

2014 Elwha River Smolt Enumeration Project Report

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Executive Summary

Smolt enumeration monitoring was successfully completed on the mainstem Elwha River and in two tributaries, Little River and Indian Creek during the 2014 outmigration season. Abnormally high spring flows and river sediment conditions as a result of dam decommissioning resulted in numerous lost fishing days at the mainstem site, however we were able to generate production estimates, 95% confidence intervals, and coefficient of variation (CV) estimates for Chinook salmon (age 0+), chum salmon (age 0+) and Coho salmon (age 0+). Low catch rates precluded estimates for 1+ salmon and other species of salmon at the mainstem trapping site. Of the fish enumerated, Chinook 0+ were the most abundant species outmigrating from the Elwha River in 2014 ranging between 38,085 and 223,633 (95% confidence interval [C.I.]). We estimated chum salmon smolt production between 3,656 and 21,740 (95% C.I.). The Chinook salmon outmigration estimates for the Elwha River in 2014 were within the range measured in the pre-dam removal period (2006-2011), while those for chum salmon were significantly lower. Given the small numbers of fish captured and number of lost fishing days (>50%) we urge caution in interpreting these early results from the mainstem. For the tributary sites, smolt trapping was nearly continuous and we successfully fished over 90% of potential fishing days. For Indian Creek we were able to develop estimates for Coho salmon (ages 0+ and 1+), Chinook salmon (age 0+) and steelhead (age 1+). In Little River, estimates were made for Coho salmon (ages 0+ and 1+), Chinook salmon (age 0+), pink salmon, and steelhead (age 1+). Indian Creek had consistently higher numbers of outmigrants than Little River for all species except pink salmon. Small numbers of adult pink salmon were relocated to Little River in 2013 and those juvenile outmigrants were thought to be the progeny of those releases. No chum salmon were encountered at either tributary site in 2014. Indian Creek produced an estimated 32,556 Coho salmon (1+) smolts, over seventeen times the number produced at Little River. These fish are progeny of both naturally colonizing fish and adult relocations from the lower river hatcheries first initiated in 2011. Both tributaries showed a dramatic increase in the number of steelhead smolts produced in 2014, two years after wild winter steelhead reintroduction and natural colonization occurred in the tributaries in 2012. We discuss planned 2015 trapping season improvements which include relocation of the mainstem trap, retrofitting of the mainstem trap, and increased use of large sized smolts for trap efficiency tests.

Introduction

Removal of two mainstem hydroelectric dams on the Elwha River was completed between 2011 and 2014. This action was authorized by the Elwha River Ecosystem and Fisheries Restoration Act of 1994 and represents the largest dam removals attempted to date. Dam removal on the Elwha has generated national interest and there is great interest amongst state, federal, and academic scientists to assess the effects of Elwha dam removals on aquatic and terrestrial ecosystems. The response of Pacific salmon is of particular interest, and for the Elwha Project, general monitoring goals have been developed that include: 1) Reestablishing self-sustaining anadromous salmon populations and habitats as quickly as possible, 2) the preservation of native anadromous salmon before, during and after dam removal, and 3) restoring the physical and biological processes of the ecosystem (Ward et al. 2008).

To guide this process the Elwha Monitoring and Adaptive Management (EMAM) plan was developed for federally listed populations of Chinook salmon (*Onchynchus tshawytscha*) and steelhead (*O. mykiss*) (Peters et al. 2014). This plan provides adaptive management targets that affect management actions for the recovery of the populations. EMAM uses performance indicators coupled with management triggers to guide project managers through four stages of recovery including: 1) preservation, 2) recolonization, 3) local adaptation, and 4) viable natural population. Performance indicators used in EMAM are based upon Viable Salmon Population (VSP) metrics including abundance, productivity, spatial distribution and diversity (McElhany et al. 2000). These factors were chosen because they are predictors of extinction, reflect general processes important to salmon and are measurable. They are thus intrinsically typed to recovery of depleted and listed Elwha salmon populations.

Fundamental questions regarding the health and trajectory Elwha River salmon populations can be addressed in whole or partially through smolt enumeration. These include not only abundance and productivity trends, but life history parameters. The Lower Elwha Klallam Tribe (LEKT) established a smolt enumeration program on the Elwha River beginning in 2006. Between 2006 and 2011 the tribe successfully estimated the number of outmigrating Chinook salmon, chum salmon (*O. keta*) and pink salmon (*O. gorbuscha*) smolts using an 8' rotary screw trap fished at river kilometer (Rkm) (0.3). This effort has resulted in estimates of pre-project (dam removal) production for the aforementioned species. Estimation of larger sized Coho salmon smolts and steelhead smolts has been more problematic because of their avoidance behavior relative to the traps. With the onset of dam removal in 2011, trapping conditions have deteriorated as the Elwha River has been transporting large volumes of sediment and wood debris that interfere with trap operations (Warrick et al. in press). In 2012, we were able to generate Elwha mainstem outmigration estimates with some difficulty using a smaller 5' rotary screw trap. However, in 2013 we were forced to abandon mainstem trapping efforts as

the trap was simply overwhelmed with sediment and debris associated with dam deconstruction efforts and no estimates of production were possible. In 2014 mainstem trapping efforts were reinitiated. During the dam removal period, LEKT has focused the majority of its efforts on estimating smolt production from Indian Creek and Little River, two large tributaries located above the former Elwha Dam site. These tributaries have been the site of both natural and human assisted (adult relocations) recolonization events. The Tribe has been able to estimate production for the aforementioned species from the tributaries during the dam removal period.

The objectives of this document are describe and discuss: 1) the field protocols for smolt outmigration data acquisition in the mainstem and tributary sites in 2014; 2) the procedure for deriving a smolt production estimates from raw catch counts in 2014; 3) the sources of uncertainty in the 2014 estimates; and 4) document issues that resulted in a coefficient of variation that was greater than 15% for the 2014 smolt outmigration estimates.

Methods

Mainstem Site/Trap Selection

In 2014 we utilized similar site selections previously established by LEKT for the tributary sites, with a major site modification based on physical changes in the mainstem following dam removal. For the mainstem site, we moved the fishing site from Rkm 0.3 upstream to the Spruce Hole at Rkm 4.43 (Figure 1). The former site has changed due to aggradation and is at least for the short term unfishable. The pool in which the trap was floated has completely filled and the site is less than 1.0 m deep at lower flows. The new site at Rkm 3.3 is located between two engineered logjams and has a pool sufficiently deep to support the trap. It is important to note that spawning does occur below this point. For example approximately 15% of all the Chinook salmon redds were located below the 2014 screw trap location. Changes in stream channel morphology have not only affected the mainstem fishing site, but also the size of trap used. During the pre-dam removal period (2006-2011), LEKT utilized an 8' rotary screw trap fished at Rkm 0.3 (Figure 2). However, as dam removal progressed the pool at Rkm 0.3 rapidly filled and was reduced from greater than 3.0 m to less than 1.0 m in depth. This forced a reduction in the size of trap to a 5' screw trap (Figure 3) that LEKT could physically operate during 2012-13 seasons. During 2014 we again used the 5' screw trap. The smaller trap has a lower efficiency than the larger trap as it fishes a smaller cross-sectional area of the rivers flow. However, the larger screw has a much larger pontoon structure and requires a minimum of 1.5 m of depth to float. In 2014 the river would not support the larger trap and we were forced to use the smaller trap. It is anticipated that after dam removal is completed in 2014, the river will slowly begin to come into balance with its sediment supply and pools will again form. Once that occurs, LEKT will reinitiate mainstem trapping efforts using the 8' screw trap.

Tributary Site/Trap Selection-2014

LEKT established tributary smolt monitoring sites on Little River in 2012 and Indian Creek in 2013. Because of the difficulty accessing those drainages, we choose county road bridge crossings as low as possible in each tributary. The bridges make for convenient launch sites and we contracted a local crane operator for deployment and retrievals. For Little River, we used the bridge crossing on Hot Springs Road located at Rkm 0.5 (Figure 4). For Indian Creek, we used the bridge crossing on Aldwell Reservoir Road located at Rkm 0.6 (Figure 5). Both crossings are maintained by the Clallam County Road Department and their permission was obtained to utilize these sites. On Little River the fishing site supports a standard 5' screw that floats in a pool approximately 1.5 m deep. The Indian Creek site is narrower and shallower and to fish this site effectively LEKT fabricated a 4' screw on a narrower pontoon. Both traps have fished with excellent results to date and it is not anticipated that additional changes will be made at the tributary sites.

Season of Operation-2014

During the pre-project period, mainstem trapping operations were initiated in mid to late February and continued until late June. These dates were predicated by flow and tidal conditions in the early portion of the season and interactions with releases of millions of Chinook salmon smolts from the WDFW hatchery in the later season. LEKT is aware that these dates are not ideal in terms of capturing the early portion of chinook outmigration (Weinheimer & Zimmerman 2012) and has committed to initiating mainstem trapping efforts in late January to early February, if possible. The end of trap operations will be determined by catch rates. During the pre-dam removal period, the mainstem trap catches tended to drop toward zero by later June. In other Puget Sound drainages chinook outmigration is typically bimodal, with earlier peaks dominated by small recently emerged migrants and later peaks dominated by larger parr migrants that rear in freshwater for several months (Kinsel et al. 2008; Kiyohara and Zimmerman 2012). As Chinook salmon colonize areas above the dam it is anticipated that a bimodal outmigration pattern will redevelop similar to other Puget Sound rivers. In 2014 LEKT commenced trapping operations in the mainstem on February 5th and ceased trapping efforts on July 22. For both tributary sites, trapping commenced on February 5th and ceased June 27th at Little River when low flows precluded trap operations. Fishing was prolonged in Indian Creek until July 9 when daily catches trended toward zero.

Daily Operations-2014

During the pre-dam removal period, the mainstem 8' screw trap was fished continuously (24 hours/day) except when flows exceeded ~2000 cfs (~56 cubic meter/second (cms)). Since dam removal was initiated in 2011, sediment and debris entrained in the river have greatly reduced

the time that the trap has been able to fish. Trapping operations were, in fact, abandoned in 2013 because of these issues. The existing trap box is essentially a welded steel box with an opening on the top to access fish and clean debris. During the peak of dam removal we found that the box would quickly be overwhelmed with sediment and debris (Figure 6). Because crews assigned to the Elwha trap sites also had responsibility for the Little and Indian traps as well as series of fence weir traps in the western Strait of Juan de Fuca, they could not stay on the Elwha mainstem site except for morning and evening checks, precluding the possibility of regular cleaning of the trap.

In 2014 LEKT made several modifications to the mainstem trap including: 1) modifications to the trap box, 2) keeping a crew at the trap during daily operations for continuous cleaning and fish enumeration, and 3) sampling as much as possible during a given 24 hour period to accommodate the extra effort associated with maintaining personal on the trap during fishing, and safety concerns. We modified the trap box by cutting a large hole in the bottom and welding 3/16" mesh screen to the opening. In theory this should allow the box to be cleaned efficiently while still retaining fish. In 2014, we also added a two person crew on the mainstem trap dedicated only to Elwha fishing operations. This allowed the trap to be continuously cleaned and catch enumerated while fishing.

In 2014 high flows in excess of the 2,000 cfs (56 cms) mainstem safety threshold occurred frequently and resulted in the termination of fishing for safety purposes on at least a dozen occasions. The longest event occurred from March 5 to March 31, unfortunately during the period of peak Chinook salmon outmigration in 2014. This event impacted smolt trapping operations throughout western Washington (Joe Anderson, WDFW, Personal Communication). In total we were able to fish the mainstem trap for 82 of the 168 (49%) total fishing days in the 2014 fishing season. During 2014 fishing was not impacted as in past years, by fine sediment and fine woody debris (Figure 5). Modifications to the trap box worked well and the sheer volume of fine woody debris was much reduced over the 2013 season. However, the trap itself was physically damaged from impact with fluvially transported large wood (Figure 7) on at least two occasions. This caused further reductions in fishing time while the trap was removed and repaired.

For the tributary sites, the traps were almost fished continuously except during three brief flood events in February and March. Indian Creek for a total of 154 out of 164 (94%) fishing days and for Little River we fished a total of 145 out 153 (95%) possible fishing days. Trapping operations were impacted at Little River during the February 5 event by fluvial debris (Figure 8). However, the trap was not seriously damaged by the event.

For all trap sites, captured fish were removed from the trap box using small dip (aquarium) nets and transferred to plastic buckets for identification. Each fish was individually examined and identified to species and immediately released downstream of the trap. A weekly subsample of all species caught was measured and weighed. A subsample of larger smolts from the tributaries were also tagged with 12 mm PIT tags (up to a total of 500 fish for each tributary). Both Indian Creek and Little River have PIT antenna arrays and tagging of smolts will allow estimation of smolt to adult survival in those tributaries.

In order to evaluate catch efficiency (proportion of total outmigrants captured), we attempted to conduct continuous mark recapture tests at all three sites. Several trap efficiency trials had to be cancelled as a result of interruptions in fishing because of floods and damage to traps. On the two tributaries, weekly samples of 50 to 100 fish, representative of the species migrating at any given time (i.e. Chinook salmon smolts, coho salmon parr, coho salmon smolts), were given a distinctive mark. For the mainstem trap site, because of the relatively low numbers of total fish captured, we used releases of 1000-1500 0+ Chinook salmon obtained from the Washington Department of Fish and Wildlife (WDFW) hatchery for trap calibration. At all sites we used Bismark brown dye to give the fish a distinctive mark, readily recognizable by trap personnel. This is a non-toxic organic dye that is absorbed into the fish's skin resulting in a brown coloration that contrasts well with silvery smolts. The mark fades over time but generally is visible for 7 to 10 days following marking. The subsample of marked smolts was released 100 to 150 m above each tributary trap site and approximately 500 m above the mainstem site. The percentage of smolts recaptured was highly variable depending upon flow and site conditions. In general, the tributary sites had relatively high recapture rates (0.0-46%) while the mainstem site had relatively low recapture rates (0.8-2.8%). Trap calibration tests for 2014 are summarized in Table 1.

Data Analysis

The sum of daily catch data will be used to estimate total production for the season. Based on past experience, we expect to be able to enumerate pink salmon, chum salmon, Chinook salmon and possibly Coho salmon. Sockeye salmon are currently considered effectively extirpated from the Elwha and we have never encountered sockeye smolts in our trapping program, although some adults are observed in the river each year.

To incorporate uncertainty due to periods of missing data and expansion based on trap efficiency we applied a parametric bootstrap approach. This approach provides more flexibility to account for large gaps in the data and small counts.

1. A spline (smooth nonlinear curve) was fit to the catch time series using a Generalized Additive Model (GAM) with a negative binomial distribution.
2. This model was then used to simulate catches for all days with data.
3. A spline was then fit to this simulated data (parametric bootstrap, again using a GAM).
4. This was used to simulate catches for the days with missing data (imputing) to produce a complete catch time series.
5. Catch was summed for each efficiency period. Here efficiency period refers to the interval of time for which a specific efficiency test is used to expand catch.
6. For each efficiency period recaptures were simulated by drawing from a binomial distribution where p is estimated as actual recaptures/number released (parametric bootstrap).
7. This value of recaptures is then used to create an estimate of total outmigrants for each efficiency period, and these estimates are summed to get an estimate of the total number of outmigrants.
8. Steps 2 – 7 are repeated N (e.g. 1000) times to generate N estimates.
9. The mean of these values is the point estimate and the 0.025 and 0.975 quantiles are the 95% C.I.

Steps 2-4 were used to generate many possible values for the missing catch data while taking uncertainty in the trend in catch into account. Steps 5-7 were used to incorporate uncertainty in the efficiency estimates into the expansion of the catch estimates. This approach was applied to all species/age class combinations for which the fish used in the efficiency tests are similar in size during the migration period.

For catch series which were clearly truncated (trap operation started after significant migration began or trap operation ended before migration ended), the catch data was augmented to include the estimated period of migration using days with hours fished = 0. When this occurred we also added a day to the beginning and/or end of the time series with hours fished = 24 and catch = 0 in order to anchor the GAM estimates. This allows for missing data at the beginning and end of the time series while adding the assumption that no fish will pass before and after these two dates respectively. For days with some but not all hours fished, total catch was calculated as: $(\text{simulated catch for day}) * (1 - \text{hoursFished})/24 + \text{observed catch}$.

There are several approaches that can be used to generate estimates, all of which involve some subjectivity. It is important to look at the detailed results for all of the population so that we can be confident that the different estimation steps make sense (i.e. filling in the catch gaps, and accounting for uncertainty in trap efficiency).

Results

Smolt trapping on the Elwha River was successfully completed, albeit with a number of difficulties particularly at the mainstem site, where there were multiple breaks in fishing due to flows and mechanical breakdowns. During the 2014 trapping season we incurred multiple flows that exceeded the safe operating conditions for the mainstem trap, including an early March event that exceeded 12,000 cfs (340 cms) (Figure 9). Based upon our experience operating the 5' screw trap in the Elwha, operations became unsafe in flows exceeding ~2,000 cfs (~56 cms). Additionally, the river in the spring of 2014 was still impacted by changes associated with the dam removal project, namely an increase in the transport of wood. The combination of high flows and increased wood supply led to an increase in the rate of collisions between the trap and large pieces of wood floating downriver.

Damage to the trap was inevitable and led to additional loss of fishing time. Despite the loss of slightly over half the potential fishing days in the mainstem, we were able to generate estimates of smolt outmigration for Chinook salmon (0+) and Coho salmon (0+) despite relatively low catch rates for those species (Table 2). However, no estimates were made for pink and chum salmon, Coho salmon (1+), Chinook salmon (1+) and steelhead due to the very low catches of those species and/or the lack of efficiency data for a similar sized fish (i.e. Coho salmon (1+), Chinook salmon (1+) and steelhead). Low capture rates of large bodied smolts such as coho 1+ and steelhead have been problematic since smolt trapping was initiated on the Elwha in 2006. Larger bodied smolts appear to be more able to avoid capture in the trap and this phenomenon has been observed at other trapping sites in western Washington (Personal Communication, Joe Anderson, WDFW). Chinook salmon (0+) and Coho salmon (0+) were the most common species captured in the mainstem trap, however their numbers were very low. Outmigration estimates of 100,396 Chinook salmon (0+) and 20,036 Coho salmon (0+) salmon were generated for the Elwha River in 2014. These estimates should be used with care given the number of missing days and the resulting interpolation necessary. It should be noted that these estimates are only for natural origin fish. Catches of hatchery reared fish are noted in the field data sheets but are not included in these estimates. Elwha hatchery produced fish can generally be recognized by the presence of unique marks such as adipose clips or the presence of coded wire tags (Coho salmon), or by size, physical appearance and the timing of release (Chinook salmon (0+), steelhead).

In contrast to the mainstem site, tributary trapping was generally seamless with only brief breaks in fishing operations due to brief periods of elevated streamflow. Both Indian Creek and Little River traps fished approximately 95% of the total potential fishing days and fishing was mostly around the clock. As a result the confidence intervals and estimates of variation were much better than for the mainstem trap site. We generated estimates for Chinook salmon (0+),

Coho salmon (0+), Coho salmon (1+), pink salmon, chum salmon, and steelhead at Little River (Table 3). Estimates for Chinook salmon (1+) at Little River were not possible due to the small numbers of individuals encountered. Species specific estimates were made for Chinook salmon (0+), Coho salmon (0+), Coho salmon (1+), and steelhead only at Indian Creek (Table 4). No Chum salmon or pink salmon were captured at Indian Creek in 2014 and therefore no estimates were made for outmigrating smolts. Only two Chinook salmon (1+) were captured at Indian Creek in 2014 and therefore no estimates were generated for that species and life history combination.

We compared total outmigration estimates between tributaries and found some striking differences in abundance and life histories (Figure 10). For Coho salmon (0+) large numbers of fry outmigrants were moving downstream, presumably to rear in other habitats or immigrating to the Strait of Juan de Fuca. This life history pattern has been documented in other nearby Strait of Juan de Fuca watersheds (Bennett et al. 2014) and is likely confirmed by the estimated outmigration of 7,576 Coho salmon (0+) at the mainstem trap. For Coho salmon (1+) smolts Indian Creek produced an estimated 32,556, seventeen times what was estimated to be produced at Little River in 2014. Both Coho salmon age classes were progeny of adults that were relocated from downstream hatcheries in 2012 and 2013 as well as natural recolonizing fish.

The numbers of outmigrating Chinook 0+ were also greater from Indian Creek relative to Little River. These numbers likely reflect the numbers of adult Chinook salmon that spawned in each system in 2013 (58 in Indian Creek and 23 in Little River). Small numbers of pink salmon were captured at the Little River trap, but were not encountered in Indian Creek. The pink salmon were likely progeny of adult relocations from the Lower Elwha Klallam Tribal Hatchery. In 2013 a total of 33 pink salmon (15 males, 18 females) surplus to the hatchery brood collection were released into Little River between September 20 and 27. No chum salmon were captured at either tributary trap site.

For steelhead, Indian Creek produced approximately 100 more outmigrating smolts than Little River in 2014. Steelhead adults were first observed in both tributaries during the spring of 2012. Assuming two years of freshwater residency, 2014 represents the first significant smolt production for both tributaries in over a hundred years. Small numbers of steelhead smolts were observed in Little River in 2012 (2 total) and 2013 (24 total) and from Indian Creek in 2013 (16 total). These were likely the progeny of resident rainbow trout populations that have retained anadromous life histories. This strategy has been previously documented in the Elwha during downstream fish passage studies in the late 1980's (Hiss and Wunderlich 1994) and in recent genetic analysis of Elwha wild steelhead (Unpublished Data, Gary Winans, NOAA) from 2013 and 2014.

We assembled the miscellaneous species catch records for all three trap sites that included three year classes of trout (*O. mykiss*), bull trout, brook trout, cutthroat trout plus all non-salmonids (Table 5). No total production estimates were made for these species however total catches were summarized and analyzed for ecological significance. For trout it is interesting to note that higher numbers of 0+, 1+ and 2+ age classes were captured at Little River than in Indian Creek. This trend included bull trout where we caught approximately 3.5 times the number than in Indian Creek. In contrast we captured 11 cutthroat smolts in Indian Creek and 0 in Little River. Anadromous forms of cutthroat trout were thought to be rare on the Elwha, at least prior to dam removal. Indian Creek/Lake Sutherland harbor what appears to be the largest source of cutthroat trout in the Elwha watershed and it will be interesting to see if there is a “reawakening” of this life history form in the Elwha over time. Such recolonization appears to be occurring for Pacific Lamprey (*Entosphenus tridentatus*) in Little River, where adult captures were first documented in 2013 and again in 2014 at the smolt trap. Juvenile Brook lamprey (*Lampetra richardsoni*) were also captured at the Indian Creek Trap. We expect that downstream migrating ammocetes from Pacific Lamprey will eventually be encountered at Indian Creek, however this is not anticipated for several more years because of their prolonged freshwater residency estimated at 5-6 years (Scott and Crossman 1973).

Discussion

Removal of two mainstem hydroelectric dams on the Elwha River was completed between 2011-2014. This is the largest intentional dam removal attempted to date and is of great scientific interest in terms of the recovery of the ecosystem and its historically large salmon populations. Long term monitoring of the response of salmon to dam removal is ongoing on the Elwha and smolt enumeration programs are a critical component of that effort. Smolt trapping on the Elwha was initiated in 2006 and the period from 2006-2011 represents pre-project conditions when anadromy was limited to 7.9 kilometers of degraded habitat and hatchery production dominated salmon returns. Smolt outmigration estimation from 2012-2014 represents the production of salmonids during dam removal period. This period is characterized by the highest rates of sediment transport as the river now can access and transport over a hundred years of accumulated sediment in the former reservoir bottoms. Mainstem smolt trapping efforts during the dam removal period have been challenging and in 2012 and 2013 we were forced to abandon trapping because of the very high level of sediment and debris interfering with trap operations. 2014 was also problematic but primarily due to elevated spring flows and large woody debris. The fact that we were able to generate any mainstem estimates at all is encouraging. We believe that the worst of the impacts from dam removal on smolt trapping operations have already occurred. In 2015 salmon now have potential access to the extent of historic habitat much of it in pristine condition within Olympic

National Park. In the years to come we are prepared to measure the post-project response. This includes generating estimates of productivity (smolts/spawner).

Despite relatively low catches and loss of fishing time mainstem smolt estimates were made for Coho and Chinook salmon (0+) in 2014 on the Elwha River. Estimates for other species were not possible due to the combination of low catch rates and the lack of calibration data for larger sized smolts. The outmigration estimates for Elwha Chinook salmon smolts ranged between 100,396 and 230,729. This is within the range of production measured from the Elwha River during the pre-project period. However this estimate should be used with care given the amount of interpolation necessary to fill in missing catch data. In 2013, adult Chinook salmon escapement to the Elwha River was the highest in over two decades and a total of 765 individual redds were counted downstream of Glines Canyon Dam. Because of the consistently elevated sediment supply from dam removal, it was hypothesized that egg to emergence survival of Chinook salmon that spawned in 2013 would be low. Our catch estimation data would seem to support that hypothesis; however an alternate explanation is that we missed too many days of fishing including the peak outmigration period during the month of March and therefore underestimated the actual outmigration. It should be noted that the winter of 2013 was characterized by low to moderate flows without large discharge events. It is possible that the 2013 Chinook salmon cohort actually performed better than our trap estimates indicated.

We compared the outmigration timing of Chinook and Coho salmon outmigrants from both tributary sites (Figure 11). In general, outmigration was earlier for Chinook salmon 0+ and both age classes of Coho salmon from Indian Creek as compared to Little River. For Chinook salmon 0+ the bulk of outmigration was completed by second week of March, while in Little River it was completed by the first week of April. For Coho salmon yearlings outmigration timing was about a month earlier between systems. These differences appear to be temperature driven. Little River has a northern aspect and drains off Hurricane Ridge and has much greater elevation landforms than Indian Creek. Little River has a snowmelt hydrology while Indian Creek is primarily rainfall driven and moderated by a large lake in its headwaters. As a result, Little River is significantly cooler than Indian Creek. Maximum temperatures in Little River are on the order of 7-10° C while in Indian Creek maximum temperatures average 10-15° C.

The large numbers of Coho salmon 1+ are likely due to the amount and quality of habitat within the sub-drainage. Indian Creek's headwaters include Lake Sutherland which moderates flow and temperature characteristics. Indian Creek also has significant groundwater influence as it flows downstream. A significant Beaver (*Castor Canadensis*) population has also hydro-modified large areas downstream of Lake Sutherland and have created excellent rearing habitat for coho rearing.

Neither tributary has been colonized by significant numbers of returning adult chum. The lack of chum and pink salmon to both tributaries is a serious concern to project co-managers. There is concern that passage conditions at the former Elwha Dam site are problematic for some species and at some flows (ONP 2014, WDFW 2014). Comparison of historic photographs prior to dam construction with post dam removal conditions suggests that the site is currently significantly steeper (cascade versus pool). It is apparent that a significant amount of boulder debris was left in place in the channel creating numerous hydraulic jumps that are difficult for fish to ascend. The lack of chum and pink salmon upstream of Elwha Dam would seem to corroborate those observations.

Sources of Error

While we have strived to keep the aforementioned sources of uncertainty low in order to stay within a coefficient of variation of 15% or less, the realities of maintaining in-stream infrastructure in a large Olympic Peninsula river continuously for up to 7-8 months inevitably involves the possibility of unknown circumstances reducing the amount of data collected and thereby the accuracy of our outmigration estimates. This phenomenon is exacerbated by the current situation of active dam removal procedures on the Elwha River. The biggest source of uncertainty confronting smolt trapping programs on the Elwha in 2014 were the number of days lost to fishing as a result of flows and debris at the mainstem site. We were only able to fish the mainstem trap on 82 of 168 (49%) of the potential fishing days in the 2014 season. While the modifications made to the mainstem trap prior to the 2014 season allowed the trap to fish (as opposed to 2013), it was still apparent that when flows exceeded ~2,000 cfs (~56 cms), implementing the trap becomes dangerous and above those flow thresholds the trap cannot be fished at all as the pressure on the trap increases to the point of jeopardizing or possibly destroying the trap itself. Collisions with fluvial transported wood occurred on several occasions and resulted in significant damage to the trap itself that caused a cessation of fishing of approximately 3 weeks. In contrast, fishing on the tributaries was relatively trouble free and over 90% of the potential fishing days were fished and continually per 24 hour day.

The CV for mainstem trapping estimates ranged from 24% to 42% in 2014. Tributary sites had lower coefficients of variation for 2014. Little River ranged from 15% for Coho salmon (0+) to 46% for pink salmon. Indian Creek ranged from 26% for steelhead to 35% for Chinook salmon (0+). During the pre-dam removal period (2005-2011) our annual CV on the mainstem Elwha ranged from 5.5% to 28%, with only two of seven years exceeding the 15% threshold. These differences are largely due to the larger 8' trap used during pre-dam removal and the number of lost fishing days experienced in 2014. The two tributary sites also had higher CVs than desired. This was likely negatively affected by trap efficiency tests that resulted in very small numbers of recaptures on two tests in Little River and for three tests on Indian Creek. LEKT is

uncertain why this occurred given the large numbers of naturally migrating fish that were captured in the tributary traps during the tests. Possible explanations include mortality from handling or predation after release. Analytical methods for attenuating the effects of these extreme values are discussed below.

The other source of significant uncertainty is the amount of missed production from areas below the mainstem and tributary trapping sites. The decision to move the mainstem trap upstream was necessary to physically be able to fish the trap in 2014. Prior to dam removal a significant portion of the total natural spawning occurred below river mile 2.5. This percentage appears to be changing as fish have gained access to new spawning site above Elwha Dam and in 2014 the first documentation of chinook salmon ascending above Glines Canyon Dam occurred (McHenry et al. 2015). The challenge of estimating smolt production below the mainstem trap is formidable during dam removal. There is simply no good method to estimate spawner abundance, survival from those spawning events or smolt abundance in the lower river below the trap. Redd counting is impossible for most of the year because of turbidity. Low flow counts of chinook have been attempted during 2012 and 2013, however no estimates of spawner abundance were made. For these reasons, we did not attempt to estimate production below the mainstem trap site in 2014. The best solution to this problem will be to relocate the trap to lower mainstem site (Rkm 0.3) as soon conditions allow.

Recommendations

Based on our experiences conducting smolt trapping on the Elwha River during the dam removal period we will implement the following changes for 2015 operations. For the mainstem Elwha River trapping effort we will relocate the trapping operation downstream to the lower river site at Rkm 0.3. A shallow pool has reformed there and while not deep enough to support the 8' screw trap, we believe it will support the 5' screw trap. This will eliminate one source of uncertainty, the unknown production downstream of the mainstem site at Rkm 3.3. We are also modifying the 5' screw trap for the 2015 season by changing from aluminum to steel pontoons to make it more stable and durable. We have contracted the construction of new pontoons using ¼" steel. The newly fabricated pontoons are also larger and the trap will be more stable and better able to withstand collisions with wood being carried downstream during floods. This new and more stable fishing platform should be able to fish at higher flows than the aluminum version and result in a higher percentage of total fishing days.

The problem of low catch rates for larger sized smolts at the mainstem trap will be partially addressed by increasing fishing time as outlined above. In theory more fishing time should result in higher catches of large smolts such as steelhead and Coho salmon 1+. However, the other problem for these species is the expansion of raw catch estimates to generate production estimates. To date all mainstem trap efficiency tests on the Elwha River have relied on small

sized hatchery produced smolts including Chinook salmon (0+), chum salmon (0+) and Coho salmon (0+). These sized fish are generally available and were convenient to use for trap efficiency tests. In 2015 we propose to add trap tests using larger sized hatchery origin smolts including Coho salmon 1+, steelhead, and Chinook salmon 1+. Alternatively we may consider marking larger sized smolts at the tributary sites to provide animals for mark-recapture evaluations on the mainstem. All other trapping operations, including timing and daily trap inspections are anticipated to remain unchanged. No modifications are proposed for the tributary sites.

We will continue to refine our estimation approach in an attempt to reduce the sensitivity of the analysis to extreme efficiency values while still maintaining defensible assumptions. In particular we will investigate hierarchically modeling the efficiency estimates which would provide a compromise between taking the average over all periods and using the individual estimates (e.g. Bonner and Schwarz 2011). This will reduce the effects of extreme efficiency trials while still allowing for variation in efficiency over time. We will also further investigate the sensitivity of the estimates to violations of the model assumptions (Rawding and Rodgers 2013).

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Tables

Table 1. Results of mark-recapture tests for Elwha River, Indian Creek and Little River for the 2014 smolt outmigration season

Site	Date	Species	Number	Recaptures	Percentage (%)
Elwha	2/27/14	Chinook 0+	1,498	12	0.80
Elwha	4/10/14	Chinook 0+	1,000	19	1.90
Elwha	4/16/14	Chinook 0+	1,000	28	2.80
Elwha	4/22/14	Chinook 0+	1,000	17	1.70
Elwha	5/29/14	Chinook 0+	1,168	15	1.29
<i>Elwha Average</i>			<i>5,664</i>	<i>91</i>	<i>1.61</i>
Little	3/1/14	Chinook 0+	50	16	32.0
Little	3/14/14	Chinook 0+	50	6	12.0
Little	3/19/14	Chinook 0+	50	7	14.0
Little	4/15/14	Coho 0+	25	5	20.0
Little	4/22/14	Chinook 0+	100	12	12.0
Little	5/7/14	Chum 0+	100	0	0.0
Little	5/20/14	Chinook 0+	100	3	3.0
<i>Little Average</i>			<i>475</i>	<i>49</i>	<i>10.3</i>
Indian	2/28/14	Chinook 0+	50	2	4.0
Indian	3/15/14	Chinook 0+	50	3	6.0
Indian	3/24/14	Chinook 0+	50	9	18.0
Indian	3/31/14	Chinook 0+	50	4	8.0
Indian	4/10/14	Coho 0+	100	10	10.0
Indian	4/15/14	Coho 0+	100	14	14.0
Indian	4/23/14	Chinook 0+	100	28	28.0
Indian	5/7/14	Coho 1+	50	23	46.0
Indian	5/17/14	Coho 1+	50	16	32.0
Indian	5/28/14	Coho 1+	50	13	26.0
<i>Indian Average</i>			<i>650</i>	<i>122</i>	<i>18.7</i>

Table 2. Total catch, estimated catch (missing catch estimated), average efficiency (weighting by efficiency period length) , days missed (trap not operational during species migration window), estimated outmigrants, 95% C.I., CV, and geometric CV for smolt outmigration from the Elwha River, 2014 outmigration year. NE = no estimate.

Species	Catch	Days missed	Estimated Total Catch	Average efficiency (weighted)	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	303	85.7	964	0.0133	100,396	56,535-230,729	0.42	0.37
Chinook Salmon(1+)	71	NE	NE	NE	NE	NE	NE	NE
Coho Salmon(0+)	96	89.5	180	0.0148	20,036	13,457-32,332	0.24	0.23
Coho Salmon(1+)	74	NE	NE	NE	NE	NE	NE	NE
Pink Salmon	8	NE	NE	NE	NE	NE	NE	NE
Steelhead	6	NE	NE	NE	NE	NE	NE	NE
Chum Salmon(0+)	21	NE	NE	NE	NE	NE	NE	NE

Table 3. Total catch, estimated outmigrants, 95% C.I., CV and geometric CV for smolt outmigration from Little River, 2014 outmigration year.

Species	Total Catch	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	923	5,757	3,777-11,324	0.33	0.29
Chinook Salmon(1+)	2	NE	NE	NE	NE
Coho Salmon(0+)	1,525	10,040	7,835-13,825	0.15	0.15
Coho Salmon(1+)	286	1,881	1,450-2,647	0.16	0.16
Pink Salmon(0+)	345	2,026	1,251-4,253	0.46	0.37
Steelhead	65	423	319-624	0.19	0.17

Table 4. Total catch, estimated outmigrants, 95% C.I., CV and geometric CV for smolt outmigration from Indian Creek, 2014 outmigration year.

Species	Total Catch	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	2,827	26,350	16,693-54,635	0.35	0.31
Chinook Salmon(1+)	10	NE	NE	NE	NE
Coho Salmon(0+)	4,360	41,487	28,683-76,467	0.29	0.25
Coho Salmon(1+)	3,426	32,556	22,412-57,920	0.29	0.25
Steelhead	53	513	365-880	0.26	0.23

Table 5. Total catch of miscellaneous species of fish encountered at Elwha River, Little River and Indian Creek smolt trap sites, 2014.

Site	0+ Trout	1+ Trout	2+ Trout	Bull Trout	Brook Trout	Cutthroat Trout	Cottids	Redside Shiner	Juvenile Brook Lamprey	Adult Pacific Lamprey
Elwha	5	0	2	5	0	0	4	0	3	0
Little	209	218	76	28	0	0	13	0	1	0
Indian	127	136	68	8	3	11	114	21	132	6

Figures

Figure 1. Elwha River smolt trap locations.

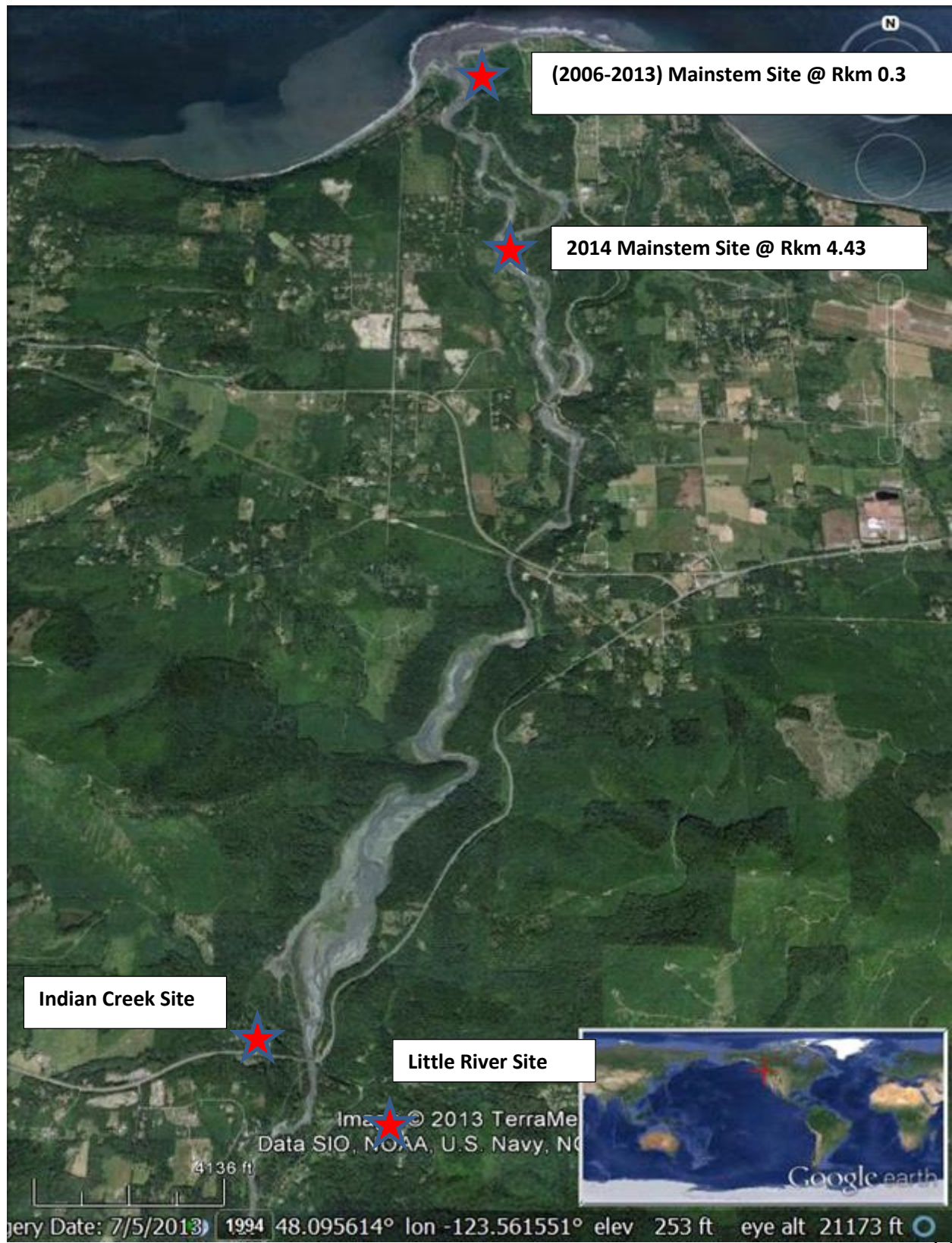


Figure 2. Elwha River 8' rotary screw trap fishing at Rkm 0.3 during the spring of 2010.



Figure 3. Elwha River 5' rotary screw trap fishing at RM 0.2, spring 2014.



Figure 4. Installing Little River screw trap, spring 2014.



Figure 5. Indian Creek 4' screw trap fishing spring 2014.



Figure 6. Mainstem Elwha River smolt trap filled with sediment and woody debris, spring 2013.



Figure 7. Mainstem Elwha River screw trap depicting damage from impact with fluvial transported wood, spring 2014.



Figure 8. Woody debris entrained into Little River rotary screw trap, February 2014.



Figure 9. Elwha River flows (cfs) measured at the McDonald Gage Site, February 5 to July 1, 2014.

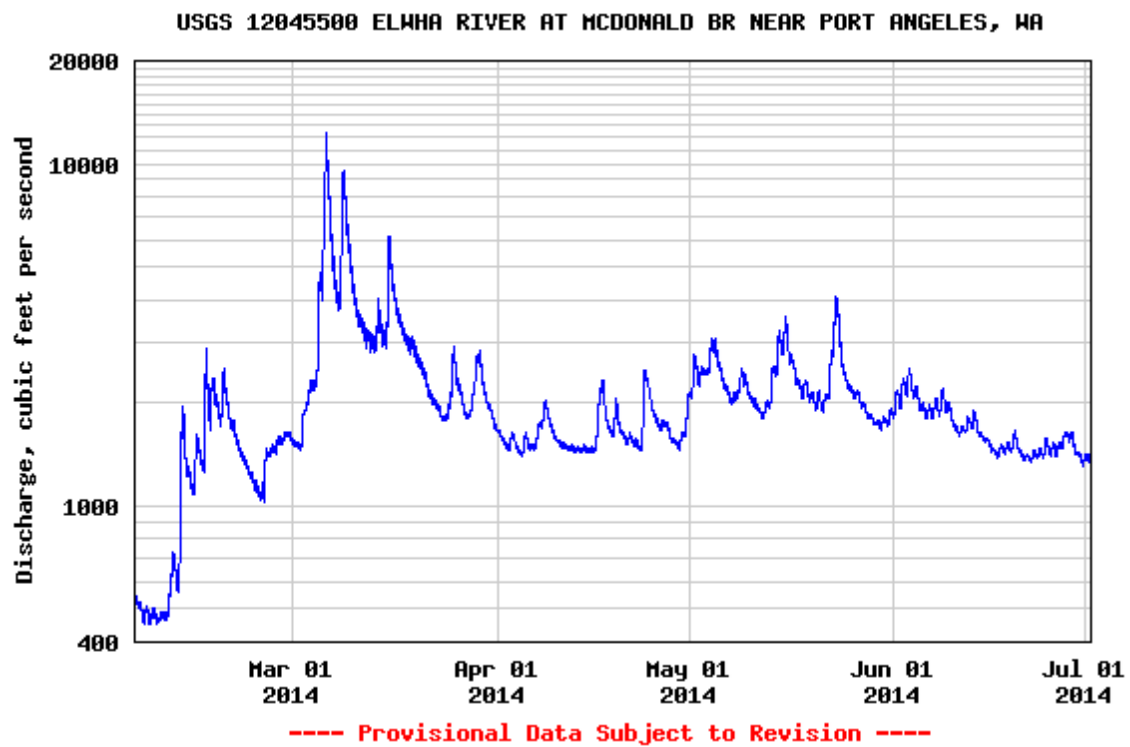


Figure 10. Estimated total outmigrants and 95% confidence intervals (95% C.I.) for Little River and Indian Creek, 2014 outmigration year.

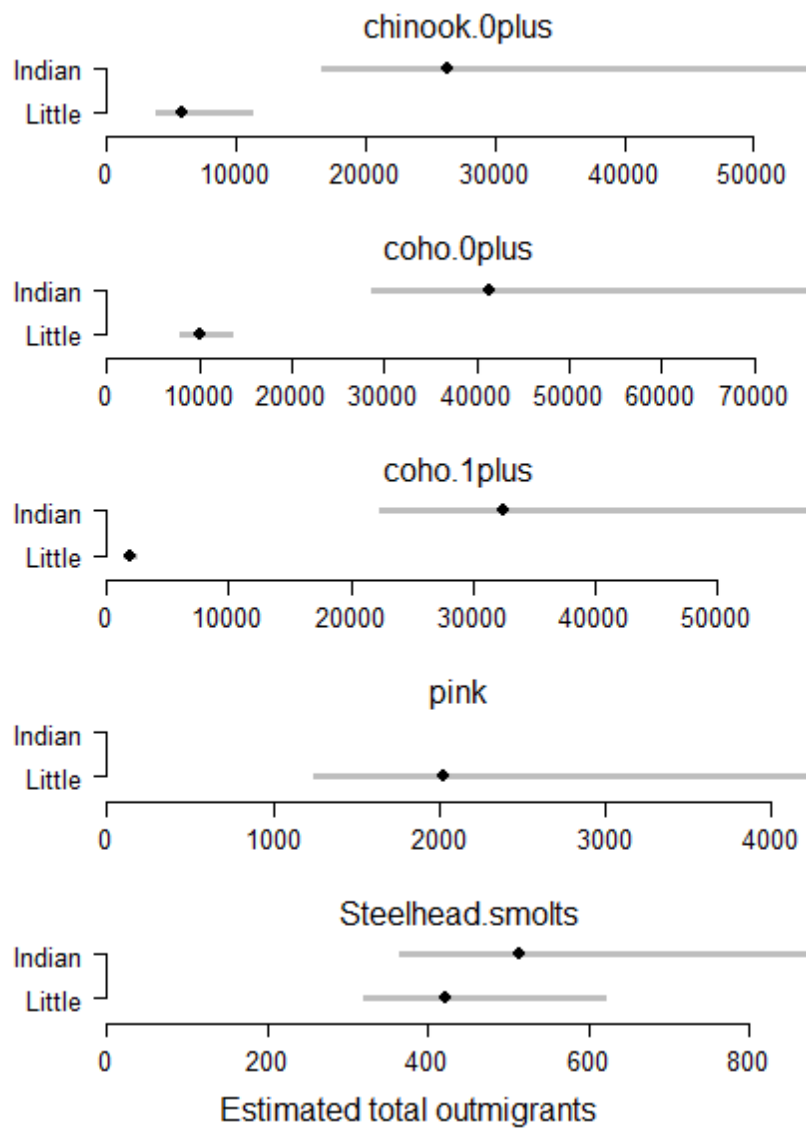
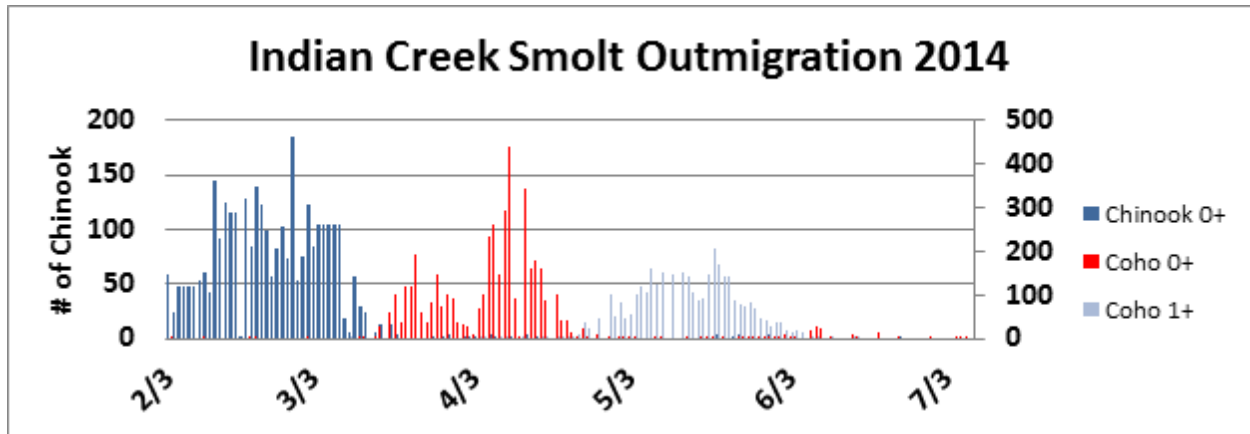


Figure 11. Outmigration timing for Chinook salmon 0+, Coho salmon 0+, and Coho salmon 1+ from Indian Creek (a) and Little River (b), 2014 outmigration season.

(a)



(b)

