ASOTIN CREEK

INTENSIVELY MONITORED WATERSHED:

SUMMARY OF MONITORING AND RESTORATION

2016 PROGRESS REPORT

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EXECUTIVE SUMMARY

Background

The Asotin Creek Intensively Monitored Watershed (IMW) was implemented in 2008 after an extensive selection process coordinated by the Snake River Salmon Recovery Board in and consultation with the Regional Technical Team. Asotin Creek was chosen as an IMW location in southeast Washington because there was extensive fish and habitat data going back to the 1980's, ongoing Washington Department of Fish and Wildlife (WDFW) fish-in fish-out monitoring, minimal hatchery influence, moderate seeding levels of steelhead, and agency and public support. Based on previous habitat assessments and preliminary IMW monitoring it was decided that riparian function and instream habitat complexity were impaired. The restoration proposed was fencing, native plant revegetation, and weed control to enhance riparian function in the long-term, and the addition of large woody debris (LWD) in the short-term to increase habitat diversity and promote a more dynamic channel (e.g., increase sediment sorting, pool frequency, and floodplain connection).

Design and Monitoring

We have implemented the IMW within an adaptive management framework and have revised the experimental design, restoration plan, and monitoring plan using the iterative evaluation process of adaptive management. The experimental design has been finalized and includes three study creeks in the upper part of the watershed: Charley Creek, North Fork Asotin Creek (North Fork) and South Fork Asotin Creek (South Fork). The first 12 km of each stream is divided into three 4 km long sections: one section of each stream was restored (treatment sections) each year from 2012-2014 with two sections within each creek used as control sections. In 2016, we treated one more section of South Fork so that there are now two treatment sections and one control section in South Fork. We are monitoring juvenile steelhead abundance, growth, survival, movement, production, and productivity in each section using mark-recapture and mobile PIT tag surveys in 300-600 m fish sites. All steelhead ≥70 mm are PIT tagged, weighed (nearest 0.1 g), and measured (fork length nearest mm) and a subsample of scales are collected to estimate the age distribution. Mark-recapture surveys are conducted in the summer (June-July) and fall (September-October) every year and mobile PIT tag surveys are conducted in the winter (December-January) and spring (March-April) each year to allow for estimation of seasonal population parameters. Stream and riparian habitat were measured using the Pacfish-Infish Biological Opinion protocol (PIBO) from 2008-2009 and are now measured using the Columbia Habitat Monitoring Protocol (CHaMP). LiDAR, aerial photography, temperature, and discharge monitoring is also conducted throughout the watershed to aid in the interpretation of habitat and fish responses. Data from the WDFW fish-in fish-out monitoring is integral to the IMW monitoring program and will be used to assess productivity at the watershed scale pre and post restoration, as well as to provide detailed information on annual variation in adult and juvenile population parameters.

Restoration

The treatment section of South Fork was restored in 2012 (after summer mark-recapture and habitat surveys). A total of 196 LWD structures were built consisting of 585 pieces of LWD (> 0.1 m diameter and > 1.0 m in length). The LWD structures were built mostly by hand using wooden fence posts driven into the stream bottom to secure LWD in place. These structures consisted of deflector, mid-channel, spanners/debris jams, and key piece structures. In 2013, the treatment section of Charley Creek was restored in a similar manner to the South Fork and a total of 207 LWD structures were built using 497 pieces of LWD. In 2014, the treatment section of North Fork was restored. A total of 135 LWD structures were built and 568 pieces of LWD were added to the North Fork. In the summer of 2016 we decided to conduct maintenance/enhancement of the existing LWD structures and to increase the extent of the existing South Fork treatment section. The restoration in 2016 was designed to 1) add another "step" in our staircase experimental design and 2) increase the robustness and extent of the existing restoration to increase the likelihood of detecting habitat and fish responses. Approximately 150-200 additional LWD pieces were added to the existing three treatment sections in 2016 and 116 new structures were built in Section 1 of the South Fork. The new treatment section increases the total length of treated stream from 12 to 14 km out of 36 km of the study area (38.9%) and the total number of LWD structures from 538 to 654 (4.7 LWD structures/100 m).

Trends and Moving Forward

We continue to assess the preliminary habitat and fish responses annually but caution that due to high natural variability, more years of post-treatment monitoring are required (as well as further analyses of existing data) to fully understand the effectiveness of the LWD treatments. Habitat changes are showing stronger trends than fish responses although not all habitat metrics that we have reviewed are trending as predicted. We have observed positive trends in fish abundance but we have not fully assessed fish responses to the restoration. Juvenile steelhead abundance increased in the treatment compared to the control sections in all three tributaries following restoration. We have not observed strong trends in growth, suggesting there is limited density dependence. We continue to collect data and calculate growth and movement annually but have not developed models yet to assess what factors effect annual variation. We are also continuing to collect data that will support the calculation of survival, productivity, and production at different temporal and spatial scales. However, we have not finished refining how we calculate these metrics or completed the development of database tools to help automate these processes to aid in the regular calculation of these metrics as new data is acquired. We are making progress however, and we anticipate a series of "research updates" that will fully document how we calculate these metrics and what assumptions have gone into the analyses. These research updates will be submitted as they are completed and will be stand-alone documents that can be edited for publication in the future. We also continue to work with ISEMP and CHaMP to utilize and refine geomorphic changed detection, net rate of energy, and habitat suitability models using treatment and control data from the Asotin IMW to synthesize multiple sources of data and to better describe the effectiveness of LWD treatments.

ACKNOWLEDGMENTS

The Asotin Intensively Monitored Watershed (IMW) is a collaborative multi-agency initiative sponsored by the Snake River Salmon Recovery Board (SRSRB). The SRSRB provides oversight and technical review of all the Asotin Creek IMW activities through support from the Regional Technical Team (RTT) and National Oceanic and Atmospheric Administration (NOAA) staff. The majority of the IMW takes place on Washington Department of Fish and Wildlife (WDFW) and US Forest Service (USFS) land, and both agencies have supported the development and implementation of the project. Funding for the primary research components of the IMW are from the NOAA Pacific Coastal Salmon Recovery Fund (PCSRF). Funding for the restoration activities comes from PCSRF through the State of Washington's Salmon Recovery Funding Board (SRFB), BPA, Conservation Commission, USFS, and WDFW. We are particularly grateful for support we receive from Ethan Crawford of WDFW in the form of field staff and data on fish-in fish-out from the Clarkston office to assist the IMW project, and Bonneville Power Administration (BPA) which supports WDFW's efforts to collect fish in-fish out data in Asotin Creek. Bob Dice, the manager of the Clarkston Wildlife Office, has also provided the IMW with accommodation, transportation, and access since the start of the project. We also wish to thank the Koch and Thornton families for graciously providing us access to private property along Charley Creek to conduct monitoring and restoration. Brad Johnson, Palouse Conservation District has also been an indispensable part of the IMW team working with the local landowners and agencies to help secure land access, operating permits, and local support and sponsorships for the IMW. The Asotin County Public Utility Department has provided us with office space and storage for field gear. Del Groat (now retired) of the USFS has provided generous donations of time and large wood for the restoration treatments and Billy Bowles, also with USFS, has helped with safety training for field crews. Bruce Heiner, WDFW Habitat Engineer and Barry Sutherland, USDA Natural Resources Conservation Service (NRCS) Fluvial Geomorphologist provided comments on the earlier versions of the restoration plan. The following groups have provided direct support to the IMW in either goods or services and we wish to thank them for their help with this important fisheries conservation project: Avista Power, Clearwater Power, Collier Electric, Inland Metals Electric, TDS Telecom, WDFW, and USFS.

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1 BACKGROUND

In 2008, Asotin Creek was chosen as a location to implement an Intensively Monitored Watersheds (IMW) project in southeast Washington (Figure 1). A series of IMWs have been established in the Pacific Northwest to assess the effect of different restoration actions on populations of salmonids at the watershed scale (Bilby et al. 2005, Bennett et al. 2016). IMWs use an experimental framework to increase the probability of detecting a population level response to restoration actions. A detailed account of the process to select and design the Asotin Creek IMW can be found in Bennett and Bouwes (2009) and a summary of the IMW monitoring methods and data collection can be found in Bennett et al. (2012). A summary of the fish-in fish-out monitoring conducted by the Washington Department of Fish and Wildlife (WDFW) in Asotin Creek is summarized by Crawford et al. (2016).

We are implementing the IMW experiment within an adaptive management framework and have revised aspects of the experimental design, restoration plan, and monitoring based on the iterative evaluation process of adaptive management (Bouwes et al. 2016). An experimental study design has been developed and refined for the Asotin Creek IMW that includes treatment and control sections within the Asotin Creek tributaries of Charley Creek, North Fork Asotin Creek (North Fork), and South Fork Asotin Creek (South Fork; hereafter referred to together as "study creeks"). The study creeks generally exhibit homogenized and degraded habitats, with poor riparian function and low frequencies of large woody debris and pool habitat which is thought to be limiting salmonid production (SRSRB 2011). A detailed Restoration Plan was developed that proposed ***riparian enhancement and large woody debris additions as restoration treatments in the Asotin Creek IMW*** (Wheaton et al. 2012). The riparian enhancement treatments include a mix of short and longer term measures ranging from fencing, planting, and weed control. These treatments are intended to create a more diverse riparian corridor (in terms of age and species structure) that is sustained by fluvial processes and more regular interaction and exchange with the channel (Opperman and Merenlender 2004). The long-term benefits of such a riparian treatment are the reestablishment of sustainable levels of wood recruitment (of all sizes) to the channel. By contrast, the LWD additions focus on intensive additions of high densities of LWD designed to work in concert with one other to initiate and promote more dynamic creation, shaping and maintenance of active bar and pool habitat by fluvial processes.

The Asotin Creek IMW is funded from NOAA's Pacific Coastal Salmon Recovery Fund (PCSRF). The PCSRF funds are used to fund the ongoing fish and habitat monitoring and data collection and analysis. These funds are now administered via the Governors Salmon Recovery Office. A separate project funded by the Bonneville Power Administration (BPA) and implemented by the WDFW provides fish-in, fish-out monitoring for the Asotin watershed (Crawford et al. 2016). Funding for the restoration actions has primarily come from Pacific Coast Salmon Recovery Fund (PCSRF) through the State of Washington's Salmon Recovery Funding Board (SRFB) and donations of wood from US Forest Service, accommodation and equipment from WDFW and SRSRB. Eco Logical Research Inc. is the primary contractor that manages the Asotin Creek IMW and implements the restoration.

The intent of this progress report is to give a brief update of i) progress of the IMW, ii) monitoring, data management, and trends, ii) restoration design, implementation, and overall treatment size, and iii) challenges and further analyses in 2017 and beyond.

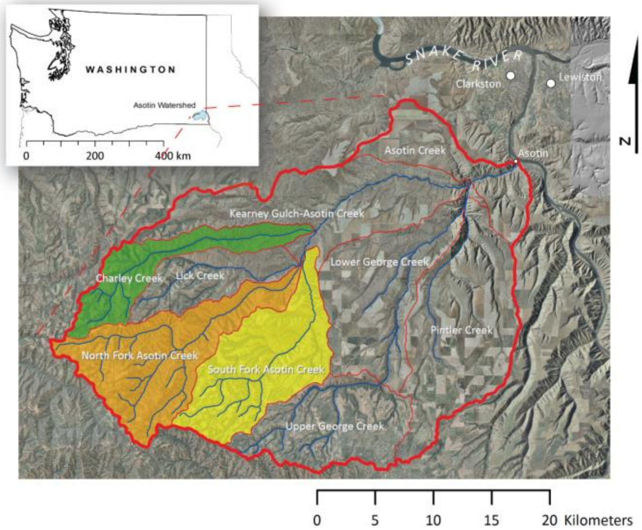


Figure 1. Location of Asotin Creek within Washington and the Asotin Creek Intensively Monitored Watershed study creek watersheds (i.e., three colored watersheds) within Asotin Creek.

2 ASOTIN IMW PROGRESS

The Asotin IMW has been running for nine years and began in 2008 (Figure 2Figure 2). Monitoring infrastructure such as PIT tag arrays, water height gages, and temperature probes were installed by 2009. The Asotin IMW also relies on the intensive monitoring of fish-in fish-out conducted by WDFW to provide detailed information on age, condition, size, migration timing, and spawning distribution of steelhead in the Asotin watershed (Crawford et al. 2016). Four PIT tag interrogation sites, a smolt trap, and adult weir provide valuable data to the IMW for assessing restoration effectiveness (Figure 3). See Bennett et al. (2015) for details on monitoring methods.

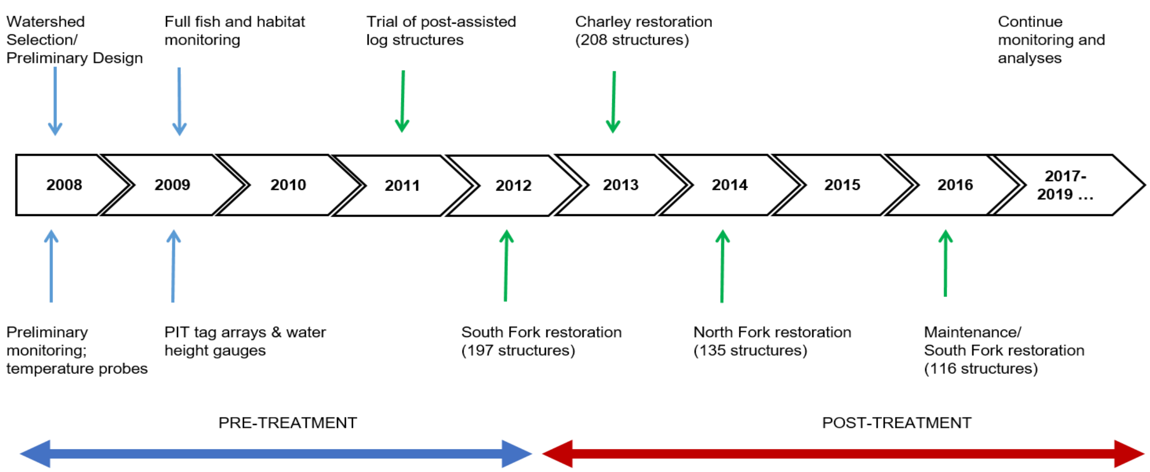


Figure 2. Timeline of Asotin Creek IMW design, monitoring, and restoration implementation. The initial restoration design of 12 km of wood treatments was completed from 2012-2014. Another restoration treatment to extend South Fork will be implemented in 2016 along with adding more wood to existing structures to enhance their function.

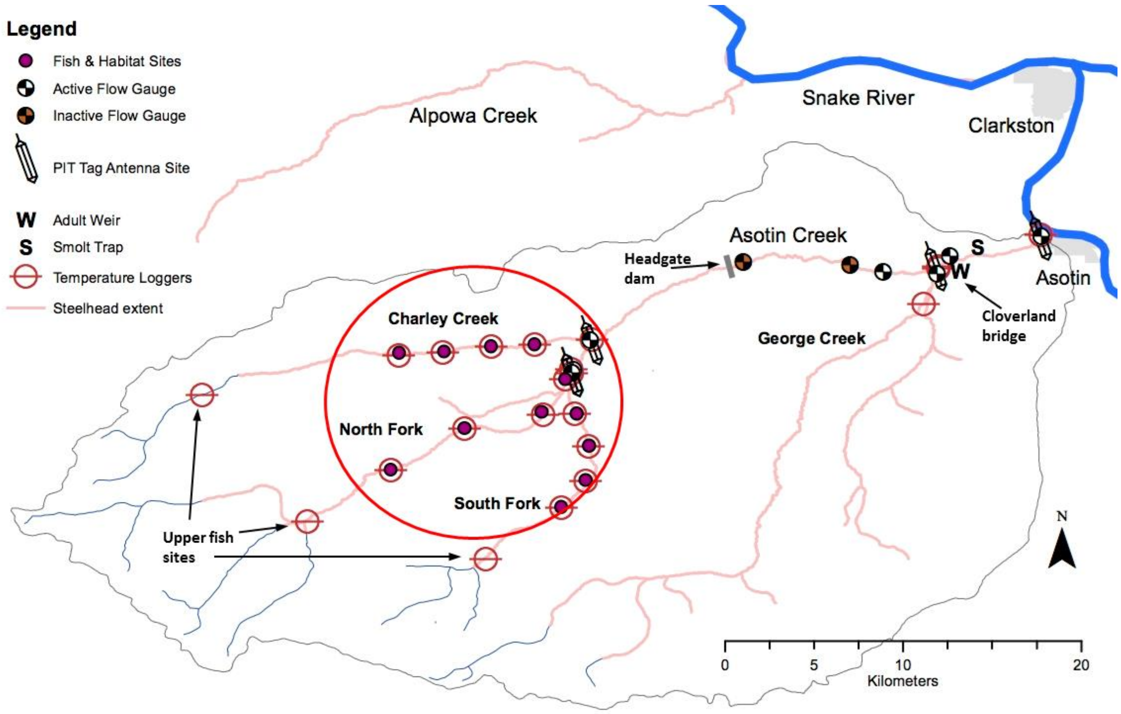


Figure 3. Monitoring infrastructure including fish and habitat sites in Charley Creek, North Fork, and South Fork Creek, temperature and discharge gauges, PIT tag antenna arrays, and the WDFW adult weir and smolt trap for fish-in fish-out monitoring.

We began restoration with a trial of 15 restoration structures in 2011 and implemented large scale restoration in each study creek between 2012-2014 (Figure 2 and 4). To increase the size of the overall restoration treatment, we implemented one more restoration treatment in the summer of 2016. We extended the existing South Fork treatment in Section 2 downstream 2 km into Section 1 to increase the percent of the IMW study area treated from 33% to approximately 40%. We also added more LWD to all the existing treatments in order to increase the potential for promoting habitat change (i.e., increasing instream habitat complexity and floodplain connection) and increasing the likelihood that we can detect a fish response to the restoration actions. We expect ongoing effectiveness monitoring to continue until at least 2019. See Section ### for more details on the size and extent of each treatment and Bennett et al. (2015) a detailed description of restoration goals, objectives, and methods.

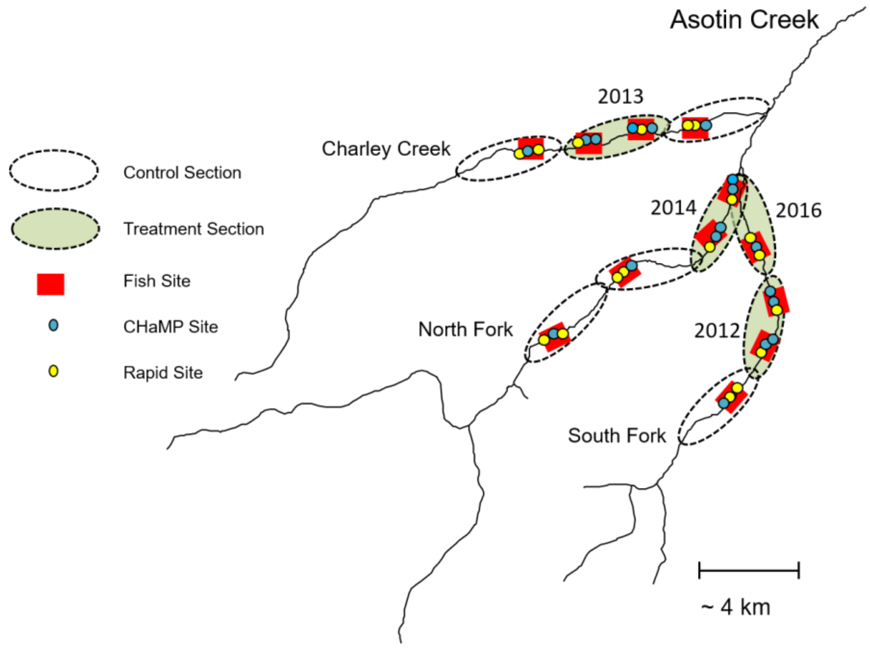


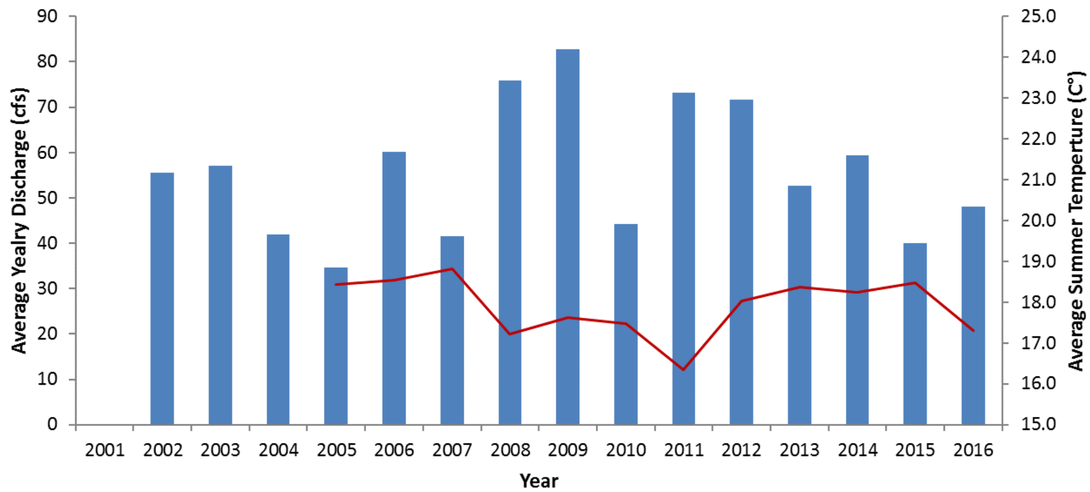
Figure 4. Experimental design of Asotin Creek Intensively Monitored Watershed. Each study stream has three 4 km long sections. One section in each stream has been restored using post-assisted log structures (shaded green): South Fork (2012), Charley Creek (2013), and North Fork (2014). Section 1 of South Fork (lower section) was restored in 2016. All other sections not colored will be controls throughout the project. Fish sites and habitat survey sites are nested within each section. CHaMP = Columbia Habitat Monitoring Protocol, Rapid = custom rapid habitat survey.

3 MONITORING, DATA MANAGEMENT, AND TRENDS

3.1 Stream Discharge and Water Temperature

Prior to the start of the IMW in 2008 there were several years of low average and peak stream discharge and high temperatures (Figure 5Figure 5). Water temperatures have generally decreased since the start of the IMW which is correlated with higher peak flows (and average flows) observed since 2008. However, 2015 had the highest 7-day maximum water temperatures and the earliest peak in temperature (June 28) compared to the project average of the beginning of August. Despite lower stream temperatures in 2016 compared to 2015, the peak flow was the lowest observed since the start of the IMW. Consistent low peak flows since the start of restoration in 2012 are suspected of limiting the effectiveness of the LWD structures to cause large changes to the channel and floodplain connection. These same effects are being observed in the Tucannon River which shares headwater areas with Asotin Creek.

a)



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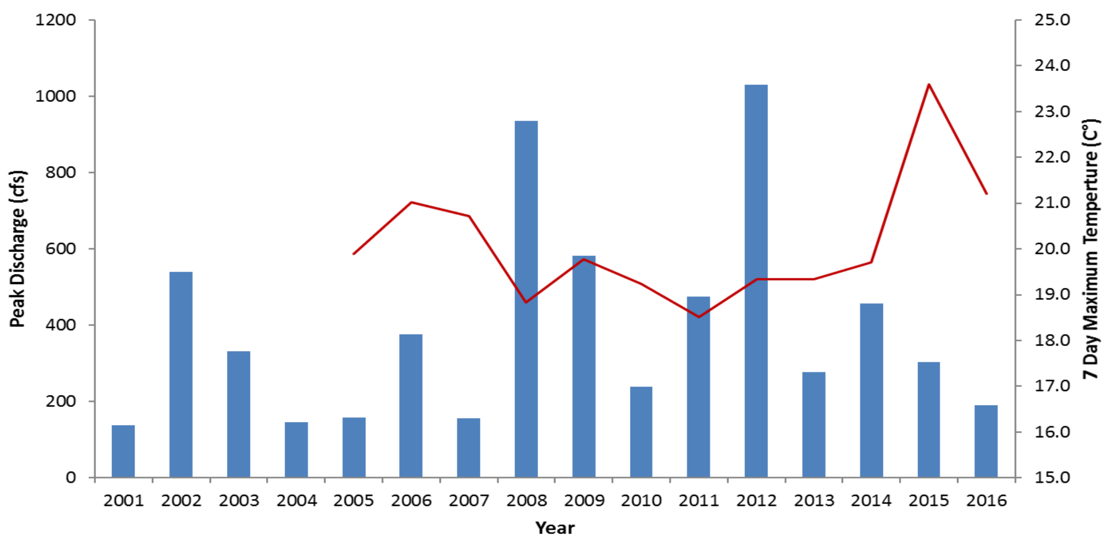

Figure 5. Asotin Creek mainstem a) average discharge (blue bars) and summer temperature (July and August – red line) by year and b) peak discharge and 7-day max summer temperature by year. Peak flows measured at USGS gauge 13334450 and water temperature measured at WDOE gauge 35D100.

3.2 Habitat Trends

The restoration actions have increased the amount of LWD ($\geq$ 0.1 m diameter and $\geq$ 1.0 m long) in the treatment sections relative to the control sections by almost 150% (mean LWD/100 m in control = 15.0 and in treatment = 37.1; Figure 6). The amount of LWD in treatment sections decreased slightly in 2016 due to an increase in LWD in the control areas due to natural recruitment. The changes in habitat since the addition of LWD have generally been positive, but there are several metrics that have not changed as predicted. For example, our habitat surveys are showing the frequency of pools has increased 77% in treatment sections relative to control sections (mean pools/100 m in control = 2.2 and in treatment = 3.9; Figure 7Figure 7). However, other metrics have not yet responded to the restoration. For example, the variability in the thalweg and residual pool depths are either not increasing as expected or are increasing in both treatment and control areas (Table 1). Geomorphic change detection based on comparison of digital elevation models of stream reaches produced from CHaMP surveys pre and post restoration have consistently shown deposition and scour in locations in and around restoration structures. However, we are still assessing whether sediment fluxes in treatment sections are changing relative to control areas.

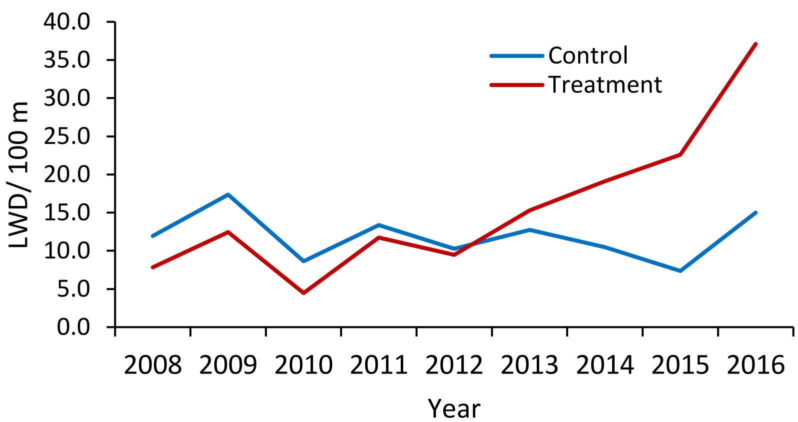

Figure 6. Frequency of large woody debris (LDW/100 m) in treatment and control sections, all study creeks combined: 2008-2016. Year 2016 includes the maintenance wood that was added to all the existing treatments and the 116 structures installed in South Fork Section 1 in 2016.

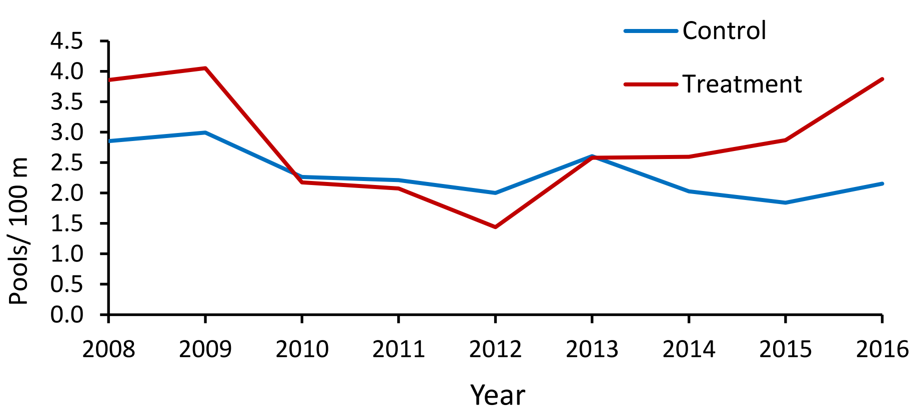

Figure 7. Average frequency of pools (pools/100 m) in treatment and control sections, all study creeks: 2008-2016.

Table 1. Summary of selected CHaMP metric by stream, control and treatment, and pre and post restoration (based on timing of treatment in each stream). Data does not include restoration implemented in summer of 2016 in South Fork.

Stream/ Location	Status	Ave Thalweg depth (m)	Ave Thalweg depth CV	Ave Max BF Depth (m)	Ave Pool/ 100 m	Ave Residual Pool Depth (m)	Ave LWD /100m	Ave % Fines < 2 mm	Ave % Fines < 6 mm	Ave % Riparian Tree Cover
					South Fork					
Control	Pre	0.21	0.43	1.18	3.20	0.21	11.98	6.70	9.08	8.90
	Post	0.19	0.43	0.84	3.14	0.24	11.55	8.43	13.76	7.33
Treatment	Pre	0.23	0.31	0.79	1.52	0.18	1.51	5.38	11.66	5.38
	Post	0.21	0.32	0.82	3.01	0.19	20.89	4.44	10.96	8.94
					Charley					
Control	Pre	0.22	0.35	0.88	2.14	0.29	17.11	10.52	20.30	9.47
	Post	0.21	0.33	0.78	1.80	0.26	16.16	16.21	28.41	7.50
Treatment	Pre	0.23	0.35	0.94	2.18	0.25	11.21	12.61	16.68	4.24
	Post	0.23	0.31	0.84	3.32	0.17	23.18	10.46	21.49	4.45
					North Fork					
Control	Pre	0.32	0.28	1.02	1.49	0.24	11.68	4.49	10.79	6.25
	Post	0.31	0.27	0.97	1.67	0.33	10.59	1.83	4.15	1.50
Treatment	Pre	0.34	0.33	1.14	1.66	0.31	19.22	4.83	11.01	11.79
	Post	0.37	0.32	1.06	2.08	0.29	37.66	4.14	7.69	5.75

3.3 Fish Tagging

Since 2008 we have tagged 35,743 juvenile steelhead > 70 mm in the three study creeks of the IMW (Error! Reference source not found.**). We capture relatively few bull trout and Chinook and have only tagged 39 bull trout and 169 Chinook since the start of IMW. WDFW has tagged 36,227 juvenile steelhead at the smolt trap and from hook and line sampling on the mainstem Asotin Creek (see Crawford et al. 2015). The majority of the juvenile steelhead we capture and tag are age 1 and very few fish are age 3 or older (Table 3).**

Stream	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***	**2014***	**2015***	**2016***	**Total**
Asotin (WDFW)	2,462	1,552	1,895	1,862	946	2,605	4,002	4,679	3,944	5,607	2,334	4,339	36,227
Charley	-	-	-	424	1,296	1,955	1,283	1,136	1,246	1,180	1,048	1,086	10,654
North Fork	-	-	-	372	470	1,397	908	931	1,797	1,549	2,037	2,245	11,706
South Fork	-	-	-	549	737	1,862	1,275	1,499	1,939	1,848	1,892	1,782	13,383
IMW subtotal	-	-	-	1,345	2,503	5,214	3,466	3,566	4,982	4,577	4,977	5,113	35,743
Total	**2,462**	**1,552**	**1,895**	**3,207**	**3,449**	**7,819**	**7,468**	**8,245**	**8,926**	**10,184**	**7,311**	**9,452**	**71,970**

* includes 620, 362, 222, and 217 juveniles PIT tagged on mainstem and captured with hook and line in 2013, 2014, 2015, and 2016 respectively

Table 3Table 2. Summary of the number of juvenile steelhead (> 70 mm) PIT tagged in Asotin Creek from 2005 to 2015 at the smolt trap on the Asotin mainstem by WDFW and in the IMW study creeks by Eco Logical Research Inc.

Stream	2005	2006	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*	2016*	Total
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* includes 620, 362, 222, and 217 juveniles PIT tagged on mainstem and captured with hook and line in 2013, 2014, 2015, and 2016 respectively

Table 3. Proportion of juvenile steelhead tagged by season and age class in all three study creeks combined: 2008-2015 (aging of steelhead captured in 2016 will be complete by late February or March).

	Age Class			
Season	0	1	2	3+
Fall	0.14	0.57	0.23	0.05
Summer	0.00	0.69	0.24	0.07

3.4 Fish Abundance

Recapture rates during mark-recapture surveys have been high throughout the tagging efforts averaging 33.1% in Charley Creek (range 0.8-50.4%, SD = 9.3), 22.1% in North Fork (range 4.7-38.8%, SD = 8.2), and 30.4% in South Fork (range 12.8-49.8%, SD = 8.9). The density of juvenile steelhead is very similar across all three study creeks and generally tracks across years (Figure 8). When comparing the density of fish, the South Fork tends to have the highest densities of juvenile steelhead and the North Fork tends to have the lowest. However, when comparing the frequency of fish, the North Fork tends to have the highest frequency and the Charley Creek has the lowest. We have chosen to use fish/100 m as the primary metric for assessing fish response because our restoration actions may increase the area of stream per linear length of stream and therefore, changes in the total number of fish per length may be a more appropriate measure than density.

a)

b)

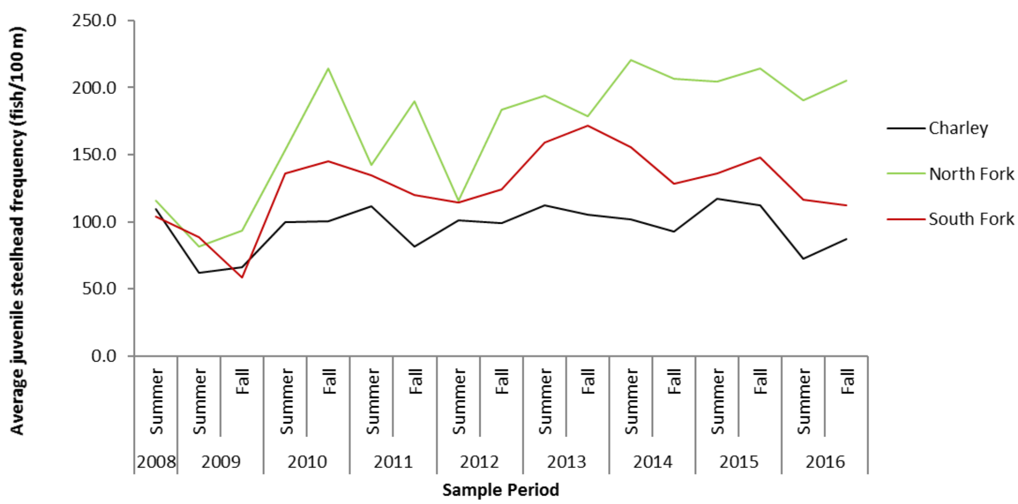

Figure 8. Average juvenile steelhead a) density (fish/m2) and b) frequency (fish/100 m) and by study creek, season, and year: 2008-2016. Based of mark-recapture surveys tagging juvenile steelhead $\geq$ 70 mm.

We have assessed the preliminary changes in fish abundance pre and post restoration using intervention analysis (Carpenter et al. 1989). The frequency of juvenile steelhead in the treatment sections appears to have increased in each study creek following restoration (Figure 9). There are large changes in fish abundance in treatment sites relative to control sites that complicate the interpretation of these data. For example, in the fall of 2014 in the South Fork and in the summer of 2014 and 2016 in Charley Creek the abundance of the steelhead in the control sections increased relative to the treatment section despite both of the treatment sections of these streams having been already treated. We have not identified the reason for these changes but suspect it could be related to adult abundance and the location of spawning activity, weather events specific to these streams (i.e., isolated thunder storms or debris torrents), or other unknown factors. These trends will be assessed further by using our hierarchical-staircase model and further investigations. We will also be updating and revising all of our growth and survival data in the spring of 2017 as part of a larger effort to develop a life cycle model for Asotin Creek.

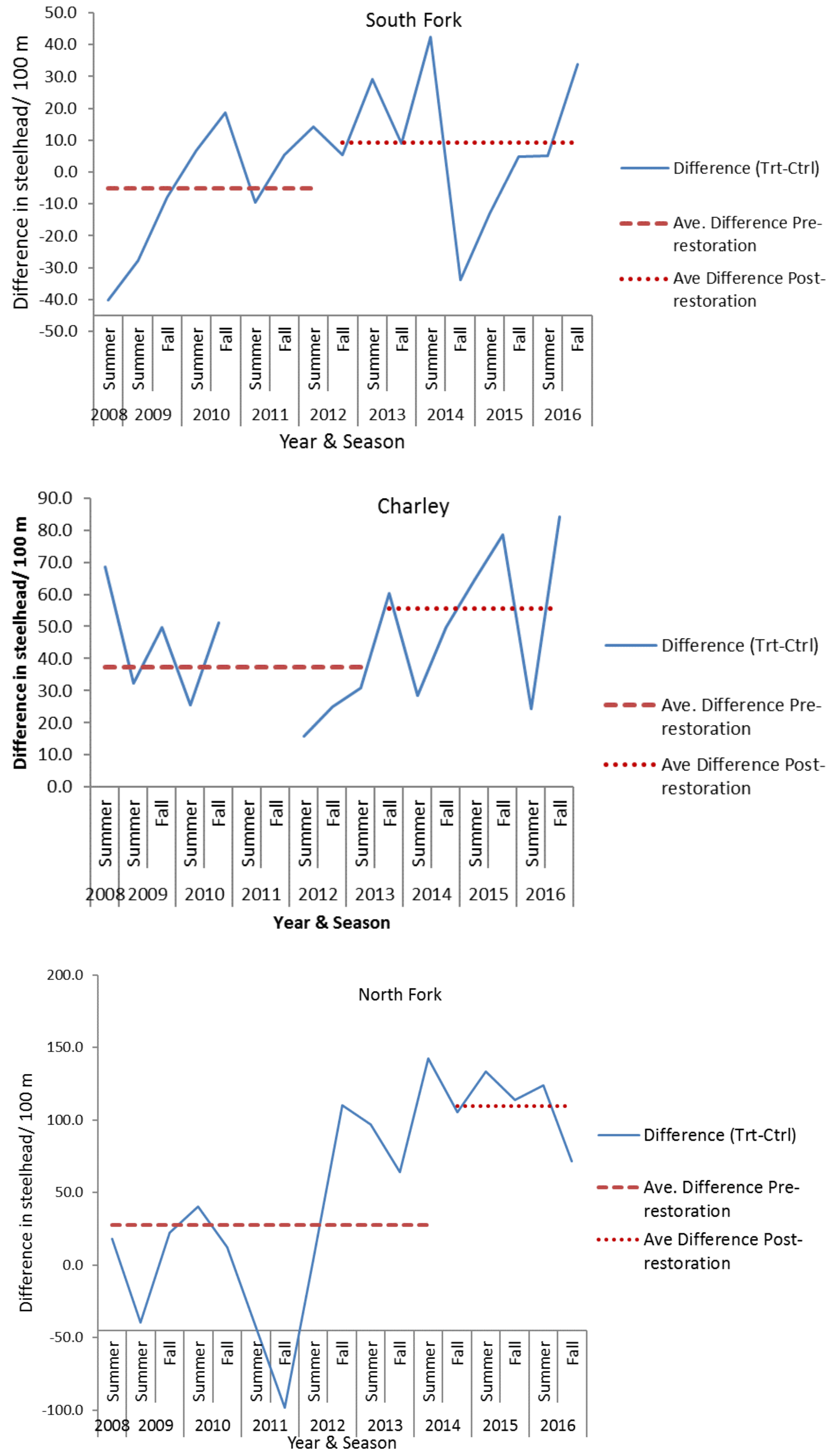

Figure 9. Difference of juvenile steelhead frequency (fish/100m) between treatment and control sections (blue line) and the average of differences (treatment minus control) pre and post restoration (red dashed lines). T-test for differences between pre and post restoration are South Fork P = 0.10, Charley P = 0.05, and North Fork P = 0.012 at α = 0.1).

3.5 Growth, Movement, Survival, Production, and Productivity

We continue to collect data and calculate growth and movement annually but have not developed models yet to assess what factors effect annual variation. We are also continuing to collect data that will support the calculation of survival, productivity, and production at different temporal and spatial scales. However, we have not finished refining how we calculate these metrics or completed the development of database tools to help automate these processes to aid in the regular calculation of these metrics as new data is acquired. We are making progress however, and we anticipate a series of "research updates" that will fully document how we calculate these metrics and what assumptions have gone into the analyses. These research updates will be submitted as they are completed and will be stand-alone documents that can be edited for publication in the future. We also continue to work with ISEMP and CHaMP to utilize and refine geomorphic changed detection, net rate of energy, and habitat suitability models using treatment and control data from the Asotin IMW to synthesize multiple sources of data and to better describe the effectiveness of LWD treatments.

4 RESTORATION IMPLEMENTATION

We built 197 structures in the South Fork, 208 in the Charley Creek, and 135 in North Fork treatment sections from 2012-2014 (Figure 10). The total number of pieces of LWD added to each treatment section was 1500 pieces in the South Fork (structures built in 2012 and 2016), 497 pieces in Charley Creek, and 568 pieces in North Fork. The majority of structures built were deflector PALS in all streams (Table 4). In 2016 we added another 116 LWD structures to the upper 2 km of South Fork Section 1 (Figure 4). The total length of stream restored with LWD is 14 km which equates to 38.9% of the IMW study area (i.e., 14/36 km). On average the LWD structures are approximately 21 m apart or 4.7 LWD structures/ 100 m. In addition to the installation of LWD structures we conducted a round of maintenance in 2016 where we added LWD the existing treatments built between 2012-2014. Approximately 600 pieces of LWD were added to the existing treatments focusing on structures that where less effective at promoting hydraulic and/or geomorphic change. Figure 11 shows an example of a stream reach before treatment and after treatment.

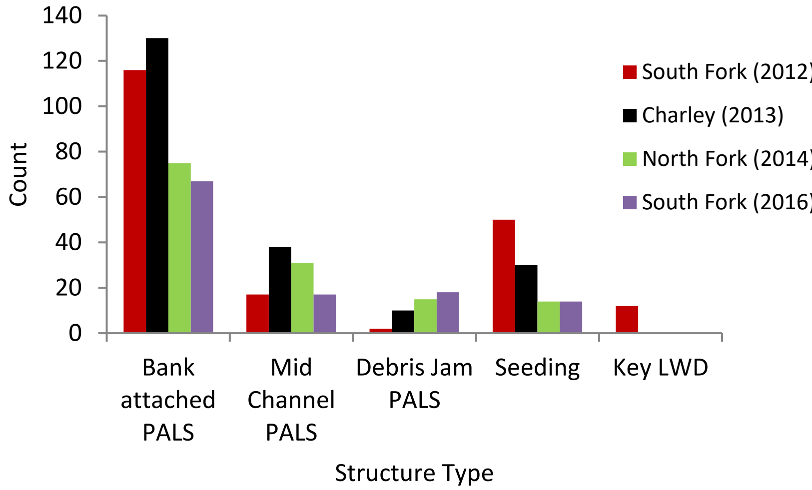

Figure 10. Count of each large woody debris structure type built in treatment sections in South Fork in 2012, Charley Creek in 2013, North Fork in 2014, and South Fork 2016 (n = 656). No wooden posts were used to secure seeding and Key LWD. All other post-assisted log structures (PALS) were built using non-treated wooden fence posts driven into the stream bottom.

Table 4. Summary of the type and count of large woody debris (LWD) structure built in each stream by year constructed. PALS = post-assisted log structure, Seeding = unsecured LWD placed in channel, Key LWD = LWD too large to move by hand (e.g., > 10 m long and > 0.4 m diameter).

Type	**South Fork (2012)**	**Charley (2013)**	**North Fork (2014)**	**South Fork (2016)**	**Total**
Bank attached PALS	115	129	75	67	386
Mid Channel PALS	17	38	31	17	103
Debris Jam PALS	2	10	15	18	45
Seeding	50	30	14	14	108
Key LWD	12	0	0	0	12
Total	**196**	**207**	**135**	**116**	**654**

Figure 11. Example of treatment section before restoration (left) and after restoration (right) in South Fork Section 1. Treatment took place in summer of 2016.

5 CHALLENGES

Two challenges we began working on recently are the effects of removing Headgate Dam and determining the spatial distribution of redds in the IMW study area. Headgate Damn is an old water diversion site on the mainstem of Asotin Creek approximately 10 km downstream of the IMW study area (Figure 3). The dam operation ceased in the 1960's and has been considered a potential juvenile fish barrier but not an adult barrier (~ 1 m drop). To assess possible changes in fish movement due to the removal of the dam we coordinated with WDFW to assess fish movement. WDFW began tagging juvenile steelhead in the mainstem above and below Headgate Dam in 2013 and in 2015 they installed a temporary PIT tag array upstream of the dam. The temporary array is operated annually from early summer to the end of December. Tagging of juveniles in ongoing in the mainstem (n = 1420 as of 2016). The dam was breached in the summer of 2016. WDFW documented at least one juvenile fish tagged below the dam managed to move upstream over the dam. We will continue to monitor the temporary array and our IMW fish sites for evidence of fish moving from below the dam upstream and potentially influencing the IMW.

To fully assess the productivity of the treatment and control sections we need to determine the distribution of adults that enter the IMW tributaries (i.e., what section do they spawn in). We intended to rely on WDFW annual redd surveys and we coordinated with WDFW in 2011 in also collect GPS locations of redds (in addition to recoding what index reach the redds where in). However, because steelhead spawn in the spring during high turbid flows and WDFW staff cannot always be available to conduct redd surveys when conditions are optimal we have gaps in the redd surveys and it will be a challenge to determine the distribution of redds. We are still assessing the historic data (redd counts have been conducted since the mid 1980's) and the GPS data that has been collected to determine estimates of spatial distribution. We also plan on using IMW funds to assist WDFW staff in collecting redd locations.

6 FUTURE ANALYSES

Below is a summary of the tasks for 2017 and beyond:

- Estimate total number of smolts emigrating from IMW study creeks and Asotin Creek by brood year
- Estimate the distribution adult steelhead in the IMW study creeks by year and section
- Calculate smolts per spawner for IMW study creeks
- Recalculate survival by age class using refined Barker model approach
- Refine NREI approach by adding LWD structures to the modeling process
- Analyze CHaMP data and incorporate into analyses
- Assist Asotin County Conservation District in riparian restoration design and planning
- Develop models to explain variability in population parameters
- Publish experimental design using hierarchical-staircase approach
- Publish life history of juvenile steelhead in Asotin Creek

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