DS	OM	6	1	7	0.070	14.2
LEKT Hatchery	OM	9	1	10	0.235	47.9
LEKT Outlet US	OM	6	0	6	0.021	4.2
Below sisson hole	WDFW	0	1	1	0.000	0.0
Sisson hole	WDFW	9	7	16	0.087	17.7
MS US Wdfw Outlet TO	WDFW	1	1	2	0.009	1.8
MS US WDFW outlet	WDFW	2	4	6	0.015	3.0
DS gauge rip rap run	Middle	0	2	2	0.000	0.0
Bedrock below gage	Middle	0	1	1	0.000	0.0
Ms madison	Middle	0	3	3	0.000	0.0
DS Fishermans Bend 3	Middle	0	2	2	0.000	0.0
DS Fishermans Bend 2	Middle	0	2	2	0.000	0.0
DS Hughes	Middle	0	1	1	0.000	0.0
Glines Powerhouse	Middle	0	3	3	0.000	0.0
Glines US	Upper	0	1	1	0.000	0.0
Windy arm DS	Upper	0	4	4	0.000	0.0
Windy arm	Upper	0	2	2	0.000	0.0
Boulder MS	Upper	0	3	3	0.000	0.0
Total		40	58	98	0.491	100

Table 3. Estimated pHOS (# hatchery/total catch – equation 1), total number of steelhead caught (in parenthesis) by sample site groups and month. The groups are ordered from downstream (top) to upstream (bottom), except that Hunts and OM are at nearly the same river kilometer but represent two channels (Hunts Rd Side Channel and Old Mainstem). NE means no estimate was possible since no fish were caught during the sampling event. NS means the site was not sampled that month.

Group	March	April	May	June	Group pHOS
Bluff	0.00 (3)	0.50 (8)	0.17 (6)	NE	0.29 (17)
Hunts	0.00 (1)	0.33 (3)	0.33 (3)	NE	0.29 (7)
OM	0.00 (1)	0.86 (14)	0.89 (9)	1.00 (1)	0.84 (25)
WDFW	0.20 (5)	0.71 (14)	0.25 (4)	0.00 (2)	0.48 (25)
Middle	NE	0.00 (13)	0.00 (1)	NS	0.00 (14)
Upper	NS	0.00 (9)	0.00 (1)	NS	0.00 (10)
pHOS by Period	0.10 (10)	0.44 (61)	0.46 (24)	0.33 (3)	0.41 (98)

Table 4. Number of steelhead provided to the Lower Elwha Hatchery for broodstock by date, sex, and origin (HOR, NOR) during the 2019 sampling effort.

Date	Female			Male		
	NOR	HOR	Total	NOR	HOR	Total
13-Mar	0	0	0	0	0	0
19-Mar	0	0	0	0	0	0
26-Mar	0	0	0	1	0	1
1-Apr	0	0	0	0	0	0
2-Apr	0	0	0	1	1	2
10-Apr	0	4	4	0	2	2
15-Apr	2	4	6	0	3	3
16-Apr	0	0	0	0	0	0
22-Apr	1	2	3	1	3	4
29-Apr	0	1	1	1	2	3
30-Apr	0	0	0	0	0	0
6-May	1	5	6	1	0	1
21-May	0	0	0	1	2	3
28-May	0	1	1	0	0	0
29-May	0	0	0	0	0	0
11-Jun	0	0	0	0	0	0
24-Jun	0	0	0	0	0	0
Total	4	17	21	6	13	19

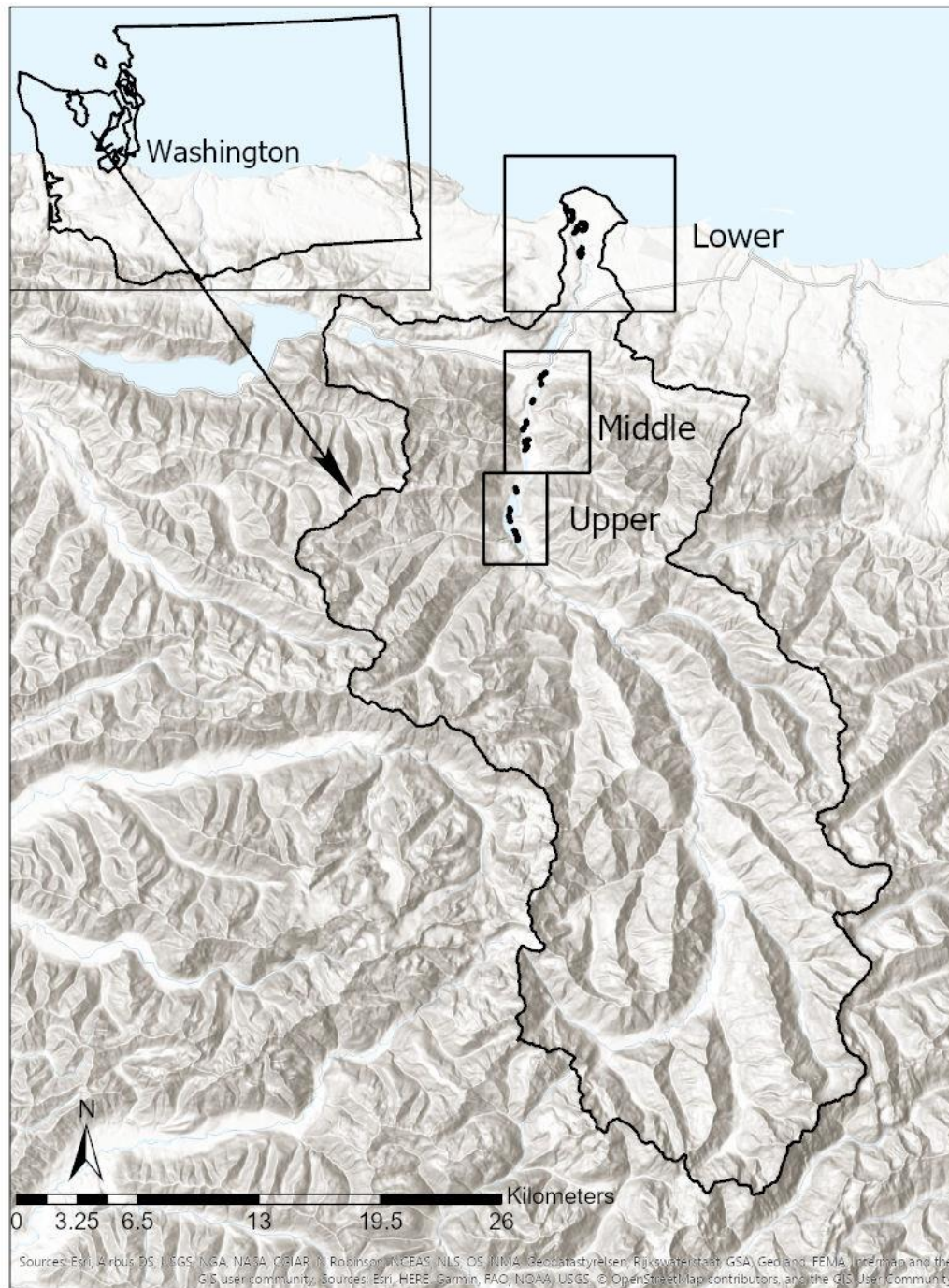


Figure 1. Study area map showing the location of the Elwha basin within Washington State (insert) and sample reaches (lower, middle, upper) and sites within the Elwha basin. The sample reaches are expanded in Figure 2.

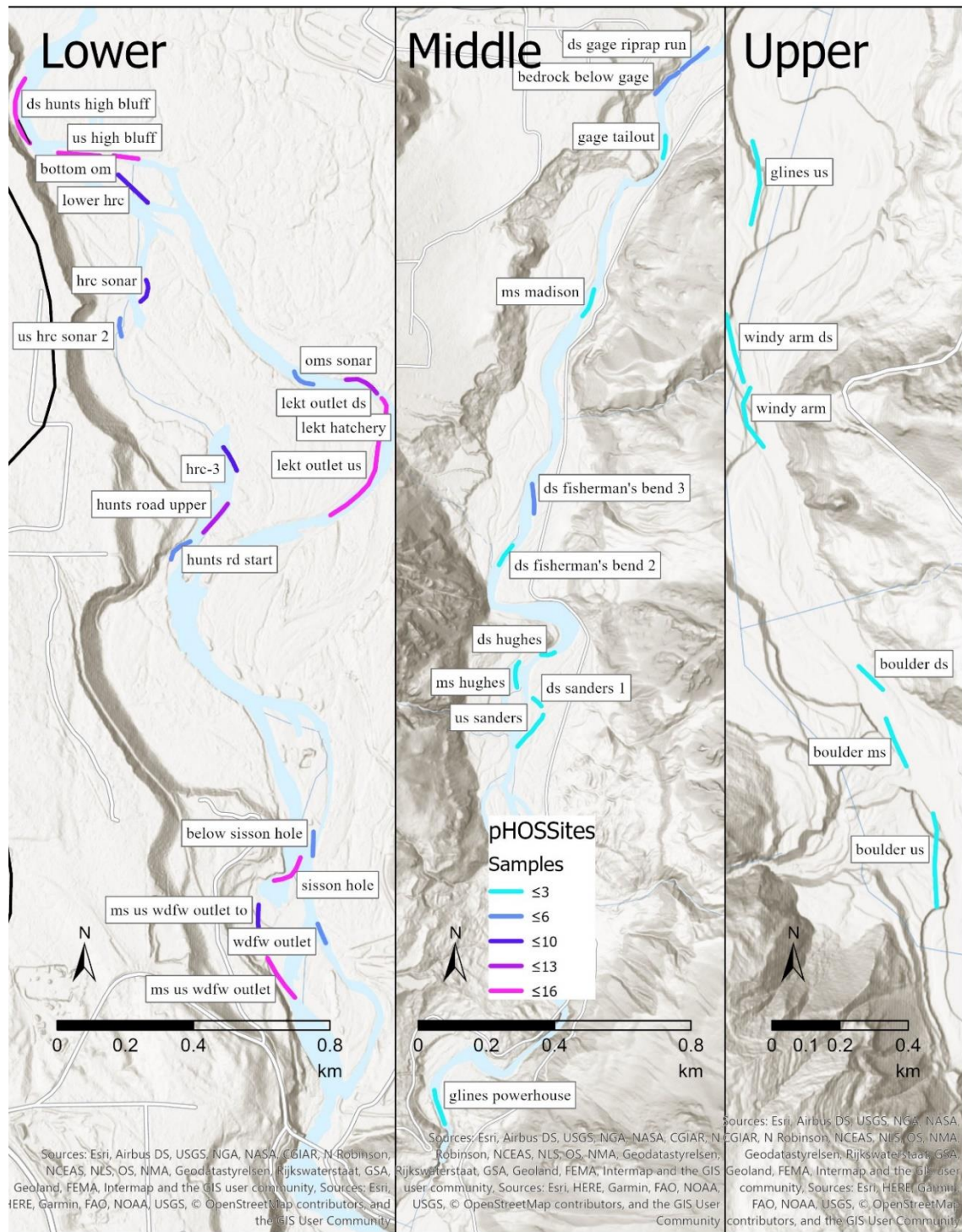


Figure 2. Sample sites in the lower, middle, and upper reaches of the Elwha River (see figure 1). The number of times each site was sampled is displayed using different colors.

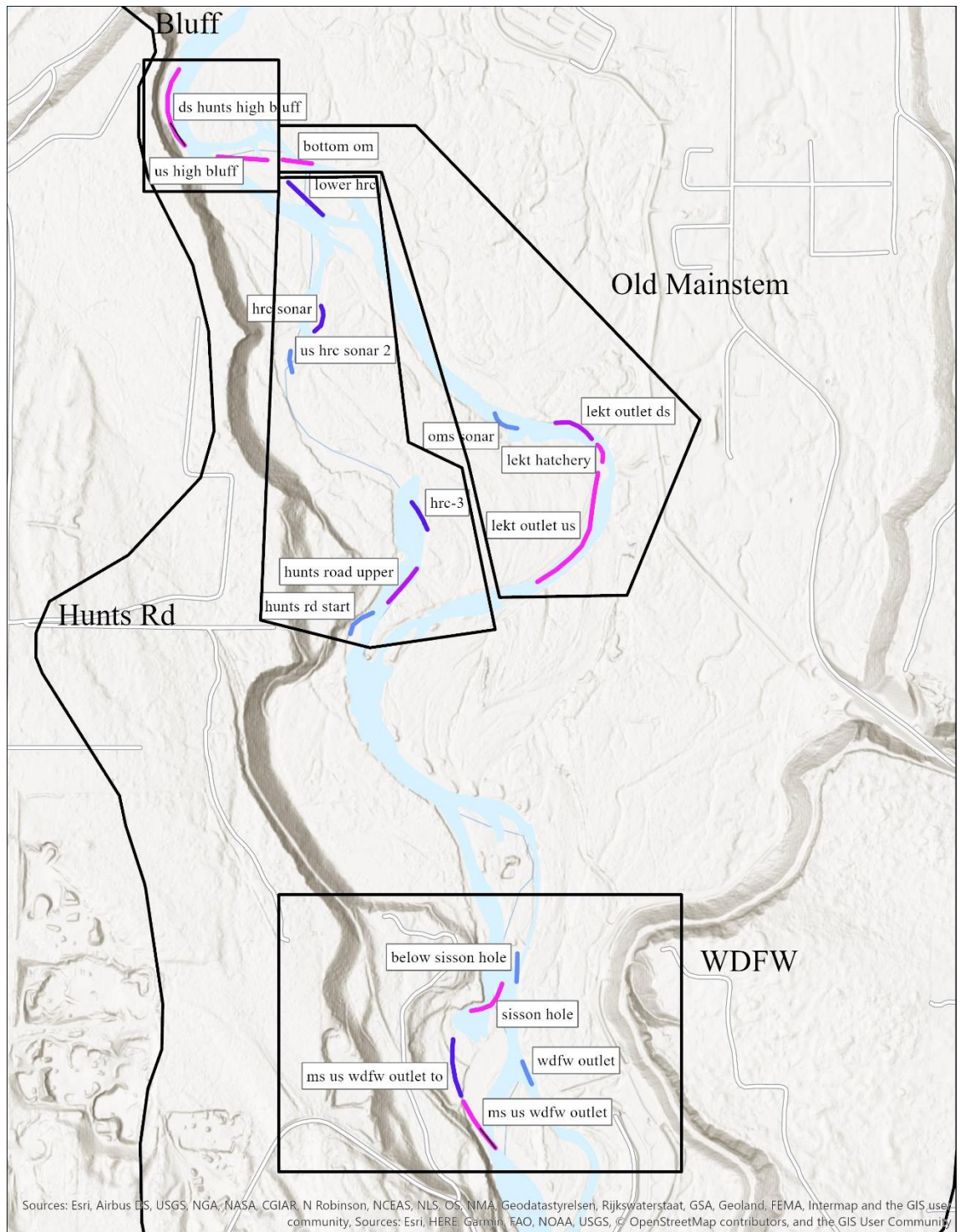


Figure 3. Sample groups in the lower river reach. The middle and upper river reaches also represented the middle and upper river groups since no hatchery fish were caught in these reaches/groups.

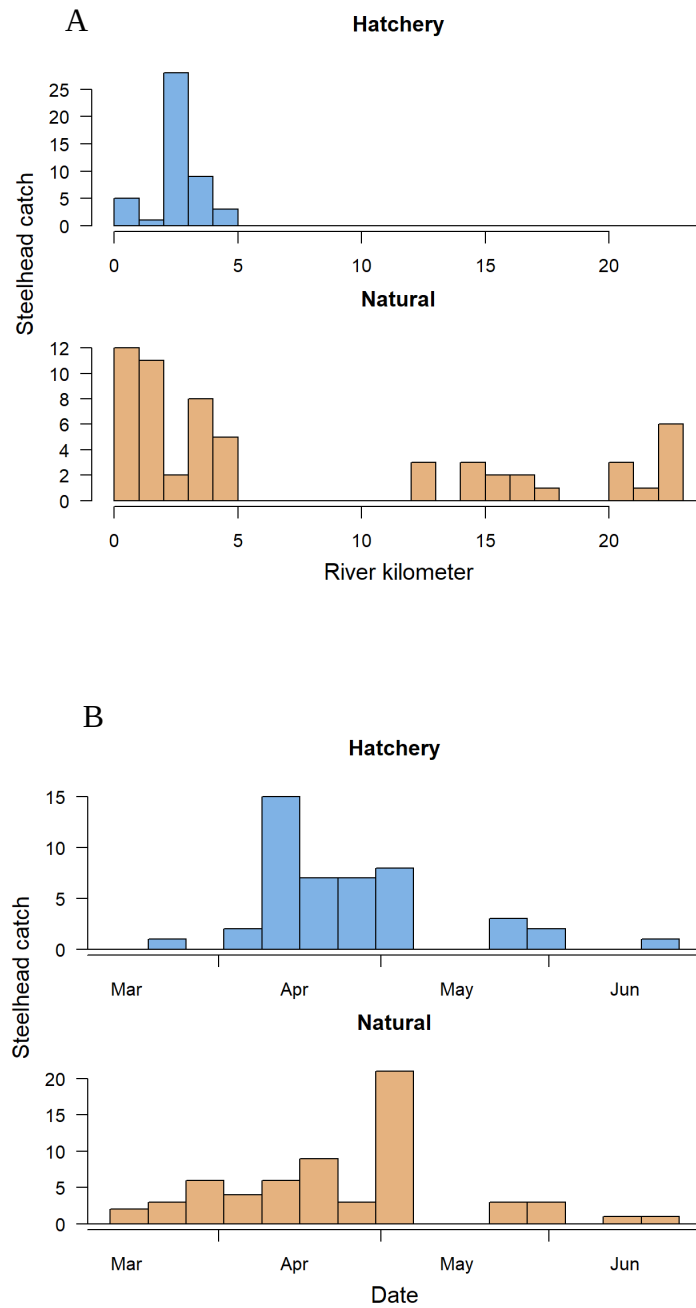


Figure 4. Hatchery- and natural-origin steelhead capture by river kilometer (A) and month (B).

Appendix A: Catch data from this project showing sample date, sample location, species caught, fork length, sex (M = Male, F = Female), adipose fin clip status (Ad Clip, Y = Yes, N = No), and whether or not the fish was taken for broodstock.

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
3/13/2019	bedrock below gage	Bulltrout	555			No	
3/13/2019	DS gauge rip rap run	Bulltrout	550			No	
3/13/2019	sisson hole	Steelhead	670	F	N	No	lost one new steelhead
3/13/2019	US high bluff	Steelhead	640	F	N	No	
3/19/2019	bottom OM	Steelhead	655	M	N	No	
3/19/2019	DS gauge rip rap run	Bulltrout	550			No	
3/19/2019	DS gauge rip rap run	Bulltrout				No	
3/19/2019	DS Hunts High Bluff	Steelhead	610	M	N	No	
3/19/2019	MS US WDFW outlet	Steelhead	705	F	N	No	
3/19/2019	sisson hole	Steelhead	705	F	Y	No	2nd pass, lost one on the 1st pass and 2nd pass, no fish 3rd pass
3/19/2019	sisson hole	Bulltrout	560			No	2nd pass
3/26/2019	below sisson hole	Steelhead	705	M	N	Yes	broodstock
3/26/2019	Hunts Rd Sonar	Steelhead	670	F	N	No	
3/26/2019	ms madison					No	lost one steelhead
3/26/2019	MS US WDFW outlet	Steelhead	620	F	N	No	
3/26/2019	US high bluff	Steelhead	690	M	N	No	
4/1/2019	LEKT Hatchery	Steelhead	910	M	N	No	This fish was found dead on bank
4/2/2019	bedrock below gage	Steelhead	657	F	N	No	dna and scale in same envelope
4/2/2019	DS gauge rip rap run	Bulltrout	580			No	
4/2/2019	DS gauge rip rap run	Bulltrout	510			No	
4/2/2019	ms madison	Steelhead	750	M	N	No	dna and scale same envelope
4/2/2019	ms madison	Steelhead	664	F	N	No	dna and scale same envelope
4/2/2019	sisson hole	Steelhead	460	M	N	Yes	broodstock, lost 2 steelhead
4/2/2019	sisson hole	Bulltrout	525			No	drift 2
4/2/2019	sisson hole	Steelhead	740	F	Y	No	drift 2
4/2/2019	sisson hole	Steelhead	600	M	Y	Yes	broodstock, drift 2
4/10/2019	DS Hunts High Bluff	Steelhead	660	F	N	No	no samples

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
4/10/2019	Hunts Rd Sonar	Steelhead	680	F	N	No	
4/10/2019	LEKT Hatchery	Steelhead	790	M	Y	Yes	broodstock
4/10/2019	LEKT Hatchery	Steelhead	790	F	Y	Yes	broodstock
4/10/2019	LEKT Outlet US	Steelhead	670	F	Y	Yes	broodstock
4/10/2019	lower HRC	Steelhead	700	M	N	No	
4/10/2019	sisson hole	Steelhead	700	M	Y	Yes	broodstock
4/10/2019	sisson hole	Steelhead	790	F	Y	Yes	broodstock
4/10/2019	sisson hole	Steelhead	710	F	Y	Yes	broodstock
4/15/2019	HRC 3	Bulltrout	605		N	No	
4/15/2019	LEKT Outlet DS	Steelhead	675	M	Y	Yes	broodstock
4/15/2019	LEKT Outlet DS	Steelhead	675	M	Y	Yes	broodstock
4/15/2019	LEKT Outlet DS	Steelhead	760	F	N	Yes	broodstock
4/15/2019	lower HRC	Steelhead	800	F	Y	Yes	broodstock
4/15/2019	MS US WDFW outlet	Steelhead	720	F	Y	Yes	broodstock
4/15/2019	MS US Wdfw Outlet TO	Steelhead	760	F	Y	Yes	broodstock
4/15/2019	sisson hole	Bulltrout	560		N	No	
4/15/2019	sisson hole	Steelhead	765	M	Y	Yes	broodstock
4/15/2019	sisson hole	Steelhead	790	F	Y	No	
4/15/2019	US high bluff	Steelhead	640	F	Y	Yes	broodstock
4/15/2019	US high bluff	Steelhead	660	F	N	Yes	broodstock
4/16/2019	DS Fishermans Bend 2	Steelhead	780	F	N	No	
4/16/2019	DS Fishermans Bend 2	Steelhead	655	F	N	No	
4/16/2019	DS Fishermans Bend 3	Steelhead	630	F	N	No	
4/16/2019	DS Fishermans Bend 3	Bulltrout	620		N	No	
4/16/2019	DS Fishermans Bend 3	Bulltrout	555		N	No	
4/16/2019	DS gauge rip rap run	Steelhead	680	F	N	No	
4/16/2019	DS gauge rip rap run	Steelhead	395	M	N	No	
4/16/2019	DS Hughes	Steelhead	640	M	N	No	
4/16/2019	DS Sanders 1					No	lost one fish, species unknown
4/16/2019	ms madison	rainbow/cutthroat	430	M	N	No	

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
4/16/2019	ms madison	Steelhead	640	F	N	No	
4/22/2019	DS Hunts High Bluff	Steelhead	800	F	Y	No	
4/22/2019	DS Hunts High Bluff	Steelhead	740	M	Y	Yes	broodstock
4/22/2019	LEKT Hatchery	Steelhead	690	M	Y	Yes	broodstock
4/22/2019	LEKT Hatchery	Steelhead	650	F	Y	Yes	broodstock
4/22/2019	LEKT Outlet DS	Steelhead	800	F	Y	Yes	broodstock
4/22/2019	LEKT Outlet US	Steelhead	805	M	Y	Yes	broodstock
4/22/2019	MS US Wdfw Outlet TO	Steelhead	650	F	N	Yes	broodstock
4/22/2019	US high bluff	Steelhead	770	M	N	Yes	broodstock
4/29/2019	DS Hunts High Bluff	Steelhead		F	N	No	est. length 730, got away
4/29/2019	DS Hunts High Bluff	Steelhead	775		Y	Yes	broodstock, no length or condition recorded
4/29/2019	LEKT Hatchery	Steelhead	460	M	Y	No	
4/29/2019	LEKT Outlet US	Steelhead	690	F	Y	Yes	broodstock
4/29/2019	LEKT Outlet US	Steelhead	650	M	Y	Yes	broodstock
4/29/2019	MS US WDFW outlet	Steelhead	730	M	Y	Yes	broodstock
4/29/2019	MS US WDFW outlet	Steelhead	445	M	N	Yes	broodstock
4/29/2019	sisson hole	Steelhead	790	F	N	No	
4/30/2019	boulder DS	Bulltrout	450			No	pass 1
4/30/2019	boulder DS	Bulltrout	530			No	pass 2
4/30/2019	boulder MS	Steelhead	690	F	N	No	
4/30/2019	boulder MS	Steelhead	730	M	N	No	
4/30/2019	boulder MS	Steelhead	720	M	N	No	pass 2
4/30/2019	boulder MS	rainbow	440	u	N	No	pass 2. resident? No fish pass 3
4/30/2019	DS Fishermans Bend 2					No	missed one steelhead
4/30/2019	DS Fishermans Bend 3	Steelhead	795	F	N	No	
4/30/2019	Glines Powerhouse	Steelhead	870	M	N	No	
4/30/2019	Glines Powerhouse	Steelhead	720	F	N	No	
4/30/2019	Glines Powerhouse	Bulltrout	620			No	
4/30/2019	glines US	Steelhead	670	F	N	No	
4/30/2019	windy arm	Bulltrout	550			No	pass 1

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
4/30/2019	windy arm	Steelhead	740	F	N	No	pass 1
4/30/2019	windy arm	Steelhead	895	M	N	No	pass 2
4/30/2019	windy arm DS	Steelhead	720	M	N	No	
4/30/2019	windy arm DS	Steelhead	680	F	N	No	
4/30/2019	windy arm DS	Steelhead	585	M	N	No	
4/30/2019	windy arm DS	Bulltrout				No	released with no data
4/30/2019	windy arm DS	Bulltrout				No	released with no data
4/30/2019	windy arm DS	Bulltrout				No	released with no data
5/6/2019	bottom OM	Steelhead	700	F	N	No	pass 2. lost 2 steelhead on pass 1
5/6/2019	DS Hunts High Bluff	Steelhead	710	F	N	No	
5/6/2019	DS Hunts High Bluff	Steelhead	735	F	N	No	
5/6/2019	DS Hunts High Bluff	Steelhead	680	F	N	No	
5/6/2019	DS Hunts High Bluff	Steelhead	650	F	Y	Yes	broodstock
5/6/2019	HRC 3	Steelhead	860	M	Y	No	
5/6/2019	Hunts Rd Sonar	Steelhead	720	M	N	Yes	broodstock
5/6/2019	Hunts Rd Sonar	Steelhead	690	F	N	Yes	broodstock
5/6/2019	LEKT Hatchery	Steelhead	725	F	Y	Yes	broodstock
5/6/2019	LEKT Hatchery	Steelhead	600	F	Y	Yes	broodstock
5/6/2019	LEKT Hatchery	Bulltrout	550			No	
5/6/2019	LEKT Hatchery	Steelhead	630	F	Y	Yes	broodstock
5/6/2019	LEKT Outlet DS	Steelhead	680	M	Y	No	
5/6/2019	LEKT Outlet DS	Steelhead	690	M	Y	No	
5/6/2019	LEKT Outlet US	Bulltrout	605			No	
5/6/2019	sisson hole	Steelhead	780	F	N	No	
5/6/2019	sisson hole	Steelhead	635	F	Y	Yes	broodstock
5/21/2019	DS Hunts High Bluff	Steelhead	700	F	N	No	
5/21/2019	Hunts Road Upper	Bulltrout	190			No	
5/21/2019	LEKT Hatchery	Steelhead	700	M	Y	Yes	broodstock
5/21/2019	LEKT Outlet US	Steelhead	670	M	Y	Yes	broodstock
5/21/2019	LEKT Outlet US	Bulltrout	625			No	

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
5/21/2019	sisson hole	Steelhead	725	F	N	No	
5/21/2019	US high bluff	Chinook	840			No	
5/21/2019	US high bluff	Steelhead	725	M	N	Yes	broodstock
5/28/2019	DS Hunts High Bluff	Chinook	930		Y	No	
5/28/2019	LEKT Outlet US	Chinook	880			No	lost one steelhead
5/28/2019	LEKT Outlet US	Steelhead	640	F	Y	Yes	broodstock
5/28/2019	sisson hole	Steelhead	700	M	N	No	Found dead on the bank
5/28/2019	US high bluff	Chinook	820			No	
5/28/2019	US high bluff	Chinook	880			No	
5/29/2019	Glines Powerhouse	Steelhead	960	M	N	No	
5/29/2019	windy arm	Bulltrout	560			No	
5/29/2019	windy arm DS	Bulltrout	470			No	drift 1
5/29/2019	windy arm DS	Steelhead	920	M	N	No	drift 1
5/29/2019	windy arm DS	Bulltrout	410			No	drift 2
6/3/2019	DS Hunts High Bluff	Chinook	870	F		No	
6/3/2019	sisson hole	Chinook	770	F		No	
6/11/2019	DS Hunts High Bluff	Chinook	880			No	
6/11/2019	LEKT Outlet US	Bulltrout	495			No	
6/11/2019	sisson hole	Chinook	820	M		No	
6/11/2019	sisson hole	Steelhead	665	F	N	No	samples taken but missing at end of day
6/11/2019	US high bluff	Chinook				No	lost 2 chinook
6/18/2019	DS Hunts High Bluff					No	lost 1 chinook
6/18/2019	sisson hole	Bulltrout	430			No	lost 1 chinook
6/18/2019	US high bluff					No	lost 2 chinook
6/24/2019	DS Hunts High Bluff	Chinook	960			No	
6/24/2019	DS Hunts High Bluff	Chinook	870			No	
6/24/2019	LEKT Outlet DS	Steelhead	630	F	Y	No	
6/24/2019	MS US WDFW outlet	Steelhead	690		N	No	summer run?
6/24/2019	sisson hole	Bulltrout	530			No	
6/24/2019	US high bluff	Chinook	850			No	length estimated

Date	Site	Species	Length (mm)	Sex	Ad Clip	Brood	Comments
6/24/2019	US high bluff	Chinook	830			No	length estimated
6/24/2019	US high bluff	Chinook	900			No	length estimated
6/24/2019	US high bluff	Chinook	870			No	length estimated

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