Hangman Creek Fisheries Enhancement
Research, Monitoring and Evaluation Report

Redband trout (Oncorhynchus mykiss gairdneri)

BPA Project # 2001-032-00
Report covers work performed under BPA contract #(s) 75767, 78986, & 82051
Report completed under BPA contract # 82051
5/1/2017 - 12/31/2019

Biladeau, T. J, and B. A. Kinkead
Coeur d'Alene Tribe, Plummer, ID 83851
January, 2020

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:

Biladeau, T. J., and B. A. Kinkead. 2020. Hangman Creek Fisheries Enhancement: Research, Monitoring and Evaluation Report, 2017-2019. Annual Report to Bonneville Power Administration, Project #2001-032-00.

Contents

List of Figures

List of Tables

Abstract

The Hangman Creek Fisheries Project monitors and evaluates multiple characteristics of redband trout *Oncorhynchus mykiss gairdneri* and their associated habitats throughout the upper Hangman Creek watershed. Within this reporting period, redband trout were sampled in stream reaches across the project area where they are known to be spatially distributed. Data from annual index monitoring suggests trout densities across the watershed are impacted by region-wide influences. Many of the fragmented subpopulations of redband trout showed high levels variation in annual densities. Indian Creek however appears to be somewhat buffered from these effects, likely due to a larger, more diverse and hospitable reach of habitat conditions. In fact, results from long-term monitoring show a steadily increasing trend in redband trout densities in this tributary. The variable trends in survival of fluvial fish rearing in Hangman Creek also appears to reflect regional influences impacting annual hydrological patterns in the watershed. As temperature trends in rehabilitated mainstem reaches continue to show favorable results, we hope to in turn elicit positive responses to survival rates in fluvial fish utilizing these reaches for rearing. Dispersal of fish into effectively isolated subpopulations continues to be a primary objective of our program, and although we have observed movement into adjacent tributaries, much of which occurs during the spring, without genetic analyses we have no evidence that these fish are contributing to the genetic richness of the subpopulations. Furthermore, genetic analyses would also inform the effectiveness of our suppression efforts in upper Nehchen Creek, where preliminary results indicate a significant reduction in Westslope cutthroat and hybrids. It is important for our program to continue to monitor the aspects in the biological communities which are essential for a healthy and resilient fish population, especially as landscape restoration expands throughout the study area. Future monitoring is proposed to measure these aspects and move from status and trend into a more focused effectiveness monitoring program.

1. Introduction

1.1.Project Background

Since 2002, the Coeur d'Alene Tribe has been assessing and monitoring fisheries and habitat conditions throughout the upper Hangman watershed. Results from these surveys indicate distinct linkages between land management practices and the presence of salmonids, specifically redband trout *Oncorhynchus mykiss gairdneri.* As late as 1950, redband trout were thought to be distributed throughout the upper watershed in a largely continuous expanse of suitable habitat (Aripa 2003). Presently however, the majority of redband trout are confined to the forest dominated tributaries which provide decent water quality and habitat conditions. This has resulted in a largely fragmented resident population exhibiting various levels of genetic drift (Small et al 2005).

A fluvial life history strategy is still present within the upper Hangman watershed. These individuals are restricted to short reaches of mainstem rearing habitat where conditions are marginal, while utilizing adjacent reaches as migratory corridors. The Coeur d'Alene Tribe has recently pursued a better understanding of how this life history strategy influences population dynamics within the upper Hangman watershed. Specifically through dispersal and the effects on gene flow, and the resiliency they may offer in light of projected climate change scenarios. Concurrently, large scale habitat restoration is being conducted to improve mainstem and tributary habitat conditions, facilitating movement between disconnected subpopulations and to increase survival across all stages of life history for remnant populations of redband trout.

1.2.Study Area

Hangman Creek drains 430,000 acres of northern Idaho and eastern Washington. The study area consists of the portion of the Hangman Creek watershed that lies within the Coeur d'Alene Reservation and east into the headwaters outside of the reservation. The Washington-Idaho State border, which corresponds to the border of the Coeur d'Alene Indian Reservation, marks the western boundary of the project area. The total acreage is 157,586, with 147,993 of that within the reservation. Elevations range from 754 meters in the northwest corner of the Project Area where Hangman Creek flows west into Washington to 1,505 meters at the top of Moses Mountain on the southeastern end of the Hangman/Coeur d'Alene Basin watershed divide (Figure 1). The named tributaries within the basin include Mission, Tensed, Sheep, Smith, Mineral, Nehchen, Indian, the SF Hangman and its' tributaries Conrad, Martin, and the upper part of Hangman Creek east of the Reservation along with its' named tributaries Hill and Bunnel (Figure 2).

The lower elevation valleys are dominated by dryland agricultural where habitat conditions frequently become inhospitable for salmonids, especially during summer base flow periods. Specific limiting habitat conditions include but are not limited to; low discharge, elevated stream temperature, low dissolved oxygen, substrate composition, and lack of complexity. These limiting conditions are thought to be the result of one large underlying problem; the loss of interaction between the stream and the adjacent floodplain.

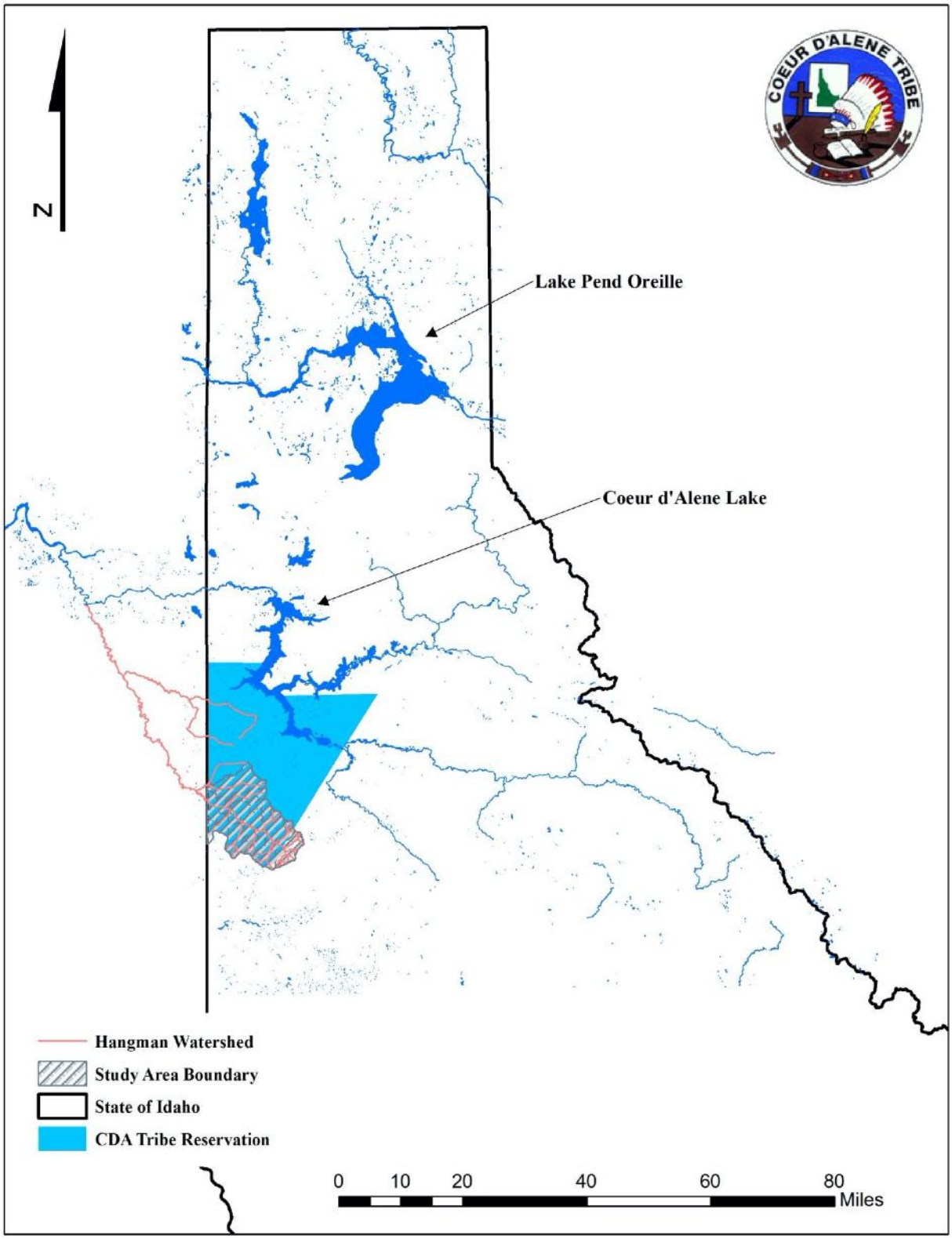

Figure 1. The Hangman Creek watershed study area, located in Idaho almost entirely within the Coeur d'Alene Reservation.

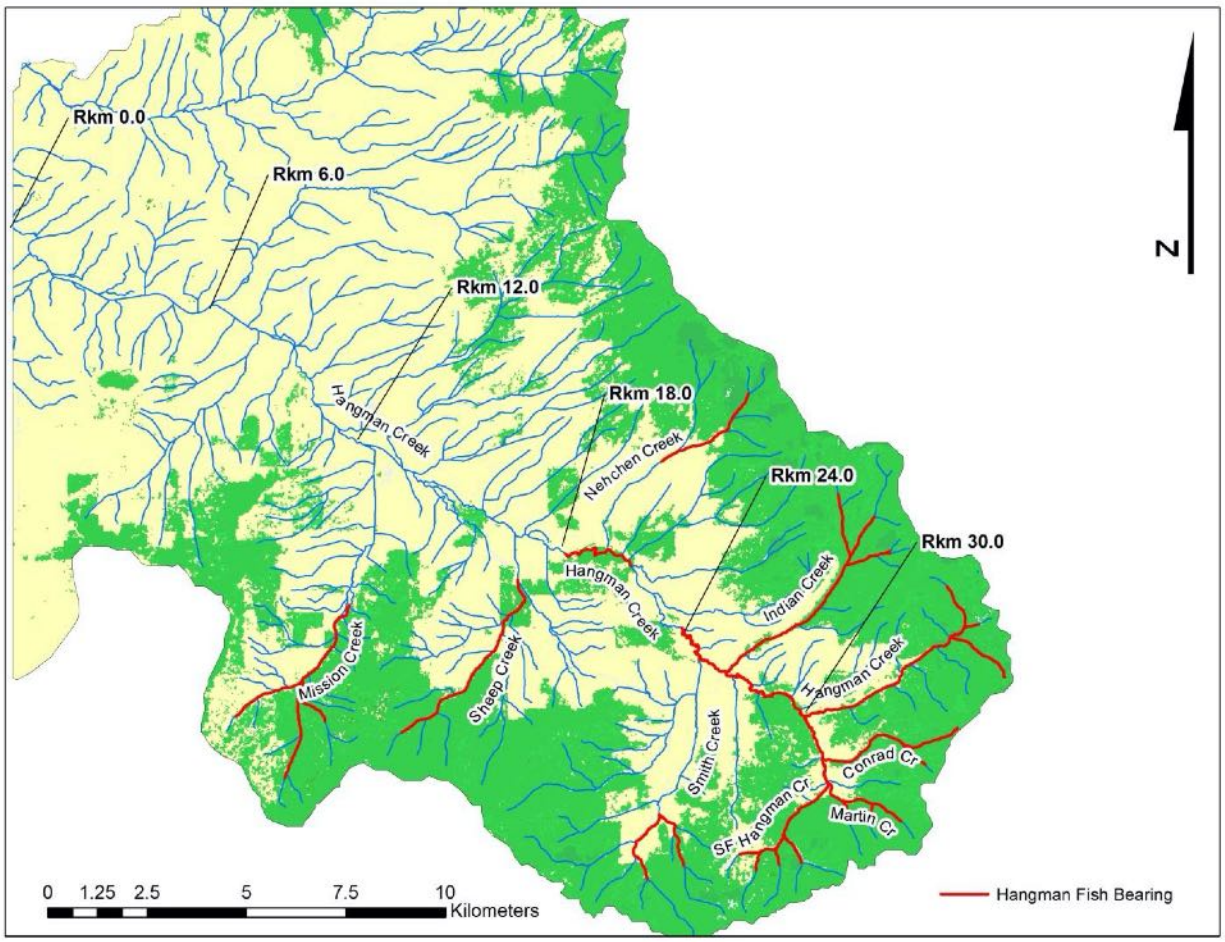

Figure 2. Hangman Creek watershed study area with updated stream kilometer reference points and current fish bearing stream reaches highlighted in red. Stream kilometer 0.0 is located at the Idaho-Washington state line.

The mainstem of upper Hangman Creek predominantly flows within large floodplain valleys which historically supported a dynamic riparian and wetland ecosystem dominated by beaver ponds and low gradient (< 0.5%) meandering streams (Washington State Dept. of Ecology 2005). The US Fish and Wildlife Service Historic Wetland Inventory (2017) estimates the upper Hangman watershed was composed of over 18,000 acres of wetland, many of which were within the floodplain(s) adjacent to valley streams. The Coeur d'Alene Tribe estimates just over 3,000 acres of 'functioning' wetland and/or floodplain are currently present in the same geographic region upstream of the state line of Idaho. Decades of channelization and stream straightening, compounded by land clearing and other land management actions have resulted in an unnaturally monotypic ecosystem with high rates of erosion, sedimentation, topsoil loss, and a hydrograph with extreme peaks and valleys.

1.3.Project Objectives

The Hangman Creek Fisheries Enhancement Project is largely an ecosystem rehabilitation program focused on restoring natural processes. Additionally, a research, monitoring and

evaluation component to the project is incorporated to track the status of redband trout across the study area and to evaluate physical and biological responses to restoration actions. Specifically, the RM&E program supports the following objectives.

Objective 1: Track Trends and Status of Redband Trout Demographics and Population Structure.

Assessments of the fisheries populations included a broad spatial sampling in order to determine distribution over the entire Hangman watershed within Idaho boundaries, and later was prioritized in 2005 to exclude the northern part of the watershed that was almost entirely devoted to dry-land farming (Green and Kinkead 2008). Previous fish abundance and spatial distribution surveys have found redband trout to be distributed throughout the upper-most portion of the watershed with fairly stable trends in density. The sub-watersheds located downstream of Smith Creek however have shown trout densities to be more variable. This is likely due to the isolation of these streams from the more connective habitat in the upper Hangman watershed and the dominant resident-type life history strategy of the trout which reside in each tributary. These populations are affected by regional as well as localized changes in habitat, whether they are anthropogenic or natural in origin. Annual precipitation and climate patterns appear to have an especially strong correlation to the variability in density among these isolated subpopulations of redband trout.

Objective 2: Evaluate Effectiveness of Restoration Actions.

As the rate and magnitude of restoration actions increase in the Hangman Creek watershed, it is important to understand not only how our efforts change the physical habitat, but what influence restoration has on the fish communities they are expected to help. In 2013, restoration efforts were initiated on what started out as a 5.8 kilometer reach of Hangman Creek mainstem habitat. Today, this same reach of Hangman Creek is 6.8 kilometers long due to the reactivation of 3.3 kilometers of historic channel. Additionally, in-stream structures have been incorporated and extensive riparian vegetation has been planted throughout this focus reach of Hangman Creek (Kinkead & Biladeau 2017). This portion of Hangman Creek is an important connection between a large area of continuous habitat and two fish bearing tributaries (Smith and Nehchen Creeks) which are relatively cut off from the rest of the population. It is our hope the restoration actions that have been initiated will provide more summer and winter rearing habitat which improves survival of fluvial fish and provides a larger extent of continuous and preferable fish habitat which facilitates dispersal and gene flow between subpopulations.

The overlap of non-native trout with redband trout in the Hangman Creek watershed was thought to be exclusive to upper Nehchen Creek. Westslope cutthroat trout *Oncorhychus clarki lewisi* have been documented in this stream reach by the Coeur d'Alene Tribe since the early 2000's, however it was not until 2015 that cutthroat and/or cutthroat X redband hybrids were documented at the mouth of Nehchen Creek in the migrant trap. The Coeur d'Alene Tribe Fisheries Program has now deemed trout hybridization in the project area a risk to the genetic integrity and overall fitness of redband trout and has therefore initiated a suppression program to identify and remove cutthroat and cutthroat X redband hybrids through electrofishing in the summer and trapping in the spring.

2. Methods

2.1.Trout Status and Trend Monitoring

2.1.1. Trout Abundance Trends

https://www.monitoringresources.org/Document/Protocol/Details/572

Twenty seven sites were sampled annually in 2017 – 2019 via single-pass electrofishing throughout the fish-bearing reaches of the upper Hangman watershed to monitor annual trends in density of age 1+ trout (**Error! Reference source not found.**). The length of each sampled site was defined as a minimum of 200 feet. Trout larger than 65mm total length captured in Indian and Nehchen Creek were implanted with a 12 mm half-duplex PIT tag to monitor for dispersal. Each trout implanted with a PIT tag was marked through the removal of the adipose fin. All other aquatic vertebrates captured during electrofishing surveys were counted and recorded. Mean densities of redband trout were also calculated for three reaches of Indian Creek. Reaches were stratified based on habitat type and slope, and included two, two and four sites each year for the lower, middle and upper reach, respectively.

2.1.2. Migrant Trout Trapping

https://www.monitoringresources.org/Document/Protocol/Details/536

Fixed weir migration traps were installed near the mouth of Nehchen Creek (km 0.4) and Indian Creek (km 2.4) to capture upstream migrating pre-spawn adults as well as emigrating post-spawn adults and juveniles (Figure 3). Traps were fished in 2017 and 2018 from early March through early June. In 2019, traps were installed May 5th and removed in early June. Each trout over 65mm captured in the trap was counted, measured, and implanted with a 12 mm half-duplex PIT tag. Each trout was also marked with an adipose clip for identification upon recapture.

2.1.3. Fluvial Life-History of Trout

https://www.monitoringresources.org/Document/Protocol/Details/3279

Passive interrogation sites were installed in the upper Hangman Creek watershed to monitor movement of PIT tagged individuals. These interrogation sites were installed near the mouths of Sheep (rkm 1.3), Nehchen (rkm 0.1), Smith (rkm 0.7), and Indian Creek (rkm 0.1), and in the mainstem of Hangman Creek at three locations (rkm 19.8, 22.1 and 26.6). Detections of tagged individuals were used to estimate the prevalence of the fluvial life-history within tributaries of upper Hangman Creek and to monitor annual survival rates. The sites were also installed strategically to monitor movements of fluvial redband trout in the mainstem of Hangman Creek, specifically into and through a reach undergoing active restoration, and to monitor seasonal movements of all tagged redband trout into adjacent tributaries. Each site, with the exception of the one in lower Sheep Creek, used multiple antennas in order to acquire direction of movement (Figure 4).

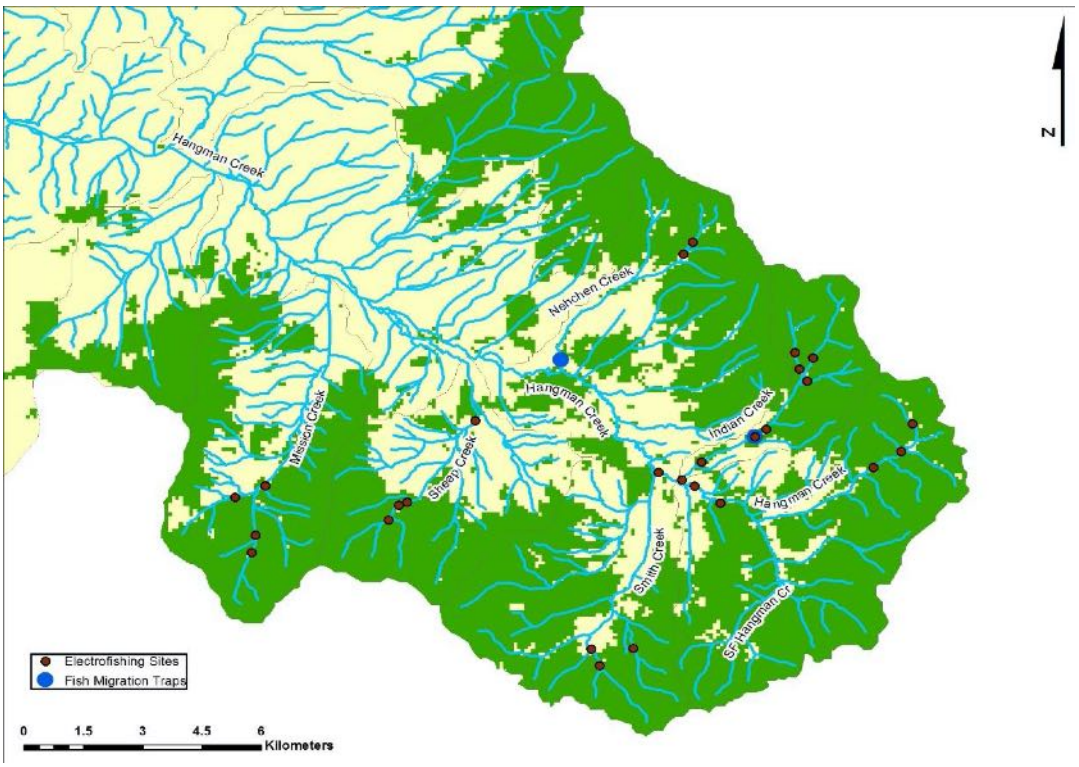

Figure 3. Location Map of trout monitoring sites within the upper Hangman Creek watershed study area.

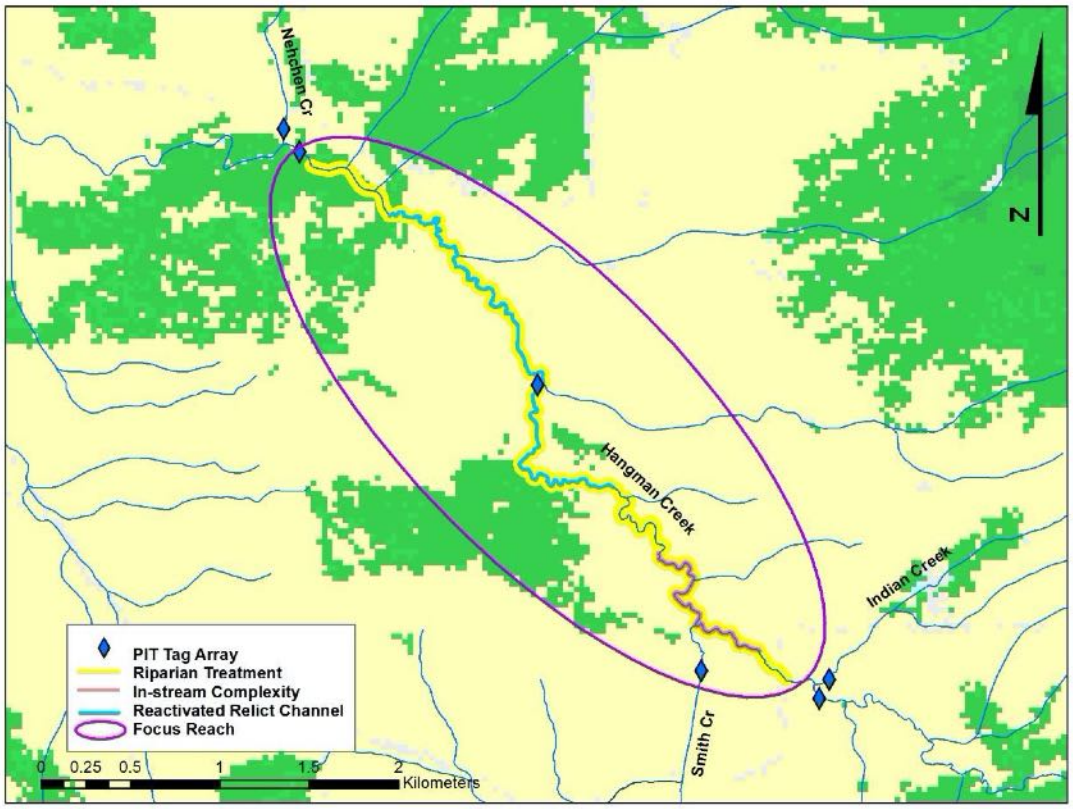

Figure 4. Hangman Creek reach undergoing active restoration and the associated fixed PIT tag interrogation sites.

2.2.Effectiveness Monitoring

2.2.1. Spatial and Temporal Temperature Trends

https://www.monitoringresources.org/Document/Protocol/Details/3280

Trends in summer stream temperatures were compared before and after active restoration in Hangman Creek from stream kilometer 19.8 through 23.9 initiated in 2014. We compared the percent time temperatures exceeded a threshold value of 20°C in July through August from 2010 through 2019 (Figure 5).

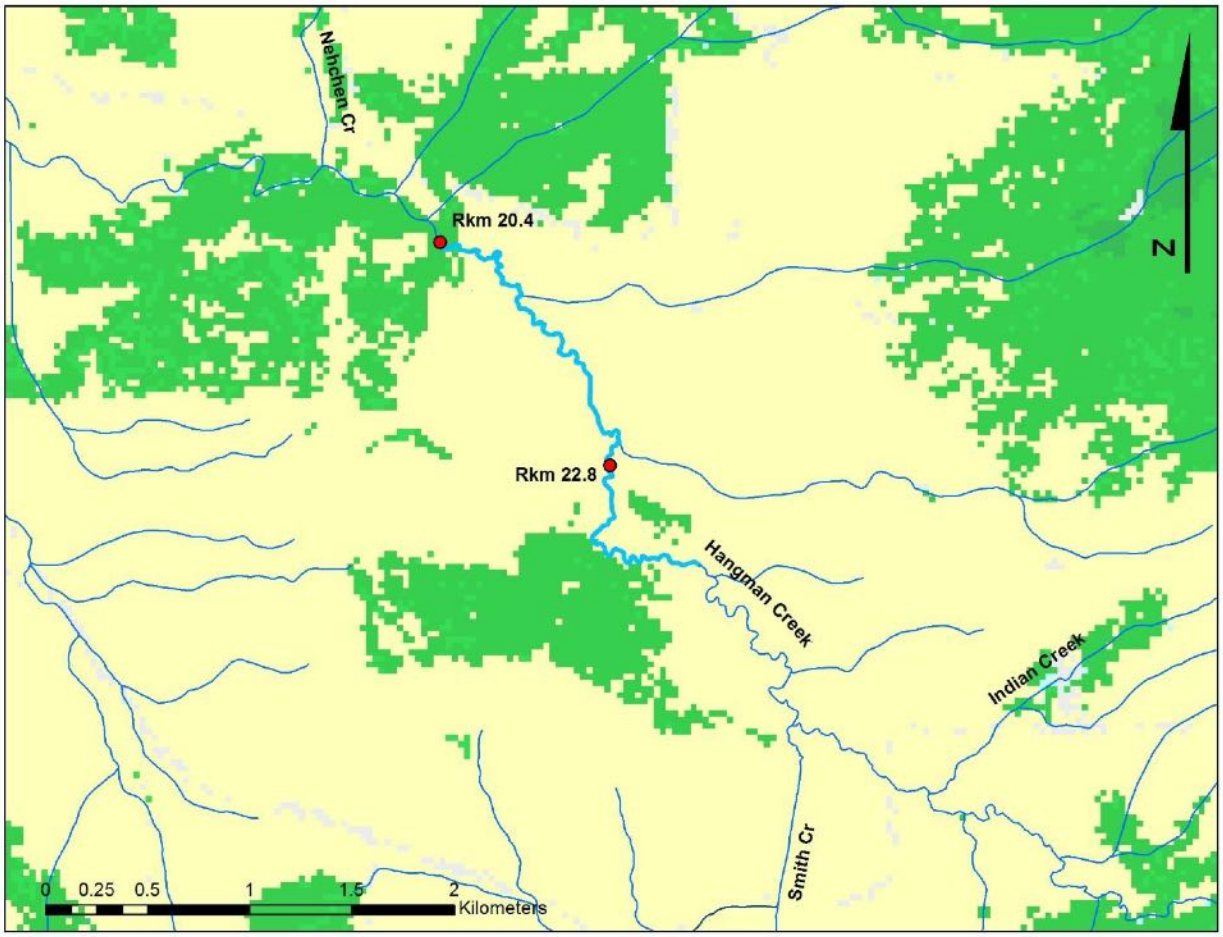

Figure 5. Stream temperature logger locations associated with the restoration reach of Hangman Creek, 2010 - 2019.

2.2.2. Non-Native Fish Suppression

Westslope cutthroat trout and cutthroat X redband hybrids were actively removed from 1,600 meters of upper Nehchen Creek using the single pass electrofishing methods described above. Cutthroat trout and hybrids were visually identified from the presence of a distinctive orange slash on the lower jaw. All trout were captured, counted and measured for length. Age 0 fish were not removed during suppression efforts.

3. Results

3.1.Trout Status and Trend Monitoring

3.1.1. Trout Abundance Trends

Mean densities of redband trout in Indian Creek exhibited an increasing trend from 2014 to 2019. Overall trends in Mission, Sheep and Smith creek during the same time period however were not apparent. In addition, changes in mean densities over consecutive years were much more variable in these three tributaries than what was observed in Indian Creek (Figure 6). Nehchen Creek was not included in this analysis as densities are likely influenced by the presence of non-native cutthroat. Upper Hangman Creek was not included in this analysis due to the influence of anthropogenic barriers and landowner habitat manipulation leading to inflated densities in the sample sites. Densities of redband trout at each sample site across the study area are included in Appendix A.

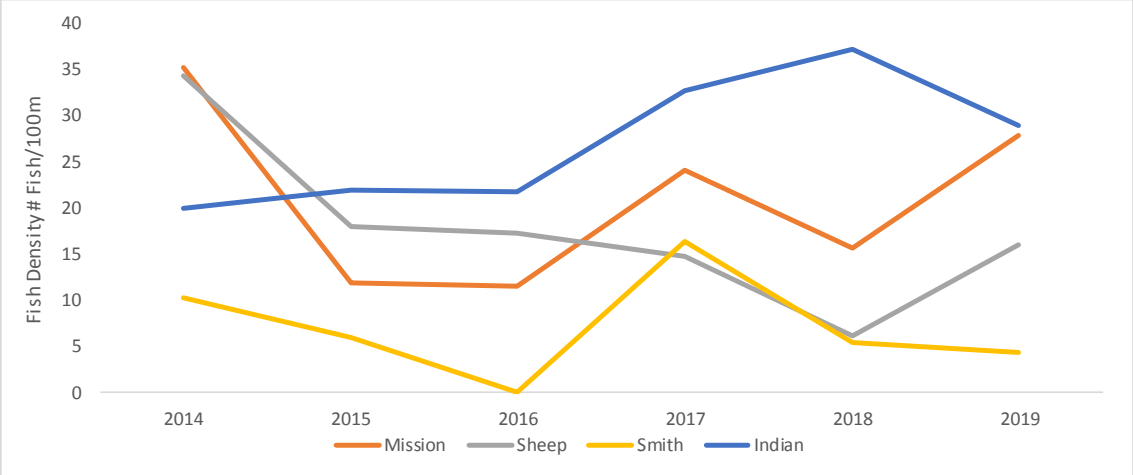

Figure 6. Mean annual trends in redband trout densities in the fish-bearing reaches of major subwatersheds sampled, 2014 - 2019.

Mean densities of redband trout in Indian Creek generated during this reporting period were greater than prior to 2017. The greatest percentage of increase was observed in lower and upper reaches of Indian Creek. The middle reach of Indian Creek has also shown an increase in trout densities, and although less variable, the rate of increase is lower than the other reaches (Figure 7).

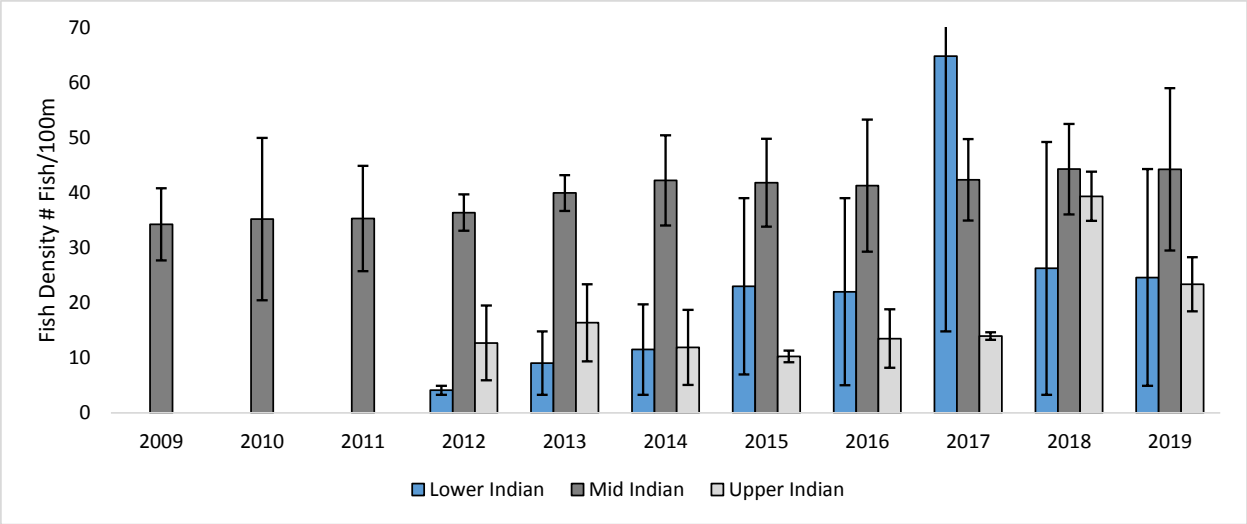

Figure 7. Mean annual density trends in the three reaches of Indian Creek, 2009 - 2019.

3.1.2. Migrant Trout Trapping

From 2017 to 2019, we trapped a total of 1,386 fish in Indian Creek and 152 fish in Nehchen Creek (Table 1). In each year, numbers of small (<150 mm) and large (>150 mm) fish in traps were substantially greater in Indian Creek than in Nehchen Creek. Collectively over three years, 77% of the ascending fish and 47% of the descending fish were considered adults (over 150mm). Of the descending adults, 66% had been previously captured ascending the trap. Conversely, descending trout smaller than 150mm were recaptured at a rate of 21%. In Nehchen Creek, 70% of the ascending fish captured over the three year period were considered adults. Adults also comprised more than 70% of the descending fish in 2017 and 2018, but only constituted 24% of descending fish in 2019. Of those descending adults, 20% had been previously captured ascending the migrant trap. In each stream, the total catch of ascending adult fish along with the recapture rate of descending adults was considerably lower in 2019 than the two previous years.

In 2017 and 2018, 50% of all ascending fish in Indian Creek (Figure 8) and Nehchen Creek (Figure Figure 9) were captured between April 27 and May 4. Over half of the descending fish in both creeks were captured in these years by May 7th. In 2019, traps were installed on May 2nd and at each trap location, 50% of the ascending trout were captured within 7 days and 50% of descending fish were captured within 12 days.

Table 1. Summary of migrant trap data for Indian and Nehchen Creek, 2017 - 2019.

	Indian Creek			Nehchen Creek		
	Ascending	Descending		Ascending	Descending	
Length (mm)	# Captured	# Captured	# (%) Recaps	# Captured	# Captured	# (%) Recaps
			2017			
0-150	56	96	18 (19%)	3	2	0
150+	195	112	81 (72%)	9	7	2 (29%)
Totals	251	208	103 (50%)	12	9	2 (22%)
			2018			
0-150	48	120	22 (18%)	5	6	2 (33%)
150+	264	111	74 (67%)	15	26	7 (27%)
Totals	312	231	96 (42%)	20	32	9 (28%)
			2019			
0-150	66	133	34 (25%)	3	56	0
150+	100	85	48 (56%)	2	18	1 (6%)
Totals	166	218	82 (38%)	5	74	1 (1%)

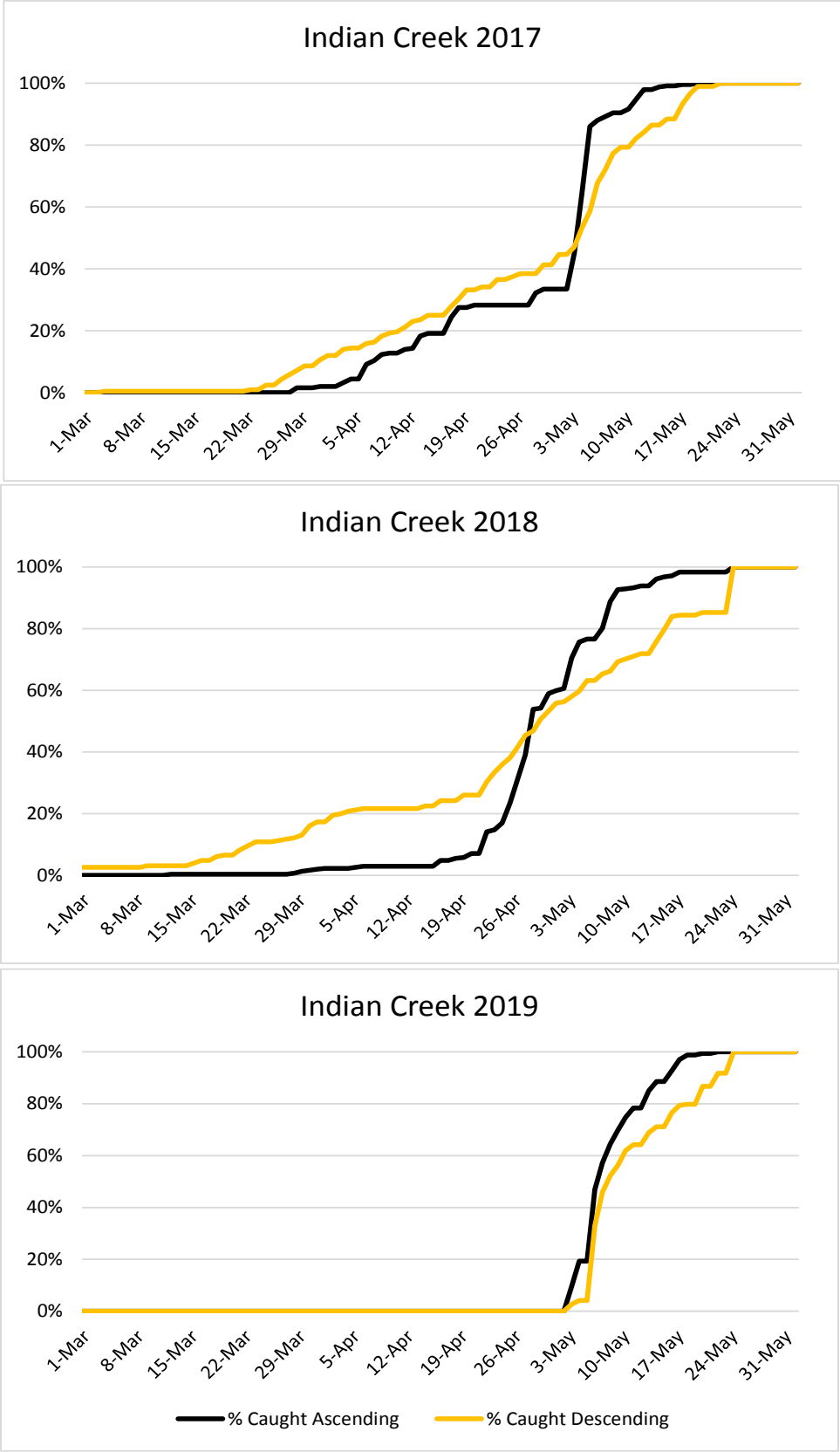

Figure 8. Cumulative catch at the Indian Creek migrant trap, 2017 - 2019.

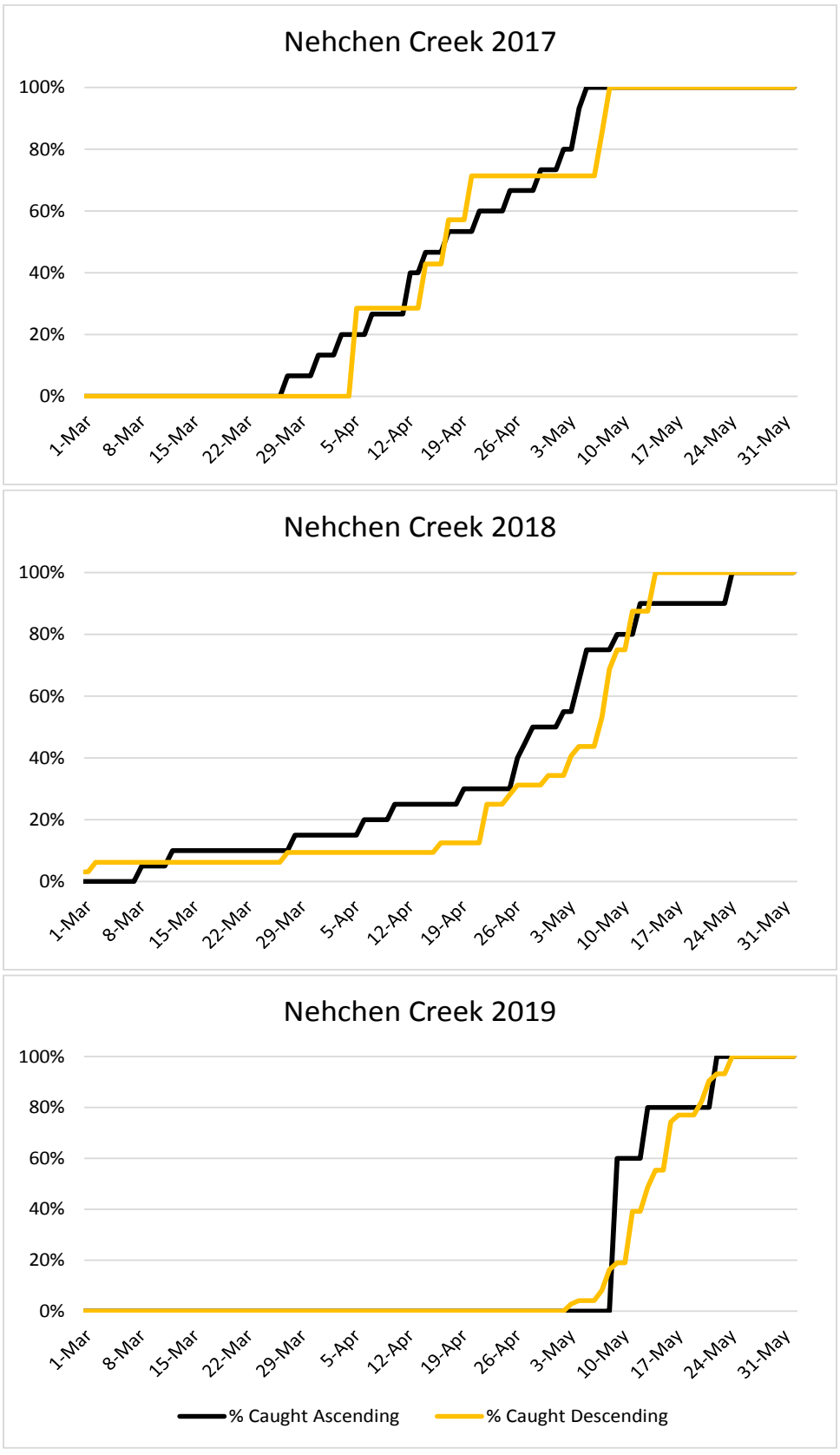

Figure 9. Cumulative catch at the Nehchen Creek migrant trap, 2017 - 2019.

3.1.3. Fluvial Life-History of Trout

Distribution of the Fluvial Life-History Variant across the Upper Hangman Watershed

From 2017 through November 2019, 238 redband trout PIT tagged in Nehchen and Indian creeks were detected moving into the mainstem of Hangman Creek. Throughout the sampling period, trout captured at the Nehchen Creek trap were much more likely to be detected in the mainstem of Hangman Creek than fish captured at the Indian Creek trap (Table 2). Regardless of size, trout tagged at the Nehchen trap were likely to be detected in Hangman Creek within the same year of capture. Conversely, trout considered to be juveniles (<150mm) captured at the Indian Creek trap were considerably more likely than adults to be detected in Hangman Creek the following year. Of the 359 fish tagged in Indian Creek during summer electrofishing surveys, 39 (11%) were detected in Hangman Creek. None of the redband trout tagged in the upper reaches of Indian Creek were detected leaving the tributary (Table 2).

Table 2. Summary of fluvial redband trout emigrating from Indian and Nehchen creeks into the mainstem of Hangman Creek, 2017 - 2019.

	2017			2018			2019	
	# Fish Marked	# (%) 1st Detected in Hangman Cr.		# Fish Marked	# (%) 1st Detected in Hangman Cr.		# Fish Marked	# (%) 1st Detected in Hangman Cr.
Indian Cr. Electrofishing		Year 1	Year 1+		Year 1	Year 1+		Year 1
Reach 1: 0 - 2km	71	3 (4%)	21 (30%)	2	2 (100%)	0	28	.
Reach 2: 2 - 4 km	34	0	1 (3%)	43	0	12 (28%)	48	.
Reach 3: 4+ km	32	0	0	55	0	0	46	.
Indian Cr. Trap (Rkm 2.3)								
< 150mm	91	7 (8%)	10 (11%)	117	6 (5%)	7 (6%)	118	10 (8%)
150mm+	163	11 (7%)	1 (<1%)	195	22 (11%)	5 (3%)	95	13 (13%)
Nehchen Cr. Trap (Rkm 0.2)								
< 150mm	5	3 (60%)	.	9	9 (100%)	.	46	37 (80%)
150mm+	13	10 (77%)	1 (8%)	32	31 (97%)	.	17	16 (94%)

Mainstem Movement and Rearing Habits of Fluvial Redband Trout

From 2017 to 2019, few fluvial redband trout tagged in Nehchen (rkm 19.8) and Indian (rkm 26.6) creeks were found to move through the 6.8 kilometer reach of mainstem Hangman Creek (rkm 19.8-26.6) that was undergoing active restoration (Table 3). Collectively over the three years, 46% and 40% of tagged fish originating from Nehchen creek were found to move either downstream or up into the restoration reach when entering the mainstem, respectively. In 2018 and 2019, 54% and 44% of tagged fish from Indian Creek were found to move either upstream or down into the restoration reach when entering the mainstem, respectively; mainstem rearing locations were not able to be properly evaluated in 2017 because of antenna placement. In general, fewer fish were found to enter proximate mainstem reaches in the winter than in the summer.

Table 3. Summary of seasonal rearing locations of fluvial redband trout within the mainstem of Hangman Creek, 2017 - 2019. The mainstem reach from rkm 19.8 to 26.6 is undergoing active restoration.

	# (%) Nehchen Origin RBT Holding in Mainstem			# (%) Indian Origin RBT Holding in Mainstem		
	< Rkm 19.8	19.8 - 26.6	> Rkm 26.6	< Rkm 19.8	19.8 - 26.6	> Rkm 26.6
			2017			
Summer	8 (62%)	4 (30%)	1 (8%)	3 (.)	16 (.)	.
Winter	2 (40%)	3 (60%)	0	0	8 (.)	.
			2018			
Summer	13 (36%)	17 (47%)	6 (17%)	2 (4%)	26 (49%)	25 (47%)
Winter	1 (25%)	3 (75%)	0	0	2 (40%)	3 (60%)
			2019			
Summer	29 (50%)	19 (33%)	10 (17%)	0	15 (38%)	24 (62%)
Winter	.	.	.	.	.	.

Annual Survival Rates of Fluvial Redband Trout

Trout tagged in Indian and Nehchen creeks that were found to reside in the mainstem of Hangman Creek from 2013-2018 were detected or recaptured the following year at overall rate of 14% and 15%, respectively (Table 4). The lowest survival rates documented for fish tagged in Nehchen Creek were for those fish found to rear in the mainstem during 2015 to 2016. Similarly, Indian Creek tagged fish that reared in the mainstem during these two years also had low survival rates compared with other years. Survival rate results from Indian Creek in 2018 are based on a new fixed PIT tag detection array positioned at the mouth of Indian Creek with the ability to detect all fish leaving the tributary, and consequently are not necessarily comparable to the previous years when only fish leaving the tributary and moving downstream were detected. Survival rates were also calculated for fish based on the rearing location within the mainstem of Hangman Creek, though conclusions were difficult to draw because of low sample size and the inconsistency in generated reach-specific survival rates from one year to the next (Appendix B).

Seasonal Tributary Use of Fluvial Redband Trout

From 2017 through 2019, 68 tagged fluvial redband trout were detected entering a different tributary than the one they were tagged in, 43 of which originated from Indian Creek and 25 from Nehchen Creek (Table 5). Fish from Indian Creek were most likely to ascend Smith Creek in all seasons, whereas fish from Nehchen Creek were most likely to ascend Indian Creek. During the fall/winter season, the length of time fish from Indian Creek inhabited Smith Creek ranged from 20 to 218 days. On average, fish entering tributaries in the spring were detected leaving after 14 days. Twenty one (31%) of the fish detected entering an adjacent tributary were never detected leaving that tributary.

Table 4. Summary of survival rates for tagged fluvial fish known to rear in the mainstem of Hangman Creek, 2013 - 2018.

	Nehchen Creek			Indian Creek		
	# Fish	# Detected 1+ years	Survival Rate	# Fish	# Detected 1+ years	Survival Rate
2013	57	16	28%	11	3	27%
2014	69	12	17%	13	3	23%
2015	99	5	5%	21	3	14%
2016	50	5	10%	21	4	19%
2017	14	3	21%	24	4	17%
2018	40	8	20%	57[a]	4	7%[a]

[a] # of fish detected and survival rate are based on a new PIT tag fixed site location

Table 5. Seasonal tributary use of fluvial fish tagged in Indian and Nehchen Creek, 2017 - 2019.

	Season Detected					
	Spring		Summer		Fall/Winter	
Stream Ascended (Hangman Creek Rkm)	# Fish	Mean # Days	# Fish	Mean # Days	# Fish	Mean # Days
			Fish Tagged in Indian Creek			
Sheep (12.2)	1[a]	.	0		0	
Nehchen (19.8)	3[b]	9	0		0	
Smith (25.7)	29[c]	22	2[a]	.	8[d]	122
			Fish Tagged in Nehchen Creek			
Sheep (12.2)	4[a]	.	0		0	
Smith (25.7)	7[e]	14	0		0	
Indian (27.7)	14[f]	11	0		0	

[a] None of these fish were detected leaving the stream

[b] 1 fish was not detected leaving Nehchen Creek

[c] 6 fish were not detected leaving Smith Creek

[d] 3 fish were not detected leaving Smith Creek

[e] 3 fish were not detected leaving Smith Creek

[f] 8 fish were not detected leaving Indian Creek

3.2.Effectiveness Monitoring

3.2.1. Spatial and Temporal Temperature Trends

Summer stream temperatures monitored at two sites located in the mainstem of Hangman Creek that received restoration treatments (rkm 19.8 – 23.9) markedly decreased after stream modifications were completed in 2014 and 2015 (Figure 10). Specifically, at rkm 22.8, the percentage of time stream temperatures exceeded 20°C decreased by over 46% from average pre-restoration values of 49% to average post-restoration values of 21%. At rkm 20.4, stream temperatures exceedance rates decreased by more than 86%, from an average of 30% of the time pre-restoration, to an average of 4% post-restoration. Additionally, maximum daily air temperatures during summer periods after 2015 were on average 1.75°C higher than in years prior to 2014. When examining data from both time periods for years with similar thermal regimes, a more dramatic difference is observed. For example, average maximum daily air temperatures were similar in 2013 (29.9°) to 2018 (30.6°) though stream temperatures at stream kilometer 20.4 only exceeded the threshold limit 2% of the time in 2018 versus 39% in 2013.

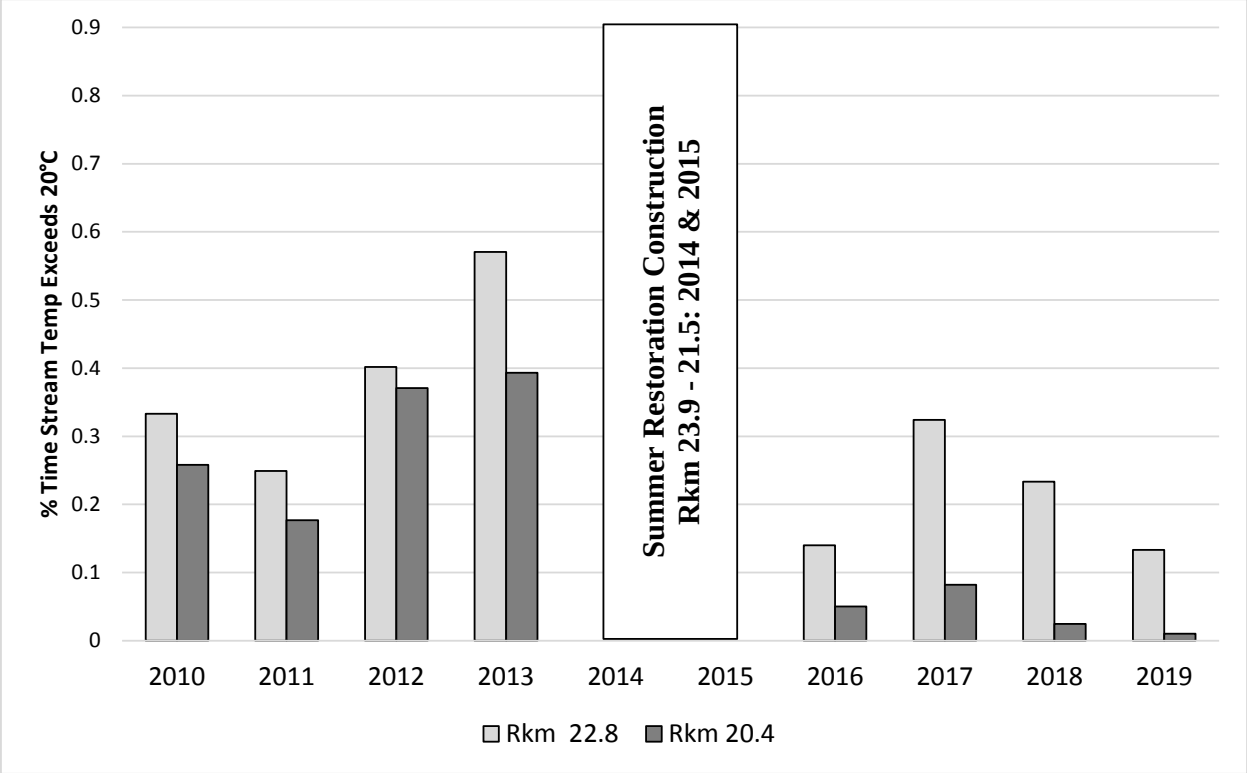

Figure 10. Stream temperature trends pre and post-restoration, 2010 - 2019. Although temperatures were recorded in 2014 & 2015, they are not reported due to the influence of construction activities during the summer.

3.2.2. Non-Native Fish Suppression

From 2015 through 2019, a total of 279 Westslope cutthroat trout and cutthroat X redband hybrids have been removed from a 1.6 kilometer reach of upper Nehchen Creek. The largest densities of cutthroat (16.9 fish/100m) were removed in 2015, though in every year following 2015, cutthroat trout densities have remained below 2.5 fish per 100 meters of stream length.

(Figure 11). Redband trout were estimated to make up 10% of the entire catch during the initial year of suppression, whereas in 2019 they comprise nearly 84% of salmonids.

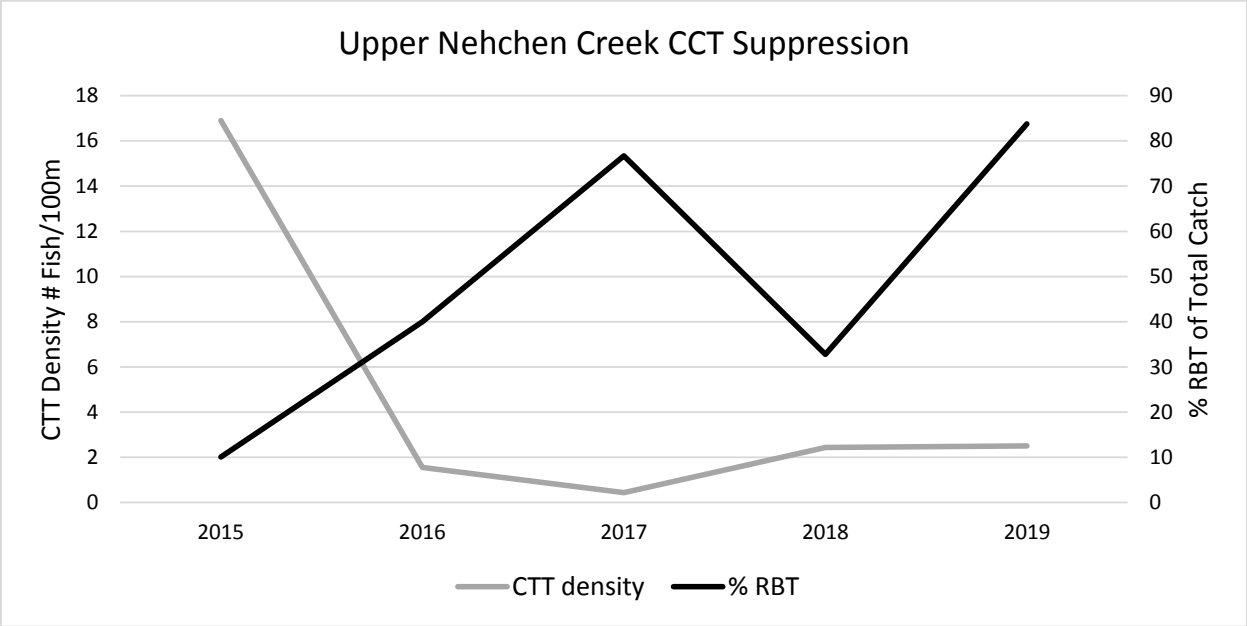

Figure 11. Trends in densities of Westslope cutthroat trout and the composition of redband trout throughout suppression efforts in upper Nehchen Creek, 2015 - 2019.

4. Discussion

Densities of trout continue to vary substantially from year to year, especially in the subwatersheds which are functionally isolated from one another. These tributaries include Mission, Sheep, and Smith creeks, all having lower reaches which are dominated by dryland agriculture and typically run dry during the summer. The subpopulations of trout inhabiting these streams are relatively small and are subject to restricted areas of refuge. Impacts to survival such as variations in annual precipitation patterns and extreme summer temperatures can have a particularly heavy impact to these subpopulations.

Trout densities in Indian Creek however exhibited less variability and displayed an overall increasing trend. Densities in this stream appear to be buffered from extreme hydrologic or climatic conditions. The Indian Creek subwatershed is considered to be a stronghold for redband trout in the upper Hangman watershed and will continue to be a primary focus for preservation and restoration by the Coeur d'Alene Tribe. This stream is the furthest downstream subwatershed in the study area with substantial densities of redband trout throughout its entirety, and supports a fluvial life-history component. Fluvial fish have a tendency to move between tributaries in the Hangman watershed and therefore a higher probability of promoting gene flow and overall population resiliency. Rasmussen (2007) determined this intrinsic tendency toward movement lead to higher rates of immigration and dispersal in freshwater fishes, and is a major driver in ecological interactions which promote intraspecific diversity. This is extremely important for the redband trout populations in the upper Hangman watershed as past genetic studies have determined that a lack of genetic richness is prevalent (Small et al 2005).

Gaining an understanding of the survival, behavior and dispersal patterns of fluvial fish in the watershed, and how that may change as large-scale restoration continues is essential for adapting our restoration approaches in the mainstem of Hangman Creek and the lower reaches of tributaries. Migrant trapping continues to be the most effective way to intercept and tag fluvial redband trout in the watershed. This is especially true in Nehchen Creek where 100% of the fluvial fish sampled are at the migrant trap. Summer electrofishing efforts in Indian Creek has also shown to be an effective way to sample fluvial fish, although that life history characteristic has been found strictly in the lower and middle reaches of the stream.

The implications of delaying trapping can have an impact on representative sampling of redband trout exhibiting the fluvial life history trait. In both Indian Creek and Nehchen Creek, although there does not appear to be a significant difference in the total number of fluvial individuals caught in migrant traps among years, there was a lower proportion of adults captured in 2019 than in earlier years. Likely, delaying trapping efforts has an impact on sampling a representative composition of age structure as larger ascending fish are sampled at the trap sites earlier in the spring. This is especially true in Nehchen Creek as past data from PIT tag fixed sites shows a tendency for fluvial fish originating from Nehchen Creek to enter this tributary throughout the late winter and early spring (Biladeau and Kinkead, 2017). Additionally, recapture rates of adults descending through the trap are much lower in Nehchen Creek than in Indian Creek during this and prior reporting periods (Biladeau and Kinkead, 2017) which also suggests earlier ascension through the trap site. In order to gain a more thorough understanding

of all life stages of fluvial fish habits and survival in the mainstem, trapping efforts in the future will need to be consistent and cover the entire spring migratory season. This is also true if our program wishes to track abundances of spawning fluvial fish in these streams with precision as a metric for assessing recovery. In addition, PIT tagging fish at migrant traps and operating stationary interrogation sites is an effective way to gain large amounts of data with little effort and resources.

The habitat conditions in the mainstem of Hangman Creek are important for the survival of fluvial fish, as this is where they spend the majority of their sub-adult and adult life. This is especially true for fish originating from Nehchen Creek where the lower and middle reaches of this tributary tend to dry up from July through November. Currently, many of the fluvial fish exiting Nehchen creek during the reporting period were found to either move downstream or to move into the restored reach upstream, indicating the importance of creating high-quality rearing habitats in proximate mainstem reaches.

Survival rates of fluvial fish from 2013 to 2018 were highly variable and likely correlated to precipitation patterns and summer temperatures during these years. The highest recorded survival rates for fish originating from each subwatershed occurred from 2013 to 2014, a water year where snowpack was above average for the region and runoff was prolonged (USGS 2020). Conversely, years of especially dry and hot summers, such as what was observed in 2015, have resulted in significantly lower survival rates. However, the data suggest that survival rates of 30% or more is achievable, and if mainstem restoration is effective, we hope to elicit sustained survival at these levels regardless of hydrologic conditions or summer temperatures. A lack of quality winter rearing habitat may also have a significant impact on survival. Due to the flashy nature of the hydrograph, largely dominated by rain-on-snow runoff events, areas of backwater and ponded refuge habitat are especially important for fluvial fish in this watershed. Decades of stream channelization and beaver exclusion has reduced this habitat to a fraction of what was historically present. Restoration in the mainstem of Hangman Creek is focused on increasing quality rearing habitat in the winter and spring via the creation of slower moving side-channel and backwater habitat and the creation of cold water refugia during the summer, conditions that are now present in the reach between stream kilometer 19.8 and 26.6.

The focus reach of Hangman Creek has undergone largescale restoration projects designed to promote natural processes which in turn should provide quality rearing habitat for salmonids. Limiting summer habitat conditions in this reach of Hangman Creek are thought to be high stream temperatures, and a lack of flow and dissolved oxygen (Kinkead & Biladeau 2012). These three physical factors are certainly correlated to one another, and our restoration objectives are focused on addressing each. Stream temperature data suggests a trend toward providing cooling stream temperatures during the summer and to buffer the projected effects of climate change in the region. Prior to 2014 and the first phase of restoration, stream temperatures from kilometer 19.8 to 22.9 were exceeding 20°C at a much higher rate than after major stream modifications were completed in 2016, even though summer air temperatures were lower before restoration actions than what was observed in the past few years.

The tendency of migrant fish to disperse into one adjacent tributary versus another is not clear. The relative position of a tributary to one another in the watershed may have an influence as Indian Creek fish are most likely to frequent Smith Creek and Nehchen Creek fish are found in Sheep creek more often than Indian Creek fish. However, there may also be an affinity towards quality of habitat as Nehchen Creek fish are found to enter Indian Creek more often than other tributaries, the majority of which were never detected leaving the tributary. We do not however have any data to definitively prove fish are interbreeding across subpopulations. Tracking data does show that fish enter these tributaries at the highest rates in the spring, which could suggest spawning movements and the possibility for interbreeding to occur. Future genetic studies may be an appropriate method for tracking genetic richness and drift over time and in turn provide insight on whether or not dispersal is occurring as connective habitat is restored.

Impacts to native redband trout in Hangman Creek due to hybridization from non-native cutthroat were previously thought to be restricted to a resident population in the headwaters of Nehchen Creek. Although not documented in the data, cutthroat have been observed at the trap site near the mouth as early as 2015. In light of the data showing the tendency for Nehchen origin fish to be dispersing at high rates into Indian Creek, the risk of hybridization spreading into adjacent subpopulations was deemed high and suppression efforts were initiated. Results from suppression efforts indicate significant changes to the composition in the fish community can be made in a relatively short amount of time and fish deemed to be cutthroat or hybrids can be reduced to very low levels. Additionally, lower than normal summer flows such as what occurred in 2015 likely help to improve suppression efforts as most fish were restricted to stranding pools. There are however questions remaining as to what a hybrid actually is and if we can positively identify them visually. In the future, genetic analyses should be initiated in conjunction with visual identification in order to verify the effectiveness of our suppression efforts.

The research, and monitoring associated with the Hangman Fisheries Enhancement project has reached a transition phase whereas assessment, status, and trend monitoring have given us a clear picture on how and where our resource management objectives should be focused and what limiting factors need to be addressed. The Coeur d'Alene Tribe Fisheries Program will begin to place much more emphasis on monitoring the effectiveness of restoration actions as they relate to physical and biological characteristics within the project area. RM&E activities which mirror the current status and trend monitoring will be down-sized and specific to proposed habitat restoration actions, serving as effectiveness monitoring in the future. Stream temperature monitoring has already given us an understanding of how our current restoration methods are influencing changes in physical stream parameters. The sampling and tagging of fluvial and resident fish during trapping and electrofishing will hopefully give us an insight on potential changes to the biological communities within the upper Hangman watershed.

5. References

Aripa, F. 2003. Personal communication with tribal elder.

Biladeau, T.J. & B.A. Kinkead. 2017. RM&E Progress Report 2014-2016: Hangman Creek Fisheries Restoration, 5/1/2014 – 4/30/2017 Annual Report, 2001-032-00.

Green, G.I., B. Kinkead, and D. Callery. 2008. Prioritization Area Selection within the Hangman Watershed of the Coeur d'Alene Reservation. Coeur d'Alene Tribe.

Kail, Jochem, D. Hering, S. Muhar, M Gerhard, and S. Preis. 2007. The use of large wood in stream restoration: experiences from 50 projects in Germany and Austria. Journal of Applied Ecology. 44: 1145-1155.

Kinkead, B.A., and T. J. Biladeau. 2012. Progress Report 2010-2011: Hangman Creek Fisheries Restoration, 5/1/2010 - 04/30/2012 Annual Report, 2001-032-00.

Kinkead, B.A. and T.J. Biladeau. 2017. Hangman Creek Habitat Restoration Progress Report 2012 - 2016, BPA Annual Report, 2001-032-00.

Rasmussen, J.E. and M.C. Belk. 2017. Individual Movement of Stream Fishes: Linking Ecological Drivers with Evolutionary Processes, Reviews in Fisheries Science & Aquaculture, 25:1, 70-83.

Roni, P. and T. P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries and Aquatic Science. 58: 282-292.

Small MP, McLellan JG, Loxterman J, Von Bargen J, Frye A, & Bowman C 2007. Fine-scale population structure of rainbow trout in the Spokane River drainage in relation to hatchery stocking and barriers. Transactions of the American Fisheries Society 136:301-317.

Washington State Department of Ecology. 2005. The Hangman (Latah) Creek Water Sampling Data Summary. Water Quality Final Report. Sponsored by The Hangman (Latah) Creek Watershed Planning Unit. Public Data File No. 05-01.

U.S. Fish & Wildlife Service. 2017. National Wetlands Inventory. https://www.fws.gov/wetlands/data/Historic-Wetlands-Product-Summary.html Internet

United States Geological Survey. 2020. Current and Historical Water Data for Idaho. https://waterdata.usgs.gov/wa/nwis/uv?site_no=12422990 Internet

6. Appendices

Appendix A: Summary of redband trout densities across the upper Hangman watershed, 2017 – 2019.

Index Site	Stream km	2017 RBT Captured	2017 RBT density fish/100m	2018 RBT Captured	2018 RBT density fish/100m	2019 RBT Captured	2019 RBT density fish/100m
			Hangman mainstem				
Hangman 1	24.5	4	6.6	5	8.2	4	6.6
Hangman 2	27.3	4	6.6	2	3.3	5	8.2
Hangman 3	29.8	7	11.5	9	14.8	5	8.2
			Mission Creek				
Mission 2	6.8	22	36.1	21	34.4	23	37.7
Mission 3	8.3	1	1.6	0	0.0	1	1.6
Mission 4	9.1	10	16.4	5	8.2	28	45.9
W.F. Mission 1	0.6	26	42.6	12	19.7	16	26.2
			Nehchen Creek				
Nehchen	4.6	0	0.0	3	4.9	11	18.0
Nehchen 3	5.0	1	1.6	0	0.0	27	44.3
			Sheep Creek				
Sheep 1	1.9	1	1.6	0	0.0	0	0.0
Sheep 2	4.8	15	24.6	9	14.8	21	34.4
Sheep 4	5.2	18	29.5	3	4.9	12	19.7
Sheep 6	5.6	2	3.3	3	4.9	6	9.8
			Upper Hangman Creek				
Hangman 5	33.3	29	47.5	35	57.4	46	75.4
Hangman 6	34	61	100.0	44	72.1	46	75.4
Bunnel 1	1.0	5	8.2	9	14.8	17	27.9
			Indian Creek				
Indian 1	0.1	9	14.8	2	3.3	3	4.9
Indian 2	0.8	70	114.8	30	49.2	27	44.3
Indian 5	2.6	19	31.1	32	52.5	36	59.0
Indian 6	2.9	28	45.9	22	36.1	18	29.5
Indian 9	5.1	8	13.1	27	44.3	19	31.1
N.F. Indian 1	0.2	9	14.8	27	44.3	9	14.8
N.F. Indian 2	0.7	9	14.8	23	37.7	13	21.3
E.F. Indian 1	0.2	8	13.1	19	31.1	16	26.2
			Smith Creek				
M.F. Smith 1	0.4	30	49.2	7	11.5	6	9.8
M.F. Smith 2	0.7	0	0	3	4.9	2	3.3
E.F. Smith 1	0.9	0	0.0	0	0.0	0	0.0

Appendix B: Summary of survival rates for tagged fluvial fish based on rearing location within the mainstem of Hangman Creek, 2019 – 2018.

	Downstream (< Rkm 19.8)			Focus Reach (Rkm 19.8 - 26.6)			Upstream (> Rkm 26.6)		
	# Fish	# Return	Survival Rate	# Fish	# Return	Survival Rate	# Fish	# Return	Survival Rate
				Nehchen Creek (Rkm 19.8) Origin Fish					
2016	23	4	17%	26	1	4%	1	0	0%
2017	6	1	17%	7	2	29%	1	0	0%
2018	15	1	7%	18	4	22%	6	2	33%
				Indian Creek (Rkm 26.6) Origin Fish					
2016	1	0	0%	20	4	20%	.	.	.
2017	3	0	0%	21	4	19%	.	.	.
2018	4	0	0%	24	2	8%	29	2	7%