

2016 Elwha River Smolt Enumeration Project Report

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Executive Summary

Smolt enumeration monitoring was conducted on the mainstem Elwha River and in two tributaries, Little River and Indian Creek during the 2016 outmigration season. This represents the second year of monitoring in the post dam removal period. River conditions have stabilized over this time span, reducing impacts associated with dam removal. In 2016, at the mainstem site, we generated watershed production estimates, 95% confidence intervals, and coefficient of variation (CV) estimates for smaller bodied (Age 0+) Chinook, Coho, chum and pink salmon. Additionally, estimates were generated for larger bodied (Age 1+) Chinook and Coho salmon as well as steelhead smolts. We estimated a total outmigration of 44,971 (range 24,126-107,386) and 1,567 (range 719-4,524) Chinook 0+ and Coho 0+ smolts, respectively, from the Elwha River in 2016. We estimated a total of 1,850 (range 487-28,180) chum salmon and 2,385 (range 632-20,159) pink salmon outmigrants at the mainstem site during the monitoring period. The relatively low numbers of pink and chum can be attributed to a combination of factors including low population size of those stocks prior to dam removal, low incubation survival during the dam removal period, and missed fishing days during the early portion of season. The 0+ Chinook salmon outmigration estimates for the Elwha River in 2016 fell within the lower end of the range measured in the pre-dam removal period (2006-2011).

The mainstem results strongly suggest that the egg-to-alevin survival of naturally produced salmon in the river continues to be poor, likely resulting from the unstable habitat conditions in the river following dam removal, coupled with a series of high flow events which occurred from November 2015 to March 2016. In 2016, we improved capture efficiency of larger-bodied smolts and were able to generate a steelhead outmigration estimate for the first time. For the Indian Creek site, smolt trapping was nearly continuous; successfully operating for over 90% of potential fishing days. For Indian Creek we generated estimates for Coho salmon (ages 0+ and 1+), Chinook salmon (ages 0+ and 1+) and steelhead. Little River produced low numbers of fish and we only generated estimates for 0+ aged Chinook and Coho as well as 1+ Coho. Indian Creek had consistently higher numbers of outmigrants than Little River for all species and is likely contributing a significant proportion of the total Elwha production for some species such as Coho salmon, steelhead and lamprey. Indian Creek produced an estimated 10,393 Coho salmon (1+) smolts, 91% of the mainstem estimate of 11,448, and an estimated total steelhead outmigration of 1,678 steelhead representing 25% of the total Elwha steelhead production. Pacific lamprey populations also appear to be expanding as the largest numbers of juveniles (ammocoetes) and outmigrating (macrophthalmia) captured to date were encountered in 2016.

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 (PL 102-495) and represents the largest dam removals to date in the United States. The Elwha Act was designed to recover native salmon populations and restore their associated ecosystems. Dam removal on the Elwha has generated national attention and significant interest amongst state, federal, and academic scientists in assessing the effects of dam removals on aquatic and terrestrial ecosystems. The response of Pacific salmon to dam removal is of particular interest and for the Elwha Project recovery goals have been developed that include: 1) the preservation of native anadromous salmon before, during and after dam removal, 2) Reestablishing self-sustaining anadromous salmon populations and habitats as quickly as possible, and 3) restoring the physical and biological processes of the ecosystem (Ward et al. 2008).

To evaluate the salmon recovery process, the Elwha Monitoring and Adaptive Management (EMAM) plan was developed for the federally listed populations of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) (Peters et al. 2014)¹. EMAM provides quantitative performance targets that affect management actions through 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 connected to the recovery of depleted and federally listed Elwha salmon populations. In addition to the EMAM plan, the National Park Service (NPS) has developed and submitted a Chinook and Steelhead Monitoring Plan pursuant to paragraph 6 of the Terms and Conditions and Reasonable and Prudent Measures sections within the July 2, 2012 National Marine Fisheries Service (NMFS) Biological Opinion for the Elwha River Restoration Project (as amended by letter dated November 30, 2012, from NMFS to ONP). This monitoring plan was approved by NMFS on March 7, 2012, and describes the specific tasks that the NPS will undertake to document the impacts of dam removal on listed salmon species and to fulfill the requirements of the Biological Opinion. Smolt outmigration monitoring is one of the required components of the Biological Opinion. This action has been contracted to the Lower Elwha Klallam Tribe.

¹ The Elwha Hatchery and Genetic Management Plan (HGMP) also is being used to evaluate salmon recovery goals in the Elwha River

Fundamental questions regarding the recovery and trajectory Elwha River salmon populations can, in part, be addressed through smolt enumeration. These include not only abundance and productivity trends, but also life history parameters such as the timing and size at outmigration. The trap also can be used to support tagging studies. The Lower Elwha Klallam Tribe (LEKT) established a smolt enumeration program on the Elwha River beginning in 2006. During the pre-dam removal period (2006-2011) 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 fishing at river kilometer 0.3. Funding of trap operations during this period was provided by the Pacific Coast Salmon Recovery Fund (NOAA). 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 problematic because of their relative lack of abundance and their avoidance behavior relative to the traps.

During the dam removal period² (2012-2014), trapping conditions deteriorated rapidly as the Elwha River eroded large volumes of stored sediment and wood debris (Warrick et al. 2015) that interfered with trapping operations. In 2012, Elwha mainstem outmigration estimates were generated with some difficulty using a smaller 5' rotary screw trap. However, in the 2013 season mainstem trapping efforts were abandoned as the trap was overwhelmed with sediment and debris rendering production estimates impossible (McHenry et al. 2014). In 2014, mainstem trapping efforts were reinitiated; however operations were negatively impacted by adverse river conditions and over half the potential fishing days were lost. During the dam removal period, LEKT added two additional trapping sites at Indian Creek and Little River, two tributaries located just above the former Elwha Dam site. These tributaries have been the site of both natural and human assisted (adult relocations) recolonization events. Little River and Indian Creek are also being used as study sites for analyses of movement, growth and survival of native salmon populations. LEKT has successfully been able to estimate production for the five aforementioned species from the tributaries during the dam removal period.

The 2016 trapping season represents the second year of main stem Elwha monitoring following dam removal. The beginning of the post-dam removal period is a significant project benchmark and metrics associated with smolt outmigration will be important for assessing rates of recovery for Pacific salmon. The objectives of this document are to describe and to discuss 1) changes in abundance for natural origin salmon; 2) report on the ecological significance of those changes; 3) refine the field protocols for smolt outmigration data

² Although dam removal was initiated in the spring of 2011 trapping was unaffected by dam removal as significant sediment transport did not begin until the fall/winter of 2012.

acquisition in the mainstem and tributary sites in 2016; 4) describe procedures for deriving a smolt production estimates from raw catch counts in 2016; 5) identify sources of uncertainty in the 2016 estimates; and lastly 6) to document issues that resulted in a coefficient of variation greater than 15% for the 2016 smolt outmigration estimates.

Methods

Site & Operations History

In 2016, similar site selection criteria to those previously established by LEKT were used for the tributary sites, but a major site modification was adopted in the mainstem based on physical changes to the channel following dam removal. Over the trapping period, changes in stream channel morphology during the dam removal process have not only affected the mainstem fishing site, but also the size of trap used. During the pre-dam removal period (2006-2011) river conditions were quite stable and an 8' rotary screw trap was used to fish at Rkm 0.3 (Figure 2). As dam removal progressed into 2013 the pool at Rkm 0.3 rapidly filled with sediment and the water depth was reduced from greater than 3.0 m to less than 1.0 m. This forced the use of a 5' screw trap (Figure 2) used during the 2012-15 seasons. Then, because of increased sediment aggradation in 2013-2014, the site was moved upstream to the Spruce Hole at Rkm 4.43 (Figure 1). However, by early winter of 2015 the lower river site (Rkm 0.3) had evacuated enough sediment to allow the use of the smaller 5' screw trap; and by the 2016 season the site was deep enough to install the 8' screw trap.

During the pre-project and dam-removal periods, mainstem trapping operations began 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 up to 3.5 million of 0+ 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 extending mainstem trapping efforts during the post dam removal period. During the pre-dam removal period, trapping ended when catch rates with mainstem trap tended toward zero; typically by mid to late 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 to many months (Kinsel et al. 2008; Kiyohara and Zimmerman 2012). As Chinook salmon colonize areas above the dams it is anticipated that a bimodal outmigration pattern will redevelop similar to other Puget Sound rivers.

Tributary Sites/Trap Selection-2016

LEKT established tributary smolt monitoring sites on Little River in 2012 and Indian Creek in 2013. Because of the difficulty accessing the lowermost portions of those drainages, county road bridge crossings as low as possible in each tributary were chosen for trap deployment. The bridges make for convenient launch sites (Figure 3) and a local crane operator was contracted for trap deployment and retrievals. The traps were lifted from a transport truck to the river by the crane and deployment was complete in less than 15 minutes. For Little River, the bridge crossing on Hot Springs Road located at Rkm 0.2 was used. For Indian Creek the bridge crossing on Aldwell Reservoir Road located at Rkm 0.6 was used. Both crossings are maintained by the Clallam County Road Department and their permission was obtained to utilize these sites. At the Little River site during 2012-2015 a standard 5' diameter screw on pontoons was installed in a pool approximately 1.5 m deep. In the 2016 the Little River trap was retrofitted with a 4' screw to reduce drag during low flow periods. The Indian Creek site is narrower and shallower and has been effectively covered by a 4' screw trap since the inception of fishing. Both traps have fished with excellent results to date and it is not anticipated that additional changes will be made at the tributary sites.

Daily Operations-2016

In 2016, LEKT commenced trapping operations in the mainstem on February 26 and ceased trapping efforts on August 15. Four days after deployment, prolonged high flows resulted in three consecutive weeks of lost fishing on the mainstem in 2016. For Indian Creek, trapping commenced on January 11 and ceased operations on September 12. At Little River trapping was initiated on January 21 and was concluded on June 16, when the screw ceased turning due to low flows. For several weeks prior to that date, flows were insufficient to consistently turn the screw, likely affecting trapping operations. Field notes indicated that the screw began turning intermittently as early mid-April. During this period, larger fish (Coho 1+, steelhead, trout) were observed swimming in and out of the trap box. This phenomenon greatly affected catch rates and ultimately our ability to generate accurate estimates of larger bodied smolts such as steelhead, 1+ Coho and 1+ Chinook.

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). During the dam-removal period (2011--2014), sediment and debris entrained in the river negatively affected trapping operations. Conditions were so poor in 2013 that trapping operations were discontinued. In 2014, several modifications were made by LEKT to the

mainstem trapping operations including: 1) reduction of the screw size from 8' to 5', 2) modifications to the trap box, 3) maintaining a crew at the trap during daily operations for continuous cleaning and fish enumeration, and 4) as much sampling 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. The trap box was further modified by cutting a large hole in the bottom and welding 3/16" mesh screen to the opening to allow fine sediment to flush during cleaning. In 2014, a two-person crew was dedicated exclusively to mainstem Elwha trap. This allowed the trap to be continuously cleaned and catch enumerated while fishing. These modifications were maintained during the 2015 and 2016 seasons with the exception of replacing the 5' trap with the 8' trap in 2016.

The mainstem trap was launched on February 26 and retrieved on August 15 and fished for 142 of the 171 (83%) total fishing days in the 2016 season. This result was similar to 2015 and was a significant improvement over 2014 when frequent spring freshets resulted in the loss of half the potential fishing days (McHenry et al. 2015). The majority of lost fishing days occurred between March 1-20 (Figure 4), a period during which a large proportion of Chinook, chum and pink salmon were likely outmigrating. Fine sediment and fine woody debris did not impact fishing as during the dam removal period.

For the tributary sites, the traps were also fished nearly continuously except during flood events in February and March. Indian Creek was launched on January 11 and retrieved on September 12 and fished for a total of 222 out of 245 (91%) fishing days, slightly less than in 2014 (94%). Little River was launched on January 21 and retrieved on June 16. The Little River trap fished a total of 131 of 147 (89%) possible fishing days. However trapping operations were impacted at Little River by a rapidly receding snowpack and the trap ceased fishing in mid-June when the screw stopped turning.

Field Methods

At all sites, the traps were inspected and cleaned daily or every other day. All captured fish were removed from the trap box using dip nets and transferred to plastic buckets for identification. Each fish was individually examined for tags or marks, identified to species, counted and immediately released downstream of the trap. All non-native brook trout encountered were lethally removed from the system. A weekly subsample of all species caught was measured and weighed throughout the outmigration period. Fish greater than 55 mm were also scanned for presence of Passive Integrated Transponder (PIT) and coded wire (CWT) tags. PIT tags are being used in the middle Elwha to assess the movements, growth and survival of salmon (Personal Communication, George Pess, NOAA Northwest Fisheries Science Center). All fish that had PIT tags were also identified to species, measured, weighed and their unique

tag number recorded. CWT's are inserted into the snouts of juvenile Coho and steelhead produced at the Elwha Hatchery.

In order to evaluate catch efficiency (proportion of total outmigrants captured), we attempted to conduct continuous mark recapture tests at all three trap sites. However, several trap efficiency trials had to be cancelled due to interruptions in fishing by high-water events. 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 and released above the screw traps. The number captured in the trap was then divided by total released to calculate trap efficiency. For the mainstem trap site, because of the relatively low trap efficiency, we used releases of 1000-1500 0+ Chinook or chum salmon obtained from the Washington Department of Fish and Wildlife (WDFW) and LEKT hatcheries for all trap calibration tests. To assess the efficiency of the mainstem trap for encountering larger bodied smolts we conducted a mark-recapture experiment using natural Coho (1+) smolts emigrating from Indian Creek. We fin clipped a total of 1,391 Coho and released them below the Indian Creek trap. Recaptures ($n=102$) were collected at the mainstem trap and this ratio was used to adjust the total estimated catch for larger bodied smolts at the mainstem trap.

At all sites we used Bismarck 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 (Figure 5). The subsample of marked smolts was released 100 m above each tributary trap site and approximately 1000 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 (Indian Mean 23%/Little Mean 13%). The mainstem recapture rates had higher variability (0.25-28.4%, average=12.2). Trap calibration tests for all sites in 2016 are summarized in Table 1.

Data Analysis

The sum of daily catch data, adjusted on the basis of efficiency trials, was used to estimate total production for the season. To incorporate uncertainty due to periods of missing data and expansion based on trap efficiency we applied a flexible Bayesian model (Appendix A). Daily passage was assumed to follow a negative binomial distribution with a mean constrained to change smoothly with time (a random walk). Catch was modeled as a binomial distribution where the probability of capture was estimated from regular efficiency trials. Period specific efficiencies were assumed to be independent due to observed temporal trends in efficiency for some traps. See appendix A for more details. We summarize the results with the median and

95% credible interval for total passage. Additionally, the coefficient of variation (standard deviation / mean) and the geometric coefficient of variation (which is more appropriate for skewed distributions) are included.

Results

Smolt trapping on the Elwha River was successfully completed at all sites although high flows in the early portion of the season resulted in a number of lost days at the mainstem site which likely affected our estimation of early outmigrating species such as Chinook 0+ chum and pink salmon. The 2016 trapping season was not significantly interrupted by sediment or debris at the mainstem site and river conditions appear to have mostly stabilized following dam removal. During the dam removal period, trapping operations were impacted by sediment and debris leading to numerous lost days of fishing. In 2015 and 2016 the mainstem trap has been fished for a total of 155 of 166 days (93%) and 142 of 171 days (83%), respectively. In comparison during 2014 the mainstem site was fished less than <50% of the days.

Total catch rates for all species remained relatively low on the mainstem Elwha River in 2016. However, with the higher efficiency of the 8' screw trap, along with better trap efficiency testing, estimates were generated for more species/life histories (Chinook (0+), Chinook 1+, Coho (0+), Coho (1+), pink, chum and steelhead (Table 2)) than in any previous year. This is a significant improvement over 2015 when estimates could only be developed for Chinook 0+ and Coho 0+. Estimates for larger bodied Coho salmon (1+), Chinook salmon (1+) and steelhead were possible on the basis of improved capture efficiency and through successful trap efficiency trials using natural Coho (1+) smolts from Indian Creek in a mark-recapture experiment which yielded 7% recapture at the mainstem. Low capture rates of large bodied smolts such as Coho (1+) and steelhead have been problematic since smolt trapping began on the Elwha in 2006. Larger bodied smolts appear to be more able to avoid capture in the trap as has been observed at other mainstem trapping sites in western Washington (Personal Communication, Joe Anderson, WDFW). This result, if repeatable in future years, represents a significant improvement in the overall smolt monitoring program.

In 2016 Coho salmon (1+), steelhead and Chinook 0+ were the most numerous species captured in the mainstem trap, however their numbers were relatively low (755, 433 and 423 total catch, respectively). We estimated a total outmigration of 44,971 Chinook (0+), 1,374 Chinook (1+), 1,567 Coho (0+), 11,448 Coho (1+), and 6,622 steelhead for the Elwha River in 2016. The estimate for steelhead is a particularly significant achievement for the program and suggests that natural production of this species may be amplifying rapidly. Low numbers of chum and pink salmon were also encountered and we estimated a total outmigration of 1,850 and 2,385 smolts, respectively. 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, the presence of coded wire tags (Coho salmon), size, physical appearance, or the timing of release (Chinook salmon (0+), steelhead).

The 2016 tributary trapping season was a tale of two sites. Indian Creek was consistently fished with only brief breaks in operations due to periods of elevated streamflow in early spring. Indian Creek continues to be the early star of Elwha salmon recovery and we measured significant increases in production for a number of species. We generated estimates for 0+ Chinook salmon (33,616), 0+ Coho salmon (1,567), 1+ Coho salmon (10,393), and steelhead (1,678) (Table 3). At Little River, trapping was characterized by extremely low catches of all species. As a result, species-specific estimates were only generated for 0+ Chinook salmon (9,860) and 1+ Coho salmon (183) (Table 4). No Chum salmon or Pink salmon were captured at either tributary in 2016 and therefore no estimates were made for those species. No Chinook salmon (1+) were captured at Little River in 2016.

We compared the total outmigration estimates between tributaries and found striking differences in abundance and timing. In past seasons, large numbers of Coho salmon (0+) fry outmigrants were counted moving downstream, presumably to rear in other habitats or emigrating to the Strait of Juan of de Fuca. This life history pattern has been documented in other nearby Strait of Juan de Fuca watersheds (Bennett et al. 2014). This pattern was not observed in 2016, likely because of the record low escapement of Coho salmon in 2015. Indian Creek produced an estimated 1,566 0+ Coho salmon smolts, a decrease of 58% from 2015. In contrast, only 37 0+ Coho and 19 1+ Coho were captured in Little River in 2016. Curiously, despite the large numbers of juvenile rainbow rearing in Little River only 8 steelhead smolts were captured in 2016. In 2015, larger bodied fish were observed swimming in and out of the trap during low flow periods and it is possible that occurred again in 2016.

The number of 0+ Chinook produced from Indian Creek (33,616) was approximately 3.5 times what was estimated at the Little River site (9,860). In 2015 a total of 51 and 18 Chinook redds were observed in Little River and Indian Creek, respectively. The discrepancy between redd counts and fry counts may stem from poor egg to emergence survival in Little River relative to Indian Creek. Additionally, The vast majority of redds were observed above the Little River trap site and below the Indian Creek trap site (McHenry et al. 2016). The estimate of Chinook out-migrants from Indian Creek is also conservative as a significant proportion of redds observed in 2015 were located downstream of the trap site.

Indian Creek produced an estimated 1,678 (1,401-2,051) outmigrating Steelhead smolts in 2016, an increase of 91% over 2015. Steelhead smolt production in Little River in 2016 could not be estimated due to low catch rates (8 captures) and low flow problems previously discussed. Steelhead adults were first observed in both tributaries during the spring of 2012.

Assuming two years of freshwater residency, 2014 represented the first significant smolt production for both tributaries in over a hundred years. The steady increase in smolt outmigration, at least in Indian Creek, suggests recolonization is occurring rapidly. Small numbers of steelhead smolts were first 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 had retained the possibility of 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 (Winans et al. 2017).

Miscellaneous species' catch records were assembled for all three trap sites which included three year classes of trout (*O. mykiss*), sockeye salmon (*O. nerka*), 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. In Indian Creek, 27 sockeye salmon smolts were captured in 2016, marking the second consecutive year the outmigration of sockeye salmon smolts. The origin of these is suspected to be the kokanee population in Lake Sutherland. A significant increase in the numbers of 0+, 1+ and 2+ age classes of trout captured at Indian Creek was recorded in 2016 (2,974, 1,930, 545). Conversely only small numbers of trout were encountered in Little River (73, 216 and 24) (Table 5). This trend was similar to 2015 but opposite of what was reported in 2014 (McHenry et al. 2015) when all ages of trout were more numerous in Little River. In 2016, no bull trout were captured in Little River and 11 were encountered at Indian Creek. Additionally, cutthroat smolts were only encountered in Indian Creek. Anadromous forms of cutthroat trout were thought to be rare on the Elwha, at least prior to dam removal. Indian Creek/Lake Sutherland supports the largest and most diverse source of cutthroat trout in the Elwha watershed, including an adfluvial population that spawns in upper Indian Creek in the fall (McMillan et al. 2015). The presence of cutthroat trout smolts may suggest a "reawakening" of this life history form in the Elwha over time.

Such recolonization also appears to be occurring for Pacific Lamprey (*Entosphenus tridentatus*) in Indian Creek, where adult captures were first documented in 2013 and again in 2014 at the smolt trap. Small numbers (7) Pacific Lamprey were captured in 2015. We believe that the observations of juvenile Brook lamprey (*Lampetra richardsoni*) previously reported (McHenry et al. 2015) at the Indian Creek Trap were incorrectly identified. We now believe these were actually Pacific lamprey ammocoetes. Ammocoetes were first encountered at Indian Creek in 2013, one year following the initial recolonization event by adults in 2012. Lamprey populations appear to be expanding rapidly in Indian Creek. In 2014 132 ammocoetes were captured, in 2015 the number increased to 407, and in 2016 the number increased to 1,805. We previously expected that downstream migrating macrophthalmia from Pacific

Lamprey will eventually be encountered at Indian Creek; however this was not anticipated for several more years because of their prolonged freshwater residency estimated at 5-6 years (Scott and Crossman 1973). However, in 2016 we encountered a total of 71 Pacific Lamprey *macrophthalmia* (Figure 6).

At the mainstem trap, catches of marine species are of ecological significance. In 2016, we report the continued presence of eulachon (*Thaleichthys pacificus*) in the trap with a total catch of 3. This population appears to vary greatly in abundance by year in the Elwha but is consistently observed. In 2015 a large number of eulachon were observed in the lower Elwha River during January and large numbers of bald eagles (>100) were observed fishing for them. In 2016, herring (*Clupea pallasii*) and American Shad (*Alosa sapidissima*) were captured. American shad are not native to the west coast of North America but are well established in the Columbia River. The captured shad were all sub-adults rearing in Puget Sound.

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 Elwha ecosystem and its historically large and diverse salmon populations. Long term monitoring of the response of salmon to dam removal is ongoing on the Elwha and the smolt enumeration programs are a critical component of that effort. Smolt trapping 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 eroded and transported millions of yards of accumulated sediment in the former reservoirs. Mainstem smolt trapping efforts during the dam removal period were challenging, and were abandoned in 2012 and 2013 due to 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. We believe that the worst of the impacts of dam removal on smolt trapping operations have already occurred. The 2015 and 2016 seasons represent the first years of post-dam removal data and provides a benchmark to assess the state of recovery early in the recovery process (recolonization phase).

The return of the 8' screw trap to the mainstem site improved smolt estimation for both small and large bodied smolts in 2016. In 2015 estimates were only made for 0+ Coho and 0+ Chinook salmon on the Elwha River. The outmigration estimates for Elwha 0+ Chinook salmon smolts in 2016 was 44,971 (range 24,126-107,386). This is within the lower end of the range of production measured from the Elwha River during the pre-project period. In 2015, adult

Chinook salmon escapement to the Elwha River was approximately half of what was observed in the previous two years. However, a total of 937 individual redds were counted in the mainstem (McHenry et al. 2016). It was hypothesized that egg-to-emergence survival of Chinook salmon that spawned in 2015 was low as a result of scour and unstable bed conditions during the winter. Catch estimation data would seem to support that hypothesis. It should be noted that the winter of 2015-16 was characterized by multiple large discharge events including six with peak flows greater than 10,000 cfs. Such flows may have produced scour events that exceeded the depth of incubation for Chinook salmon eggs and resulted in high mortality. Negative correlation between peak flows and Chinook survival has been reported in Skagit River (Greene et al. 2005). Adult Chinook salmon did not access areas above Glines Canyon dam during 2015, as full access above the dam was not established until 2016. As a result the distribution of spawners was mostly confined to the mainstem where incubation conditions were hypothesized to be most unstable.

The estimates of Chinook 0+ outmigrants from Indian Creek and Little River was nearly equivalent to that of the estimated total for the Elwha River mainstem trap. This appears to be coincidental and we do not believe that all the natural origin Chinook production is occurring in the tributaries. The majority of the Little River and Indian River Chinook 0+ outmigrants passed their respective trap sites before the Elwha mainstem trap was installed on February 26. If these fish migrated directly to the ocean they would have therefore been missed. Additionally, there is 8 miles of mainstem habitat between the Indian River trap and the mainstem trap. Given that these are 0+ fish, substantial mortality could have occurred between the two traps, especially if they didn't migrate out immediately. Finally, the mainstem trap efficiency was low and the efficiency estimates may be over-optimistic resulting in an underestimate of total Chinook 0+ production.

In 2015, a significant number of adult Chinook ascended Little River and Indian Creek, and 51 and 18 redds, respectively were counted during fall surveys (McHenry et al. 2016). It is estimated that 9,860 and 33,616 0+ Chinook outmigrants were produced in 2015 from these events. This result suggests that egg-to-alevin survival in Little River was likely poor as a result of scour impacts in the winter. Habitat conditions in Little River are considered highly degraded due to historic logging practices (NSD 2016). A habitat restoration project in the lower 1.5 miles of Little River is planned for 2018 and offers an excellent opportunity to assess the effectiveness of those treatments.

The outmigration timing of Chinook and Coho salmon were compared from both tributary sites. In general and consistent with previous years, outmigration timing 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+ in Indian Creek the bulk of outmigration was completed by

second week of March, while in Little River it was completed by the first week of April (Figure 7). For Coho salmon yearlings outmigration timing was about a month earlier between systems (Figure 9). These differences appear to be temperature driven. Little River has a northern aspect, drains off Hurricane Ridge and has much greater elevation profile 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, thus 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. Little River also is severely degraded in terms of in stream habitat features. A recent assessment of the watershed shows that the system has lost most of its in-channel large wood and has incised by 0.5-3.5 meters (NSD 2016), greatly limiting its pool habitat and quality. Without adequate pool structure, juvenile Coho salmon have fewer areas to rear and may be seeking other habitats downstream.

Indian Creek has consistently produced larger numbers of Coho salmon outmigrants relative to Little River over the period of monitoring. Since 2012, surplus Coho adults from the LEKT hatchery have been relocated to the two middle Elwha tributaries (Table 6). All of these relocated fish have been visually tagged using colored spaghetti tags. Based upon observations on the spawning areas of the tributaries, the majority of the Coho spawners to date originated from these relocation efforts (McHenry et al. 2017). While the number of adults relocated into the two tributaries is similar (Table 6), the differences in production are not. The larger numbers of Coho salmon 1+ outmigrants in Indian Creek 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 large Beaver (*Castor canadensis*) population has also hydro-modified large areas downstream of Lake Sutherland and has created excellent habitat for Coho rearing. Interestingly, our estimate of Indian Creek 1+ Coho outmigrants represents 91% of the total production from the Elwha watershed.

Smolt trapping operations have documented several ecologically significant events that suggest the "reawakening" of anadromy or natural recolonization events. Those include the documentation of sockeye salmon smolts from Indian Creek/Lake Sutherland, the natural recolonization of Indian Creek by Pacific Lamprey, and the continued presence of eulachon in the lower river. The Elwha Fisheries Recovery Plan (Ward et al. 2008) indicates that for sockeye salmon natural recovery is the preferred means of rebuilding this stock. Because Elwha sockeye are thought to have extirpated by dam construction, the plan states that the primary mechanism for recovery of sockeye is from adults straying from other watersheds or by contribution of smolts originating from the landlocked kokanee salmon population in Lake Sutherland. While there have been adult sockeye salmon observations in Indian Creek since Elwha Dam was removed, the numbers have been very low and spawning has not been

documented. This would suggest that the Sutherland kokanee population is still producing sockeye smolts, albeit at a very low level. This mechanism has been previously documented in the Coquitlam and Allouette Rivers in British Columbia where sockeye were extirpated by dams constructed in the early twentieth century (Godbout et al. 2011). The retention of anadromous life history by a population of sockeye thought to have been trapped by dam construction in 1914 and retained for 25 generations bodes well for the Elwha River. Indeed, analysis of egg size showed that Sutherland kokanee have a larger egg than other known kokanee populations and are similar only to a land locked population in New Zealand derived from an anadromous population (Quinn et al. 2015). The authors infer that Lake Sutherland kokanee also likely have an anadromous origin. We intend to collect tissue samples from sockeye in future years in order to elucidate the origin of this population.

Neither tributary to date has been colonized by significant numbers of returning adult chum or pink salmon. The lack of chum and pink salmon in 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 have been difficult for some species of fish to ascend at least through the calendar year 2014. Passage conditions appeared to have improved during the winter of 2014-15, following floods that transported several large boulders downstream. However, during the summer of 2015, during very low flow conditions, the base of the former Elwha Dam was discovered. This indicates that the entire structure was not removed and needs to be closely monitored as conditions could change again. The lack of chum and pink salmon upstream of Elwha Dam through 2016 would seem to support those observations³. Similarly, passage through Glines Canyon has only recently been improved, but it is unclear if chum and pink can pass this area. A large rock fall in the canyon entrance shortly following the removal of the structure has largely precluded upstream passage. This obstruction was systematically blasted in the fall of 2015 and will need to be closely monitored. Recovery of upriver populations and life histories is contingent upon successful fish passage at this site.

³ Pink and Chum salmon were observed in moderate numbers above Elwha Dam for the first time in 2015 indicating that passage conditions were adequate during that year. Additionally 11 adult chum were relocated to Indian Creek in 2016. Fish passage conditions through the former Elwha Dam site are dynamic and may change between years and flow conditions.

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 was exacerbated by dam removal and elevated sediment and debris transport on the Elwha River, at least through 2014. In contrast to the dam removal years, when large portions of the fishing season were lost, the biggest source of uncertainty confronting smolt trapping programs on the mainstem Elwha in 2016 was not physical conditions but the low numbers of small bodied fish captured. The CV for mainstem trapping estimates ranged from 23% (0+ Coho) to 26% (0+ Chinook) in 2015. In 2016 CV were higher for smaller bodied outmigrants (range 56-517%) but near targets for larger bodied smolts (17-19%). We expect the CV values to improve over time as populations expand and catch rates rise. During the pre-dam removal period (2005-2011) our annual CV on the mainstem Elwha ranged from 5.5% to 28%, with 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 low number fish encountered in 2015.

In contrast, fishing on the tributaries was relatively trouble free and ~90% of the potential fishing days were fished and continually per 24 hour day. Little River had a slightly higher coefficient of variation for 0+ Coho salmon than in 2015 (the only species estimated). Little River estimated CV was 30% for Coho salmon (0+) and 116% for 0+ Chinook. Indian Creek CV's were improved compared to 2015 and ranged from 10% for steelhead to 35% for Chinook salmon (0+). The high V+CV values in Little River are attributable to both low catch rates due to abundance and flow issues that reduce trap efficiency.

Recommendations

Based on our experiences conducting smolt trapping on the Elwha River during the dam removal period the following changes will be implemented for 2017 operations. In the mainstem Elwha River we will continue the trapping operations at the downstream site at Rkm 0.3. A 1.5-2.0 m deep pool has reformed there and we intend to fish the 8' screw trap in the immediate future. This will increase our overall catch and trap efficiency relative to the 5' trap. The long term future of the mainstem trap site is threatened by the dynamic nature of the river in the vicinity of the trap site. Dramatic changes in channel position may limit our ability to launch the trap from the terminus of Lower Elwha Road. Additionally Lower Elwha Road is threatened by overflow channels that could erode the road to the point that it is no longer accessible to vehicles. If this access point is lost, we propose to move the trap upstream near

the Elwha River Road bridge. This is the only reliable road access point. It places the trap further upstream than desired, but offers the advantage of being above both hatcheries.

The problem of low catch rates for larger sized smolts at the mainstem trap will be partially addressed by attempting to maximize 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 fish were generally available and convenient to use for trap efficiency tests. In 2016 we used marked natural coho 1+ smolts from Indian Creek as test animals for the mainstem trap. This trial was successful and will be repeated in 2017. In 2017 we propose to add trap tests using larger sized hatchery origin smolts including Coho salmon 1+, steelhead, and Chinook salmon 1+. Alternatively we will use larger sized smolts collected 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. We are also considering modifying the Little River screw trap for the 2017 by motorizing the screw (Volkhardt et al. 2007) so that the screw will turn consistently and be able to operate at lower velocities.

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 2016 smolt outmigration season.

Site	Date	Species	Number	Recaptures	Percentage (%)
Elwha	3/21/16	Pink 0+	1000	25	0.25
Elwha	3/28/16	Chinook 0+	1,000	169	16.9
Elwha	4/5/16	Chinook 0+	1,000	87	8.7
Elwha	4/13/16	Chinook 0+	1,000	284	28.4
Elwha	5/4/16	Chum 0+	1,000	68	6.8
<i>Elwha Average</i>			<i>3,000</i>	<i>612</i>	<i>12.2</i>
Little	2/9/16	Chinook 0+	82	8	9.7
Little	2/17/16	Chinook 0+	100	15	15.0
Little	2/28/16	Chinook 0+	100	9	9.0
Little	4/4/16	Chinook 0+	100	17	17.0
Little	4/13/16	Chinook 0+	100	13	13.0
Little	5/16/16	Chinook 0+	100	19	19.0
Little	5/25/16	Chinook 0+	50	4	8.0
<i>Little Average</i>			<i>632</i>	<i>85</i>	<i>13.4</i>
Indian	1/20/16	Chinook 0+	200	32	16.0
Indian	2/9/16	Chinook 0+	71	20	28.1
Indian	3/17/16	Chinook 0+	100	16	16.0
Indian	3/21/16	Chinook 0+	100	10	10.0
Indian	3/28/16	Chinook 0+	100	9	9.0
Indian	4/4/16	Chinook 0+	100	18	18.0
Indian	4/13/16	Chinook 0+	100	43	43.0
Indian	5/16/16	Coho 1+	100	29	29.0
Indian	5/25/16	Coho 1+	45	8	17.8
Indian	6/7/16	Chinook 0+	50	30	60.0
<i>Indian Average</i>			<i>966</i>	<i>225</i>	<i>23.3</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 mainstem Elwha River, 2016 outmigration year. NE = no estimate.

Species	Catch	Estimated Total Catch	Average efficiency (weighted)	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	423	604	0.0697	44,971	24,126- 107,386	0.92	0.43
Chinook Salmon(1+)	86	98	0.0756	1,374	960- 3,672	0.85	0.36
Coho Salmon(0+)	38	45	0.1749	1,567	719- 4,524	0.56	0.49
Coho Salmon(1+)	755	837	0.0741	11,448	9,124- 16,250	0.19	0.15
Chum Salmon	15	59	0.0613	1,850	487- 28,180	5.17	1.34
Pink Salmon	13	63	0.0278	2,385	632- 20,159	1.99	1.05
Steelhead	433	482	0.0730	6,622	5,222- 9,022	0.17	0.14

Table 3. Total catch, estimated outmigrants, 95% C.I., CV and geometric CV for smolt outmigration from Indian Creek, 2016 outmigration year.

Species	Total Catch	Estimated Total Catch	Average Efficiency (weighted)	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	4,309	5,969	0.1961	33,616	22,407-78,671	0.35	0.30
Chinook Salmon(1+)	4	NE	NE	NE	NE	NE	NE
Coho Salmon(0+)	282	348	0.2951	1,566	1,184-2,321	0.20	0.18
Coho Salmon (1+)	3,616	3,618	0.3766	10,393	8,795-12,565	0.09	0.09
Pink Salmon(0+)	7	NE			NE	NE	NE
Chum Salmon(0+)	8	NE			NE	NE	NE
Steelhead	517	521	0.3684	1,678	1,401-2,057	.10	0.10

Table 4. Total catch, estimated outmigrants, 95% C.I., CV and geometric CV for smolt outmigration from Little River, 2016 outmigration year.

Species	Total Catch	Estimated Total Catch	Average Efficiency (weighted)	Estimated Outmigrants	95% C.I.	CV	gCV
Chinook Salmon(0+)	735	1,138	0.1217	9,860	4,825-41,097	1.16	0.06
Chinook Salmon(1+)	4	NE	NE	NE	NE	NE	NE
Coho Salmon(0+)	37	38	NE	NE	NE	NE	NE
Coho Salmon(1+)	19	21	0.1263	183	104-325	0.30	0.29
Pink Salmon(0+)	0	NE	NE	NE	NE	NE	NE
Chum Salmon(0+)	0	NE	NE	NE	NE	NE	NE
Steelhead	8	NE	NE	NE	NE	NE	NE

Table 5. Total catch of miscellaneous fish encountered at Elwha River, Little River and Indian Creek smolt traps, 2016.

Site	0+ Trout	1+ Trout	2+ Trout	Bull Trout	Brook Trout	Cutthroat Trout (Smolts)	Cottids	Redside Shiner	Ammocoete	Macrothallimia	Adult Pacific Lamprey
Elwha	8	17	5	4	0	0	78	2	13	2	7
Little	73	216	24	0	0	0	1	0	0	0	0
Indian	2,974	1,930	545	11	89	1	125	198	18805	71	13

Table 6. Adult Coho relocations and redd counts to Little River and Indian Creek 2011-2015.

	Indian Creek		Little River		Mainstem	
	Transfer	Redds	Transfer	Redds	Transfer	Redds
2011	134	95	137	-	326	Not Surveyed
2012	162	38	60	8	None	Not Surveyed
2013	596	126	442	160	None	Not Surveyed
2014	124	30	None	5	None	Not Surveyed
2015	None	0	None	NS*	None	Not Surveyed

Figures

Figure 1. Elwha River smolt trap locations.

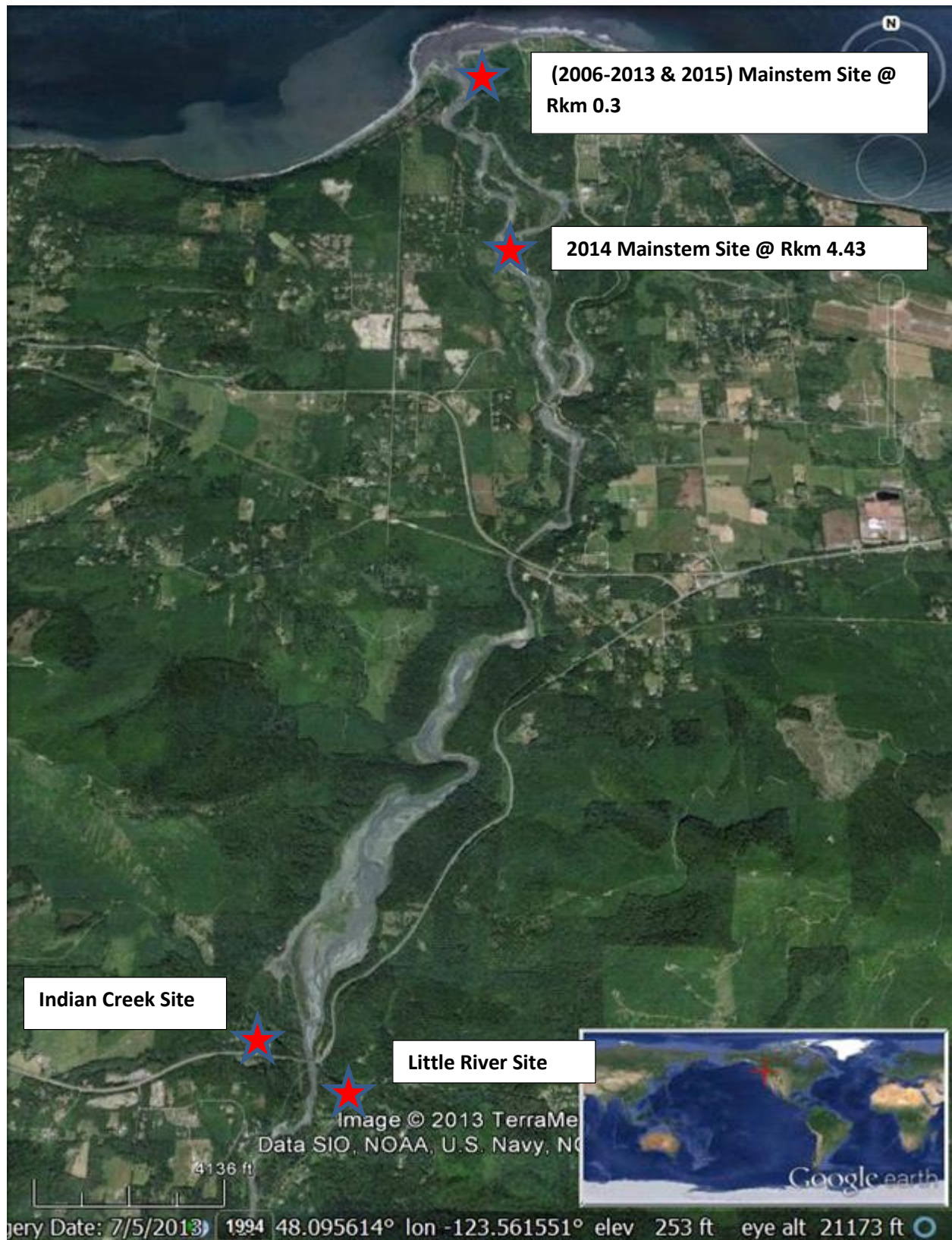


Figure 2. Top Elwha River 8' rotary screw trap fishing at Rkm 0.3 during the pre-dam and post-dam removal periods and bottom 5' rotary screw trap used during dam removal.



Figure 3. Little River (top) and Indian Creek smolt traps.



Figure 4. Elwha River flows (cfs) measured at the McDonald Gage Site, January 1 to July 1, 2016.

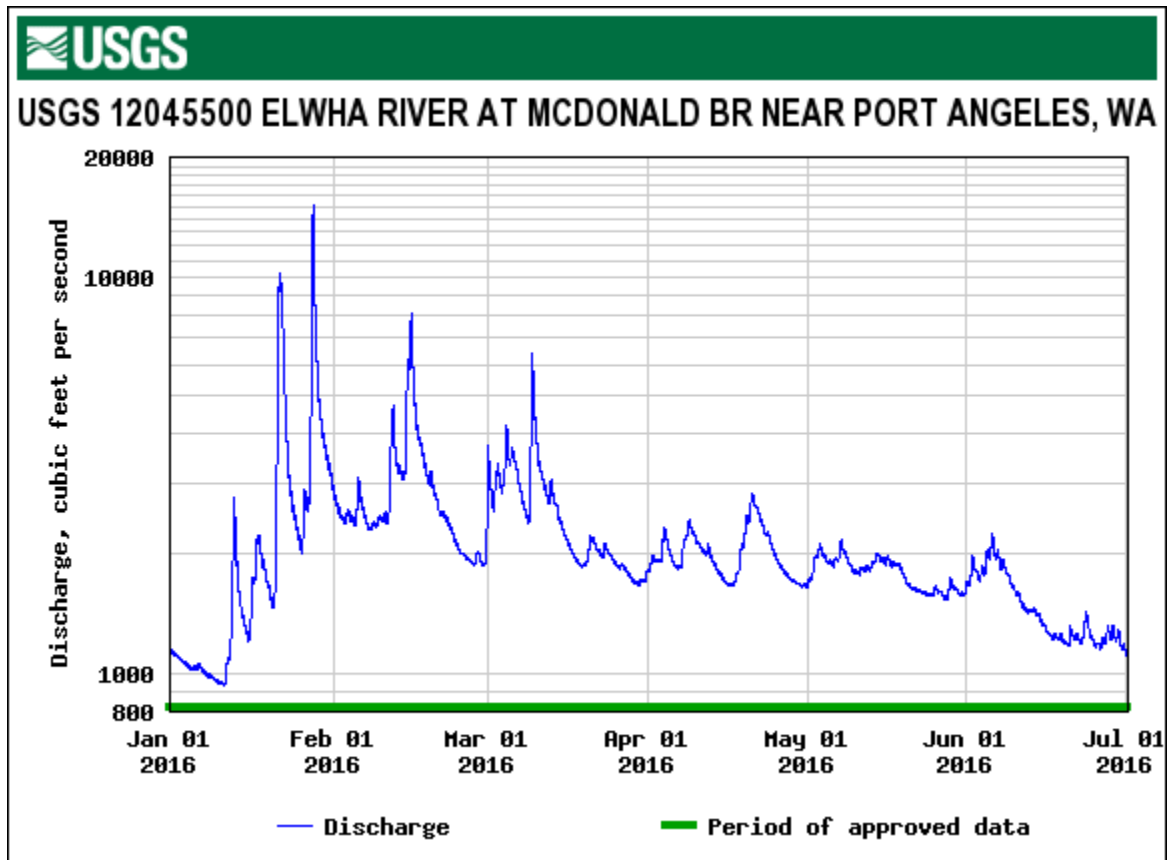


Figure 5. Bismarck brown marked 1+ Coho salmon for mark-recapture trap calibrations.



Figure 6. Pacific Lamprey ammocoetes (top) and macrophthalmia (bottom) captured at Indian Creek trap.



Figure 7. Length of Chinook outmigrants at Indian, Little and mainstem Elwha Trap Sites during 2016.

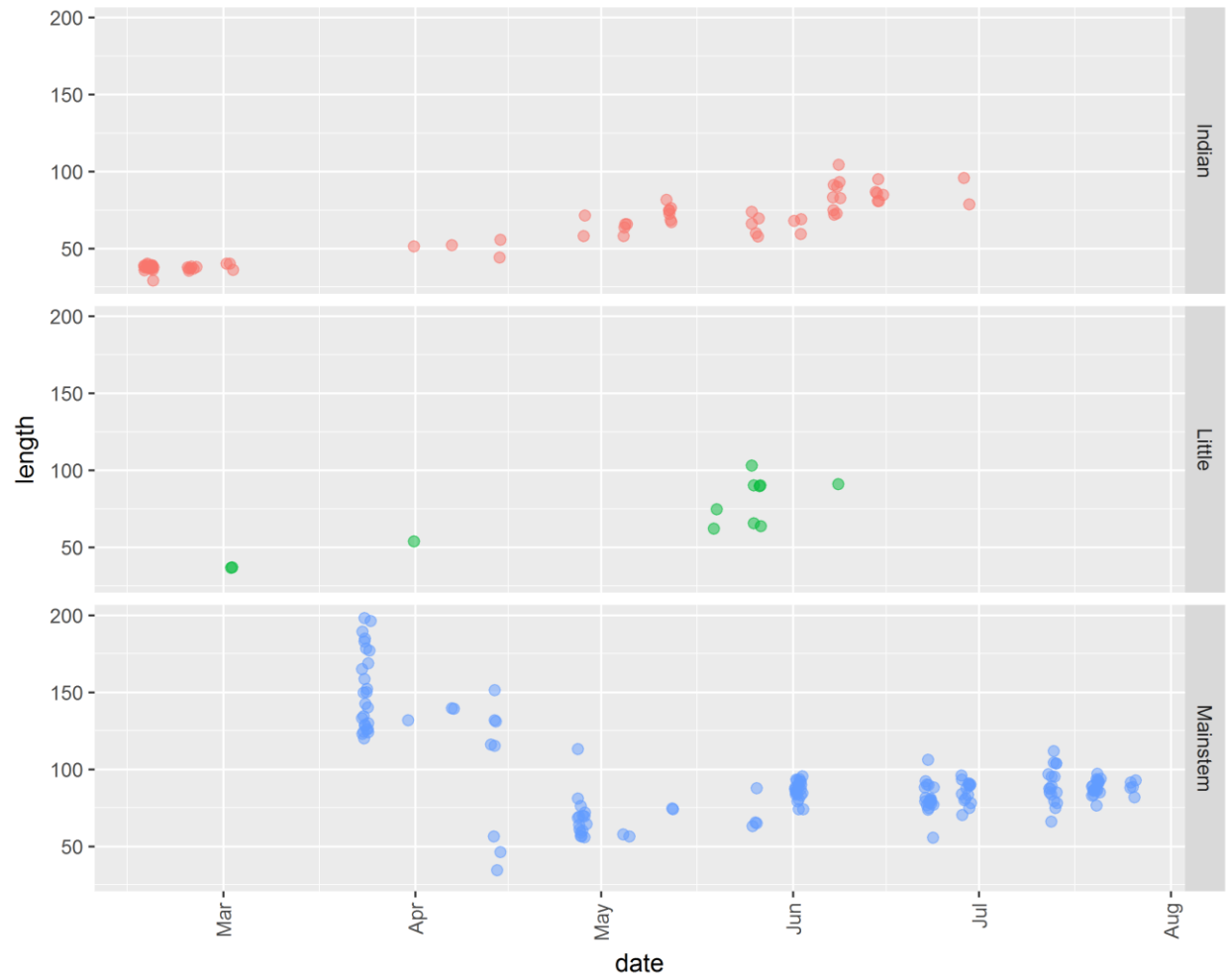


Figure 8. Length of *O. mykiss* outmigrants at Indian, Little and mainstem Elwha Trap Sites during 2016.

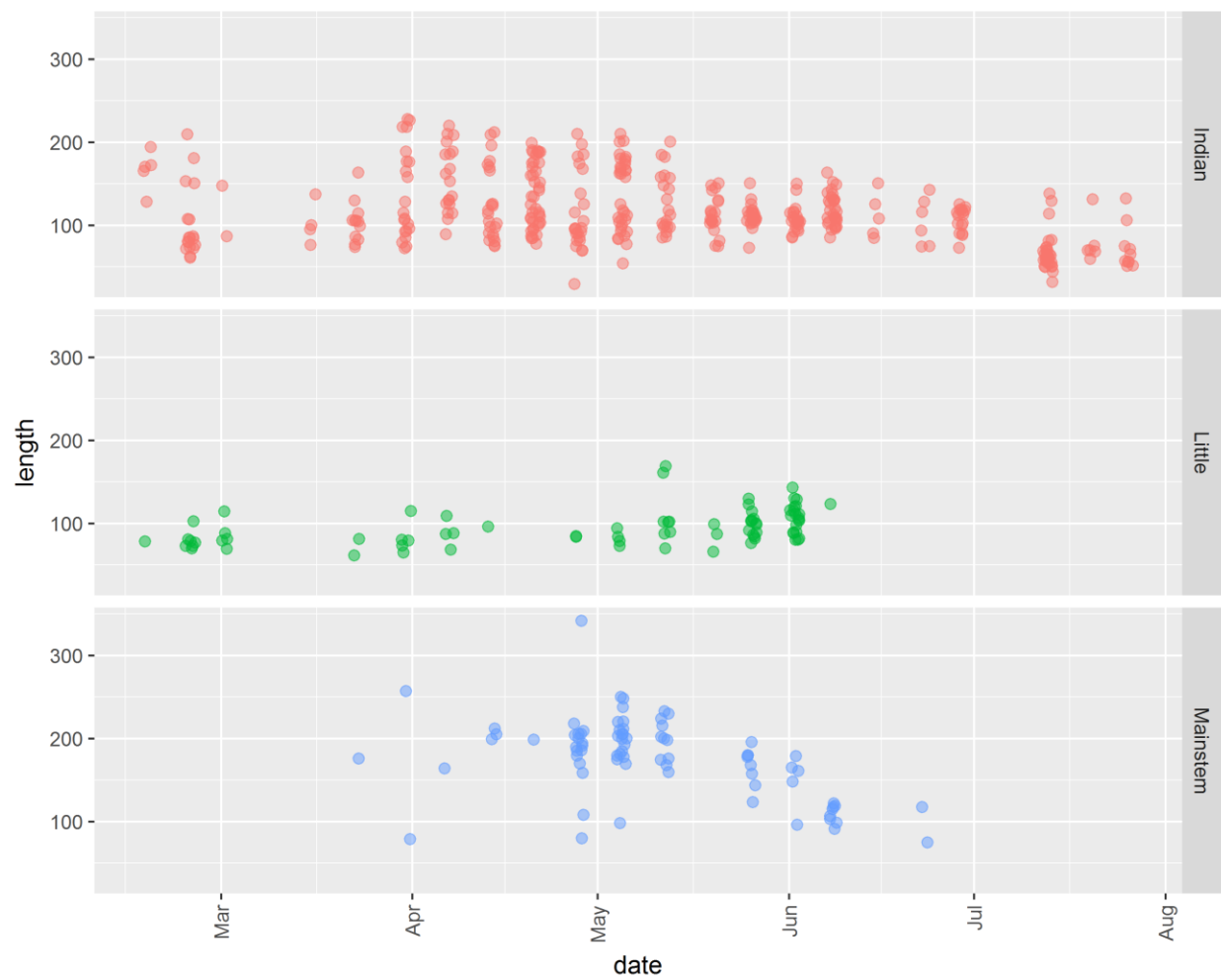


Figure 9. Length of Coho outmigrants at Indian, Little and mainstem Elwha Trap Sites during 2016.

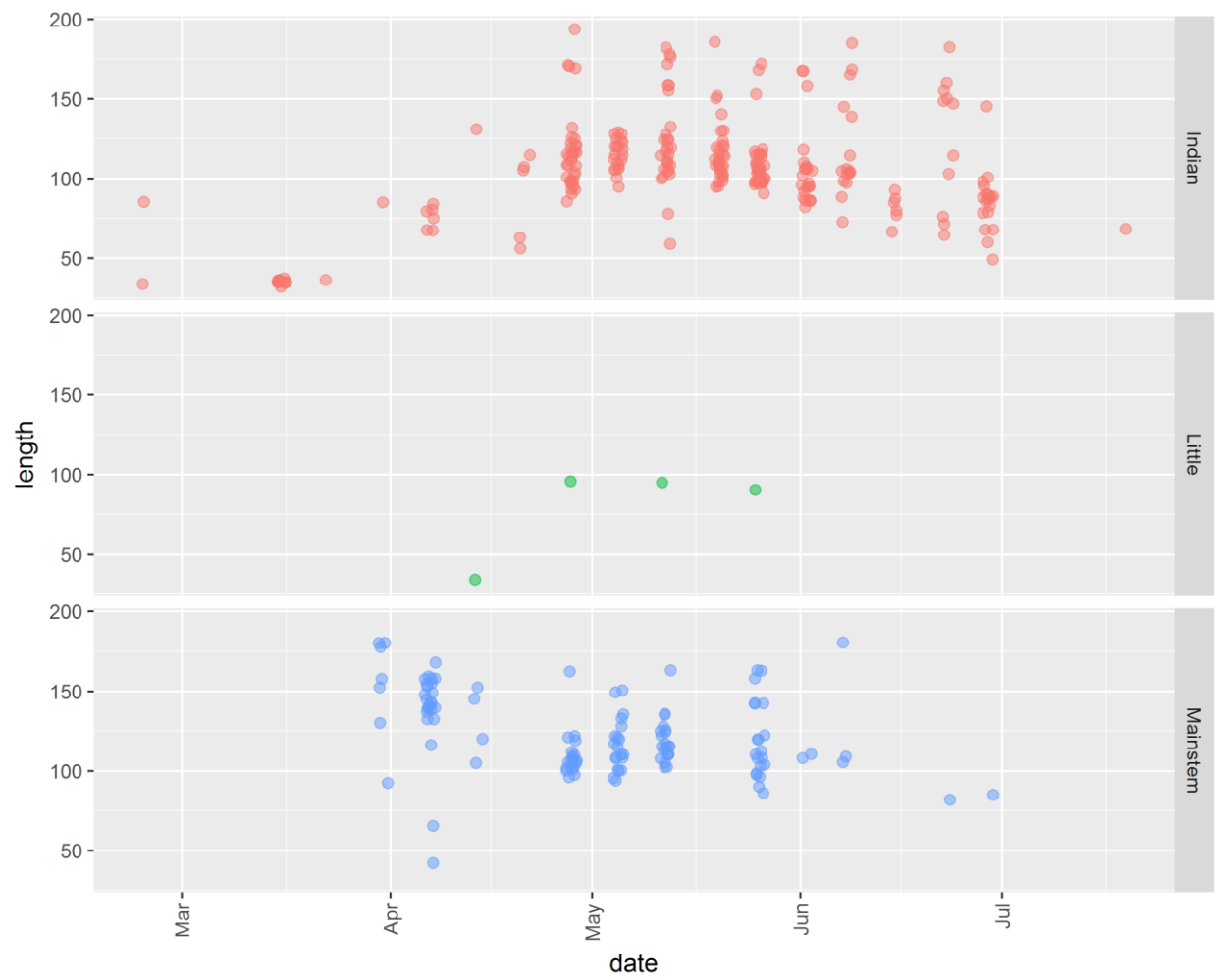
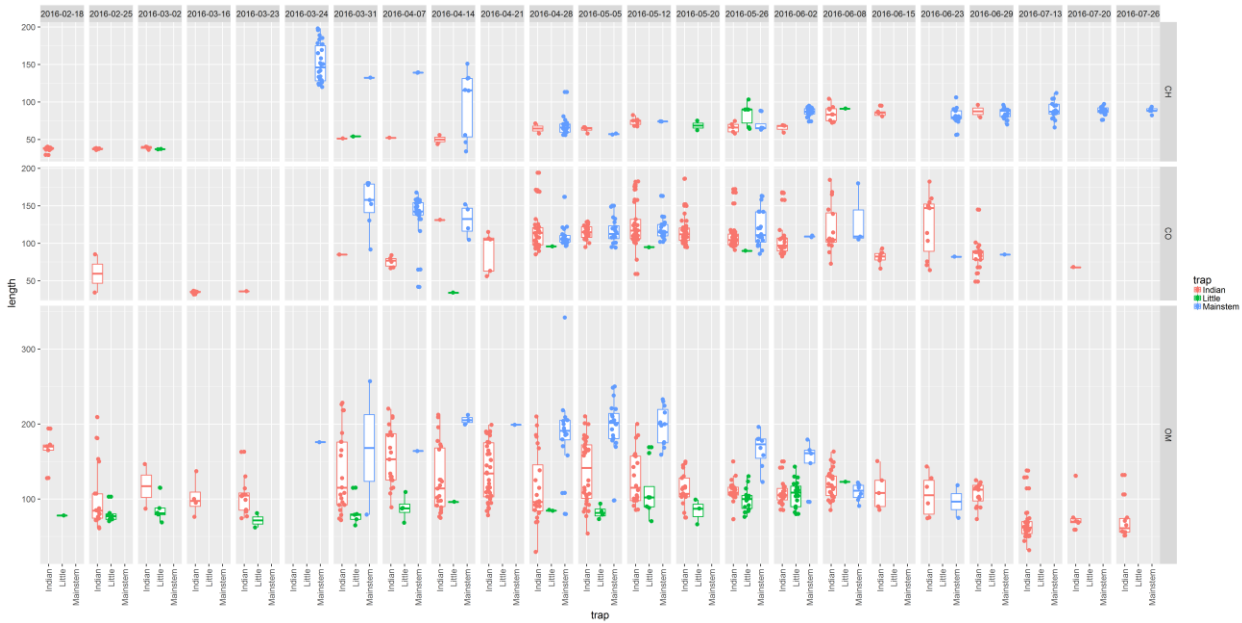


Figure 10. Length of Chinook, Coho and mykiss by date and trap site during the 2016 outmigration season, Elwha River.



Appendix A.

Total passage past the trap (T_i) was assumed to follow a negative binomial distribution. This allows for over-dispersed counts (i.e. more variability than expected based on other distributions such as the poisson).

$$T_i \sim \text{negbinom}(\text{mean}_i \text{days}_i, \text{disp}_i)$$

$$\log(\text{disp}) \sim \text{normal}(0, 100)$$

Where the mean daily passage is a temporal random walk with the variance of the jump size proportional to the number of days the trap was fished before it was checked (days). This allows the mean to change from day to day but only incrementally.

$$\log(\text{mean}_i) \sim \text{normal}(\log(\text{mean}_{i-1}), \text{rwSD}_i \text{days}_i^{-1/2})$$

$$\text{rwSD}_i \sim \text{normal}(0, 100)$$

The observed catch (C_i) was modeled as a binomial distribution where a period specific proportion (p_i) of total passage past the reader (T_i) was captured.

$$C_i \sim \text{binomial}(p_i, T_i)$$

The proportion captured by the trap (i.e. the efficiency, p_i), was estimated from efficiency trials where a large groups of marked fish (M_j) were released above the trap and the number of marked fish recaptured at the trap (R_j) was recorded.

$$R_j \sim \text{binomial}(p_j, M_j)$$

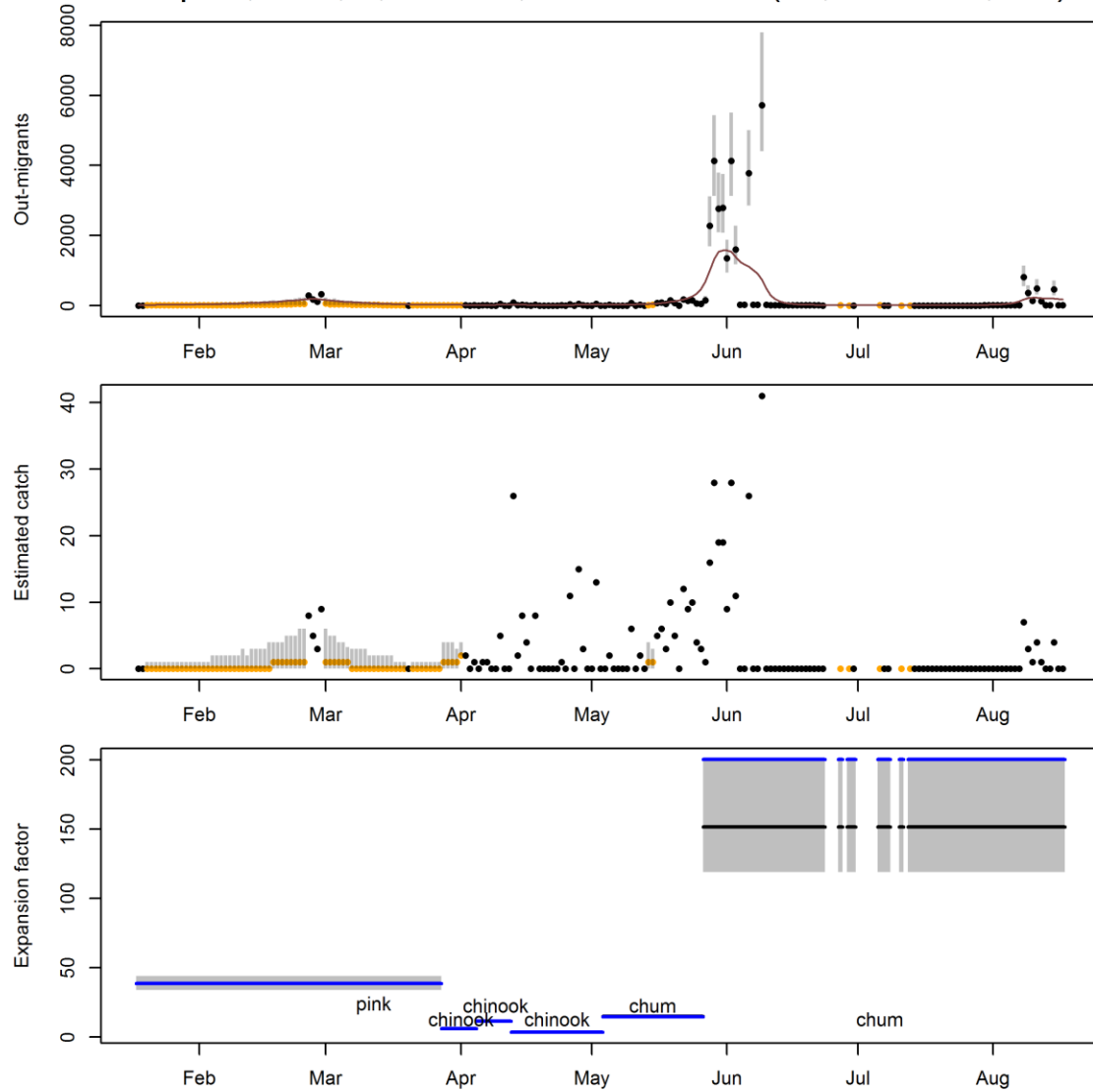
$$p_j \sim \text{beta}(1, 1)$$

The models were implemented in the JAGS software (Plummer 2003) and the R language (R Core Team 2015) was used for all synthesis. Chains were run until the model appeared to converge. Visual inspection of the trace plots and the Rhat statistic were used to assess convergence and determine the appropriate number of simulations. Model fit was also examined using plots of the data with estimated quantities overlaid.

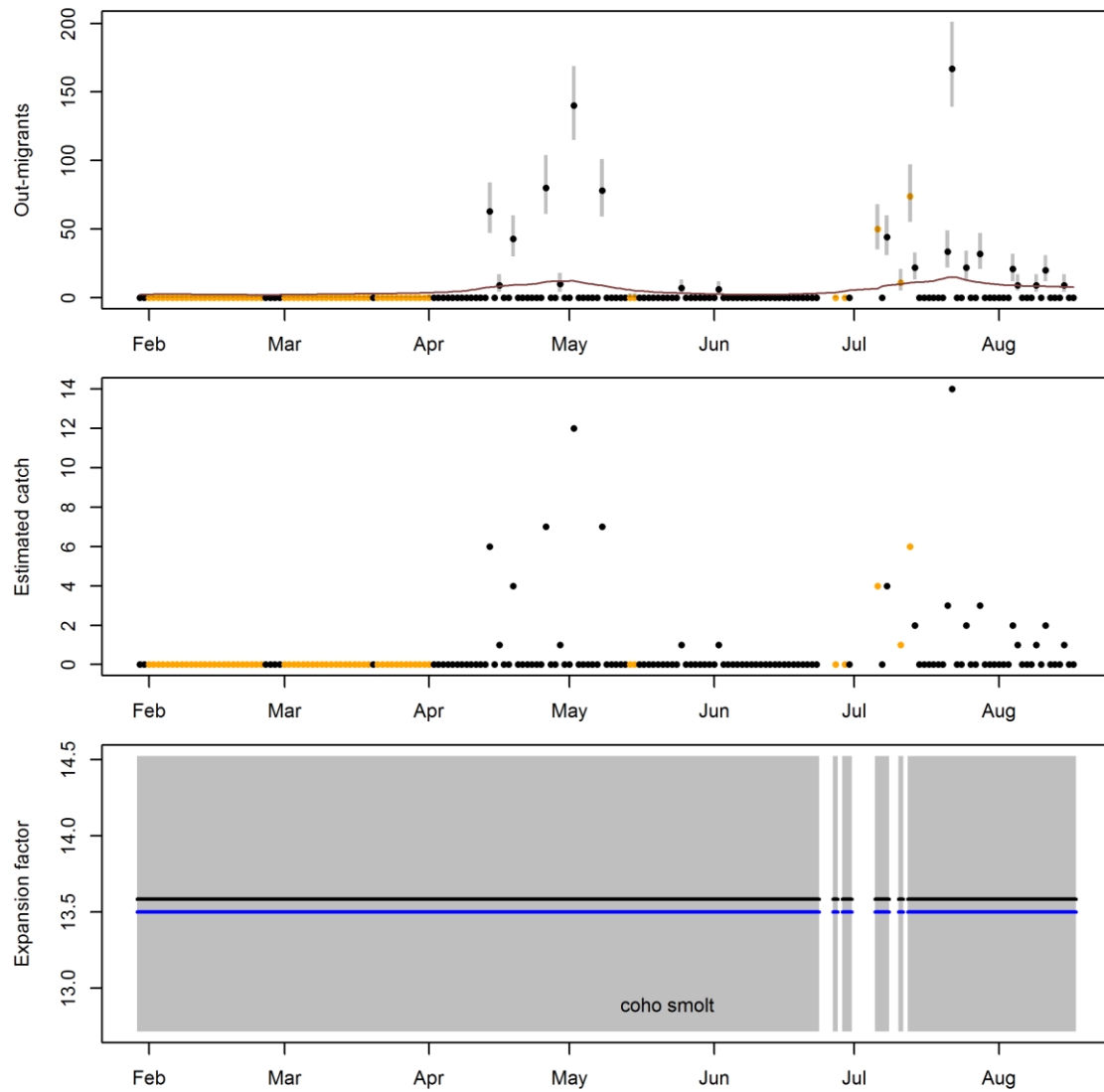
The estimates only incorporate passage during the trap operation. Therefore, if the trap was not in place during fish passage, these fish were not included in the estimate.

Appendix B. Plot of outmigrants, estimated catch and expansion factor by species and trap site for the 2016 smolt trapping season.

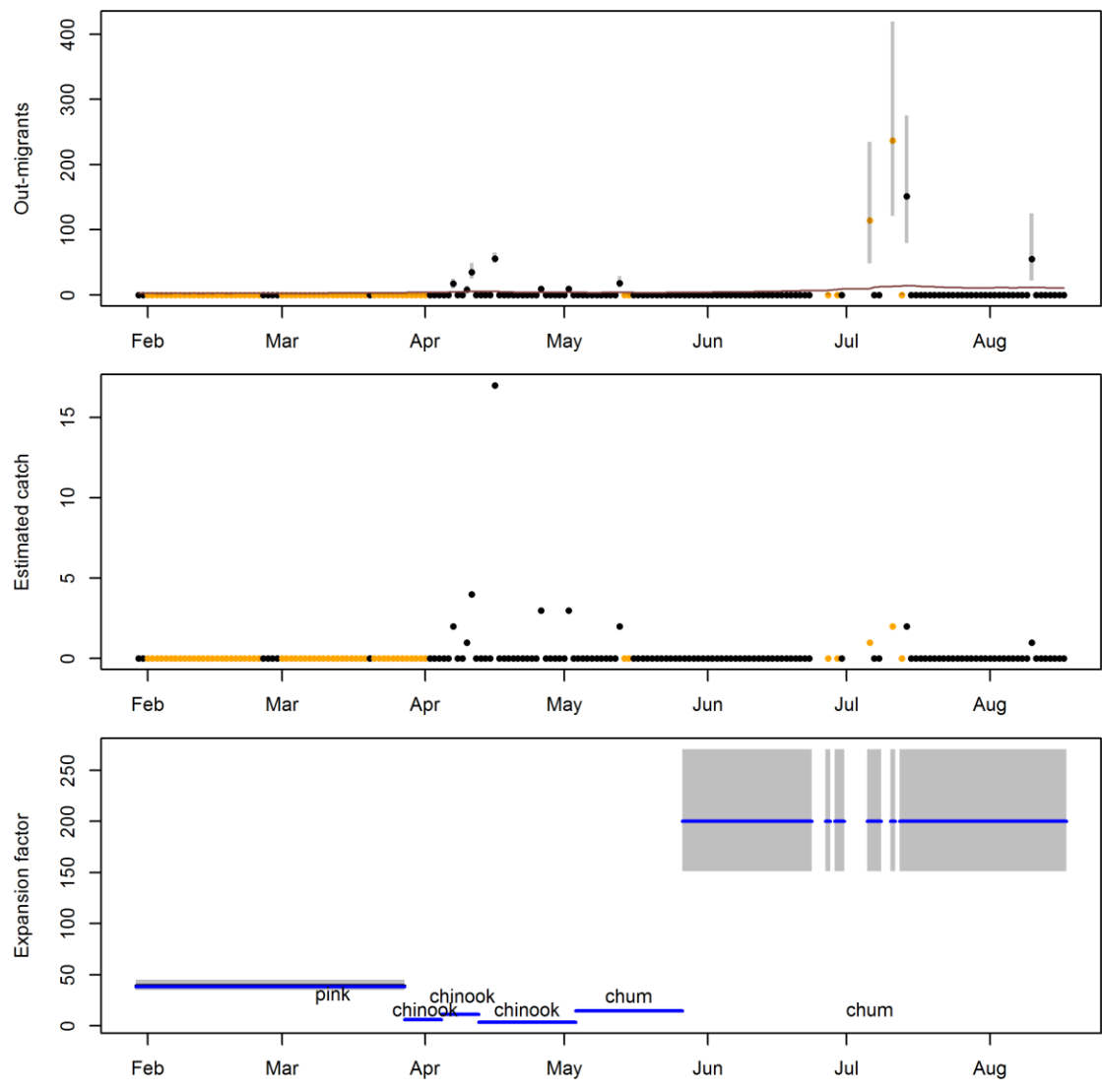
Chin.0.plus,2016, ,est = 44,971 95% CI = (24,126 - 107,386)



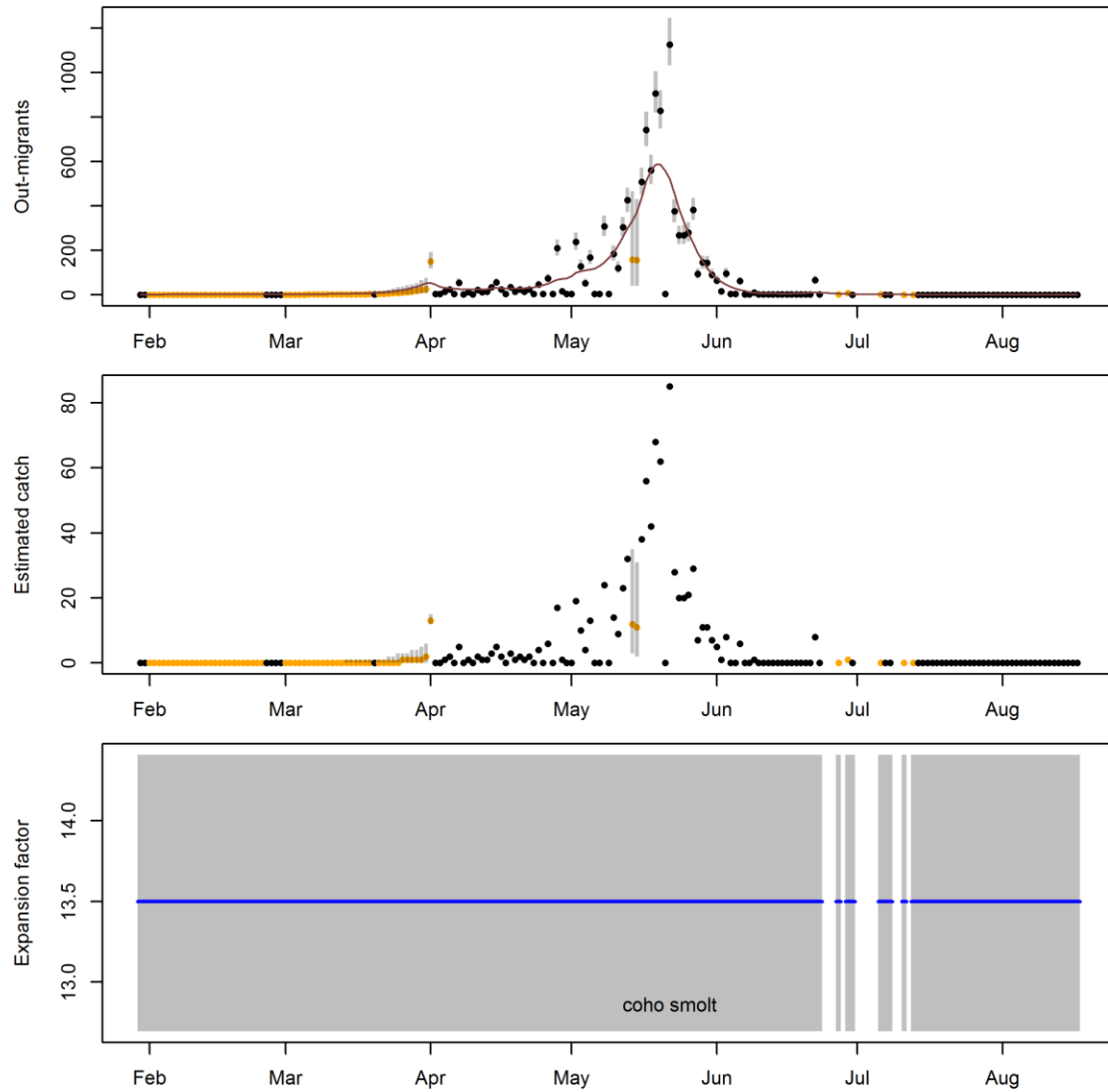
Chin.1.plus,2016, ,est = 1,374 95% CI = (960 - 3,672)



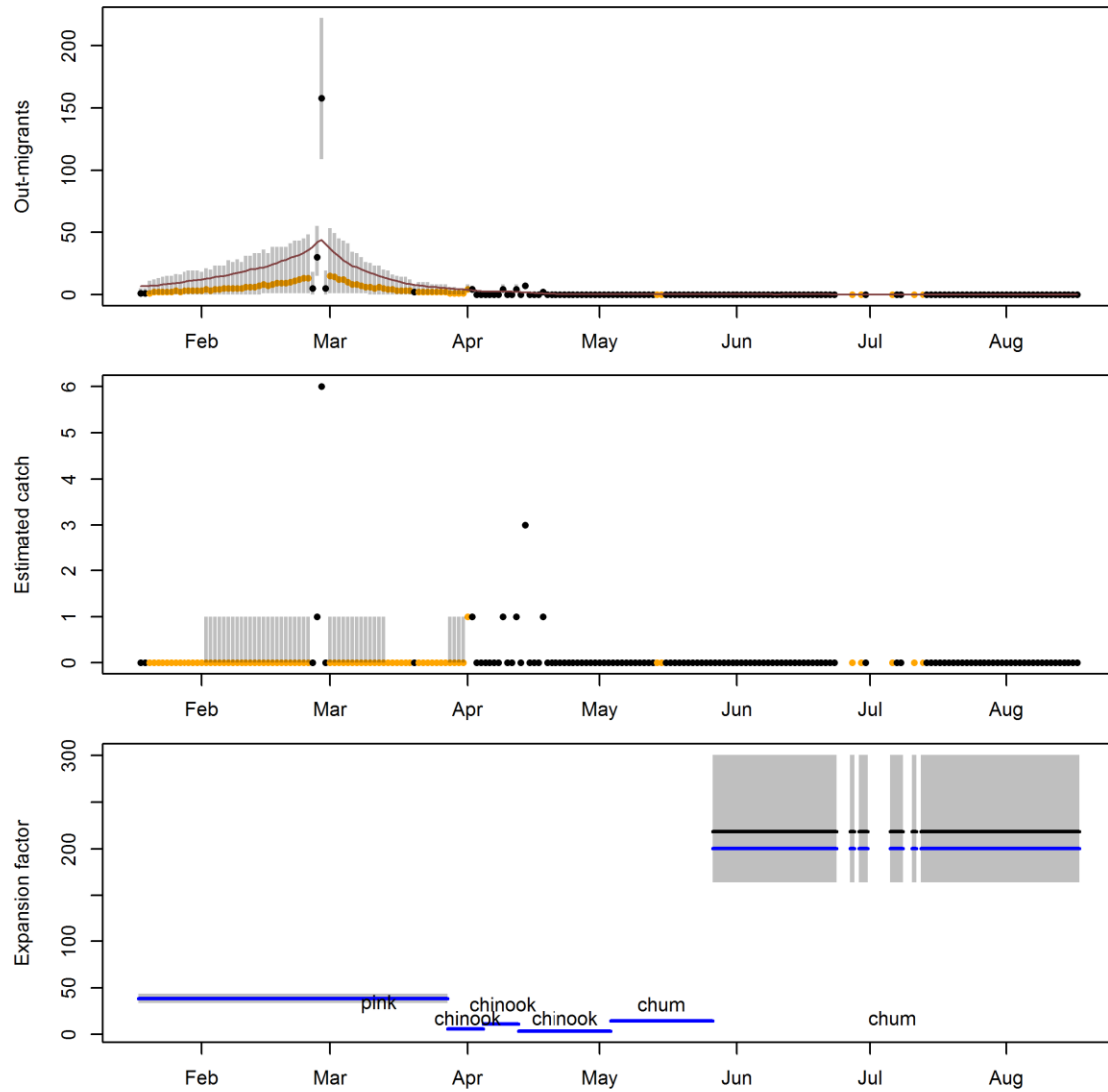
Coho.0.plus,2016, ,est = 1,567 95% CI = (719 - 4,524)



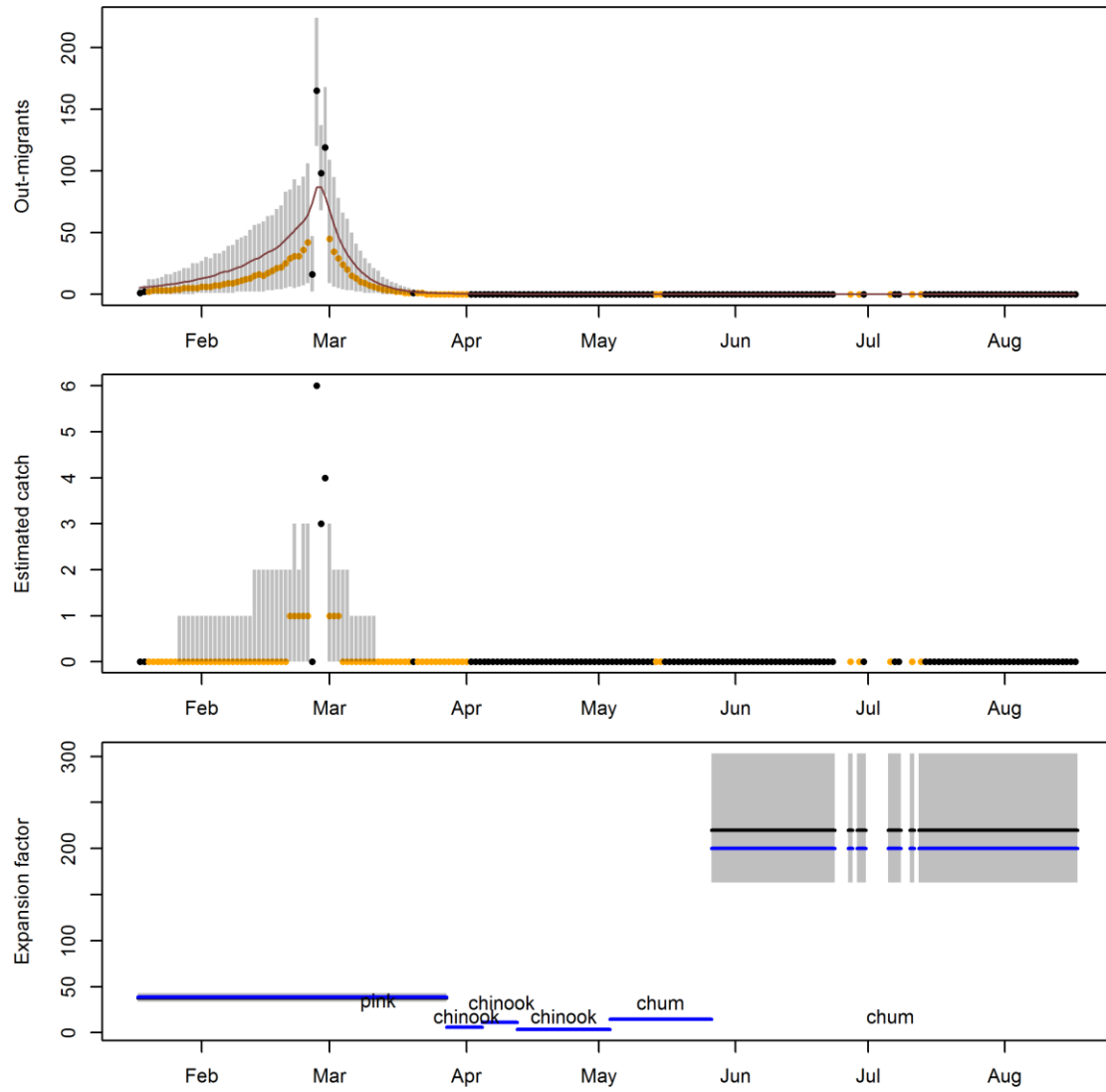
Coho.1.plus,2016, ,est = 11,448 95% CI = (9,124 - 16,250)



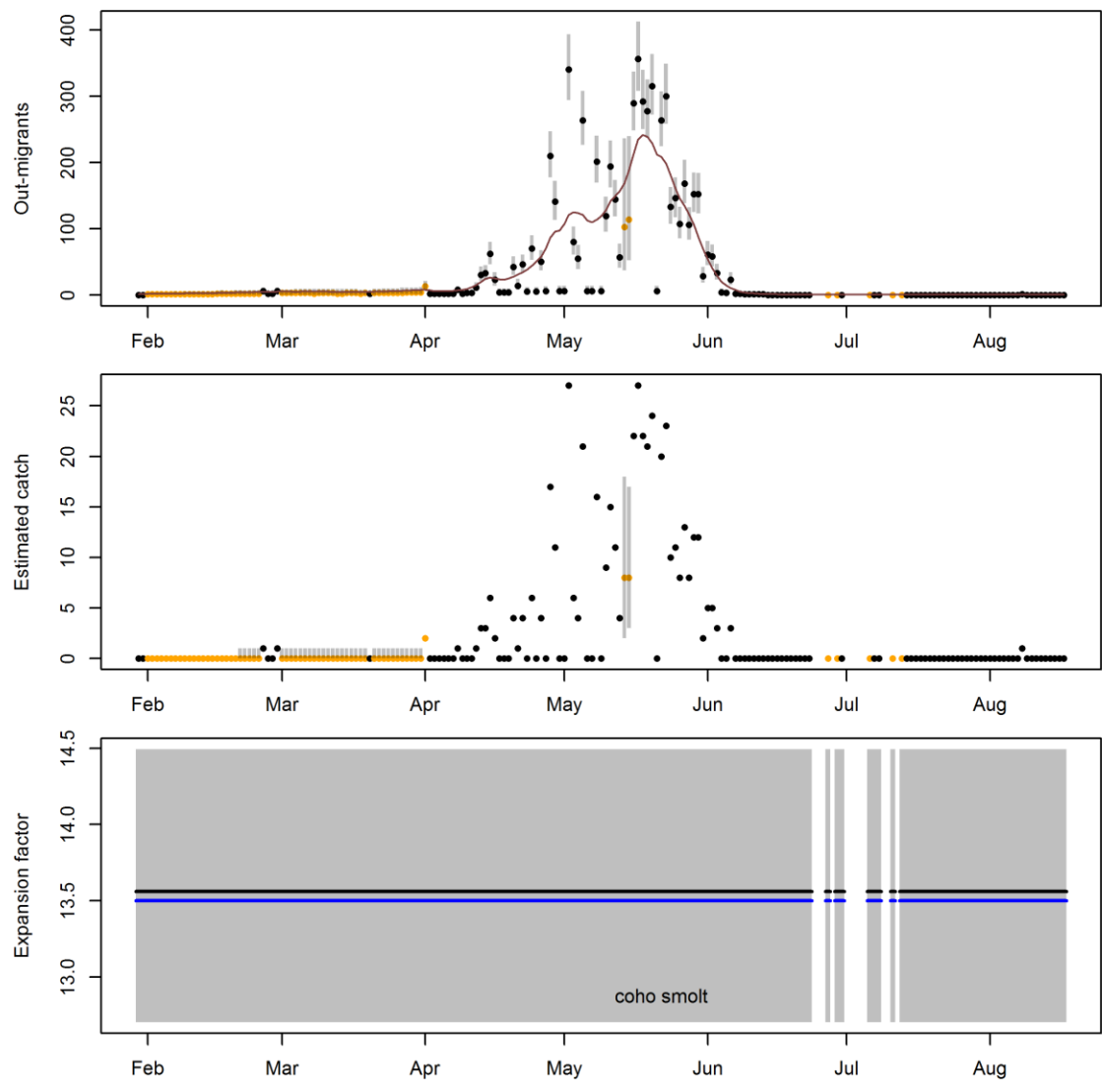
Chum,2016, ,est = 1,850 95% CI = (487 - 28,180)



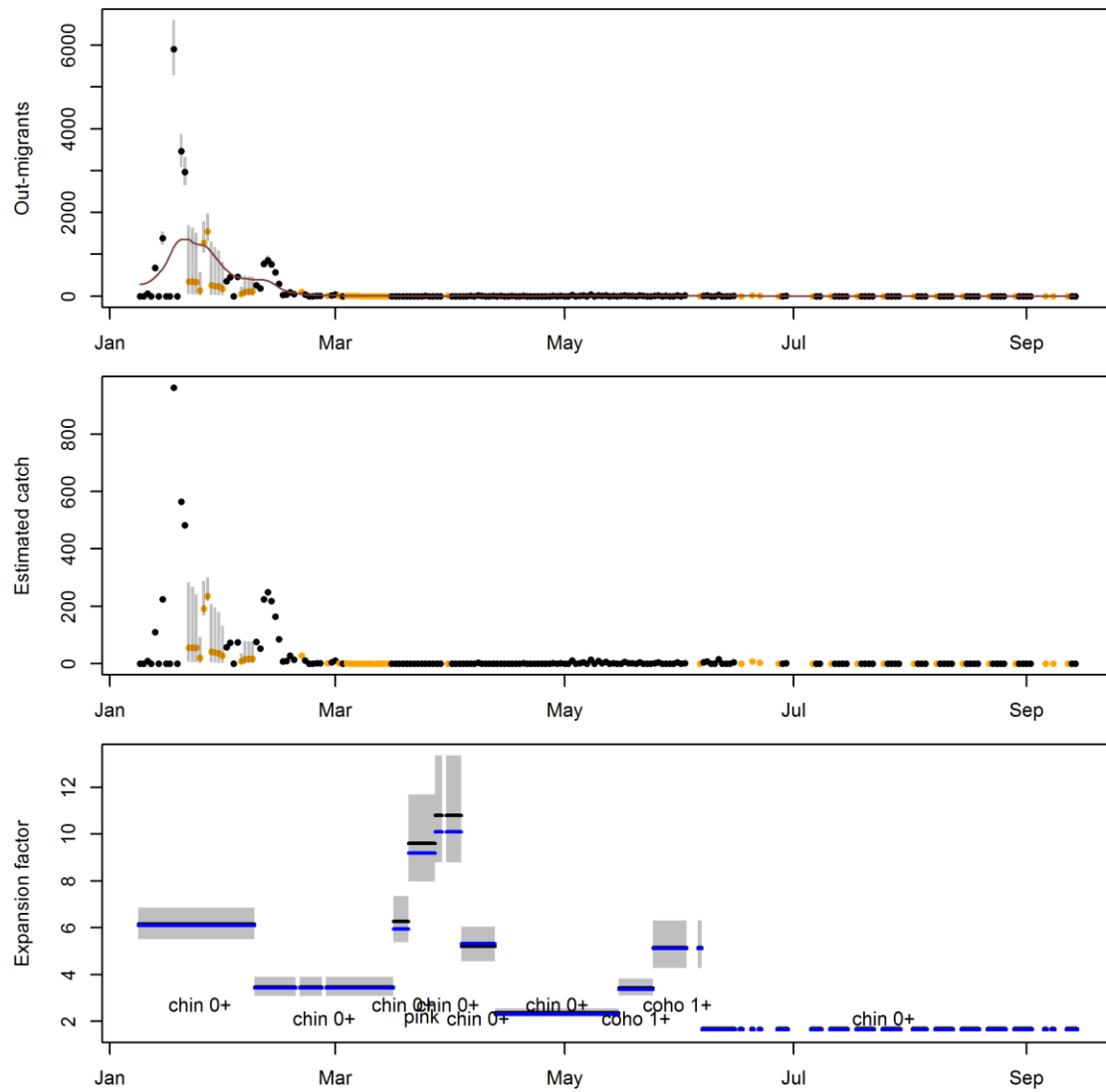
Pink,2016, ,est = 2,385 95% CI = (632 - 20,159)



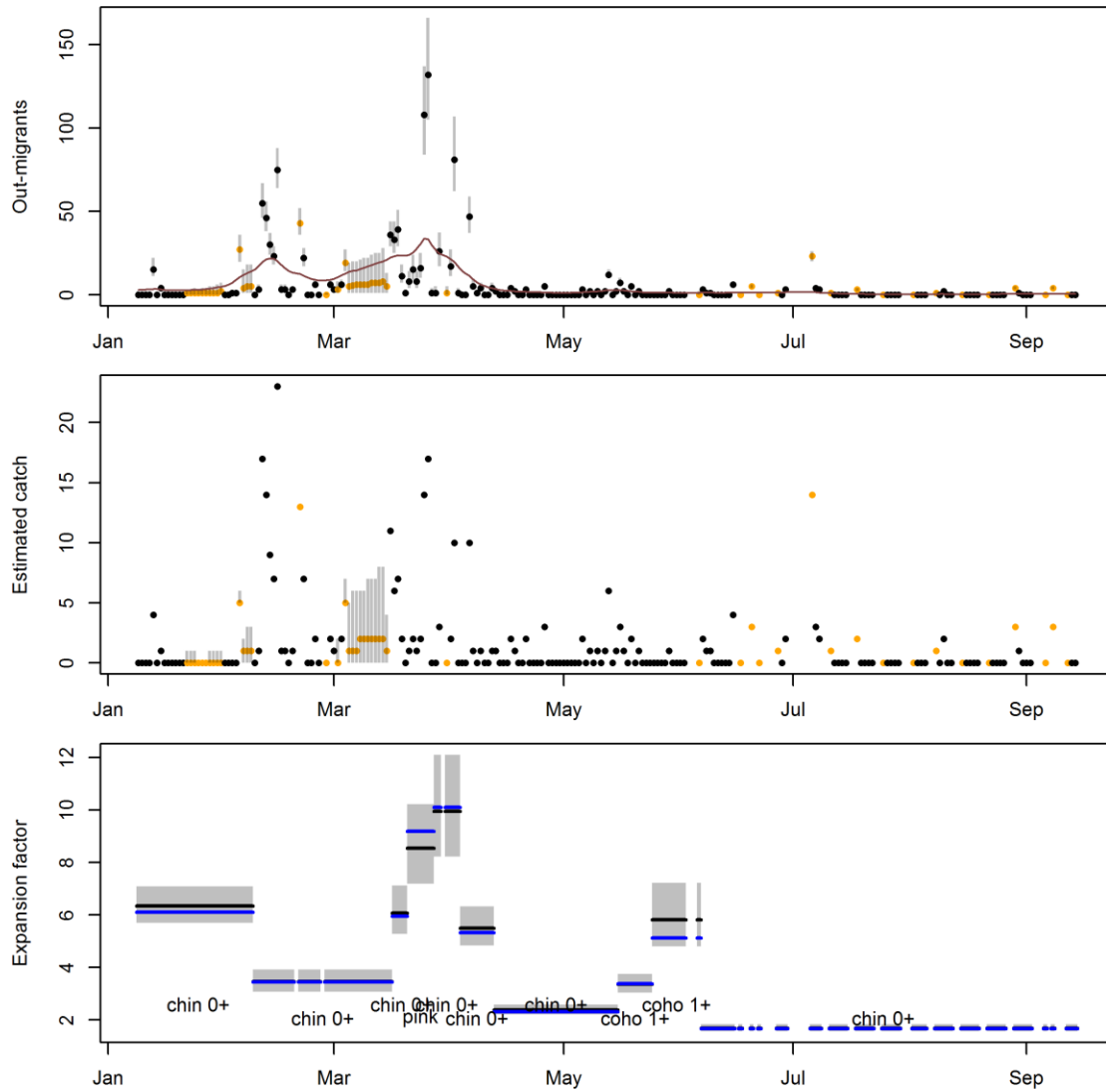
Steelhead,2016, ,est = 6,622 95% CI = (5,222 - 9,022)



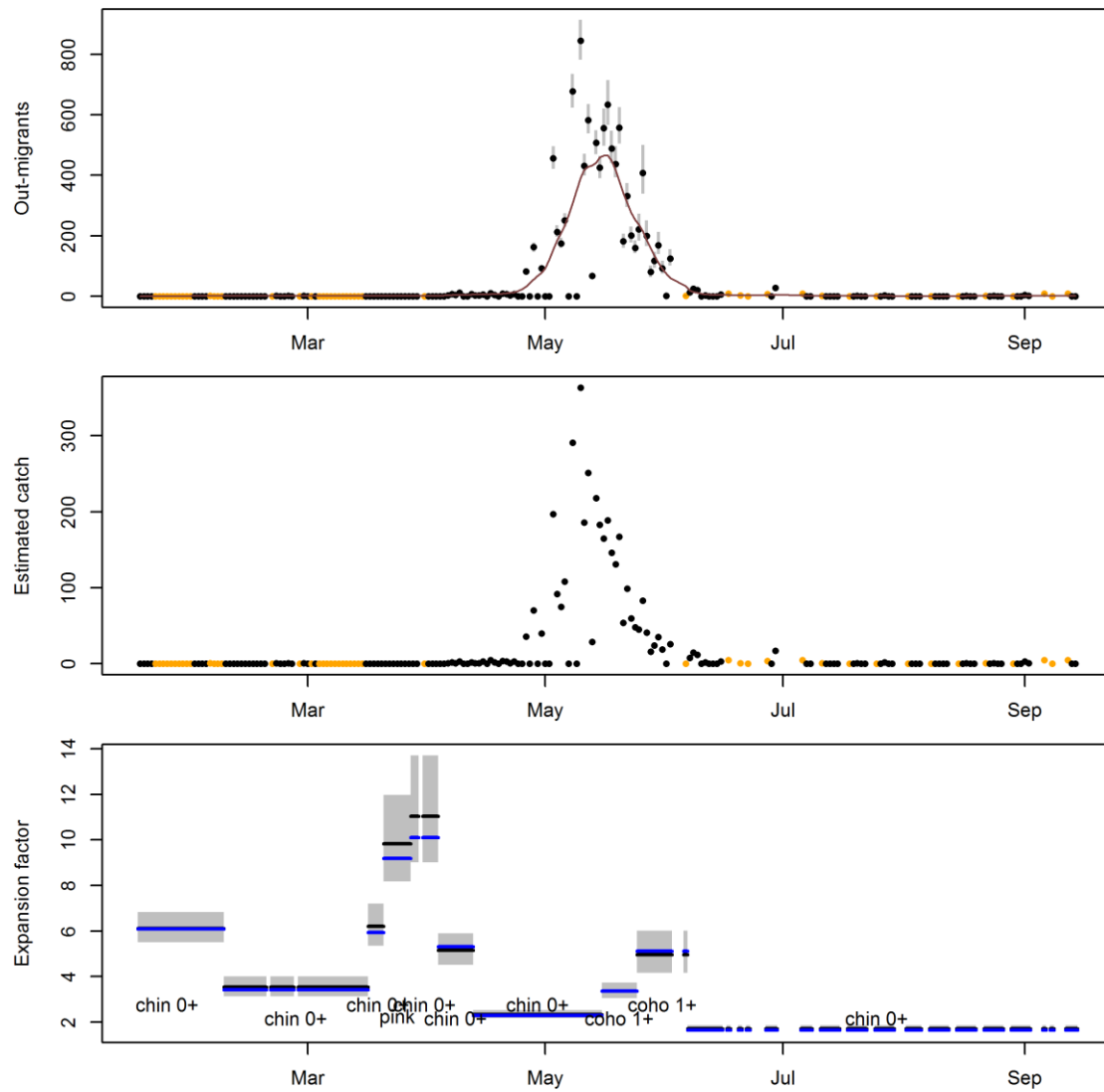
chinook.0plus,2016,Indian ,est = 33,616 95% CI = (22,407 - 70,671)



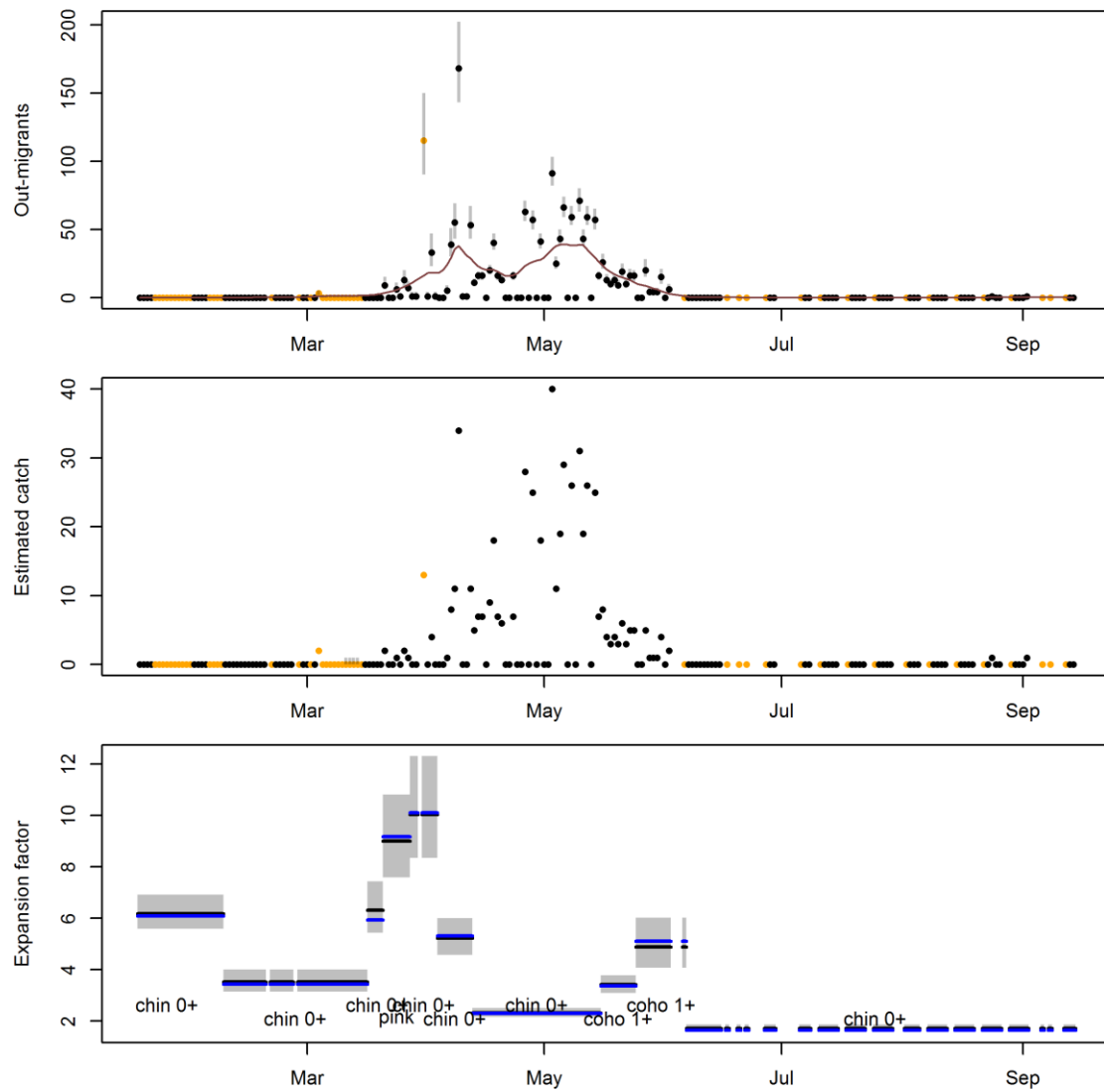
coho.0plus,2016,Indian ,est = 1,566 95% CI = (1,184 - 2,321)



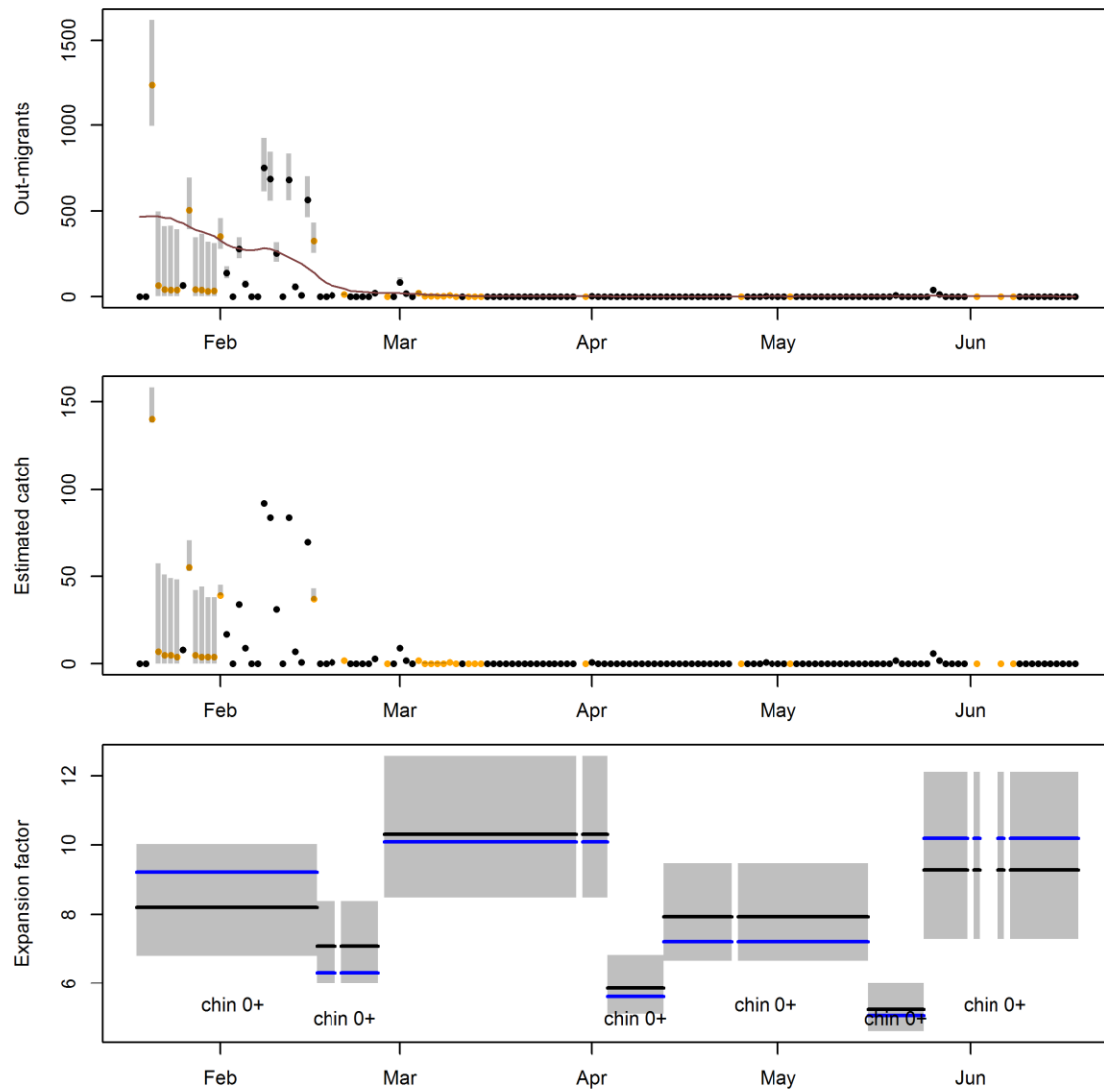
coho.1plus,2016,Indian ,est = 10,393 95% CI = (8,795 - 12,565)



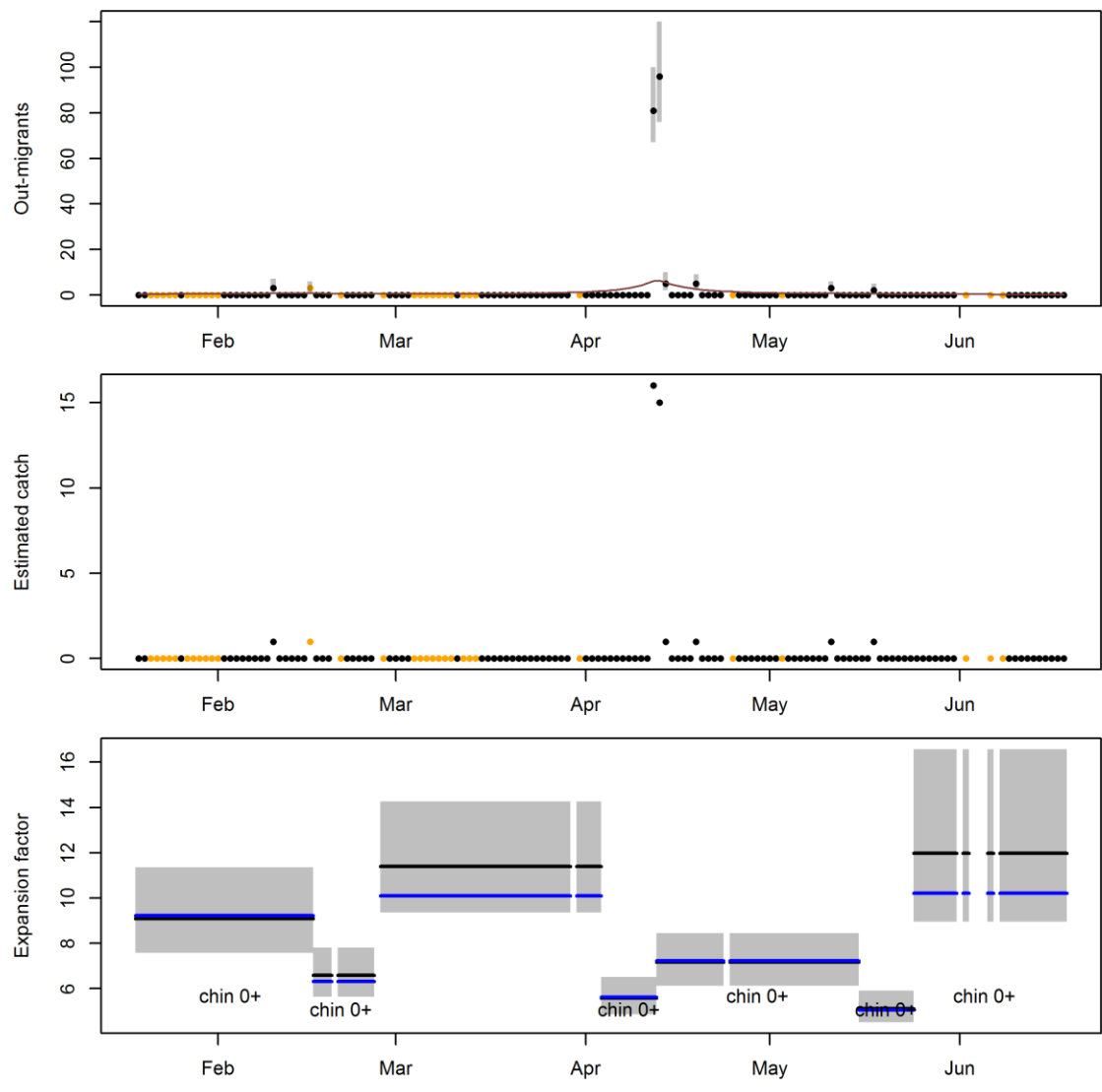
Steelhead.smolts,2016,Indian ,est = 1,678 95% CI = (1,401 - 2,051)



chinook.0plus,2016,Little ,est = 9,860 95% CI = (4,825 - 41,097)



coho.0plus,2016,Little ,est = 268 95% CI = (171 - 463)



coho.1plus,2016,Little ,est = 183 95% CI = (104 - 325)

