

**Winter Steelhead (*Oncorhynchus mykiss*) Redd Survey Summary for Middle Elwha
River 2012/2013**

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Introduction

As part of the Elwha River dam removal project the Lower Elwha Klallam Tribe (LEKT), the National Oceanic and Atmospheric Administration – Northwest Fisheries Science Center (NOAA), and the Washington Department of Fish and Wildlife (WDFW) (all hereafter referred to as the "partners") relocated adult winter steelhead above the former Elwha Dam site and into a tributary, Little River, that is not affected by sediment related to dam removal. The adult steelhead we captured and relocated in winter/spring of 2012/2013 were primarily volunteering into the WDFW hatchery outfall and attempting to spawn in sub-optimal habitat that was heavily influenced by sediment from dam removal, and would likely result in poor to no survival of eggs. Relocation represented an excellent opportunity to initiate the recolonization process in Little River prior to completion of dam removal and full restoration of anadromous access. However, it is important to note that the former Elwha River dam site was considered passable by steelhead in April 2011, so some fish were expected to naturally recolonize the middle Elwha River. Still, relocation provided information about behavior and helped ensure fish in the lower Elwha would not endure the heightened loads of suspended solids in the main-stem Elwha River.

Prior to and after releasing the fish LEKT and NOAA conducted weekly foot surveys to enumerate winter steelhead redds in Little River, as well as locations where fish were not released, including Indian Creek and Hughes Creek, two sidechannels associated with the main-stem Elwha River (middle Elwha River) and the WDFW Hatchery outflow (lower Elwha River). The timing of surveys ranged from late winter through summer until steelhead were no longer observed spawning. Here we provide the results by describing for each survey location; 1) the number of redds enumerated, 2) timing of redd excavation, 3) the number of live winter steelhead and resident rainbow trout observed actively spawning during the surveys, and (4) estimating the number of female steelhead per redd in Little River,

Methods

Steelhead tagging and relocation

Most steelhead transported to Little River were captured at the WDFW Hatchery trap outflow (67 steelhead), but a portion (21 steelhead) were caught with gill-nets in the lower main-stem Elwha River (Table 1). Those caught in the main-stem were part of ongoing species composition study to help identify the timing of each salmonid species entering the Elwha River that are enumerated with a DIDSON multi-beam SONAR. Importantly, steelhead were not been observed spawning in the hatchery outflow in years previous to dam removal. However, during dam removal the hatchery outflow provides one of the only clear water sources in the lower Elwha River, and steelhead were presumably spawning there to avoid high levels of suspended solids in the main-stem Elwha River.

Redd Survey Location and Timing: Elwha River Winter Steelhead

We conducted weekly foot surveys to determine the location and timing of adult steelhead spawning activity, with areas of emphasis including four tributaries (Little River and Indian Creek outside the ONP and Griff, Madison, and Hughes Creeks inside the ONP), two sidechannels in the middle Elwha River (from Glines Canyon Dam down to former Elwha Dam), and the WDFW Hatchery outflow channel in the lower Elwha River (Figure 1 and Table 1). Surveys began on February 5, 2012 (Table 2), approximately two months prior to the initial release date of April 17, 2012, and ended on July 24, 2013, about one month after the final fish relocation on June 24, 2013. Redd counts started in February and were conducted once per week as environmental conditions allowed. For example, surveys were not consistently conducted during some months, such as May in Little River, because water clarity was too poor for visual surveys (Table 2). We classified stream visibility as: excellent (≤ 1 NTU), very good (2-3 NTU's), fair (>3 and <10 NTU's), and poor (>10 NTU's), based on NTU's measured with a McVan Analite turbidity meter NEP160.

Redd Enumeration, Marking and Fish Data

Surveyors walked upstream to enumerate redds in all cases. Redds were identified as disturbed areas in the stream bed where gravels were overturned. Each redd was identified with a distinct location (latitude and longitude) 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). In addition to redds, we counted live and dead spawning *O. mykiss* and classified those fish by sex (male/female) and life history (steelhead/resident rainbow trout) based on size (resident rainbow trout < 20" in length), degree of darker coloration, and presence of numerous spots below the lateral line (as described in McMillan et al. 2007). If a floy tag was visible on the steelhead, when possible we also denoted the color and number.

Data Analysis

We analyzed the data in four steps. First, we delineated redd counts by date for all sites combined to describe spawn timing. Second, we mapped the spatial distribution of redd counts within the middle Elwha River in Google Earth®. Third, we described the total number of alive and dead winter steelhead observed during the surveys and delineated those fish by sex and life history. Lastly, we calculated the number of winter steelhead females per redd for Little River.

Results

Steelhead tagging and relocation

We captured, tagged, and relocated 88 adult steelhead. There were sex differences in the ratio of steelhead captured overall and at each location. In total, 55%, (48 steelhead) of the 88 steelhead were male. However, 40 of the 67 steelhead captured at the WDFW trap were male (60%), while only eight of the 21 fish captured with gillnets in the main-stem Elwha River were male (38%). All of the fish were relocated to Little River (Table 1; Figures 1 and 3).

Based on radio telemetry, the majority of fish appeared to remain and spawn in Little River within 0-3 km of where they were relocated, except for one male that returned to spawn in the WDFW trap where it was originally collected. We were able to determine this because, 1) all radio-tags remained active in the streams through summer of 2013, indicating the fish died in the stream, or 2) the fish that left the streams did so after days to weeks and were never again recorded in the Elwha River, suggesting the fish had spawned and emigrated to the ocean as kelts.

Survey conditions

Stream flows and visibility were variable but generally allowed for weekly surveys in all locations, except for higher flows that reduced visibility in SC 26 during most of March and April and again in Little River during much of May (which was related to snowmelt) (Table 2). Visibility was fair to excellent in all surveys in Indian Creek, Hughes Creek, and Griff Creek, 40% of the surveys in Little River, 70% of the surveys in SC 26, and was consistently excellent in Madison Creek sidechannel except for a single week. In contrast, visibility was poor in WDFW Hatchery outflow 69% of the time from February through May, which was due to increased flows and sediment associated with the main-stem Elwha River. Visibility was never adequate for surveys in the main-stem Elwha River, though we were able to visually identify two redds in the main-stem Elwha River at the mouth of Little River because flow from the Little River dramatically improved visibility for a short area.

Redd enumeration

NOAA-NWFSC and the LEKT conducted 91 redd surveys from February through July in Little River, Indian Creek, Madison Creek SC, SC 26, and the WDFW trap, while ONP conducted 44 surveys from February through July in Hughes and Griff Creeks (Table 2). Surveys ended July 22, 2013 due to a lack of fish and new redds. NOAA-NWFSC and LEKT enumerated a total of 66 winter steelhead redds across a cumulative total of 46.4 km of stream, with the greatest length of stream being surveyed in Little River (25.6 km) and Indian Creek (13.0 km: Table 1). ONP surveyors did not observe any redds in Hughes or Griff Creeks across 12.6 and 11.5 km of stream, respectively.

Redd distribution: time and location

Most redds (47 redds) were counted in the Little River because it was the relocation destination for the majority of the steelhead (Table 1). We also counted 31 redds at the WDFW outflow channel and nine redds in Indian Creek (Table 1).

Temporal patterns suggested a protracted breeding season for steelhead. The first redd at the WDFW hatchery outflow channel was observed on March 27, 2013 and the last on July 17, 2013 (Figure 2). The first redd in the middle Elwha was observed on April 26, 2013 in the Little River, nine days after the initial release and the last on July 17, 2013, also in Little River, almost a month after the final release on June 24, 2013 (Figure 2). The temporal distribution of redds was bimodal in the WDFW outflow channel, with an initial peak in late April/early May and a later peak in June (Figure 2). Redd counts in Little River peaked sharply in late June, while spawning was observed in Indian Creek from May through mid-July (Figure 2).

Spatial patterns revealed two important results. First, while many redds were centered around the release location in Little River, some steelhead also moved 3.0-4.0 km upstream to spawn in the upper canyon area where there are a series of waterfalls, and several fish moved downstream and spawned near the mouth (Figure 3a). At least some of the redds in the lower portion of Little River were spawned well after the final release and when our radio-tracking indicated there were very few remaining females, suggesting that some of those redds were excavated by naturally recolonizing steelhead that made it into Little River on their own accord. Second, all nine redds counted in Indian Creek were excavated by natural colonizing steelhead and one of those fish spawned over 4.0 km upstream from the mouth (Figure 3b).

Observations of tagged and untagged steelhead

During redd surveys in Little River we identified nine steelhead with floy tags or radio-tags, including five male and three females. In Little River we also observed two steelhead (1 male and 1 female) without tags of any kind, and hence, we presumed those fish were natural colonizers (Table 1). We observed ten steelhead without tags in Indian

Creek, and those fish (4 females, 6 males) were also presumed to be natural colonizers (Table 1). All untagged fish were observed fairly late in the season, in June and July, except for one female steelhead that was observed in February in Indian Creek.

Number of female steelhead per redd

Given that we relocated a known number of female steelhead to a stream and then counted redds (Table 1), we were able to estimate the number of females per redd for Little River. However, we know that some redds -- four in our estimation -- were constructed by natural colonizing fish. Conversely, we also released six female steelhead into Little River that had already partially spawned (based on sunken stomachs) in the WDFW outflow channel, and those fish may or may not have spawned further in Little River. Given these issues, we run the data as is, but acknowledge that there is some level of uncertainty in the numbers of females that actually spawned in Little River.

We released 40 female steelhead into Little River and observed one untagged female steelhead, and counted 48 redds, for an estimate of 0.83 female steelhead/redd. The total number of steelhead, assuming an equal sex ratio of 50:50 males and females, would thus equate to 1.83 steelhead/redd or 73 steelhead. The latter estimate is lower than the total 88 steelhead released because the sex ratio was not 50:50 and there were more males than females released into Little River.

Adult winter steelhead and resident rainbow trout observed during spawning

In addition to redds we also enumerated spawning steelhead and resident rainbow trout and distinguished their sex when possible. Overall, we observed very few steelhead actively spawning in Little River and Indian Creek, but we did observe some smaller male rainbow trout attempting matings with female steelhead (Figure 4a). Conversely, at the WDFW outflow channel we observed numerous spawning steelhead, including several small male steelhead "jacks" (35-45 cm in length) and male resident rainbow trout (27-35 cm in length) (Figure 4b). We found very few dead steelhead, but of the three we did find all were male.

Conclusions and Discussion

As with the previous year's surveys (McMillan et al. 2011; McMillan and Moses 2012), our data indicate that flow and visibility in the tributaries often allowed for weekly redd counts, except for May in Little River when runoff increased flows and limited visibility. Also like previous years, high flows and poor visibility did truncate the temporal breadth of our surveys in the WDFW outflow channel and SC 26, but not in the Madison Creek sidechannel. Despite the often adequate visibility for surveys, it was still difficult to discern redds during winter because algal growth is reduced and the contrast being spawned and unspawned gravel is less clear. Consequently, we likely missed redds. For example, our surveys in Indian Creek appear to have missed redds because NOAA and LEKT fish tagging efforts in June found several young-of-the-year *O. mykiss* 30 mm or less that were presumably steelhead offspring. This suggests the female we observed in February in Indian Creek may have spawned much earlier, or some other steelhead did, and we did not observe the redd with our surveys.

While difficult to predict how many redds we missed, our efforts appear to have accounted for a fairly substantial portion of the winter steelhead run. Relocation and redd surveys accounted for at least 98 steelhead, including 88 steelhead that were relocated to Little River and another 10 steelhead that natural recolonized Indian Creek. Given that we saw another two steelhead and five redds that were likely from natural colonizers in Little River, it is possible that an additional 5-10 steelhead spawned in the tributaries.

A total basin escapement for steelhead in the Elwha is provided each season by a DIDSON multi-beam sonar project which operates in the lower 1KM of the river. For the 2012/2013 season, the same time period covered by this report, the SONAR project preliminarily estimated 224 steelhead returned to the river, though some of those were non-native Chambers Creek stock (Denton et al. 2013) that were not relocated or tagged. Therefore, our redd surveys detected approximately 44% of the total SONAR based escapement estimate. This suggests that almost half of the actual spawning in the watershed is occurring in only a few locations, perhaps because they offer better visibility

and in the case of the WDFW hatchery outflow, a small respite from turbidity in the nearby main-stem Elwha River.

Importantly, the redd counts are increasingly providing a sense of the temporal breadth of steelhead spawning in the Elwha River. For example, the observation of first steelhead spawning was March 26, 2013 in the lower Elwha River, which was over one month earlier than the date at which spawning was first observed last year (May 4, 2012: McMillan and Moses 2012). Further, as we already mentioned, it is likely that some steelhead spawned as early as mid-February, and were observed spawning into mid-July - a period of six months. Steelhead have typically been thought to be late spring spawners in the Elwha River (Brenkman et al. 2008a), and indeed, our data suggests most spawning occurs in late spring. But, our data also indicate that steelhead spawned relatively early this year, and has been later than previously thought during both of the last two years.

The earlier spawning this year and the protracted spawning period could be explained in different ways. First, this year we started surveys earlier because the former Elwha Dam site was passable for steelhead. Second, surveys have often started later in previous years because water visibility in winter and early spring, and again in summer, often precluded visual redd counts in the main-stem Elwha River below the Elwha Dam. Stream visibility in tributaries is unaffected by the sediment however and thus, surveys are possible over a longer period of time. Similarly, much of the steelhead population is condensing into the WDFW outflow channel, which also allows for easy observation over time. Lastly, steelhead maybe spawning earlier and later because they are experiencing a greater range of water temperatures in the tributaries than they did when limited to the lower five-miles of the main-stem Elwha River (Mike McHenry, Personal Communication, Unpublished Data). Most likely it is a combination of these factors where steelhead did spawn over a longer period of time but were not seen in the turbid main-stem Elwha River and water temperatures are influencing the rate of sexual development (e.g., earlier spawning in warmer streams).

Also important is that we are beginning to understand the relationship between number of female steelhead and number of redds. This year we estimated 0.83 females/redd, which is similar to the 0.80 females/redd used by WDFW based on data from Snow Creek, Washington (WDFW, Unpublished Data), and is higher than the 0.69 females/redd we estimated last year in Little River (McMillan and Moses 2012). This year's estimate was well within the range of values WDFW observed from 1977-1989: 0.58 - 1.16 females/redd. But last year's was at the lower end, as the WDFW estimates only fell below 0.70 females/redd in two of the eleven years. Snow Creek and Little River are vastly different streams, but the estimates of females/redd do overlap.

Although the female/redds estimate for Little River appears reasonable, it still does not necessarily tell us about the number of males. In Snow Creek WDFW (WDFW, Unpublished Data) documented an approximate equal number of male and female steelhead across the sampling period, meaning they could use redds to estimate population size by simply doubling the estimate of females/redd. In contrast to Snow Creek, our sample of 88 steelhead, 55% were male this year while 78% were female last year. Further, this year's estimate would have been skewed even further towards males if the resident rainbow trout, which were observed mating with female steelhead, were counted as part of the population. It is hard to explain the difference between years and suggests there may be a high level of annual variability in sex ratios, which could potentially confound the assumption of a 50:50 sex ratio that is used to estimate run size based on redd counts in much of western Washington State (Mike Gross, WDFW, Personal Communication). This raises questions about the importance of considering sex ratio and resident male rainbow trout when estimating steelhead population size based on redd counts and highlights that sex ratio may be equally or more important than the number of females/redd.

Perhaps most importantly the surveys lead to two observations particularly relevant to recolonization. First, while many redds were observed within 1.0-2.0 km of the release sites, fish dispersed broadly in Little River and moved over 4.0 km upstream. This is also what we observed last year in Little River. This suggests that releasing

steelhead from a single location does not necessarily mean that all spawning activity will be limited to areas around the release site, which likely improves chances of successful recolonization in a given stream (Anderson et al. 2012). Second, the presence of clear water refugia, such as the tributaries, can provide spawning habitat if there is adequate flow and access. We observed numerous steelhead recolonize Indian Creek and Little River over the past two years, but not in Griff or Hughes Creeks. Indian Creek and Little River have 2-3 times the discharge and 10-20 times the length of available habitat compared to the smaller Griff and Hughes Creeks. This suggests that tributary size and flow may play a key role in determining which streams are colonized by larger-bodied salmonids, such as steelhead (Pess et al. 2012).

Overall, we conclude that the relocation of steelhead above the Elwha Dam was effective in several ways. First, relocation established a broad spatial distribution of spawning winter steelhead within Little River prior to deconstruction of both dams. Second, we were also able to draw correlations between the number of spawning steelhead and the number of redds, and sex ratios, both of which have important implications for methods that will be used to estimate run sizes in the future. Lastly, we again confirmed that adult steelhead are recolonizing tributaries in the middle Elwha River on their own accord. Continued efforts to relocate steelhead, enumerate redds, count steelhead with SONAR, and track their behavior via telemetry thus seem like critical components for understanding the recolonization process and most importantly, for jumpstarting a population of ESA listed steelhead in streams not affected by the sediment from dam deconstruction.

References

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TABLES

1. Description of survey locations and redd surveys, including site, reach (all - indicates entire stream was surveyed), beginning and end river kilometer of each survey reach (reach) and cumulative length of stream surveyed over season (total survey), the number of surveys conducted, number of steelhead relocated to each site (relocated steelhead), number of redds counted and number of test redds/digs, number of floy tags observed, and number of radio-tagged steelhead encountered. SC - sidechannel. Middle Elwha - refers to reach of Elwha River between Altaire Campground downstream to Highway 101 bridge. NA -- WDFW Hatchery outflow was area where steelhead were captured for tagging and relocation.

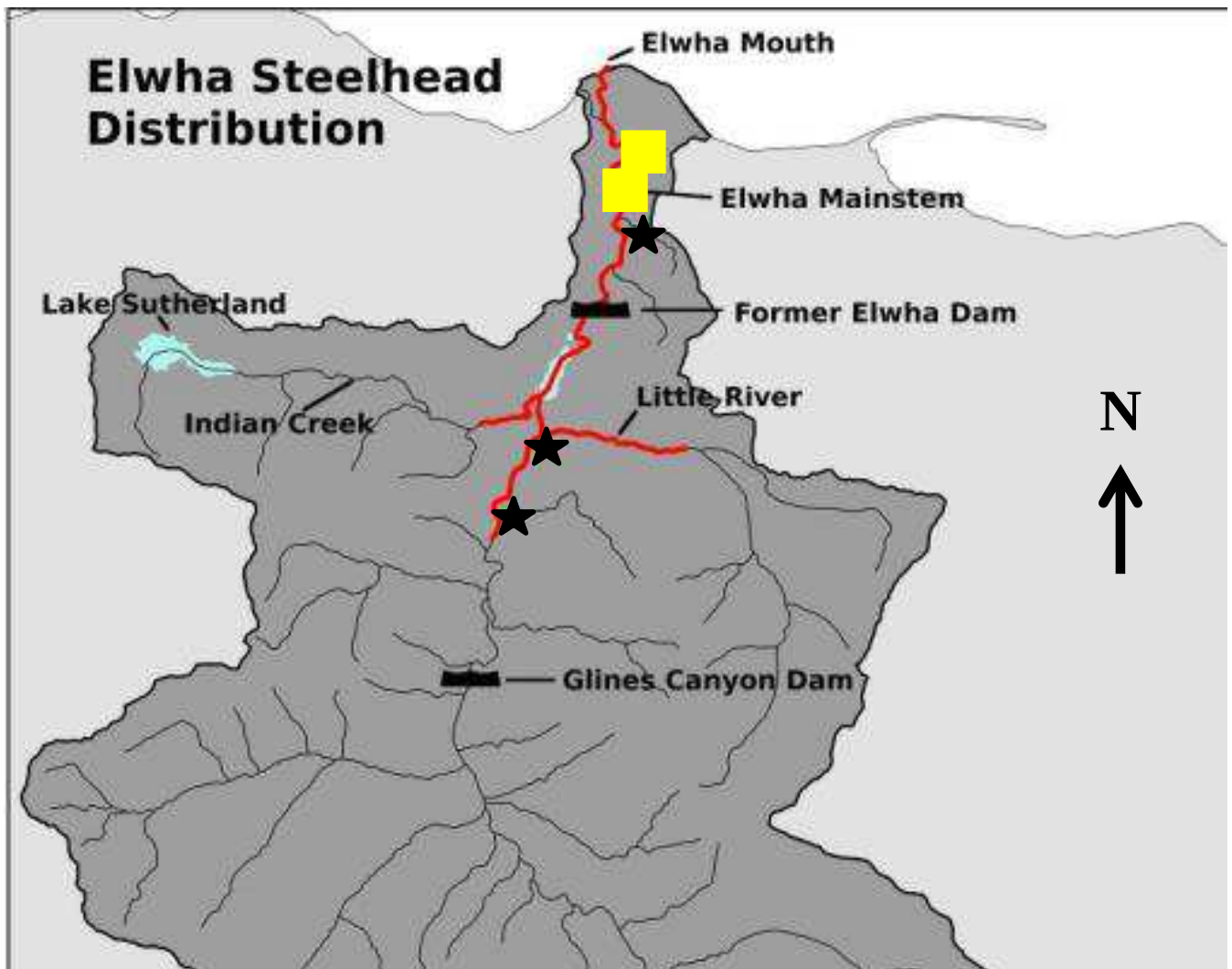
Site	Reach	Length (km)		# Surveys	Relocated steelhead	Redds	Test Digs	Fish w/out tags
		Reach	Total survey					
Little River			25.6	24	40♀:48♂	47	3	2
	Lower	0.0 - 0.9	18.0	22		38	2	1♀:1♂
	Upper	0.9 - 4.7	7.6	2		9	1	0
Indian Creek			13.0	24	None	9	0	10
	Lower	0.0 - 0.4	8.8	22		5	0	4♀:6♂
	Middle	0.3 - 2.4	4.2	2		4	0	0
Madison Ck and SC	all	0.1 - 0.3	4.4	22	None	0	0	0
SC 26	all	0.0 - 0.2	2.0	10	None	0	0	0
Griff Ck	Lower	0.0 - 0.5	11.5	23	None	0	0	0
Hughes Ck	Lower	0.0 - 0.6	12.6	21	None	0	0	0
WDFW Hatchery Outflow	all	0.0 - 0.1	1.4	16	NA	31	0	0

2. Weeks during which redd surveys were conducted (grey cells) for each location.

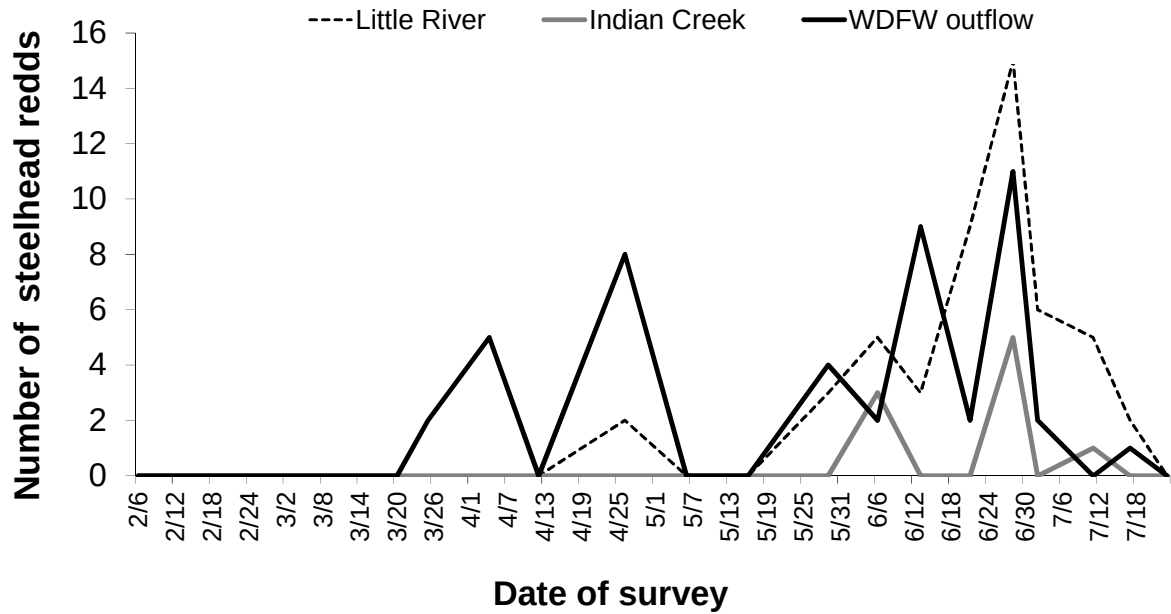
Site	February				March				April				May				June				July			
	4	11	18	25	4	11	18	25	1	8	15	22	6	13	20	27	3	10	17	24	1	8	15	22
Little River																								
Lower																								
Upper																								
Indian Creek																								
Lower																								
Middle																								
Madison Ck SC																								
SC 26																								
Hughes Ck																								
Griff Ck																								
WDFW Hatchery Outflow																								

FIGURES

1. Map of Elwha River basin, including Indian Creek and Little River where most redd surveys were conducted for winter steelhead from February - July 2012/2013. Stars indicate locations of -- working north to south -- Sidechannel 26, Madison Creek floodplain channel, and the WDFW Hatchery outflow. Yellow squares indicate locations of Didson sonar counting stations.

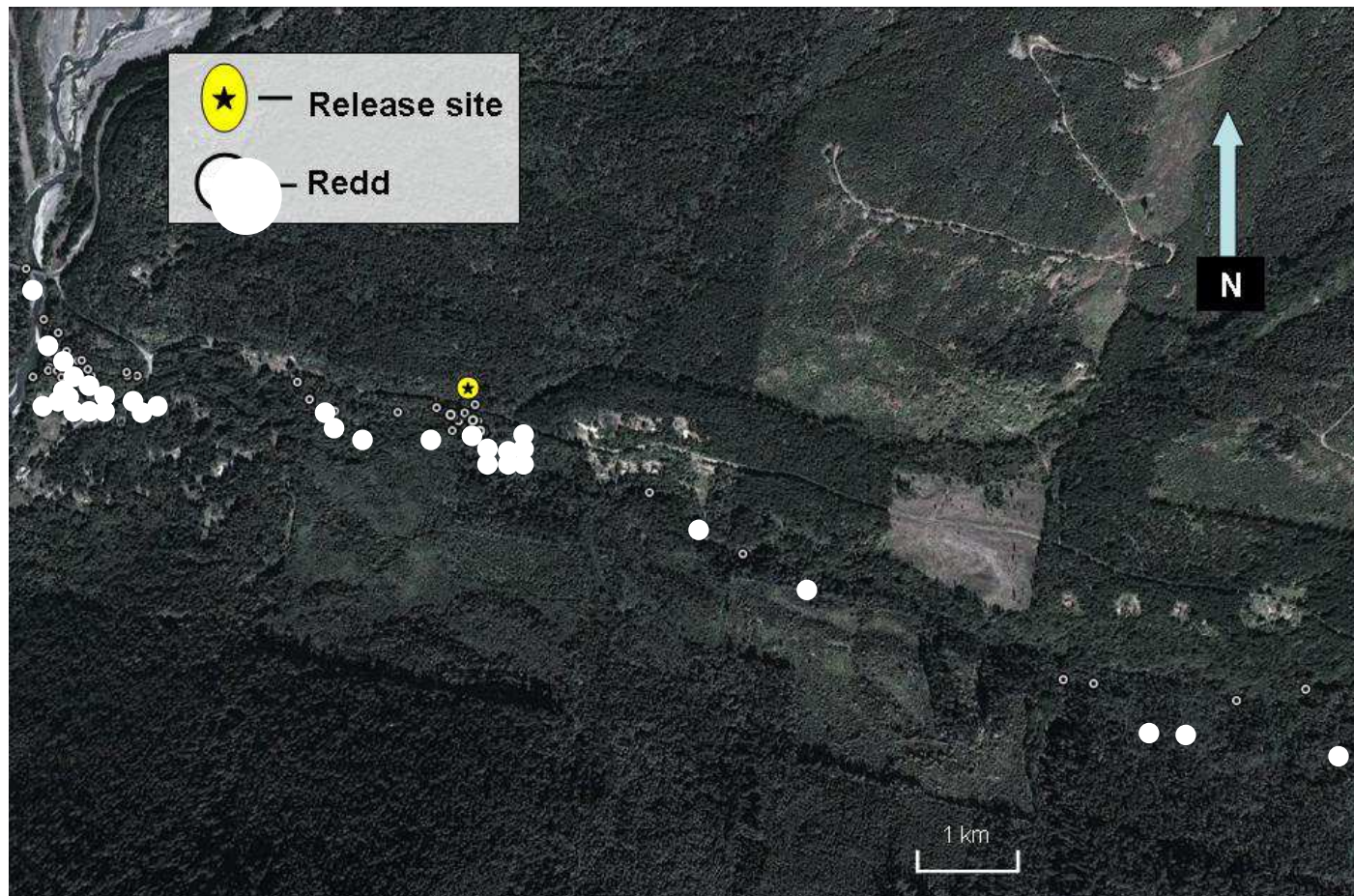


2. Number of winter steelhead redds counted during weekly redd surveys in Little River, Indian Creek, and the WDFW hatchery outflow (lower Elwha River). Redds in Indian Creek were solely from natural colonizing steelhead that made it past the former Elwha Dam site on their own accord.

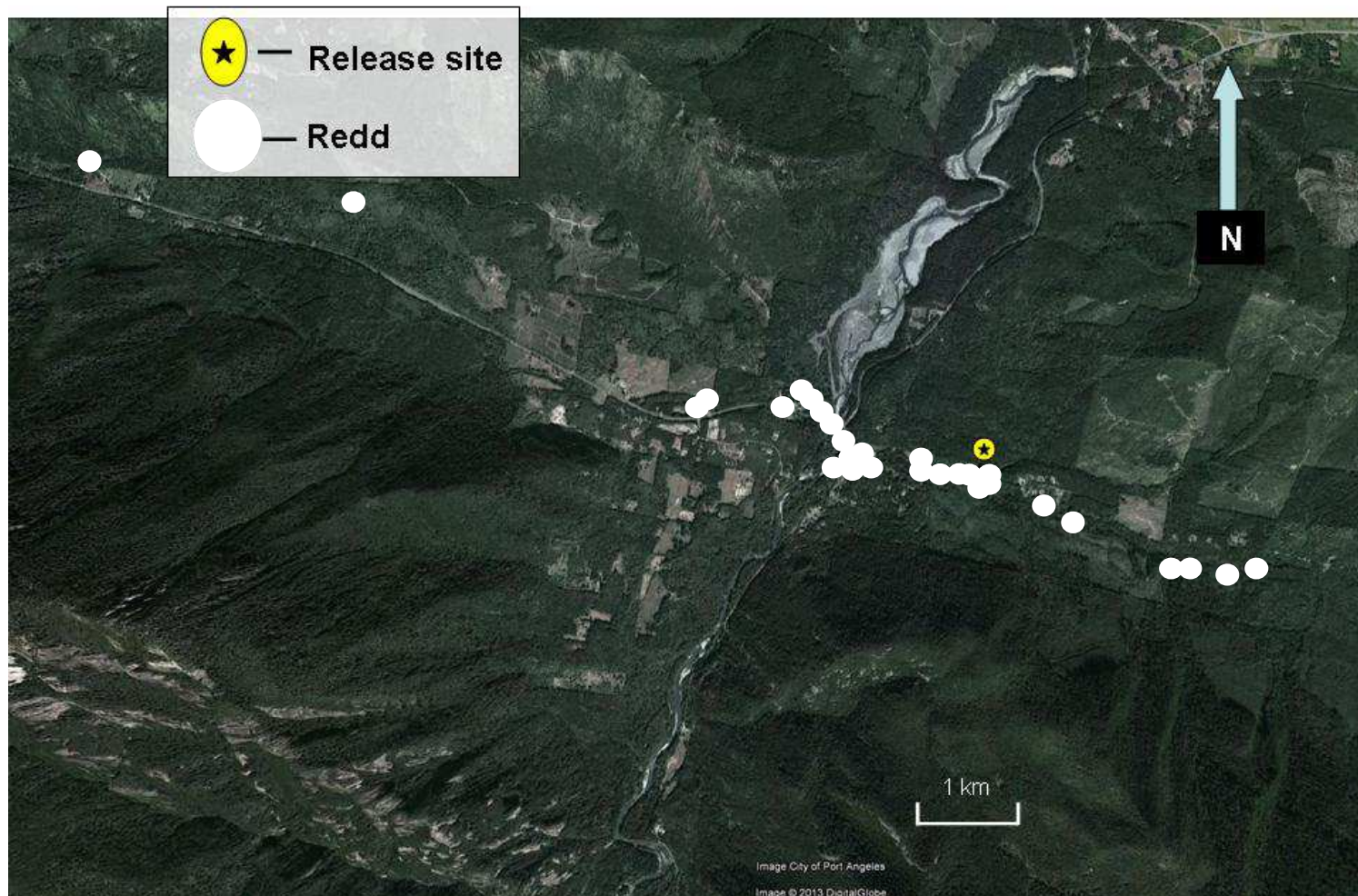


3. Map of redd locations in (a.) the Little River, and (b) in Indian Creek and Little River, along with location where steelhead were released in Little River during 2012-2013 spawning season.

a.

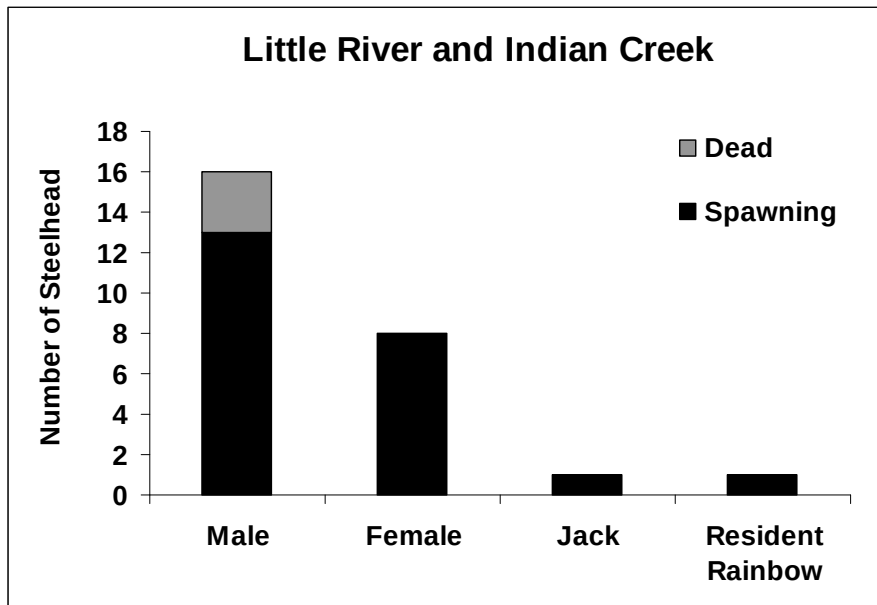


b.



4. Number of adult male and female steelhead, small "jack" male steelhead (14-18" in length), and male resident rainbow trout (as determined by shorter head, more dense spotting, and coloration relative to male jack steelhead) observed alive and actively spawning in (a.) Little River and Indian Creek and (b.) the WDFW outflow. Resident rainbow trout were all presumed to be male based on their mating behavior (e.g., sneaking fertilizations with female steelhead).

a.



b.

