



Lower Yakima Subbasin Larval Lamprey Monitoring Report, 2017



[Cover Photo: Overview of a larval lamprey survey site on the Yakima River (river km 13.0 near Richland, WA), where larval lampreys were captured in October, 2017.]

Project No. 2008-470-00

Report was completed under BPA Contract No. 56662 REL 123

Report covers work performed from: June 2017 – October 2017

Tyler Beals and Ralph Lampman

**Confederated Tribes and Bands of the Yakama Nation
Yakama Nation Fisheries Resource Management Program, Pacific Lamprey Project
P.O. Box 151, Toppenish, Washington 98948, USA**

Report Created: March, 2018

This report was funded in part 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.

ABSTRACT

In this report, we summarize our 2017 findings from larval lamprey habitat surveys in the lower Yakima Subbasin (Yakima River and all tributaries downstream of the Naches River confluence, river km 191.9). Both index sites (long term status and trend monitoring sites) and exploratory sites (sites to supplement knowledge of distribution throughout the subbasin) were surveyed. Larval Pacific Lamprey (*Entosphenus tridentatus*) was the primary target of the surveys. Western Brook Lamprey (*Lampetra richardsoni*), a predominately resident species, was also documented when encountered. Electrofishing surveys in 50 m reach sites were conducted in the mainstem of the lower Yakima River, and three major tributary streams; Satus Creek, Toppenish Creek and Ahtanum Creek. Throughout our survey, young of year (YOY) lampreys were separated from larger, older lampreys (non-YOY lampreys) to evaluate specific rearing preferences of young of year lampreys. We also monitored the temperature underneath the sediment where the highest densities of lampreys were found (in relation to the open water temperature above the sediment) to assess temperature preferences of larval lampreys between sites and the temperature relationship patterns and trends throughout the subbasin.

In the mainstem of the lower Yakima River (downstream of the Naches River confluence at river km 191.9), a total of four index sites were surveyed (river km 13.0, 74.1, 134.3 and 171.1). Pacific Lamprey were found at 3 of 4 (75%) sites. Pacific Lamprey were not present at river km 134.3, despite being present at surrounding sites (river km 74.3 and 171.1). In October of 2017, both larval Pacific Lamprey and Western Brook Lamprey were found at river km 13.0. Prior to 2017, the lowest distribution of larval lampreys (all species) was river km 73.5. Interestingly, river km 13.0 also had the highest estimated density of lampreys in Type I (preferred) habitat (26.5 #/m²). The lowest estimated lamprey density in Type I habitat was at river km 74.1 (0.7 #/m²), despite this site having the largest area of Type I habitat (900 m²). Similarly, the estimated lamprey density at river km 134.3 was also low (1.0 #/m²). Young of year (YOY) lampreys were found at 1 of 4 (25%) sites (river km 171.1). The density of young of year lampreys at this site was estimated at 10 #/m² in Type I habitat. The temperature under the sediment in Type I habitat (measured at a maximum of 10 cm under the sediment) was higher than the plot temperature (measured directly above the sediment), ranging from 0.5 to 1.0°C warmer).

In Satus Creek, three index sites (river km 12.9, 29.2 and 43.8) and one exploratory site (river km 50.2) were surveyed. Pacific Lamprey were found at 3 of 3 (100%) index sites. No lampreys were present at the exploratory site at river km 50.2. Upstream sites had a higher ratio of Pacific Lamprey than more downstream sites (67%, 90%, and 93%, at river km 12.9, 29.2 and 43.8, respectively). The highest estimated lamprey density was at river km 29.2 in Type I habitat (36.5 #/m²). Despite having the largest area of Type I habitat (175 m²), river km 12.9 had the lowest estimated lamprey density (3.7 #/m²). Young of year lampreys were found at 2 of 3 (66%) sites where lampreys were found. Estimated densities of YOY lampreys ranged from 75.0 #/m² (river km 12.9) to 245.0 #/m² (river km 29.2). At the most upstream site (river km 43.8), the sediment temperature in Type I habitat was 3.0°C cooler than the plot temperature; the highest observed temperature difference between the sediment and plot temperatures in Satus Creek.

A total of three index sites were electrofished in Toppenish Creek (river km 7.1, 43.5, 59.9), and one index site in Simcoe Creek (tributary of Toppenish Creek; river km 9.0). Lampreys were present at 2 of 3 (66%) index sites in Toppenish Creek and 1 of 1 (100%) sites in Simcoe Creek. Despite having the largest area of Type I habitat, no lampreys were found at river km 7.1 in Toppenish Creek. Pacific Lamprey were found at all the sites where lamprey was present in Toppenish and Simcoe Creek. At the two sites in Toppenish Creek, the ratio of Pacific Lamprey was similar (52% and 48% at river km 43.5 and 59.9, respectively). In Simcoe Creek, the ratio of Pacific Lamprey was much lower (18%). The highest estimated density of lampreys was in Simcoe Creek (25.3 #/m²). In Toppenish Creek, estimated densities of lampreys (excluding YOY lampreys) was higher at the upper most survey site at river km 59.9 (6.7 #/m²) compared to river km 43.5 (0.5 #/m²). Young of year (YOY) lampreys were found at 1 of 2 (50%) index sites with lampreys in Toppenish Creek (river km 59.9), and 1 of 1 (100%) sites in Simcoe Creek (river km 9.0). The YOY density was estimated to be 2.0 #/m² in Toppenish Creek and 25.7 #/m² in Simcoe Creek. Overall, the sediment temperature was cooler than the plot temperature (ranging between 0.2 and 1.1°C cooler at Toppenish Creek, river km 7.1 and Simcoe Creek, river km 9.0, respectively).

A total of four index sites were electrofished in Ahtanum Creek (river km 1.1, 11.5, 22.8 and 34.8). Pacific Lamprey were found at 4 of 4 (100%) sites. Similar to Satus Creek, the ratio of Pacific Lamprey generally increased with site distance upstream (11%, 86%, 79% and 94% at river km 1.1, 11.5, 22.8 and 34.8, respectively). Pacific Lamprey macrophthalmia (smolt stage with eyes) were captured at river km 1.1, 11.5 and 22.8 in September, 2017 (captured 2, 1, and 1, respectively). Despite having the largest area of Type I habitat, river km 11.5 had the lowest estimated lamprey density in Type I habitat, excluding YOY lampreys (10.5 #/m²). Young of year lampreys were found at 4 of 4 (100%) sites. At river km 11.5, the estimated density of YOY lampreys was highest (66.7 #/m²), despite this site having the lowest estimated density of larger (older) lampreys. At all sites, the sediment temperature was less than 1.0 C cooler than the plot temperature (sediment temperature 0.6, 0.5, 0.5 and 0.1°C cooler than the plot temperature at river km 1.1, 11.5, 22.8 and 34.8, respectively).

INTRODUCTION

Starting in 2010, the Yakama Nation Pacific Lamprey Project initiated electrofishing surveys targeting larval lamprey in the Lower Yakima Subbasin (the mainstem of the Yakima River, and its tributaries downstream of the Naches River confluence with Yakima River, river km 191.9). These surveys showed that Pacific Lamprey densities in the lower reaches of the Yakima River, and its tributaries, were low and on the decline. In 2012, efforts began (and are currently ongoing) to translocate adult Pacific Lamprey into tributary streams of the lower Yakima River (Satus, Toppenish, and Ahtanum). Additionally, in 2014, adult translocation began (and is currently ongoing) in the mainstem of the lower Yakima River (to evaluate passage efficiency over mainstem dams, and investigate migration patterns within the subbasin). Since adult translocation began, electrofishing surveys targeting larval lampreys have shown an increase in population and abundance of Pacific Lamprey throughout the lower Yakima Subbasin. Additionally, Western Brook Lamprey (*Lampetra richardsoni*), a more common, primarily resident species, of lamprey were documented during these surveys. The following report provides a concise summary of our 2017 larval lamprey electrofishing surveys in the Lower Yakima Subbasin.

METHODS

Throughout the Yakama Nation Ceded Lands, the YNPLP (Yakama Nation Pacific Lamprey Project) has conducted surveys for larval lampreys (beginning in 2009). Index sites, or long-term repeat monitoring sites, have been established throughout the Ceded Lands. The index sites are spatially distributed within watersheds with the potential to hold Pacific Lamprey. The primary goal of these index sites is to monitor the status and trend of Pacific Lamprey in the lower, middle, and upper reaches of interest watersheds. In addition to the index sites, exploratory sites are established each year to further our knowledge on Pacific Lamprey distribution and habitat availability within each watershed.

Field Survey

For all site types, survey sites were chosen based on aerial images from Google Earth and GIS software and site visits. Sites that had higher chances of being a Type I habitat [such as visibly recognizable areas on aerial image with slow water, shallow channel margin with dark tints (usually indicating fine sediment), backwater eddies, confluence of side channels, behind island bars, and tail end of deposition bars, etc.] were given priority. We determined that targeting the preferred habitat more effectually will provide us with a better framework for evaluating presence/absence, distribution, and relative abundance. Further, due to restricted survey time, the ease of access to a survey site (e.g. sites with public road access, short hikes, or near bridges, or private properties who permit access to the rivers/streams) was a critical issue and strongly considered when choosing sites. By prioritizing accessibility, more ground could be covered throughout the expansive area of interest. Chosen habitat sites were ultimately spatially distributed throughout individual watersheds.

Surveys were focused on Type I (preferred) and/or Type II (acceptable) habitat to provide optimal opportunity to capture the largest number of larval lamprey. Type I habitat primarily consists of fine sand, silt and/or clay and is absent of coarse substrate (gravel/cobble/boulder/bedrock). Type II habitat is coarse shifting sand or other fine substrate mixed with coarse substrate. Type III (unsuitable) habitat consists of no fine sediments and was not surveyed. Type I and II habitat is generally found in backwater areas, point bars, mainstem channel margins, and side channels.

At each electrofished site (index or exploratory), a 50 m reach was measured out which encompassed the most accessible and abundant Type I and Type II larval lamprey habitat. The total area (m²) of Type I and Type II larval lamprey habitat was estimated within the 50 m reach. Electrofishing surveys targeted representative areas of Type I habitat. Type II habitat was opportunistically surveyed (based on available time and survey purpose). At index sites, a minimum area of 5 m² of Type I habitat was surveyed. If Type II was surveyed, a minimum area of 5 m² was surveyed in addition to Type I habitat. At exploratory sites, a minimum area of 5 m² of either habitat type was surveyed, but varied depending on available time and survey purpose.

Throughout the course of the survey, young of year (YOY) larvae were kept separate from larger (older) lampreys. Larvae were considered YOY when their length was less than or equal to (\leq) 25 mm between June and August, and this threshold was increased to \leq 30 mm during the months of September and October.

Sediment type (sand, silt or clay) was recorded for the specific area (1 m²) where the most lampreys were observed (separate measurements for YOY and all other lampreys). The sediment depth (cm), water depth (cm), plot temperature ($^{\circ}$ C) and sediment temperature (a max of 10 cm below the sediment), were also recorded at this location (separate measurements were taken for YOY larvae). If no fish were observed, plot temperature was taken where the best available habitat was observed. Thalweg temperature was recorded to represent the main channel temperature.

Electrofishing surveys were conducted with an AbP-2 Backpack Electrofisher (ETS Electrofishing Systems Inc., Madison, WI), specially designed for the sampling of larval lampreys. Surveys targeted available (wetted) larval habitat using standard survey methods (slow tickle pulse of 3 pulses/sec and fast stunning pulse of 30 pulses/sec, 25% duty cycle, 3:1 burst pulse train, and 125 volts). Another person, equipped with a fine-mesh hand net was also present to help capture any electrofished larvae. Electrofishing time (seconds) and area (m²) covered (of each habitat type) was recorded. For YOY larvae, we recorded the total area where YOY larvae were observed during the course of the survey.

Captured lampreys were separated by habitat type, tallied by life stage, age class (YOY lampreys separated from all other lampreys), and identified to species (if of identifiable length > 50 mm). A minimum of 30 lampreys of identifiable length were identified to species. If less than 30 lampreys were of identifiable length, then all identifiable lampreys were identified.

For non-YOY lamprey, 15 representative lengths were taken (+/- 1 mm). Four of these lampreys were measured to the nearest 0.01 gram (length and weight was taken on the largest, smallest and two medium sized larvae relative to the site). The combined weight of all captured lampreys was

also measured (nearest 0.01 g). Missed larvae were counted and tallied by size class (small <50 mm, medium 50-90 mm, and large > 90 mm).

Once a tally was obtained for each habitat type, all YOY larvae were placed together, and five lengths were recorded (largest, smallest, and three medium sizes relative to the collected sample [+/- 1 mm]). The total weight of the collected YOY larvae was also recorded to the nearest 0.01 gram.

Genetic samples were collected from Pacific Lamprey (> 50 mm) with scissors or 2 mm hole punch (top or bottom of the caudal fin). Lampreys less than 50 mm were generally collected as whole samples (by placement on a genetic sheet or preservation in 70% Ethanol), but efforts were made to take genetic clips from larger unidentifiable larvae (> 35mm) rather than whole samples. Macrophthalmia were clipped on the back of the second (rear) dorsal fin with scissors or small (2mm) hole punch. Samples were primarily collected in areas where adult Pacific Lamprey translocation efforts are ongoing, or where the distribution of Pacific Lamprey is uncertain.

Additionally, genetic samples were collected from Western Brook Lamprey (> 50 mm) with scissors or 2 mm hole punch (top or bottom of the caudal fin). Photos were taken of the caudal fin prior to taking the genetic clip. In general, Western Brook Lamprey are separated into two classes, based on the pigment of their caudal fin; Class A (no pigment present) and Class B (pigment present). Genetic samples were collected from Western Brook Lamprey in each surveyed watershed when they were present (representative samples of Class A and Class B). The goal of these samples is 1) confirm the presence of Western Brook Lamprey in areas where Western Brook Lamprey are thought to be absent, or limited in number and 2) better understand the genetic variance between these two classes of Western Brook Lamprey throughout the Columbia River Basin.

Data Analysis

Captured and missed larvae were tallied together to determine the total number of observed lampreys from electrofishing for each habitat type. If the number of captured lampreys was less than half of the observed total, the number of captured lampreys was doubled, and used as the final observed total. If the number of captured lampreys was equal to or more than half, the recorded observed number was used as the final observed total (represented by “total number observed” in the following report). A histogram of all captured lampreys (excluding YOY lampreys), separated by species, for each watershed is displayed in this report. Representative measurements of all YOY lampreys were not recorded at each site; therefore, YOY lampreys are excluded from these histograms.

In many cases, survey visibility was less than ideal, and many lampreys went unseen. To account for unseen lamprey, the total number of lampreys observed (final observed total) was adjusted (increased) based on a 1-5 visibility scale. A separate adjustment value was given for non-YOY larvae, and YOY larvae (in an attempt to account for the small size of YOY larvae). For non-YOY larvae, the following 1-5 visibility scale was used: (1) poor (60%), (2) fair (70%), (3) good (80%),

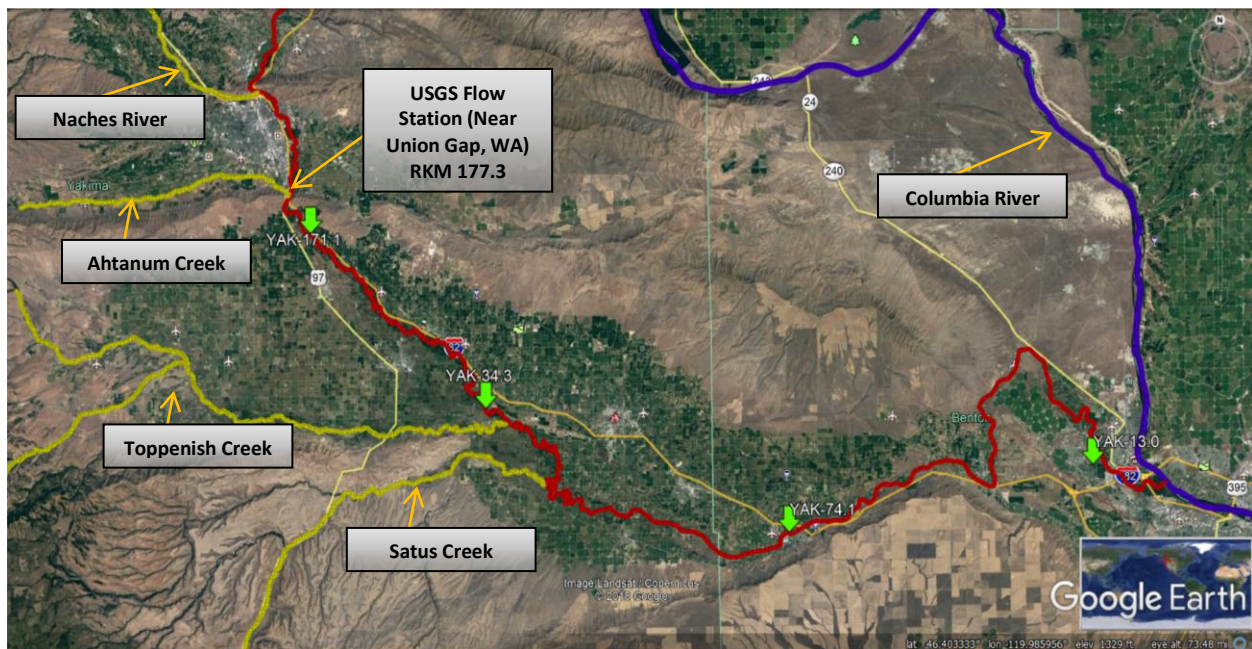
(4) very good (90%) and (5) excellent (100%). For YOY larvae, a more generous visibility adjustment scale was used: (1) poor (10%), (2) fair (20%), (3) good (30%), (4) very good (40%) and (5) excellent (50%).

For each survey, and each age class, the total number of observed lampreys was increased (by the percentage listed above) based on the survey's visibility rank. The adjusted observed value is represented as "Sampled Estimated Number" in the following report. Survey densities on non-YOY lampreys (#/m²) were calculated using the estimated sample number, and the total survey area. However, for YOY larvae, survey densities were calculated from the estimated sample number, and the survey area where YOY lamprey were observed during the survey. A mean condition factor was calculated for each site. The mean condition factor was calculated from the condition factor of each of the larvae measured by both length and weight.

RESULTS

Lower Yakima River Mainstem

A total of four index sites were surveyed in the lower reach of the mainstem Yakima River (Map 1). Electrofished sites were spatially distributed between river km 13.0 and 171.1. The confluence of the Naches River is at river km 191.9. The flow at a USGS flow station (river km 177.3) at the time of survey is shown in Figure 1.



Map 1. Overview of 2017 survey sites in the lower mainstem of the Yakima River (red line) downstream of the Naches River confluence (river km 191.9), displaying surveyed index sites (green arrows) where electrofishing occurred. The location of a USGS Flow Station (near Union Gap, WA; river km 177.3) is also labeled. Tributary streams are also labeled accordingly.

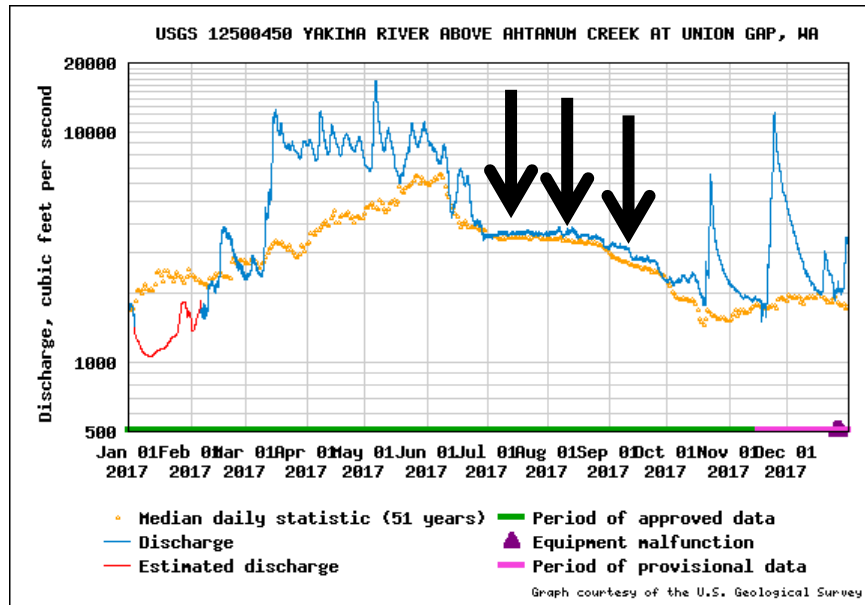


Figure 1. Discharge (cubic feet per second indicated by the narrow blue line) of the lower Yakima River near Union Gap, WA (river km 177.3) in 2017; black arrow indicates YN survey periods (August, September, and October, 2017).

Lower Yakima River Mainstem Survey Highlights

- Type I habitat availability was similar at river km 13.0, 134.3 and 171.1 (48, 30, and 64 m², respectively; Table 1). At river km 74.1, larval habitat was much higher (900 m²). Type II habitat was absent from river km 74.1, and highest at river km 171.1 (3000 m²).
- At 3 of 3 (100%) sites where both the plot temperature and the sediment temperature were measured, the temperature under the sediment was higher than the plot temperature (0.5 C to 1.0 C; Table 1).
- The highest estimated density of lampreys (excluding YOY lampreys) was observed at river km 13.0 in Type I habitat (26.5 #/m²). Despite having the largest area of Type I habitat, river km 74.1 had the lowest estimated lamprey density in Type I habitat (0.7 #/m²; Table 3). Similarly, the estimated lamprey density at river km 134.3 was also low (1.0 #/m²). The density at river km 171.1 was over nine times higher than river km 134.3 (9.1 #/m²).
- Young of year (YOY) lampreys were found at 1 of 4 (25%) sites (river km 171.1; Table 2 and Table 3). The density of young of year lampreys at this site was estimated at 10 #/m² in Type I habitat.
- Pacific Lamprey were found at 3 of 4 (75%) sites (Table 7). Pacific Lamprey were not present at river km 134.3, despite being present at surrounding sites (river km 74.3 and 171.1). Pacific Lamprey were found at river km 13.0, at a ratio of 16% (Table 6). Immediately downstream of Sunnyside Dam, river km 171.1, the ratio of Pacific Lamprey was near equal to that of Western Brook Lamprey in Type I habitat (55% Pacific Lamprey, and 45% Western Brook Lamprey).

Habitat Overview (Lower Yakima River)

Table 1. Larval lamprey habitat details for lampreys greater than one year of age from index sites surveyed in the lower Yakima River. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates this took place on the edge of the main channel. Plot and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	Stream	River	KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type I/II Area (m ²)	Fish Age Class	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Type I Habitat Type	Plot Temp (Best) °C	Sed. Temp (Best) °C	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Yakima	13.0	10/6/2017	48	110	158		Sand	-	Edge	14.6	15.2	0.6	14.5	
Index	Yakima	74.1	9/8/2017	900	0	900	> 1 Year	Sand	-	Edge	16	16.5	0.5	15.8	
Index	Yakima	134.3	10/6/2017	30	230	260		Silt	-	Edge	12.5	13.5	1.0	12.5	
Index	Yakima	171.1	8/3/2017	64	3000	3064		Sand	Sand	Edge	21.6	-	-	20.6	

Table 2. Larval lamprey habitat details for young of year (YOY) lampreys from index sites surveyed in the lower Yakima River. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates survey took place on the edge of the main channel. Plot and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	Stream	River	KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type I/II Area (m ²)	Fish Age Class	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Type I Habitat Type	Plot Temp (Best) °C	Sed. Temp (Best) °C	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Yakima	13.0	10/6/2017	48	110	158		-	-	-	-	-	-	-	-
Index	Yakima	74.1	9/8/2017	900	0	900	YOY	-	-	-	-	-	-	-	-
Index	Yakima	134.3	10/6/2017	30	230	260		-	-	-	-	-	-	-	-
Index	Yakima	171.1	8/3/2017	64	3000	3064		Silt	-	Edge	21.6	-	-	20.6	

Lamprey Capture Details and Estimated Density (Lower Yakima River)

Table 3. Lamprey capture details and estimated lamprey density for lampreys greater than one year of age in Type I and Type II habitat from index sites surveyed in the lower Yakima River in 2017. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (100%). The adjusted number of observed lampreys is referred to as the “Sampled Estimated Number (#)”. Estimated densities (#/m²) were calculated using the sampled estimated number. In the “Habitat Summary” row, values are a sum of displayed values, except “Estimated Density” which is a weighted average.

Site Type	River Stream	River KM	Fish Age Class	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m ²)
Index	Yakima	13.0	> 1 Year	Type I	482	8	106	207	5	212	26.5
Index	Yakima	74.1			593	10	2	2	1	7	0.7
Index	Yakima	134.3			620	10	4	4	3	10	1.0
Index	Yakima	171.1			576	11	45	48	4	100	9.1
Index	Yakima	13.0	> 1 Year	Type II	0	-	-	-	-	-	-
Index	Yakima	74.1			0	-	-	-	-	-	-
Index	Yakima	134.3			0	-	-	-	-	-	-
Index	Yakima	171.1			40	2.5	7	7	4	16	6.2
Habitat Summary		-	> 1 Year	Type I	2271	39	157	261	-	329	9.3
				Type II	40	3	7	7		16	6.2

Table 4. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys from index sites surveyed in the lower Yakima River in 2017 (sites and habitat types without YOY lampreys are excluded). YOY lampreys are ≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017. The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (10%), (2) fair (20%), (3) good (30%), (4) very good (40%) and (5) excellent (50%). The adjusted number of observed lampreys is referred to as the “Sampled Estimated Number (#)”. “YOY Area” is the area (within the overall survey area) where YOY lampreys were observed. Survey densities (#/m²) were calculated using the sampled estimated number and the “YOY Area”.

Site Type	River Stream	River KM	Fish Age Class	Habitat Type Surveyed	YOY Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m ²)
Index	Yakima	171.1	YOY	Type I	1	2	4	4	10	10.0

Lamprey Measurement Details (Lower Yakima River)

Table 5. Measurement details of captured lampreys greater than one year old at index sites surveyed in the lower Yakima River in Type I habitat 2017 (sites and habitat types without lamprey measurements are excluded). Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 25 mm for lampreys collected prior to September 1, 2017, and > 30 mm for lampreys collected after September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Yakima	13	> 1 Year	Type I	106	36.5	0.34	39	109	59
Index	Yakima	74.1			2	3.39	1.70	48	123	86
Index	Yakima	134.3			4	5.62	1.41	46	113	83
Index	Yakima	171.1			-	-	-	39	113	82

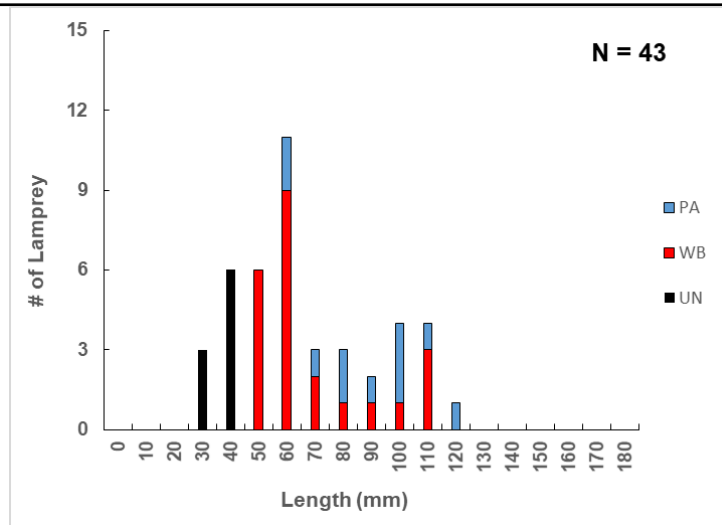


Figure 2. Histogram of measured lampreys (excluding YOY lampreys) captured during 2017 electrofishing surveys in the lower Yakima River, separated by species [“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red)] .

Species Composition and Genetic Samples (Lower Yakima River)

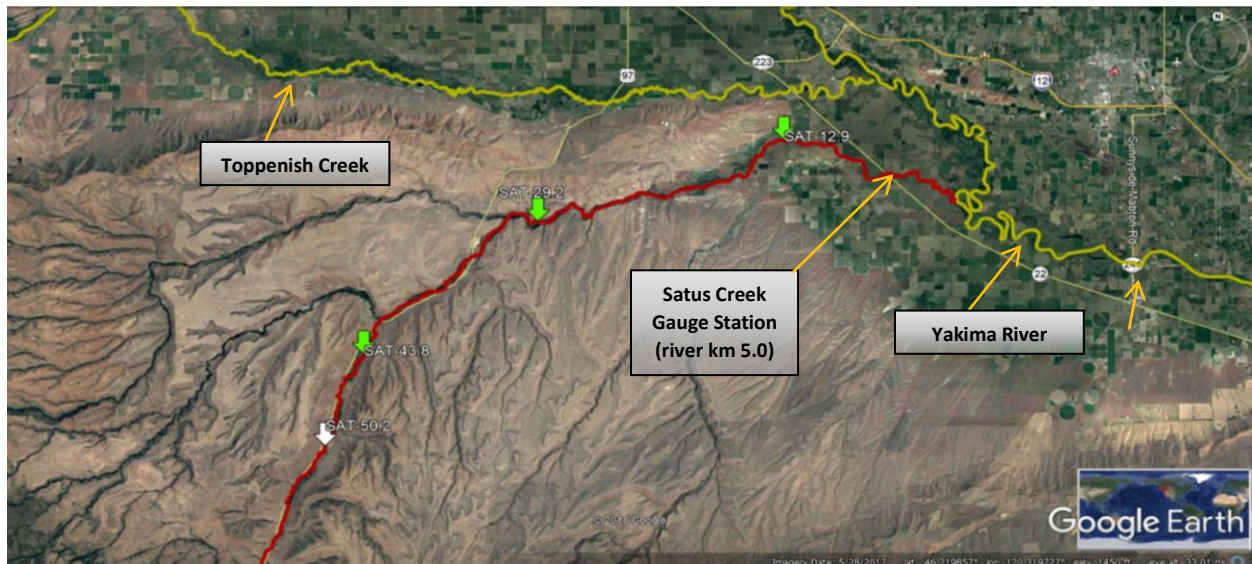
Table 6. Species composition of captured lampreys from lower Yakima River index sites surveyed in 2017. “Number (#) Captured” includes all captured lampreys (of all age classes). Under “Number (#) Pacific Lamprey Gen. Sampl.,” “Gen. Sampl.” stands for “Genetic Samples”. * Identification of lampreys is questionable at this site due to their small size; we made our best educated guess, although several samples are awaiting genetic confirmation of species.

Site Type	Stream	River KM	Habitat Type	# Captured	# Identified	# of Pacific	# Eyed Pacific Lamprey	# of Western Brook	% Pacific	% Western Brook	# Pacific Lamprey Gen. Sampl.
Index	Yakima	13.0		106	25 *	4 *	0	24	16%	96%	2
Index	Yakima	74.1	Type I	2	1	1	0	0	100%	0%	0
Index	Yakima	134		4	3	0	-	3	0%	100%	0
Index	Yakima	171		45	29	16	0	13	55%	45%	8
Index	Yakima	13	Type II	-	-	-	-	-	-	-	-
Index	Yakima	74.1		-	-	-	-	-	-	-	-
Index	Yakima	134		-	-	-	-	-	-	-	-
Index	Yakima	171		11	6	0	-	6	0%	100%	-
Habitat Summary					58	21		40	36%	69%	10
					6	0		6	0%	100%	

Lower Yakima River Tributaries

Satus Creek (confluence with Yakima River at river km 112.2)

A total of four sites were electrofished in Satus Creek (Map 2). Of the four surveyed sites, three were index sites, and one was an exploratory site. The surveyed sites were spatially distributed between river km 12.9 and 50.2. A hydrograph of Satus Creek (from a Yakama Nation gauging station downstream of Longhouse Road, river km 5.0), and our relative time of survey, is shown in Map 2 and Figure 3.



Map 2. Overview of 2017 survey sites in Satus Creek (red line; confluence with the Yakima River at river km 112.2). Surveyed index sites (green arrows) and exploratory sites (white arrows) are shown. The location of the gauge station (monitored by Yakama Nation; river km 5.0) is also shown. Streams in close proximity to Satus Creek are also labeled.

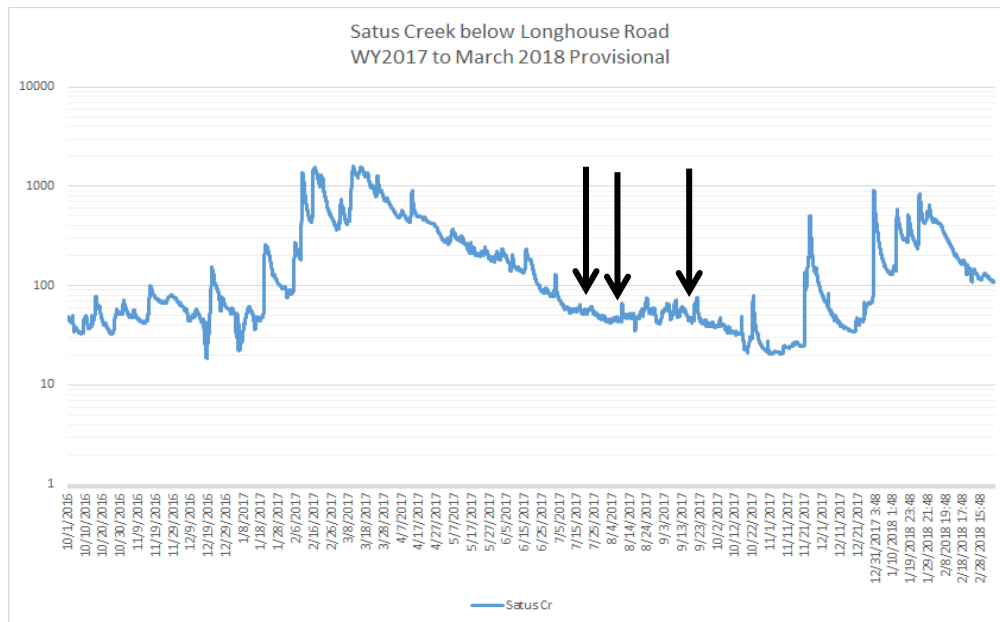


Figure 3. Yakama Nation discharge data (cubic feet per second indicated by the narrow blue line) of Satus Creek near Satus Longhouse Road, Granger, WA (river km 5.0) from October 1, 2016 to February 28, 2017; black arrows indicate YN survey periods (July, August, and September, 2017).

Satus Creek Survey Highlights

- Type I larval lamprey habitat decreased in available area as sites increased in distance upstream (175 m², 56 m², 21m², 1m² at river km 12.9, 29.2, 43.8 and 50.2, respectively; Table 7). Type II larval lamprey habitat also showed a decreasing trend from downstream to upstream (150 m², 130 m², 29 m², 1.5 m², at river km 12.9, 29.2, 43.8 and 50.2, respectively).
- The sediment was 3.0 C cooler than the plot temperature at river km 43.8 (Table 7). This is the most upstream site with lamprey, as well as the largest temperature difference observed between the sediment and plot temperatures in Satus Creek. At the most downstream site, the sediment was warmer than the plot temperature (0.5 C); the lowest observed temperature difference between the sediment and plot temperatures.
- No lampreys were found at river km 50.2 (Table 9).
- The highest estimated lamprey density was at river km 29.2 in Type I habitat (36.5 #/m²; Table 9). Despite having the largest area of Type I habitat (175 m²), river km 12.9 had the lowest estimated lamprey density (3.7 #/m²).
- Young of year lampreys were found at 2 of 3 (66%) sites where lampreys were found. Estimated densities of YOY lampreys ranged from 75.0 #/m² (river km 12.9) to 245.0 #/m² (river km 29.2; Table 10).
- Pacific Lamprey were found at all three sites where lampreys were present (Table 13). The ratio of Pacific Lamprey (to Western Brook Lamprey) was high (87.5% cumulative for all sites). The ratio of Pacific Lamprey was actually higher at the most upstream sites, compared to the lower most site in Type I habitat where the majority of lampreys were captured and identified (67%, 90%, and 93%, at river km 12.9, 29.2 and 43.8, respectively).

Habitat Overview (Satus Creek)

Table 7. Larval lamprey habitat details for lampreys greater than one year of age from index sites surveyed in Satus Creek. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates this took place on the edge of the main channel, and “Side Ch.” indicates the survey took place in a side channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	River Stream	River KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type I/II Area (m ²)	Fish Age Class	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Type I Habitat Type	Plot Temp °C (Best)	Sed. Temp °C (Best)	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Satus	12.9	9/19/2017	175	150	325	> 1 Year	Silt	Silt	Edge	15.1	15.6	0.5	14.9
Index	Satus	29.2	7/20/2017	56	130	186		Sand	Sand	Edge	22.2	20.8	-1.4	22.9
Index	Satus	43.8	8/10/2017	21	29	50		Sand	Silt	Main	22.3	19.3	-3.0	20.8
Expl.	Satus	50.2	8/10/2017	1	1.5	3		Sand	-	Edge	24.2	23.2	-1.0	22.8

Table 8. Larval lamprey habitat details for young of year (YOY) lampreys collected from index sites surveyed in Satus Creek. Under “Site Type”, “Expl.” stands for “Exploratory”. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates survey took place on the edge of the main channel, and “Side Ch.” indicates the survey took place in a side channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	River Stream	River KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type I/II Area (m ²)	Fish Age Class	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Type I Habitat Type	Plot Temp °C (Best)	Sed. Temp °C (Best)	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Satus	12.9	9/19/2017	175	150	325	YOY	Silt	-	Edge	15.1	15.6	0.5	15.2
Index	Satus	29.2	7/20/2017	56	130	186		Sand	CL	Edge	23	21.8	-1.2	22.9
Index	Satus	43.8	8/10/2017	21	29	50		-	-	-	-	-	-	-
Expl.	Satus	50.2	8/10/2017	1	2	3		-	-	-	-	-	-	-

Lamprey Capture Details and Estimated Density (Satus Creek)

Table 9. Lamprey capture details and estimated lamprey density for lampreys greater than one year of age in Type I and Type II habitat from index sites surveyed in Satus Creek in 2017. Under “Site Type”, “Expl.” stands for “Exploratory”. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (100%). The adjusted number of observed lampreys is referred to as the “Sampled Estimated Number (#)”. Estimated densities (#/m²) were calculated using the sampled estimated number. In the “Habitat Summary” row, values are a sum of displayed values, except “Estimated Density” which is a weighted average.

Site Type	River Stream	River KM	Fish Age Class	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m ²)
Index	Satus	12.9	> 1 Year	Type I	776	13	17	23	2	49	3.7
Index	Satus	29.2			534	10	146	251	3	365	36.5
Index	Satus	43.8			599	10	28	43	3	70	7.0
Expl.	Satus	50.2			187	1	0	0	5	-	-
Index	Satus	12.9	> 1 Year	Type II	380	7	3	6	2	9	1.2
Index	Satus	29.2			190	5	9	16	2	26	5.1
Index	Satus	43.8			305	6	4	5	4	9	1.6
Expl.	Satus	50.2			0	-	-	-	-	-	-
Habitat Summary		-	> 1 Year	Type I	2096	34	191	317	-	484	15.7
				Type II	875	18	16	27	-	43	2.7

Table 10. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I and Type II habitat from index sites surveyed in the Klickitat River in September, 2017 (sites and habitat types where no YOY lampreys were found are excluded). Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (10%), (2) fair (20%), (3) good (30%), (4) very good (40%) and (5) excellent (50%). The adjusted number of observed lampreys is referred to as the “Sample Estimated Number [#]”. “YOY Area” is the area (within the overall survey area) where YOY lampreys were observed. Survey densities (#/m²) were calculated using the sampled estimated number and the “YOY Area”. In the “Habitat Summary” row, values are a sum of displayed values, except “Estimated Density” which is a weighted average.

Site Type	River Stream	River KM	Fish Age Class	Habitat Type Surveyed	YOY Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m ²)
Index	Satus	12.9	YOY	Type I	13	25	390	4	975	75.0
Index	Satus	29.2			6	48	588	4	1470	245.0

Lamprey Measurement Details (Satus Creek)

Table 11. Measurement details of captured lampreys greater than one year old at index sites surveyed in Satus Creek in Type I and Type II habitat in July through September, 2017. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 25 mm for lampreys collected prior to September 1, 2017, and > 30 mm for lampreys collected after September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys. In the “Habitat Summary” row, “Mean Weight” and “Mean Length” are averages of displayed values for the respective habitat type.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Satus	12.9			-	-	-	44	141	81
Index	Satus	29.2	> 1 Year	Type I	146	111.78	0.77	42	144	84
Index	Satus	43.8			28	119.90	4.28	104	150	130
Index	Satus	12.9			0	-	-	115	120	118
Index	Satus	29.2	> 1 Year	Type II	9	13.52	1.50	49	136	88
Index	Satus	43.8			4	16.31	4.08	96	147	130
Habitat Summary		-	> 1 Year	Type I	174	232	2.52	42	150	98
				Type II	13	30	2.79	49	147	112

Table 12. Measurement details of captured lampreys for Satus Creek index sites (sites where YOY larvae were not found are excluded) surveyed in July and September, 2017. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys. The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Satus	12.9	YOY	Type I	0	-	-	19	29	24
Index	Satus	29.2			48	0.54	0.01	9	20	15

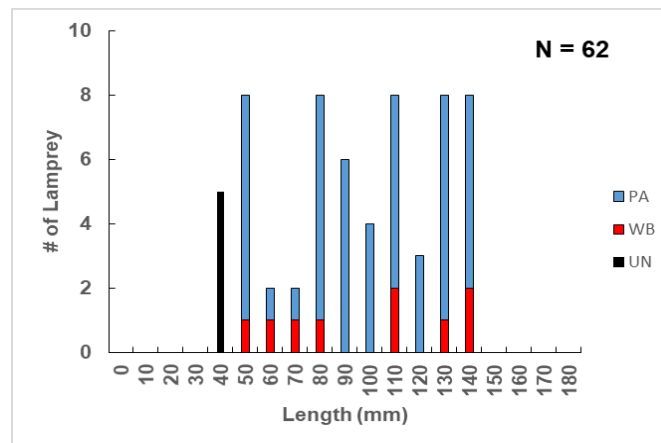


Figure 4. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red), in Satus Creek during surveys conducted in July through September, 2017.

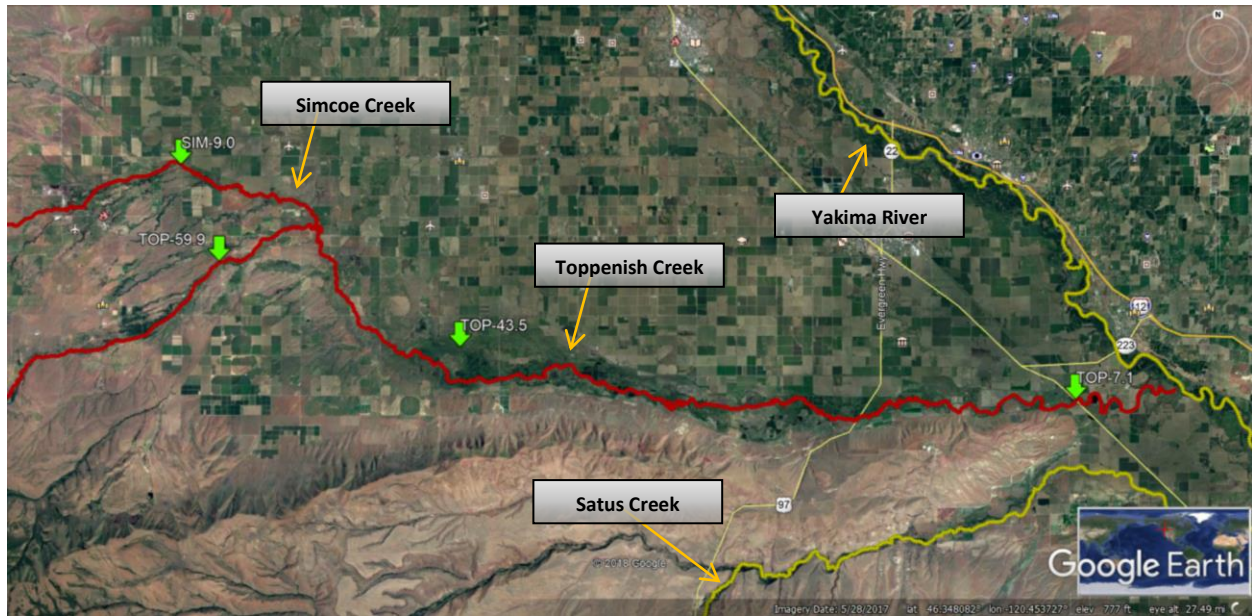
Species Composition and Genetic Samples (Satus Creek)

Table 13. Species composition of captured lampreys from Satus Creek index sites surveyed in July through September, 2017. “Number (#) Captured” includes all captured lampreys (of all age classes). Under “Number (#) Pacific Lamprey Gen. Sampl.,” “Gen. Sampl.” stands for “Genetic Samples”.

Site Type	Stream	River KM	Habitat Type	# Captured	# Identified	# of Pacific	# Eyed Pacific Lamprey	# of Western Brook	% Pacific	% Western Brook	# Pacific Lamprey Gen. Sampl.
Index	Satus	12.9		42	15	10	0	5	67%	33%	13
Index	Satus	29.2	Type I	194	30	27	0	3	90%	10%	30
Index	Satus	43.8		28	28	26	0	2	93%	7%	3
Index	Satus	12.9		3	3	2	0	1	67%	33%	
Index	Satus	29.2	Type II	9	8	8	0	0	100%	0%	-
Index	Satus	43.8		4	4	4	0	0	100%	0%	
Habitat Summary	-		Type I	264	73	63		10	86%	14%	
			Type II	16	15	14		1	93%	7%	46

Toppenish Creek Watershed (confluence with the Yakima River at river km 130.8)

A total of three sites were electrofished in Toppenish Creek, and one index site in Simcoe Creek (tributary of Toppenish Creek; Map 3). All surveyed sites were established index sites. The surveyed sites were spatially distributed between river km 7.1 and 59.9 in the mainstem of Toppenish Creek, and one site at river km 9.0 in Simcoe Creek.



Map 3. Overview of 2017 survey sites in Toppenish Creek and Simcoe Creek (red lines; Toppenish Creek confluence with the Yakima River at river km 130.8). Surveyed index sites (green arrows) are shown. Streams in close proximity are labeled accordingly.

Toppenish Creek Survey Highlights

- At Toppenish Creek, the largest area of Type I habitat was at river km 7.1 (400 m²; Table 14). In Simcoe Creek, at the one surveyed site, Type I habitat was more available (41 m²) than Type II habitat (36 m²).
- At 3 of 4 (75%) sites (including Simcoe Creek), the sediment temperature was cooler than the plot temperature in areas of high lamprey densities (Table 14). The sediment temp ranged from 0.2 (Toppenish Creek, river km 7.1) to 1.1 (Simcoe Creek, river km 9.0) cooler below the sediment. At river km 43.5 in Toppenish Creek, no difference between the sediment and plot temperatures was observed.
- Lampreys were present at 2 of 3 (66%) sites in Toppenish Creek and 1 of 1 (100%) sites in Simcoe Creek (Table 16). Despite having the largest area of Type I habitat, no lampreys were found at river km 7.1.
- In Toppenish Creek, estimated densities of lampreys (excluding YOY lampreys) was highest at the upper survey site at river km 59.9 (6.7 #/m²; Table 16); compared to the most downstream survey site with lampreys river km 43.5 (0.5 #/m²).
- Young of year lamprey were found at 1 of 2 (50%) sites surveyed where lampreys were present in Toppenish Creek (Table 17), and 1 of 1 (100%) sites in Simcoe Creek. In Toppenish Creek, the YOY density was estimated to be 2.0 #/m² (river km 59.9). In Simcoe Creek, YOY density was estimated to be 25.7 #/m²; Table 17).
- Pacific Lamprey were found at 2 of 2 (100%) of sites where lampreys were present in Toppenish Creek (Table 20). Pacific Lamprey were also found 1 of 1 (100%) sites in Simcoe Creek. The ratio of Pacific Lamprey was similar in Toppenish Creek for the two survey sites (52%, 48% at river km 43.5 and 59.9, respectively). In Simcoe Creek, the ratio of Pacific Lamprey was much lower (18%).

Habitat Overview (Toppenish Creek)

Table 14. Larval lamprey habitat details for lampreys greater than one year of age from index sites surveyed Toppenish Creek and Simcoe Creek (Toppenish Creek tributary). Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates this took place on the edge of the main channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	Stream	River KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type I/II Area (m ²)	Fish Age Class	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Type I Habitat Type	Plot Temp (Best) °C	Sed. Temp (Best) °C	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Toppenish	7.1	9/19/2017	400	0	400		Silt	-	Edge	15	14.8	-0.2	15
Index	Toppenish	43.5	8/3/2017	35	12	47	> 1 Year	Silt	-	Edge	21.6	21.6	0	21.6
Index	Toppenish	59.9	7/19/2017	16	72	88		Clay	Silt	Edge	19.3	18.5	-0.8	19.1
Index	Simcoe	9	7/19/2017	41	36	77		Silt	Silt	Edge	19.9	18.8	-1.1	19.9

Table 15. Larval lamprey habitat details for young of year (YOY) lampreys collected from index sites surveyed in Toppenish Creek and Simcoe Creek (Toppenish Creek tributary). Under “Fish Age

Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Main” indicates survey took place within the main channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site Type	River Stream	River KM	Date	50 m	50 m	50 m Type I/II Area (m ²)	Fish Age Class	Primary	Primary	Type I Habitat Type	Plot	Sed.	Sed.	Thalweg
				Type I Area (m ²)	Type II Area (m ²)			Fine Sediment (Type I)	Fine Sediment (Type II)		Temp °C (Best)	Temp °C (Best)	Temp Diff. °C	Temp °C
Index	Toppenish	7.1	9/19/2017	400	0	400		-	-	-	-	-	-	-
Index	Toppenish	43.5	8/3/2017	35	12	47		-	-	-	-	-	-	-
Index	Toppenish	59.9	7/19/2017	16	72	88	YOY	Silt	-	Main	-	-	-	-
Index	Simcoe	9	7/19/2017	41	36	77		Clay	-	Main	21.4	19.8	-1.6	21.2

Lamprey Capture Details and Estimated Density (Toppenish Creek)

Table 16. Lamprey capture details and estimated lamprey density for lampreys greater than one year of age in Type I and Type II habitat from index sites surveyed in Toppenish Creek and Simcoe Creek (Toppenish Creek tributary) in July through September, 2017. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (100%). The adjusted number of observed lampreys is referred to as the “Sample Estimated Number [#]”. Survey densities (#/m²) were calculated using the sampled estimated number. In the “Habitat Summary” row, values are a sum of displayed values, except “Estimated Density” which is a weighted average.

Site Type	River Stream	River KM	Fish Age Class	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (L/m ²)
Index	Toppenish	7.1	> 1 Year	Type I	586	10	0	0	5	-	-
Index	Toppenish	43.5			574	10	2	3	3	5	0.5
Index	Toppenish	59.9			590	10	30	37	4	67	6.7
Index	Simcoe	9.0			550	10	101	121	3	253	25.3
Index	Toppenish	7.1	> 1 Year	Type II	-	-	-	-	-	-	-
Index	Toppenish	43.5			-	-	-	-	-	-	-
Index	Toppenish	59.9			381	7	2	3	4	4	0.6
Index	Simcoe	9.0			201	5	2	2	4	4	0.9
Habitat Summary			> 1 Year	Type I	2300	40	133	161	-	324	10.8
				Type II	582	12	4	5		9	0.8

Table 17. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I habitat from index sites surveyed in Toppenish and Simcoe Creek (Toppenish Creek tributary) in July, 2017 (sites and habitat types where no YOY were found are excluded). Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (10%), (2) fair (20%), (3) good (30%), (4) very good (40%) and (5) excellent (50%). The adjusted number of observed lampreys is referred to as the “Sample Estimated Number [#]”. “YOY Area” is the area (within the overall survey area) where YOY lampreys were observed. Survey densities ($\#/m^2$) were calculated using the sampled estimated number and the “YOY Area”.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	YOY Area (m ²)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (L/m ²)
Index	Toppenish	59.9	YOY	Type I	10	1	1	1	20	2.0
Index	Simcoe	9			7	18	33	2	180	25.7

Lamprey Measurement Details (Toppenish Creek)

Table 18. Measurement details of captured lampreys greater than one year old at index sites surveyed in Toppenish Creek and Simcoe Creek (Toppenish Creek tributary) in Type I and Type II habitat in July and August, 2017 (sites where no lampreys were found are excluded). Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 25 mm for lampreys collected prior to September 1, 2017, and > 30 mm for lampreys collected after September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys. In the “Habitat Summary” row, “Mean Weight” and “Mean Length” are averages of displayed values for the respective habitat type.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Toppenish	43.5			-	-	-	97	132	115
Index	Toppenish	59.9	> 1 Year	Type I	30	18.3	0.61	45	112	74
Index	Simcoe	9.0			101	84.9	0.84	42	128	82
Index	Toppenish	43.5			-	-	-	-	-	-
Index	Toppenish	59.9	> 1 Year	Type II	2	3.52	1.76	84	126	105
Index	Simcoe	9.0			2	1.00	0.50	68	72	70
Habitat Summary		-	> 1 Year	Type I	131	103	0.73	42	132	90
				Type II	4	5	1.13	68	126	88

Table 19. Measurement details of captured young of year (YOY) larval lampreys at index sites surveyed in Toppenish Creek and Simcoe Creek (Toppenish Creek tributary) in July, 2017 (sites and habitat types where no YOY lampreys were found are excluded). Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Toppenish	59.9	YOY	Type I	0	-	-	18	18	18
Index	Simcoe	9.0			0	-	-	15	23	19

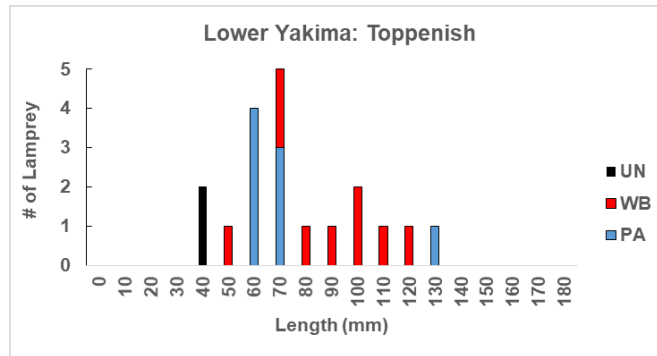


Figure 5. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red), in Toppenish Creek in July and August, 2017.

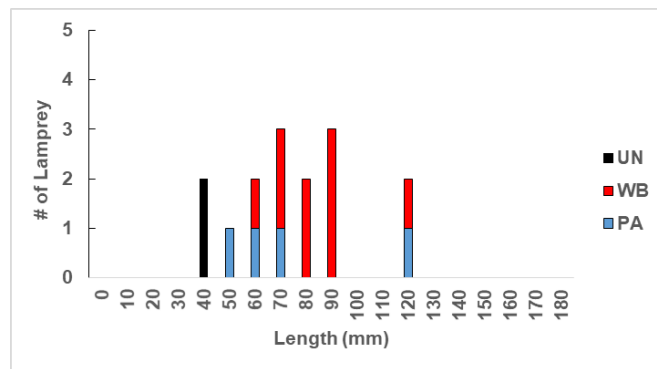


Figure 6. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red), in Simcoe Creek in July, 2017.

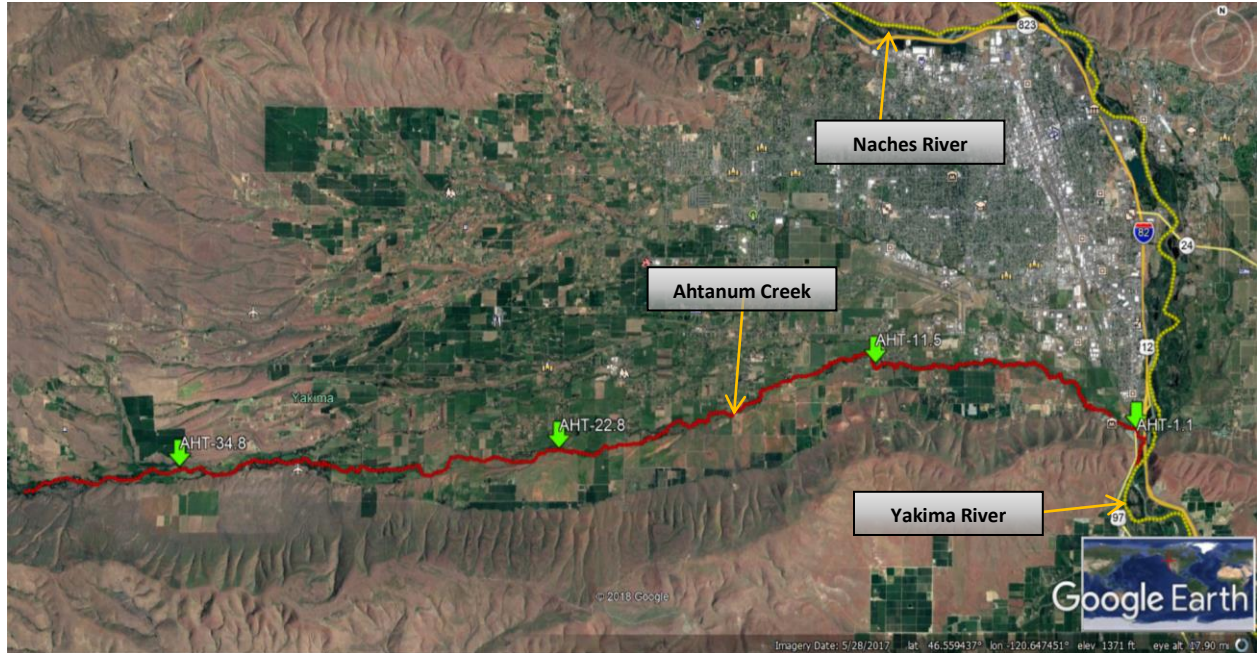
Species Composition and Genetic Samples (Toppenish Creek)

Table 20. Species composition of captured lampreys from Toppenish Creek and Simcoe Creek (Toppenish Creek tributary) index sites surveyed in July and August, 2017. “Number (#) Captured” includes all captured lampreys (of all age classes). Under “Number (#) Pacific Lamprey Gen. Sampl.,” “Gen. Sampl.” stands for “Genetic Samples”.

Site Type	Stream	River KM	Habitat Type	# Captured	# Identified	# of Pacific	# Eyed Pacific Lamprey	# of Western Brook	% Pacific	% Western Brook	# Pacific Lamprey Gen. Sampl.
Index	Toppenish	43.5		2	2	1	0	1	50%	50%	1
Index	Toppenish	59.9		31	25	12	0	13	48%	52%	12
Index	Simcoe	9.0		119	87	16	0	71	18%	82%	16
Index	Toppenish	43.5		-	-	-	-	-	-	-	-
Index	Toppenish	59.9	Type II	2	2	0	-	2	0%	100%	-
Index	Simcoe	9.0		2	0	0	-	-	-	-	-
Habitat Summary			Type I	152	114	29	0	85	25%	75%	
			Type II	4	2	0	0	2	0%	100%	29

Ahtanum Creek (confluence with the Yakima River at river km 176.8)

A total of four sites were electrofished in Ahtanum Creek (Map 4). All surveyed sites were established index sites. The surveyed sites were spatially distributed between river km 1.1 and 34.8 in Ahtanum Creek.



Map 4. Overview of 2017 survey sites in Ahtanum Creek (red lines; confluence with the Yakima River at river km 176.8). Surveyed index sites (green arrows) are shown. Streams in close proximity to Ahtanum Creek are labeled accordingly.

Ahtanum Creek Survey Highlights

- The largest area of Type I habitat was river km 11.5 (75 m²), and the smallest area was observed at river km 34.8 (7 m²; Table 21).
- All sites were all less than 1.0 C cooler under the sediment, compared to the plot temperature directly above the sediment (0.6 C, 0.5 C, 0.5 C and 0.1 C lower under the sediment compared to the plot temperature at river km 1.1, 11.5, 22.8 and 34.8, respectively).
- Despite having the largest area of Type I habitat, river km 11.5 had the lowest estimated lamprey density in Type I habitat, excluding YOY lampreys (10.5 #/m²; Table 23).
- Young of year lampreys were found at 4 of 4 (100%) sites. Densities of YOY larvae were estimated between 66.7 #/m² (river km 11.5) and 15.0 #/m² (river km 1.1; Table 24).
- Pacific Lamprey were found at 4 of 4 (100%) sites (Table 27). The ratio of Pacific Lamprey was lowest at the river km 1.1, the lower most survey site (11%). The ratio of Pacific Lamprey was high at the other three sites (86%, 79% and 94% at river km 11.5, 22.8 and 34.8, respectively). A total of 18 genetic samples were collected from Pacific Lamprey. Pacific Lamprey macrophthalmia (eyed smolt stage) were captured at river km 1.1, 11.5 and 34.8. Genetic samples were collected from the macrophthalmia (included in the 18 total samples).

Habitat Overview (Toppenish Creek)

Table 21. Larval lamprey habitat details for lampreys greater than one year of age from index sites surveyed in Ahtanum Creek. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 30 mm for lampreys collected after September 1, 2017, and > 25 mm for lampreys collected prior to September 1, 2017). The total area (m²) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates this took place on the edge of the main channel, and “Side Ch.” indicates the survey took place in a side channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site	River	50 m	50 m	50 m	Fish Age	Primary	Primary	Type I	Plot	Sed.	Sed.	Thal-
Type	Stream	Area	Area	Type I/II	Class	Fine	Fine	Habitat	Temp	Temp	Temp	weg
	KM	(m2)	(m2)	Area (m2)		(Type I)	(Type II)	Type	(°C)	(°C)	Diff.	Temp
	Date								(Best)	(Best)	(°C)	(°C)
Index	Ahtanum	1.1	9/8/2017	60	90	150						
Index	Ahtanum	11.5	9/18/2017	75	45	120	> 1 Year	Edge	18.6	18	-0.6	18.6
Index	Ahtanum	22.8	9/21/2017	26	21	47		Edge	15.1	14.6	-0.5	15.1
Index	Ahtanum	34.8	9/21/2017	7	8	15		Side Ch	12.2	11.7	-0.5	12.2
Index	Ahtanum	34.8	9/21/2017	7	8	15		Edge	9.3	9.2	-0.1	9.2

Table 22. Larval lamprey habitat details for young of year (YOY) lampreys collected from index sites surveyed in Ahtanum Creek. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The total area (m2) of Type I and Type II habitat within the surveyed 50 m stream reach is shown. Under “Type I Habitat Type”, “Edge” indicates survey took place on the edge of the main channel, and “Side Ch.” indicates the survey took place in a side channel. Plot temperature and sediment temperature were taken where the most lampreys were found. “Sed. Temp Difference.” was calculated by subtracting the plot temperature from the sediment temperature (a negative value indicates that the sediment temperature is cooler than the plot temperature).

Site	River	50 m	50 m	50 m	Fish Age	Primary	Primary	Type I	Plot	Sed.	Sed.	Thal-
Type	Stream	Area	Area	Type I/II	Class	Fine	Fine	Habitat	Temp	Temp	Temp	weg
	KM	(m2)	(m2)	Area (m2)		(Type I)	(Type II)	Type	(°C)	(°C)	Diff.	Temp
	Date								(Best)	(Best)	(°C)	(°C)
Index	Ahtanum	1.1	9/8/2017	60	90	150						
Index	Ahtanum	11.5	9/18/2017	75	45	120	YOY	Edge	18.6	18	-0.6	18.6
Index	Ahtanum	22.8	9/21/2017	26	21	47		Edge	15.1	14.6	-0.5	15.1
Index	Ahtanum	34.8	9/21/2017	7	8	15		Side Ch	12.3	10.8	-1.5	12.2
Index	Ahtanum	34.8	9/21/2017	7	8	15		Edge	9.3	9.2	-0.1	9.2

Lamprey Capture Details and Estimated Density (Ahtanum Creek)

Table 23. Lamprey capture details and estimated lamprey density for non-YOY (lamprey older than one year) in Type I habitat in Ahtanum Creek in September, 2017. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for non-YOY lampreys. The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (100%). The adjusted number of observed lampreys is referred to as the “Sample Estimated Number [#]”. Survey densities (#/m²) were calculated using the sampled estimated number. In the habitat summary row, estimated density is a mean of individual site densities.

Stream	River KM	Fish Age Class	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m2)
Ahtanum	1.1			450	8	96	113	3	240	30.0
Ahtanum	11.5	> 1 Year	Type I	596	10	37	50	2	106	10.6
Ahtanum	22.8			427	7	77	83	3	193	27.5
Ahtanum	34.8			300	5	33	42	5	66	13.2

Table 24. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I habitat from index sites surveyed in the Ahtanum Creek in September, 2017. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The number of observed lampreys was adjusted (increased) based on the following 1-5 visibility scale (estimated % visibility in parenthesis): (1) poor (10%), (2) fair (20%), (3) good (30%), (4) very good (40%) and (5) excellent (50%). The adjusted number of observed lampreys is referred to as the “Sample Estimated Number [#]”. “YOY Area” is the area (within the overall survey area) where YOY lampreys were observed. Survey densities (#/m²) were calculated using the sampled estimated number and the “YOY Area”.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	YOY Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (#/m2)
Index	Ahtanum	1.1			4	3	3	1	60	15.0
Index	Ahtanum	11.5	YOY	Type I	3	10	20	1	200	66.7
Index	Ahtanum	22.8			2	2	12	2	60	30.0
Index	Ahtanum	34.8			4	12	32	3	107	26.7

Lamprey Measurement Details (Ahtanum Creek)

Table 25. Measurement details of captured lampreys greater than one year old at index sites surveyed in Ahtanum Creek in Type I habitat in September, 2017. Under “Fish Age Class”, “> 1 Year” signifies that the displayed values are for lampreys assumed greater than one year old (> 25 mm for lampreys collected prior to September 1, 2017, and > 30 mm for lampreys collected after September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weighed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Ahtanum	1.1			-	-	-	45	133	96
Index	Ahtanum	11.5	> 1 Year	Type I	-	-	-	48	127	91
Index	Ahtanum	22.8			77	108.82	1.41	45	130	93
Index	Ahtanum	34.8			33	37.03	1.12	48	154	80

Table 26. Measurement details of captured young of year (YOY) larval lampreys at index sites surveyed in Ahtanum Creek in Type I habitat in September, 2017. Under “Fish Age Class”, “YOY” signifies that the displayed values are for YOY lampreys (≤ 30 mm for lampreys collected after September 1, 2017 and ≤ 25 mm for lampreys collected prior to September 1, 2017). The “Mean Weight” was calculated by dividing the total weight of lampreys by the number of lampreys weighed. The “Min”, “Max” and “Mean” lengths are calculated from measured lampreys.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	# Weigh-ed	Total Weight (g)	Mean Weight (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)
Index	Ahtanum	1.1			0	-	-	16	24	20
Index	Ahtanum	11.5	YOY	Type I	10	1.00	0.10	21	28	25
Index	Ahtanum	22.8			0	-	-	24	27	26
Index	Ahtanum	34.8			10	0.62	0.06	24	33	27

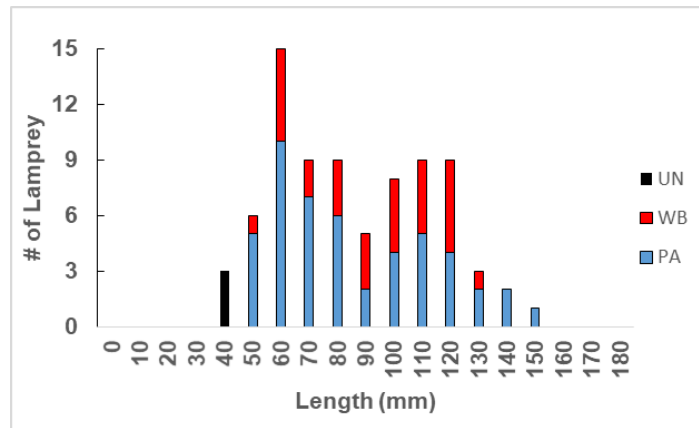


Figure 7. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red), in Ahtanum Creek in September, 2017.

Species Composition and Genetic Samples (Ahtanum Creek)

Table 27. Species composition of captured lampreys from Ahtanum Creek index sites surveyed in September, 2017. “Number (#) Captured” includes all captured lampreys (of all age classes). Under “Number (#) Pacific Lamprey Gen. Sampl.,” “Gen. Sampl.” stands for “Genetic Samples”.

Site Type	Stream	River KM	Habitat Type	# Captured	# Identified	# of Pacific	# Eyed Pacific Lamprey	# of Western Brook	% Pacific	% Western Brook	# Pacific Lamprey Gen. Sampl.
Index	Ahtanum	1.1		99	28	3	2	25	11%	89%	6
Index	Ahtanum	11.5	Type I	47	36	31	1	5	86%	14%	1
Index	Ahtanum	22.8		79	75	59	1	16	79%	21%	1
Index	Ahtanum	34.8		45	32	30	0	2	94%	6%	10

APPENDIX: Additional Site Maps and Photos
Lower Yakima



Map A1. Site map of Yakima index site at river km 13.0 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A1. Yakima River index site at river km 13.0; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.



Map A2. Site map of Yakima index site at river km 74.1 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m. The displayed image is during a high water event in May, 2017 and does not accurately represent the water level at the time of survey.



Photo A2. Yakima River index site at river km 74.1; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.



Map A3. Site map of Yakima index site at river km 134.3 (surveyed in October, 2017); yellow balloon indicates presence of lamprey of unknown species. The small red dots indicate stream distance of 100 m. The displayed image is during a high water event in May, 2017 and does not accurately represent the water level at the time of survey.



Photo A3. Yakima River index site at river km 134.3; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/clay (right) from 2017 survey.



Map A4. Site map of Yakima index site at river km 171.1 (surveyed in August, 2017); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m. The displayed image is during a high water event in May, 2017 and does not accurately represent the water level at the time of survey.



Photo A4. Yakima River index site at river km 171.1; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.

Satus Creek



Map A5. Site map of Satus index site at river km 12.9 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A5. Satus Creek index site at river km 12.9; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/clay (right) from 2017 survey.



Map A6. Site map of Satus index site at river km 29.2 (surveyed in July, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A6. Satus Creek index site at river km 29.2; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of sand/clay (right) from 2017 survey.



Map A7. Site map of Satus index site at river km 34.3 (surveyed in July, 2017); white balloon indicates no lamprey found at this site. The small yellow dots indicate stream distance of 100 m.



Photo A7. Satus Creek index site at river km 34.3; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of cobble (right) from 2017 survey.



Map A8. Site map of Satus index site at river km 43.8 (surveyed in August, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A8. Satus Creek index site at river km 47.2; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2016 survey.



Map A9. Site map of Satus exploratory site at river km 50.2 (surveyed in August, 2017); white balloon indicates no lamprey found at this site. The small yellow dots indicate stream distance of 100 m.



Photo A9. Satus Creek exploratory site at river km 50.2; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.

Toppenish Creek



Map A10. Site map of Toppenish index site at river km 7.1 (surveyed in September, 2017); white balloon indicates no lamprey found at this site. The small yellow dots indicate stream distance of 100 m.



Photo A10. Toppenish Creek index site at river km 7.1; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/clay (right) from 2017 survey.



Map A11. Site map of Toppenish index site at river km 43.5 (surveyed in August, 2017); red balloon indicates presence of Pacific Lamprey.



Photo A11. Toppenish Creek index site at river km 43.5; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.



Map A12. Site map of Toppenish index site at river km 59.9 (surveyed in July, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A12. Toppenish Creek index site at river km 59.9; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.

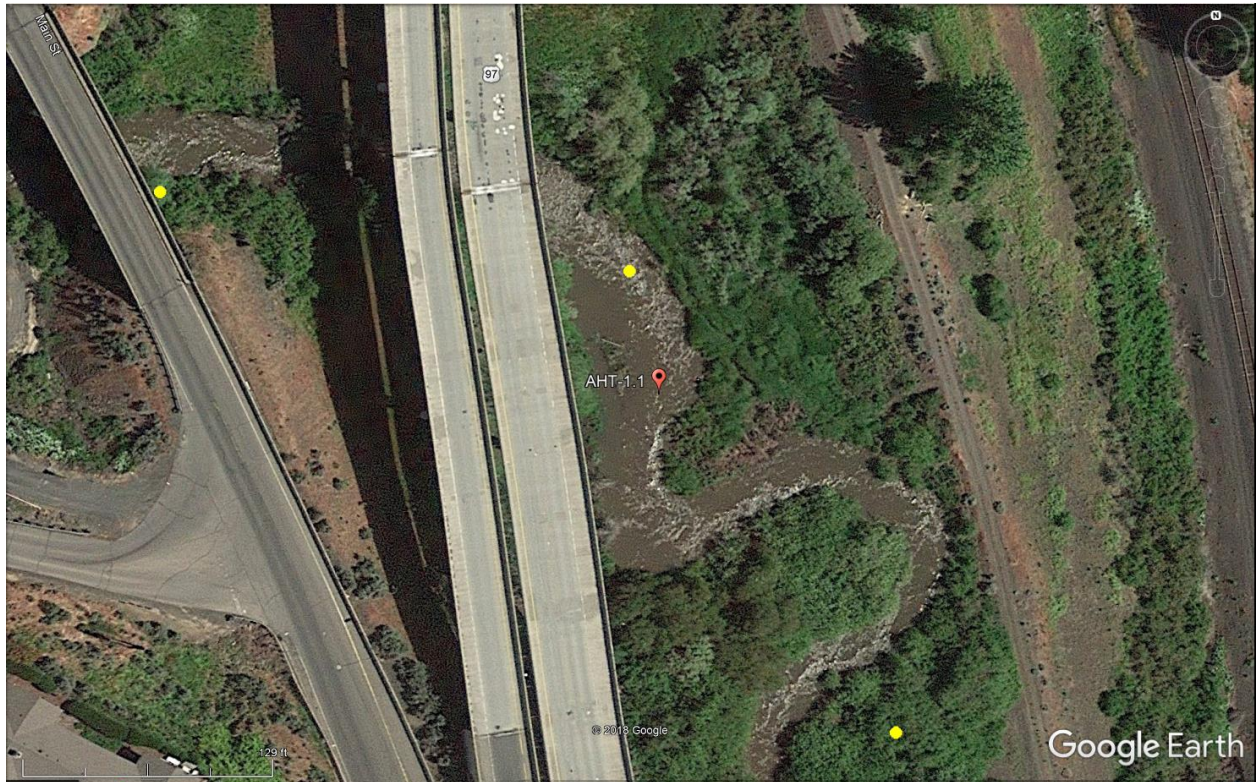


Map A13. Site map of Simcoe index site at river km 9.0 (surveyed in July, 2017); red balloon indicates presence of Pacific Lamprey. The small green dots indicate stream distance of 100 m.



Photo A13. Simcoe Creek index site at river km 9.0; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt (right) from 2017 survey.

Ahtanum Creek



Map A14. Site map of Ahtanum index site at river km 1.1 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m. The presented image is during a high water event in May, 2017. The survey was conducted during low flows.



Photo A14. Ahtanum Creek index site at river km 1.1; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt (right) from 2017 survey.



Map A15. Site map of Ahtanum index site at river km 11.5 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m. The presented image is during a high water event in May, 2017. The survey was conducted during low flows.



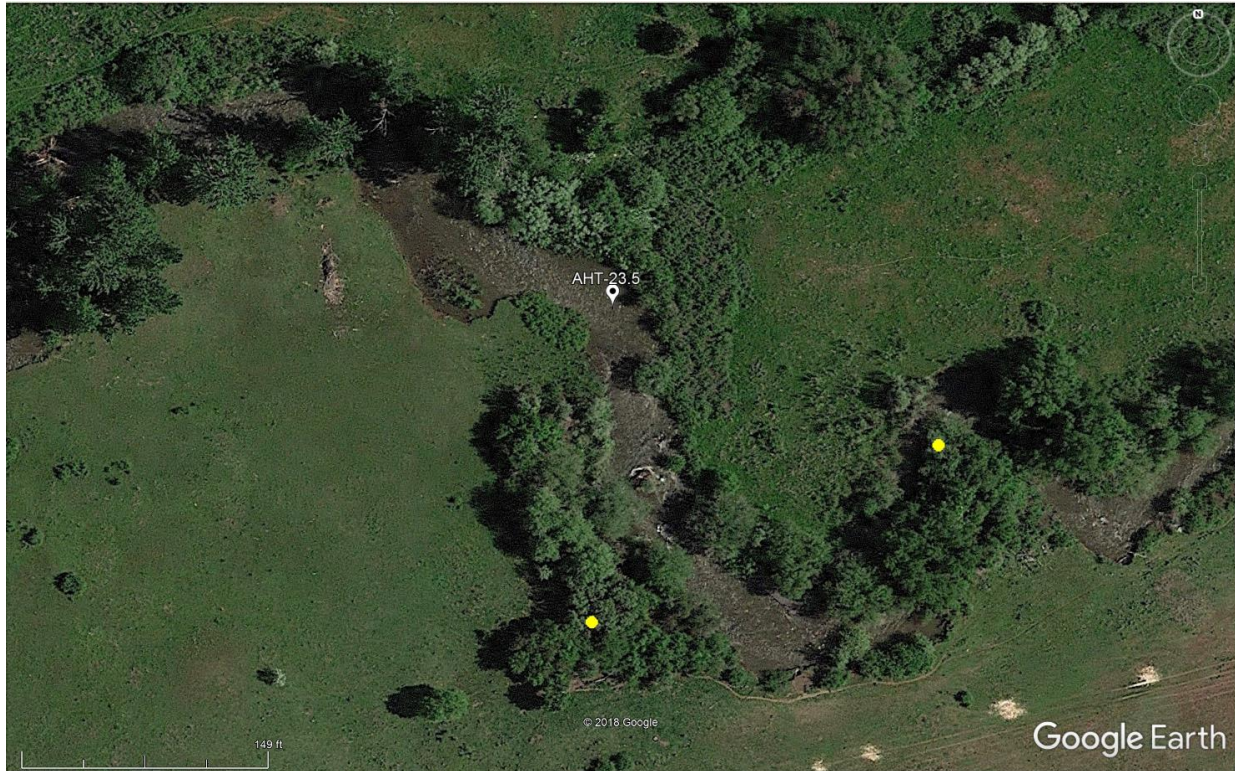
Photo A15. Ahtanum Creek index site at river km 11.5; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.



Map A16. Site map of Ahtanum index site at river km 22.8 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m. The presented image is during a high water event in May, 2017. The survey was conducted during low flows.



Photo A16. Ahtanum Creek index site at river km 22.8; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/clay (right) from 2017 survey.



Map A17. Site map of Ahtanum index site at river km 23.5 (surveyed in July, 2017); white balloon indicates no lamprey found at this site. The small yellow dots indicate stream distance of 100 m. The presented image is during a high water event in May, 2017. The survey was conducted during low flows.



Photo A17. Ahtanum Creek index site at river km 23.5; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2017 survey.



Map A18. Site map of Ahtanum exploratory site at river km 34.8 (surveyed in September, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m. The presented image is during a high water event in May, 2017. The survey was conducted during low flows.



Photo A18. Ahtanum Creek exploratory site at river km 34.8; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/clay (right) from 2017 survey.