Klickitat Subbasin Monitoring and Evaluation

- Yakima/Klickitat Fisheries Project (YKFP)

BPA Project # 1995-063-35

Report covers work performed under BPA contract #(s) 53312, 56662 REL 19, 56, & 82

Report was completed under BPA contract #(s) 56662 REL 82

1/1/2013 - 12/31/2015

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3/2016

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows:

Joseph Zendt, Nicolas Romero, Shane Keep, Michael Babcock, Klickitat Subbasin Monitoring and Evaluation - Yakima/Klickitat Fisheries Project (YKFP), 1/1/2013 - 12/31/2015 Annual Report, 1995-063-35.

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I. Executive Project Summary/Abstract

This report describes the results of monitoring and evaluation (M&E) activities for salmonid fish populations and habitat in the Klickitat River subbasin in south-central Washington. The M&E activities described here were conducted as a part of the Bonneville Power Administration (BPA)-funded Yakima/Klickitat Fisheries Project (YKFP). Anadromous salmonid populations present in the Klickitat subbasin on which M&E activities focus include spring Chinook salmon and steelhead (both of which are native populations and focal species in this subbasin), and fall Chinook and coho salmon (which are both nonnative populations primarily sustained in this subbasin by hatchery production for harvest augmentation).

Major tasks conducted under this project include: adult salmonid monitoring (monitoring adult salmonid population sizes, demographics, and spatial distribution via spawner surveys, adult salmonid trapping at the Lyle Falls Fishway on the lower Klickitat River, and radio telemetry); juvenile and resident salmonid monitoring (monitoring outmigration, survival, spatial distribution, and life history patterns via smolt trapping, stream population surveys, and PIT tagging); genetic analysis (characterizing genetic traits of salmonid stocks and within-stock and between-stock variation); and habitat monitoring (monitoring physical habitat parameters and ecosystem responses to habitat actions via habitat surveys, sediment, temperature, water quality, and streamflow monitoring). The primary M&E type accomplished by the project is status and trend monitoring of fish populations and habitat, with designs also in place to monitor effectiveness of hatchery and habitat actions in the Klickitat subbasin.

Results of mark-recapture run size estimates at Lyle Falls at rivermile (RM) 2.4 on the Klickitat River indicate a depressed adult return of wild spring Chinook, averaging about 500 fish including adults and jacks from 2007-2015. Current returns are not consistent with historical reports of a large run of spring Chinook on the Klickitat River; these results are a continued cause for significant concern regarding the status and trend of this native population. Estimates of hatchery spring Chinook return to Lyle Falls are considerably higher, averaging about 3300 adults and jacks for 2007-2012. Run reconstruction estimates of spring Chinook run size (which use a combination of hatchery returns, harvest estimates, and redd counts) generally produce lower run size estimates than the mark-recapture methods, and support the depressed status determination for wild spring Chinook.

Mark-recapture estimates for steelhead returns to Lyle Falls from 2005-2014 indicate an average of about 1500-1600 wild steelhead and 2800 hatchery steelhead. This may meet National Marine Fisheries Service (NMFS)-recommended mean minimum abundance criteria for this ESA-listed stock, but may not meet broader-sense recovery goals as defined by regional recovery partners and co-managers.

Results from spawning ground surveys (redd counts) indicate that majority of wild spring Chinook spawning occurs in the upper middle Klickitat River between Big Muddy Creek (RM 54) and Castile Falls (RM 64), but that a potentially large percentage of spawners on natural spawning grounds in the Klickitat River are hatchery-origin fish. Redd counts also agree with other adult monitoring

methods in the determination that wild spring Chinook currently have low escapement numbers to natural spawning grounds. Trends in spring Chinook redd counts are currently relatively stable at low levels, but true trends in natural-origin spawners are difficult to accurately assess due to the presence of hatchery-origin fish on spawning grounds. Results also suggest that spring Chinook recolonization in the upper Klickitat River above Castile Falls following enhancements to past anthropogenically-impaired passage has been slow.

Redd count and carcass recovery results for fall Chinook and coho indicate both populations are largely sustained by hatchery production. Large numbers of fall Chinook escape to spawning grounds in most years, with most spawning occurring from the Klickitat Hatchery (RM 42) downstream to the Twin Bridges (RM 18) area near the town of Klickitat. Redd counts for coho are highly variable due to frequent high flows during surveys and some variation in actual returns above Lyle Falls.

Spawning ground surveys indicate a fairly spatially diverse steelhead population in the Klickitat subbasin, with spawning occurring in many geographic locations throughout the middle and lower Klickitat subbasin, including multiple tributary streams, with the most use observed in the White Creek watershed and the middle and lower mainstem from RM 11 to 42. There is also some use (likely a lower amount, but with high uncertainty due to limited survey access) in the upper Klickitat River above Castile Falls.

Results to date from radio telemetry monitoring (from radio tagging of returning adults at the Lyle Falls fishway) provide the following preliminary conclusions regarding several uncertainties in the Klickitat subbasin: stray or "dip-in" rates are quite high for steelhead that enter the lower Klickitat River (which corroborates genetic analysis results); spawning distribution is similar to what is observed from spawning ground surveys (widespread spawning throughout the mid and lower subbasin for steelhead); the majority of hatchery steelhead do not appear to spawn in the wild, and for those that do the majority do not overlap in spawn timing with wild steelhead; and the Klickitat Hatchery weir does not present a difficult passage obstruction for most fish. More results and conclusions from this ongoing study will be presented in future reports.

Precise smolt abundance estimates from smolt trapping (using floating rotary screw traps) have been difficult to obtain due to various hatchery releases and high flows. Rough monthly estimates for some species (primarily natural-origin steelhead) have been generated, but are undergoing further development.

Genetic sampling and analysis conducted under this project has provided valuable data in monitoring hatchery/wild interactions, stock identification of fish use of the lower Klickitat River, subpopulation structure within the subbasin, and anadromous/resident relationships. The summary of results for steelhead to date suggests the following: natural-origin and hatchery-origin steelhead sampled as adults and juveniles in the Klickitat appear to remain genetically distinct suggesting low introgression/interbreeding rates (with further monitoring to determine introgression rates between the stocks underway); multiple anadromous subpopulations (at least 6 or 7) exist within different areas of the Klickitat subbasin; primarily anadromous populations reside in the mid and lower subbasin downstream of major passage obstructions; resident

populations use upstream areas but intermix with some anadromous populations; and there is a fairly high rate of use of the lower Klickitat River by out-of-subbasin populations.

Conclusions from spring Chinook genetic analysis are that hatchery interbreeding with Wells Hatchery summer Chinook in the late 1970s and 1980s is the most likely cause of a hybridized genotype observed in Klickitat spring Chinook. Present hatchery releases of upriver bright fall Chinook stocks in the Klickitat do not appear to be exacerbating this status; but this finding does highlight the need for changes to the current spring Chinook program at Klickitat Hatchery (which are proposed in the Klickitat Master Planning process).

Scale age analysis has provided the following conclusions to date: for spring and fall Chinook, 4-year-olds continue to be the most common age of returning adults; for coho, 3-year-olds continue to dominate the returning adult population; for steelhead, 3- and 4-year-olds comprise similar percentages of returning adults with 5-year-olds making up a small percentage of the population. Also, freshwater (juvenile rearing) ages for steelhead were primarily age 1 for hatchery-origin fish with a fairly even split between age 1 and age 2 for natural-origin fish.

Preliminary smolt-to-adult return rate estimates (from PIT tagging) for Klickitat Hatchery spring Chinook are fairly low (approximately 0.5%). Preliminary smolt-to-adult return rate estimates for Skamania Hatchery steelhead released in the Klickitat River are higher, at approximately 3%.

A PIT tag study in the White Creek watershed (a primary steelhead tributary watershed in the Klickitat subbasin) using a PIT tag detection array in lower White Creek was begun to yield valuable life history and migratory movement pattern information. PIT-tagged steelhead/rainbow trout were detected outmigrating from White Creek from all tagging sites, indicating that a variety of life histories likely exists and that multiple locations throughout the watershed may contribute to migratory rainbow trout and anadromous steelhead populations. Lower White Creek (which maintains more perennial flow than upstream reaches) likely functions as both a refugia and staging area for downstream migrants during the low flow period. Lower White Creek also had the highest estimated densities of outmigrants. Downstream migrants exited the watershed over most of the year with peaks in the early winter and the spring. For fish detected migrating downstream past Bonneville Dam, preliminary results suggest two distinct life history stages with some fish rearing in the Klickitat River for at least an additional year prior to outmigrating to the Columbia River and other fish migrating directly down the Klickitat and Columbia rivers to Bonneville Dam within about a month after leaving White Creek. These results indicate that steelhead/rainbow trout in the White Creek watershed exhibit a "spreading of risk" strategy, with some utilizing rearing habitats in White Creek and some in the mainstem Klickitat River.

Other Klickitat tributary streams are undergoing study via PIT tagging and detection including Dillacort, Logging Camp, Wheeler, Snyder, Swale, and Summit creeks; these streams constitute a variety habitats with a potentially wide array of *O. mykiss* life history strategies and adaptations. East-side tributaries with seasonally dry channel conditions exhibited higher rates of outmigrating *O. mykiss* juveniles (and likely higher rates of anadromy) while in west-side tributaries with more perennial flow conditions fish appeared more likely to adopt a resident life history. Coho

(hatchery-released smolts and in some cases naturally-produced fish) are present in these streams as well.

Preliminary results from an ongoing food web study in White and Tepee creeks (which incorporates a before-after-control-impact study design to monitor effectiveness of a habitat improvement project and responses in fish, macroinvertebrates [aquatic and terrestrial insects], and riparian vegetation) indicate little differences overall in macroinvertebrate taxa richness between the treatment and control sites, significant seasonal effects on macroinvertebrate taxa richness, and significant contributions to aquatic food webs by terrestrial invertebrates (highlighting the potential importance of riparian vegetation to these food webs). Complete results will be presented in future reports and publications; this study will be conducted through approximately 2015 to include post-treatment data collection and analysis.

Habitat surveys using a new rapid aquatic habitat survey methodology have been conducted to provide information on status and trends in habitat conditions (and expand the spatial extent of this information) and to monitor effectiveness of habitat projects. Surveys in this reporting period focused on important fish-bearing stream reaches that had not been surveyed in recent years in Swale Creek, Summit Creek, and the mainstem Klickitat River. Pool frequency was similar in Swale and Summit creek, and was higher for both tributary streams than for the Klickitat, although pools were deeper in the mainstem. Large woody debris was most abundant in Summit Creek; the riparian zone of Swale Creek does not currently supply high amounts of large woody debris. Results will be compiled and compared to other streams for habitat status monitoring and planning purposes.

Status and trend monitoring of stream temperature, sediment levels (via gravel sampling in spawning habitats), and streamflow is also being accomplished under this project. Stream temperatures are generally higher in the lower subbasin, with low summer streamflow (and associated fish stranding and mortality) observed in some tributaries (especially White, Tepee, Brush, Dead Canyon, Swale, and Dillacort creeks). Percent of fine sediment at most monitored sites fluctuated at moderate levels with some sites having high fine sediment levels (greater than 20%).

II. Acknowledgements

YN Fisheries/YKFP technicians (Sandy Pinkham, Rodger Begay, Roger Stahi, Jeremy Takala, Jacob Richards, Dean Antone, Bennie Martinez, Steven Begay, John Washines, and Scott Spino) collected most of the field data presented in this report. YN Fisheries/YKFP Klickitat subbasin coordinator Bill Sharp (under Klickitat Management, Data, & Habitat Project, BPA Project # 198812035) provided oversight and management. Jeff Trammel, Flo Wallahee, and Winna Switzler of YN/YKFP provided fish video counts for Castile Falls. Jerod Bartholomew and Gregg Knott of YN/YKFP maintained facilities and equipment at Lyle Falls and Castile Falls. Will Conley, YN/YKFP hydrologist, and David Lindley, YN/YKFP habitat biologist (under the Klickitat Watershed

Enhancement Project, BPA Project # 199705600), assisted with data collection and management and database report development for many habitat-related monitoring tasks. Jeanette Burkhardt, YN/YKFP watershed planner/outreach coordinator, provided website content development and assisted with field data collection. Shawn Narum and Jon Hess with Columbia River Inter-Tribal Fish Commission (CRITFC) provided genetic analysis information. Lyle adult trap operation and population estimation began as a joint project between WDFW and YN/YKFP – methods have been adapted from that effort as begun by Steve Gray and Dan Rawding of WDFW. U.S. Geological Survey Columbia River Research Laboratory staff (Brady Allen, Ian Jezorek, Carrie Munz, Phil Haner, Scott Evans, and Leroy Sutton) installed and maintained PIT and radio tag equipment, and collected and managed field data. YN Water Resources Program staff (Scott Ladd and Rocco Clark) collected streamflow data.

III. Introduction

This report describes the results of monitoring and evaluation (M&E) activities for salmonid fish populations and habitat in the Klickitat River subbasin in south-central Washington (map in Figure 1). The M&E activities described here were conducted as a part of the Bonneville Power Administration (BPA)-funded Yakima/Klickitat Fisheries Project (YKFP) and were designed by consensus of the scientists with the Yakama Nation (YN) Fisheries Program. YKFP is a joint project between YN and Washington Department of Fish and Wildlife (WDFW). Overall YKFP goals are to increase natural production of and opportunity to harvest salmon and steelhead in the Yakima and Klickitat subbasins using hatchery supplementation, harvest augmentation and habitat improvements. Klickitat subbasin M&E activities have been subjected to scientific and technical review by members of the YKFP Science/Technical Advisory Committee (STAC) as part of the YKFP's overall M&E proposal. Yakama Nation YKFP biologists have transformed the conceptual design into the tasks described. YKFP biologists have also been involved in various Columbia basin regional efforts to standardize M&E data collection and reporting protocols, and are working towards keeping Klickitat M&E activities consistent with applicable standards.

Anadromous salmonid populations present in the Klickitat subbasin on which M&E activities focus include spring and fall Chinook salmon (*Oncorhychus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*). Spring Chinook salmon and steelhead are both native populations and focal species in this subbasin; fall Chinook and coho salmon are nonnative populations primarily sustained in this subbasin by hatchery production for harvest augmentation (NPCC 2004). Steelhead in the Klickitat subbasin are part of the Endangered Species Act (ESA)-listed (threatened) Middle Columbia River distinct population segment.

Other important salmonid populations present in the Klickitat subbasin include resident rainbow trout (*O. mykiss*), cutthroat troat (*O. clarkii*), ESA-threatened bull trout (*Salvelinus confluentus*) and nonnative brook trout (*S. fontinalis*).

This report describes progress and results for the following major categories of YN-managed tasks under this contract:

1. Adult salmonid monitoring – monitoring adult salmonid population sizes, demographics, and spatial distribution via spawner surveys, adult salmonid trapping at the Lyle Falls Fishway on the lower Klickitat River, video monitoring at the Castile Falls fishway on the upper Klickitat River, and radio telemetry monitoring

2. Juvenile and resident salmonid monitoring – monitoring outmigration, survival, spatial distribution, and life history patterns via smolt trapping, stream population surveys, and PIT tagging

3. Genetic analysis – characterizing genetic traits of salmonid stocks, and developing YKFP supplementation broodstock collection protocols for the preservation of genetic variability, by refining methods of detecting within-stock and between-stock variation

4. Habitat monitoring – monitoring physical habitat parameters and ecosystem responses to habitat actions via habitat surveys, sediment, temperature, water quality, and streamflow monitoring

These tasks have elements of status and trend monitoring of fish populations and habitat, as well as incorporating designs aimed at monitoring effectiveness of hatchery and habitat actions in the Klickitat subbasin.

Additional and updated information for this project is also available at the YKFP website (www.ykfp.org/klickitat/).

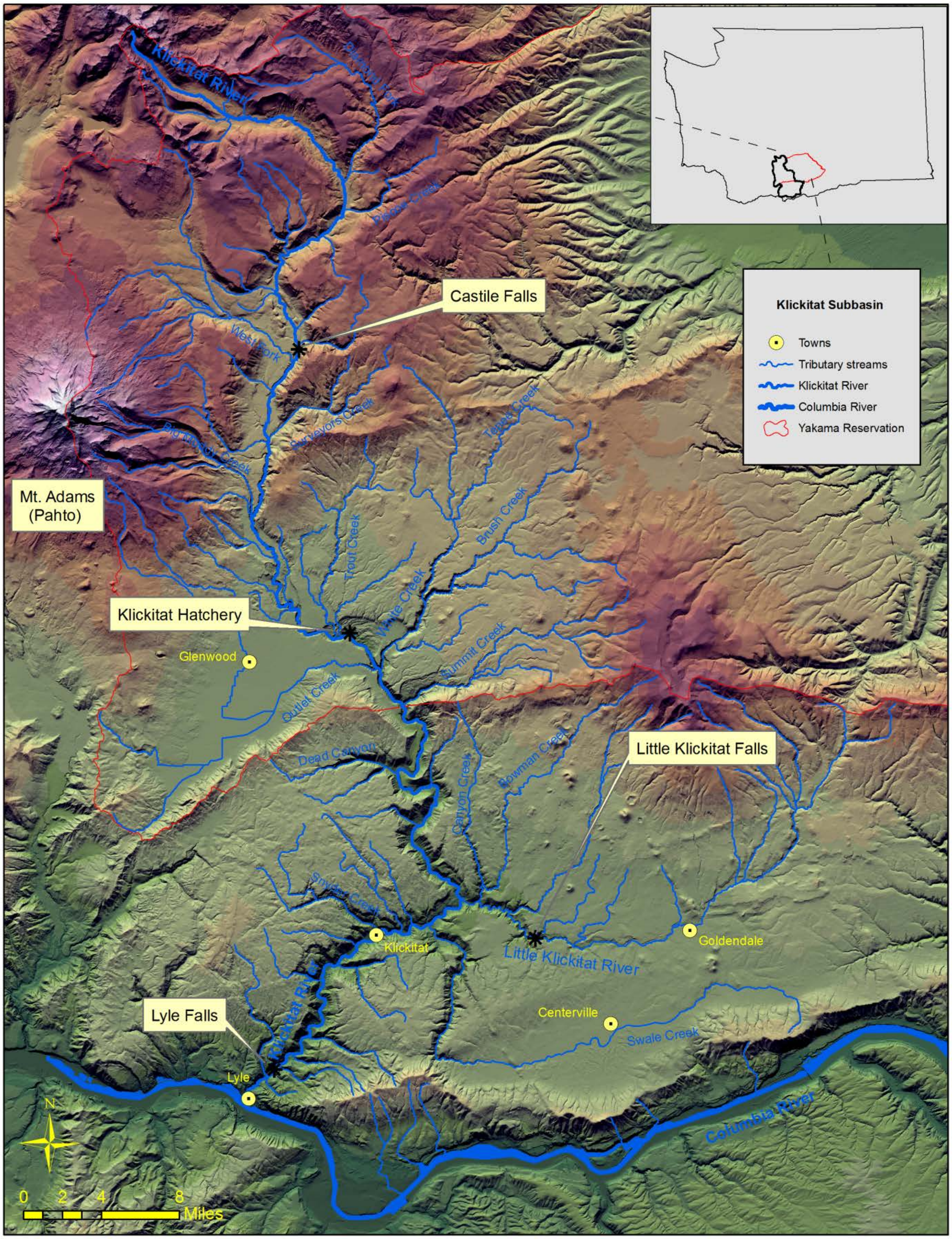

Figure 1. Map of the Klickitat subbasin with major landmarks.

IV. Work Elements / Tasks

Fish Population Status Monitoring (RM&E) and Hatchery RM&E

Adult salmonid monitoring at Lyle Falls fishway

Introduction

Monitoring adult salmonid run size, run timing, and passage, and collecting biological data from returning adults are ongoing important objectives in the Klickitat River. The Lyle Falls fishway at RM 2.4 (Figure 1) on the Klickitat River was constructed in the early 1950s to improve fish passage; however the natural falls are not a complete barrier and many adult salmonids do ascend the falls (counts of fish in the fish ladder are not a census of fish returning to the Klickitat River). This facility provides a key monitoring site via operation of an adult salmonid fish trap in the fishway. During 2010-2013, significant construction improvements to the fishway and adult trap were completed under BPA Project # 1988-115-35 (YKFP Klickitat River Design and Construction Project); major tasks included upstream extension of the fishway to an improved fish exit location, screened auxiliary water intake to allow for improved attraction flow; modified weirs in the lower fishway to improve hydraulic conditions, and an offline adult trap that allows for mechanical crowding, lifting, and water-to-water transfer (via a false weir and flume system) to a fish handling and sampling facility (a mobile trailer that can be moved during flood flows). The improved adult trap and fish handling facility were operational in early 2013; during this period operations were tested and modified to allow for efficient fish handling and collection of biological data.

Adult run size monitoring, especially with mark-recapture methods, focuses on spring Chinook and steelhead, as these are native focal species in the Klickitat subbasin (NPCC 2004). Fall Chinook and coho are important production stocks providing harvest opportunities and are also monitored, but adequate sample sizes of marks and recaptures are not achieved in all years to establish mark-recapture estimates for those stocks.

Methods

Adult salmonids were trapped, enumerated, sampled, and then released in the Lyle Falls fish ladder. Under previous trap operations (through 2012), water levels inside the fishway were lowered via gate operation to allow personnel to enter the fishway trap area and capture adult salmonids with dipnets. Beginning in early 2013, new trap facilities allowed for mechanical crowding and lifting from the offline trap, followed by volitional attraction via false weir into a flume that transported fish into a mobile trailer that serves as the fish handling and sampling area. Inside the trailer fish were held in 325-gallon holding tanks lined and covered with custom-made soft mesh nets that allowed for fish retrieval and handling. A low-voltage electronarcosis system (Hudson et al. 2011) with fixed electrodes in the holding tanks was used to immobilize fish for sampling. After sampling, fish were released via the flume system into a low-velocity area of the fishway which allowed for continued upstream migration. Details of the electronarcosis system as well as results of an evaluation of effects of this technique are found in Keep et al. (2015). This evaluation found no differences in travel times, after release to points 10 and 20 miles upstream, between fish treated

either with electronarcosis or carbon dioxide (another widely-used fish sedative). Hudson et al. (2014) also found a lack of effect on embryo mortality and fry growth from adult coho salmon treated with electronarcosis prior to spawning. Other chemical sedatives were deemed inappropriate for use due to the fact that fish can be harvested after release from this facility, and most chemical agents require a withdrawal period prior to human consumption. Biological data were collected from individual fish including fork length, sex, scales, genetic samples, body and gill color, existing marks, and presence of CWT (coded wire tag) and PIT (passive integrated transponder) tags. Because counts of fish in the adult trap are not a census of fish returning to the Klickitat River, mark-recapture methods are used to monitor run size. Marks (opercle punches and floy tags) were administered and subsequently used along with a second sampling event to develop mark-recapture population estimates. Spring Chinook population estimates were made following recapture of hatchery fish that voluntarily returned to the adult holding pond at the Klickitat Hatchery. Carcass recovery during spawner surveys also potentially provides recapture data on marked fish for salmon species, but in most years too few marked carcasses have been observed to yield precise population estimates with that method. Steelhead recaptures occurred via anglers; a select group of anglers fishing at various locations on the middle and lower Klickitat River (but above Lyle Falls) recorded total numbers of steelhead caught and numbers of tagged steelhead caught during the sport steelhead fishing season (June 1 – November 30). Steelhead in the Klickitat River are listed as threatened under the Endangered Species Act (ESA), and only hatchery steelhead were tagged with floy tags at Lyle Falls. For population estimation, wild steelhead were assumed to use the fish ladder in the same proportion as hatchery fish, and the same capture-recapture ratio was used to generate wild steelhead estimates (using the total number of wild steelhead trapped at Lyle Falls as the "marked" fish). Steelhead were also divided into two runs for estimation purposes: summer run (those passing Lyle Falls from May 1 through November 30) and winter run (those passing Lyle Falls December 1 through April 30). The mark-recapture population estimates were generated for summer steelhead (hatchery and wild), but for winter steelhead due to the lack of a recapture effort (there is no sport steelhead angling season during the winter run), trap counts for the December-April period were used as a census count. This assumes all steelhead during the winter period use the fish ladder and do not ascend the natural falls; although this is what is believed to occur at falls on other nearby rivers such as the Wind and Kalama due to low water temperatures (Gray 2006), this assumption requires further evaluation on the Klickitat River. Winter steelhead ascending the natural falls on the Klickitat River likely leads to a winter steelhead estimate that is biased low. Hatchery steelhead passing Lyle Falls December 1 through April 30 were counted as summer steelhead because all hatchery juveniles released in the Klickitat River are summer-run Skamania Hatchery stock. The counts of these hatchery fish were simply added to the mark-recapture estimates for summer hatchery steelhead.

Population estimates were generated using the Peterson estimator with modification for small sample size (Chapman 1951, as described in Seber 1982):

$$N = \frac{(m-1)(c-1)}{(r-1)} - 1$$

where N = population estimate (in this case N represents the population/run size estimate at Lyle

Falls), m = the number of fish marked or tagged and released back into the population, c = total number of fish captured at the second sampling event, and r = number of fish captured in the second sampling event that were marked or tagged (recaptures). Variance was estimated as:

$$S^2 = \frac{(m+1)(c+1)(m-r)(c-r)}{(r+1)^2(r+2)}$$

(Seber 1982). Normal confidence intervals (CI) can be calculated as:

$$95\%\ CI = 1.96 * S$$

However, a non-normal, asymmetric confidence interval calculation with improved coverage was generally used (Arnason et al. 1991):

$$T = N^{-1/3}$$

$$S(T) = T * \frac{S(N)}{3N}$$

$$(T_L, T_U) = T \pm 1.96 * S(T)$$

$$(N_L, N_U) = (1/T_L^3, 1/T_U^3)$$

where N_L and N_U are the lower and upper 95% confidence limits.

In cases where winter steelhead trap counts were added to population estimates (as described above), these assumed census counts were also simply added to the upper and lower confidence limits that resulted from the above equations.

Results

Results of mark-recapture population/run size estimates at Lyle Falls for spring Chinook are shown in Figure 2 below and in Table 4 (Appendix B). The first year that all returning adults were 100% adipose fin marked was 2007. Estimates of total run size (adults and jacks) for 2007-2015 indicate an average of approximately 4000 hatchery spring Chinook (ranging from about 1200 to 5900) and approximately 500 wild spring Chinook (ranging from about 300 to 685). The 2014 wild spring Chinook estimate (309) is on the low end of that range, while the 2015 estimate (663) is near the high end. Jacks averaged about 21% of the run at Lyle Falls in those years.

Results for summer steelhead are in Figure 3 below; total wild and hatchery steelhead estimates are shown in Table 5 (Appendix B). For 2005 through 2014 (estimates were generated for all but 2 years during that period, and 2015 data is not yet available), wild steelhead returns to Lyle Falls averaged approximately 1670 fish (ranging from 1060 to 2950) and hatchery steelhead returns averaged 2785 fish (ranging from 1250 to 5150). The geometric mean of wild steelhead returns to Lyle Falls for the same time period is 1565 fish.

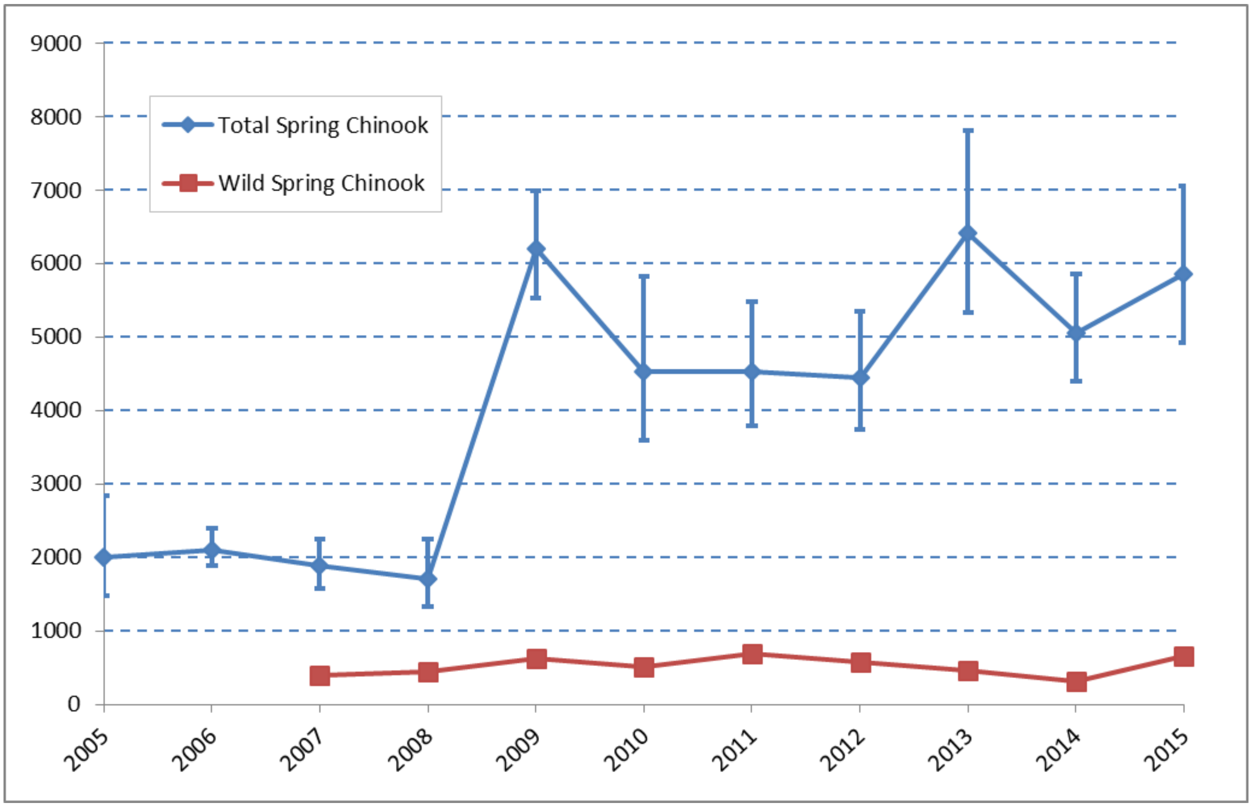

Figure 2. Mark-recapture estimates of spring Chinook run size at Lyle Falls on the lower Klickitat River. Error bars represent 95% confidence intervals.

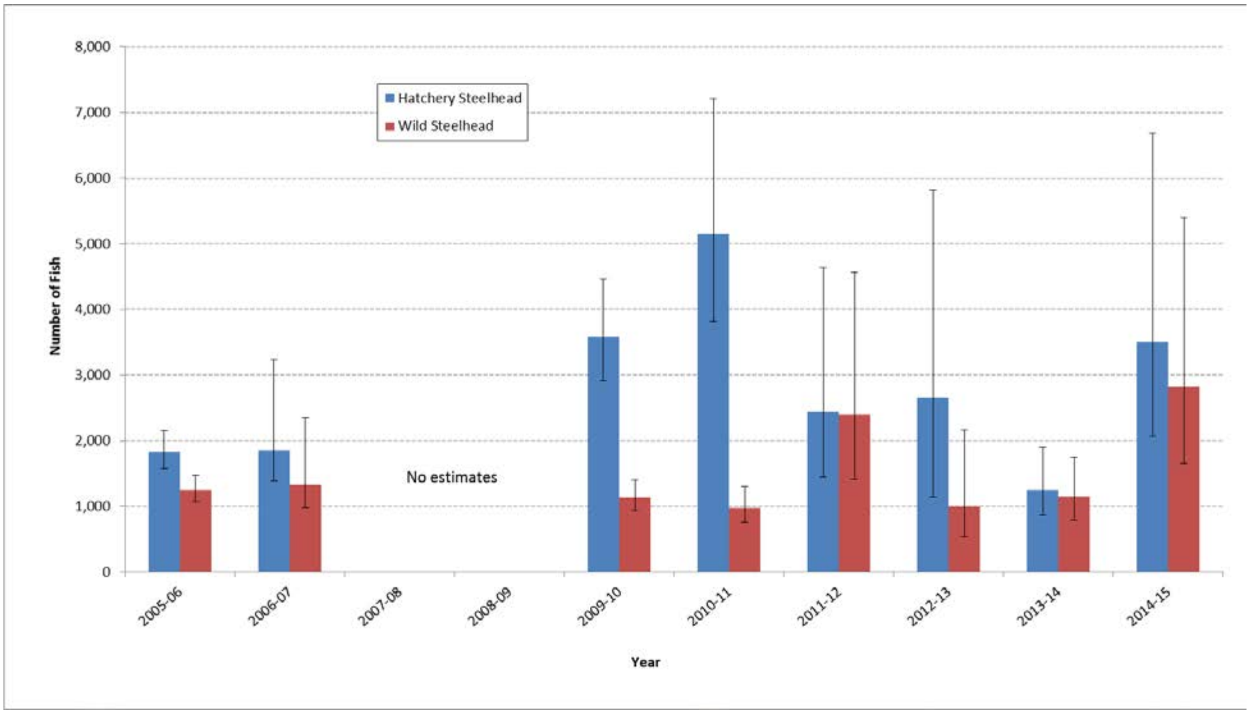

Figure 3. Mark-recapture estimates of summer steelhead run size at Lyle Falls on the lower Klickitat River. Error bars represent 95% confidence intervals.

Current updated daily and annual trap count data are available at the YKFP website (http://www.ykfp.org/klickitat/Data_lyleadulttrap.htm).

Conclusions

With an average run size of about 500 fish at Lyle Falls, current wild spring Chinook returns do not seem consistent with historical reports of a "large run of spring chinook" (Bryant 1949). Although Klickitat spring Chinook, as part of the Middle Columbia River evolutionarily significant unit, are not listed under the ESA, they are rated as "depressed" by WDFW's Salmonid Stock Inventory (SaSI) due to chronically low returns (WDFW 2002). These results continue to cause significant concern to co-managers regarding the status and trend of this native population.

For steelhead, which in the Klickitat subbasin are part of the Middle Columbia River distinct population segment and are listed under the ESA as threatened, a National Marine Fisheries Service (NMFS)-recommended recovery goal for delisting includes, among other criteria, a mean minimum abundance threshold of 1,000 naturally-produced spawners in order to achieve viable status or a 5% or less risk of extinction over a 100-year timeframe (NMFS 2009). In addition, broad-sense recovery goals can be defined, and the Yakama Nation has proposed the achievement of a highly viable status for this population (which corresponds to a 1% risk of extinction in a 100-year period) as a recovery goal (NMFS 2009). The 2005-2014 estimates yield a mean and a geometric mean of about 1500-1600 total wild steelhead return to Lyle Falls (Table 5 in Appendix B); whether or not this constitutes achievement of the abundance criteria would require a determination by NMFS and

regional recovery partners and co-managers. Important additional factors in that analysis would include: the mark-recapture estimates reported here are estimates of population size at Lyle Falls on the lower Klickitat River and not necessarily the resulting spawner abundance as specified in NMFS criteria (i.e., pre-spawning mortality likely results in an actual spawner abundance somewhat less than the Lyle Falls run size); genetic analysis and tagging data indicate some out-of-subbasin temporary stray (dip-in) steelhead migrate past Lyle Falls before exiting the Klickitat River and would be included in the mark-recapture estimates (see Genetic Analysis section below); and the fact that winter steelhead abundance estimates are likely biased low at Lyle Falls (see Methods description above).

Adult salmonid monitoring at Castile Falls fishway

Introduction

Monitoring adult salmonid passage into the upper Klickitat River is an important ongoing objective. Castile Falls is a series of 11 falls on the upper Klickitat River (Figure 1) which limited but did not preclude natural passage of native spring Chinook and steelhead; fishways were constructed in the early 1960s to improve passage but likely limited natural passage further (NPCC 2004). Passage improvements (weir reconstruction) at the Castile Falls #10 and 11 fishway at RM 64.6 were completed in 2005. Additional upgrades (video monitoring, PIT tag detection, and on-site power generation) were completed in 2012 under BPA Project # 1988-115-35 (YKFP Klickitat River Design and Construction Project).

Adult passage monitoring focuses on spring Chinook and steelhead, as these are native focal species in the Klickitat subbasin (NPCC 2004), and other anadromous species rarely ascend above Castile Falls. Video counts in the Castile Falls 10/11 fishway are currently presumed to be census counts as virtually all passage is through this fishway; a weir above Falls 10 limits natural upstream passage in the river.

Methods

A digital video camera in the below-grade observation room adjacent to the upper end of the Castile Falls 10/11 fishway was used to record video footage through a window into the fishway; a vertical aluminum picket crowder crowds fish to within approximately 1 foot of the observation window. Video footage with detected motion was transferred via satellite internet connection to technicians who then viewed the video and enumerated upstream migrating anadromous salmonids, recording species, adult/jack status, and adipose clip status.

Results

Video monitoring began at the Castile Falls 10/11 fishway on June 28, 2012. Because of its location high in the subbasin and the fact that the vast majority of fish passing Castile Falls in a given run year do so in summer through early fall, the run year is considered as June 1 through May 31. To date relatively low numbers of fish per return year have been observed; the highest overall counts were during the first return year of 2012-13 when 40 steelhead (33 wild and 7 hatchery fish) and

12 spring Chinook (11 wild and 1 hatchery) were observed. Subsequent years have seen lower numbers of fish – generally fewer than 10 fish of a given species/origin per return year (Figure 4). To date only spring Chinook and steelhead have been counted; no other anadromous salmonid species has been observed. For spring Chinook, the majority passes through the fishway in July and the run is generally complete by the end of August. For steelhead, most fish pass in July-August, with small numbers passing in winter and spring months.

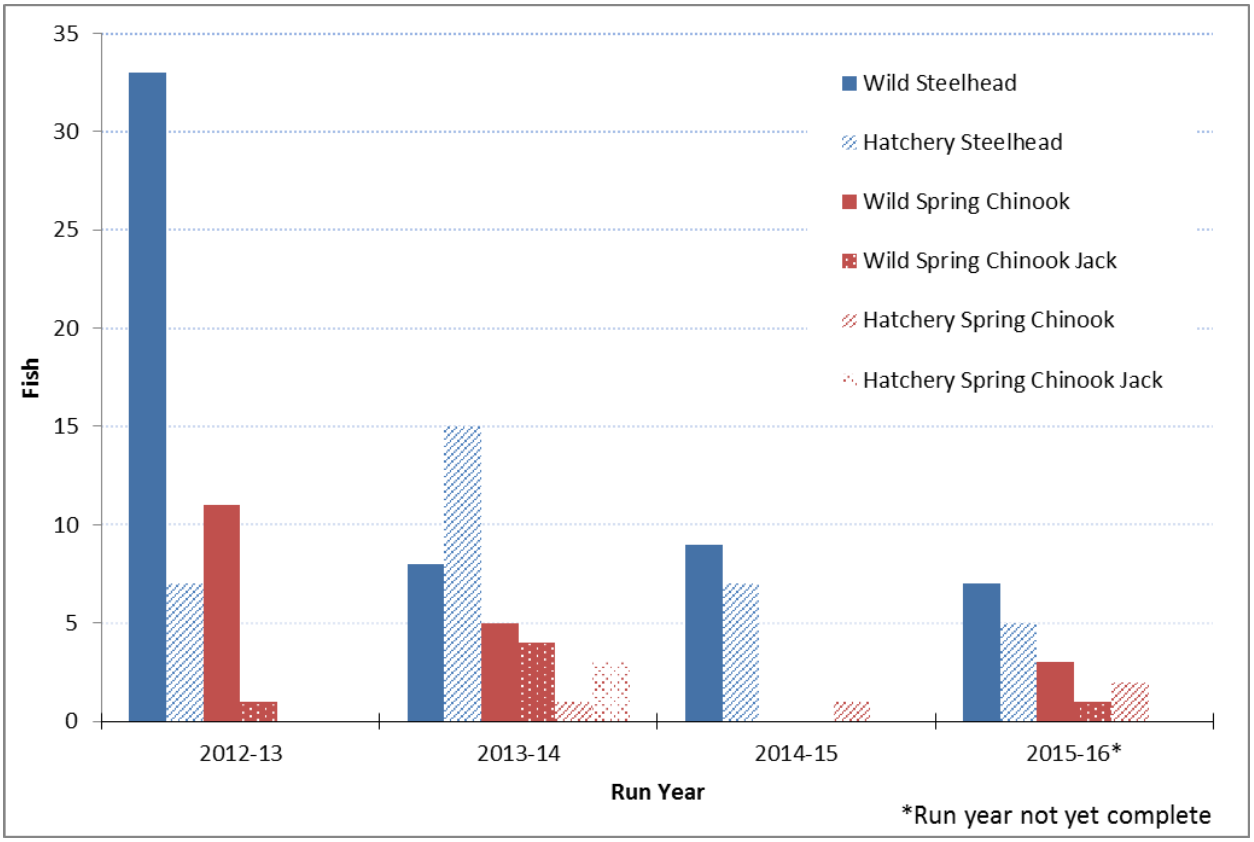

Figure 4. Video counts by run year of anadromous salmonids at the Castile Falls 10/11 fishway on the upper Klickitat River. Run year is June 1 – May 31.

Conclusions

With overall low numbers of fish observed to date at the Castile Falls 10/11 fishway video monitoring facility, results suggest (and generally agree with results from spawning ground surveys) that large numbers of fish are not utilizing the upper Klickitat subbasin, despite now having enhanced access to significant amounts of high quality spawning habitat. The role of the hatchery steelhead that are observed at the Castile Falls 10/11 fishway is unknown; since these fish are mostly migrating in the summer and early fall, it is unknown if they remain in the upper Klickitat River to spawn or move to other areas prior to spawning season. The draft Klickitat Master Plan (Yakama Nation 2012) contains recommended plans if populations (primarily steelhead) do not recolonize the upper Klickitat at a rate accordant with previous production potential estimates; these include possible hatchery releases in the upper Klickitat, dependent on returns and other population metrics.

Spawning ground surveys (redd counts)

Introduction

In order to monitor spatial and temporal redd distribution of spring and fall Chinook, coho, and steelhead, and to collect biological data from carcasses, spawning ground surveys are conducted throughout the Klickitat subbasin. Spawning ground surveys provide a means of monitoring annual adult spawner escapement as well as spawner distribution.

Methods

Regular foot and/or raft surveys were conducted within the known geographic range for each species. Surveys were generally conducted every two weeks in each river reach. Individual redds were counted and their locations recorded using handheld GPS units. Counts of live fish and carcasses were also recorded. Carcasses were examined for sex determination, egg/milt retention (percent spawned), and presence of CWT tags or external experimental marks. Observations of carcasses with floy tags (inserted into adult salmon and hatchery steelhead at the Lyle Falls adult trap at RM 2.4) aided in population estimation. Scale samples were also taken from carcasses using methods outlined in Crawford et al. (2007).

Spawning ground surveys were conducted as follows: spring Chinook – mid August through early October; fall Chinook – late October through mid December; coho – late October through late January; steelhead – late February through mid June. Attempts were made to cover the entire known spawning range of each species, although in some cases, access, flows, and visibility limited surveys. Stream reaches were surveyed multiple times during the spawning periods, with most reaches receiving at least 2-3 passes, and survey passes being conducted approximately two weeks apart in each reach. Subsequent survey passes generally continued in each reach until no live spawners were observed. Methods generally followed those of Gallagher et al. (2007).

Results

Spawner survey results are briefly discussed by species below. Figure 5 through Figure 8 show the observed spawning distribution for spring Chinook, fall Chinook, coho, and steelhead, respectively. Additional tabular and graphical summaries of spawning ground survey results are presented in Appendix B.

Spring Chinook

Observed spring Chinook spawning distribution for 200 through 2015 is shown in Figure 5. Natural spring Chinook spawning typically occurs in the Klickitat mainstem upstream of the Little Klickitat River confluence (RM 20), with most of the spawning occurring upstream of the Big Muddy Creek confluence (RM 54) up to Castile Falls (RM 64). Additional spawning occurs above Castile Falls which historically had some natural passage and had also been seeded in recent years (2000 and 2002-4) by transporting and releasing surplus adult spring Chinook that returned to the Klickitat Hatchery. No adult fish have been transported above Castile Falls since 2004. Recently completed

(summer 2005) improvements at the Castile Falls fish ladders have enhanced fish passage, correcting problems with the original 1960s ladders which had actually impaired natural passage and had likely reduced fish numbers above the falls from historic levels.

Surveys for 2013 were conducted from August 13 through October 10 and covered a total of 66.6 river miles; surveys in 2014 were conducted from August 18 through October 8 and covered 74.9 river miles; surveys in 2015 were conducted from August 5 through October 1 and covered 60.5 river miles. In 2015, the Cougar Creek wildfire on the Yakama Reservation limited road access and prevented surveys from Signal Peak Bridge to the old U.S. Geological Survey stream gage site above Klickitat Hatchery – this river reach includes the key spawning habitat above Big Muddy Creek where most spring Chinook redds are found. Otherwise survey conditions during these three years provided generally good water clarity and visibility, with the exception of high turbidity that limited visibility during portions of the 2013 season. While this turbidity limited surveys and visibility for two different periods in early and late September and early October, it likely did not result in significantly lower redd counts for that year. Table 7 in Appendix B shows results of spring Chinook redd counts for 1989-2015 by river reach. For the key spawning reach described above that was not surveyed in 2015, redd counts were estimated based on linear regression of this reach's past redd counts against the mark-recapture estimate of wild run size at Lyle Falls for 2007-2014 (see Adult monitoring section above). Surveys for the 2010-2015 period years show a general increase over counts from the 2004-2009 period, during which some of the lowest redd counts on record were recorded. This could be partly due to larger numbers of hatchery-origin fish on the natural spawning grounds (see description below). The average redd count for 1996-2015 (the time period with the most consistency in geographic coverage of redd surveys) is 117 (using total redd counts minus counts above Castile Falls in years of hatchery adult releases there, assuming virtually no passage above Castile in those years); the average redd count for 2013-2015 is 134.

As in other recent years, results of spawner surveys above Castile Falls showed relatively low numbers of redds in the upper Klickitat River, with 0, 0, and 3 redds being observed in 2013, 2014, and 2015, respectively. A peak number of redds of 36 was observed in 2007; some of the returning fish in that year may have resulted from the past releases of surplus hatchery adults in that area. Figure 29 in Appendix B shows results of redd counts above Castile Falls.

Spring Chinook redd counts provide a more accurate indicator of annual spawner escapement than other species in the Klickitat due to the fairly limited geographic area of spawning and relatively good survey conditions in most years (low flows and good visibility). Spring Chinook redd counts also provide one of the longest-term datasets for anadromous salmonids in the Klickitat. The total redd counts minus hatchery adult releases above Castile Falls (in Table 7, Appendix B) provides the most consistent year-to-year comparison and these data were used for trend analysis. Trends in redd counts from 1996 to 2012 (a time period with consistency in geographic coverage of redd surveys) do not currently show a significant downward trend, as had been observed in previous years. Regression analysis of natural logarithm-transformed redd counts (methods described in Thompson et al. 1998) yields a slope estimate of +0.1% with a 95% confidence interval (CI) of -3.3

to +3.0% and one-sided p-value for the slope of 0.46 (i.e., the 95% CI for the slope includes 0 and the null hypothesis that there is no decline in redd counts over time cannot be rejected).

However, one significant factor in the redd count trends is the presence of hatchery-origin fish on spring Chinook spawning grounds. From 2007-2014 (2007 is the first year in which all returning 4- and 5-year-old hatchery spring Chinook adults were 100% ad-clipped), the percentage of hatchery-origin carcasses recovered on spawner surveys has averaged 42% (Table 8 in Appendix B). Sample sizes of recovered spring Chinook carcasses are quite low due to typically low overall returns and fast river conditions in some reaches, so conclusions are somewhat tentative, but results to date indicate a significant percentage of hatchery-origin adults, including in core wild spring Chinook spawning reaches.

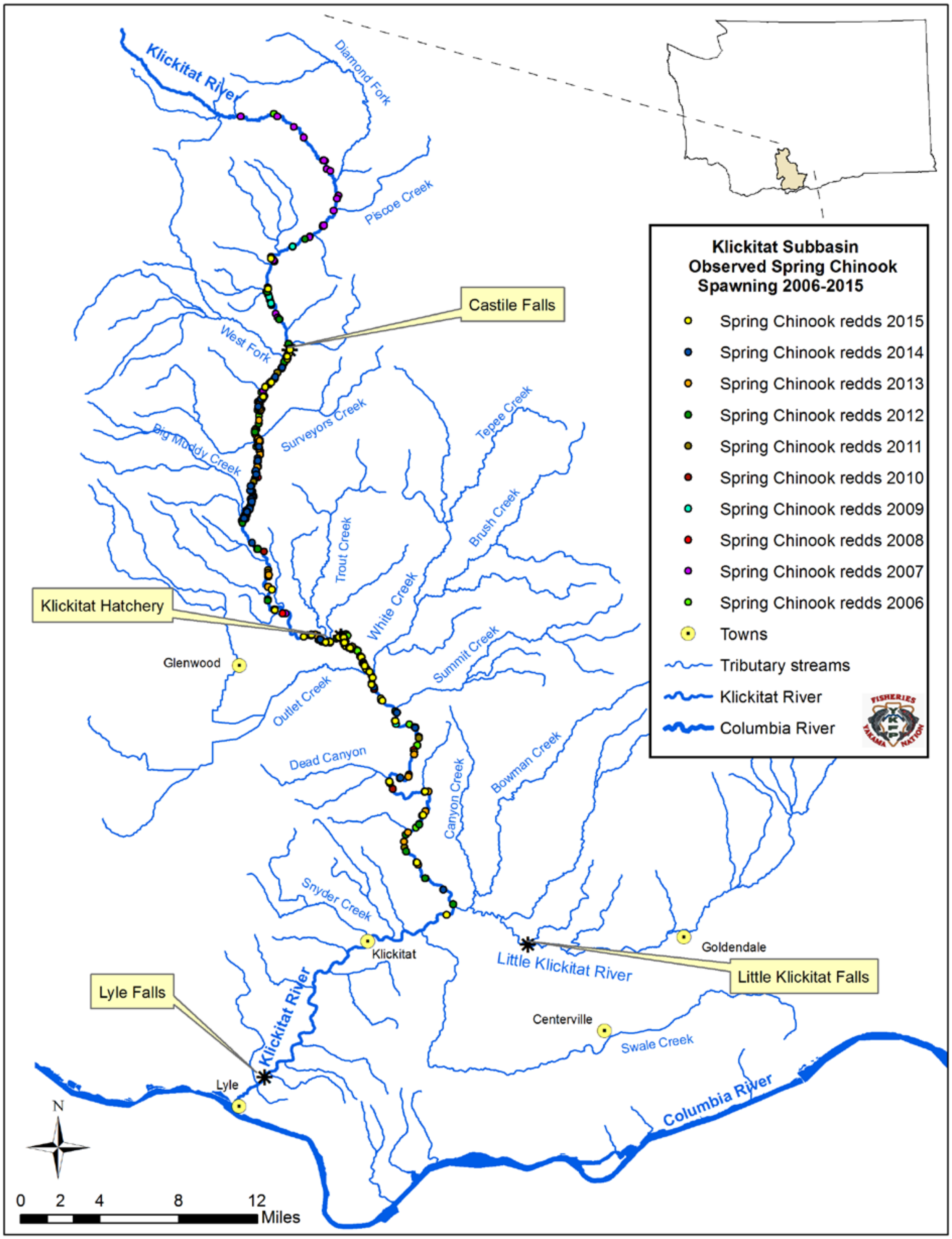

Figure 5. Observed spring Chinook spawning distribution in the Klickitat subbasin for 2006-2015.

Fall Chinook

Fall Chinook are mainstem spawners and generally utilize the lower portion of the river, downstream of the Klickitat Hatchery. Observed fall Chinook spawning distribution for 2006 through 2015 is shown in Figure 6.

Table 9 in Appendix B shows results of fall Chinook redd counts in the Klickitat subbasin for 1995-2015 by river reach. Redd counts in 2013 and 2014 reached record highs (3657 and 3818 respectively) for this period of surveys; the 1996-2015 average redd count is about 1130. Overall Columbia River basin runs of fall Chinook were also very high for all three of these years, with record high counts at Bonneville Dam in 2013 and again in 2015. Surveys for 2013 were conducted from October 23 through December 20 and covered a total of 48.7 river miles; surveys in 2014 were conducted from October 23 through December 18 and also covered 48.7 river miles; surveys in 2015 were conducted from October 27 through December 7 and covered 40.5 river miles. Surveys in 2013 and 2014 had minor limitations due to high flows and turbidity. Surveys in 2015 had more significant limitations during several periods (two occasions in November and again in mid-December which effectively ended surveys early); this likely biased 2015 redd counts somewhat low at 1593. The highest redd densities occurred in the river reach from Klickitat Hatchery (RM 42) downstream to Stinson Flats (RM 29), as well as just upstream of the Little Klickitat River confluence (RM 20).

For 2013, of the carcasses for which adipose fin presence/absence could be determined, 239 out of 1503 (15.9%) were ad-clipped (the rest were either wild or unmarked hatchery fish), and 0.4% (6/1503) were floy-tagged. In 2014, 36.2% (59/163) were ad-clipped and 0 were floy-tagged. In 2015, 31.6% (25/79) were ad-clipped, and 0 were floy-tagged. As in recent previous years, these observed percentages of ad-clipped carcasses correspond roughly with ad-clipped percentages of hatchery juveniles released in years that would produce adults for these return years (in this case, release years 2009-2012). On average approximately 28.0% of juveniles were ad-marked in those release years (Fish Passage Center data), while the average of ad-clipped carcasses across those return years was 27.9%. This would suggest that, despite observed spawning activity and relatively high redd counts in some years, fall Chinook natural production in the Klickitat River in most years does not successfully produce high numbers of returning adults.

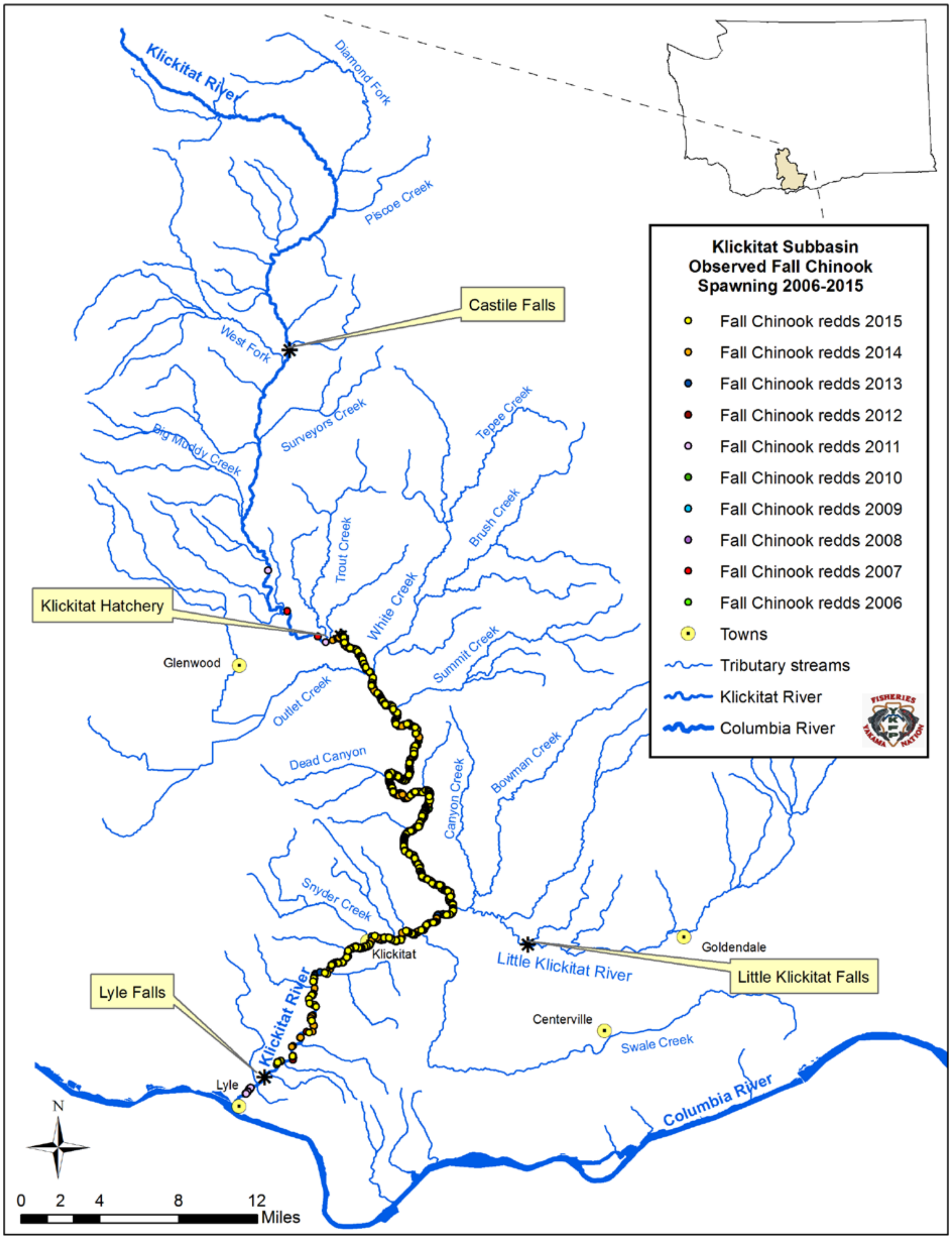

Figure 6. Observed fall Chinook spawning distribution in the Klickitat subbasin for 2006-2015.

Coho

Coho spawning generally occurs in the lower reaches of most lower river tributaries and the mainstem below Parrott's Crossing (RM 49.4). Observed coho spawning distribution for 2003 through 2014 is shown in Figure 7; surveys in fall/winter 2015 extended past the reporting period for this report and will be shown in future reports. Surveys for 2012-13 were conducted from October 24 through February 5 and covered a total of 65.2 river miles (including mainstem Klickitat and tributaries). A total of 112 redds were counted; 86 were in the mainstem Klickitat and 26 were in tributaries. Surveys in 2013-14 were conducted from December 12 through March 3 and covered 57.9 river miles. Coho surveys normally start earlier than December 12, but this date was earliest confirmed live coho observation, due to high numbers of fall Chinook in the river in 2013. A total of 296 redds were counted; 258 were in the mainstem and 38 in tributaries. Surveys in 2014-15 were conducted from October 21 through February 3 and covered 68.0 river miles. A total of 555 redds were counted; 407 were in the mainstem Klickitat and 148 were in tributaries. Tributary streams in which coho spawning was observed during this report period included Dead Canyon Creek, lower Little Klickitat River, Bowman Creek, Swale Creek, Snyder Creek, Logging Camp Creek, Wheeler Creek, Dillacort and Canyon Creek (below Lyle Falls). Surveys during all three years were limited by high flow and turbidity several times in each year, with some snow/ice limitations in December 2013. These conditions probably had the highest effect in 2012 as far as biasing redd counts somewhat low.

For 2012-13, of the carcasses for which adipose fin presence/absence could be determined, 100% (11 out of 11) were ad-clipped. For 2013-14, the ad-clipped percentage was 55% (11/20); the rest were either wild or unmarked hatchery fish. For 2014-15, the ad-clipped percentage was 100% (253/253). No floy-tagged carcasses were observed in any of the three years. Similar to fall Chinook, the correspondence in these percentages of ad-clipped carcasses to ad-clipped percentages of hatchery juveniles in release years that produce returning adults for these years (which average 99.3% for release years 2011-13 [Fish Passage Center data]) suggest that natural coho production in the Klickitat subbasin in most years does not successfully produce large numbers of returning adults. In this report period, return year 2013 appears to be an outlier in this pattern, with either a higher success rate of natural production or other factors such as different mark-selective fishery harvest rates having resulting in a lower ad-clip rate in returning adults. Small sample sizes and difficult sampling conditions may also result in higher year-to-year variation in this metric.

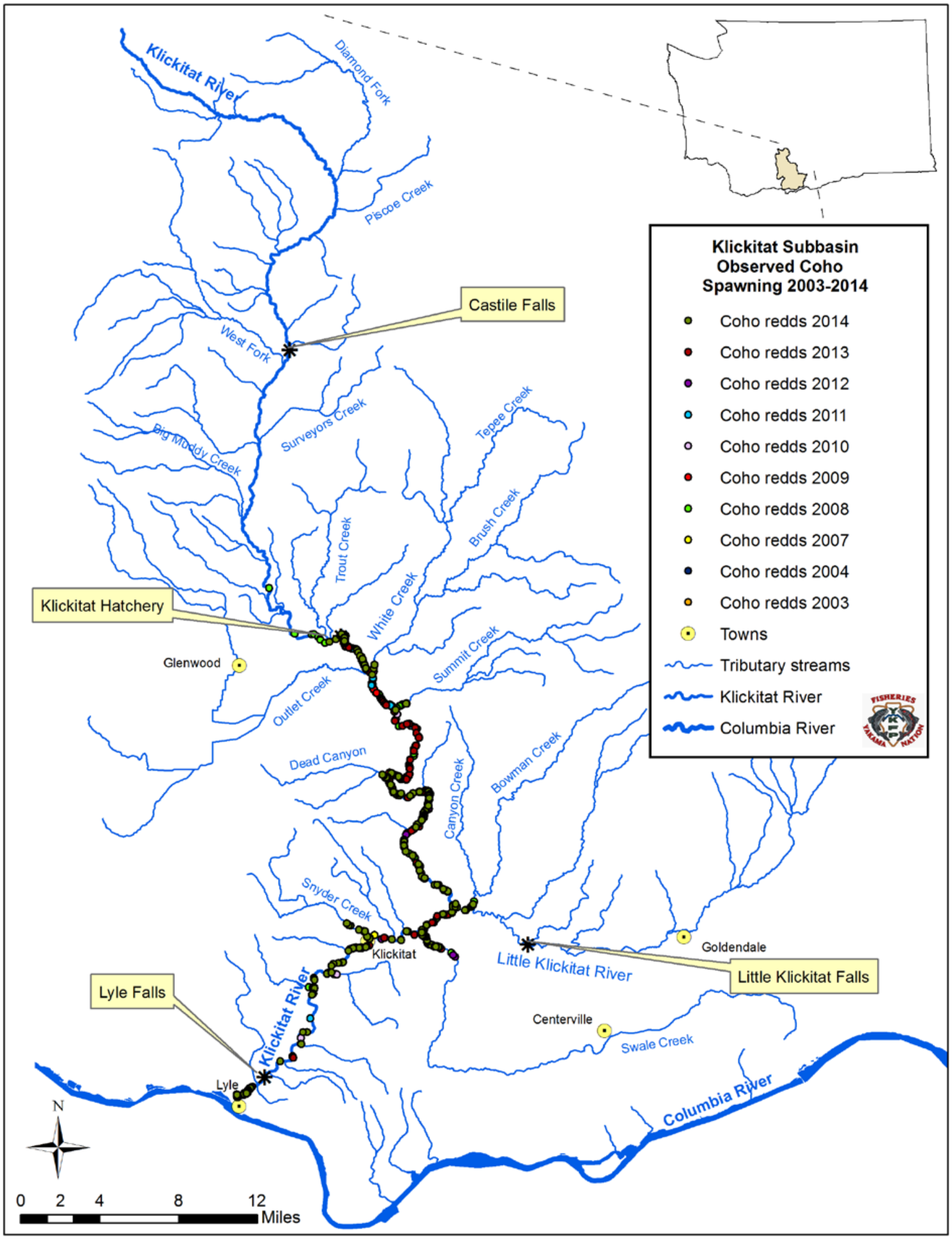

Figure 7. Observed coho spawning distribution in the Klickitat subbasin for 2003-2014.

Steelhead

Steelhead spawner surveys are typically conducted from February through mid June. Attempts are made to cover the entire known spawning range of the species, although in some cases, access, flows, and visibility limited surveys. In most years, high spring flows and turbidity limit the effectiveness of the mainstem Klickitat steelhead redd surveys, leading to an unavoidable bias toward undercounting of redds. Several areas are undersurveyed in most years; these include the mid and upper Klickitat River above Big Muddy Creek (including the area above Castile Falls which frequently has limited access due to snow), and the Little Klickitat River from Little Klickitat falls to Goldendale (with surveys being limited due to landowner access).

Observed steelhead spawning distribution for 2006 through 2015 is shown in Figure 8. Key steelhead spawning areas include the mainstem Klickitat from just downstream of the town of Klickitat to the Klickitat Hatchery (RM 11 to 42), with tributary spawning occurring in the White Creek watershed, Summit Creek, Dead Canyon Creek, the lower Little Klickitat watershed (including Bowman and Canyon Creeks), Swale Creek, Snyder Creek, and occasional use of tributaries below the town of Klickitat. The White Creek watershed (including Brush and Tepee creeks) is one of the most heavily used tributary watersheds, accounting for an average of 39.1% of the observed steelhead redds from 2006-2015 (ranging from 20% to 72% over that entire period, with percentages no lower than 60% during 2013-2015).

Surveys for 2013 were conducted from February 6 through June 18 and covered a total of 125.3 river miles (including mainstem Klickitat and tributaries). A total of 264 redds were counted; 43 were in the mainstem Klickitat and 221 were in tributaries. High flows and/or turbidity prevented surveys in lower White Creek until mid May, in the middle and lower mainstem Klickitat in early to mid May, and in most of upper Klickitat the for entire season. Surveys in 2014 were conducted from February 12 through June 4 and covered 75.4 tributary stream miles. The mainstem Klickitat River was not surveyed in 2014 due to additional efforts during that spawning season at PIT tagging and sampling tributary stream fish populations. A total of 81 redds were counted. Surveys in 2015 were conducted from December 29 through June 4 and covered 149.9 river miles. A total of 217 redds were counted; 62 were in the mainstem and 155 in tributaries. Flows during the latter part of the spawning season in 2015 were quite low, which made for good visibility in many areas but also prevented a second pass in the upper Little Klickitat River where floating surveys are necessary. Survey conditions and sampling efforts likely resulted in the 2013 redd counts being biased slightly low, the 2014 redd counts significantly lower (due to sampling efforts elsewhere and no surveys in the mainstem Klickitat), and relatively little impact on the 2015 redd counts.

Very few steelhead carcasses are typically recovered on spawner surveys in the Klickitat, as steelhead can survive the spawning process and migrate downstream as kelts. During the three years reported here, a total of eight carcasses were recovered which adipose fin presence/absence could be determined (6 wild fish and 2 ad-clipped hatchery fish).

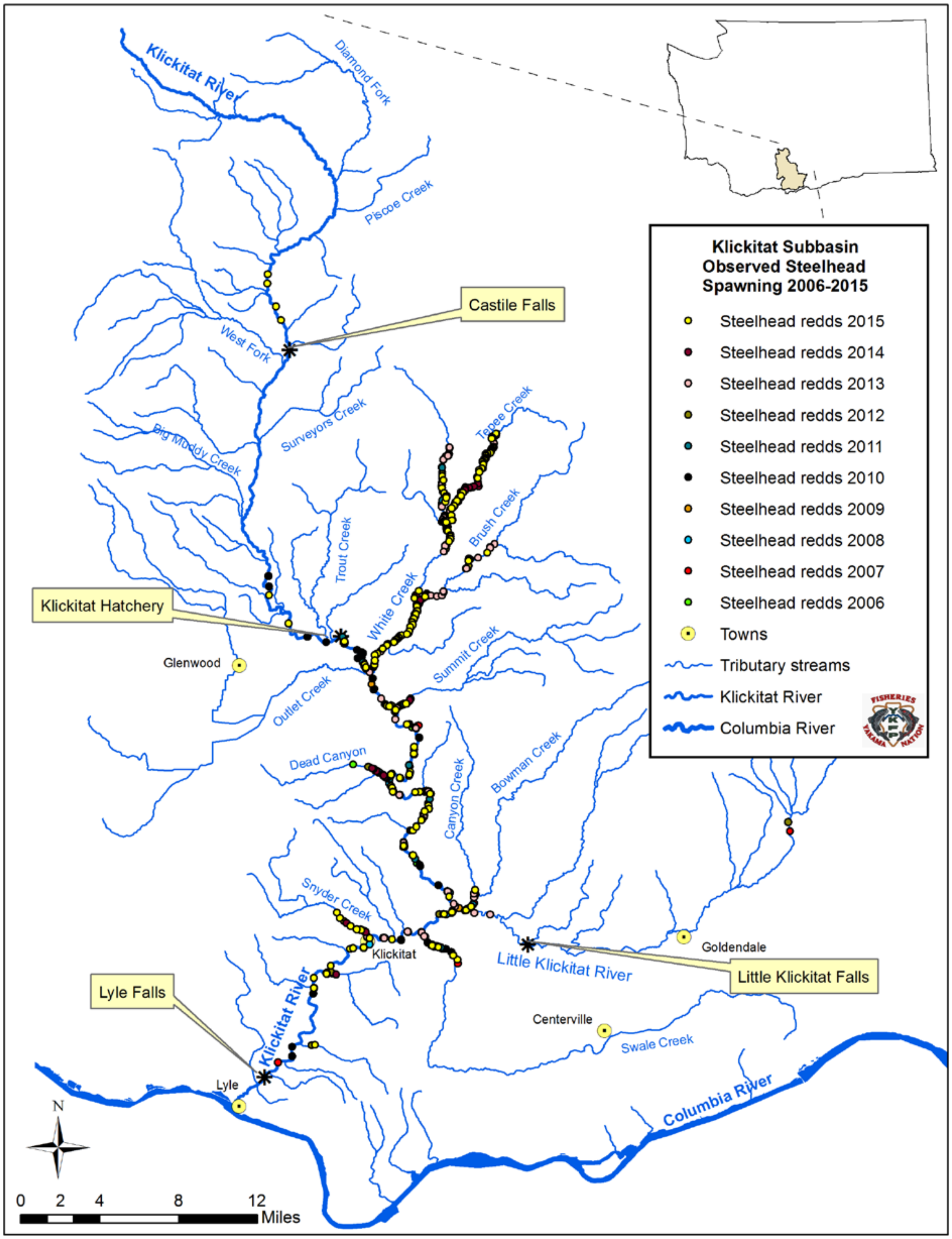

Figure 8. Observed steelhead spawning distribution in the Klickitat subbasin for 2006-2015. Note – the upper Klickitat River (upstream of Big Muddy Creek) and Little Klickitat River between the falls and Goldendale are often not surveyed.

Conclusions

Spring Chinook

Surveys indicate that majority of wild spring Chinook spawning occurs in the upper middle Klickitat River between Big Muddy Creek (RM 54) and Castile Falls (RM 64), but that a potentially large percentage of spawners on natural spawning grounds in the Klickitat River are hatchery-origin fish. Because of genetic introgression concerns likely caused by hatchery interbreeding with previously-released summer Chinook stocks (see description in Genetic analysis section), and because of overall low numbers of spring Chinook redds observed in most years, the status of the wild population of Klickitat spring Chinook appears to be quite depressed. Spring Chinook redd counts provide a more accurate indicator of annual spawner escapement than other species in the Klickitat due to the fairly limited geographic area of spawning and relatively good survey conditions in most years. Results from redd counts generally agree with results from mark-recapture estimates and other run size monitoring (in Adult salmonid monitoring section) as to this depressed status of this native population, and suggest that current spring Chinook runs are not nearly as large as historic runs (Bryant 1949). Results also suggest that spring Chinook recolonization in the upper Klickitat River above Castile Falls following enhancements to past anthropogenically-impaired passage has been slow. This is most likely due to low overall returns of spring Chinook. Trends in spring Chinook redd counts are currently not showing significant declines as had been observed in recent years, but the redd counts include potential hatchery-origin spawners, which may be masking true trends in natural-origin spawners.

Fall Chinook

Redd counts indicate that a fairly large number of fall Chinook spawners return to the Klickitat River in most years, and that most of the spawning occurs from the Klickitat Hatchery (RM 42) downstream to the Twin Bridges (RM 18) area near the town of Klickitat. Carcass recoveries suggest that, while some small amount of natural production may exist, this non-native population is largely sustained by hatchery production.

Coho

Spawner surveys indicate that coho spawners use the lower Klickitat River from the Klickitat Hatchery downstream and many lower subbasin tributaries. Redd counts for coho are highly variable due to frequent high flows during surveys and some variation in actual returns above Lyle Falls, making robust assessments of spawner abundance from redd counts difficult. There are however, large returns of coho evident in some years. Carcass recoveries suggest that, while some natural production does exist in some years, this non-native population is largely sustained by hatchery production.

Steelhead

Surveys indicate that steelhead are spawning in many geographic locations throughout the middle and lower Klickitat subbasin, including multiple tributary streams, with the most use observed in the White Creek watershed and the middle and lower mainstem from RM 11 to 42. There is also some use (likely a lower amount, but with high uncertainty due to limited survey access) in the upper Klickitat River above Castile Falls. These results, along with the finding of multiple genetically distinct subpopulations (see Genetic analysis section) suggest a fairly spatially diverse steelhead population in the Klickitat subbasin. Status and trends in spawner abundance is difficult to assess for steelhead from redd count data due to high variation from flow and visibility limitations. More robust conclusions can be drawn from the mark-recapture estimates of run size (see the Adult salmonid monitoring section) for this native ESA-listed population. Also, due to low numbers of recovered steelhead carcasses, conclusions regarding percentages of hatchery-origin spawners from spawner surveys are not very reliable (although some are present on spawning grounds); that assessment is occurring under the ongoing radio telemetry monitoring.

Spring Chinook run reconstruction

Introduction

In addition to adult monitoring at the Lyle Falls fishway and on spawner ground surveys, a long-term run reconstruction dataset is maintained for spring Chinook returns to the Klickitat River. Data is compiled from harvest monitoring, age sampling, hatchery returns, and redd counts to populate this dataset, which is provided to co-managers and used for long-term monitoring and run forecasting purposes.

Methods

Data is compiled from spring Chinook adult returns to the Klickitat Hatchery, harvest from both sport (provided by WDFW) and tribal (provided by YN Fisheries Resource Management Program) fisheries, redd counts (described in the Spawning ground survey section), and scale age sampling at Lyle adult trap and Klickitat Hatchery (described in the Scale and Coded Wire Tag analysis section) to generate a run reconstruction table. Harvest, and escapement (to the hatchery and to natural spawning grounds) by age are estimated from the compiled data, and total returns to the mouth of the Klickitat River are estimating by summing the harvest and escapement estimates. It should be noted that the natural escapements resulting from redd counts may underestimate the actual natural spawner escapement in some years, and that this estimate also includes hatchery-origin fish that spawn on the natural spawning grounds (see Spawning ground survey section).

Results

See Table 6 in Appendix B for complete results of the run reconstruction estimates. The long-term average for adult (age 4, 5, and 6) spring Chinook return to the mouth of the Klickitat River under these methods is just over 1900 fish, with about 1400 hatchery-origin fish and about 540 wild fish. Estimates of escapement average about 790 hatchery fish and 360 wild fish. Figure 28 in Appendix B shows the total run reconstruction estimates (including adults and jacks) in comparison to the

Lyle Falls mark-recapture run size estimates (which are described in the Adult salmonid monitoring section).

Conclusions

The results of the run reconstruction estimates are generally lower than the mark-recapture estimates, which may be due to underestimation of escapement (from redd counts) and harvest (although harvest estimates are likely more accurate than red-count-based natural escapement estimates). Both sets of estimates, however, indicate that while hatchery spring Chinook returns are quite variable, returns of several thousand fish are possible. And for wild fish, returns of only several hundred fish, with natural spawner escapements of only about 300 or fewer fish are not uncommon. The run reconstruction estimates, like the mark-recapture estimates, indicate a wild spring Chinook return that is much lower than likely historic numbers (Bryant 1949), support the WDFW "depressed" rating for this stock, and warrant significant concern regarding the status and trend of this native population.

Juvenile outmigration monitoring

Introduction

The objective of juvenile outmigration monitoring work is to continue developing methods of using rotary screw traps for long term monitoring of various aspects of juvenile production and population characteristics in the upper and lower Klickitat River. Screw traps provide a means of estimating outmigration timing and magnitude on a daily, seasonal or annual basis. Screw traps also provide a means of collecting biological data and samples, and tagging juvenile fish for survival and smolt-to-adult rate estimation.

Methods

Floating rotary screw traps were fished at two locations in during this reporting period. One trap located just above Lyle Falls (RM 2.8) was operated on a year-round basis. A second trap located above Castile Falls (RM 64.6) was fished seasonally as access and flows allowed.

At each daily trap check, environmental and trap data is recorded along with biological data on 10 to 30 of each salmonid species represented. The excess and non-salmonid fish are tallied by species. Biodata consists of fork lengths, weights and smoltification stage. Environmental and trap data recorded includes weather conditions, water temperature and clarity, trap cone revolution speed, and debris load in the trap cone and live box.

Trap efficiency studies have been conducted at both traps in order to establish a fish-entrainment-to-river-discharge relationship, using trap efficiency modeling methods as described in Volkhardt et al (2007). During each efficiency trial, a sample of fish (generally ranging from 50 to 500 fish) was marked with a fin clip and released a short distance (approximately 1 mile) upstream of the

trap. Beginning in July of 2015, a sample of fish (generally ranging from 20 to 75 fish per week) was marked with a 12 mm PIT tag, replacing fin clips as a mark. These fish were released upstream of the trap in the same manner as fin-clipped fish. All fish captured in the screw trap, subsequently, were scanned for the presence of a PIT tag. The proportion of marked fish that were recaptured over the following week to ten days allowed for an estimate of the trap's catch rate. Efficiency trials have been conducted at various streamflows over the last several years.

Results

Catch summary results for the Lyle Falls screw trap are shown in Table 10, Table 11, and Table 12 in Appendix B. Catch summary results for the Castile Falls screw trap are shown in Table 13, Table 14 , and Table 15 in Appendix B. The Lyle Falls trap was operated year-round during this reporting period. The Castile Falls was only operated from July into October or November for all three reporting years due to high early summer flows in the upper Klickitat River. In 2015, trap repair issues also limited the numbers of days fished.

Developing flow/entrainment relationships and estimating trap efficiency (the percentage captured of the total number of fish moving past the trap site) is a continuing project goal. For the Castile trap, efficiency estimates ranged from approximately 19% to 45%. For the Lyle trap, efficiency estimates ranged from 1.2% to 20.1%. For both traps, efficiency depends largely on streamflow, but other factors (such as trap position in current and species/size of fish) also play a role. These relationships will continue to be developed, with the overall goal of producing valid juvenile production estimates. Gaps in trap operation during high flows and multiple large hatchery releases during peak smolt outmigration periods (over 8 million hatchery smolts are released in the Klickitat River between March and June) continue to make precise smolt abundance estimates difficult to obtain.

Conclusions

The large multiple gaps in trap data from various hatchery releases and high flows have to date made precise smolt abundance estimates difficult to obtain. Rough monthly estimates for some species (primarily natural-origin steelhead) have been generated, but are undergoing further development. These estimates use monthly catch expanded for percent of the month fished, and expanded again based on mean monthly flow and trap efficiency at that flow. Past efforts with existing staff to fish traps during hatchery releases and high spring flows have resulted in some fish mortality and trap damage; additional staff and more frequent trap checks during certain periods may help reduce these gaps, and this will likely be attempted in the future. However, it seems likely that smolt abundance estimates based solely on screw trap sampling on the Klickitat will not have high precision. Additional methods including PIT tag detection in the lower Klickitat River are being explored to augment juvenile outmigration monitoring.

Radio telemetry monitoring

Introduction

Radio telemetry (fish tagging and tracking via fixed sites and mobile surveys) is being used to provide answers to several important questions relating to Klickitat anadromous stocks including evaluation of passage at several critical sites, geographic distribution of winter and summer steelhead spawning habitat, and geographic distribution of hatchery vs. wild spawners for steelhead and spring Chinook. This study began in fall 2009; field data collection ended in 2014 and data compilation and analysis have continued through 2014-2015 with final analysis and report preparation anticipated for 2016.

Methods

Fish were caught in the Lyle Falls Adult Trap (LAT) at river mile 2.4 of the mainstem Klickitat River. Fish were netted in the LAT and sampled for length, species, sex, and origin. A scale sample was taken from each study fish as well as a tissue sample for use in DNA analysis. Study fish were anesthetized using electronarcossis. A regulated DC power supply (Protek brand, model 3006B) was used to produce an electrical current in a holding tank. A heavy-duty plastic trough, approximately 15 cubic foot capacity, was filled with river water. A thin aluminum plate (approximately 12" x 14") was fastened to the inside of each end of the trough. The positive lead was connected to one plate while the negative was connected to the other causing a current to pass through the water which, under proper settings, caused immediate incapacitation of the fish. The electrical output was set at approximately 30 Volts and 0.03 Amps for anesthetizing steelhead while approximately 55 Volts and 0.06 Amps were required to produce the desired results with Chinook. Electrical current was run through the water continually while fish were being tagged.

Once a fish was sufficiently anesthetized, it was held belly-up in the water and against the inside wall of the cooler with just its mouth above the water surface while a single radio tag was inserted through the fish's mouth and into its stomach leaving approximately eight inches of the antenna exposed. The antenna was crimped at the corner of the fish's mouth to prevent it from protruding out and in front of the fish. A single, 12mm passive integrated transponder (PIT) tag was injected into the dorsal sinus or pelvic girdle of each radio-tagged fish. Immediately after being tagged, study fish were placed in large, insulated coolers containing river water for recovery and transport to release site. Recovery coolers were oxygenated continuously and monitored for dissolved oxygen content and water temperature. No more than two fish were placed in a single cooler. Water temperature in the recovery coolers was maintained at the temperature of the river at the time of tagging. Dissolved oxygen content was monitored using a YSI meter and was maintained between 120% and 140% saturation. Study fish were transported upstream roughly 0.5 miles in recovery coolers to a large pool where they were released directly into the river provided they made a full recovery after tagging. This release site was selected for its distance upstream of the Lyle Falls complex and for its deep water and slow current theoretically decreasing the likelihood of fish being washed downstream immediately upon release.

Lotek brand (model SRX 400) radio receivers were installed at all but one of the ten fixed-receiver sites. An Orion radio receiver (Grant Systems Engineering Inc) was installed at the lower Castile

site due to the inaccessibility of that site during winter months and the capability of the Orion receiver to shut down and restart itself as solar electricity production allows. Solar panel (Sharp brand, 80 Watt) arrays were used to power six of the sites. Two sites were plugged directly into 110 Volt hard power. The upper Castile site was powered by a Thermo-electric generator and propane, during the initial two years of the study, due to its inaccessibility during winter. In the fall of 2011, 110 Volt hard power became available at the upper Castile site and use of the Thermo-electric generator was abandoned. Six-element, aerial antennas were installed at all sites in locations providing directionality of tagged fish movement. Two antennas were installed at the Klickitat/Columbia river confluence; a minimum of three aerial antennas were installed at all other sites with three sites also utilizing lower-sensitivity "whip antennas" constructed of stripped coaxial cable which were placed in fishways/ladders at the Lyle Falls, Klickitat Hatchery, lower Castile, and upper Castile sites. See Figure 30 (Appendix B) for a map of fixed telemetry sites.

Mobile tracking of fish was done on a weekly basis using a Lotek SRX 400 radio receiver and an omni-directional, car-top antenna. The majority of the lower 40 miles of the Klickitat River was tracked via river-adjacent roads/highway. A six-element, hand-held Yagi antenna was also used to find more precise locations when necessary. On several occasions in the spring of 2012 and 2013, inaccessible reaches of the mainstem Klickitat, as well as tributary streams, were tracked from a fixed-wing aircraft. Locations of tagged fish were recorded and stored as waypoint data with a Garmin (model GPSmap 76CSx) GPS unit.

Locations, dates, and times from fixed and mobile tracking detections were compiled by individual fish/tag, and once a complete history was recorded and the fish or tag was no longer active (determined by recovery of the tag with or without a fish carcass or by sufficient time passage with no further detections), the compiled tracking history was analyzed for a determination of final fate or outcome of that individual fish. Possible fates included: pre-spawn mortality/regurgitated tag (it was frequently impossible to distinguish between these two if no fish carcass was found); spawned in the wild; left the Klickitat River; kelted (generally for steelhead that spawned in the wild and then left the Klickitat River); fallback over Lyle Falls; reascended Lyle Falls via the fish ladder or natural falls; probable harvest; definite harvest (usually accompanied by an angler/fisher report of recovered tag); presence at Klickitat Hatchery weir, hatchery adult ladder, hatchery adult holding pond, and/or upstream of the weir. These fates were not all mutually exclusive (one fish could be placed into more than one category). Dates were determined for each of these events, and if the fish was determined to have spawned in the wild, approximate start and end dates for spawning were assigned based on fish movement/behavior and location. This fate analysis and determination was conducted by a panel of three experienced biologists familiar with Klickitat subbasin fish populations, habitat use, and geography, using a consensus approach.

Results

As the data analysis phase of this study is ongoing, results presented here are partial and preliminary and will be added to in future reports or separate manuscripts. A total of 488 steelhead and 226 spring Chinook were radio-tagged during the study. Of the 488 steelhead tagged, 176 were adipose fin-clipped (hatchery origin) and 312 were adipose fin-present (presumed wild origin). Of the 226 spring Chinook tagged, 142 were adipose fin-clipped (hatchery origin) and 84

were adipose fin-present (wild origin). An additional 73 fall Chinook were tagged in the last year of tagging (2013) to evaluate fish behavior following sedation using the electronarcosis system described above.

Results of the evaluation of effects of the electronarcosis system used for fish sedation during this study are found in Keep et al. (2015). This evaluation found no differences in travel times, after release to points 10 and 20 miles upstream, between fish treated either with electronarcosis or carbon dioxide (another widely-used fish sedative).

Data suggest a substantial temporary straying or “dip in” rate among fish entering the Klickitat River. Approximately 25% (77/312) of all wild steelhead and 41% (72/176) of all hatchery steelhead radio tagged during the study descended Lyle Falls after being tagged, did not re-ascend Lyle Falls and left the Klickitat River subbasin. Likewise, 38% (32/84) of all wild spring Chinook and 26% (32/142) of all hatchery spring Chinook radio tagged descended Lyle falls shortly after being tagged and left the Klickitat River. Tagging effects could be influencing fish behavior and may be playing a role in this observed migration out of the subbasin, especially for spring Chinook, as has been noted in other radio tagging studies (e.g., Bernard et al 1999).

Fixed-site and mobile tracking detections during the study showed radio-tagged steelhead ascending and spawning in nine different tributary watersheds including Dead Canyon Creek, Dillacort Creek, Little Klickitat River (and its tributary Bowman Creek), Logging Camp Creek, Snyder Creek, Summit Creek, Swale Creek, Wheeler Creek, and White Creek, in addition to multiple locations in the mainstem Klickitat River. Spring Chinook primarily spawned in the mainstem Klickitat; one radio-tagged spring Chinook ascended Summit Creek where it presumably spawned and died (its radio tag was recovered at approximately river mile 0.5 of Summit Creek).

Two examples of steelhead that were assigned fates of having spawned in the wild and then kelted are fish #56022 (a wild female summer steelhead) and fish #44141 (a wild female winter steelhead). The behavior of these two fish represents fairly typical movements of steelhead that were determined to have spawned in the wild.

Fish #56022 was tagged on June 16, 2010 and migrated upstream taking 35 days to reach river mile 28 where it remained through the winter before entering Dead Canyon Creek on March 15, 2011. On March 20, five days later, it exited Dead Canyon Creek and was detected shortly thereafter at each fixed-site receiver before returning to the Columbia River on March 31, 2011 for a total of 288 days (after being radio-tagged) in the Klickitat River drainage, taking only 11 days to reach the confluence of the Klickitat and Columbia rivers after spawning. See Figure 9 for a spawning migration graph of #56022.

Fish #44141 was tagged on February 29, 2012 and migrated upstream taking approximately 25 days to reach, and enter, Wheeler Creek. On March 27th it was observed exhibiting spawning behavior at river mile 1.2 of Wheeler Creek. It was detected at river mile 7.2 of the Klickitat River nine days later as it out-migrated after spawning. It was detected exiting the Klickitat River drainage and entering the Columbia River on April 9, 2012 for a total of 40 days (after being radio-tagged) in the Klickitat River drainage. See Figure 10 for a spawning migration graph of #44141.

Results suggest temporal separation in spawn timing between hatchery and wild steelhead (Figure 31 in Appendix B). The majority (75%) of hatchery steelhead that were determined to have spawned in the wild did so between mid-November and mid-March; the majority (85%) of wild steelhead spawned from mid- March to mid-May (Zendt et al. 2015). Results also show that about 15% of the tagged hatchery steelhead appeared to have spawned in the wild, versus 58% for wild steelhead; these percentages are for known-fate fish only (excluding those that either regurgitated their tags or were pre-spawn mortalities, fates that could not always be separated) and therefore are likely lower than the true percentages of fish with these fates. Hatchery steelhead smolts that are released in the Klickitat River originate from Skamania Hatchery stock; this steelhead stock has been selected for and currently exhibits an early spawn timing (November-January) in the hatchery environment (Crawford 1979; J. Allen, WDFW Skamania Hatchery Manager, pers. comm.)

Results also suggest that there is some spatial separation in spawning locations between hatchery and wild steelhead. Approximately 90% of hatchery steelhead that spawned in the wild did so in the lower mainstem Klickitat River or in tributaries to that reach (from RM 20 downstream, or in the Little Klickitat River and tributaries downstream). Approximately 64% of wild steelhead that spawned in the wild did so from RM 20 upstream, or in tributaries upstream of the Little Klickitat River (Zendt et al. 2015).

In contrast to steelhead, results for spring Chinook indicate that hatchery and wild fish spawn at the same time (in August and September) and with some overlap in locations for those hatchery spring Chinook that spawn in the wild (Zendt et al. 2015). This is not unexpected as the broodstock origin of the Klickitat Hatchery originated from the Klickitat River spring Chinook population.

Observations to date of both spring Chinook and steelhead show that multiple fish moved back and forth upstream and downstream over the Klickitat Hatchery weir, or simply moved from downstream to upstream of the weir, in a fairly short time period, indicating that the weir does not present a difficult passage obstruction.

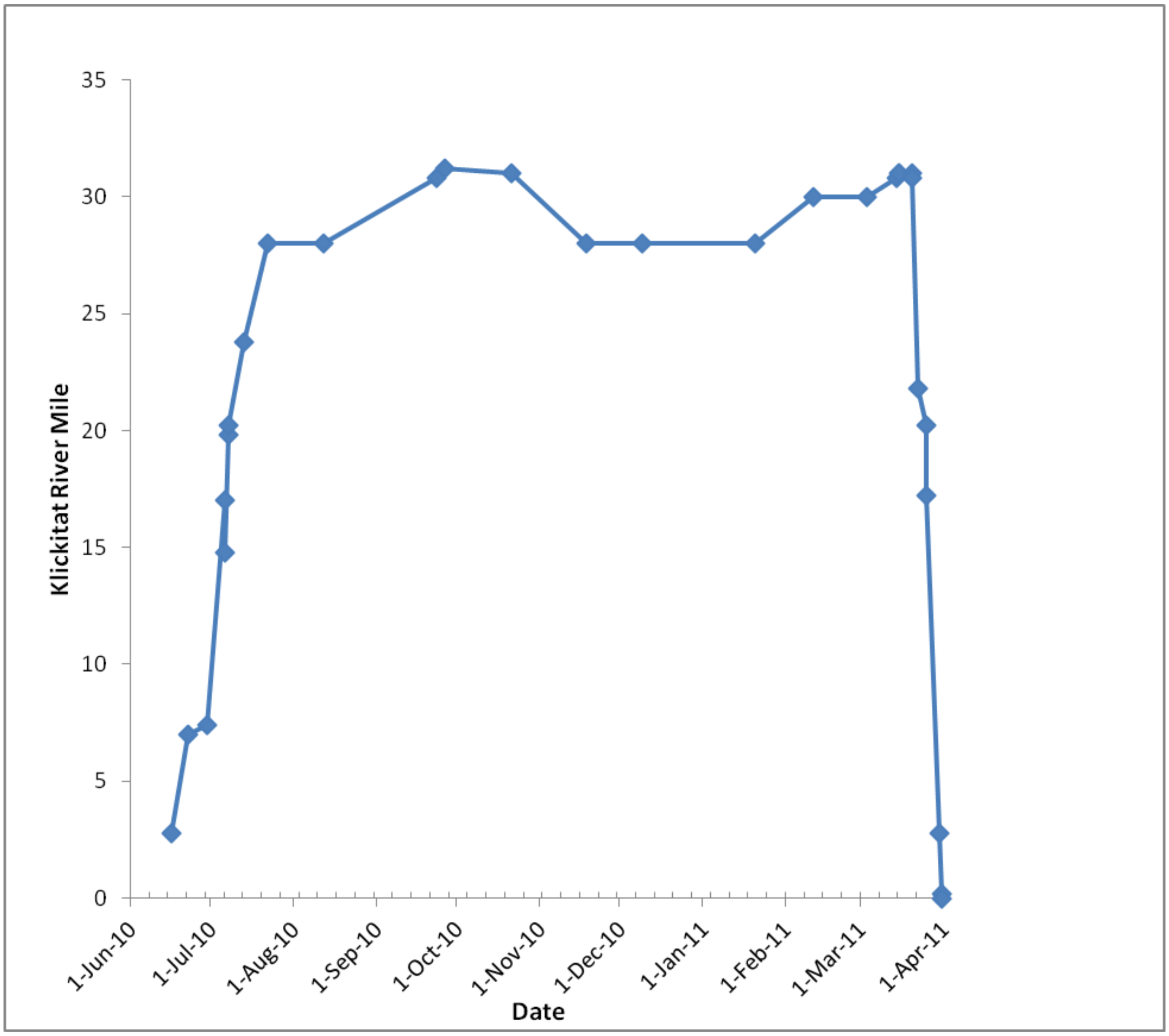

Figure 9. Detected locations by date for wild summer steelhead with radio tag #56022

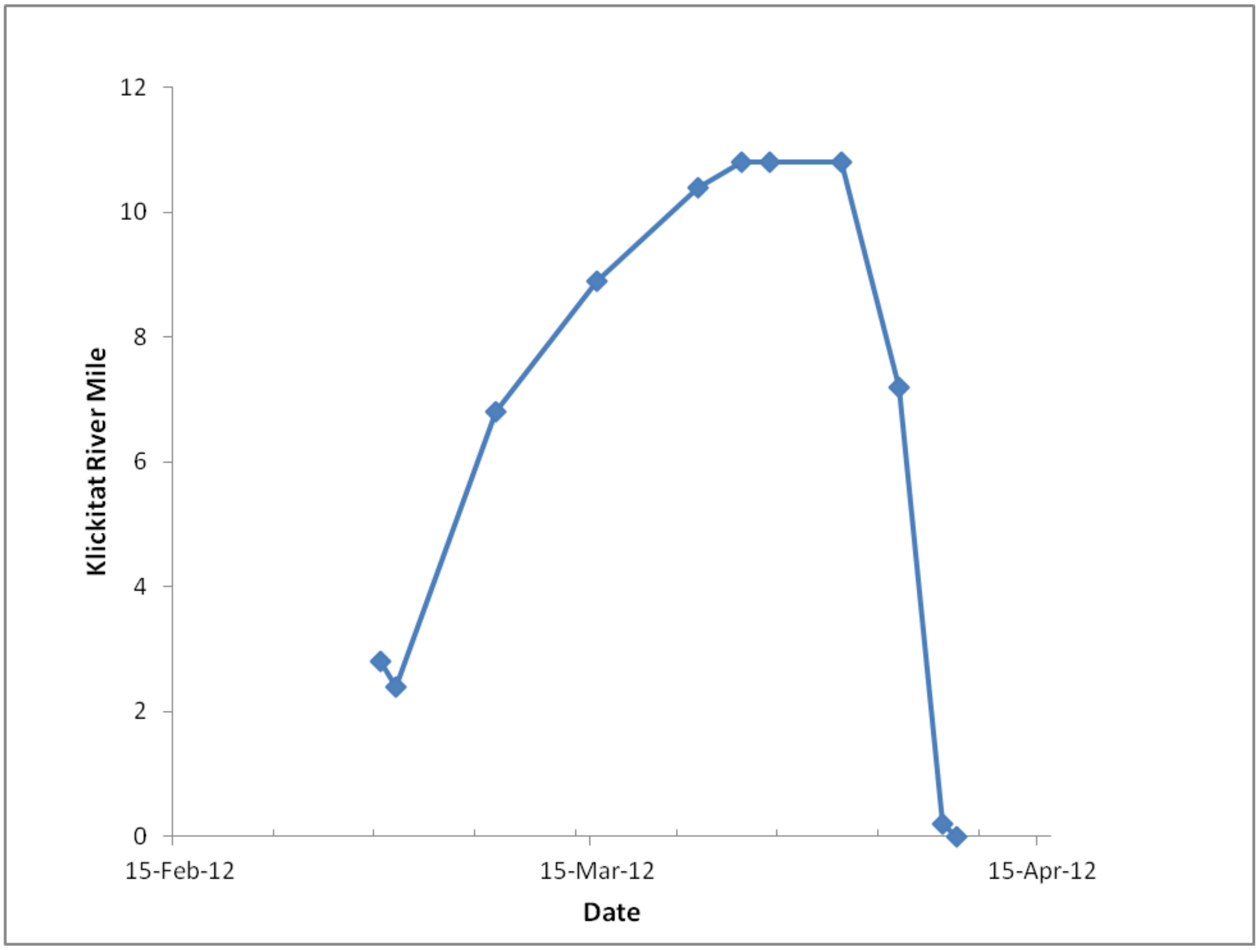

Figure 10. Detected locations by date for wild winter steelhead with radio tag #44141.

Conclusions

Results to date from the radio telemetry provide the following preliminary conclusions regarding several uncertainties in the Klickitat subbasin: stray or "dip-in" rates are quite high for fish that enter the lower Klickitat River (which corroborates findings presented in the Genetic analysis section for steelhead); spawning distribution is similar to what is observed from spawning ground surveys (widespread spawning throughout the mid and lower subbasin for steelhead); the majority of hatchery steelhead do not appear to spawn in the wild, and for those that do the majority do not overlap in spawn timing with wild steelhead; and the Klickitat Hatchery weir does not present a difficult passage obstruction for most fish.

More results and conclusions from this ongoing study will be presented in future reports and/or manuscripts.

Genetic analysis

Introduction

Objectives of genetic analysis are to gain a thorough understanding of the genetic characteristics (including stock identification, diversity, and degree of introgression between various stocks) of anadromous salmonid populations in order to maintain long term genetic variability and minimize the impacts of artificial production on native populations (spring Chinook and steelhead). A thorough knowledge of baseline genetic conditions, landscape and habitat influences, effects of past and current hatchery practices, anadromous/resident interactions, and dip-in rates by out-of-basin adults is important in order to adhere to YKFP genetic guidelines, minimize negative effects, and monitor hatchery actions aimed at improving population parameters.

Methods

Genetic samples were collected from adult steelhead and Chinook salmon at the Lyle Falls adult trap on the lower Klickitat River (RM 2.4). As fish were enumerated, netted and removed from the live trap, small fin clips or opercle punches of Chinook and steelhead were collected. Genetic samples were also collected from adult spring Chinook spawned for broodstock at the Klickitat Hatchery, beginning in 2006. In addition, genetic samples were collected from juvenile and resident fish during stream electrofishing activities and from outmigrating juveniles at the floating rotary screw traps (via a non-lethal fin clip). Samples were stored in 95% non-denatured ethanol or on gridded paper. A genetic sample number was recorded with the biodata collected for each fish.

Samples were sent to the Columbia River Intertribal Fish Commission (CRITFC) Genetics Laboratory in Hagerman, Idaho, for analysis and archival. Information resulting from tissue analysis is added to existing regional genetic databases and incorporated into reports, manuscripts, and management actions. Various types of genetic information are derived from sample analysis, including: genetic stock identification, parentage-based tagging identification (where possible), diversity metrics, introgression rates, and determination of phylogenetic relationships both within the Klickitat subbasin and between the Klickitat and other subbasins.

Results

Steelhead

Analysis of juvenile *O. mykiss* samples from Klickitat River screw traps found that an estimated 6 to 7 genetically distinct subpopulations were present in the subbasin, approximately 4.0% of naturally-produced steelhead smolts had their most likely assignment to Skamania Hatchery stock, and that genetic integrity and variation of native Klickitat steelhead was fairly intact (Narum et al. 2006).

Analysis of *O. mykiss* samples collected via stream electrofishing from multiple tributary locations throughout the subbasin found primarily anadromous populations (with higher genetic diversity) in the lower elevation, warmer portions of the Klickitat subbasin; primarily resident populations (with lower genetic diversity) were found in higher elevation areas above higher gradient stream

reaches and passage obstructions. Intermediate areas also exist with varying levels of mixing of the two life history types (Narum et al. 2008).

Further analysis of samples collected via stream electrofishing shows relatively small amounts of gene flow between the Skamania Hatchery stock and native Klickitat steelhead (similar to what was observed in screw trap samples), with certain tributaries showing a somewhat higher level of gene flow (e.g., Logging Camp, Swale, Bowman, and Dead Canyon creeks all showed a preliminary percentage Skamania ancestry of between 10 and 20%; CRITFC unpublished data). Determining whether this gene flow is recent or ongoing vs. historic is difficult as Klickitat native steelhead were used in the founding of the Skamania Hatchery stock (Crawford 1979).

Analysis of samples from returning adult steelhead has yielded estimates of relative production of different areas within the subbasin (in terms of proportions of adults sampled at Lyle Falls), with middle Klickitat tributaries (e.g. White Creek, lower Summit Creek) contributing a high proportion of adults (over 50%) and other significant contributions coming from lower subbasin tributaries such as Dead Canyon, Bowman Creek, lower Little Klickitat River, and Swale Creek (Narum et al. 2007). Results of genetic stock identification indicate on average for 2007-2012 approximately 25% of natural-origin steelhead and 30% of hatchery-origin steelhead sampled at the Lyle Falls adult trap are from outside the Klickitat subbasin (including an average of nearly 12% of fish being identified as Snake River stocks).

Additional analysis using the various collections of *O. mykiss* samples from the Klickitat subbasin led to identification of several candidate genetic markers associated with anadromy (Narum et al. 2011). A predictive multivariate logistic model developed from the allele frequencies of these markers was tested against Klickitat populations with previous knowledge of likely anadromy or residency. The results were generally consistent with these previous determinations, indicating the possible strength of the candidate markers. Further study is needed to determine whether these findings apply to other geographic areas (Narum et al. 2011).

Spring Chinook

Analysis of spring Chinook samples from Lyle Falls adult trap and Klickitat Hatchery have resulted in the identification of an introgressive hybridized genotype in the Klickitat spring Chinook population that contains alleles normally found in the interior stream type Chinook (typically spring Chinook) and in ocean type Chinook (typically fall or summer Chinook) in the Columbia basin (Hess et al. 2011). Phylogenetically the Klickitat spring Chinook population sits in an intermediate position between (and distinct from) other interior stream type stocks and lower Columbia and ocean type stocks. The introgressed genotype appears in both wild and hatchery spring Chinook in the Klickitat. A combination of computer simulations and empirical samples were used to evaluate four hypothetical causes of this introgression: historical admixture, recent admixture (which could include hatchery intermixing), isolation by distance gene flow, and selection. Simulations excluded isolation by distance and selection as they were the least likely to result in the observed introgression patterns, leaving historical or recent admixture as likely causes. Comparisons of samples collected from Klickitat spring Chinook in the early 1980s to more recent (2006-2008) samples showed a substantial shift in genetic composition: samples from the

early 1980s were predominantly interior stream type pure genotypes while more recent samples showed markedly more ocean type influence (Hess el al 2011). This shift coincided in time with the adult returns of Wells Hatchery summer (Upper Columbia ocean type) Chinook that were released in the Klickitat in the late 1970s. Hatchery records and anecdotal evidence from Klickitat Hatchery staff point to the likelihood that some of these returning summer Chinook were incorporated into broodstock collections for spring Chinook, and possible interbreeding occurred via this mechanism. These fish returned (volunteering into hatchery holding ponds via the hatchery adult fish ladder) and sexually matured at a later date than most of the spring Chinook, but enough overlap in this timing was present to provide for potential interbreeding.

Additional analysis to date has provided little evidence that this introgression has resulted in reduced fitness or altered run timing in Klickitat spring Chinook (CRITFC unpublished data). Further analysis, especially with regard to effects on run timing, is ongoing using restriction site associated DNA (RAD) sequencing.

Conclusions

Steelhead

Genetic sampling and analysis conducted under this project has provided valuable data in monitoring hatchery/wild interactions, stock identification of fish use of the lower Klickitat River, subpopulation structure within the subbasin, and anadromous/resident relationships. The summary of results for steelhead to date suggests the following: natural-origin and hatchery-origin steelhead sampled as adults and juveniles in the Klickitat appear to remain genetically distinct suggesting low introgression/interbreeding rates (with further monitoring to determine introgression rates between the stocks underway); multiple subpopulations (at least 6 or 7) exist within different areas of the Klickitat subbasin; primarily anadromous populations residing in the mid and lower subbasin downstream of major passage obstructions; resident populations using upstream areas but intermixing with some anadromous populations; and a fairly high rate of use of the lower Klickitat River by out-of-subbasin populations.

The results from the O. mykiss candidate anadromous genetic markers study were useful in predicting anadromy/residency for Klickitat subbasin fish. Additional study in other geographic areas is needed, but these findings could be very useful in characterizing relationships and interactions between anadromous and resident populations, traits that lead to anadromous behavior (typically a combination of genetic and environmental factors are involved), and the role of resident rainbow trout in the recovery of steelhead populations.

Spring Chinook

Conclusions from the spring Chinook analysis are that hatchery interbreeding with Wells Hatchery summer Chinook is the most likely cause of the introgressive hybridized genotype observed in Klickitat spring Chinook. It is unknown if this introgression has effects on stock fitness or is playing a role in depressed abundance (described in Adult salmonid monitoring and Spawning ground survey sections), but it is quite possible (see discussion in Hess et al 2011). Present hatchery releases of Upper Columbia upriver bright fall Chinook stocks in the Klickitat produce returning

adults that spawn largely at different times and different river reaches than spring Chinook (see Spawning ground survey section). And decades of releases of Lower Columbia tule Chinook (among other stocks) appears not to have significantly affected Klickitat spring Chinook genetic composition, as evidenced in the samples analyzed from the early 1980s. These factors point primarily to the Wells Hatchery releases. This finding highlights the need for changes to the current spring Chinook program at Klickitat Hatchery; many changes are proposed in the draft Klickitat Master Plan (Yakama Nation 2012) including a shift to natural-origin broodstock and continued genetic and population monitoring.

Scale and Coded Wire Tag analysis

Introduction

The objective of scale and coded wire tag (CWT) analysis is to determine age composition, length-at-age, and origin stock of adult salmonid stocks. Results are used by state and tribal fisheries managers for run reconstruction and forecasting.

Methods

Scale samples were collected from adult carcasses encountered during spawner surveys, from fish captured at the Lyle Falls adult trap (RM 2.4 on the Klickitat River), and from spring Chinook collected at the Klickitat Hatchery adult holding pond during hatchery spawning activities. Scale collection follows methods outlined in Crawford et al. (2007). Scales were analyzed by YKFP/YN Fisheries Program staff; scales are pressed and read according to methods described in DeVries and Frie (1996). Coded wire tags (CWT), collected from carcasses on spawner surveys and at Klickitat Hatchery, were also used to validate and correct age determinations from scale reading when possible. CWT data is uploaded to the Regional Mark Information System (RMIS) database. Age data are presented in the "year-old" format as described in Groot and Margolis (1991), i.e., number of years old for an individual fish represents number of winters starting with the egg stage.

Results

Readable scale samples were obtained from a total of 21 adult spring Chinook, 472 fall Chinook, and 104 coho salmon, and 10 steelhead carcasses during 2013-2015 spawner surveys. A total of 544 adult spring Chinook, 554 fall Chinook, 227 coho salmon, and 677 were sampled and yielded readable scales in the Lyle adult trap in 2013-2015. Coho adult trap and spawner survey samples (as well as steelhead) from 2015-6 are still being collected and processed as of the writing of this report.

A brief description of the results by species is below. Table 16 through Table 24 in Appendix B presents the age breakdown by year and marks with accompanying fork and postorbital-hypural length averages and ranges for each species sampled. Due to a lack of 100% marking of fall Chinook, origin (hatchery or wild) of these fish sampled could not always be reliably determined. Hatchery spring Chinook and coho salmon, as well as Skamania Hatchery steelhead, that are released in the Klickitat River are currently 100% adipose-clip marked.

Overall during the 2013-15 return years the majority (73.6%) of spring Chinook adults were 4-year-olds. Age and length data for spring Chinook carcasses recovered on spawning ground surveys are in Table 16; data for fish captured in the Lyle Falls adult trap are in Table 17; data for fish returning to the Klickitat Hatchery adult holding pond are in Table 18 (all in Appendix B).

For fall Chinook during 2013-2015, 4-year-old fish made up the largest portion of the returns at 61.8%; 5-year-olds made up 22.5% and 3-year-old jacks made up 15.3% of the returns. Age and length data for fall Chinook carcasses recovered on spawning ground surveys are in Table 19; data for fish captured in the Lyle Falls adult trap are in Table 20 (Appendix B).

For coho in 2010-2012 the vast majority of returning fish (99.7%) were 3-year-olds. Age and length data for carcasses recovered on spawning ground surveys are in Table 21; data for fish captured in the Lyle Falls adult trap in Table 22 (Appendix B).

For steelhead in 2013-2015, 3-year-olds represented 47.2% of the adult returns, 44.1% were 4-year-olds, and 5.3% were 5-year-olds. In addition, freshwater (juvenile rearing) ages estimated from adult scales were as follows: for ad-clipped fish, 85.0% were age 1 and 15.0% were age 2; for unmarked (natural-origin) fish, 51.9% were age 1, 47.3% were age 2, and 0.8% were age 3. Total age and length data for carcasses recovered on spawning ground surveys are in Table 23; data for fish captured in the Lyle Falls adult trap are in Table 24 (Appendix B).

Conclusions

For spring and fall Chinook, 4-year-olds continue to be the most common age of returning adults; 5-year-olds comprise a small percentage of the spring Chinook return and a somewhat larger percentage of the fall Chinook return. For coho, 3-year-olds continue to dominate the returning adult population. For steelhead, 3-year-olds comprised the highest percentage of returning adults during this reporting period, with 4-year-olds making up slightly less of the population and 5-year-olds a small percentage. Also, freshwater (juvenile rearing) ages for steelhead were primarily age 1 for hatchery-origin fish and a fairly even split between age 1 and age 2 for natural-origin fish.

Hatchery spring Chinook and steelhead PIT tagging

Introduction

Objectives of using Passive Integrated Transponder (PIT) tagging as a means of monitoring spring Chinook salmon and steelhead travel and/or holdover time between the Klickitat River and Bonneville Dam detection sites, estimating smolt survival rates, and estimating smolt-to-adult return rates for these hatchery populations. Monitoring smolt survival and smolt-to-adult rates under current hatchery production practices will provide effectiveness monitoring information for comparisons of these parameters under planned future hatchery actions.

Methods

Spring Chinook salmon juveniles from the Klickitat Hatchery were injected with PIT tags in early summer of each year and released from the hatchery into the Klickitat River in early spring of the following year. PIT tagging of the spring Chinook production population at Klickitat Hatchery began in 2006. During this reporting period, over 20,000 fish were tagged each year; estimated numbers of fish released per year are shown in Table 1. The most reliable estimate of number of fish released came from monitoring the hatchery pond for tagged-fish mortalities and subtracting these fish from the total number of fish tagged. Steelhead juveniles at Skamania Hatchery were also tagged in the early fall each year beginning in 2009; these fish are transported via truck and released in the Klickitat River the following spring. Approximately 10,000 hatchery steelhead are tagged per year; numbers of fish released per year are shown in Table 2. The estimates of fish released also come from numbers of fish tagged minus mortalities tallied by hatchery staff. Tag data was entered into the regional PIT Tag Information System (PTAGIS) database for monitoring at mainstem Columbia River detection sites. Returning adult fish are detected at Bonneville Dam adult fish ladders to provide smolt-to-adult return rate (SAR) information. SAR estimates are generated by dividing Bonneville Dam detections of adults by estimated release numbers.

Results

A summary of tagging and returning fish detections is given below in for spring Chinook (Table 1) and for steelhead (Table 2). A preliminary average spring Chinook SAR estimate (using projected returns of 5- and 6-year-old fish for the more recent brood years based on average age compositions) for brood years 2005 through 2007 fish is fairly low, at approximately 0.5%. Additional returns in subsequent years will yield more complete SAR estimates for Klickitat Hatchery spring Chinook.

Table 1. Klickitat Hatchery spring Chinook PIT-tagged releases and returns to Bonneville Dam to date.

Brood Year	Tagging Year	Release Year	Total Jack/Adult Returns[3] (Age 3-6)	Total Adult Returns[3] (Age 4-6)	Number of Tagged Fish Released[2]	SAR[3] (incl. jacks)
2004	2005	2005	0	0	9830	0%[4]
2005	2006	2007	17	14	4916	0.35%
2006	2007	2008	24	19	4635	0.52%
2007	2008	2009	35	34	6848	0.51%
2008	2009	2010	259	154	34643	0.75%
2009	2010	2011	*96*	*69*	23848	*0.40%*
2010	2011	2012	*117*	*86*	20954	*0.56%*
					Average	*0.51%*

[1]Based on detections at Bonneville adult ladders
[2]Based on known tagged fish minus known pre-release mortalities at Klickitat Hatchery
[3]Italicized numbers are projections based on partial brood year returns and average age composition
[4]2005 release was thinning group with lower survival expected, not included in average

For steelhead, the estimated SAR is very preliminary, with two brood years (2009 and 2010, release years 2010 and 2011 respectively) having 4- and 5-year-old returns. More recent release years

have projected numbers in older age classes based on average age compositions. The preliminary SAR estimate is approximately 3%. Additional returns in subsequent years will yield more complete SAR estimates for Skamania Hatchery steelhead released in the Klickitat River.

Table 2. Klickitat River Skamania Hatchery steelhead PIT-tagged releases and returns to Bonneville Dam to date.

Tagging Year	Release Year	Total Adult Returns[3] (Age 2-6)	Number of Tagged Fish Released[2]	SAR[3]
2009	2010	322	9937	3.24%
2010	2011	*148*	9737	*1.52%*
2011	2012	*438*	9960	*4.40%*
2012	2013	*312*	9945	*3.14%*
2013	2014		9996	
			Average	*3.07%*

[1]Based on detections at Bonneville adult ladders

[2]Based on known tagged fish minus known pre-release mortalities at Skamania Hatchery

[3]Italicized numbers are projections based on partial brood year returns and average age composition

Conclusions

Preliminary SAR estimates for Klickitat Hatchery spring Chinook are fairly low (approximately 0.5%) when compared with other hatchery spring Chinook stocks in the Mid-Columbia region (CSS 2015) and are also quite low considering that these fish have only one mainstem Columbia dam (Bonneville Dam) to negotiate as outmigrating smolts and returning adults. Preliminary SAR estimates for Skamania Hatchery steelhead released in the Klickitat River are higher, at approximately 3%.

Future analysis will include additional methods of SAR and other survival rate estimation such as those described in Buchanan and Skalski (2007). Continued PIT tagging and monitoring will also allow for analysis of changes in SAR following changes to hatchery production programs.

White Creek PIT tag study

Introduction

Spawning surveys conducted since the early 2000s point to White Creek as an important producer of steelhead in the Klickitat River sub-basin. In some years, the greater White Creek drainage accounted for as much as 40% of the observed steelhead redds. Given the importance of the White Creek drainage to steelhead production, increasing understanding of *O. mykiss* life history strategies provides important baseline information to guide monitoring and management objectives. The main objectives of the White Creek PIT Tag Study are to determine: 1) the proportion of *O. mykiss* that leave the White Creek sub-basin as downstream out-migrants, 2) run timing of downstream out-migrants, 3) how different life history types are displayed temporally

and spatially throughout the sub-basin, 4) and quantify in-timing migration of anadromous salmonids.

Figure 11. White Creek PIT tag array site.

Methods

A Destron Fearing Multiplexing transceiver (Model FS1001M) and antennae array installed in lower White Creek, approximately 200 feet upstream of the confluence with the Klickitat River, is used to interrogate PIT tagged fish. Antennas are comprised of wire cable encased in watertight PVC tubing (Figure 11 and Figure 12). The PIT tag interrogation system consisted of three arrays. Each array consists of paired antenna that covered the wetted width to maximize detection capability. Paired antennae arrays were longitudinally spaced approximately 50 feet apart. The transceiver records a date, time, antenna, and PIT tag code stamp for each detection record.

Twenty-one monitoring/tagging sites were established at the start of the study in 2009. In 2011, another four tagging sites (in Brush Creek, Blue Creek, and White Creek) were added to address spatial gaps in sampling (Figure 13). Single-pass electrofishing was used to capture fish. Captured fish were held in 5-gallon buckets with aeration supplied by battery-powered aerators. Captured *O. mykiss* ≥65 millimeters were anesthetized with MS-222, injected with a Passive Interrogator Transponder (PIT) tag, length and weight recorded and held in a recovery bucket. Handled fish recovered in flow-through buckets in the stream and released at the completion of sampling. Injected PIT tag codes and fish metrics were entered directly into the PTAGIS 3 program in the field.

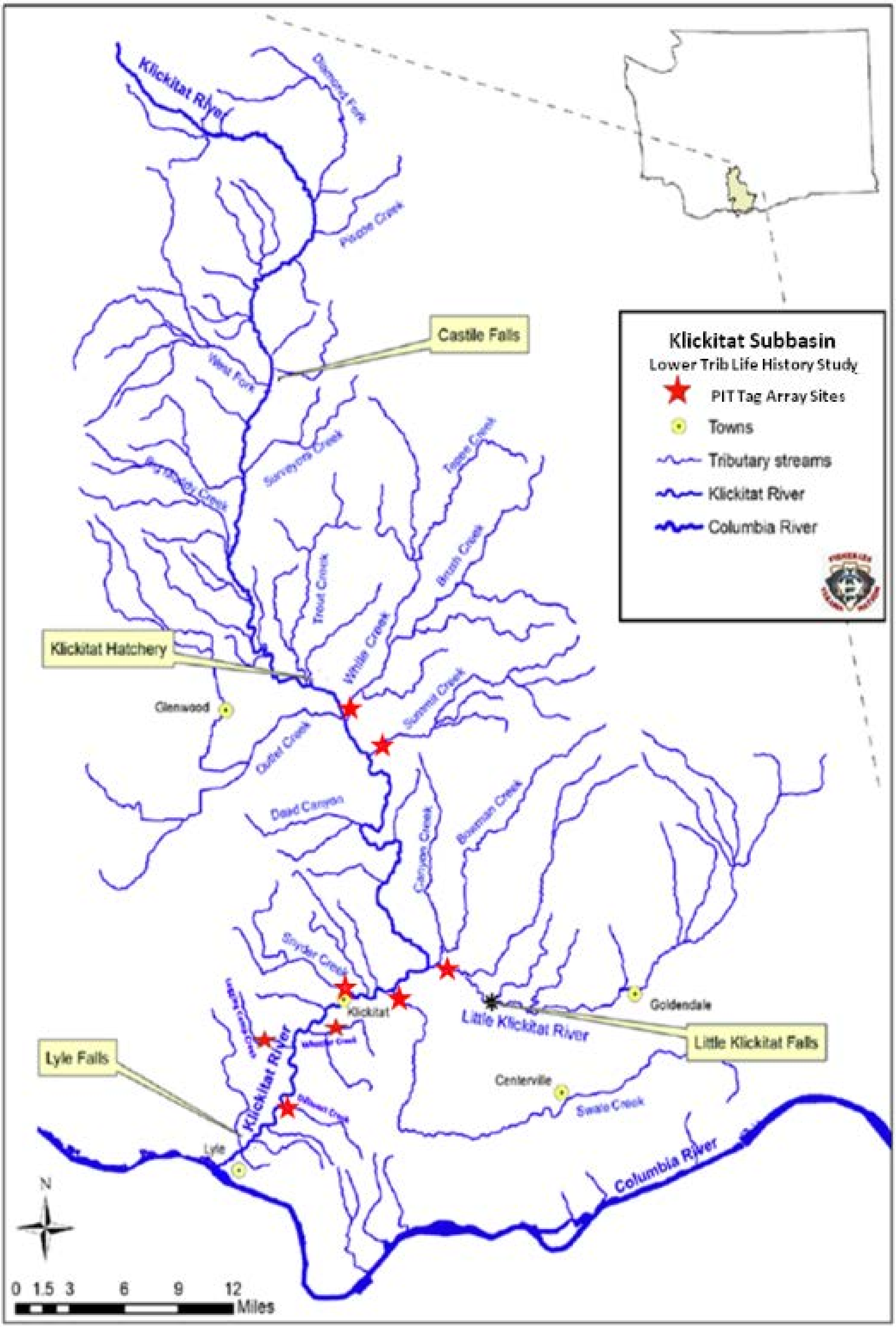

Figure 12. Map of PIT tag interrogation array sites in Klickitat River sub-basin.

Results

In the 2013 sample season, 2,727 fish were collected consisting of 2,618-tagged individuals and 109 recaptures (Table 25 in Appendix). White Creek, Tepee Creek, and Brush Creek accounted for 94% of the PIT tagged fish. Collectively Blue Creek, East Fork Tepee Creek, and West Fork White Creek accounted for the fewest tags (~7%). Overall, the mean fish length and weight were 95.4 (SE ±0.4) millimeters and 11.3 (SE ±0.2) grams, respectively. Mean fish lengths were greatest in White Creek (98.4±0.6 mm) and lowest in West Fork White Creek (83.8±2.4 mm). Fish in the 71-105 millimeter size range dominated the 2013 tag group accounting for 1,831 (73%) of 2,727 tagged individuals (Figure 14). Fish in the 106-140 millimeter size range comprised the second largest group accounting for 476 (18%) tagged individuals. Fish ≥140 millimeters accounted for 109 (4%) tagged individuals and fish measuring ≤70 millimeters accounted for 5% of the tagged individuals.

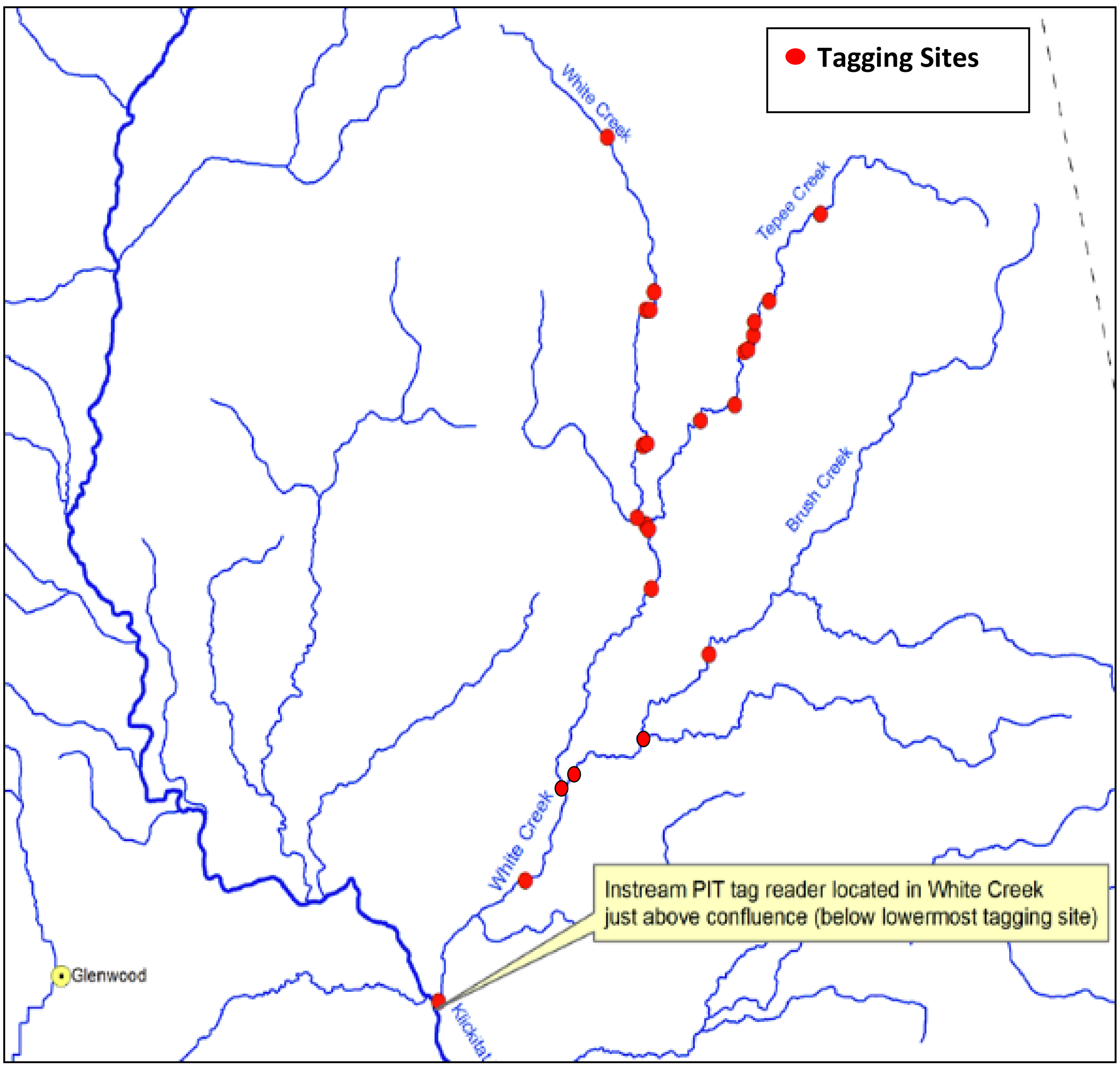

Figure 13. Map of PIT tagging sites in the White Creek Drainage.

The number of fish PIT tagged declined substantially from 2013 to 2014. The total number of fish tagged in 2014 dropped to 60% of the 2013 level (Table 25 in Appendix B). White Creek, Tepee Creek, and Brush Creek accounted for approximately 97% of the PIT tagged fish. Overall, the mean fish length and weight were 93.9 (SE ±0.6) millimeters and 11.2 (SE ±0.3) grams, respectively. Mean fish lengths were greatest in Blue Creek (113.1±3.2 mm) and again lowest in West Fork White Creek (78.9±5.2 mm). Fish in the 66-100 millimeter size range were most abundant accounting for approximately 70% of tagged fish (Figure 14). Fish in the 101-150 millimeter size range comprised the second largest group accounting for 27% of tagged individuals.

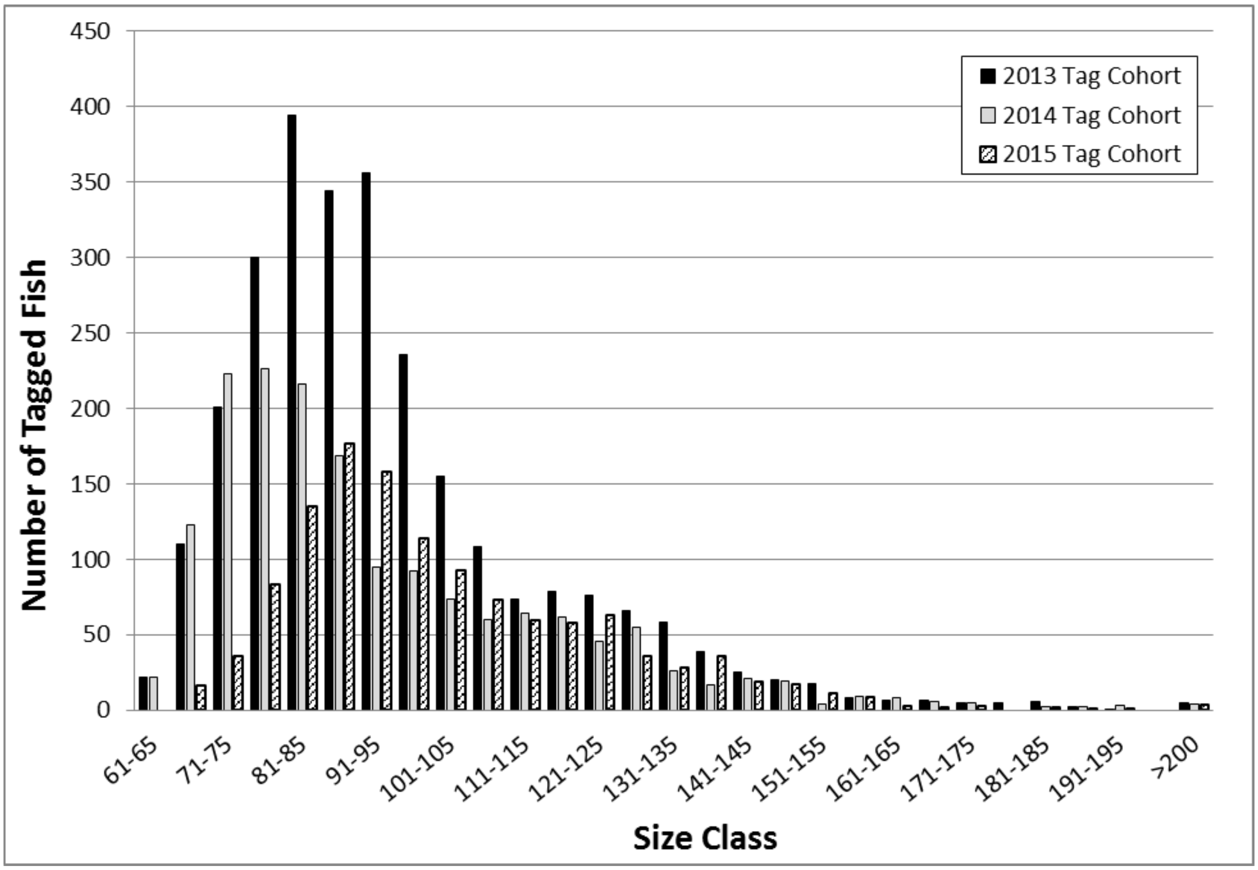

Figure 14. Length frequency histogram of 2013, 2014, and 2015 *Oncorhynchus mykiss* annual tag groups.

The 2015 sampling season marked another sizable decline in the number of fish PIT tagged in comparison to previous years. The total number of PIT tagged fish in 2015 declined to ~40% and ~70% of 2013 and 2014 levels, respectively (Table 25 in Appendix B). The substantial drop in the number of tagged fish to previous years was likely due to early intermittent surface flow conditions resulting from low snowpack. Electrofishing did not occur in upper White Creek at IXL Road and West Fork White Creek sites in late June because the stream channel was dry. This marked the first time that a site was not sampled in the summer since the start of the study in 2009. As with previous years, 95% of fish tagging occurred in White Creek, Tepee Creek, and Brush Creek in 2015. Although fewer fish were collected in 2015 compared to the two previous years, mean fish length and weight were substantially greater (102±0.6 millimeters; 13.6 ±0.3 grams, respectively). Fish in

the 76-105 millimeter size range accounted for 61% of the tagged fish (Figure 14). Fish in the 106-125 millimeter size range comprised the second largest group accounting for 21% of tagged individuals. Mean fish lengths were greatest in Blue Creek (113.1±3.2 mm) and again lowest in West Fork White Creek (78.9±5.2 mm).

During the 2013-2015 migration years (October 1, 2012 through December 31, 2015), 868 out-migrants spanning five tag year groups were detected at the White Creek PIT tag array (Figure 15). Of the 868 out-migrants detected at the array, 2, 26, 481, 298, and 61 out-migrants originated from the 2011, 2012, 2013, 2014, and 2015 tag groups, respectively. All fish out-migrated from the White Creek drainage within 3 years of tagging and by ≤ 171 millimeters (extrapolated length at time of detection). All other fish are assumed to have either passed the array undetected, adopt a residualized life history, or met a mortality fate.

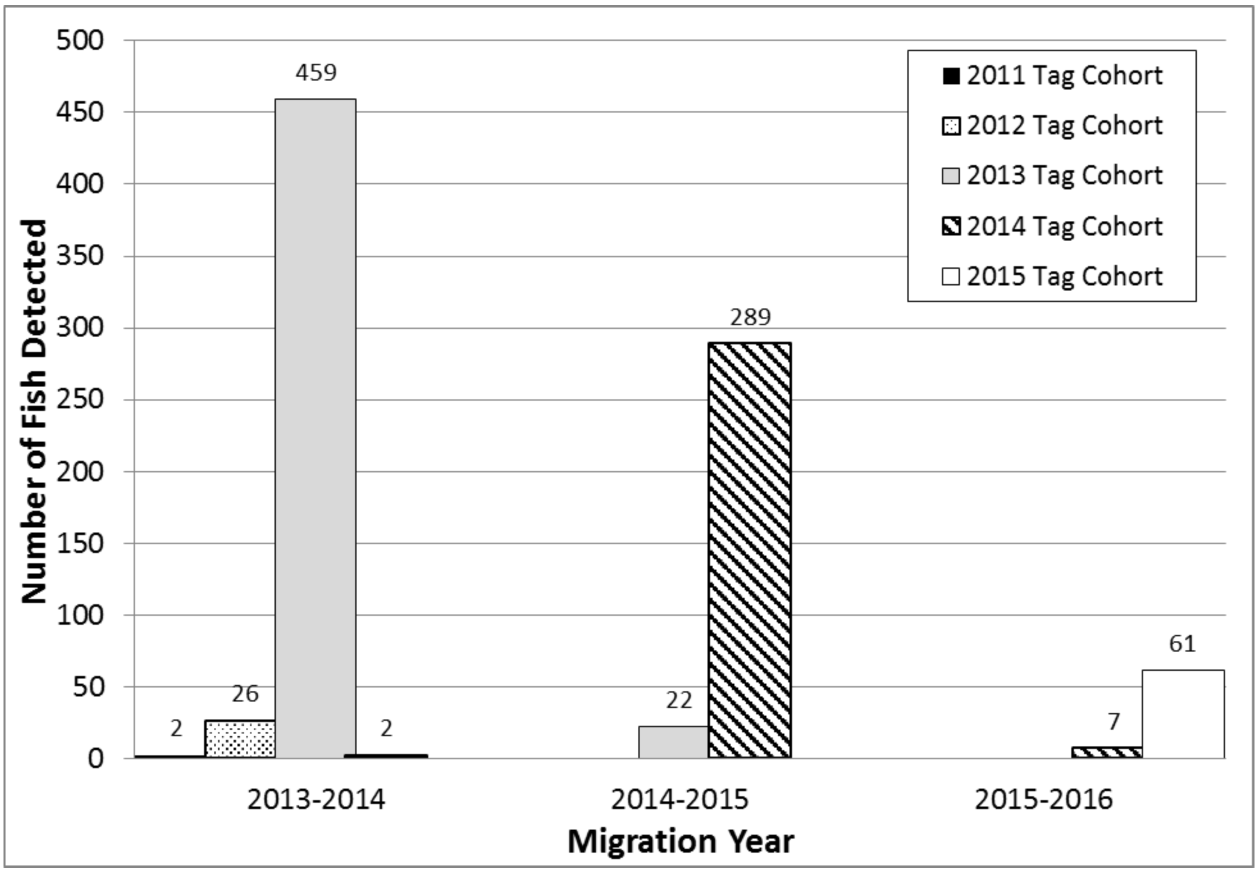

Figure 15. Out-migration detections at the White Creek PIT tag array by tagging and migration years.

Fish in mainstem White Creek exhibited a greater tendency to out-migrate compared to fish tagged in other streams in the White Creek drainage. White Creek accounted for slightly more than half (54%) of the tagged fish but ~61% of the fish detected at the White Creek PIT tag array (Table 26 in Appendix B). Tepee Creek accounted for 28% of tagged fish but ~25% of fish detected at the array. Brush Creek accounted for ~12% of the tagged fish and ~9% of the detected fish. Collectively Blue Creek, East Fork Tepee Creek, and West Fork White Creek accounted for 5.5% of the tagged fish and a proportionally similar percentage of the detections. Preliminary results indicate that the lower 5-

kilometer section of White Creek below the Brush Creek confluence may function as both refugia and staging for downstream migrants during the low flow period. White Creek below the confluence of Brush Creek maintains perennial flow as opposed to intermittent and seasonal flow patterns above the confluence. Evidence of the importance of this area to the survival of staging out-migrants is highlighted by the observation that nearly half (48%) of the detected fish originated from the lower 5-kilometers and yet only account for 27% of the tagged fish.

Out-migrants exhibited a consistent bi-modal out-migration pattern spanning an 11-month period. The initial pulse of out-migrating fish occurred in the winter during the ascending limb of hydrograph and decreasing water temperatures. The majority of fish out-migrated in the spring during the descending limb of the hydrograph and increasing water temperature. Each year the out-migration peak consistently occurred at the intersection of descending stage height and increasing water temperature (Figure 16). This intersection occurred each year within a 2-week window between late-April and mid-May. The year-to-year difference of average daily stage height and water temperature was only 0.15 feet and ~1.2 Celsius.

Ninety-eight PIT tagged fish from the White Creek drainage were detected in the Columbia River from October 1, 2012 – December 31, 2015 (Table 26 in Appendix B). White Creek fish detected in the Columbia River originated from 19 of 25 tagging sites spanning all creeks. Eight of the 19 tagging sites are located in White Creek, five in Tepee Creek, three in Brush Creek, and one in Blue Creek, E.F Tepee Creek, and W.F. White Creek. Seventy-eight downstream migrants were detected in the Columbia River by interrogation sites at Bonneville Dam (70 fish) and the estuary towed array (8 fish). Twenty-one fish returned to Bonneville as adults. Four fish passed The Dalles Dam and McNary Dam but not Bonneville Dam suggestive of a fluvial life history.

Out-migrants passed Bonneville Dam over a 4-month period between March–June of each year. After pooling all juvenile detections at Bonneville for the reporting period October 1, 2012 – December 31, 2015, the bulk of out-migrants passed Bonneville Dam in May (71%) followed by June (15%) and April (11%). Each year, the timing of out-migration occurred at or near the peak of the hydrograph. There appears to be an energetic and survival advantage to timing out-migration with peak flows. High flow conditions may reduce the energetic cost to migrate down the Columbia River because high flows efficiently transport fish downstream. In addition, higher flows decrease travel time through the Columbia River and likely reducing the risk of piscivorous and avian predation.

An analysis of out-migrant travel time between the White Creek array and Bonneville Dam illustrates two distinct life history strategies. Smolts migrating from White Creek to Bonneville Dam group into two temporally distinct clusters (Figure 17). The mean travel time between White Creek and Bonneville Dam was 31.5 days (SE±8.8) and 378.1 days (SE±9.3) for the early and late arriving groups, respectively. Fish in the early arrival group migrated directly down the Klickitat River and Columbia River after leaving White Creek. These fish reached Bonneville in as little 2 days but no longer than 6 months (Figure 17). Approximately 40% of the out-migrants employed this strategy. Fish in the late arrival group reared in the mainstem Klickitat River ~1 -1.5 years prior to out-migrating to the Columbia River (Figure 17). Fish rearing an additional year in the

Klickitat River were slightly smaller (at time of tagging) than fish that migrated directly down the Columbia River. Preliminary results suggest that the mainstem Klickitat River provides important rearing habitat to juvenile steelhead of tributary origin. Identifying key mainstem reaches that provide important juvenile steelhead rearing is an area that requires more understanding.

Adults returned to Bonneville Dam between the months of June and September with the exception of one fish that ascended Bonneville Dam in November. Five of twenty-one adults detected at Bonneville Dam were also detected at the juvenile bypass facility as downstream migrants. Of these five fish, four returned to Bonneville Dam as 2-salt fish and one as a 1-salt fish. Five of the twenty-one adults were also detected in the Klickitat River. Travel time from Bonneville Dam to the Lyle Adult Fish Facility ranged from 3-48 days.

Thirty wild adult steelhead were detected at the White Creek PIT tag array from October 1, 2012 through December 31, 2015. Twenty-seven fish were PIT tagged at the Lyle Adult Fish Trap as part of an on-going M&E study. Three fish were PIT tagged in White Creek as juveniles. Summer-run steelhead comprised 27 of 30 adults detected at the array. Three winter-run steelhead were also detected. Three adult coho passed the array of which 2 and 1 were of wild and hatchery origin, respectively.

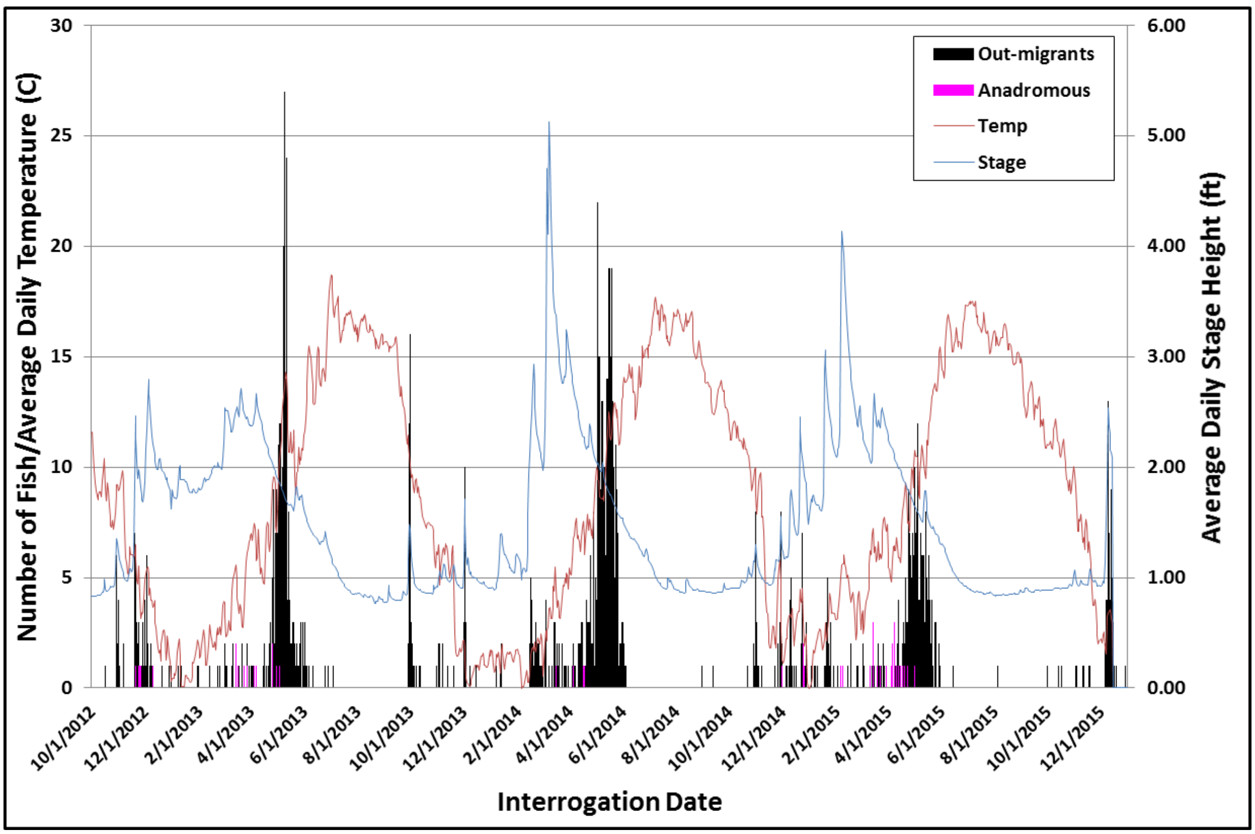

Figure 16. Relationship between *Oncorhynchus mykiss* detection at the White Creek PIT tag array, average daily stage height and temperature during the 2012-2013, 2013-2014, and 2014-2015 migration years (October 1, 2012 - December 31, 2015).

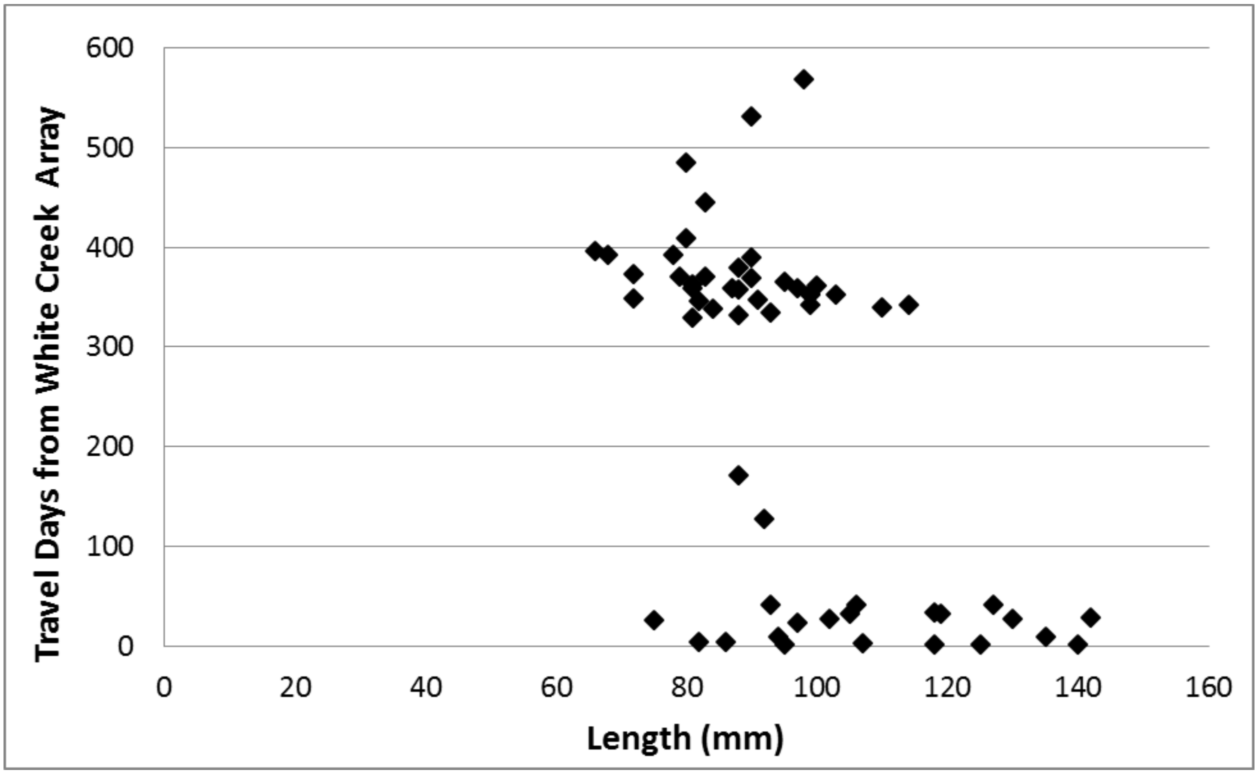

Figure 17. Juvenile *Oncorhynchus mykiss* out-migrant travel time (in days) between the White Creek PIT tag array and Bonneville dam by fish tag length between October 1, 2012 and December 31, 2015

Conclusions

PIT-tagged *O. mykiss* were detected outmigrating from White Creek from all tagging sites, indicating that a variety of life histories likely exists and that multiple locations throughout the watershed may contribute to migratory *O. mykiss* and anadromous steelhead populations. Lower White Creek below the Brush Creek confluence (which maintains more perennial flow than upstream reaches) likely functions as both a refugia and staging area for downstream migrants during the low flow period. Fish tagged in lower White Creek also made up a disproportionately high percentage of the total outmigrants. Downstream migrants exited the watershed over an 11-month period with a consistent bimodal outmigration pattern, with peaks in the early winter and the spring. A small percentage of tagged fish was detected migrating downstream past Bonneville Dam with the bulk passing Bonneville in late spring. Results suggest two distinct life history stages with some fish rearing in the Klickitat River for at least an additional year prior to outmigrating to the Columbia River and other fish migrating directly down the Klickitat and Columbia rivers to Bonneville Dam within about a month after leaving White Creek. These results indicate that *O. mykiss* in the White Creek watershed exhibit a "spreading of risk" strategy, with some utilizing rearing habitats in White Creek and some in the mainstem Klickitat River. Identification of key mainstem Klickitat rearing areas is likely an important part of informing natural steelhead population recovery strategies. The

number of PIT-tagged adult steelhead that has been detected at the White Creek PIT detection array has not been high, but includes mostly wild steelhead tagged at the Lyle adult trap on the lower Klickitat river, along with a few fish that were tagged in the White Creek watershed as juveniles, and a small number of coho.

Lower Tributaries Life History and PIT tag Study

Introduction

In partnership with Klickitat Water Enhancement Project (KWEP), M&E staff conducted habitat assessments and fish surveys in Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Snyder Creek in 2011 to quantify baseline physical and biological conditions in seasonally disconnected tributaries to the mainstem Klickitat River (Figure 18). Initial surveys documented viable populations of *Oncorhynchus mykiss* present in each stream. Results from the 2011 surveys led YN fisheries staff to express the need to document the fish usage in the five lower fish bearing tributaries. Specific objectives of the study are to document the following:

- Quantify the proportion of O. mykiss displaying anadromy
- Quantify annual variation in abundance
- Timing of in- and out-migration of adults and juveniles
- Seasonal usage of rearing habitat by juvenile *O. mykiss*
- Hatchery vs. wild adult returns and introgression
- Hatchery coho smolt vs. juvenile *O. mykiss* interactions

In 2012, PIT tag arrays were installed in Wheeler Creek and Logging Camp Creek to begin to address study objectives. PIT tag array installations in Dillacort Creek, Snyder Creek, and Swale Creek followed in 2014.

Figure 18. Seasonally connected and disconnected surface flow conditions at Logging Camp Creek in 2013.

Methods

Paired antenna arrays (consisting of a single antenna per array) spaced longitudinally apart were anchored to the stream bottom by straps, earth anchors, and bolts in Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Snyder Creek (Figure 19). Antenna arrays provided complete interrogation coverage of the wetted channel width. The PIT tag interrogation array at Swale Creek consisted of three arrays spaced longitudinally apart (Figure 19). Each Swale Creek array consists of two antenna (20-foot each) to cover the 40-foot channel width. Each antenna array detects PIT tags, affixes a date/time stamp, and records data via an external data logger. Each PIT tag interrogation array site is paired with a staff gage and sensor/data logger (to record continuous water surface elevation and water temperature) operated by KWEP staff (Lindley and Conley 2015).

Figure 19. View of PIT tag array sites at Dillacort Creek, Wheeler Creek, Snyder Creek, and Swale Creek in 2014.

Single-pass electrofishing was used to capture fish for PIT tagging and to determine relative fish abundance. The fish bearing length of stream determined whether a continuous sample or randomized sub-sampling methodology was used to survey fish. A continuous sampling approach (or census) was used in Dillacort Creek, Logging Camp Creek, and Wheeler Creek because the fish bearing length of stream was less than 2-kilometers. Logistical limitations precluded efforts to sample continuously in longer fish bearing portions of Snyder Creek (5.5-klilometers) and Swale Creek (8-kilometers). Randomly selected electrofishing reaches 300-meters in length were established in each fish-bearing kilometer. Established 300-meter electrofishing reaches were sampled continuously from the downstream to upstream boundary each year to compare differences among years. In each stream, captured *O. mykiss* ≥65 millimeters were anesthetized with MS-222, injected with a PIT tag, DNA collected, and fish length and capture location recorded. Handled fish recovered in flow-through buckets in the stream and released at the completion of sampling.

Results

The total number of juvenile salmonids PIT tagged in the five streams during the reporting period (January 1, 2013 – December 31, 2015) was 3,217 (Table 27 in Appendix B). With the exception of a 2013 electrofishing survey in Wheeler Creek, 2014 and 2015 accounted for ~96% of the PIT tagged fish during the reporting period. The total number of tagged fish varied widely among streams. For example, the number of fish tagged in Snyder Creek was ~7.5, ~3, 2.2, and 1.8 times more than Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Swale Creek, respectively. Logging Camp Creek had the greatest inter-annual variation in number of fish tagged; the number in 2015 was 7.5 times greater than 2014. In 2014, Logging Camp was surveyed in the spring when water discharge was high and capture efficiency low. In 2015, electrofishing was conducted in the summer at low water conditions that resulted in high capture efficiency.

Fish detections at the PIT tag arrays highlight a clear life history distinction between streams that drain the east vs. west side of the Klickitat River. A significantly higher proportion of tagged fish out-migrated from east side streams (Dillacort Creek, Wheeler Creek, and Swale Creek). The proportion of fish out-migrating ranged from a low of approximately one-third in Dillacort Creek to two-thirds in Wheeler Creek (Table 27 in Appendix B). Conversely, only 1.5% and 15% of tagged individuals out-migrated from Logging Camp Creek and Snyder Creek, respectively. Surface flow duration is significantly lower in Dillacort, Wheeler Creek, and Swale Creek. By July, surface flows in Dillacort Creek are limited to the upper 200 meters of fish bearing channel, isolated pools in Swale Creek and completely dry in Wheeler Creek. Low flow conditions exist in Logging Camp Creek and Snyder Creek is predominantly perennial. Fish in east side streams appear to be adapted to seasonal flow conditions with survival linked to out-migrating before stranding. Perennial flow conditions in Logging Camp Creek and Snyder Creek are suitable to a resident life history.

Each year approximately 3.5 million hatchery reared coho smolts are released into the Klickitat River. In the span of a week, the Washington Department of Fish and Wildlife directly releases approximately two-thirds of the fish at river kilometers 16 and 28 in late-March. The remaining fish are reared in the Klickitat River Hatchery and subsequently volitionally released. Natural barriers near the confluence with the Klickitat River limit the distribution of hatchery coho smolts to the lower 50 meters of Dillacort Creek and Logging Camp Creek (Figure 20). An 800-meter concrete flume also limits the distribution of hatchery-reared coho in Snyder Creek to the confluence with the Klickitat River (Figure 20). The alluvial fans of Wheeler Creek and Swale Creek are free of barriers to coho smolt movement. Consequently, hatchery reared coho smolt distribution extends 0.85 and 3.2 kilometers in Wheeler Creek and Swale Creek, respectively. Hatchery-reared coho smolts were approximately 4-fold greater than *O. mykiss* juveniles in Wheeler Creek (2013 and 2014) and Swale Creek (2014 and 2015) in co-occurring areas.

Figure 20. View of barriers to coho smolt movement into Dillacort Creek, Logging Camp Creek, and Snyder Creek.

Anadromous adults were detected in all streams during the reporting period (Table 28 in Appendix B). Adult coho of hatchery origin were most abundant accounting for ~two-thirds of the anadromous adults detected. The remaining fish in order of abundance consisted of hatchery steelhead (28%), wild steelhead (12%), and a single wild coho and hatchery fall chinook. Nearly two-thirds of all adults detected occurred in Swale Creek. Hatchery coho accounted for 70% of the fish detected in Swale Creek followed by hatchery steelhead and wild steelhead. Wheeler Creek accounted for approximately 15% of the documented adults in the lower five tributaries. Hatchery coho and steelhead adults accounted for all detected fish in Wheeler Creek with the exception of a single wild steelhead adult. Snyder Creek accounted for approximately 14% of the anadromous adults detected. Hatchery coho, hatchery steelhead, and wild steelhead entered Snyder Creek in comparatively proportional numbers. Hatchery steelhead was the only species-run-rear type documented in Logging Camp Creek. Dillacort Creek contained the fewest anadromous adults with a single wild steelhead, hatchery steelhead, and hatchery coho detected entering the stream over the reporting period.

Anadromous adults entered the lower five tributaries from December-April each year (Figure 21). Coho adults typically ascended tributary streams in the months of December and January. Of the 57

adult coho detected, only three adult coho entered a tributary (Swale Creek) after January. Hatchery steelhead adults generally entered tributary streams in December, January, and February. Wild steelhead generally entered tributary streams in December or March-April (Figure 20). There was temporal overlap of hatchery and wild steelhead in December in Swale Creek and Snyder Creek.

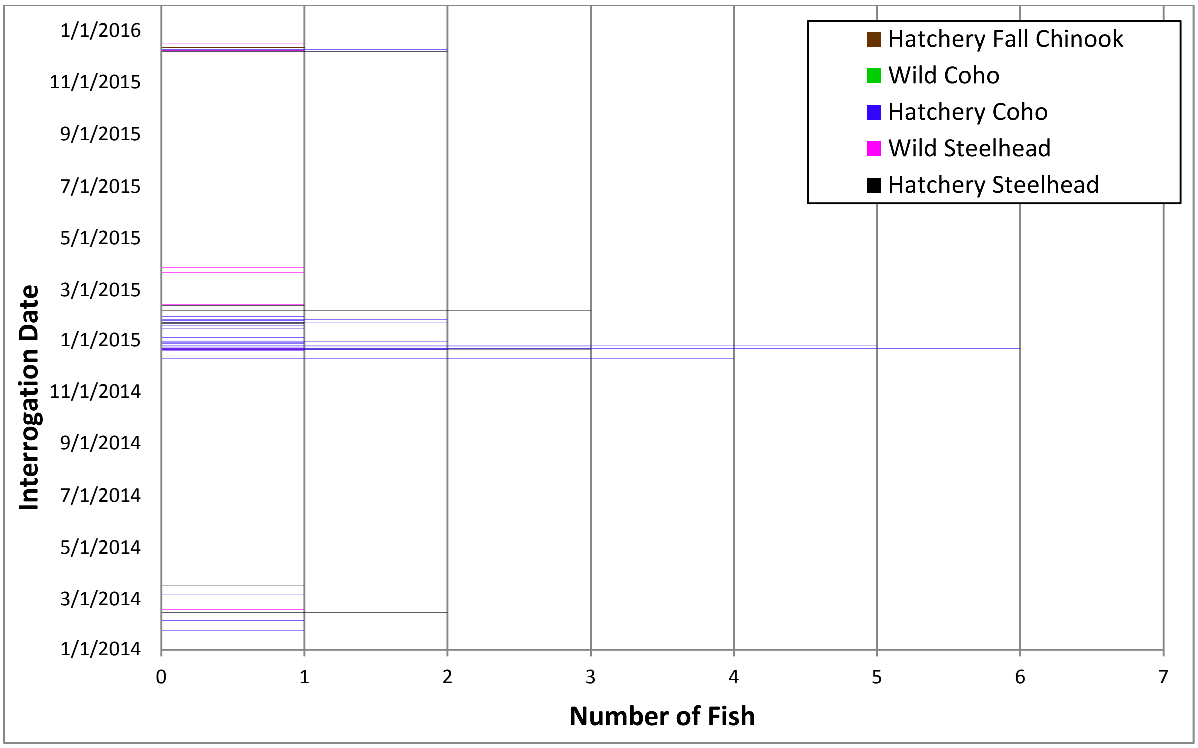

Figure 21. In-migration timing of anadromous adults (n = 99) into Dillacort Creek, Logging Camp Creek, Wheeler Creek, Snyder Creek, and Swale Creek January 1, 2013 – December 31, 2015

Conclusions

The five lower Klickitat tributary streams of Dillacort, Logging Camp, Wheeler, Snyder, and Swale creeks constitute a variety habitats with a potentially wide array of *O. mykiss* life history strategies and adaptations. East-side tributaries with seasonally dry channel conditions (Dillacort, Wheeler, and Swale) exhibited higher rates of outmigrating *O. mykiss* juveniles (and likely higher rates of anadromy) while in west-side tributaries with more perennial flow conditions (Logging Camp and Snyder) fish appeared more likely to adopt a resident life history. In streams without barriers to passage, hatchery coho smolts also enter and occupy these habitats for at least some period of time in the spring following their release. The most commonly detected adult fish in these streams were hatchery coho, hatchery steelhead, and wild steelhead. Ongoing monitoring via PIT tagging and detection will help further quantify key metrics and answer questions regarding production and the roles of these streams.

Summit Creek PIT tag Study

Introduction

Summit Creek, located at river kilometer ~60, is one of three tributaries along the lower 70-kilometers of the Klickitat River that maintains perennial surface flow connection at the confluence (Figure 12). Electrofishing surveys conducted in the 1990s documented the presence of *O. mykiss* and Brook Trout. On-going spawning surveys conducted since the early 2000s document spawning in the lower 2.1-kilometers by adult coho and steelhead. YN fisheries staff expressed the need to improve understanding of fish usage (rearing and spawning) in Summit Creek given the availability of perennial fish habitat and surface flow connection to the mainstem Klickitat River. In 2014, a PIT tag array was installed in Summit Creek to begin to address study objectives. Specific objectives of the study are to document the following:

- Quantify the proportion of *O. mykiss* displaying anadromy
- Quantify annual variation in abundance
- Timing of in- and out-migration of adults and juveniles
- Document different *O. mykiss* life history types and how they are displayed temporally and spatially

Methods

Paired antenna arrays (consisting of a single antenna per array) spaced longitudinally apart were anchored to the stream bottom by straps, earth anchors, and bolts. Antenna arrays provided complete interrogation coverage of the wetted channel width. Each antenna array detects PIT tags, affixes a date/time stamp, and records data via an external data logger. The PIT tag interrogation array is paired with a staff gage and sensor/data logger (to record continuous water surface elevation and water temperature) operated by KWEP staff (Lindley and Conley 2015). Operation of the Summit Creek PIT tag array began October 31, 2014.

Summit Creek was sampled continuously from the confluence to a waterfall, located 2.1 kilometers upstream, which is a barrier to anadromy (Figure 22). Single-pass electrofishing was used to capture fish for PIT tagging and to determine relative fish abundance. Captured *O. mykiss* ≥65 millimeters were anesthetized with MS-222, injected with a PIT tag, DNA collected, and fish length and capture location recorded. Handled fish recovered in flow-through buckets in the stream and released at the completion of sampling.

Results

Four hundred twenty-eight fish were PIT tagged July 20-28, 2015. The composition of tagged fish consisted of 354 *O. mykiss* and 74 juvenile coho. Although juvenile coho were one-sixth as common as *O. mykiss*, their distribution extended throughout the lower 2.1 kilometers. In addition, all captured coho had an intact adipose fin indicating natural production of coho occurs in Summit Creek in at least some years (2014, the likely brood year for these fish, saw high adult coho returns

and tributary spawning activity). *O. mykiss* were significantly larger than coho in Summit Creek. Average fork lengths were 114 and 70 millimeters for *O. mykiss* and coho, respectively. Length frequency analyses of captured fish indicate that coho are limited to a single age class as opposed to multiple age classes for *O. mykiss*. Length-frequency of age-0 fish was similar for *O. mykiss* and coho (Figure 23). However, the absence of coho size classes beyond age-0 suggests most coho out-migrate from Summit Creek within 1-year of emergence.

A total of 170 PIT tagged juvenile salmonids passed the Summit Creek array between October 31, 2014 and December 31, 2015 (Table 3). Four spring chinook juveniles from the Klickitat River Hatchery and eleven *O. mykiss* tagged in White Creek entered Summit Creek during the reporting period. Spring chinook smolts entered Summit Creek in the months of January and February. White Creek fish entered Summit Creek over six different months. Four of the White Creek fish passed the Summit Creek array in the months of January, June, August, and October. Five of eleven passed the array in November and two in December.

Summit Creek PIT tagged fish comprised 155 of 170 salmonid juveniles detected at the array. Of the fish PIT tagged in Summit Creek, juvenile *O. mykiss* accounted for 89% of the fish detected. The proportion of fish detected to fish tagged was greater for *O. mykiss* than coho.

Figure 22. View of Summit Creek barrier to anadromy in 2014.

Approximately 42% of PIT tagged *O. mykiss* passed the array compared to 24% of tagged juvenile coho. All but a single coho passed the array in July and August (Table 29 in Appendix B). *O. mykiss*

passed the Summit Creek array over eight different months. The vast majority of detections occurred in the latter half of the year (Table 29 in Appendix B). Ninety-nine percent of detected fish passed the array July-December.

Eighteen anadromous adults comprising four species-rear-run combinations passed the Summit Creek array during the reporting period. The majority of adult fish consisted of hatchery reared coho (Table 3). In-migration of adult hatchery coho spanned the months of November – January. The remaining fish consisted of two wild coho detected in December, two wild steelhead detected in February and April, and one summer chinook adult of hatchery origin detected in August.

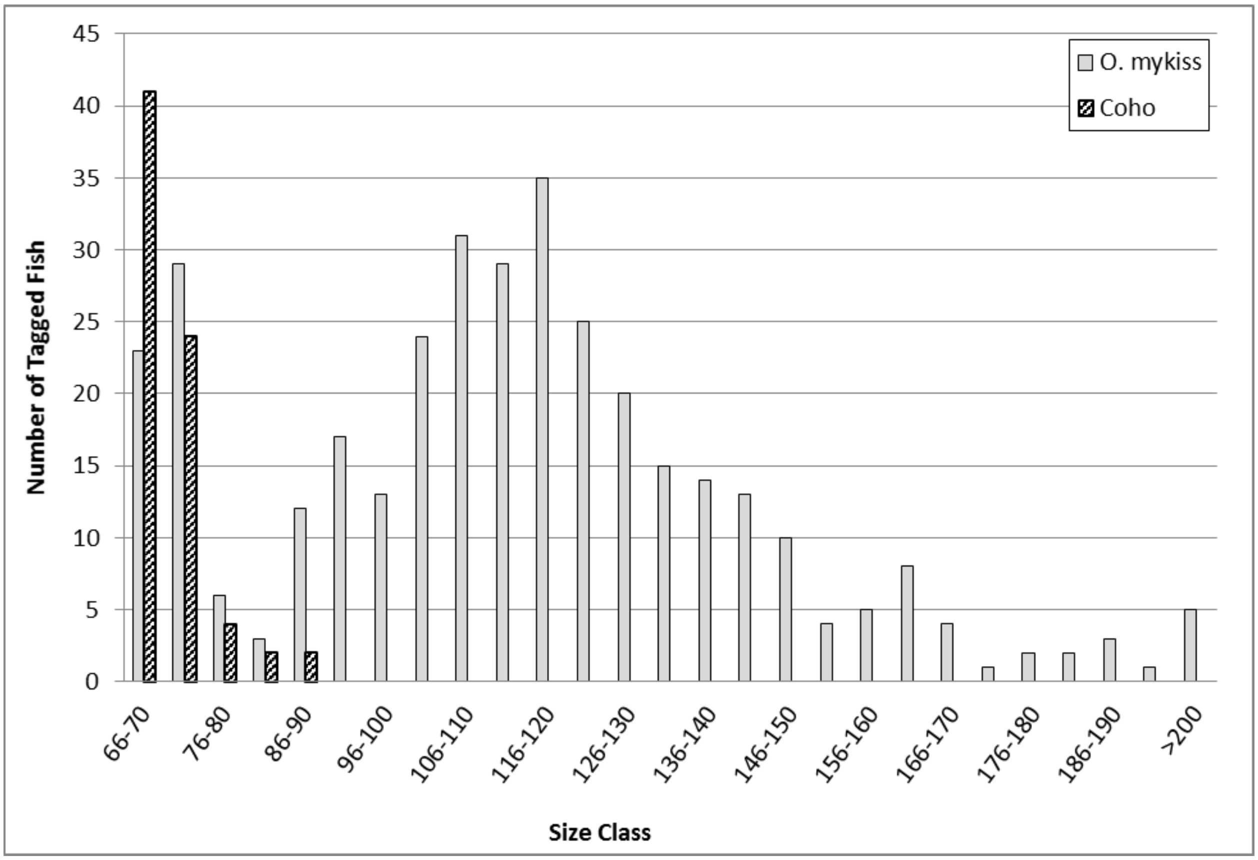

Figure 23. Length frequency histogram of PIT tagged *O. mykiss* and coho in Summit Creek (July 20-28, 2015).

Table 3. Summary of salmonids detected at the Summit Creek PIT tag array (October 31, 2014 – December 31, 2015).

Species Rear Run	Juveniles	Adults
Wild steelhead (O. mykiss)	148 (11)*	2
Hatchery steelhead (O. mykiss)	0	0
Wild coho	18	2
Hatchery coho	0	13
Hatchery spring/summer chinook	4	1
Total	**170**	**18**

*Parentheses denote fish tagged in White Creek

Conclusions

Summit Creek is an important steelhead-bearing tributary stream within the Klickitat subbasin. While the length of anadromous-accessible habitat is not long, multiple age classes of *O. mykiss* juveniles were present with a relatively high percentage of these fish outmigrating across much of the year. Summit Creek provides both natural production of steelhead as well as possible temporary rearing refuge for fish produced in other nearby ttributary subwatersheds (e.g., White Creek). Natural production of coho is also evident in at least some years. Ongoing monitoring via PIT tagging and detection will help further quantify key metrics and answer questions regarding production and the role of Summit Creek.

Tributary Habitat RM&E

Tepee Creek / White Creek Food Web Study

Introduction

The objective of the Food Web Study is to examine how aquatic and terrestrially derived invertebrate prey sources and *Oncorhynchus mykiss* diet are affected by in-stream habitat restoration efforts along a 1.3-kilometer section of Tepee Creek. The focus of the study is to

compare abiotic and biotic conditions within and between pre-project, post-project, and control conditions. More specifically, the study examines intra-and-inter annual changes in trophic linkages among riparian vegetation, macro-invertebrates, and fish by:

- Quantifying riparian habitat conditions in treatment and control sample sections.
- Comparing invertebrate prey availability (biomass and composition) from benthic, drift, and allochthonous sources.
- Comparing fish diet (biomass and composition) in treatment and control sample sections.

Methods

A Before-After-Control-Impact (BACI) study design was developed to quantify invertebrate prey availability (from benthic, drift, and allochthonous sources) and fish diet. Pre-treatment samples were collected in multiple seasons between 2009 and 2011 (Figure 24). In each sample section, benthic invertebrates were collected with a 500-μm net Surber sampler (0.09 m^2 area) at three random locations in riffle habitat. Drift nets positioned for 20-minute intervals at the upstream and downstream boundaries of each sample section collected drifting invertebrates. For each sampling event, nine randomly placed pan traps (0.071 m^2) in each sample section collected allocthonous invertebrate inputs over a 7-day period. During each sampling period, an attempt was made to collect 20 stomach samples from *Oncorhynchus mykiss* in each sample section.

Results

The study is currently in the post-treatment monitoring phase (Figure 24). During the reporting period, the in-treatment implementation phase was completed in fall 2013. After completion of the implementation phase, sampling was delayed for 1-year while seeded streamside and floodplain vegetation took hold. In 2015, post-treatment samples were collected in spring, summer, and fall (Table 30 in Appendix B). Drought conditions resulted in long sections of dry or standing water in summer and fall 2015. Consequently, collection of benthic, drift, and stomach samples fell significantly short of sample size projections. Samples are currently undergoing enumeration and identification in the laboratory.

Study Phase	2009	2010			2011			2012			2013			2014			2015		
	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Pre-Treatment Sampling	√	√	√	√			√												
Treatment Implementation																			
Post-Treatment Sampling																	√	√	√

Figure 24. Food Web Study sampling event and implementation timeline. Grey bar denotes active phase and yellow bar completed Food Web Study phase. Check marks denote completed sampling events.

Conclusions

As this study is ongoing, results presented here are partial and preliminary; complete results will be presented in future reports and publications following 2015 post-treatment sampling and analysis. Preliminary results indicate little differences overall in macroinvertebrate taxa richness between the treatment and control sites, significant seasonal effects on macroinvertebrate taxa richness, and significant contributions to aquatic food webs by terrestrial invertebrates (highlighting the potential importance of riparian vegetation to these food webs).

Habitat surveys

Introduction

The Klickitat Monitoring and Evaluation Project (M&E) in collaboration with Klickitat Watershed Enhancement Project (KWEP) initiated a new basin wide rapid aquatic habitat survey methodology (RAHAP) in 2009. The objective of aquatic habitat surveys is three-fold:

- Determine the effectiveness of habitat enhancement projects by quantifying differences pre-and-post-project stream enhancement conditions.
- Expand the spatial extent of instream habitat conditions in fish bearing portions of stream.
- Habitat assessments provide baseline information to identify stream sections in need of enhancement and guide design of management objectives.

Methods

Field crews were comprised of two people collectively responsible for quantifying reach delineations, habitat units, spawning patches, wood pieces, and wood jams. Surveys start at a designated point and proceed upstream by delineating and sequentially numbering each habitat unit. The following variables were collected for each delineated habitat unit: habitat type (pool, riffle, or glide), wetted width, maximum and residual pool depth, percent undercut banks, and bankfull width. Each delineated habitat type was geo-referenced with a GPS point and documented by a photo with a digital camera. LWD piece and jam surveys were conducted in conjunction with the habitat surveys using methods described in Schuett-Hames et al. 1999b. Each piece LWD and jam was geo-referenced to a delineated habitat unit.

Results

In partnership with KWEP, M&E crews conducted habitat surveys in Swale Creek located at river kilometer ~28 in mid-May 2014. Swale Creek was selected for habitat assessment surveys because of documented usage by multiple salmonid species through on-going spawning surveys and installation of a PIT tag array in summer 2013. The habitat survey was discontinued May 21 at

stream kilometer 8.1 after encountering long stretches of dry channel (Figure 25). In June 2015, the habitat survey began at the point where crews discontinued the previous year. An additional 1.6 kilometers was surveyed in 2015.

During the low-flow period in 2014, M&E and KWEP crews conducted habitat surveys in Summit Creek over three days in September (9/15-9/17/2014). Approximately 2.1 kilometers of stream was surveyed from the confluence to a waterfall, which is a barrier to anadromy (Figure 22). Summit Creek, located at river kilometer ~60, was selected for habitat assessment surveys because it maintains perennial surface flow connection at the confluence and has usage by multiple salmonid species (Figure 26).

In the early fall of 2015, the lower portion of the mainstem Klickitat River was surveyed from the confluence of the Little Klickitat River to a screw trap located at river kilometer 4.3. Approximately 28 kilometers of the mainstem Klickitatat River was surveyed (Figure 27). The lower section of the Klickitat River was selected in an effort to quantify baseline habitat conditions from the Klickitat Hatchery (RKM 69) to the Klickitat River delta (RKM 0).

Approximately 47-kilometers of stream length was surveyed during the reporting period (Table 31 in Appendix B). Nearly three-quarters of the total surveyed stream length was competed in the Klickitat River. Swale Creek accounted for one-quarter of the surveyed stream length. Side-channels accounted for 21% of the total surveyed stream length in the Klickitat River to 12% in Swale Creek. There were no side channels documented in Summit Creek. Pool frequency was lowest in the Klickitat River and highest in Swale Creek. Pool frequency in Summit Creek was comparable to Swale Creek but 6-fold greater than the Klickitat River. Residual pool depth was substantially greater in the Klickitat River compared to pools in Swale Creek and Summit Creek. In comparing tributaries, residual pool depths were notably greater in Summit Creek. The frequency of large woody debris pieces in Summit Creek was 2.5 and 6 times greater than Swale Creek and mainstem Klickitat River, respectively (Table 32 in Appendix B). However, large woody debris piece frequency in Summit Creek was >1.5 times greater than in side channels of the Klickitat River. Many pieces encountered in Swale Creek did not meet the minimum diameter criteria of 0.2 meters. The riparian forest in Swale Creek is composed of small-diameter deciduous trees (predominantly alder and willow), whereas Summit Creek is bordered by a mature coniferous forest (Figure 26).

Figure 25. **Riparian lined glide in Swale Creek (left) and upper extent where 2014 survey was discontinued.**

Figure 26. **Typical higher gradient riffle habitat (left) and lower gradient glide habitat in Summit Creek.**

Figure 27. **Bedrock scour pool (left) and alder lined side channel in the Klickitat River.**

Conclusions

Habitat surveys in the Klickitat subbasin focused on important fish-bearing stream reaches that had not been surveyed in recent years in Swale Creek, Summit Creek, and the mainstem Klickitat River. Pool frequency was similar in Swale and Summit creek, and was higher for both tributary streams

than for the Klickitat, although pools were deeper in the mainstem. Large woody debris was most abundant in Summit Creek; the riparian zone of Swale Creek does not currently supply high amounts of large woody debris. Results will be compiled and compared to other streams for habitat status monitoring and planning purposes.

Temperature and water quality monitoring

Introduction

Objectives are to monitor stream temperatures and record water quality measurements on selected tributaries and within selected habitat survey reaches on a seasonal basis. This provides basic water quality and temperature information for important salmonid habitat and baseline information for comparing changes through time due to land use and climate change.

Methods

Stream temperatures were monitored via continuously-recording Onset thermographs (set to record at 30-min. intervals) at 35 locations on 23 streams within the Klickitat subbasin. Air temperatures were also monitored at five locations in lower-, mid-, and upper-elevation areas within the subbasin. Portable field meters were used to measure and record the following parameters on a seasonal basis at these same sites: temperature, dissolved oxygen, conductivity, pH, and turbidity. See Figure 32 for a map and Table 33 (both in Appendix B) for a tabular description of thermograph locations. Temperature and water quality data are being stored in relational databases.

Results

Summaries of temperature data for each location (including data from the full period of record for each site) is available at the YKFP website (http://www.ykfp.org/klickitat/Data_thermo.htm). These summaries include (for each month during the reporting period): the number of days during which temperature was recorded; the number of times the daily minimum temperature was less than 0.5°C and 4.4°C; the number of times the daily average temperature was less than 0.5°C and 4.4°C; the number of times the daily maximum temperature was greater than 23°C and 24°C; the number of times the 7-day average daily maximum temperature was greater than 12°C, 16°C, 17.5°C, 18°C, and 22°C (the 7-day average daily maximum was calculated by averaging the daily maximum temperatures across the time period that started 3 days prior to and ended 3 days after a given day); the monthly 1-day maximum temperature (the highest instantaneous temperature recorded in a given month); the monthly 1-day maximum range (the largest daily range in temperature recorded during a given month); and the monthly average daily range (the average daily range in temperature recorded during a given month).

Other basic water quality parameters that have been recorded have been entered into a relational database. Development and quality control of this database is ongoing; these data will be used to monitor trends and differences between selected sites.

Conclusions

Water temperatures are generally higher in the lower subbasin, from White Creek downstream. High temperatures and associated reductions in dissolved oxygen, along with dewatering, present potentially significant habitat limitations for juvenile salmonids, especially for Mid-Columbia steelhead. Stranding has been observed in a number of tributaries. Considerable mortality likely occurs annually in White, Tepee, Brush, Dead Canyon, Swale, and Dillacort creeks as a result of dewatering and/or warming of refugia pools.

Sediment monitoring

Introduction

Objectives of this work are to monitor stream sediment loads associated with anthropogenic factors (e.g., logging, agriculture and road building), affecting streams basin wide. Excessive sediment loads can significantly decrease egg-to-fry survival, and can depress survival and alter habitat for many other life stages of salmonids.

Methods

Twelve sites throughout the basin (8 in the mainstem Klickitat, 3 in Diamond Fork Creek, and 1 in White Creek) have been identified for sediment sampling. See Figure 33 in Appendix B for a map showing locations of sampling sites. Current sampling plans call for 4 of these sites (4 mainstem Klickitat sites at McCormick Meadow, Cow Camp, Leidl Bridge, and Icehouse) to be sampled every year, with the full set of 12 sites being sampled every 5 years. Twelve samples were collected from representative spawning gravels at each site (from 3 different riffles at each site, 4 samples from each riffle) using McNeil core gravel samplers. Samples from each site were analyzed to estimate the percentage of fine particles present and determine the particle size distribution. Samples were collected and analyzed using TFW Salmonid Spawning Gravel Composition Survey methodology (Schuett-Hames et al. 1999a). Information gathered was used to characterize sediment levels throughout the basin.

Results

Detailed results from sediment monitoring at the sites sampled, including particle size distributions and percentages of fine sediments (presented as particles < 1.7 mm and particles < 6.73 mm), are available at the YKFP website (http://www.ykfp.org/klickitat/Data_SedRpts.htm). Some general trends that are indicated by the data are described below. Monitoring at most of these sites began in 1998, 1999, or 2000, and continued through 2009. Changes in channel morphology at 2 sites

(Klickitat R. near Stinson Flats and Klickitat R. at Ice House Park) led to sampling of different riffles than what had been sampled in previous years; recent data are presented for these sites but is not lumped with past data for trend analysis.

Percentage of fines at many sites appears to be fluctuating over periods of several years, with no long-term directional trend readily apparent. Fines percentages at some of the sites appear to be fluctuating within the range of approximately 10% to 20% (particles < 1.7 mm). These sites tend to be the higher elevation sites, and include: Klickitat R. at McCormick Meadows, Klickitat near Cow Camp, and the Diamond Fork sites. Fines percentages at most other sites range higher, up to 25-30%. One site that does appear to show an increasing trend in fine sediments is Klickitat R. near Leidl Bridge, with particles < 1.7 mm generally increasing from 21 to 29%, and particles < 6.73 mm increasing from 26 to 39% over the period of 1998 to 2009.

Conclusions

Status and trend monitoring of sediment levels at key Klickitat subbasin sites is being accomplished under this work element. Percentage of fine sediment at higher elevation sites are fluctuating between 10% and 20%, with other sites having fine sediment levels over 20%, which is considered high enough to have detrimental effects on salmonid spawning habitat (Bjornn and Reiser 1991), and at least one site showing an apparent increasing trend in this parameter.

Streamflow monitoring

Introduction

In order to develop and maintain stage-discharge rating curves and tables, for developing annual hydrographs, and flood peak analyses, streamflow is monitored at various sites within the Klickitat subbasin. These data are collected in conjunction with YKFP Klickitat Watershed Enhancement Project (#199705600) and YN Water Resources Program, and assist with status and trend monitoring and prioritization and design of restoration projects.

Methods

Instantaneous measurement of stream discharge was collected at established locations on the upper mainstem Klickitat River and within the subwatersheds of Swale, Summit, White, Tepee, Surveyors, Piscoe, and Diamond Fork. Staff gauges were maintained at each site to develop stage-discharge rating curves. Crest stage data was also collected from each of the sites one time to record the annual maximum. These data are stored in an internal relational database.

Results

Twelve sites were monitored during this reporting period. Rating curves have been developed for nearly all sites. Data is stored in a database maintained by YN Water Resources Program.

Conclusions

Status and trend monitoring of streamflow at key Klickitat tributary sites is being accomplished under this work element. Future analyses will provide relevant information regarding design requirements for restoration projects, trends in hydrographs and flood flows, and where possible, relationships to land use hydrology and climate change.

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VI. Appendix A: Use of Data & Products

Data generated from this project is available at several web sites and publicly-accessible databases, as outlined below. Use of these data is conditional upon a sufficient understanding of data limitations and knowledge of valid inferences that can be made from various data analyses. Contact lead project biologist Joseph Zendt (jzendt@ykfp.org) or data systems manager Michael Babcock (mbabcock@ykfp.org) with questions regarding data collection, use, and limitations.

Fish population and tagging monitoring data:
http://www.ykfp.org/klickitat/Data.htm
http://www.ptagis.org/
http://www.rmpc.org/

Habitat data:
http://www.ykfp.org/klickitat/Data.htm

Past reports and publications:
http://www.ykfp.org/klickitat/Reports&Pubs.htm

VII. Appendix B: Detailed Results

Table 4. Mark-recapture estimates of spring Chinook run size at Lyle Falls on the lower Klickitat River for 2005-2015.

Year	Pop. Estimate (total)	L 95% CL	U 95% CL	- 95% CI	+ 95% CI	% Wild[3]	Hatchery	Wild	% Jacks[4]	Adult total
2005 *1/*	2011	1475	2842	536	831					
2006 *1/*	2100	1884	2391	216	291					
2007 *2/*	1882	1585	2257	297	375	20.9%	1489	393	17.7%	1549
2008	1712	1330	2256	382	544	26.2%	1263	449	35.9%	1097
2009	6204	5526	6997	678	793	10.0%	5584	620	22.2%	4827
2010	4535	3599	5825	936	1290	11.2%	4027	508	9.8%	4091
2011	4536	3794	5483	742	947	15.1%	3851	685	21.0%	3583
2012	4452	3740	5357	712	905	13.0%	3873	579	21.4%	3499
2013	6421	5339	7817	1082	1396	7.2%	5959	462	38.8%	3930
2014	5060	4399	5861	661	801	6.1%	4751	309	20.0%	4048
2015	5865	4928	7056	937	1191	11.3%	5202	663	5.7%	5531
Avg.	4071						4000	519		3573
Geomean	3637						3565	504		3218

1/ Estimates from Gray 2007
2/ 2007 is first year all returning adult age classes were 100% ad marked
3/ Percentage of wild (adipose-present) fish as counted at Lyle Falls adult trap
4/ Percentage of jacks as counted at Lyle Falls adult trap

Note: Hatchery/wild numbers estimated from proportions observed at Lyle adult trap. Estimates include jacks and adults (except Adult total column).

Table 5. Mark-recapture estimates of steelhead run size at Lyle Falls on the lower Klickitat River for 2005-2014.

	Total				Hatchery				Wild (Summer and Winter)				Wild (Summer)				
Year	Pop. Estimate	SE	L 95% CL	U 95% CL	Pop. Estimate	SE	L 95% CL	U 95% CL	Pop. Estimate	SE	L 95% CL	U 95% CL	Pop. Estimate	SE	L 95% CL	U 95% CL	Wild (Winter)[1]
2005-06 [2]	3,410	250	2,967	3,961	1,833	148	1,572	2,160	1,577	102	1,395	1,801	1,252	102	1,070	1,476	325
2006-07 [2,3]	3,523	610	2,718	5,918	1,854	349	1,394	3,231	1,669	261	1,324	2,687	1,325	261	980	2,343	344
2007-08 [4]																	90
2008-09 [4]																	82
2009-10 [5]	4,868	506	4,003	6,021	3,578	390	2,913	4,470	1,290	116	1,090	1,551	1,137	116	937	1,398	153
2010-11 [3,5]	6,265	971	4,698	8,647	5,154	834	3,813	7,209	1,111	137	885	1,438	979	137	753	1,306	132
2011-12	4,926	1,424	2,945	9,279	2,443	715	1,448	4,630	2,483	709	1,497	4,649	2,399	709	1,413	4,565	84
2012-13	3,726	1,277	1,750	8,048	2,663	929	1,146	5,818	1,063	348	604	2,230	999	348	540	2,166	64
2013-14 [3]	2,477	478	1,741	3,726	1,255	248	873	1,904	1,222	230	868	1,822	1,146	230	792	1,746	76
2014-15	6,456	1,875	3,857	12,221	3,500	1,035	2,066	6,687	2,956	840	1,791	5,534	2,815	840	1,650	5,393	141
Avg:	4,456	924	3,085	7,228	2,785	581	1,903	4,514	1,671	343	1,182	2,714	1,507	343	1,017	2,549	149
								Geometric means:	**1,565**		**1,122**	**2,407**	**1,394**		**963**	**2,219**	**125**

[1]Count of fish captured in Lyle adult trap Dec 1 - Apr 30 (assumes no winter steelhead ascend falls, which likely biases estimate low). No recaptures of winter fish due to no winter sport fishery.
[2]From Gray 2007
[3]Winter steelhead counts estimated from previous winters' proportion of total, due to winter trap shutdowns.
[4]No estimate; angler recapture data not collected.
[5]Estimate of hatchery fish may be biased high by a high dip-in rate by out-of-basin fish

Table 6. Klickitat spring Chinook (Adult age 4, 5, and 6) returns, harvest, and escapement (from run reconstruction estimation).

Return	Returns			Harvest					Escapement		
					Sport		Tribal				
Year	Total	Hatchery	Wild	Total	Hatchery	Wild	Hatchery	Wild	Total	Hatchery	Wild
1977	533	380	153	95	6	3	61	25	438	312	126
1978	1,528	1,160	368	906	202	64	486	154	622	472	150
1979	851	773	78	89	81	8	0	0	762	692	70
1980	1,685	1,619	66	67	6	0	59	2	1,618	1,555	63
1981	2,528	2,211	317	574	133	19	369	53	1,954	1,709	245
1982	3,238	2,988	250	1,775	399	33	1,239	104	1,463	1,350	113
1983	2,417	2,190	227	1,745	256	27	1,325	137	672	609	63
1984	1,323	1,086	237	754	268	59	350	77	569	467	102
1985	848	340	508	716	73	108	215	320	132	53	79
1986	1,112	860	252	485	19	5	357	104	627	485	142
1987	1,682	1,235	447	507	118	42	255	92	1,175	863	312
1988	3,929	2,239	1,690	1,353	141	107	630	475	2,576	1,468	1,108
1989	5,254	4,807	447	1,783	760	71	871	81	3,471	3,176	295
1990	2,583	1,858	725	1,785	256	100	1,028	401	798	574	224
1991	1,477	1,018	459	702	96	43	388	175	775	534	241
1992	1,540	1,026	514	587	82	41	309	155	953	635	318
1993	3,702	2,985	717	1,483	228	55	967	233	2,219	1,789	430
1994	958	831	127	233	44	7	158	24	725	629	96
1995	696	606	90	140	0	0	122	18	556	484	72
1996	1,156	782	374	308	97	46	112	53	848	574	274
1997	1,861	1,083	778	437	157	113	97	70	1,424	829	595
1998	702	397	305	149	8	6	76	59	553	313	240
1999	728	578	150	151	60	16	60	15	577	458	119
2000	2,708	1,601	1,107	1,446	233	162	621	430	1,262	746	516
2001	1,162	614	548	500	85	75	180	160	662	350	312
2002	2,549	1,250	1,299	787	183	190	203	211	1,762	864	898
2003	3,976	1,936	2,040	1,750	374	393	479	504	2,226	1,084	1,142
2004	3,039	1,710	1,329	1,171	338	262	321	250	1,868	1,051	817
2005	1,428	1,140	288	809	322	81	324	82	619	494	125
2006	1,603	1,182	420	681	226	0	336	119	922	621	301
2007	1,078	647	430	337	73	0	159	105	741	416	325
2008	1,115	707	409	593	121	0	299	173	522	287	236
2009	1,607	1,366	241	513	390	0	123	0	1,094	853	241
2010	1,784	1,370	413	641	242	0	371	28	1,143	757	385
2011	1,699	1,070	629	559	475	0	79	5	1,140	516	624
2012	2,298	1,471	827	1,148	698	0	411	39	1,150	362	788
2013	1,623	1,138	485	484	359	0	122	3	1,139	657	482
2014	2,724	2,257	466	1,358	327	0	923	108	1,366	1,007	358
2015	2,810	1,864	946	1,099	350	0	722	27	1,711	792	919
Min	533	340	66	67	0	0	0	0	132	53	63
Max	5254	4807	2040	1785	760	393	1325	504	3471	3176	1142
Avg	1,937	1,394	542	787	212	55	390	130	1,150	792	358

Table 7. Results of spring Chinook spawning ground surveys (redd counts) in the Klickitat subbasin for 1989-2015.

REACH	MILES	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*
		Redd Counts																										
Diamond Fork	8.5	ns	0	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0	0	0	0	0	ns	0	ns	ns	ns	0	ns
McCormick Mdws - Castile Falls	18.0	0	0	0	0	0	1	0	0	0	0	0	64	2	243	165	122	4	6	36	0	4	1	0	5	0	0	3
Castile Falls #10 - Falls #1	0.8	ns	ns	ns	ns	ns	ns	ns	ns	3	3	2	0	7	0	4	0	0	0	3	0	0	0	3	3	2	2	1
Castile Falls - Signal Peak Br.	3.3	20	17	28	34	33	18	17	24	87	56	40	39	33	50	41	18	11	14	18	15	21	13	31	20	35	18	22
Signal Peak Br. - Big Muddy Cr.	6.9	33	42	61	63	84	20	25	51	118	53	38	29	78	75	71	38	9	39	34	34	26	44	38	57	44	29	41
Big Muddy Cr. - Old USGS gage	3.3	ns	ns	0	5	15	0	0	0	0	0	0	2	0	5	0	0	0	0	0	2	0	2	2	5	1	2	3
Old USGS gage - Klickitat Hatchery	8.2	ns	ns	ns	ns	ns	ns	ns	14	2	0	0	27	1	16	34	10	15	4	8	5	3	18	28	35	26	10	28
Klickitat Hatchery - Summit Cr.	5.5	ns	ns	2	ns	ns	ns	ns	8	14	1	2	4	1	0	17	3	7	15	5	9	9	14	45	19	7	14	78
Summit Creek - Leidl	5.6	ns	ns	2	ns	ns	ns	ns	8	3	0	1	2	1	0	0	1	3	3	0	11	2	3	4	1	7	7	1
Leidl - Stinson Flats	3.2	ns	ns	ns	ns	ns	ns	ns	5	4	ns	ns	ns	ns	ns	ns	0	1	0	0	0	2	2	0	0	1	1	2
Stinson Flats - Soda Springs/Beeks Canyon	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	3	0	1	0	0	3	0	0	2	4	1	2
Soda Springs/Beeks - Twin Bridges	6.4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0	6	7	3	2	4
Twin Bridges - Pitt Bridge	8	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0	0
Pitt - Turkey Farm	5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Turkey Farm - Lyle Falls	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Totals	**88.7**	**53**	**59**	**93**	**102**	**132**	**39**	**42**	**110**	**231**	**113**	**83**	**167**	**123**	**389**	**332**	**195**	**50**	**82**	**104**	**76**	**70**	**97**	**157**	**154**	**130**	**86**	**185**
Totals (minus releases above Castile)		**53**	**59**	**93**	**102**	**132**	**39**	**42**	**110**	**231**	**113**	**83**	**103**	**123**	**146**	**167**	**73**	**50**	**82**	**104**	**76**	**70**	**97**	**157**	**154**	**130**	**86**	**185**
Totals above Castile (minus releases)		**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**4**	**6**	**36**	**0**	**4**	**1**	**0**	**5**	**0**	**0**	**3**
Totals in Wild index reach		53	59	89	97	117	38	42	75	205	109	78	68	111	125	112	56	20	53	52	49	47	57	69	77	79	47	ns
Percent of Total in Wild index reach		100%	100%	96%	95%	89%	97%	100%	68%	89%	96%	94%	66%	90%	86%	67%	77%	40%	65%	50%	64%	67%	59%	44%	50%	61%	55%	ns

ns = not surveyed

* In 2015, Cougar Creek fire-related road closures prevented surveys from Signal Peak Bridge to Old USGS gage site. 2015 redd counts for those reaches are estimated based on linear regression with total wild fish run size at Lyle Falls in 2015 and recent years' proportions of total redd counts observed in those reaches.

Note: In 2000, 2002, 2003, and 2004 surplus spring Chinook adults from Klickitat Hatchery were transported and released above Castile Falls. High redd counts above Castile Falls in those years are almost exclusively a result of those releases. For this reason the "Totals (minus releases above Castile)" row provides for a more consistent across-year comparison of natural spawner escapement in the Klickitat subbasin. The "Totals above Castile (minus releases)" row provides an across-year comparison of natural spawner escapement and passage above Castile Falls, assuming virtually no natural passage in 2000, 2002, 2003, and 2004. The "Wild Index Reach" is Castile Falls to Big Muddy Cr.

Table 8. Klickitat subbasin spring Chinook spawner survey carcass observations for 2007-2015. 2007 is the first year in which all returning hatchery-origin adults were 100% ad-clipped. 2015 data is not used due to wildfire-related road closures that prevented surveys in key wild spawning reaches.

	Carcasses observed		
Year	**Ad-clipped**	**Unclipped**	**% Ad-clipped**
2007	6	10	38%
2008	2	4	33%
2009	1	8	11%
2010	4	3	57%
2011	11	7	61%
2012	4	3	57%
2013	1	5	17%
2014	5	3	63%
		Avg.	42%

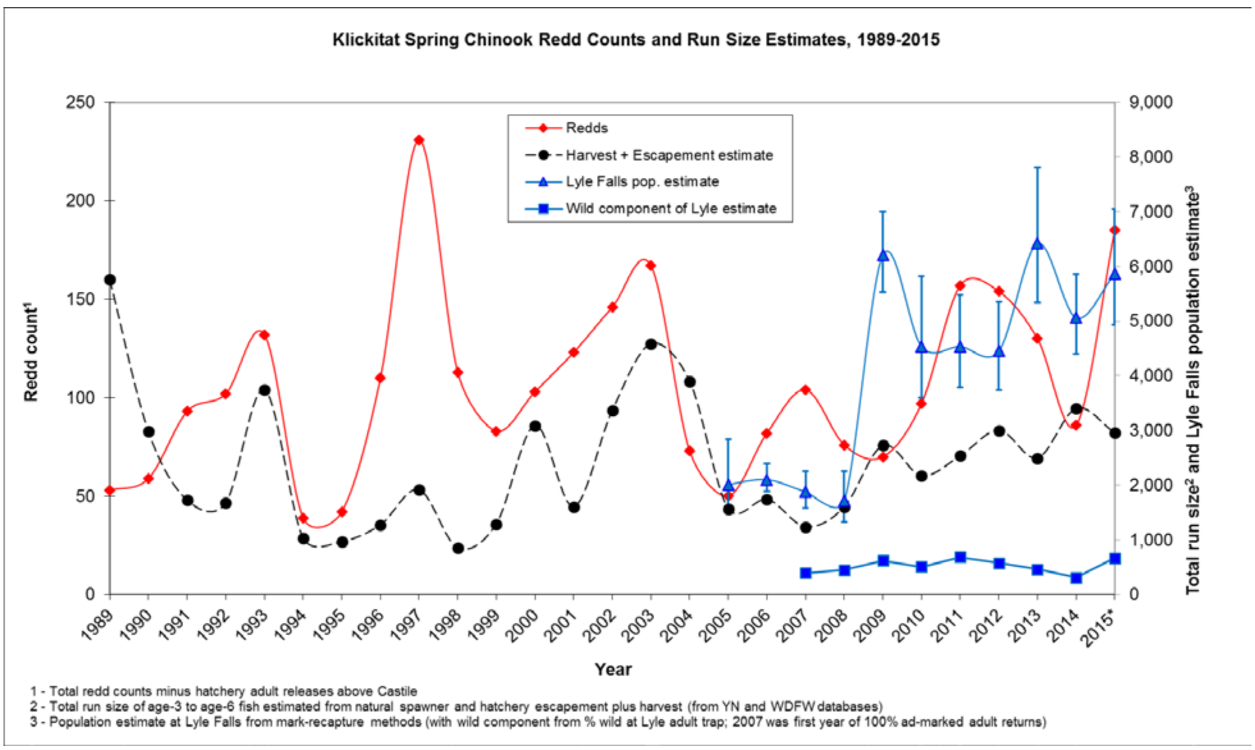

Figure 28. Results of spring Chinook redd counts and run size estimates in the Klickitat subbasin for 1989-2015. Error bars on Lyle Falls mark-recapture population estimates represent 95% confidence intervals.

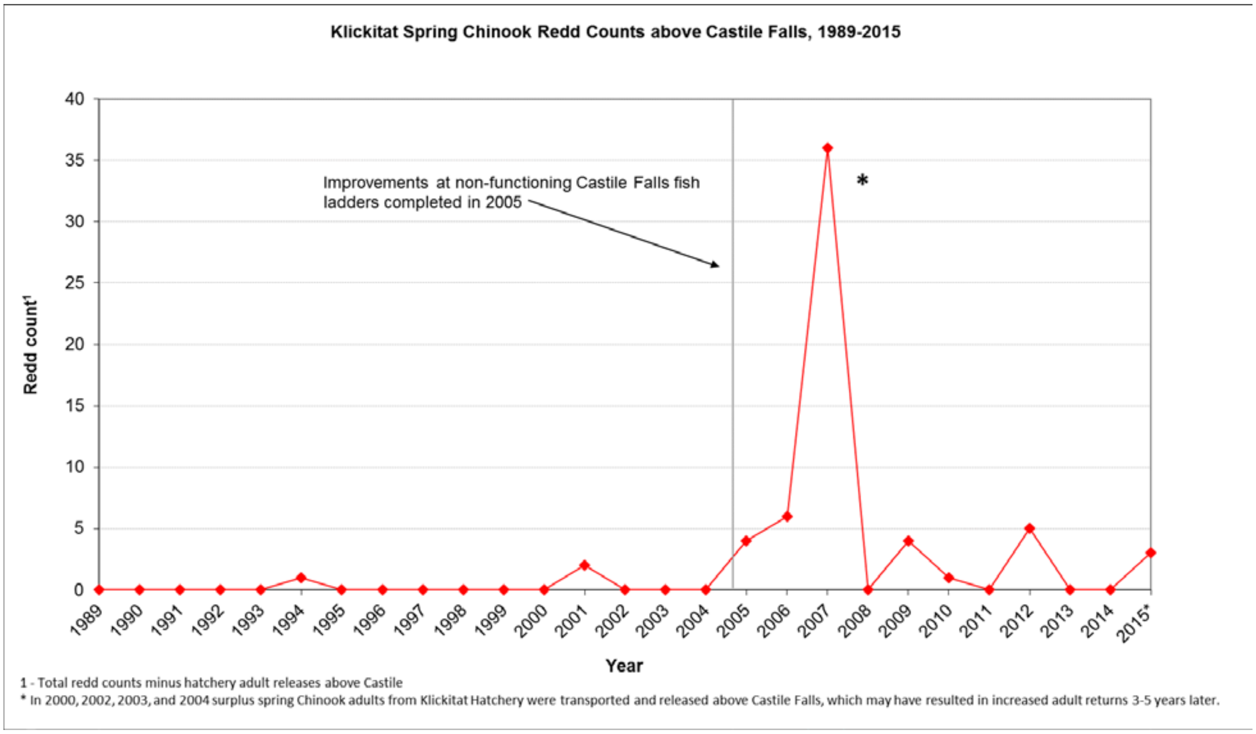

Figure 29. Results of spring Chinook redd counts above Castile Falls (RM 64) in the upper Klickitat River for 1989-2015.

Table 9. Results of fall Chinook spawning ground surveys (redd counts) in the Klickitat subbasin for 1995-2015.

		Redd Counts																				
REACH	MILES	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Old USGS gage - Klickitat Hatchery	8.2	ns	1	12	6	0	0	0	3	ns	4	1	ns	5	0	ns	0	1	12	0	11	ns
Klickitat Hatchery - Summit Cr.	5.5	194	300	248	475	263	468	35	75	18	65	88	72	112	92	313	423	336	58	416	537	132
Summit Creek - Leidl	5.6		303	310	434	239	492	49	258	159	94	199	1	23	16	108	291	232	143	498	273	87
Leidl - Stinson Flats	3.2	120	104	144	183	160	207	138	97	190	52	55	2	39	21	101	132	157	65	404	164	269
Stinson Flats - Soda Springs/Beeks Canyon	7.5		159	68	180	66	86	53	160	26	84	68	23	24	2	60	119	134	6	445	689	282
Soda Springs/Beeks - Twin Bridges	6.4	140	146	90	413	82	227	112	420	43	368	77	21	32	12	152	152	322	71	1324	1536	532
Twin Bridges - Pitt Bridge	8	27	100	46	1	19	138	1	163	34	68	13	0	15	0	12	65	309	51	512	508	246
Pitt - Turkey Farm	5	15	18	11	8	6	31	7	38	0	18	4	0	0	0	8	46	64	26	50	89	37
Turkey Farm - Lyle Falls	2	ns	2	ns	ns	ns	ns	ns	11	4	10	0	0	2	ns	0	10	25	4	8	11	8
Below Lyle Falls	0.3	ns	ns	ns	ns	ns	ns	13	ns	ns	14	0	ns	1	4	ns	41	19	ns	ns	ns	ns
Totals	**51.7**	**496**	**1133**	**929**	**1700**	**835**	**1649**	**408**	**1225**	**474**	**777**	**505**	**119**	**253**	**147**	**754**	**1279**	**1599**	**436**	**3657**	**3818**	**1593**

ns = not surveyed

Note: High flows and/or turbidity in some years (especially 2003, 2006, 2008, 2009, 2012, and 2015) limit survey coverage and visibility and may bias redd counts low. High flows and suspended sediment in October 2003 and November 2006 also caused significant pre-spawn mortality of fall Chinook. Some survey reaches were combined in 1995 data.

Table 10. Catch summary of target species at the Lyle Falls screw trap (RM 2.8 on the Klickitat River) from May 1, 2012 to April 30, 2013.

Month	Days Fished	Chinook	Coho	Hatchery O.mykiss	Wild O.mykiss	Totals
May	5		108	582		690
June	3		988	6		994
July	13	3750				3750
August	9	1186	1			1187
September	9	27	5	1	2	35
October	0					0
November	0					0
December	4	2				2
January	12	1			1	2
February	15					0
March	11	2111	2			2113
April	18		62			62
Totals	99	7077	1166	589	3	8835

Table 11. Catch summary of target species at the Lyle Falls screw trap (RM 2.8 on the Klickitat River) from May 1, 2013 to April 30, 2014.

Month	Days Fished	Chinook	Coho	Hatchery O.mykiss	Wild O.mykiss	Totals
May	2		7			7
June	0					0
July	0					0
August	0					0
September	4	11				11
October	14	15	1			16
November	8	6				6
December	0					0
January	4					0
February	7					0
March	0					0
April	15		38	1		39
Totals	54	32	46	1	0	79

Table 12. Catch summary of target species at the Lyle Falls screw trap (RM 2.8 on the Klickitat River) for May 1, 2014 through April 30, 2015.

Month	Days Fished	Chinook	Coho	Hatchery O.mykiss	Wild O.mykiss	Totals
May	9		33	22		55
June	0					
July	3	196				196
August	11	382				382
September	13	222				222
October	0					
November	0					
December	6					
January	9					
February	0					
March	7	1	1100			1101
April	2	14	22	56	1	93
Totals	60	815	1155	78	1	2049

Table 13. Catch summary of target species at the Castile Falls screw trap (RM 64.6 on the Klickitat River) for May through November 2013.

Month	Days Fished	Chinook	Coho	Hatchery O.mykiss	Wild O.mykiss	Brook Trout	Totals
May							
June							
July	1						
August	16				4		4
September	14				2		2
October	8						
November							
Totals	39				6		6

Table 14. Catch summary of target species at the Castile Falls screw trap (RM 64.6 on the Klickitat River) for May through November 2014.

Month	Days Fished	Wild Chinook	Hatchery Chinook	Hatchery O.mykiss	Wild O.mykiss	Brook Trout	Totals
May							
June							
July	9	6					6
August	31	17			9		26
September	25	13			7	1	21
October	20	71			9		80
November	10						
Totals	95	107			25	1	133

Table 15. Catch summary of target species at the Castile Falls screw trap (RM 64.6 on the Klickitat River) for May through November 2015. Trap repair issues limited the number of days fished.

Month	Days Fished	Chinook	Hatchery Chinook	Hatchery O.mykiss	Wild O.mykiss	Brook Trout	Totals
May							
June							
July							
August	25	1			7		8
September							
October	1						
November							
Totals	26	1			7		8

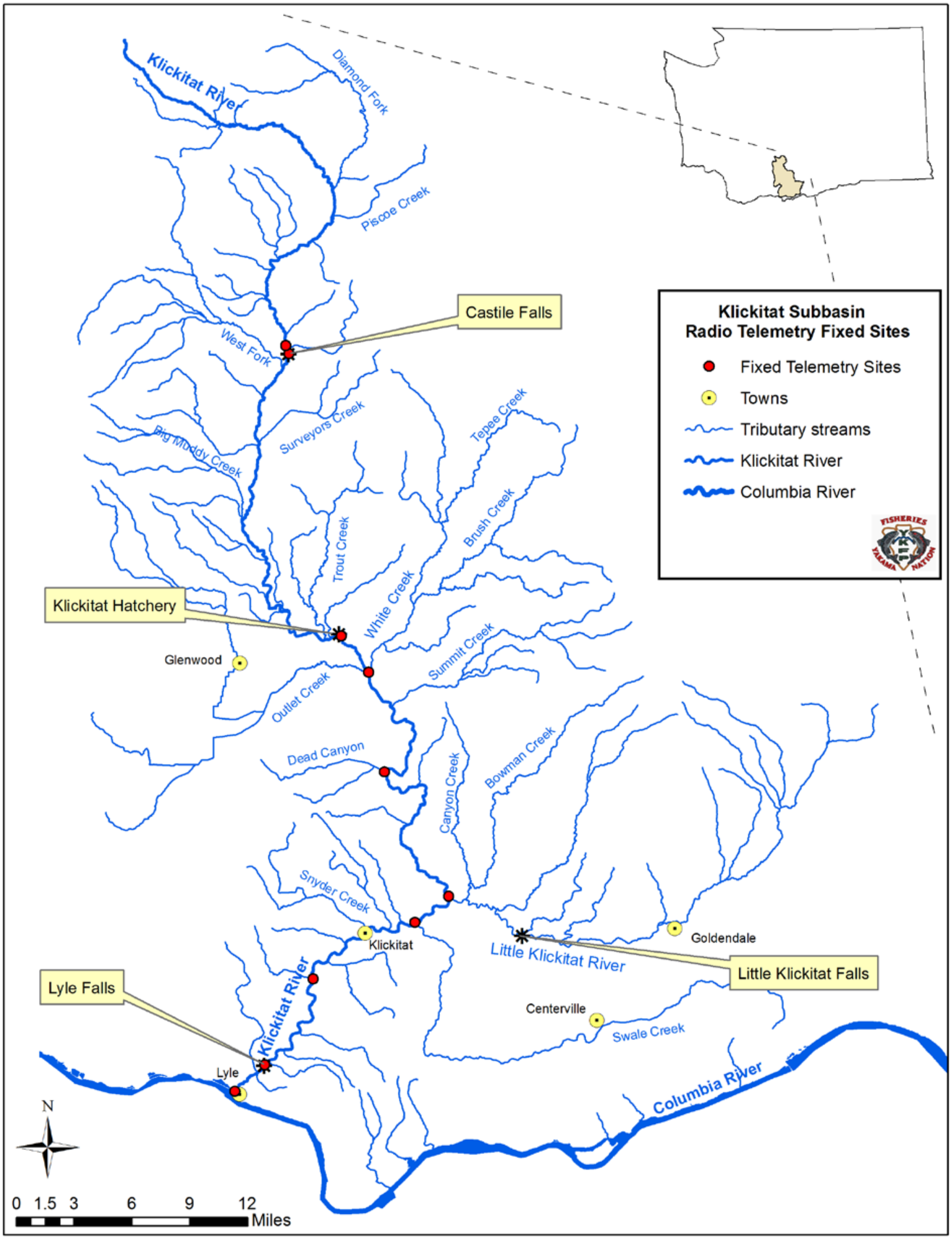

Figure 30. Map of fixed radio telemetry sites in the Klickitat subbasin.

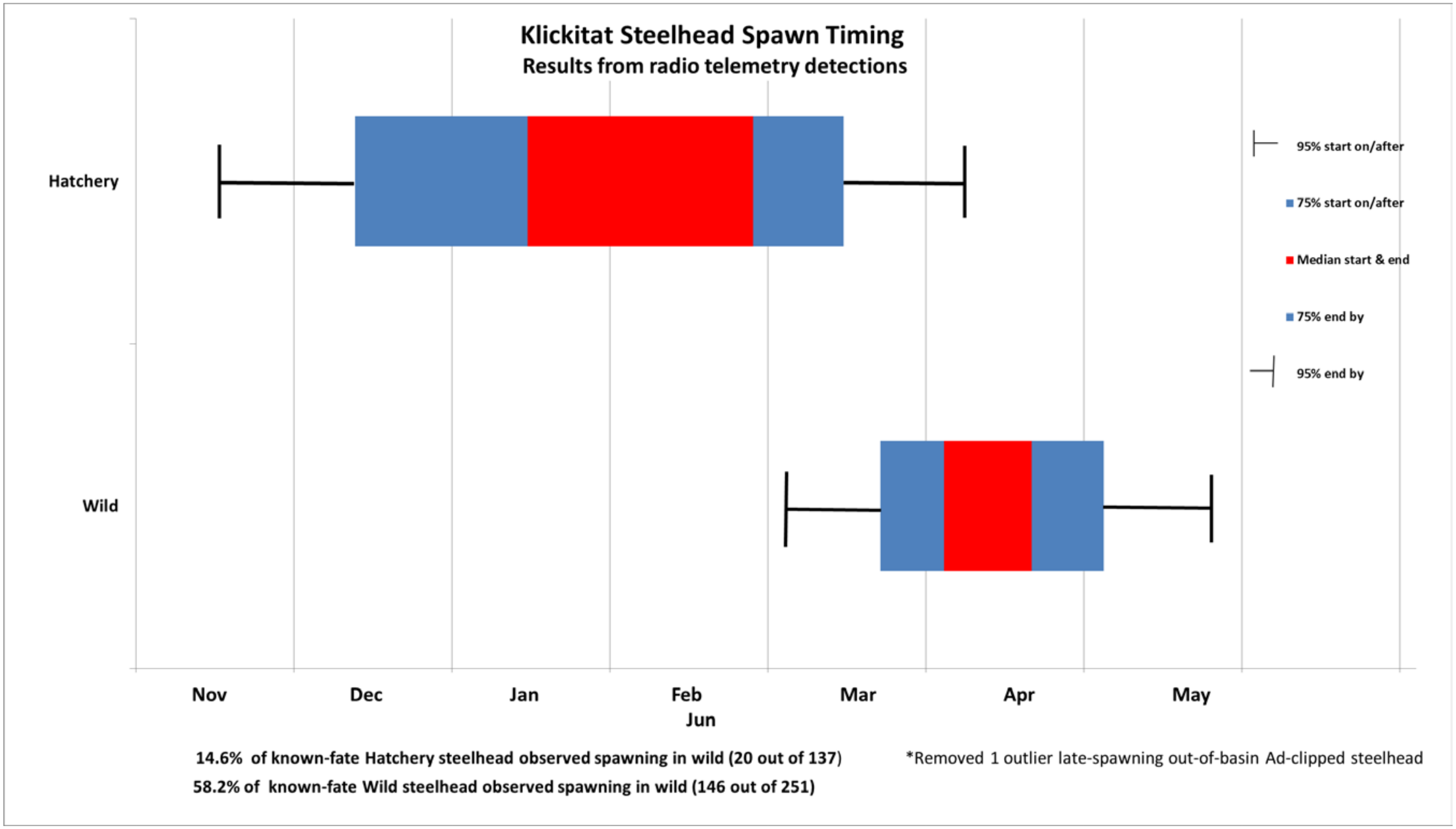

Figure 31. Steelhead spawn timing as determined by radio telemetry detections.

Table 16. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for spring Chinook recovered on spawning ground surveys in the Klickitat River in 2013-2015.

		Fork Length			POH length			
Spring Chinook	**Count**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**% of Total**
2013								
Ad Clipped								
Age 5	1	885	885	885	710	710	710	100.0%
Total	1							
Unmarked								
Age 4	2	759	720	797	612	550	674	50.0%
Age 5	2	1004	1003	1004	809	800	817	50.0%
Total	4							
2014								
Ad Clipped								
Age 4	5	752	715	829	625	580	680	100.0%
Total	5							
Unmarked								
Age 4	2	655	638	671	496	460	532	50.0%
Age 5	2	936	911	960	746	726	765	50.0%
Total	4							
2015								
Ad Clipped								
Age 3	1	560	560	560	461	461	461	25.0%
Age 4	3	768	743	808	637	611	669	75.0%
Total	4							
Unmarked								
Age 3	1	590	590	590	450	450	450	33.3%
Age 4	2	810	757	863	639	603	675	66.7%
Total	3							

Table 17. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for spring Chinook captured in the Lyle Falls adult trap in 2013-2015.

Spring Chinook		Count	Fork Length			POH length			% of Total
			Mean	Min	Max	Mean	Min	Max	
2013									
Ad Clipped									
	Age 3	24	529	452	738	443	391	624	15.9%
	Age 4	98	679	507	870	571	424	728	64.9%
	Age 5	29	811	630	910	689	522	774	19.2%
	Total	151							
Unmarked									
	Age 3	1	491	491	491	408	408	408	5.6%
	Age 4	10	687	588	801	579	487	665	55.6%
	Age 5	7	849	778	954	724	658	813	38.9%
	Total	18							
2014									
Ad Clipped									
	Age 3	27	539	440	685	467	402	695	14.7%
	Age 4	138	724	528	862	617	460	746	75.0%
	Age 5	19	820	695	952	700	646	801	10.3%
	Total	184							
Unmarked									
	Age 3	4	503	462	572	421	395	490	19.0%
	Age 4	17	691	536	794	583	417	682	81.0%
	Total	21							
2015									
Ad Clipped									
	Age 3	6	584	550	660	487	460	550	4.3%
	Age 4	113	731	610	880	619	505	740	81.9%
	Age 5	19	813	645	905	691	555	765	13.8%
	Total	138							
Unmarked									
	Age 3	1	530	530	530	455	455	455	3.1%
	Age 4	26	715	558	848	605	480	728	81.3%
	Age 5	5	761	665	820	652	575	700	15.6%
	Total	32							

Table 18. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for spring Chinook returning to the Klickitat Hatchery adult holding pond in 2013-2015.

		Fork Length			POH length			
Spring Chinook	**Count**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**% of Total**
2013								
Ad Clipped								
Age 2	4	295	255	325	246	210	275	3.0%
Age 3	31	548	465	628	445	363	511	23.0%
Age 4	77	725	556	949	583	450	751	57.0%
Age 5	23	841	636	919	678	580	741	17.0%
Total	135							
2014								
Ad Clipped								
Age 3	41	565	475	720	474	125	615	21.6%
Age 4	147	731	625	842	626	530	720	77.4%
Age 5	2	780	760	800	673	655	690	1.1%
Total	190							
Unmarked								
Age 3	1	564	564	564	490	490	490	12.5%
Age 4	7	719	665	765	611	565	660	87.5%
Total	8							
2015								
Ad Clipped								
Age 3	13	645	550	740	552	475	625	11.6%
Age 4	96	719	605	835	619	520	710	85.7%
Age 5	3	807	765	840	702	665	740	2.7%
Total	112							
Unmarked								
Age 4	1	760	760	760	650	650	650	100.0%
Total	1							

Table 19. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for fall Chinook recovered on spawning ground surveys in the Klickitat River in 2013-2015.

			Fork Length			POH length		
Fall Chinook		**Count**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**% of Total**
2013									
Ad Clipped									
	Age 2	1	431	431	431	345	345	345	0.8%
	Age 3	43	673	599	773	544	480	656	34.1%
	Age 4	66	775	634	890	627	515	711	52.4%
	Age 5	16	822	701	980	676	571	770	12.7%
	Total	126							
Unmarked									
	Age 2	1	430	430	430	350	350	350	0.7%
	Age 3	19	692	550	820	552	440	675	14.2%
	Age 4	80	793	612	1000	641	490	772	59.7%
	Age 5	34	822	694	920	665	523	740	25.4%
	Total	134							
2014									
Ad Clipped									
	Age 2	1	449	449	449	366	366	366	1.9%
	Age 3	2	558	466	650	463	385	540	3.8%
	Age 4	40	790	706	993	637	520	740	76.9%
	Age 5	9	862	831	896	696	638	790	17.3%
	Total	52							
Unmarked									
	Age 3	8	652	587	822	523	477	660	8.4%
	Age 4	69	794	694	946	648	560	742	72.6%
	Age 5	18	856	776	946	702	625	779	18.9%
	Total	95							
2015									
Ad Clipped									
	Age 2	1	432	432	432	342	342	342	4.2%
	Age 3	4	653	625	676	531	515	545	16.7%
	Age 4	12	739	620	876	609	498	720	50.0%
	Age 5	7	826	787	893	693	648	781	29.2%
	Total	24							
Unmarked									
	Age 3	1	559	559	559	466	466	466	2.4%
	Age 4	25	774	636	893	630	513	725	61.0%
	Age 5	15	828	743	929	676	625	775	36.6%
	Total	41							

Table 20. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for fall Chinook captured in the Lyle Falls adult trap in 2013-2015.

		Fork Length			POH length			
Fall Chinook	**Count**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**% of Total**
2013								
Ad Clipped								
Age 3	15	644	430	714	539	356	605	27.8%
Age 4	33	760	599	857	639	509	732	61.1%
Age 5	6	826	744	907	702	622	776	11.1%
Total	54							
Unmarked								
Age 3	44	682	492	840	571	413	709	23.4%
Age 4	123	766	622	907	645	520	742	65.4%
Age 5	21	842	756	933	711	633	788	11.2%
Total	188							
2014								
Ad Clipped								
Age 3	1	708	708	708	596	596	596	3.1%
Age 4	24	774	644	915	646	545	760	75.0%
Age 5	7	813	745	885	695	632	735	21.9%
Total	32							
Unmarked								
Age 3	8	604	465	865	505	385	725	8.0%
Age 4	55	777	645	885	654	550	760	55.0%
Age 5	37	828	692	910	707	584	772	37.0%
Total	100							
2015								
Ad Clipped								
Age 3	8	605	525	650	504	430	545	13.1%
Age 4	41	707	610	815	594	510	700	67.2%
Age 5	12	864	770	955	728	645	800	19.7%
Total	61							
Unmarked								
Age 3	4	549	470	630	459	395	530	3.4%
Age 4	66	752	615	970	634	510	820	55.5%
Age 5	49	862	750	970	728	560	830	41.2%
Total	119							

Table 21. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for coho recovered on spawning ground surveys in the Klickitat River in 2013-2014. 2015 samples are still being collected and processed as of the writing of this report.

			Fork Length			POH length		
Coho		Count	Mean	Min	Max	Mean	Min	Max	% of Total
2013									
Ad Clipped									
	Age 2	1	411	411	411	329	329	329	5.3%
	Age 3	18	687	522	772	546	440	608	94.7%
	Total	19							
Unmarked									
	Age 3	1	665	665	665	526	526	526	100.0%
	Total	1							
2014									
Ad Clipped									
	Age 3	83	620	509	735	492	393	640	100.0%
	Total	83							
Unmarked									
	Age 3	1	534	534	534	410	410	410	100.0%
	Total	1							

Table 22. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for coho captured in the Lyle Falls adult trap in 2013-2014. 2015 samples are still being processed as of the writing of this report.

			Fork Length			POH length			
Coho		Count	Mean	Min	Max	Mean	Min	Max	% of Total
2013									
Ad Clipped									
	Age 3	36	702	560	793	583	460	666	100.0%
	Total	36							
Unmarked									
	Age 3	2	747	745	748	605	603	606	100.0%
	Total	2							
2014									
Ad Clipped									
	Age 3	184	646	475	880	529	395	695	100.0%
	Total	184							
Unmarked									
	Age 3	5	674	600	755	559	515	620	100.0%
	Total	5							

Table 23. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for steelhead recovered on spawning ground surveys in the Klickitat River in 2013-2015.

		Fork Length			POH length			
Steelhead	**Count**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**% of Total**
2013								
Ad Clipped								
Age 3	1	745	745	745	605	605	605	100.0%
Total	1							
Unmarked								
Age 3	2	490	490	490				100.0%
Total	2							
2014								
Ad Clipped								
Age 4	2	724	721	727	603	589	616	100.0%
Total	2							
Unmarked								
Age 2	2	531	531	531	410	410	410	40.0%
Age 3	3	630	630	630	510	510	510	60.0%
Total	5							

Table 24. Scale ages by return year and mark with mean, minimum, and maximum fork lengths and postorbital-hypural lengths for steelhead captured in the Lyle Falls adult trap in 2013-2015.

Steelhead		Count	Fork Length Mean	Fork Length Min	Fork Length Max	POH length Mean	POH length Min	POH length Max	% of Total
2013									
Ad Clipped									
	Age 2	7	552	512	594	471	443	511	5.8%
	Age 3	81	678	528	780	579	450	654	67.5%
	Age 4	29	759	635	904	646	551	767	24.2%
	Age 5	3	794	720	903	685	622	773	2.5%
	Total	120							
Unmarked									
	Age 2	3	544	520	556	462	443	472	7.0%
	Age 3	17	667	514	760	567	443	648	39.5%
	Age 4	21	725	658	837	619	556	719	48.8%
	Age 5	2	792	756	827	672	650	694	4.7%
	Total	43							
2014									
Ad Clipped									
	Age 2	5	577	555	601	485	460	508	3.6%
	Age 3	76	691	472	795	589	400	684	54.7%
	Age 4	57	721	530	900	617	480	750	41.0%
	Age 5	1	720	720	720	610	610	610	0.7%
	Total	139							
Unmarked									
	Age 2	4	572	555	581	484	475	503	1.8%
	Age 3	90	664	500	880	562	423	710	39.8%
	Age 4	115	695	555	855	591	465	852	50.9%
	Age 5	17	788	643	951	665	542	784	7.5%
	Total	226							
2015									
Ad Clipped									
	Age 3	29	693	650	770	590	560	650	35.4%
	Age 4	46	717	620	860	610	540	715	56.1%
	Age 5	7	759	695	950	642	585	790	8.5%
	Total	82							
Unmarked									
	Age 2	2	543	535	550	478	450	505	3.0%
	Age 3	26	661	590	735	565	510	650	38.8%
	Age 4	37	702	630	848	596	522	719	55.2%
	Age 5	2	735	685	785	613	580	645	3.0%
	Total	67							

Table 25. Summary statistics of PIT tagged *Oncorhynchus mykiss* collected from single-pass electrofishing in the White Creek watershed from 2013-2015. ± denotes 1 standard error (SE) of the mean.

Tag Year	Stream	No. Fish* Tagged	No. Fish Recaps	Fish/ $100m^2$	Mean Length (mm)	Median Length (mm)	Length Range (mm)	Mean Weight (g)	Median Weight (g)	Weight Range (g)
2013	Blue Creek	78	1	12.3	86.3 ±1.5	83	65-137	7.4 ±0.4	6.3	2.9-26.9
2013	Brush Creek	290	24	6.3	98.1 ±1.2	92.0	68-172	12.2 ±0.5	8.8	3.3-56.1
2013	EF Tepee Creek	84	2	6.3	89.9 ±2.5	81.5	65-182	9.6 ±1.0	6.0	3.2-56.5
2013	Tepee Creek	752	33	12.8	90.6 ±0.7	85.0	65-182	9.8 ±0.3	7.1	1.4-76.2
2013	WF White Creek	19	0	1.8	83.8 ±2.4	82.0	73-117	7.5 ±0.8	6.6	4.5-20.0
2013	White Creek	1395	49	9.8	98.4 ±0.6	93.0	65-226	12.3 ±0.3	9.0	2.9-142.6
2013	**Total**	**2618**	**109**	**9.4**	**95.4 ±0.4**	**90.0**	**65-226**	**11.3 ±0.2**	**8.3**	**1.4-142.6**
2014	Blue Creek	12	2	2.2	113.1 ±3.2	114.5	92-135	16.5 ±1.4	16.1	9.1-27.1
2014	Brush Creek	205	13	4.4	101.9 ±1.6	97.0	69-186	13.8 ±0.8	9.9	3.8-78.6
2014	EF Tepee Creek	29	4	2.4	98.0 ±5.5	92.0	65-193	13.3 ±3.0	7.7	2.0-78.4
2014	Tepee Creek	443	35	7.8	92.4 ±1.1	84.0	64-198	10.7 ±0.4	6.7	1.9-68.0
2014	WF White Creek	12	0	1.1	78.9 ±5.2	72.5	65-130	6.4 ±1.8	4.3	2.8-25.2
2014	White Creek	873	25	6.1	92.6 ±0.8	85.0	65-265	10.7 ±0.4	6.9	2.4-210.9
2014	**Total**	**1574**	**79**	**5.7**	**93.9 ±0.6**	**86.0**	**64-264**	**11.2 ±0.3**	**7.1**	**1.9-210.9**
2015	Blue Creek	13	2	2.3	123.5 ±7.0	116.0	89-174	23.6 ±4.1	17.3	7.5-61.2
2015	Brush Creek	159	24	3.7	102.6 ±1.9	94.0	73-221	14.4 ±1.2	8.5	1.3-138.9
2015	EF Tepee Creek	45	8	3.9	102.7 ±4.0	95.0	67-219	15.3 ±2.3	10.4	2.5-111.3
2015	Tepee Creek	292	17	5.0	102.0 ±1.3	95.0	68-181	14.0 ±0.6	10.6	3.5-78.5
2015	WF White Creek	0	0	0	0	0	0	0	0	0
2015	White Creek	612	33	4.4	101.2 ±0.8	96.0	66-225	12.9 ±0.4	10.1	1.7-133.0
2015	**Total**	**1121**	**84**	**4.2**	**102 ±0.6**	**90.0**	**65-226**	**13.6 ±0.3**	**8.3**	**1.7-133.0**

Table 26. PIT tag detection summary of *Oncorhynchus mykiss* at the White Creek PIT tag interrogation array and Columbia River for the 2013-2015 migration years (October 1, 2012 - September 30, 2015)

	Fish Detections at White Creek Array by Tag Group					Fish Detections in Columbia River by Tag Group					
Stream	**2011**	**2012**	**2013**	**2014**	**2015**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Blue Creek	0	0	17	1	0	0	0	0	1	1	1
Brush Creek	0	3	46	29	0	0	0	2	2	7	3
E.F. Tepee Creek	0	1	16	4	0	0	0	0	0	1	0
Tepee Creek	0	11	140	68	0	1	2	8	3	5	2
W.F. White Creek	0	0	0	1	0	0	0	1	5	0	0
White Creek	2	11	262	195	61	2	4	23	1	18	5
Total	**2**	**26**	**481**	**298**	**61**	**3**	**6**	**34**	**12**	**32**	**11**

Table 27. PIT tag detection summary of juvenile salmonids at lower Klickitat River tributaries interrogation arrays for 2013-2015 migration years (January 1, 2013 - December 31, 2015). Parentheses denote total the number of juvenile coho tagged.

	Number of Fish Tagged				Fish Detections at PIT Tag Arrays by Tag Group				
Stream	**2013**	**2014**	**2015**	**Total**	**2012**	**2013**	**2014**	**2015**	**Total**
Dillacort Creek	-	94	75	169			33	24	57
Logging Camp Creek	-	55	416	471	1	-	7	0	7
Wheeler Creek	140	248	179	567	17	67	187	106	360
Snyder Creek	-	657	638	1295	-	-	181	12	193
Swale Creek	-	434	281	715	-	-	178 (98)	95 (40)	273
Total	**140**	**1488**	**1589**	**3217**		**67**	**586**	**237**	**890**

Table 28. PIT tag detection summary of anadromous adults at lower Klickitat River tributary interrogation arrays for 2013-2015 migration years (January 1, 2013 – December 31, 2015).

Stream	Detection Year	Wild Steelhead	Hatchery Steelhead	Wild Coho	Hatchery Coho	Hatchery Fall Chinook
Dillacort Creek	2013	-	-	-	-	-
	2014	0	1	0	1	0
	2015	1	0	0	0	0
Logging Camp Creek	2013	0	0	0	0	0
	2014	0	2	0	0	0
	2015	0	2	0	0	0
Wheeler Creek	2013	0	0	0	0	0
	2014	1	3	0	6	0
	2015	0	4	0	1	0
Snyder Creek	2013	-	-	-	-	-
	2014	1	2	0	6	0
	2015	3	2	0	0	0
Swale Creek	2013	-	-	-	-	-
	2014	2	4	0	25	0
	2015	4	8	1	18	1
Total		**12**	**28**	**1**	**57**	**1**

Table 29. Timing of salmonids detected at the Summit Creek PIT tag array (October 31, 2014 – December 31, 2015).

Species Rear Run	Detection Month										
Anadromous Adults	**Jan**	**Feb**	**Apr**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Hatchery summer chinook	0	0	0	0	0	1	0	0	0	0	1
Hatchery coho	2	0	0	0	0	0	0	0	4	7	13
Wild coho	0	0	0	0	0	0	0	0	0	2	2
Wild steelhead/O. mykiss	0	1	1	0	0	0	0	0	0	0	2
Total	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**4**	**9**	**18**
Juveniles											
Hatchery spring chinook	2	2	0	0	0	0	0	0	0	0	4
Wild coho	0	0	0	0	10	7	0	0	1	0	18
Wild steelhead/O. mykiss	1	0	0	1	40	15	14	25	21	30	147
Total	**3**	**2**	**0**	**1**	**50**	**22**	**14**	**25**	**22**	**30**	**169**

Table 30. Summary of post-treatment food web samples collected spring 2015 – October 2015. NC denotes no data collected.

Stream	Sample Type	Year	Season	# Benthic Samples	# Drift Samples	# Pan Trap Samples	# Stomach Samples
Tepee Ck	Treatment	2015	Spring	15	NC	NC	NC
		2015	Summer	3	NC	43	40
		2015	Fall	12	NC	43	NC
		2015	**Total**	**30**	**0**	**86**	**40**
White Ck	Control	2015	Spring	12	NC	NC	NC
		2015	Summer	3	4	36	56
		2015	Fall	12	NC	34	6
		2015	**Total**	**27**	**4**	**70**	**62**

Table 31. Summary of aquatic habitat inventory data collected May 1, 2010 – April 30, 2012. Parentheses denote side channel values. NC denotes no data collected.

Project	Survey Date	Stream	Total Survey Length (m)	Total Survey Area (m^2)	Avg. Bankfull Width (m)	Avg. Habitat Unit Width (m)	Avg. Habitat Unit Area (m^2)	Pool Frequency (pools/km)	Avg. Residual Pool Depth (m)
Lower Tributary Life History Study	5/14-5/21/2014 4/2/2015	Swale Ck	9,786.2 (1200.0)	59,146.1 (3234.8)	13.7 (8.6)	5.2 (2.7)	165.2 (55.8)	6.7 (8.3)	0.66 (0.73)
Summit Creek PIT Tag Study	9/15-17/2014	Summit Ck	2,133.1	9476.95	7.2	3.25	121.50	6.1	0.85
Mainstem Habitat Inventory	9/22-10/20/2014	Klickitat R.	28100 (6041)	-	-	-	-	1.0 (2.5)	3.3 (1.2)

Table 32. Summary of Large Woody Debris (LWD) and LWD Jam inventory data collected May 1, 2010 – April 30, 2012. Parentheses denote side channel values to differentiate from mainstem values. NC denotes no data collected.

Project	Survey Date	Stream	Total Survey Length (m)	Total Survey Area (m^2)	# LWD Pieces (pieces/km)	# LWD Jams (jams/km)
Lower Tributary Life History Study	5/14-5/21/2014 4/2/2015	Swale Ck	9,786.2 (1200.0)	59,146.1 (3234.8)	10.8 (8.3)	0.7 (1.7)
Summit Creek PIT Tag Study	9/15-17/2014	Summit Ck	2,133.1	9476.95	24.2	0.0
Mainstem Habitat Inventory	9/22-10/20/2014	Klickitat R.	28100 (6041)	-	4.2 (14.2)	0.18 (1.2)

Table 33. Site name and stream of Klickitat subbasin temperature and water quality monitoring locations.

Site Name	Stream
BEARMOUTHX	Bear
BOWMNMOUTH	Bowman
BUTTEMEDWS	Butte Meadows
CLEARWATER	Clearwater
DIALOWMEDW	Diamond Fork
DIAMOUTHRX	Diamond Fork
DIAUPPMEDW	Diamond Fork
DILLACORTX	Dillacort
EFTEPEE175RDX	East Fork Tepee
FISHLAKRDX	Fish Lake
KLCASTLEBR	Klickitat
KLCKYKFPHQ	Klickitat
KLCOWCAMPX	Klickitat
KLHATCHTRP	Klickitat
KLnewLYLETRP	Klickitat
LKLIKLODGE	Little Klickitat
LKLIKMOUTH	Little Klickitat
LKLIKOLSEN	Little Klickitat
LOGGCAMPCR	Logging Camp
MCCREEDRDX	McCreedy
OUTLETRDXG	Outlet
PISCOMOUTH	Piscoe
SNYDERMILL	Snyder
SNYDRMOUTH	Snyder
SUMITMOUTH	Summit
SURVEYORSX	Surveyors
SWALEHARMS	Swale
SWALEMOUTH	Swale
TEPEEIXLRDX	Tepee
TRAPPERRDX	Trappers
TROUTRVRTRDX	Trout
WESTFORKRX	West Fork
WHITEIXLRDX	White
WHITEMOUTH	White
WHITEUPPER	White

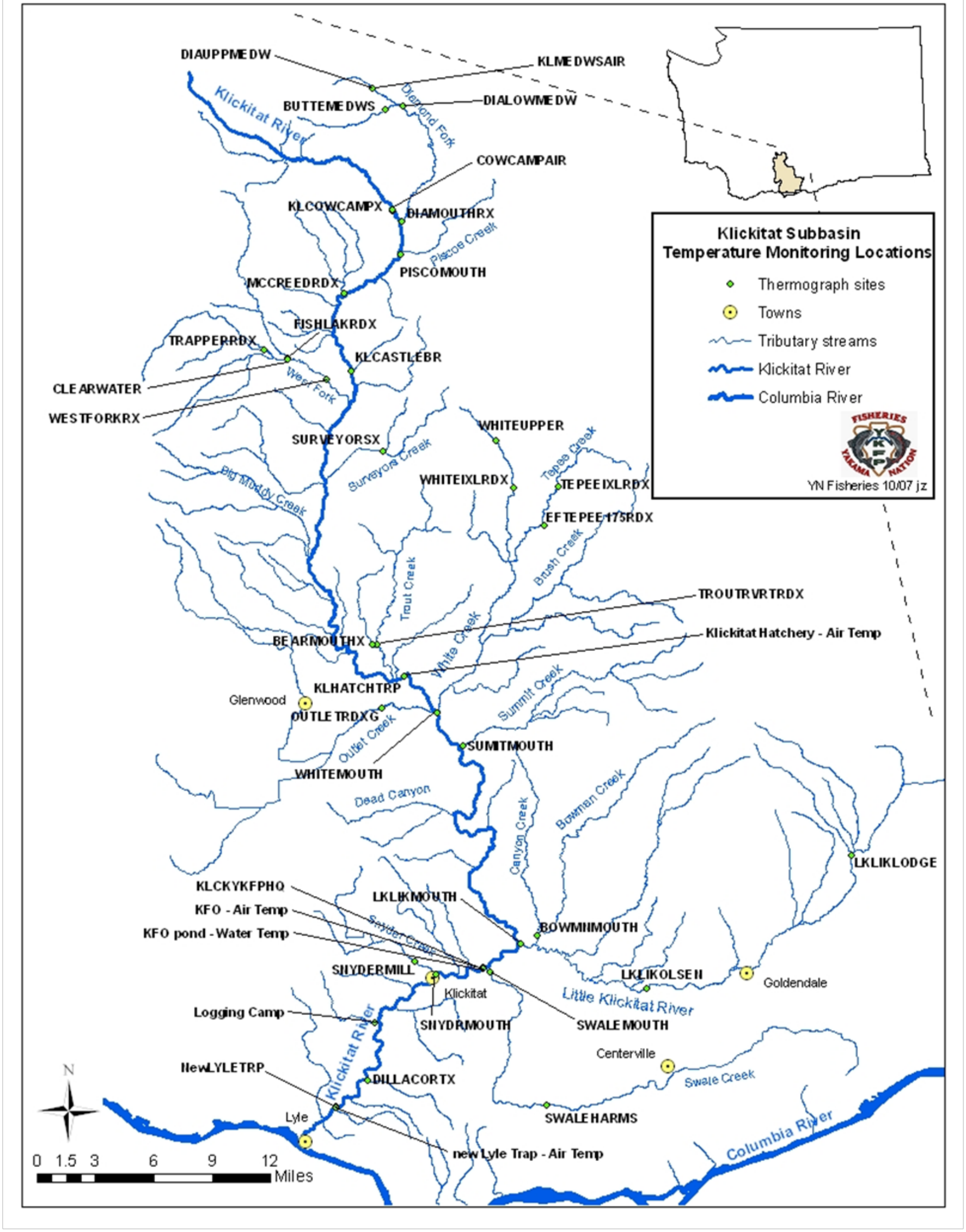

Figure 32. Locations of Klickitat subbasin temperature and water quality monitoring sites.

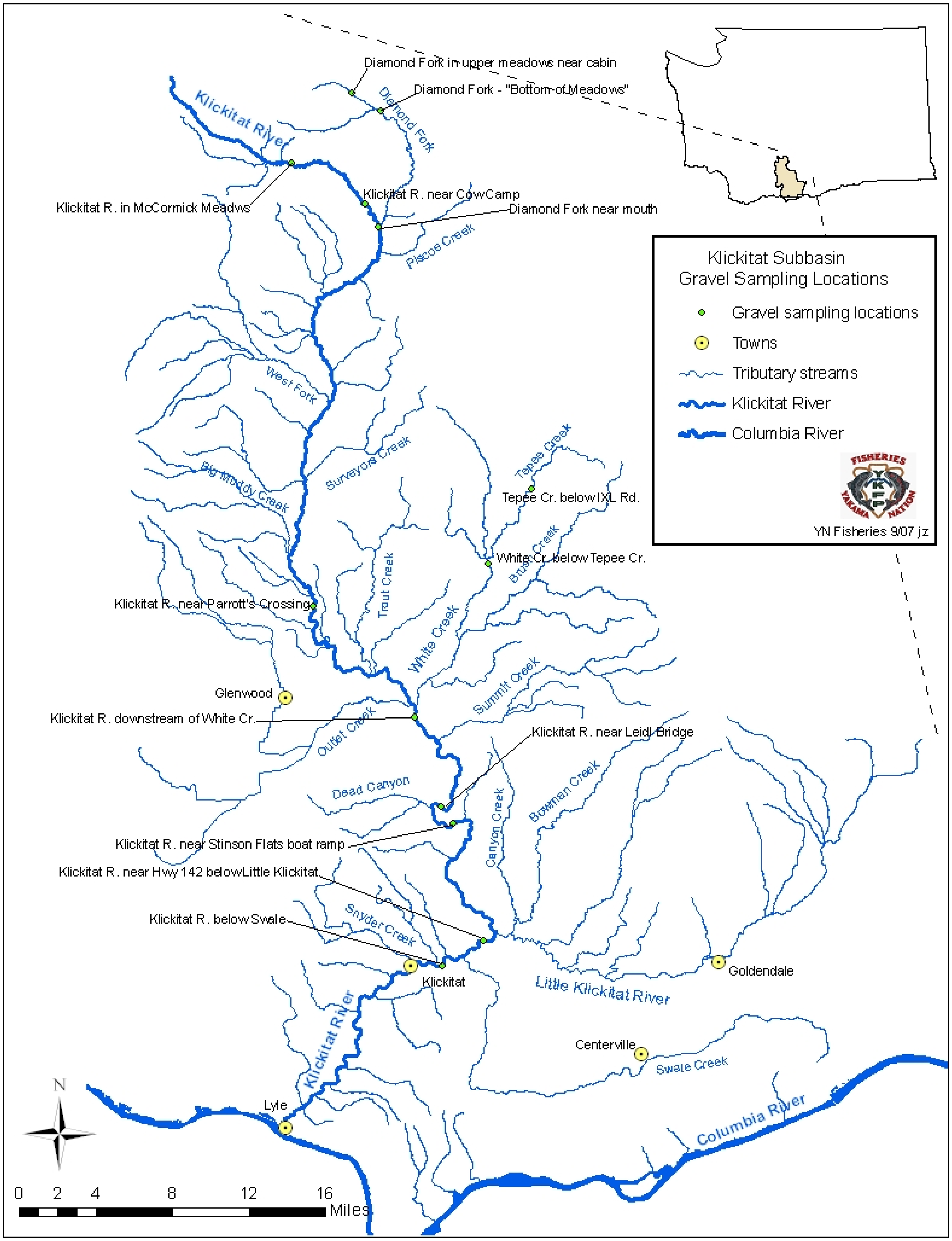

Figure 33. Locations of Klickitat subbasin sediment sampling sites.