Klickitat Subbasin Monitoring and Evaluation

- Yakima/Klickitat Fisheries Project (YKFP)

BPA Project # 1995-063-35

Report covers work performed under BPA contract #(s) 42481, 53312

Report was completed under BPA contract #(s) 42481, 53312

5/1/2010 - 12/31/2012

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06/2013

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), 5/1/2010 - 12/31/2012 Annual Report, 1995-063-35, 92 pp.

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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 2007-2012. 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 2005-2012 indicate an average of about 1600 wild steelhead and 2900 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, 4-year-olds comprised the highest percentage of returning adults with 3-year-olds making up slightly less of the population. Also, freshwater (juvenile rearing) ages for steelhead were primarily age 1 for hatchery-origin fish and mostly 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 4%.

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 fall and the spring. A small number of fish was 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.

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. Habitat surveys in the upper Klickitat River above Castile Falls focused on reaches with planned habitat enhancement work by the BPA-funded Klickitat Watershed Enhancement Project; two reaches had pre-project surveys completed and one has both pre- and post-project surveys completed. In the reach with both pre- and post-project data, habitat complexity increased (with a 2-fold increase in number of habitat units delineated), pool frequency more than tripled, residual pool depths increased slightly, non-jam large woody debris density remained similar, and large woody debris jams and jam pieces increased 2.5 fold and 3.0 fold, respectively, from pre- to post-project.

Habitat surveys, and associated fish assessment surveys, were also conducted in four tributaries of the lower Klickitat River (Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Snyder Creek). Fish abundance was substantially lower in streams with east aspect drainages than streams with west aspect drainages; this is likely the result of seasonally-limited flow duration and widespread channel drying. Ongoing fish monitoring (via PIT tag detection arrays) will provide important information on the proportion of steelhead/rainbow trout displaying anadromy, the timing of in- and out-migration, proportion of hatchery vs. wild adult returns, and the usage of rearing habitat by juveniles.

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, Bennie Martinez, 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. 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, and radio telemetry

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/).

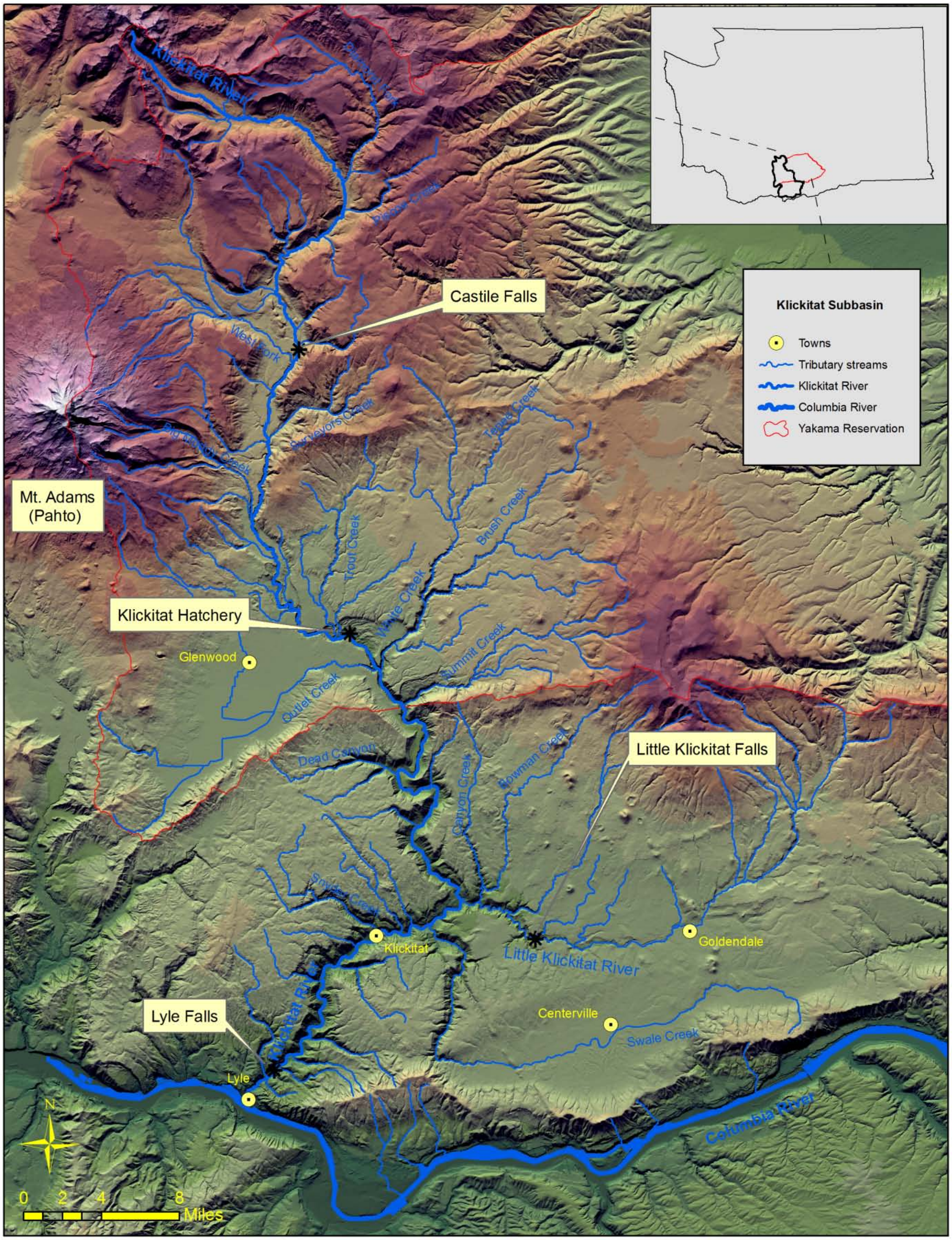


Figure 1. Map of the Klickitat subbasin with major landmarks.

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 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 this reporting period, significant construction improvements to the fishway and adult trap were being conducted; these improvements are expected to be fully functional in 2013.

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 have not been achieved to establish mark-recapture estimates for those stocks.

Methods

Adult salmonids were trapped, enumerated, and then released in the Lyle Falls fish ladder. 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. 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 to date 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 may lead 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 7 (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 2007-2012 indicate an average of approximately 3300 hatchery spring Chinook (ranging from about 1000 to 5800) and approximately 530 wild spring Chinook (ranging from 400 to 675). Jacks averaged about 19% 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 8 (Appendix B). For 2005 through 2012 (estimates were generated for all but 2 years during that period), wild steelhead returns to Lyle Falls averaged approximately 1600 fish (ranging from 1100 to 2400) and hatchery steelhead returns averaged 2900 fish (ranging from 1830 to 5170). Estimates for 2012 (which as of this report writing only include summer-run fish and no winter fish) are approximately 990 wild steelhead (with a 95% CI of 535 to 2144) and approximately 2600 hatchery steelhead (with a 95% CI of 1402 to 5774).

During this reporting period, construction was occurring on the Lyle Falls fishway to improve fish passage (by improving fishway entrance hydraulics and constructing a new fish exit channel) and to construct a new fish trapping and handling facility. This construction resulted in periodic shutdowns of trap operation, the most significant of which occurred from September 8, 2010 through March 1, 2011. This undoubtedly resulted in a low trap count for that year, especially for fall Chinook, coho, and winter steelhead. Other trap shutdowns were shorter in duration, typically lasting 1 or 2 weeks in 2011, with only a few short shutdowns during 2012. While the shutdowns affected the raw trap counts, because a known number of marked fish could still be released around the shutdown periods, mark-recapture estimates could still be generated. The count of winter steelhead for the 2010-11 winter was expanded based on the previous year's winter proportion of the total to estimate a more accurate winter steelhead count (Table 8).

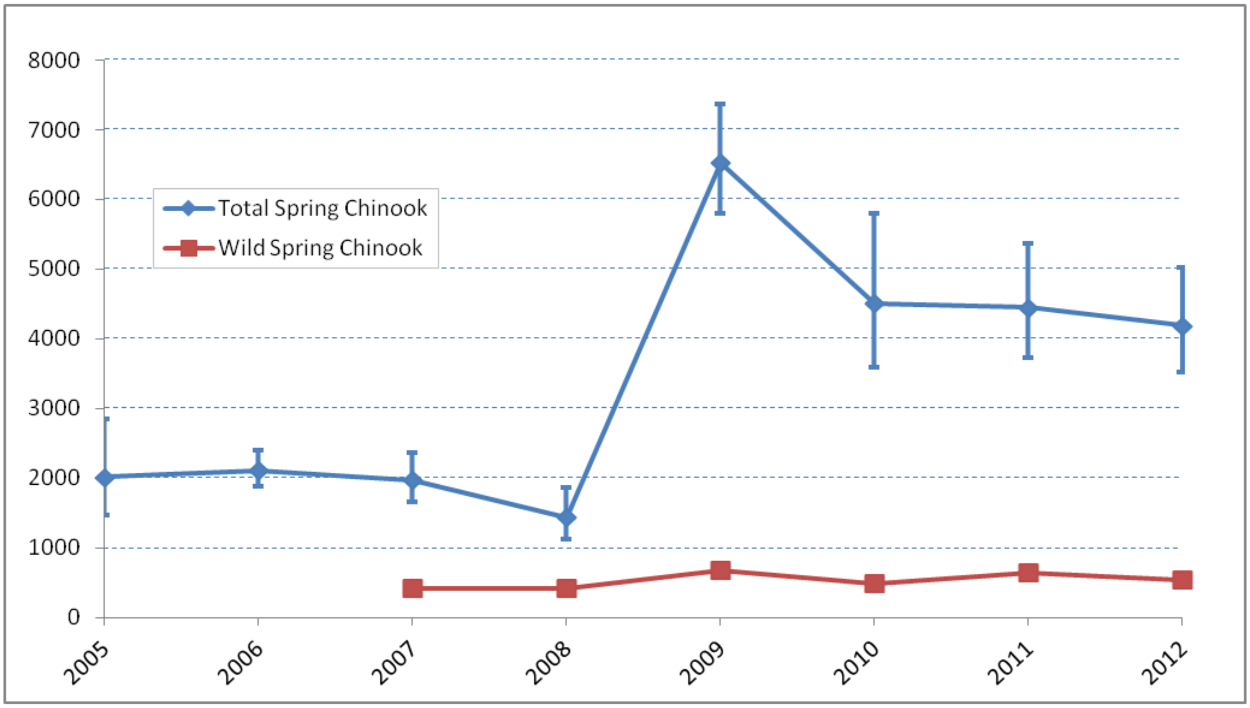


Figure 2. Mark-recapture estimates of spring Chinook run size at Lyle Falls on the lower Klickitat River.

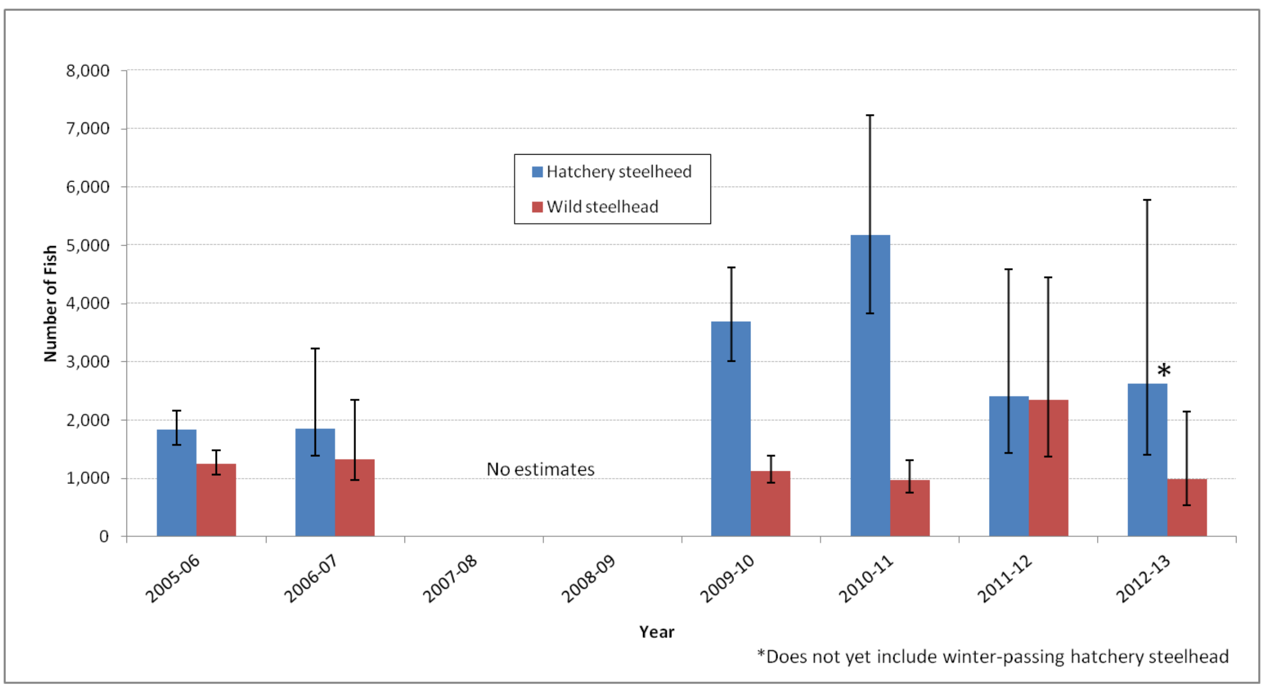


Figure 3. Mark-recapture estimates of summer steelhead run size at Lyle Falls on the lower Klickitat River.

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 around 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 2005-2012 estimates yield an average of about 1600 total wild steelhead return to Lyle Falls (Table 8 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 fact that 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) and the fact that winter steelhead abundance estimates are likely biased low at Lyle Falls (see Methods description above).

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 4 through Figure 7 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 2003 through 2012 is shown in Figure 4. 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 2010 were conducted from August 17 through October 7 and covered a total of 64.0 river miles; surveys in 2011 were conducted from August 11 through October 5 and covered 66.6 river miles; surveys in 2012 were conducted from August 13 through October 9 and covered 68.1 river miles. Survey conditions during all three of these years provided consistently good water clarity and visibility. Table 10 in Appendix B shows results of spring Chinook redd counts for 1989-2012 by river reach. Surveys for the most recent 3 years show an increase over counts from the 2004-2009 period, during which some of the lowest redd counts on record were recorded. This could be due to larger numbers of hatchery-origin fish on the natural spawning grounds (see description below). The average redd count for 1996-2012 (the time period with the most consistency in geographic coverage of redd surveys) is 114 (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).

Results of spawner surveys above Castile Falls showed relatively low numbers of redds in the upper Klickitat River, with 1, 0, and 5 redds being observed in 2010, 2011, and 2012, 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 16 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 10, 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 -1.4% with a 95% confidence interval (CI) of -5.5 to +2.7% and one-sided p-value for the slope of 0.23 (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 2007-2012 (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 43% (Table 11 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.

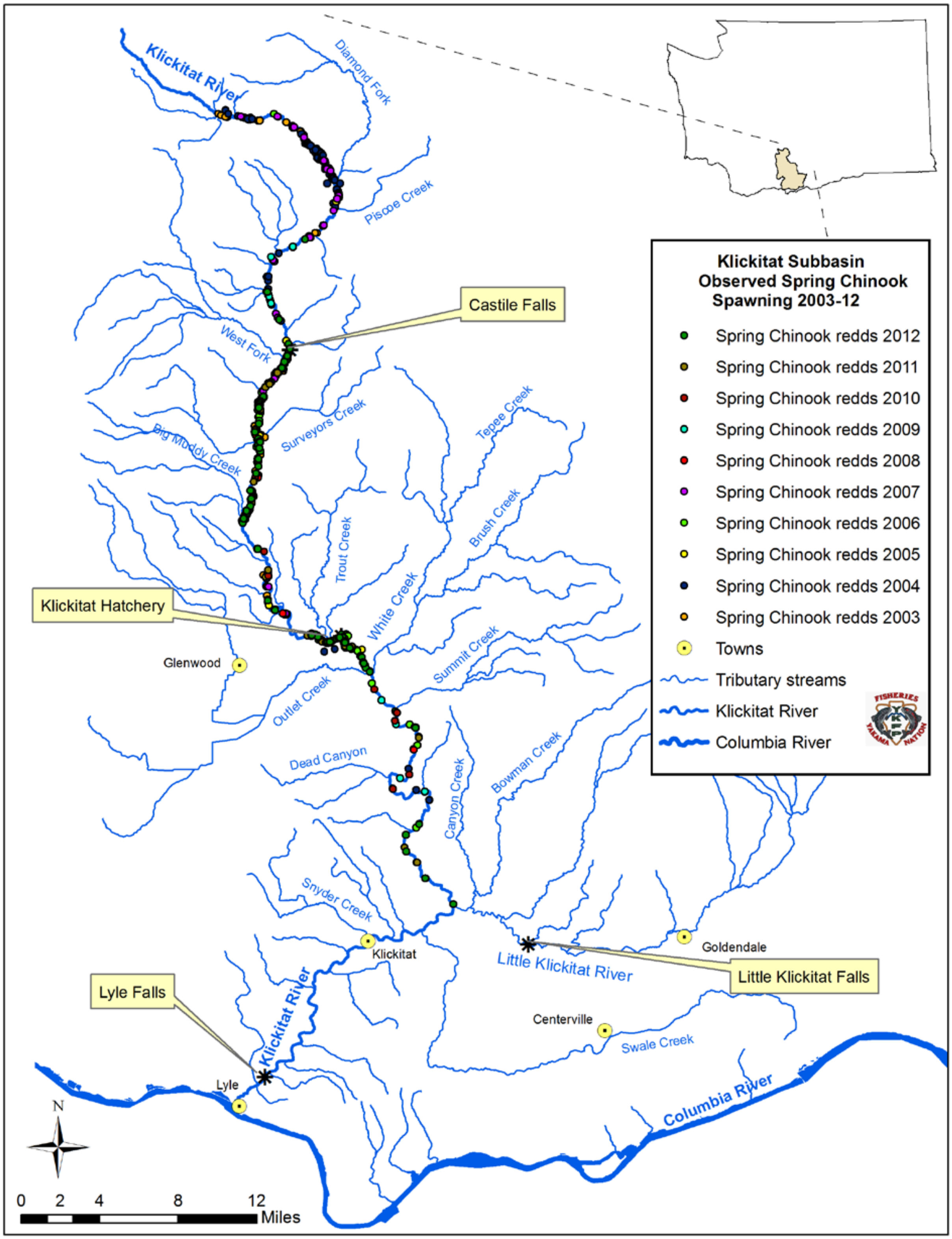


Figure 4. Observed spring Chinook spawning distribution in the Klickitat subbasin for 2003-2012. Note - Large numbers of redds above Castile Falls in 2000 and 2002-2004 resulted from releases of surplus hatchery adults in that area.

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 2003 through 2012 is shown in Figure 5.

Table 12 in Appendix B shows results of fall Chinook redd counts in the Klickitat subbasin for 1995-2012 by river reach. Surveys for 2010 were conducted from October 27 through December 9 and covered a total of 49.7 river miles; surveys in 2011 were conducted from October 31 through December 20 and also covered 49.7 river miles; surveys in 2012 were conducted from October 22 through December 21 and covered 48.7 river miles. Surveys in 2012 were limited by high flows and turbidity in late October to early November, again in mid-November, and again in mid-December; this may have biased 2012 redd counts somewhat low. As in most years, the highest redd densities occurred in the river reach from Klickitat Hatchery (RM 42) downstream to Stinson Flats (RM 29).

For 2010, of the carcasses for which adipose fin presence/absence could be determined, 31 out of 152 (20.4%) were ad-clipped (the rest were either wild or unmarked hatchery fish), and 0 fish were floy-tagged. In 2011, 30.8% (52/169) were ad-clipped and 1.2% (2/169) were floy-tagged. In 2012, 19.1% (17/89) were ad-clipped, and 1.1% (1/89) were floy-tagged. The percentages of ad-clipped carcasses observed correspond roughly with percentages of released hatchery juveniles that were ad-clipped in release years 2006-2009; on average approximately 24% of juveniles were ad-marked in those years (Fish Passage Center data).

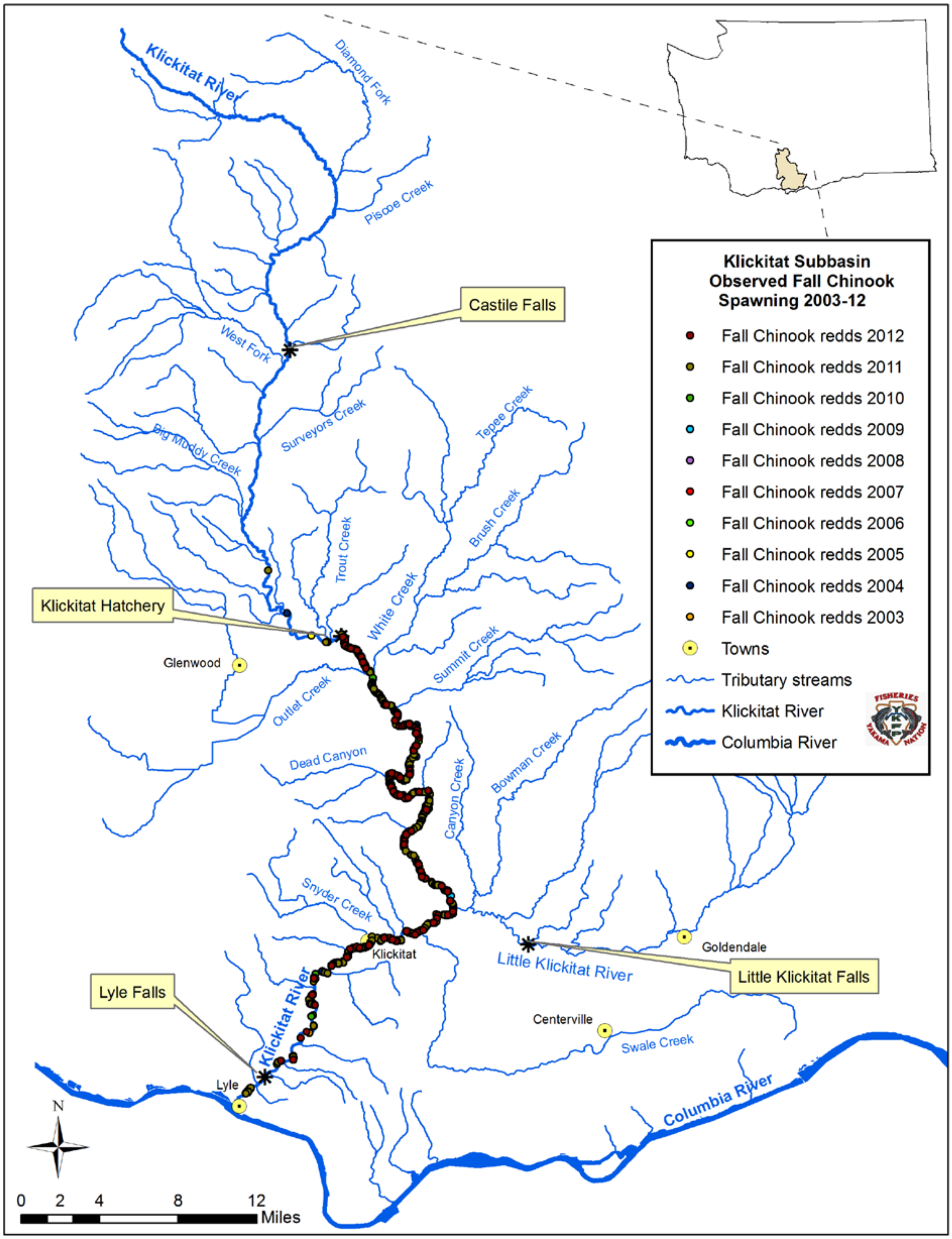


Figure 5. Observed fall Chinook spawning distribution in the Klickitat subbasin for 2003-2012.

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 2011 is shown in Figure 6; surveys in fall/winter 2012 extended past the reporting period for this report and will be shown in future reports. Surveys for 2010-11 were conducted from October 27 through February 28 and covered a total of 66.6 river miles (including mainstem Klickitat and tributaries). A total of 186 redds were counted; 111 were in the mainstem Klickitat and 75 were in tributaries. Surveys in 2011-12 were conducted from November 29 through March 8 and covered 54.1 river miles. A total of 204 redds were counted; 183 were in the mainstem and 21 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, and Canyon Creek (below Lyle Falls). Surveys during both years were limited by high flow and turbidity periods in late December through January, with some snow/ice limitations in January.

For 2010-11, of the carcasses for which adipose fin presence/absence could be determined, 47% (7 out of 15) were ad-clipped (the rest were either wild or unmarked hatchery fish). For 2011-12, the ad-clipped percentage was 93% (14/15). No floy-tagged carcasses were observed in either year.

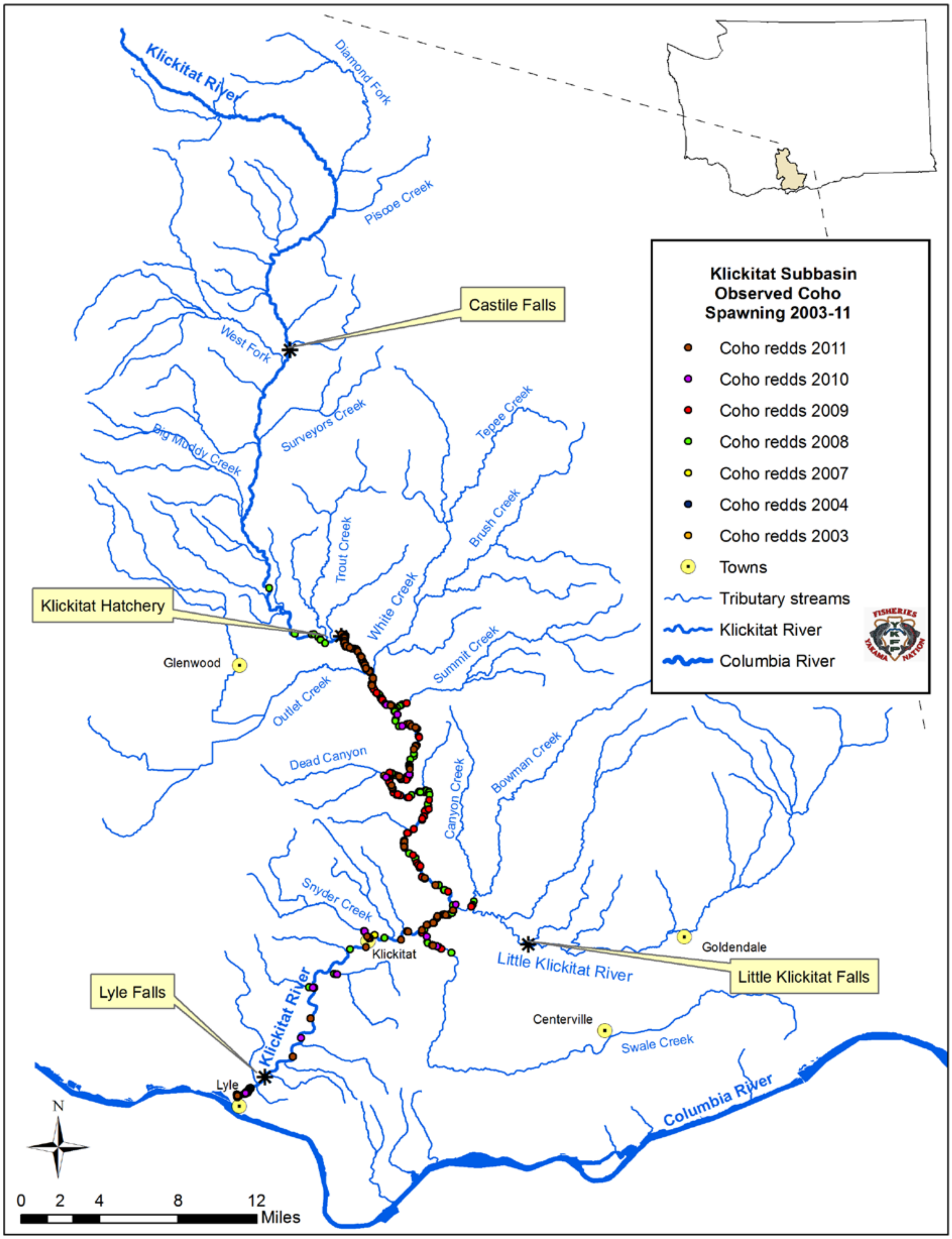


Figure 6. Observed coho spawning distribution in the Klickitat subbasin for 2003-2011.

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 2004 through 2012 is shown in Figure 7. 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 34% of the observed steelhead redds from 2002-2012.

Surveys for 2010 were conducted from February 2 through June 11 and covered a total of 135.6 river miles (including mainstem Klickitat and tributaries). A total of 181 redds were counted; 114 were in the mainstem Klickitat and 67 were in tributaries. High flows in 2010 delayed surveys until late in the season in White Creek (especially in lower reaches) and prevented full surveys in the upper Klickitat River above Castile Falls. High June flows and turbidity also prevented a late season mainstem Klickitat survey pass. Surveys in 2011 were conducted from February 8 through June 28 and covered 141.7 river miles. A total of 112 redds were counted; 62 were in the mainstem and 50 in tributaries. In 2011, high flows in March limited surveys in many areas. High flows and limited access (due to snow) precluded surveys in many mid- and upper basin locations including much of White Creek and the upper Klickitat until early May. High flows again in mid-May prevented surveys on the mainstem and in mid- and upper basin areas (especially the upper Klickitat and lower White Creek) until June. Surveys in 2012 were conducted from February 17 through June 13 and covered 129.8 river miles. A total of 73 redds were counted; 17 were in the mainstem and 56 in tributaries. In 2012, high flows in late March through early April, then again in late April through mid May limited survey coverage. High flows through the end of May prevented a full survey pass in the upper mainstem Klickitat. Survey conditions likely biased the 2010 redd counts slightly low, the 2011 redd counts somewhat low, and the 2012 redd counts significantly lower.

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 five carcasses were recovered which adipose fin presence/absence could be determined (3 wild fish and 2 ad-clipped hatchery fish).

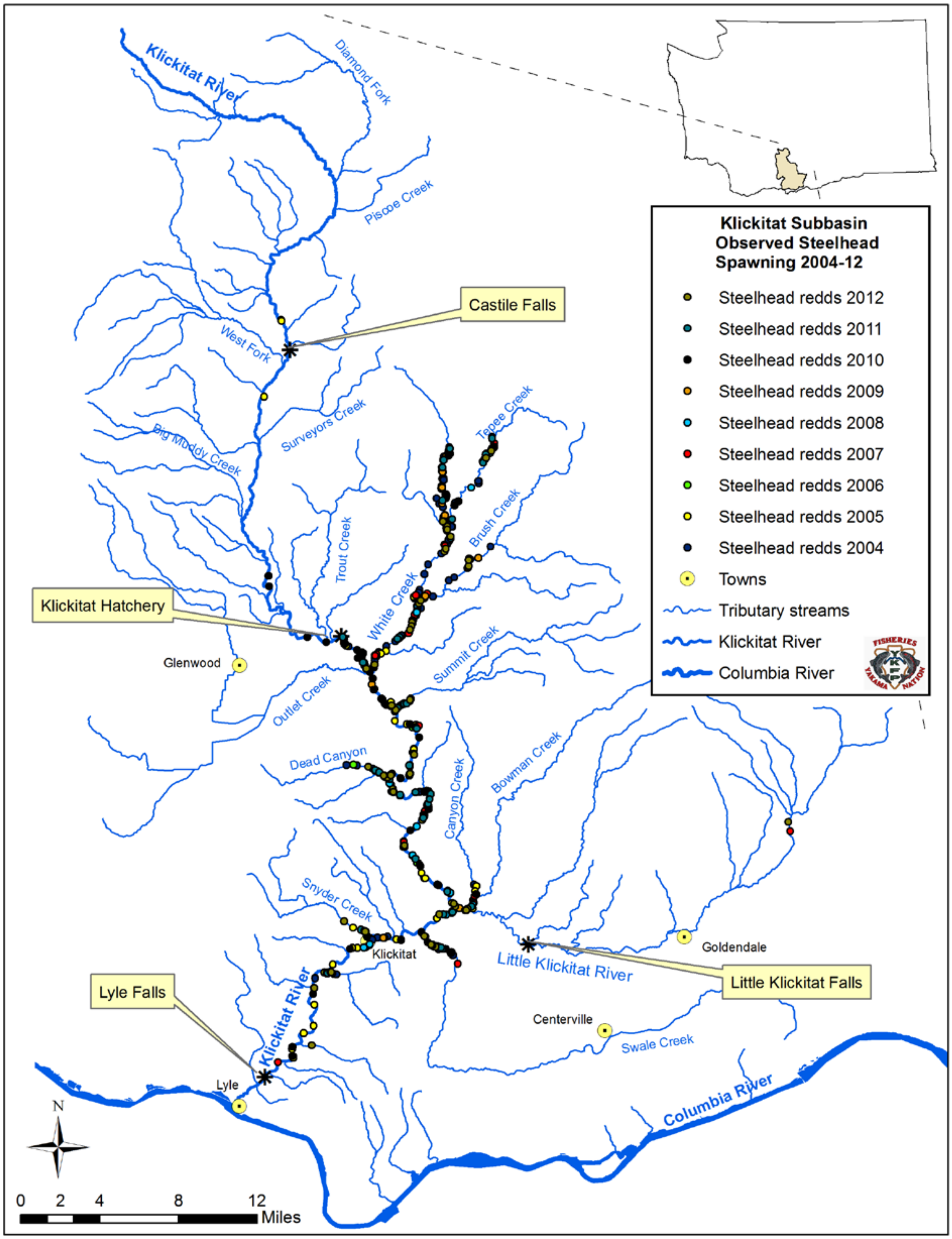


Figure 7. Observed steelhead spawning distribution in the Klickitat subbasin for 2004-2012. Note – the upper Klickitat River (upstream of Big Muddy Creek) and Little Klickitat River between the falls and Goldendale are often not surveyed.

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 many years. Carcass recoveries suggest that, while some small amount of natural production does exist, 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 9 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 under 1900 fish, with about 1350 hatchery-origin fish and about 530 wild fish. Estimates of escapement average about 790 hatchery fish and 336 wild fish. Figure 15 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 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. 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 13 and Table 14 in Appendix B. Catch summary results for the Castile Falls screw trap are shown in Table 15 and Table 16 in Appendix B. The Lyle Falls trap was operated year-round during this reporting period. The Castile Falls was only operated from July into November for both reporting years due to high early summer flows in the upper Klickitat River.

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 on the Klickitat will not have high precision.

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 and is anticipated to occur through 2014 and possibly into 2015, depending on project success and results.

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 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 nine 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 Table 17 (Appendix B) for fixed-site descriptions.

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. In the spring of 2012, on two occasions, 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. Examples of two individual fish detection histories are shown in the results sections.

Results

As this study is ongoing, results presented here are partial and preliminary and will be added to in future reports. A total of 234 Steelhead and 110 spring Chinook were radio-tagged during the reporting period of May 1, 2010 and April 30, 2012. Of the 234 Steelhead tagged, 90 were adipose fin-clipped (hatchery origin) and 144 were adipose fin-present (wild origin). Of the 110 spring Chinook tagged, 68 were adipose fin-clipped (hatchery origin) and 42 were adipose fin-present (wild origin). See Table 18 (Appendix B) for a detailed description of tagged-fish by species, origin, and stock.

Preliminary data suggest a substantial straying or “dip in” rate among fish entering the Klickitat River. Twenty-six percent (N=144; 37/144=0.26 x 100=26%) of all wild Steelhead and 47 percent (N=90; 42/90=0.47 x 100=47%) of all hatchery Steelhead radio tagged during the reporting period descended Lyle Falls after being tagged and did not re-ascend Lyle Falls and continue spawning migration behavior in the Klickitat River drainage. Likewise, 40 percent (N=42; 17/42=0.4 x 100=40%) of all wild spring Chinook and 21 percent (N=68; 14/68=0.21 x 100=21%) of all hatchery spring Chinook radio tagged during the reporting period descended Lyle falls shortly after being tagged and did not re-ascend and/or continue spawning behavior in 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 between May 1, 2010 and April 30, 2012 showed radio-tagged Steelhead ascending and spawning in eight different tributary streams including Bowman Creek, Dead Creek, Dillacort Creek, Little Klickitat River, Snyder Creek, Swale Creek, Wheeler Creek, and White Creek. One radio-tagged Chinook ascended Summit Creek where it presumably spawned and died; its radio tag was recovered at approximately river mile 0.5 of Summit Creek.

Preliminary results to date suggest some temporal separation in spawn timing between hatchery and wild steelhead. The majority (approximately 90%) of hatchery steelhead that were determined to have spawned in the wild did so between mid-November and late February; the majority (approximately 90%) of wild steelhead spawned between early-mid March and mid-May. Overall results to date also show that 10% of the tagged hatchery steelhead appeared to have spawned in the wild, versus 38% for wild steelhead.

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.

Particularly interesting are the migrations of fish #56022, a wild, female summer Steelhead, and of fish #44141, a wild, female winter Steelhead. 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 Table 19 (Appendix B) for a table of fixed-site detections of #56022; see Figure 8 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 Table 20 (Appendix B) for a table of detections of #44141; see Figure 9 for a spawning migration graph of #44141.

These two fish were both assigned fates of having spawned in the wild and then kelted; their behavior represents fairly typical movements of fish that were determined to have these fates.

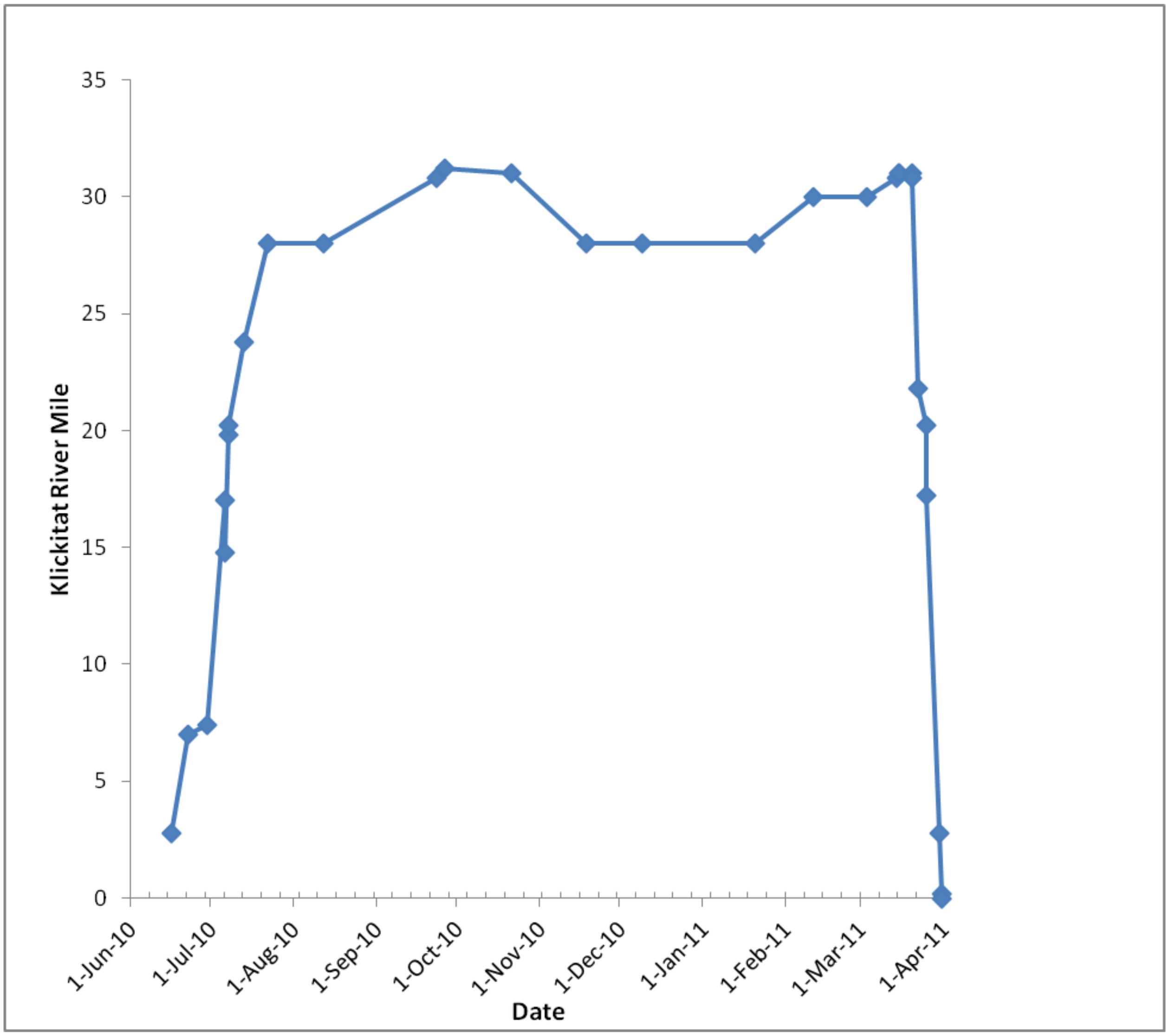


Figure 8. Detected locations by date for wild summer steelhead with radio tag #56022

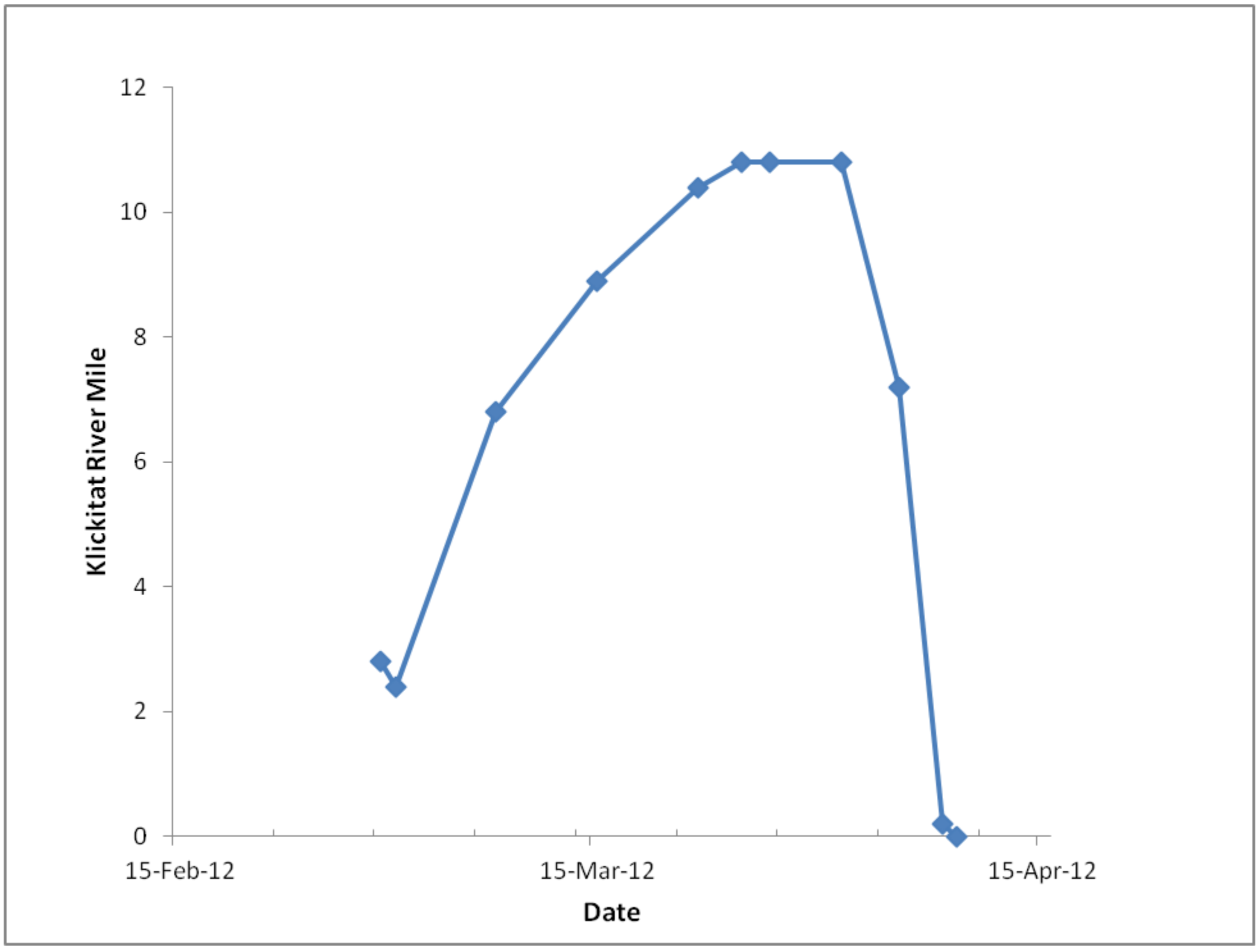


Figure 9. Detected locations by date for wild winter steelhead with radio tag #44141.

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.

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).

Analysis of samples from returning adult steelhead has yielded estimates of relative production of different areas within the subbasin, 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). Additionally, preliminary 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.

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 29 adult spring Chinook, 387 fall Chinook, and 39 coho salmon carcasses during 2010-2012 spawner surveys. A total of 288 adult spring Chinook, 54 fall Chinook, and 1 coho salmon were sampled and yielded readable scales in the Lyle adult trap in 2010-2012. A total of 477 steelhead were sampled for scales at the adult trap in during this reporting period (steelhead carcasses are rarely encountered on spawner surveys; a total of 3 samples were obtained from steelhead). Adult trap shutdowns for construction improvements (described in the Adult salmonid monitoring section) resulted in no sampling of fall Chinook or coho during fall-winter 2010-11 runs. Additionally, fall Chinook and coho adult trap samples from 2012 are still being processed.

A brief description of the results by species is below. Table 21 through Table 29 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 and coho stocks, origin (hatchery or wild) of these fish sampled could not always be reliably determined. Klickitat Hatchery spring Chinook salmon are 100% adipose-clip marked, as are Skamania Hatchery steelhead released in the Klickitat River.

Overall during the 2010-12 return years the majority (71.6%) of spring Chinook adults were 4-year-olds. Age and length data for spring Chinook carcasses recovered on spawning ground surveys are in Table 21; data for fish captured in the Lyle Falls adult trap are in Table 22; data for fish returning to the Klickitat Hatchery adult holding pond are in Table 23.

For fall Chinook during 2010-2012, 4-year-old fish made up the largest portion of the returns at 48.8%; 5-year-olds made up 29.3% and 3-year-old jacks made up 21.5% of the returns. Age and length data for fall Chinook carcasses recovered on spawning ground surveys are in Table 24; data for fish captured in the Lyle Falls adult trap are in Table 25.

For coho in 2010-2012 the vast majority of returning fish (97.5%) were 3-year-olds. Age and length data for carcasses recovered on spawning ground surveys are in Table 26; data for fish captured in the Lyle Falls adult trap in Table 27.

For steelhead in 2010-2012, 3-year-olds represented 44.6% of the returns, 50.8% were 4-year-olds, and 1.9% were 5-year-olds. In addition, freshwater (juvenile rearing) ages estimated from adult scales were as follows: for ad-clipped fish, 69.0% were age 1 and 30.6% were age 2; for unmarked (natural-origin) fish, 41.0% were age 1 and 58.6% were age 2. Total age and length data for carcasses recovered on spawning ground surveys are in Table 28; data for fish captured in the Lyle Falls adult trap are in Table 29.

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, 4-year-olds comprised the highest percentage of returning adults during this reporting period, with 3-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 mostly 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	4917	0.35%
2006	2007	2008	24	19	4644	0.52%
2007	2008	2009	*35*	*34*	6848	*0.51%*
2008	2009	2010			34643	
2009	2010	2011			23851	
2010	2011	2012			21436	
					Average	*0.46%*

[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 only one brood year (2009) having 4-year-old returns and projected 5-year-old returns. The preliminary SAR estimate is approximately 4%. Additional returns in subsequent years will yield more complete SAR estimates for Skamania Hatchery steelhead released in the Klickitat River.

Future analysis will include additional methods of SAR and other survival rate estimation such as those described in Buchanan and Skalski (2007).

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 3-6)	Number of Tagged Fish Released[2]	SAR[3]
2009	2010	*407*	9937	*4.10%*
2010	2011		9737	
2011	2012		9961	
			Average	*4.10%*

[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 2012) 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 4%.

White Creek PIT tag study

Introduction

The over arching objective of the White Creek PIT Tag Study is to evaluate the temporal and spatial movement patterns of juvenile steelhead and resident *Oncorhynchus mykiss* in the White Creek drainage. 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 White Creek watershed (including Tepee and Brush creeks) accounted for 30-40% of the observed steelhead redds in the Klickitat sub-basin. Increasing knowledge of life history strategies exhibited by *O. mykiss* in the White Creek drainage will provide baseline information to guide future monitoring and management objectives. The three primary objectives of this study are to: 1) determine the proportion of *O. mykiss* that leave the White Creek watershed as downstream out-migrants, 2) determine run timing of downstream out-migrants, 3) and determine how these life history types are displayed spatially throughout the watershed.

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, interrogated PIT tagged fish. Antennas are comprised of wire cable encased in watertight PVC tubing. The PIT tag interrogation system consisted of three arrays. Each array consisted of paired antenna that covered the wetted width to maximize detection capability. Paired antennae arrays were longitudinally spaced approximately 50 feet apart. The transceiver logged a record (indicating date, time, antenna, and PIT tag code) for each fish detection.

Twenty-one monitoring/tagging sites were established at the start of the study in 2009. In 2011, four other tagging sites (in Brush Creek, Blue Creek, and White Creek) were added to address spatial gaps in sampling (Figure 10 Site Map; Table 30 in Appendix B). Single-pass electro-fishing 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.

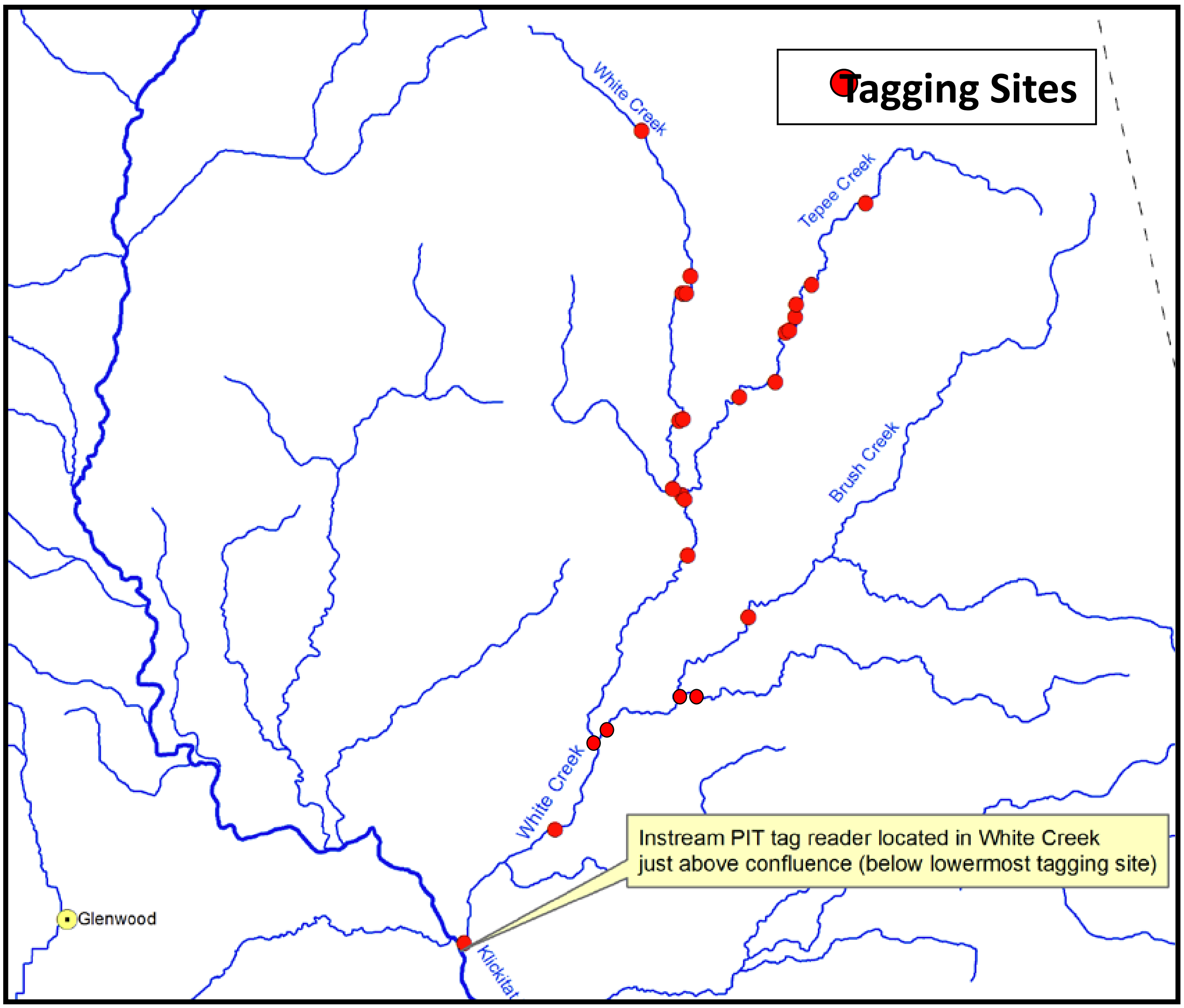


Figure 10. Map of tagging sites in the White Creek drainage.

Results

During the 2010 field season, 1,299 *O. mykiss* were PIT tagged (Table 31 in Appendix B). The number of fish tagged at the sampling sites ranged from 6-175 individuals. Overall, the mean fish length and weight were 108.9 (SE ±0.9) millimeters and 19.3 (SE ±0.6) grams, respectively. Fish in the 76-110 millimeter size range dominated the 2010 tag group accounting for 649 (50%) of the 1,299 tagged individuals (Figure 11). Fish in the 111-160 millimeter size range comprised the second largest group accounting for 476 (37%) tagged individuals. Fish ≥165 millimeters accounted for 57 (4%) tagged individuals and fish measuring ≤75 millimeters accounted for 9% of the tagged individuals.

During the 2011 sampling season, 2,404 *O. mykiss* were PIT tagged (Table 32 in Appendix B). The number of fish tagged at the sampling sites ranged from 9-338 individuals. Overall, the mean fish length and weight were 103.4 (SE ±0.6) millimeters and 16.4 (SE ±0.4) grams, respectively. Fish in the 76-120 millimeter size range dominated the 2011 tag group accounting for 71% of the tagged individuals (Figure 11). Fish measured in the 121-185 millimeter size range comprised the second largest group accounting for 24% of tagged individuals. Fish ≥186 millimeters and ≤75 millimeters accounted for 1% and 4% of tagged individuals, respectively.

During the 2010-2012 migration years (October 1, 2010 through September 20, 2012), 586 tagged fish were detected at the White Creek PIT tag array (Table 33 in Appendix B). Of the 586 detected fish, 53, 202, and 331 fish were tagged in the 2009, 2010 and 2011 field seasons, respectively. The mean length and weight (measured at the time of tagging) of detected fish was 92.9 (SE ±0.8) millimeters and 10.8 (SE ±0.3) grams, respectively. In general, lengths of detected fish tracked the length frequency of tagged fish with the exception of fish >150 millimeters (Figure 11). Only 2% of the detected fish had a tag length >150 millimeters (compared to 6% for the overall tagged population) suggesting larger fish likely display a resident life history form.

Fish detected at the White Creek PIT tag array originated from all the tagging sites during the 2010-2012 migration years (Table 33 in Appendix B). White Creek accounted for the majority (70%) of the fish detected at the White Creek PIT tag array (Table 33). Tepee Creek and Brush Creek accounted for 20% and 7% of the detected fish, respectively. Blue Creek, East Fork Tepee Creek, and West Fork White Creek collectively accounted for the remaining 3%. PIT tagged fish exhibited substantial variation in distance traveled ranging from 0.2-29.1 kilometers within the White Creek drainage (Table 30 in Appendix B). Approximately 48% of the detected fish originated from the three downstream-most tagging sites (90, 99, and 60) located in the lower 5 kilometers of the White Creek (Figure 10 Site Map; Table 33 in Appendix B). White Creek below the confluence of Brush Creek maintains a perennial flow as opposed to intermittent and seasonal flow patterns above the confluence. Preliminary results suggest that the section of White Creek below the Brush Creek confluence may function as both a refugia and staging area for downstream migrants during the low flow period. The middle portion of mainstem White Creek (consisting of tagging sites 92, 94, and 95) accounted for approximately one-fifth (18%) of the detected fish. The remaining one-third originated from the other 19 tagging sites.

After normalizing the abundance and out-migrant detection data (by fish/100m^2) for fish captured by single-pass electrofishing at each tagging site in the summer of 2010 and 2011, *O. mykiss* abundance in the White Creek drainage was estimated at 4.3 fish/100m^2 and 7.0 fish/100m^2 in 2010 and 2011, respectively (Table 34 and Table 35 in Appendix B). The density of out-migrants increased from 0.81 fish/100m^2 in 2010-2011 to 1.16 fish/100m^2 in the 2011-2012 migration year. Fish abundance ranged from a high of 6.5 fish/100m^2 in Tepee Creek to a low of 1.6 fish/100m^2 in Brush Creek in 2010 (Table 34). Fish detections ranged from a high of 1.06 fish/100m^2 in White Creek to a low of 0.15 fish/100m^2 in East Fork Tepee Creek. In 2011, abundance ranged from a high of 13.9 fish/100m^2 in Blue Creek to a low of 2.2 fish/100m^2 in West Fork White Creek (Table 35). Fish detections ranged from a high of 1.66 fish/100m^2 in White Creek to a low of 0.28 fish/100m^2 in West Fork White Creek. The tagging site located in the Tepee Creek IXL Meadow Restoration Project reach had the highest observed abundance in both 2010 and 2011 (Table 34 and Table 35). The downstream most site, located 200 feet upstream of the PIT tag array, had the highest density of out-migrants in both migration years (Table 34 and Table 35). Overall, approximately 19% and 17% of the tagged *O. mykiss* exited the White Creek drainage during the 2010-2011 and 2011-2012 migration years, respectively.

Downstream migrants exited the White Creek watershed over an 11-month period during each migratory period (Figure 12). Preliminary results indicate that downstream migrants exhibit a consistent bi-modal out-migration pattern (Figure 12). The initial pulse of out-migrating fish occurred in the winter during with the ascending limb of the hydrograph. The majority of fish out-migrated in the spring during the descending limb of the hydrograph. Fish started to out-migratein the winter when stage height and water temperature reached ~2 feet and ~2° Celsius, respectively. Out-migration in the spring began when stage height and water temperature reach ~3 feet and ~6° Celsius, respectively.

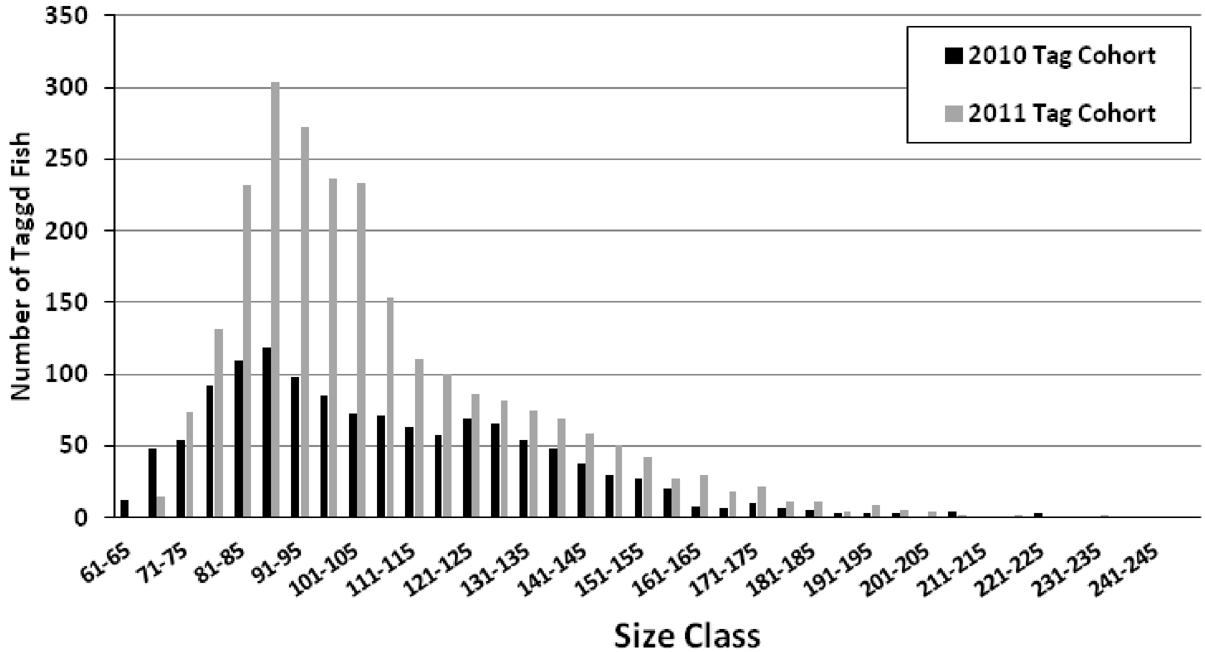
Thirty-four fish tagged in the White Creek watershed were detected in the Columbia River during the 2010-2012 migration years (Table 33). White Creek fish detected in the Columbia River originated from 15 of 25 tagging sites. Eight of the 15 tagging sites are located in White Creek, six in Tepee Creek, and one in Brush Creek.

Downstream migrants passing Bonneville Dam exhibited a consistent annual out-migration timing pattern (Figure 13). All PIT tagged out-migrating fish passed Bonneville Dam in April (15%), May (65%), June (17%), or July (3%) from October 1, 2010 – September 30, 2012. Each year, the timing of out-migration occurred in spring 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 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 picivorous and avian predation.

Overall, the mean travel time between White Creek and Bonneville Dam was 215 days (SE±45 days). An analysis of out-migrant travel time between the White Creek PIT tag array and Bonneville Dam indicates that *O. mykiss* out-migrants exhibit two distinct life history strategies. The analysis was limited to fish (20 of 34) detected at both the White Creek array and Columbia River. One strategy involved rearing in the Klickitat River sub-basin for at least an additional year prior to out-migrating to the Columbia River (Figure 14). The mean number of days spent rearing in the Klickitat River was 395 days (SE±35 days). The other strategy involved migrating directly down the Klickitat River and Columbia River after leaving White Creek. These fish spent as little as 2 days to reach Bonneville but took no longer than 4 months. The mean travel time for this group of fish was 35 days (SE±14 days). The results indicate that *O. mykiss* originating from White Creek exhibit a "spreading of risk" strategy. There are a number of advantages to rearing in the Klickitat River over White Creek. During low flow years large areas of the White Creek drainage are prone to decreased flow duration, channel drying, fish stranding, and fish mortality. Additionally, fish are subject to elevated water temperatures and predation during low flow conditions in White Creek. Third, episodic flooding events in the spring may contribute to fish mortality in White Creek. Conversely, water temperatures are more moderate, channel drying unlikely, and episodic flooding less frequent given the larger volume of water conveyed in the Klickitat River. Although the Klickitat River may provide refuge from stranding, high water temperatures, and episodic flooding events, fish rearing in the Klickitat River may be subject to harmful episodic turbidity events. The Big Muddy Creek (which drains the east side of Mt. Adams) delivers high levels of suspended sediments into the Klickitat River during prolonged heat spells. These episodic turbidity events can be lethal to salmonids as evidenced by large fish kills documented in the past. These results suggest that the mainstem Klickitat River is an important rearing component to juvenile steelhead of tributary origin. Additional studies are needed to identify mainstem reaches that function as important juvenile steelhead rearing areas.

Fourteen PIT tagged adult steelhead were detected at the White Creek PIT tag array from October 1, 2010 through September 20, 2012. Nine fish were PIT tagged at the Lyle Adult Fish Trap as part of an on-going M&E radio telemetry study. Three fish were PIT tagged at the Bonneville Dam Adult Fish Facility. Two fish entered the Klickitat River sub-basin as strays. One fish was PIT tagged in the John Day River as an out-migrant at river kilometer 351. The other was a Snake River out-migrating smolt PIT tagged at Lower Granite Dam. Ten fish were of wild origin, one hatchery, and three of unknown origin. Summer-run steelhead comprised eight of fourteen adult steelhead detected at the array. The remaining steelhead consisted of four winter-run and two of unknown run-type.

a) Tagged Fish



b) Detected Fish

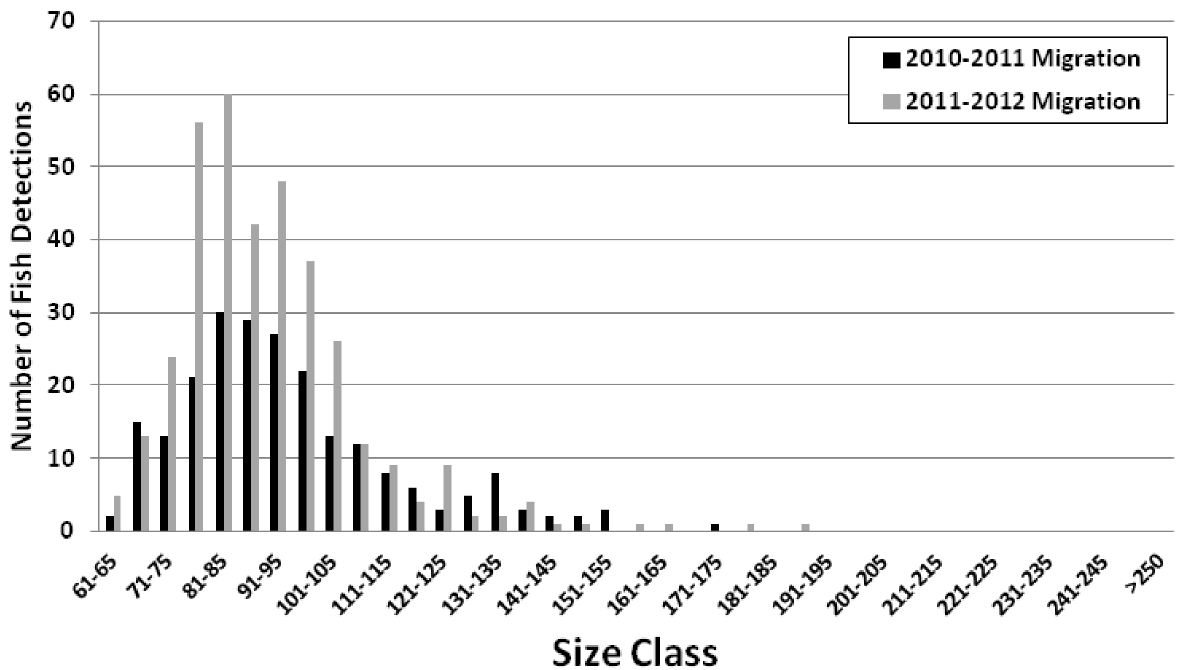


Figure 11. a) Length (at time of tagging) frequency histogram of 2010 and 2011 *O. mykiss* tag cohorts and b) detected O. mykiss at the White Creek PIT tag array during the 2010-2011 and 2011-2012 migration years (Oct.1 – Sept.30).

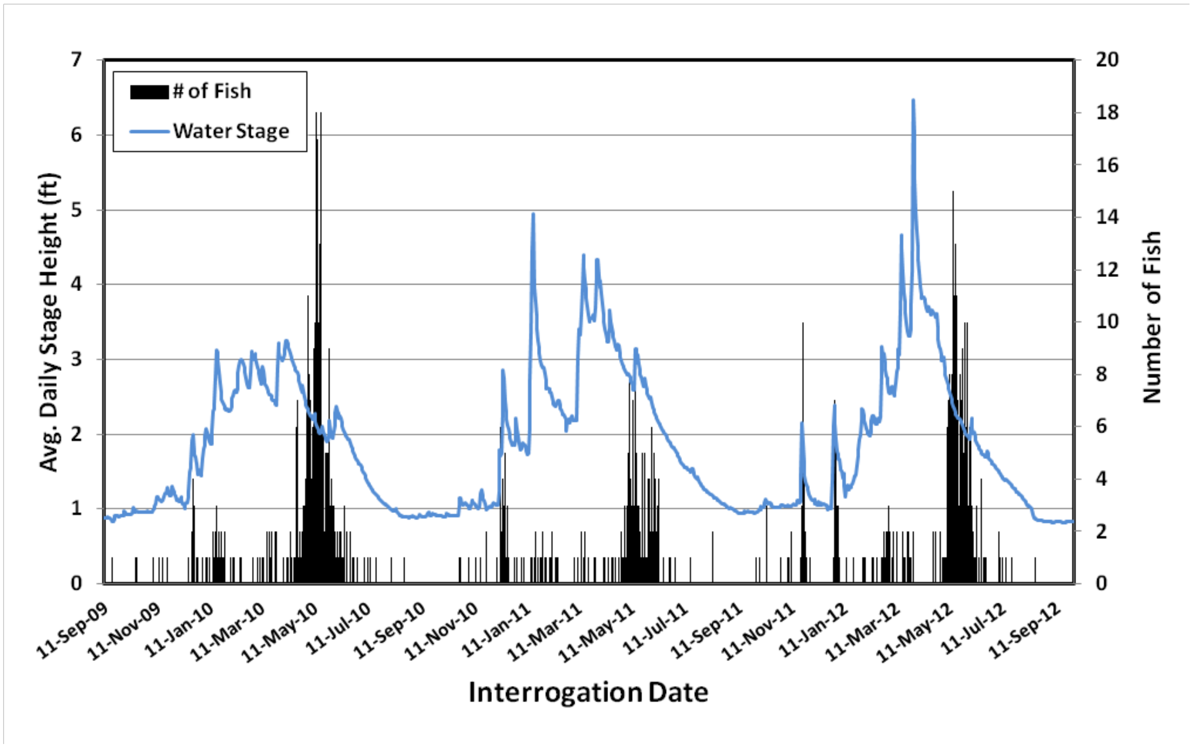


Figure 12. Graph examining the relationship between *O. mykiss* detections at the White Creek PIT tag array and average daily stage height during the 2009-2010, 2010-2011, and 2011-2012 migration years (August 25, 2009 – September 30, 2012).

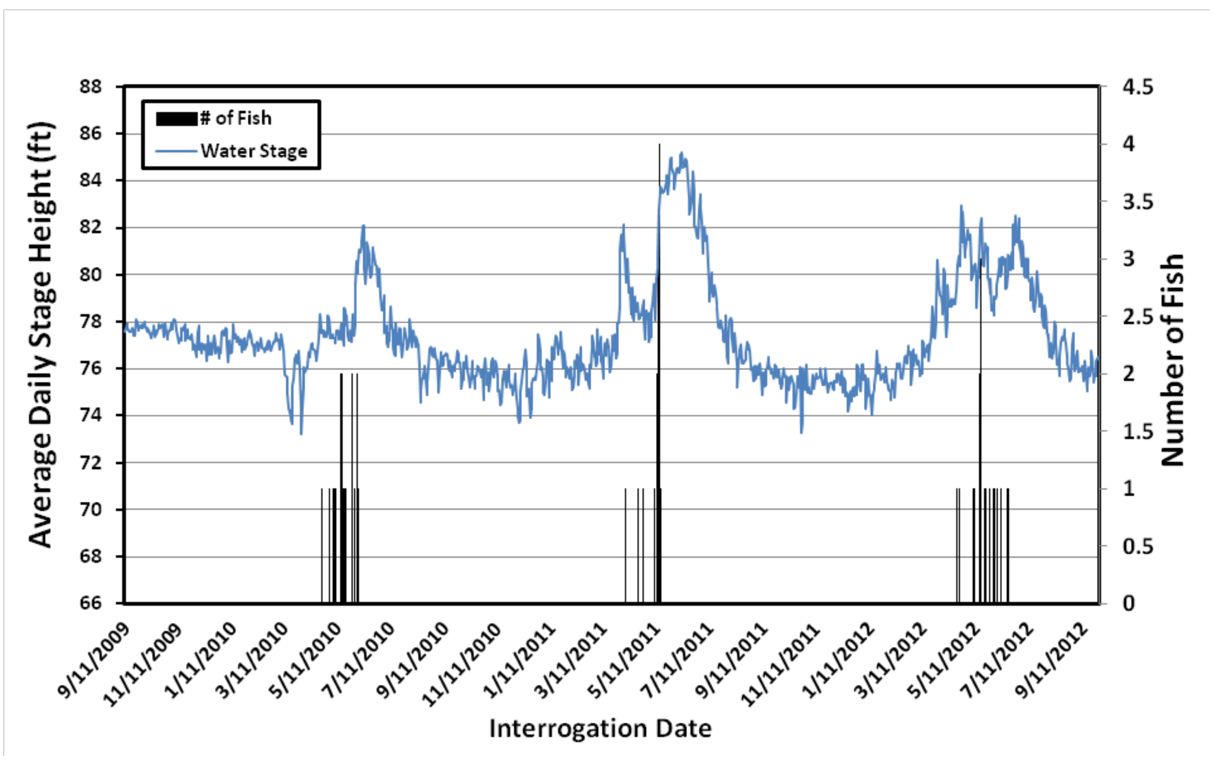


Figure 13. Graph examining the relationship between *O. mykiss* detections at Bonneville Dam and the Columbia River average daily stage height during the 2009-2010, 2010-2011, and 2011-2012 migration years (August 25, 2009 – September 30, 2012).

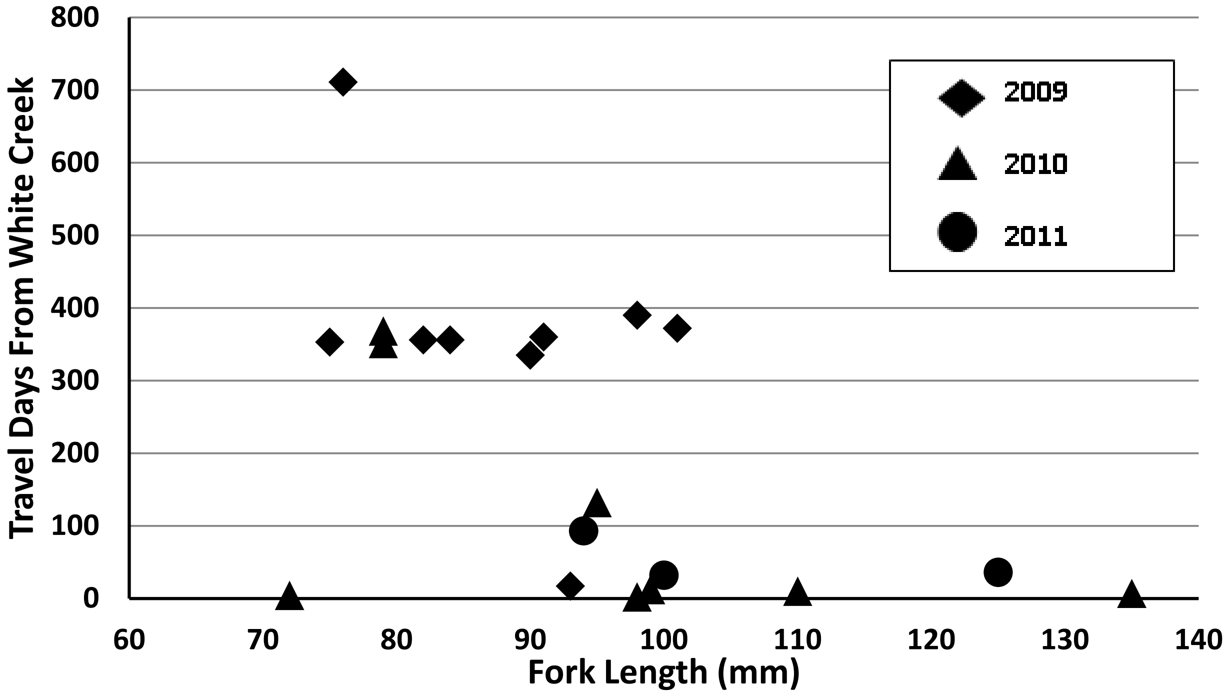


Figure 14. ***O. mykiss*** **out-migrant travel time (in days) between the White Creek array and Bonneville Dam by fish length (at the time of tagging) and tag cohort between October 1, 2010 and September 30, 2012.**

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. Lower White Creek also had the highest estimated densities of outmigrants. Overall, just under one fifth of the tagged *O. mykiss* exited the White Creek drainage. Downstream migrants exited the watershed over an 11-month period with a consistent bimodal outmigration pattern, with peaks in the fall and the spring. A small number of fish was 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 *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. A small number of PIT-tagged adult steelhead has been detected at the White Creek PIT detection array. To date these have been tagged in areas other than White Creek; most have been tagged at the Lyle adult trap on the lower Klickitat River or the Bonneville Dam adult fish facility with two strays (from the John Day and Snake River subbasins) having been detected.

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 enhancement 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: 1) quantifying riparian habitat conditions in treatment and control sample sections; 2) comparing invertebrate prey availability (biomass and composition) from benthic, drift, and allochthonous sources; and 3) 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 (Table 3). 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 in-stream treatment implementation phase (Table 3). The implementation phase began Summer 2012 and scheduled to end Fall 2013. The pre-project phase concluded after Fall 2011 sampling. Post-treatment sampling is scheduled to begin Spring 2014.

Pre-project data collection consisted of five sampling events beginning Fall 2009 and ending Fall 2011 (Table 36 in Appendix B). The total number of pre-project samples collected included 101 benthic, 104 drift, 281 pan traps, and 470 stomachs (Table 36). An additional 24 benthic, 32 drift, 72 pan traps, and 160 stomach samples are anticipated from the Fall 2011 sampling event.

Preliminary results indicate little differences in taxa richness between treatment and control sites with the exception of Fall 2009 and 2011 (Figure 17 in Appendix B). The number of aquatically-derived taxa was 4 times greater in the control reach compared to the treatment reach in Fall 2009 (Figure 17b). The number of terrestrially-derived Families in the control reach was nearly double of the treatment reach in Fall 2011 (Figure 17a). Terrestrially-derived taxa richness was greater in the summer than the Fall in both treatment and control reaches. Benthic taxa richness was lowest in the spring and similar between summer and fall.

Fish in the treatment reach ingested a greater proportion of aquatically-derived invertebrates than fish in the control reach in two of three seasons (Figure 18 in Appendix B). Fall 2010 was the only season where terrestrially-derived insects comprised greater than 50% of the diet of fish in the treatment reach. Terrestrially-derived insects comprised more than 50% of the diet of fish in the control reach in two of three seasons. Preliminary results indicate that terrestrial invertebrates are an important seasonal prey subsidy to fish and other higher order consumers in food webs.

Table 3. Food Web Study sampling event and implementation timeline. Grey cells denote time span of each Food Web Study phase. Check marks denote completed sampling events and X's denote scheduled sampling events.

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											X			X	X	X	X	X	X

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) initiated a new basin wide rapid aquatic habitat survey methodology in 2009. The objective of aquatic habitat surveys is three-fold. First, aquatic habitat surveys are used as an effectiveness-monitoring tool to quantify differences between pre-and-post-project stream enhancement conditions. Second, habitat surveys are conducted to expand the spatial extent of instream habitat conditions in anadromous bearing portions of stream. Third, aquatic habitat assessments provide baseline information to guide design of future 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. Fish surveys were conducted in stream sections following completion of habitat inventories. Fish surveys (by electrofishing or snorkeling) were conducted to spatially quantify fish distribution, composition, and relative abundance.

Results

Habitat surveys during this reporting period were conducted for effectiveness monitoring of three stream enhancement projects in the upper Klickitat River. Pre-treatment baseline habitat data totaling 2.2 kilometers was collected in the Upper Klickitat River Phase 3 and Phase 4 In-Channel and Floodplain Enhancement Project areas. In addition, a 1.3-kilometer post-treatment habitat survey was completed in the Upper Klickitat River Phase 2 Stream Enhancement Project to compare pre-project and post-project conditions (Table 4). The Upper Klickitat River Enhancement Projects are being implemented by the BPA-funded Klickitat Watershed Enhancement Project (Project # 199705600) with additional funding from the Washington state Salmon Recovery Funding Board (SRFB).

The Phase 3 Enhancement Project was implemented to reestablish connectivity between a 1200 meter side channel and maninstem Klickitat River near river kilometer 122. The project goal is to enhance spawning and rearing habitat for spring Chinook salmon and steelhead. The project area, located within the "Upper Klickitat Mainstem: McCreedy Creek (RK 122) to Diamond Fork" reach, is ranked in the top tier of priority geographic areas identified in the Klickitat Lead Entity Region Salmon Recovery Strategy (Klickitat Lead Entity 2012). A continuous habitat and fish inventory (1,218 meters) of the entire side-channel length quantified pre-project baseline conditions. The total area surveyed was 2,859 meters^2 (Table 4). The average unit area and bankfull width measured 32.5 meters^2 and 6.0 meters, respectively. Pools were abundant (20.5 pools/kilometer) averaging a residual pool depth of 0.49 meters. Large woody debris (LWD) pieces (46.0 pieces/kilometer) were abundant but LWD jams (0.8 jams/kilometer) were not (Table 5). *O. mykiss* and brook trout were present in similar densities (Table 6).

The goal of the Phase 4 Enhancement Project was to increase steelhead and spring Chinook habitat quantity and quality by increasing floodplain connectivity, pool quantity and quality, and large woody debris levels. To quantify pre-project baseline conditions, a continuous habitat and fish survey (949 meters) was completed along the mainstem (771 meters) and side channel (178 meters). The total survey area was 11,595 and 1,007 meters^2 in the mainstem and side channel, respectively (Table 4). The average habitat unit area and bankfull width in the mainstem measured 828.2 meters^2 and 23.1 meters, respectively. The average habitat unit area and bankfull width in side channels was substantially less at 91.5 meters^2 and 11.4 meters, respectively. Pool frequency was substantially lower in the mainstem compared to the side channel but residual pool depths were more than twice as deep. Although mainstem LWD piece abundance (41.5 pieces/kilometer) was similar to observed estimates in other upper mainstem Klickitat River sections, side channel large woody debris abundance was approximately 1.5-fold higher (Table 5). *O. mykiss* densities were slightly higher in the mainstem (5.2 fish/100m^2) than the side channel (4.4 fish/100m^2; Table 6). Brook trout densities were a fraction of *O. mykiss* densities in both the mainstem and side channel. *O. mykiss* densities were approximately 5.5 times greater than Brook Trout in the side channel. Brook Trout were negligible in the mainstem.

The goal of the Phase 2 Enhancement Project was to increase physical habitat complexity, reduce river-road interaction, and enhance rearing, holding, and spawning for steelhead and spring Chinook. Specifically, the intent of the project was to enhance instream habitat and water quality by increasing pool quantity and quality and large woody debris levels. The change in reach length from pre-to-post project was negligible (Table 4). Wetted area decreased from pre-treatment to post-treatment. The reduction in wetted area from pre-treatment to post-treatment was likely an artifact of sampling at a lower flow period and decreased mainstem flow resulting from reconnection of an upstream side-channel. Average habitat unit area decreased from 1835 meters^2 to 705.1 meters^2 pre-project to post-project. Habitat complexity increased from pre-to-post project as evident by 2-fold increase in the number of habitat units delineated. Pool frequency more than tripled and residual pool depths increased slightly from pre-project to post-project. LWD pieces (not associated with jams) remained similar from pre-to-post conditions. A 2.5-fold and 3.0-fold increase in LWD jams and jam pieces occurred pre-project to post-project, respectively (Table 5).

The Lower Klickitat River Tributary Study was initiated in Spring 2011 to describe *O. mykiss* life history strategies displayed in four tributaries (Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Snyder Creek) of the lower Klickitat River. The surface flow of each stream becomes disconnected from the mainstem beginning early summer and lasting through mid-fall. Habitat inventory and fish assessment data collected from each tributary is used to quantify the proportion of *O. mykiss* displaying anadromy, the timing of in- and out-migration, proportion of hatchery vs. wild adult returns, and the usage of rearing habitat by juveniles.

In the spring of 2011, a total of 11.1 kilometers of stream length was collectively surveyed in the four tributaries (Table 4). The survey length was limited to anadromous bearing portions of each stream. Survey length and area was similar among Dillacort Creek, Logging Camp Creek, and Wheeler Creek. In Snyder Creek, the survey length and area was substantially greater (nearly 3 times; Table 4). Average bankfull width and habitat unit area was lowest in Logging Camp Creek.

Pool frequency was highest in Dillacort Creek and lowest in Wheeler Creek. Residual pool depths were similar among Dillacort Creek, Wheeler Creek, and Snyder Creek but substantially shallower in Logging Camp Creek. The number of large woody debris (LWD) pieces was highest in Logging Camp Creek (Table 5). The number of LWD pieces was 3, 1.7, and 1.5 times greater in Logging Camp Creek compared to Dillacort Creek, Wheeler Creek, and Snyder Creek, respectively. No LWD jams were present in Logging Camp Creek even though it contained the greatest densities of LWD pieces (48 pieces/km). LWD jams were infrequent in Dillacort Creek, Wheeler Creek, and Snyder Creek. Although the number of LWD jams was similar among the three streams, LWD jams in Dillacort Creek consisted of nearly half the pieces of jams in Wheeler Creek and Snyder Creek (Table 5).

Fish abundance was substantially lower in streams with east aspect drainages (Dillacort Creek and Wheeler Creek) than streams with west aspect drainages (Logging Camp Creek and Snyder Creek). *O. mykiss* abundance in Logging Camp Creek and Snyder Creek was 4.6 and 6.7 greater than Dillacort Creek. Similarly, *O. mykiss* abundance in Logging Camp Creek and Snyder Creek was 3.3 and 4.8 greater than Wheeler Creek. Fish abundance in side-channels was similar in Logging Camp Creek and Snyder Creek. No fish were observed in side-channels of Dillacort Creek and Wheeler Creek. Lower fish abundances in east side streams were likely the result of seasonally-limited flow duration and widespread channel drying. The entire fish bearing portion of Wheeler Creek is generally dry by early Fall. With the exception of a 300-m section downstream of the barrier falls, the fish-bearing length of Dillacort Creek is dry by early Fall. Conversely, Logging Camp Creek and Snyder Creek are perennial with the exception of the stream channel along the alluvial fan.

Juvenile coho sampled in the lower tributaries were of hatchery origin released into the Klickitat River near river mile 17. Dillacort Creek, Logging Camp Creek, and Wheeler Creek contained juvenile coho but Snyder Creek did not (Table 6). Juvenile coho movement into Snyder Creek is restricted by a 2,400 foot concrete flume with fish weirs located near Klickitat River confluence. Barriers to juvenile coho movement located near the confluence with Klickitat River limited distribution in Dillacort Creek and Logging Camp Creek. A high gradient cascade located 60 meters from the Klickitat River marked the upper extent of juvenile coho in Dillacort Creek. A head-cut (located 20 meters from the Klickitat River) was the upper extent of juvenile coho in Logging Camp Creek. Although juvenile coho were sampled in Wheeler Creek up to 540 meters above the confluence with the Klickitat River, spawning surveys conducted in Winter 2011 identified the upper extent of coho redds at 720 meters. Juvenile coho densities in Wheeler Creek were slightly higher than Dillacort Creek and more than twice as high as Logging Camp Creek (Table 6).

Table 4. Summary of aquatic habitat inventory data collected from 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)
Upper Klickitat - Phase 2 Pre-Treatment (Reach 2 - Reach 4B)	08 Aug. 2009	Klickitat R.	1297 (57)	20189 (340)	31.7 (NC)	14.3 (5.1)	1835 (84.9)	1.5 (0.0)	0.59 (0.0)
Upper Klickitat - Phase 2 Post-Treatment (Reach 2 - Reach 4B)	06 Oct. 2010	Klickitat R.	1253 (114)	18334 (551)	26.5 (NC)	13.5 (5.2)	705 (110)	4.8 (0.0)	0.66 (0.0)
Upper Klickitat - Phase 3 Pre-Treatment (Side Channel Reconnection)	14 Sept. 2010	Klickitat R.	(1218)	(2859)	(6.0)	(2.3)	(33)	(20.5)	(0.49)
Upper Klickitat - Phase 4 Pre-Treatment (255 Bridge - Twin Bridges)	15 Sept. 2010	Klickitat R.	771 (178)	11595 (1007)	23.1 (11.4)	14.5 (5.0)	828 (92)	3.9 (16.9)	0.78 (0.36)
Lower Tributaries Life History Study	13-14 Apr. 2011	Dillacort Cr.	1636 (34)	7670 (110)	7.5 (NC)	4.6 (2.9)	59 (18)	23.8 (0.0)	0.58 (0.0)
Lower Tributaries Life History Study	26-29 Apr. 2011	Wheeler Cr.	1765 (87)	7501 (306)	8.2 (NC)	4.0 (3.3)	58 (44)	18.1 (11.5)	0.59 (0.36)
Lower Tributaries Life History Study	9-23 May 2011	Logging Camp Cr.	1915 (58)	6261 (97)	4.4 (NC)	3.1 (1.7)	42 (24)	19.8 (0.0)	0.33 (0.0)
Lower Tributaries Life History Study	3-15 June 2011	Snyder Cr.	5429 (152)	27074 (520)	8.2 (NC)	8.2 (NC)	70 (29)	22.7 (13.2)	0.50 (0.24)

Table 5. 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)	# Jam Pieces (pieces/km)
Upper Klickitat – Phase 2 Pre-Treatment (Reach 2 - 4B)	08 Aug. 2009	Klickitat R.	1297 (57)	20189 (340)	47.1 (0.0)	3.9 (0.0)	94.9 (0.0)
Upper Klickitat - Phase 2 Post-Treatment (Reach 2 - Reach 4B)	06 Oct. 2010	Klickitat R.	1253 (114)	18334 (551)	48.7 (0.0)	10.4 (0.0)	280.0 (0.0)
Upper Klickitat - Phase 3 Pre-Treatment (Side Channel Reconnection)	14 Sep. 2010	Klickitat R.	(1218)	(2859)	(45.9)	(0.82)	10.7
Upper Klickitat - Phase 4 Pre-Treatment (255 Bridge - Twin Bridges)	15 Sep. 2010	Klickitat R.	771 (178)	11595 (1007)	41.5 (61.8)	7.9 (5.6)	191.9 (376.6)
Lower Tributaries Life History Study	13-14 Apr. 2011	Dillacort Cr.	1636 (34)	7670 (110)	15.9 (88.2)	0.6 (0.0)	4.9 (0.0)
Lower Tributaries Life History Study	26-29 Apr. 2011	Wheeler Cr.	1765 (110)	7501 (306)	28.3 (0.0)	0.6 (0.0)	9.6 (0.0)
Lower Tributaries Life History Study	9-23 May 2011	Logging Camp Cr.	1915 (58)	6261 (97)	48.0 (17.2)	0.0 (0.0)	0.0 (0.0)
Lower Tributaries Life History Study	3-15 June 2010	Snyder Cr.	5429 (152)	27024 (520)	33.0 (72.4)	0.7 (0.0)	10.5 (0.0)

Table 6. Summary of fish abundance and composition collected during aquatic habitat inventory surveys (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	*O. mykiss* Abundance (fish/100m^2)	Brook Trout Abundance (fish/100m^2)	Juvenile Coho Abundance (fish/100m^2)
Upper Klickitat – Phase 2 Pre-Treatment (Reach 2 - 4B)	08 Aug. 2009	Klickitat R.	NC	NC	NC
Upper Klickitat - Phase 2 Post-Treatment (Reach 2 - Reach 4B)	06 Oct. 2010	Klickitat R.	NC	NC	NC
Upper Klickitat - Phase 3 Pre-Treatment (Side Channel Reconnection)	14 Sept. 2010	Klickitat R.	(3.3)	(3.2)	(0.0)
Upper Klickitat - Phase 4 Pre-Treatment (255 Bridge - Twin Bridges)	15 Sept. 2010	Klickitat R.	5.2 (4.4)	<0.01 (0.8)	0.0 (0.0)
Lower Tributaries Life History Study	13-14 Apr. 2011	Dillacort Cr.	1.5 (0.0)	0.0 (0.0)	0.9 (0.0)
Lower Tributaries Life History Study	26-29 Apr. 2011	Wheeler Cr.	2.1 (0.0)	0.0 (0.0)	1.2 (0.0)
Lower Tributaries Life History Study	9-23 May 2011	Logging Camp Cr.	6.9 (2.5)	0.0 (0.0)	0.5 (0.0)
Lower Tributaries Life History Study	3-15 June 2010	Snyder Cr.	10.0 (3.0)	0.0 (0.0)	0.0 (0.0)

Conclusions

Habitat surveys in the upper Klickitat River above Castile Falls focused on reaches with planned habitat enhancement work by the BPA-funded Klickitat Watershed Enhancement Project; two reaches had pre-project surveys completed and one has both pre- and post-project surveys completed. In the reach with both pre- and post-project data, habitat complexity increased (with a 2-fold increase in number of habitat units delineated), pool frequency more than tripled, residual pool depths increased slightly, non-jam LWD piece density remained similar, and LWD jams and jam pieces increased 2.5 fold and 3.0 fold, respectively, from pre- to post-project.

Habitat surveys, and associated fish assessment surveys, were also conducted in four tributaries of the lower Klickitat River (Dillacort Creek, Logging Camp Creek, Wheeler Creek, and Snyder Creek). Pool frequency was highest in Dillacort Creek and lowest in Wheeler Creek. Residual pool depths were shallowest in Logging Camp Creek but similar among the other streams. LWD was most abundant in Logging Camp Creek (although no LWD jams were present); LWD piece density was somewhat similar in the other streams and LWD jams were infrequent. Fish abundance was substantially lower in streams with east aspect drainages (Dillacort Creek and Wheeler Creek) than streams with west aspect drainages (Logging Camp Creek and Snyder Creek); this is likely the result of seasonally-limited flow duration and widespread channel drying. Ongoing fish monitoring (via PIT tag detection arrays) will provide important information on the proportion of O. mykiss displaying anadromy, the timing of in- and out-migration, proportion of hatchery vs. wild adult returns, and the usage of rearing habitat by juveniles.

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 19 for a map and Table 37 (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) were sampled during this reporting period. See Figure 20 in Appendix B for a map showing locations of sampling sites. 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 incorporated into the EDT model and used to characterize sediment levels throughout the basin.

Results

Detailed results from sediment monitoring at the 11 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.

V. References

Arnason, A.N., C.J. Schwartz, and J.M. Gerrard. 1991. Estimating closed population size and number of marked animals from sighting data. Journal of Wildlife Management 55(4):718-730.

Bernard, D.R., J.J. Hasbrouck, and S.J. Fleischman. 1999. Handling-induced delay and downstream movement of adult Chinook salmon in rivers. Fisheries Research 44:37-46.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pp. 83-138 in W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19. Bethesda, Maryland.

Bryant, F.G. 1949. A survey of the Columbia River and its tributaries with special reference to the management of its fishery resources – 2. Washington streams from the mouth of the Columbia River to and including the Klickitat River (Area I). U.S. Department of the Interior, Fish and Wildlife Service. Special Scientific Report No. 62.

Buchanan, R.A. and J.R. Skalski. 2007. A Migratory Life-Cycle Release-Recapture Model for Salmonid PIT-Tag Investigations. Journal of Agricultural, Biological, and Environmental Statistics, Volume 12, Number 3, Pages 325-345.

Crawford, B., T.R. Mosey, and D.H. Johnson. 2007. Carcass counts. Pages 59-86 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

CSS 2012. Comparative Survival Study (CSS) of PIT-tagged spring/summer Chinook and summer steelhead. 2012 Annual Report. Prepared by CSS Oversight Committee and Fish Passage Center. BPA Contract #19960200. Available at: http://www.fpc.org/documents/CSS.html

DeVries, D.R., and R.V. Frie. 1996. Determination of age and growth. Pages 483-512 in B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Fish Passage Center. 2013. Available at: http://www.fpc.org/

Gallagher, S.P., P.K.J. Hahn, and D.H. Johnson. 2007. Redd counts. Pages 197-234 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Gray, S.W. 2006. Determine the Origin, Movements, and Relative Abundance of Bull Trout in Bonneville Reservoir. 2005-2006 Annual Report. Project No. 200306500, 81 electronic pages (BPA Report DOE/BP-00022537-1). Available at: https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P103852

Gray, S.W. 2007. Determine the Origin, Movements, and Relative Abundance of Bull Trout in Bonneville Reservoir. 2006-2007 Annual Report. Project No. 200306500, 159 electronic pages (BPA Document ID # P103326). Available at: http://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P103326

Groot, C., and L. Margolis. 1991. Preface. Pages ix-xi in Groot, C. and L. Margolis. Pacific salmon life histories. UBC Press, Vancouver, BC.

Hess, J.E., A.P. Matala, J.S. Zendt, C.R. Frederiksen, B. Sharp, and S.R. Narum. 2011. Introgressive hybridization among major Columbia River Chinook salmon (*Oncorhynchus tshawytscha*) lineages within the Klickitat River due to hatchery practices. Canadian Journal of Fisheries and Aquatic Sciences 68: 1876-1891.

Klickitat Lead Entity 2012. Klickitat Lead Entity Region Salmon Recovery Strategy. May 2012. Available at: http://klickitatcounty.org/NaturalR/Content.asp?fC=22&fD=5

Narum, S. R., M. S. Powell, R. Evenson, B. Sharp, and A. J. Talbot. 2006. Microsatellites reveal population substructure of Klickitat River native steelhead and genetic divergence from an introduced stock. North American Journal of Fisheries Management 26:67-75.

Narum, S.R , J.S. Zendt, C. Frederiksen, N. Campbell, A. Matala, and W.R. Sharp. 2011. Candidate genetic markers associated with anadromy in *Oncorhynchus mykiss* of the Klickitat River. Transactions of the American Fisheries Society 140:843-854.

Narum, S.R., J.S. Zendt, C. Frederiksen, and W.R. Sharp. 2007. Substructure of native steelhead in the Klickitat River and genetic identification of spawning populations. Pages 294-295 in Carline, R.F. and C. LoSapio, eds. Sustaining wild trout in a changing world; Proceedings of Wild Trout IX symposium. 2007 October 9-12. West Yellowstone, Montana.

Narum, S.R., J.S. Zendt, D. Graves, and W.R. Sharp. 2008. Influence of landscape on resident and anadromous life history types of Oncorhynchus mykiss. Canadian Journal of Fisheries and Aquatic Sciences 65:1013-1023.

National Marine Fisheries Service (NMFS). 2009. Recovery Plan for the Klickitat River Population of the Middle Columbia River Steelhead Distinct Population Segment. Available at http://www.nwr.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/middle_columbia/middle_columbia_river_steelhead_recovery_plan.html

Northwest Power and Conservation Council (NPCC). 2004. Klickitat Subbasin Plan. Available at http://www.nwcouncil.org/fw/subbasinplanning/klickitat/plan/.

Pleus, A.E., and D. Schuett-Hames. 1998a. TFW Monitoring Program Method Manual for Stream Segment Identification. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-98-001. DNR #103. May.

Pleus, A.E., and D. Schuett-Hames. 1998b. TFW Monitoring Program Method Manual for the Reference Point Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM998-002. DNR #104. May.

Pleus, A.E., D. Schuett-Hames, and L. Bullchild. 1999. TFW Monitoring Program Method Manual for the Habitat Unit Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-003. DNR #105. June.

Roni, P., editor. 2005. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Roni, P., A.H. Fayram, and M.A. Miller. 2005. Monitoring and evaluating instream habitat enhancement. Pages 209-236 in P. Roni, editor. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

Schuett-Hames, D., R. Conrad, A. Pleus, and M. McHenry. 1999a. TFW Monitoring Program Method Manual for the Salmonid Spawning Gravel Composition Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-001. DNR #101. March.

Schuett-Hames, D., A.E. Pleus, J. Ward, M. Fox, and J. Light. 1999b. TFW Monitoring Program Method Manual for the Large Woody Debris Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-004. DNR #106.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters. 2nd edition. The Blackburn Press, Caldwell, New Jersey.

Thiesfeld, S. L., R. H. McPeak, B. S. McNamara, and I. Honanie. 2002. Fiscal Year 2001 Annual Report, Bull Trout Population Assessment in the White Salmon and Klickitat Rivers, Columbia River Gorge, Washington. Project No. 199902400, 77 electronic pages (BPA Report DOE/BP-00004474-1). Available at http://efw.bpa.gov/Publications/R00004474-1.pdf.

Thompson, W.L., G.C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, Inc., San Diego, California.

Volkhardt, G.C., S.L. Johnson, B.A. Miller, T.R. Nickelson, and D.E. Seiler. 2007. Rotary screw traps and inclined plane screen traps. Pages 235-266 in D.H. Johnson, B.M. Shrier, J.S. O'Neal, J.A. Knutzen, X. Augerot, T.A. O'Neil, and T.N. Pearsons. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

Washington Department of Fish and Wildlife (WDFW). 2002. Salmonid Stock Inventory. Available at http://wdfw.wa.gov/fish/sasi/.

White, G.C., D.R. Anderson, K.P. Burnham, and D.L. Otis. 1982. Capture-Recapture and Removal Estimates for Sampling Closed Populations. LA-8787-NERP. U.S. Department of Energy, Los Alamos National Laboratory. Los Alamos, New Mexico.

Yakama Nation. 2012. Klickitat River Anadromous Fisheries Master Plan. Prepared for the Northwest Power and Conservation Council.

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 7. Mark-recapture estimates of spring Chinook run size at Lyle Falls on the lower Klickitat River for 2005-2012.

Year		Pop. Estimate (total)	L 95% CL	U 95% CL	- 95% CI	+ 95% CI	Hatchery	Wild	% Jacks	Adult total
2005	*1/*	2011	1475	2842	536	831				
2006	*1/*	2100	1884	2391	216	291				
2007	*2/*	1965	1653	2362	312	397	1553	413	16.1%	1649
2008		1432	1125	1861	307	429	1016	416	22.1%	1116
2009		6522	5803	7364	719	842	5846	675	22.0%	5087
2010		4511	3581	5793	930	1282	4022	489	9.4%	4087
2011		4445	3721	5371	724	926	3809	636	20.9%	3516
2012		4187	3523	5029	664	842	3657	530	20.5%	3329
Avg.		3844					3317	527		3130

1/ Estimates from Gray 2007
2/ 2007 is first year all returning adult age classes were 100% ad marked

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

Table 8. Mark-recapture estimates of steelhead run size at Lyle Falls on the lower Klickitat River for 2005-2012.

		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	4,972	520	4,084	6,157	3,700	405	3,010	4,626	1,272	115	1,074	1,531	1,127	115	929	1,386	145
2010-11	3,5	6,278	975	4,706	8,668	5,173	838	3,827	7,236	1,105	137	879	1,432	979	137	753	1,306	126
2011-12		4,844	1,401	2,895	9,125	2,417	709	1,431	4,583	2,427	692	1,464	4,542	2,343	692	1,380	4,458	84
2012-13	6					2,619	929	1,402	5,774					989	344	535	2,144	
Avg:		4,605	751	3,474	6,766	2,933	563	2,106	4,602	1,610	261	1,227	2,399	1,336	275	941	2,186	171

[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 winter's proportion of total. Trap ice damage (2005-6) and fishway construction (2010-11) prevented accurate winter counts.
[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
[6]Does not yet include any winter fish

Table 9. 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	1,126	595	531	464	66	58	180	160	662	350	312
2002	2,549	1,250	1,299	787	183	190	203	211	1,762	864	898
2003	3,966	1,931	2,035	1,740	369	388	479	504	2,226	1,084	1,142
2004	2,994	1,685	1,309	1,126	312	243	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	1,595	1,356	239	501	378	0	123	0	1,094	855	239
2010	1,727	1,327	400	584	185	0	371	28	1,143	771	372
2011	1,701	1,071	629	561	477	0	79	5	1,140	515	624
2012	2,100	1,344	755	950	500	0	411	39	1,150	433	716
Min	533	340	66	67	0	0	0	0	132	53	63
Max	5254	4807	2035	1785	760	388	1325	504	3471	3176	1142
Avg	1,889	1,358	531	761	193	58	382	137	1,128	792	336

Table 10. Results of spring Chinook spawning ground surveys (redd counts) in the Klickitat subbasin for 1989-2012.

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
		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
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
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
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
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
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
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
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
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
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
Stinson Flats - Soda Springs	7.5	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	3	0	1	0	0	3	0	0	2
Soda Springs - 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
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
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
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
Totals	**92.2**	**53**	**59**	**93**	**102**	**132**	**39**	**42**	**110**	**231**	**113**	**83**	**167**	**123**	**389**	**332**	**195**	**50**	**82**	**104**	**76**	**70**	**97**	**157**	**154**
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**
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**
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
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%

ns = not surveyed

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 11. Klickitat subbasin spring Chinook spawner survey carcass observations for 2007-2012. 2007 is the first year in which all returning hatchery-origin adults were 100% ad-clipped.

	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%
		Avg.	43%

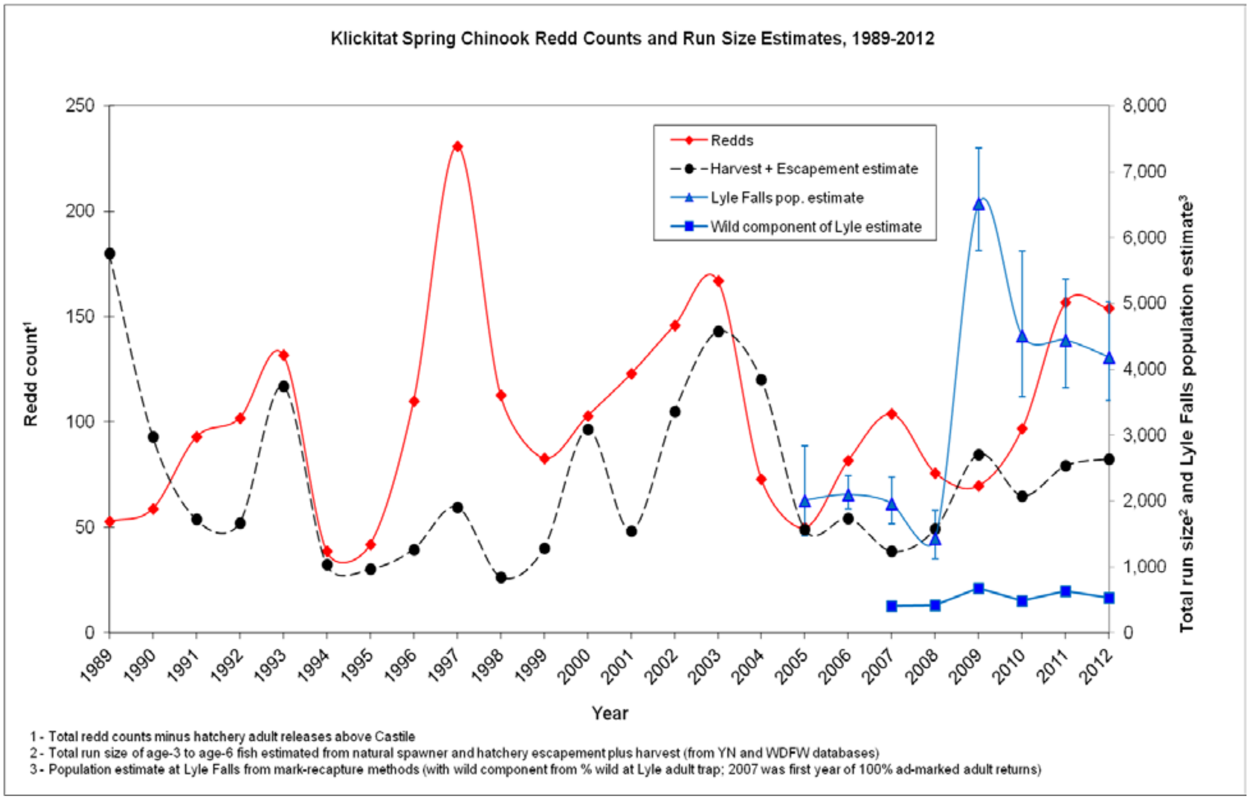


Figure 15. Results of spring Chinook redd counts and run size estimates in the Klickitat subbasin for 1989-2012. Error bars on Lyle Falls mark-recapture population estimates represent 95% confidence intervals.

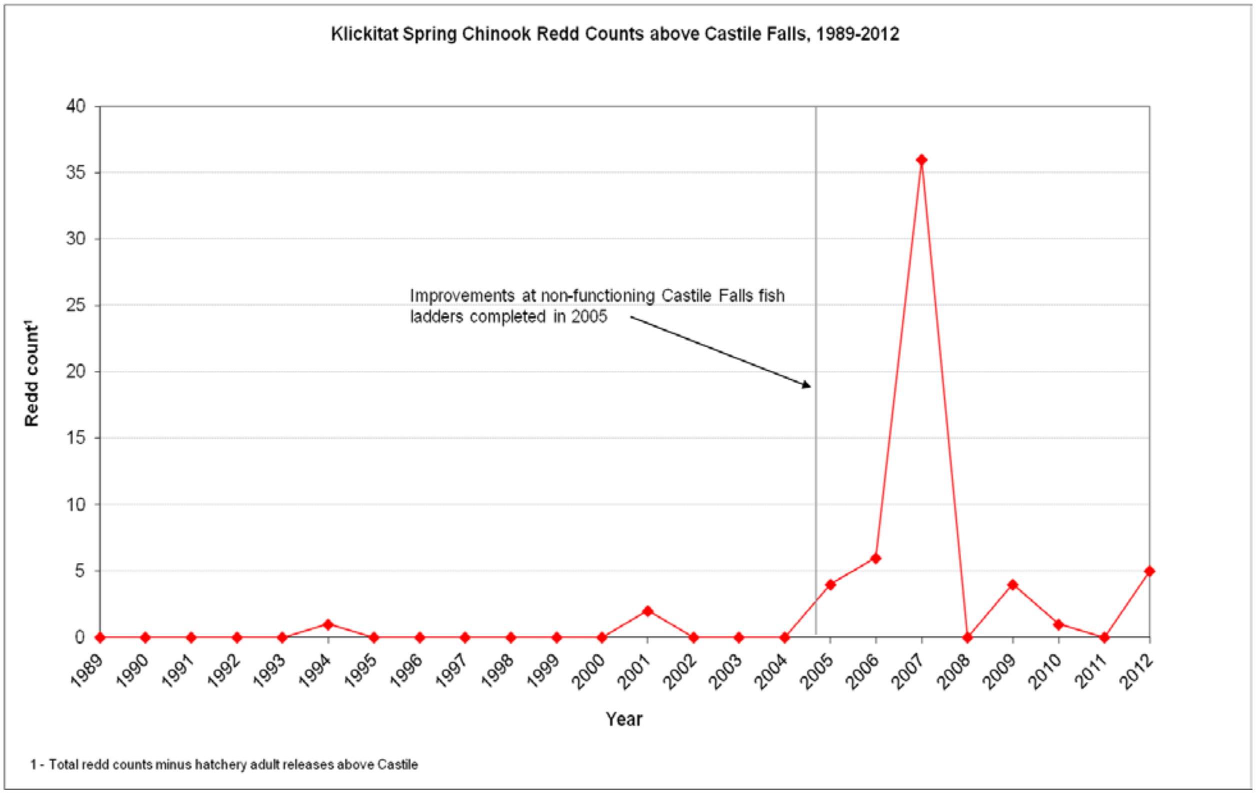


Figure 16. Results of spring Chinook redd counts above Castile Falls (RM 64) in the upper Klickitat River for 1989-2012.

Table 12. Results of fall Chinook spawning ground surveys (redd counts) in the Klickitat subbasin for 1995-2012.

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

ns = not surveyed

Note: High flows and/or turbidity in some years (especially 2003, 2006, 2008, 2009, and 2012) 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 13. Catch summary of target species at the Lyle Falls screw trap (RM 2.8 on the Klickitat River) from May 1, 2010 to April 30, 2011.

Month	Days Fished	Chinook	Coho	Hatchery *O.mykiss*	Wild *O.mykiss*	***Totals***
May	2		1780			1780
June	6	168	14	5		187
July	6	4375		1	1	4377
August	18	9816			1	9817
September	14	880	22		6	908
October	0					0
November	1		1			1
December	0					0
January	5					0
February	8	2	1			3
March	12	8855	7		1	8863
April	12	2	5433	311	23	5769
Totals	84	24098	7258	317	32	31705

Table 14. Catch summary of target species at the Lyle Falls screw trap (RM 2.8 on the Klickitat River) from May 1, 2011 to April 30, 2012.

Month	Days Fished	Chinook	Coho	Hatchery *O.mykiss*	Wild *O.mykiss*	***Totals***
May	14	263	389	1084	18	1754
June	3	103	16	15		134
July	4		4			4
August	15	69	54	1		124
September	10	18	69			87
October	3					0
November	1		2			2
December	6		1			1
January	8					0
February	3					0
March	9	2415				2415
April	4	3	102			105
Totals	80	2871	637	1100	18	4626

Table 15. Catch summary of target species at the Castile Falls screw trap (RM 64.6 on the Klickitat River) for May through November 2010.

Month	Days Fished	Wild *O.mykiss*	Wild Chinook	Hatchery Chinook	Brook Trout	***Totals***
May						
June						
July	7	9	33			42
August	31	13	79		1	93
September	12	5	6			11
October	15	3	31		1	35
November	16		22		1	23
Totals	81	30	171	0	3	204

Table 16. Catch summary of target species at the Castile Falls screw trap (RM 64.6 on the Klickitat River) for May through November 2011.

Month	Days Fished	Wild *O.mykiss*	Wild Chinook	Hatchery Chinook	Brook Trout	***Totals***
May						
June						
July	1					0
August	13					0
September	7	2				2
October	11	3	1		3	7
November	3					0
Totals	35	5	1	0	3	9

Table 17. Description of fixed radio telemetry stations in the Klickitat subbasin.

Site Name	River mile	Physical location	Receiver type	Power source	# of antennas
Lyle	0.1	45.697N, 121.291W	Lotek	Hard power (110V)	2
Lyle Falls	2.5	45.717N, 121.259W	Lotek	solar panels	5
Wahkiacus	16	45.825N, 121.099W	Lotek	solar panels	3

Little Klickitat	19	45.845N, 121.063W	Lotek	solar panels	3
Dead Creek	31	45.938N, 121.133W	Lotek	solar panels	3
White Creek	40	46.013N, 121.151W	Lotek	solar panels	3
Klickitat Hatchery	43	46.040N, 121.181W	Lotek	Hard power (110V)	4
Lower Castile	64	46.252N, 121.240W	Orion	solar panels	3
Upper Castile	64.5	46.258N, 121.244W	Lotek	Thermo-electric generator, Hard power (110V)	4

Table 18. Numbers of radio-tagged adult salmonids at the Lyle Falls adult trap by species, stock, and origin, from May 1, 2010 to April 30, 2012.

Steelhead		Spring Chinook	
Winter, Hatchery	Winter, Wild	Hatchery	Wild
9	55	68	42
Summer, Hatchery	Summer, Wild		
81	89		

Table 19. Fixed site radio telemetry detections for radio tag #56022.

Watershed	River Mile	Date:Time	Receiver	Location	Date
Klickitat River	2.8	6/16/10 10:45		mobile	6/16/2010
Klickitat River	7	6/22/10 9:55		mobile	6/22/2010
Klickitat River	7.4	6/29/10 10:07		mobile	6/29/2010
Klickitat River	17	7/6/10 5:31	U03	Wahkiacus	7/6/2010
Klickitat River	14.8	7/6/10 12:50		mobile	7/6/2010
Klickitat River	19.8	7/7/10 12:57	U04	Little Klickitat: DN	7/7/2010
Klickitat River	20.2	7/7/10 15:22	U04	Little Klickitat: UP	7/7/2010
Klickitat River	23.8	7/13/10 12:48		mobile	7/13/2010
Klickitat River	28	7/22/10 11:39		mobile	7/22/2010
Klickitat River	28	8/12/10 12:44		mobile	8/12/2010
Klickitat River	30.8	9/23/10 4:15	U05	Dead Canyon: DN	9/23/2010
Klickitat River	31.2	9/26/10 18:46	U05	Dead Canyon: UP	9/26/2010
Klickitat River	31	10/21/10 8:55		mobile	10/21/2010
Klickitat River	28	11/18/10 12:00		mobile	11/18/2010

Klickitat River	28	12/9/10 10:39		mobile	12/9/2010
Klickitat River	28	1/20/11 13:05		mobile	1/20/2011
Klickitat River	30	2/11/11 12:01		mobile	2/11/2011
Klickitat River	30	3/3/11 8:31		mobile	3/3/2011
Klickitat River	30.8	3/14/11 23:17	U05	Dead Canyon: DN	3/14/2011
Dead Cr	31	3/15/11 0:00		in Dead Cr	3/15/2011
Dead Cr	31	3/15/11 7:28		in Dead Cr	3/15/2011
Dead Cr	31	3/20/11 6:08		in Dead Cr	3/20/2011
Klickitat River	30.8	3/20/11 6:24	U05	Dead Canyon: DN	3/20/2011
Klickitat River	21.8	3/22/11 11:04		mobile	3/22/2011
Klickitat River	20.2	3/25/11 15:49	U04	Little Klick: UP	3/25/2011
Klickitat River	17.2	3/25/11 21:17	U03	Wahkiacus:UP	3/25/2011
Klickitat River	2.8	3/30/11 1:13	U02	Lyle Falls: UP	3/30/2011
Klickitat River	0.2	3/31/11 4:16	U02	Lyle: UP	3/31/2011
Klickitat River	0	3/31/11 6:04	U01	Lyle	3/31/2011

Table 20. Fixed site radio telemetry detections for radio tag #44141.

Watershed	River Mile	Receiver_Antenna	Location	Date
Klickitat River	2.8	mobile	Klickitat River	2/29/2012
Klickitat River	2.4	mobile	Klickitat River	3/1/2012
Klickitat River	6.8	mobile	Klickitat River	3/8/2012
Klickitat River	8.9	mobile	Klickitat River	3/15/2012
Klickitat River	10.4	mobile	Klickitat River	3/22/2012
Klickitat River	10.8	mobile	Wheeler Creek	3/25/2012
Klickitat River	10.8	mobile	Wheeler Creek	3/27/2012
Klickitat River	10.8	mobile	Wheeler Creek	4/1/2012
Klickitat River	7.2	mobile	Klickitat River	4/5/2012
Klickitat River	0.2	Lyle: UP	Klickitat River	4/8/2012
Klickitat River	0	Lyle: DN	Klickitat River	4/9/2012

Table 21. 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 2010-2012.

Spring Chinook	Count	Fork Length			POH Length			% of Total
		Mean	Min	Max	Mean	Min	Max	
2010								
Ad clipped								
Age 4	3	744	731	757	631	610	652	100.0%
Total	3							
Unmarked								
Age 4	1	741	741	741	610	610	610	33.3%
Age 5	2	945	936	954	770	754	786	66.7%
Total	3							
2011								
Ad clipped								
Age 3	1	596	596	596	495	495	495	12.5%
Age 4	7	808	720	957	663	585	777	87.5%
Total	8							
Unmarked								
Age 3	1	665	665	665	520	520	520	11.1%
Age 4	4	749	712	800	623	595	665	44.4%
Age 5	4	840	784	906	710	658	758	44.4%
Total	9							
2012								
Ad clipped								
Age 2	1	290	290	290	240	240	240	33.3%
Age 4	2	755	706	804	609	607	610	66.7%
Total	3							
Unmarked								
Age 3	1	550	550	550	445	445	445	33.3%
Age 4	2	818	683	952	655	535	775	66.7%
Total	3							

Table 22. 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 2010-2012.

		Fork Length			POH Length			
Spring Chinook	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2010								
Ad clipped								
Age 3	15	607	495	836	507	405	715	23.4%
Age 4	47	744	640	886	635	522	787	73.4%
Age 5	2	826	810	842	696	680	712	3.1%
Total	64							
Unmarked								
Age 4	7	773	691	870	649	594	717	50.0%
Age 5	7	768	704	810	663	604	710	50.0%
Total	14							
2011								
Ad clipped								
Age 3	6	543	492	600	464	418	518	9.1%
Age 4	46	737	566	866	636	497	755	69.7%
Age 5	14	862	794	915	752	677	855	21.2%
Total	66							
Unmarked								
Age 3	2	522	522	522	455	455	455	6.7%
Age 4	24	749	573	841	640	504	700	80.0%
Age 5	4	871	784	916	758	690	821	13.3%
Total	30							
2012								
Ad clipped								
Age 3	5	531	447	640	446	371	548	6.5%
Age 4	49	714	580	830	606	490	710	63.6%
Age 5	23	840	714	940	726	606	831	29.9%
Total	77							
Unmarked								
Age 3	1	530	530	530	451	451	451	2.7%
Age 4	19	732	640	834	625	545	709	51.4%
Age 5	17	846	745	943	722	641	828	45.9%
Total	37							

Table 23. 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 2010-2012.

Spring Chinook	Count	Fork Length			POH Length			% of Total
		Mean	Min	Max	Mean	Min	Max	
2010								
Ad clipped								
Age 2	9	297	247	345				3.2%
Age 3	12	556	460	643	462	377	536	4.3%
Age 4	246	745	567	916	628	474	767	87.2%
Age 5	15	846	740	920	712	608	770	5.3%
Total	282							
Unmarked								
Age 4	2	782	765	798	658	645	670	100.0%
Total	2							
2011								
Ad clipped								
Age 3	59	529	435	635	449	370	545	
Age 4	107	738	485	910	624	410	780	
Age 5	15	831	725	943	707	610	810	
Total	181							
Unmarked								
Age 4	1	686	686	686	585	585	585	100.0%
Total	1							
2012								
Ad clipped								
Age 2	6	297	250	395	240	215	265	2.4%
Age 3	37	602	455	715	508	390	600	15.1%
Age 4	170	726	585	943	619	495	790	69.4%
Age 5	32	827	710	975	706	590	810	13.1%
Total	245							
Unmarked								
Age 2	1	282	282	282	240	240	240	50.0%
Age 3	1	675	675	675	570	570	570	50.0%
Total	2							

Table 24. 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 2010-2012.

Fall Chinook	Count	Fork Length			POH Length			% of Total
		Mean	Min	Max	Mean	Min	Max	
2010								
Ad clipped								
Age 3	19	701	592	790	573	483	686	59.4%
Age 4	8	727	609	875	611	496	775	25.0%
Age 5	5	922	830	1022	742	665	815	15.6%
Total	32							
Unmarked								
Age 2	2	491	465	517	384	341	426	1.9%
Age 3	25	710	476	862	578	390	700	23.8%
Age 4	37	824	647	1097	669	533	855	35.2%
Age 5	41	908	766	1045	733	629	826	39.0%
Total	105							
2011								
Ad clipped								
Age 3	8	712	457	791	580	373	658	14.8%
Age 4	40	807	716	923	666	590	764	74.1%
Age 5	6	843	758	924	697	631	750	11.1%
Total	54							
Unmarked								
Age 3	30	675	404	923	551	325	750	28.0%
Age 4	61	827	698	1057	679	575	815	57.0%
Age 5	16	892	776	1007	728	635	820	15.0%
Total	107							
2012								
Ad clipped								
Age 3	2	549	433	664	434	334	534	12.5%
Age 4	6	726	623	870	598	512	715	37.5%
Age 5	8	858	783	934	688	577	755	50.0%
Total	16							
Unmarked								
Age 3	8	501	410	654	415	340	553	11.0%
Age 4	38	728	555	922	581	446	722	52.1%
Age 5	27	848	660	969	694	565	775	37.0%
Total	73							

Table 25. 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 2010-2012. Adult trap shutdowns during construction improvements at the Lyle Falls Fishway resulted in no 2010 samples; 2012 samples are still being processed.

		Fork Length			POH Length			
Fall Chinook	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2011								
Ad clipped								
Age 3	2	556	536	575	459	427	490	13.3%
Age 4	8	742	610	833	637	517	740	53.3%
Age 5	5	852	790	934	717	670	780	33.3%
Total	15							
Unmarked								
Age 3	1	420	420	420	360	360	360	2.6%
Age 4	17	777	620	943	657	490	810	43.6%
Age 5	21	852	734	1036	720	592	850	53.8%
Total	39							

Table 26. 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 2010-2012.

		Fork Length			POH Length			
Coho	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2010								
Unmarked								
Age 3	1	833	833	833	640	640	640	100.0%
Total	1							
2011								
Ad clipped								
Age 3	9	719	620	799	583	520	641	100.0%
Total	9							
Unmarked								
Age 3	7	748	690	785	601	536	654	100.0%
Total	7							
2012								
Ad clipped								
Age 2	1	390	390	390	300	300	300	4.8%
Age 3	20	678	490	787	559	395	653	95.2%
Total	21							
Unmarked								
Age 3	1	610	610	610	485	485	485	100.0%
Total	1							

Table 27. 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 2010-2012. Adult trap shutdowns during construction improvements at the Lyle Falls Fishway resulted in no 2010 samples; 2012 samples are still being processed.

		Fork Length			POH Length			
Coho	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2011								
Ad clipped								
Age 3	1	501	501	501	429	429	429	100.0%
Total	1							

Table 28. 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 2010-2012.

		Fork Length			POH Length			
Steelhead	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2010								
Unmarked								
Age 4	1	715	715	715	565	565	565	100.0%
Total	1							
2011								
Ad clipped								
Age 4	1	783	783	783	658	658	658	100.0%
Total	1							
Unmarked								
Age3	1	81	81	81	66	66	66	100.0%
Total	1							

Table 29. 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 2010-2012.

		Fork Length			POH Length			
Steelhead	Count	Mean	Min	Max	Mean	Min	Max	% of Total
2010								
Ad clipped								
Age 3	2	582	571	592	517	506	527	3.8%
Age 4	50	709	610	780	605	516	672	94.3%
Age 5	1	870	870	870	781	781	781	1.9%
Total	53							
Unmarked								
Age 3	6	660	540	750	559	480	611	15.0%
Age 4	33	733	620	835	624	512	731	82.5%
Age 5	1	760	760	760	670	670	670	2.5%
Total	40							
2011								
Ad clipped								
Age 2	4	577	552	591	501	478	519	4.1%
Age 3	63	691	590	802	596	494	706	64.9%
Age 4	27	788	578	905	673	490	791	27.8%
Age 5	3	828	813	851	702	690	710	3.1%
Total	97							
Unmarked								
Age 2	7	600	534	640	510	480	552	6.0%
Age 3	51	677	510	780	577	475	680	44.0%
Age 4	56	745	597	921	640	473	809	48.3%
Age 5	2	808	798	817	700	690	710	1.7%
Total	116							
2012								
Ad clipped								
Age 2	1	695	695	695	591	591	591	1.3%
Age 3	56	703	585	860	600	490	748	71.8%
Age 4	21	744	634	835	635	541	724	26.9%
Total	78							
Unmarked								
Age 2	1	635	635	635	530	530	530	1.1%
Age 3	35	690	580	854	588	485	708	37.6%
Age 4	55	731	598	837	621	502	720	59.1%
Age 5	2	774	753	795	647	630	663	2.2%
Total	93							

Table 30. Location and physical characteristics in fish tagging sites located in the White Creek drainage. ± indicate standard error of the mean.

Stream	Site ID	Length (m)	Mean Sample Width (m)	Sample Area (m)	Start Elevation (m)	Distance from Klickitat River (km)	Start Latitude	Start Longitude	End Latitude	End Longitude
Brush Ck	**---**	**1164**	**4.0 ±0.32**	**4975.4**	**577**	**7.97**	**46.09513**	**-121.04949**	**46.098467**	**-121.04719**
	70	664	4.4 ±0.12	2892.3	799	14.98	46.09513	-121.04949	46.098467	-121.04719
	71	200	4.3 ±0.78	856.7	679	11.38	46.07639	-121.07273	46.07727	-121.07229
	72	300	3.4 ±0.24	1226.4	577	7.97	46.06453	-121.10219	46.06668	-121.10004
Blue Creek		**204**	3.1±0.16	**641.7**	**681**	**11.48**	**46.07669**	**-121.07150**	**46.07682**	**-121.06883**
	50	204	3.1±0.16	641.7	681	11.48	46.07669	-121.07150	46.07682	-121.06883
E. F. Tepee Ck	**---**	**355**	**3.8 ±0.25**	**1360.2**	**857**	**22.17**	**46.15306**	**-121.0405**	**46.153094**	**-121.0372**
	89	355	3.8 ± 0.25	1360.2	857	22.17	46.15306	-121.0405	46.153094	-121.0372
Tepee Ck		**1635**	**3.4 ±0.14**	**6131.6**	**780**	**16.63**	**46.12509**	**-121.07334**	**46.172789**	**-121.03274**
	80	406	4.3 ±0.17	1736.1	780	16.63	46.12509	-121.07334	46.126242	-121.07011
	81	440	4.2 ±0.16	1852.4	835	20.81	46.14936	-121.05336	46.151743	-121.05241
	82	90	2.7 ±0.11	241.9	882	23.74	46.16527	-121.03702	46.165544	-121.03621
	83	76	2.6 ±0.14	199.4	884	23.86	46.16579	-121.03566	46.165961	-121.03519
	84	119	2.9 ±0.15	350.2	889	24.33	46.1691	-121.03373	46.169612	-121.03431
	85	258	3.8 ±0.13	967.5	902	25.63	46.17712	-121.02783	46.178553	-121.02627
	86	164	3.1 ±0.11	515.0	958	29.64	46.19728	-121.00887	46.201535	-121.0045
	87	82	3.3 ±0.16	269.1	892	24.77	46.17226	-121.03324	46.172789	-121.03274
W.F. White Ck	**---**	**410**	**2.6 ±0.16**	**1081.6**	**785**	**16.94**	**46.12661**	**-121.0766**	**46.126404**	**-121.08101**
	79	410	2.6 ±0.16	1081.6	785	16.94	46.12661	-121.0766	46.126404	-121.08101
White Ck	**---**	**2960**	**4.0 ±0.61**	**14805.9**	**348**	**0.20**	**46.01432**	**-121.1495**	**46.043311**	**-121.11423**
	60	300	6.1 ±0.35	1843.1	576	7.81	46.06318	-121.10184	46.06564	-121.10290
	90	275	5.9 ±0.48	1617.6	348	0.20	46.01432	-121.1495	46.016153	-121.14855
	91	192	1.8 ±0.14	340.4	1029	28.72	46.21475	-121.08874	46.215477	-121.09045
	92	588	7.2 ±0.32	4206.2	768	14.74	46.11029	-121.07119	46.114495	-121.06848
	93	360	3.9 ±0.23	1400.2	892	24.05	46.17906	-121.07102	46.181672	-121.07072
	94	615	4.8 ±0.35	2963.9	778	16.94	46.12399	-121.07249	46.127757	-121.07686
	95	96	1.9 ±0.14	184.8	814	19.21	46.14345	-121.07463	46.143617	-121.07369
	96	107	3.2 ±0.23	341.4	815	19.32	46.14389	-121.07333	46.144527	-121.07336
	97	65	1.9 ±0.16	121.6	884	23.33	46.17473	-121.07377	46.17494	-121.07301
	98	80	1.8 ±0.15	145.3	885	23.44	46.17485	-121.07234	46.174933	-121.07141
	99	282	5.8 (0.290	1641.4	514	4.86	46.04247	-121.11752	46.043311	-121.11423

Table 31. Summary statistics of 2010 PIT tagged *Oncorhynchus mykiss* collected from single-pass electrofishing. Parentheses denote the additional number of fish sampled in multiple pass depletion. ± indicate standard error of the mean.

Stream	Sample Date	Site ID	No. Fish* Tagged	Mean Length (mm)	Median Length (mm)	Length Range (mm)	Mean Weight (g)	Median Weight (g)	Weight Range (g)
Brush Ck	---		**47**	**108.7 ±4.1**	**101**	**73-183**	19.7 **±2.4**	**12.4**	**4.5-82.9**
	6/15/10	70	47	108.7 ±4.1	101	73-183	19.7 ±2.4	12.4	4.5-82.9
	---	71	---	---	---	---	---	---	---
	---	72	---	---	---	---	---	---	---
Blue Ck	---	---	---	---	---	---	---	---	---
	---	50	---	---	---	---	---	---	---
EF Tepee Ck	---		**32**	**117.0 ±5.9**	**119**	**70-190**	**22.9 ±3.2**	**20.2**	**3.8-74.8**
	6/28/10	89	32	117.0 ±5.9	119	70-190	22.9 ±3.2	20.2	3.8-74.8
Tepee Ck			**455 (101)**	**110.7 ±1.3**	**109.0**	**65-207**	**19.7 ±0.8**	**15.4**	**2.7-114.5**
	6/17/10	80	64	105.7 ±3.7	95.5	68-197	19.1 ±2.4	10.2	3.7-99.8
	6/21/10	81	53	109.9 ±3.5	109	74-190	18.6 ±2.2	14.4	4.1-86.8
	7/19/10	82	11 (2)	112.0 ±5.4	109	90-156	17.9 ±2.4	14.7	9.6-33.5
	10/12/10	82	13 (20)	104.1 ±5.3	104	64-158	19.5 ±4.2	14.4	3.1-42.9
	7/19/10	83	14 (10)	118.3 ±5.7	114.5	79-207	27.1 ±7.5	19.8	6.2-114.5
	10/12/10	83	13 16)	100.2 ±6.4	95	66-210	18.2 ±7.9	4.5	3.0-106.6
	7/20/10	84	17 (18)	114.9 ±4.2	107	85-180	25.1 ±4.2	18.1	8.9-77.8
	10/13/10	84	17 (11)	108.1 ±5,2	106.5	70-160	14.2 ±2.5	11.1	3.5-32.9
	6/22/10	85	175	112.2 ±1.9	109	75-195	19.8 ±1.1	15.7	3.7-97.5
	6/25/10	86	45	104.6 ±3.8	106	65-152	17.2 ±1.8	16.0	2.7-49.2
	7/21/10	87	22 (17)	117.3 ±3.9	112	87-185	21.7 ±2.7	17.8	8.2-57.1
	10/13/10	87	11 (7)	94.2 ±6.1	92	68-159	6.2 ±1.1	4.1	2.3-12.1
WF White Ck	---		**19**	**96.4 ±4.2**	**88**	**75-136**	**11.8 ±1.8**	**7.6**	**4.5-30.9**
	6/29/10	79	19	96.4 ±4.2	88	75-136	11.8 ±1.8	7.6	4.5-30.9
White Ck	---		**556 (61)**	**108.6 ±1.4**	**102.0**	**65-292**	**19.7 ±1.0**	**11.9**	**2.2-235.1**
	---	60	---	---	---	---	---	---	---
	8/19/10	90	148	107.3 ±2.6	100.5	65-268	19.1 ±2.1	11.4	2.2-235.1
	7/9/10	91	28	107.9 ±4.0	109.5	65-145	16.5 ±1.8	14.6	3.2-36.5
	7/1/10	92	124	103.1 ±2.9	94	65-292	16.0 ±1.4	9.5	2.8-103.6
	6/16/10	93	14	133.2 ±10.8	119.5	82-225	37.2 ±9.8	21.9	6.4-132.1
	7/8/10	94	51	106.0 ±4.1	94	70-175	18.6 ±2.5	10.3	3.5-83.3
	7/26/10	95	13 (14)	99.6 ±5.7	86	71-173	16.4 ±4.0	8.1	5.1-44.6
	10/19/10	95	19 (11)	98.6 ±4.3	92.5	73-176	12.3 ±2.3	8.8	6.0-49.2
	7/26/10	96	11 (10)	111.3 ±6.9	101	74-175	19.2 ±4.2	9.5	5.7-44.1
	10/19/10	96	7 (7)	89.2 ±3.9	86	72-129	9.7 ±2.6	8.1	4.4-24.6
	7/29/10	97	14 (9)	125.4 ±6.9	127	73-207	30.9 ±7.3	29.3	5.6-101.8
	10/20/10	97	14 (7)	118.1 ±6.8	105	79-182	24.1 ±5.6	17.2	5.6-76.4
	7/29/10	98	7 (2)	102.2 ±10.3	110	66-155	19.2 ±5.5	17.4	3.5-46.6
	10/20/10	98	5 (1)	92.2 ±14.6	82.5	68163	16.0 ±9.9	6.9	4.2-55.3
	7/27/10	99	129	113.0 ±2.6	109	65-223	22.5 ± 2.3	14.4	3.2-165.9
Total	---	---	**1137 (162)**	**108.9 ±0.9**	**104**	**65-292**	**19.7 ± 0.6**	**12.5**	**2.2-235.1**

Table 32. Summary statistics of 2011 PIT tagged *Oncorhynchus mykiss* collected from single-pass electrofishing. Parentheses denote the additional number of fish sampled in multiple pass depletion. ± indicate standard error of the mean.

Stream	Sample Date	Site ID	No. Fish Tagged	Mean Length (mm)	Median Length (mm)	Length Range (mm)	Mean Weight (g)	Median Weight (g)	Weight Range (g)
Brush Ck	---		**304**	**110.5 ±1.6**	**100.0**	**66-202**	**20.1 ±1.0**	**13.0**	**3.7-92.7**
	7/11/11	70	119	124.3 ±2.6	123	84-202	27.9±1.7	23.7	8.0-92.7
	8/18/11	71	91	105.7 ±2.4	97.0	76–187	16.66 ±1.4	11.2	8.0-92.7
	8/15/11	72	94	97.5 ±2.4	91.5	66-194	13.4 ±1.2	9.5	3.7-83.9
Blue Ck	---	---	**89**	**101.7**	**96.0**	**73–163**	**14.5**	**10.0**	**4.5–16.9**
	8/18/11	50	89	101.7	96.0	73–163	14.5	10.0	4.5–16.9
EF Tepee Ck	---		**35**	**103.5 ±4.8**	**93.0**	**70-160**	**16.3 ±2.3**	**9.1**	**4.3-47.3**
	7/19/11	89	35	103.5 ±4.8	93.0	70-160	16.3 ±2.3	9.1	4.3-47.3
Tepee Ck			**590 (112)**	**102.6 ±1.1**	**96.0**	**60-194**	15.5±0.6	11.1	2.7-93.3
	7/13/11	80	69	93.8 ±2.8	85.0	61-158	11.6 ±1.2	7.6	3.2-46.5
	7/14/11	81	92	92.3 ±2.7	83.0	60-169	12.1 ±1.3	6.7	3.0-64.1
	7/27/11	82	15 (11)	102.3 ±7.6	96.0	71-167	12.8 ±3.0	8.2	3.5-42.3
	10/25/11	82	10 (8)	97.0 ±10.6	86.0	68-171	10.0 ±3.5	5.4	3.0-38.6
	7/27/11	83	18 (3)	105.1 ±6.8	93.0	66-152	14.1 ±2.5	8.3	2.7-33.3
	10/25/11	83	23 (19)	98.9 ±5.2	96.0	65-155	10.2 ±1.5	8.0	2.7-31.9
	7/27/11	84	48 (17)	104.2 ±7.6	94.5	71-149	16.5 ±3.3	11.7	4.3-39.1
	10/27/11	84	22 (21)	102.1 ±6.0	95.0	67-167	15.9 ±3.1	10.2	3.5-59.6
	8/10/11	85	206	112.1 ±1.7	105.0	76-194	19.5 ±1.1	13.7	5.2-93.3
	7/08/11	86	51	95.7 ±2.7	94.0	65-142	12.2 ±1.1	9.4	3.3-36.7
	7/28/11	87	21 (17)	109.7 ±5.8	100.0	78-168	18.9 ±3	13.4	5.9-56.4
	10/27/11	87	15 (16)	105.1 ±7.4	98.0	70-156	13.5 ±3.0	7.9	3.3-41.4
WF White Ck	---		**24**	**88.5 ±3.0**	**85.5**	**67-134**	**9.2 ±1.0**	**7.7**	**3.8-28.0**
	7/20/11	79	24	88.5 ±3.0	85.5	67-134	9.2 ±1.0	7.7	3.8-28.0
White Ck	---		**1150 (100)**	**102.3 ±0.8**	**95.0**	**63-320**	**16.1 ±0.6**	**10.4**	**2.7-223.5**
	8/16/11	60	134	105.6 ±2.6	96.0	66-268	18.5 ±2.1	11.3	3.0-223.5
	8/09/11	90	235	102.0 ±1.6	95.0	68-208	14.9 ±0.9	10.1	4.3-105.8
	7/22/11	91	25	103.2 ±4.7	105.0	63-144	16.2 ±2.1	15.0	3.2-40.6
	7/26/11	92	101	103.6 ±3.5	96	70-320	15.5 ±1.5	10.9	3.8-114.2
	7/12/11	93	56	114.1 ±3.5	114.1	80-205	21.6 ±2.2	14.6	6.2-92.2
	7/21/11	94	105	97.2 ±2.5	89	65-193	14.2 ±1.4	8.9	3.7-98.9
	8/01/11	95	26 (417)	88.1 ±4.8	81	65-177	11.0 ±2.4	7.2	3.4-63.7
	10/18/11	95	31 (24)	83.8 ±1.4	83.0	69-100	7.1 ±0.4	6.6	3.5-11.3
	8/01/11	96	26 (7)	91.6 ±3.2	91.0	70-132	10.4 ±1.2	9.2	3.9-28.7
	10/18/11	96	33 (16)	90.6 ±3.6	82.0	70-151	10.2 ±1.5	6.6	4.3-37.5
	8/02/11	97	6 (10)	111.0 ±11.3	106	81-158	19.6 ±6.6	14.1	7.2-51.2
	10/19/11	97	13 (10)	125.8 ±10.2	111	89-190	28.6 ±7.3	16.1	8.0-86.9
	8/02/11	98	12 (7)	113.0 ±8.8	102	82-173	21.4 ±5.0	12.45	7.8-62.1
	10/19/11	98	9 (6)	111.1 ±9.5	114.0	67-149	19.4 ±4.0	18.0	4.7-38.8
	8/03/11	99	338	101.9 ±1.5	93.0	70-250	16.4 ± 1.2	9.8	3.9-203.4
Total	---	---	**2192 (212)**	**103.4±0.6**	**96.0**	**60-320**	**16.4 ±0.4**	**10.9**	**2.7-223.5**

Table 33. PIT tag detection summary for *Oncorhynchus mykiss* at the White Creek PIT tag array and Columbia River (CR) for the 2010-2012 migration years (Oct.1, 2010 – Sept. 30, 2012).

Stream	Site ID	No. Fish Detected at White Creek (WC) array				No. Fish Detected in Columbia River (CR)			
		2009 Tag Group	2010 Tag Group	2011 Tag Group	Total WC Detections	2009 Tag Group	2010 Tag Group	2011 Tag Group	Total CR Detections
Brush Creek	---	**3**	**8**	**28**	**39**	**1**	**2**	**2**	**5**
	70	3	8	8	19	1	2	2	5
	71	---	---	5	5	0	0	0	0
	72	---	---	15	15	0	0	0	0
Blue Creek		---	---	**6**	**6**				
	50	---	---	6	6				
E.F. Tepee Creek		**1**	**2**	**5**	**8**	**0**	**0**	**0**	**0**
	89	1	2	5	8	0	0	0	0
Tepee Creek		**11**	**54**	**52**	**117**	**3**	**5**	**1**	**9**
	80	3	4	12	19	0	2	1	3
	81	2	5	6	13	0	0	0	0
	82	0	5	5	10	1	1	0	2
	83	1	9	6	16	0	1	0	1
	84	2	5	8	15	0	1	0	1
	85	3	12	11	26	1	0	0	1
	86	0	2	0	2	1	0	0	1
	87	0	12	4	16	0	0	0	0
W.F. White Creek	---	**0**	**3**	**3**	**6**	**0**	**0**	**0**	**0**
	79	0	3	3	6	0	0	0	0
White Creek	---	**38**	**135**	**237**	**410**	**8**	**7**	**5**	**20**
	60	---	---	22	22	0	0	1	1
	90	20	50	87	157	1	1	1	3
	91	1	0	0	1	0	0	0	0
	92	2	26	17	45	1	4	1	6
	93	0	0	4	4	0	0	1	1
	94	3	11	12	26	2	0	0	2
	95	3	16	15	34	1	0	0	1
	96	0	4	9	13	1	1	0	2
	97	1	0	4	5	0	0	0	0
	98	0	1	2	3	0	0	0	0
	99	8	27	65	100	2	1	1	4
Total	---	**53**	**202**	**331**	**586**	**12**	**14**	**8**	**34**

Table 34. Summary statistics of *O. mykiss* abundance for the summer 2010 tag cohort and out-migrant densities for 2010-2011 migration years. Analysis limited to single-pass electrofishing.

Stream	Sample Date	Site ID	No. Fish Tagged	2010 *O. mykiss* Abundance (fish/100m^2)	2010-2011 *O. mykiss* Out-migrants (fish/100m^2)
Brush Ck	---		**47**	**1.6**	**0.38**
	6/15/10	70	47	1.6	0.38
	---	71	---		
	---	72	---		
Blue Ck	---	---	---		
	---	50	---		
EF Tepee Ck	---		**32**	**2.4**	**0.15**
	6/28/10	89	32	2.4	0.15
Tepee Ck			**401**	**6.5**	
	6/17/10	80	64	3.7	0.29
	6/21/10	81	53	2.9	0.32
	7/19/10	82	11	4.5	1.65
	7/19/10	83	14	7.0	2.51
	7/20/10	84	17	4.9	1.14
	6/22/10	85	175	18.1	1.45
	6/25/10	86	45	8.7	0.39
	7/21/10	87	22	8.2	1.86
WF White Ck	---		**19**	**1.8**	**0.28**
	6/29/10	79	19	1.8	0.28
White Ck	---		**539**	**4.2**	**1.06**
	---	60	---	---	
	8/19/10	90	148	9.1	3.96
	7/9/10	91	28	8.2	0.29
	7/1/10	92	124	2.9	0.48
	6/16/10	93	14	1.0	0.0
	7/8/10	94	51	1.7	0.37
	7/26/10	95	13	7.0	4.33
	7/26/10	96	11	3.2	0.88
	7/29/10	97	14	11.5	0
	7/29/10	98	7	4.8	0
	7/27/10	99	129	7.9	1.89
Total	---	---	**1038**	**4.3**	**0.81**

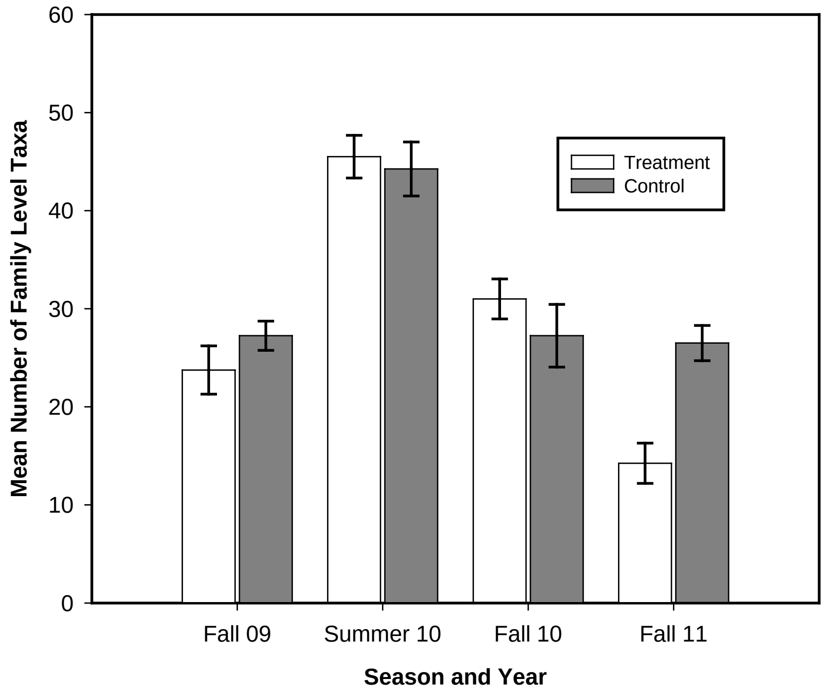
Table 35. Summary statistics of *O. mykiss* abundance for the summer 2011 tag cohort and out-migrant densities for 2011-2012 migration years. Analysis limited to single-pass electrofishing.

Stream	Sample Date	Site ID	No. Fish Tagged	2011 *O. mykiss* Abundance (fish/100m^2)	2011-2012 *O. mykiss* Out-migrants (fish/100m^2)
Brush Ck	---		**304**	**7.5**	**0.56**
	7/11/11	70	119	4.1	0.28
	8/18/11	71	91	10.6	0.58
	8/15/11	72	94	7.7	1.22
Blue Ck	---	---	**89**	**13.9**	**0.95**
	8/18/11	50	89	13.9	0.95
EF Tepee Ck	---		**35**	**2.6**	**0.44**
	7/19/11	89	35	2.6	0.44
Tepee Ck			**520**	**8.6**	**0.78**
	7/13/11	80	69	4.0	0.86
	7/14/11	81	92	5.0	0.38
	7/27/11	82	15	6.2	1.24
	7/27/11	83	18	9.0	2.51
	7/27/11	84	48	13.7	0.86
	8/10/11	85	206	21.3	1.24
	7/08/11	86	51	9.9	0
	7/28/11	87	21	7.8	1.11
WF White Ck	---		**24**	**2.2**	**0.28**
	7/20/11	79	24	2.2	0.28
White Ck	---		**1064**	**7.2**	**1.66**
	8/16/11	60	134	7.3	1.19
	8/09/11	90	235	14.5	5.56
	7/22/11	91	25	7.4	0
	7/26/11	92	101	2.4	0.59
	7/12/11	93	56	4.0	0.29
	7/21/11	94	105	3.5	0.51
	8/01/11	95	26	14.1	5.41
	8/01/11	96	26	7.6	2.05
	8/02/11	97	6	4.9	1.64
	8/02/11	98	12	8.3	0.69
	8/03/11	99	338	20.6	4.26
Total	---	---	**2036**	**7.0**	**1.16**

Table 36. Summary of pre-treatment food web samples collected October 2009 – October 2011. NC denotes no data collected.

Stream	Sample Type	Year	Season	# Benthic Samples	# Drift Samples	# Pan Trap Samples	# Stomach Samples
Tepee Ck	Treatment	2009	Fall	3	4	36	20
		2010	Spring	12	NC	NC	NC
		2010	Summer	12	16	35	74
		2010	Fall	12	16	35	77
		2011	Fall	12	16	35	70
		2010	**Total**	**51**	**52**	**141**	**241**
White Ck	Control	2009	Fall	3	4	36	26
		2010	Spring	12	NC	NC	NC
		2010	Summer	12	16	33	67
		2010	Fall	12	16	35	61
		2011	Fall	12	16	36	75
		2010	**Total**	**51**	**52**	**140**	**229**

a) Terrestrial Taxa



b) Aquatic Taxa

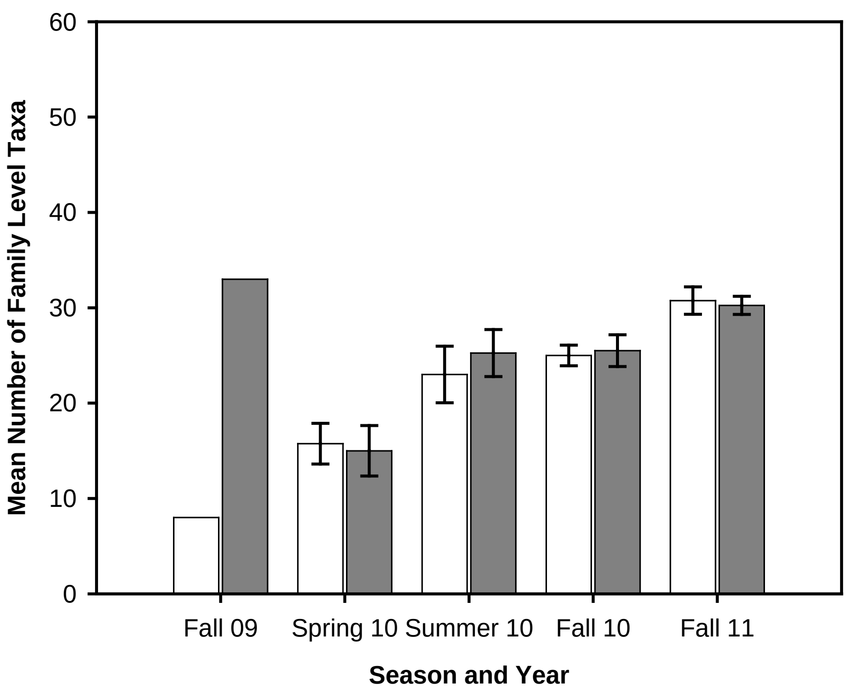


Figure 17. Comparison of the mean number of (a) terrestrially derived and (b) aquatically derived Family level tax in pre-treatment and control sites. Error bars indicate ± standard error of the mean.

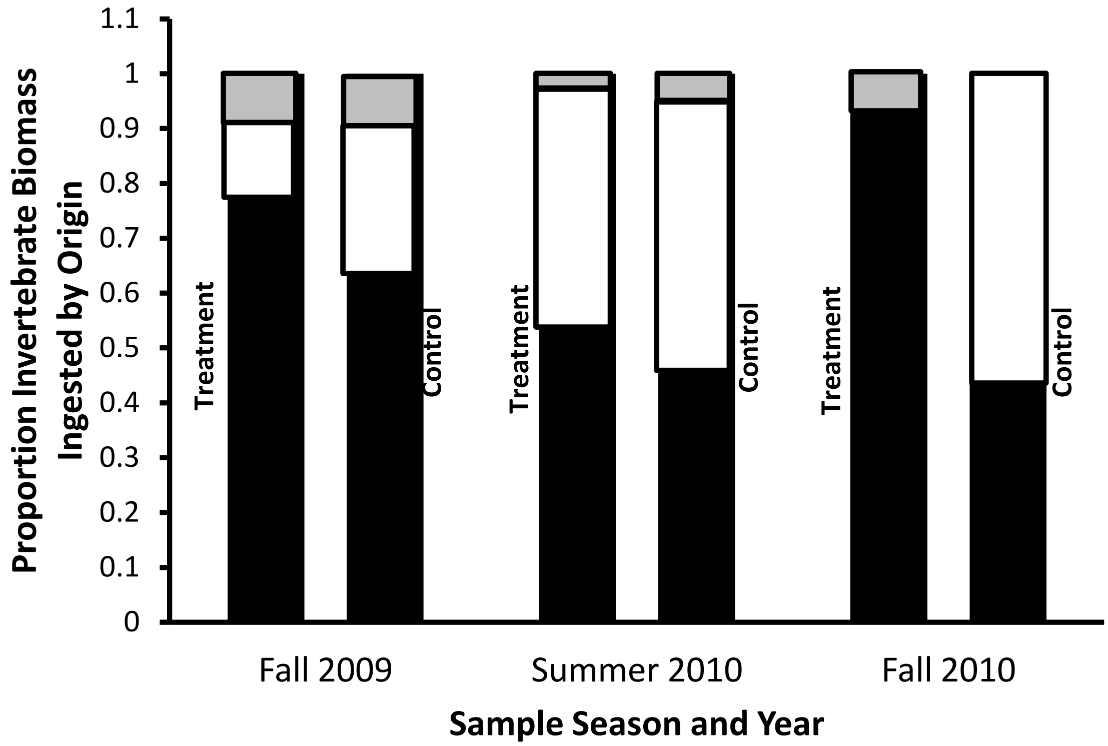


Figure 18. Seasonal comparison of ingested invertebrate biomass composition by aquatic (black), terrestrial (white), and unknown (grey) origin in treatment and control sites.

Table 37. 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

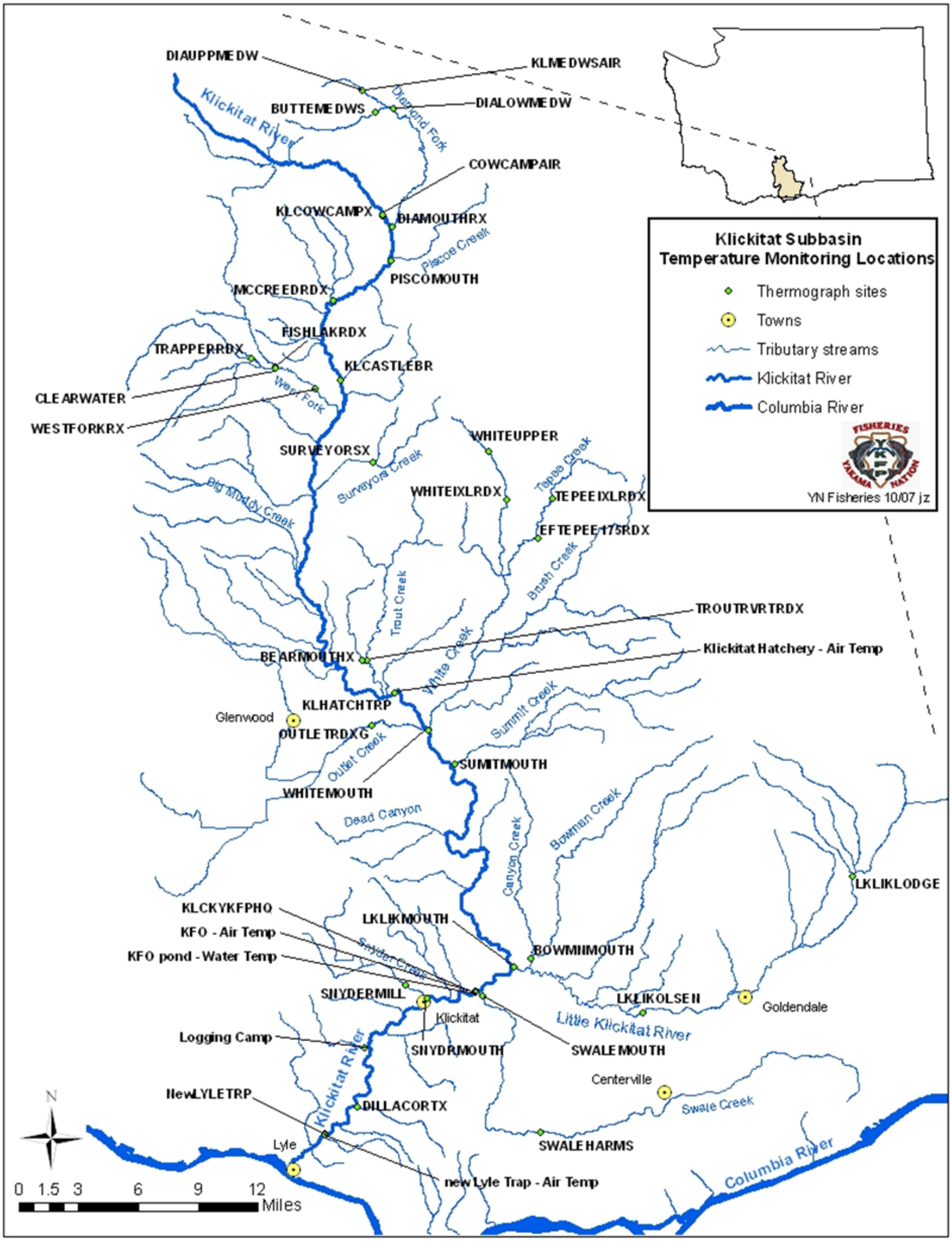


Figure 19. Locations of Klickitat subbasin temperature and water quality monitoring sites.

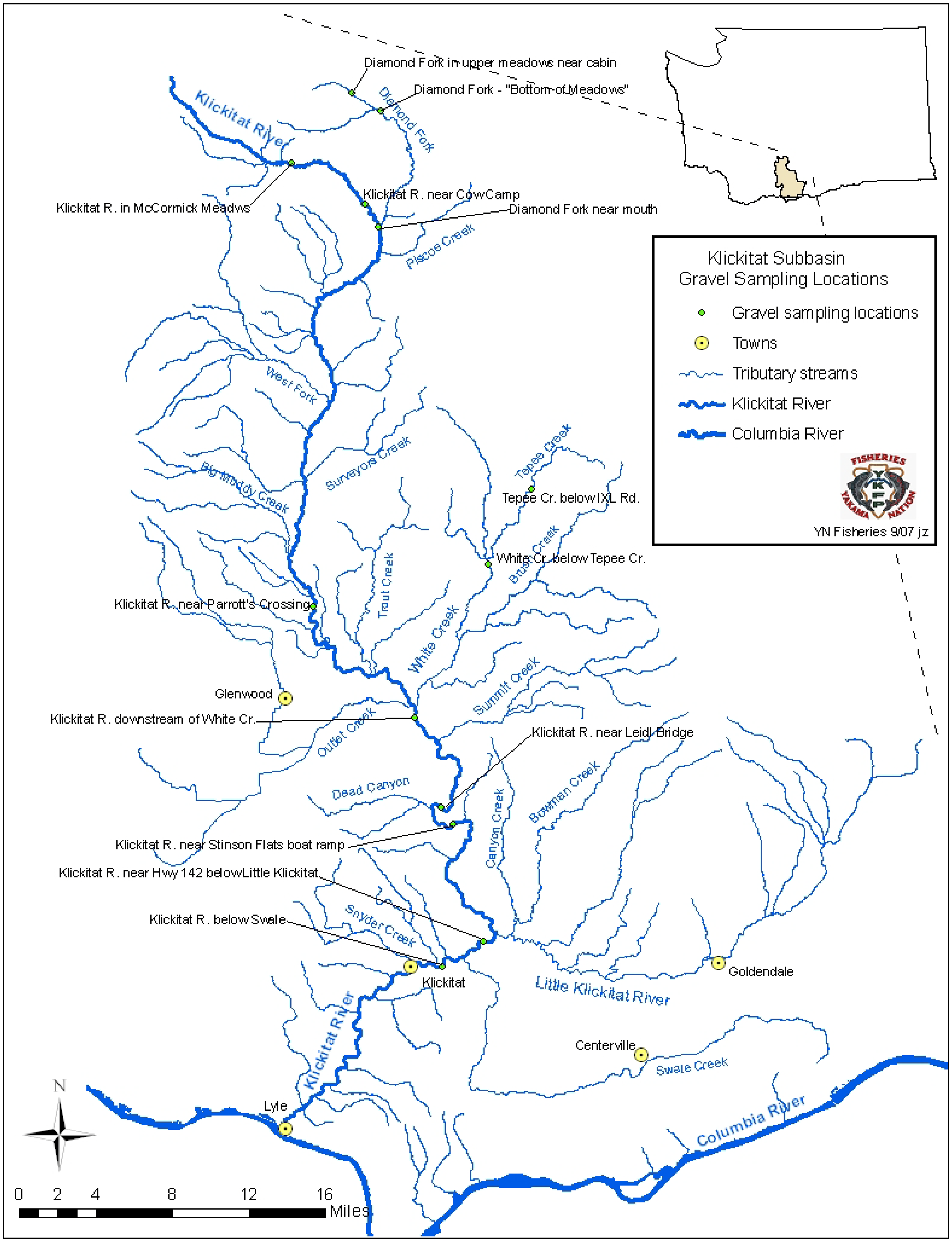


Figure 20. Locations of Klickitat subbasin sediment sampling sites.