



Naches Subbasin Larval Lamprey Monitoring Report, 2017



[Cover Photo: Overview of a larval lamprey survey site on the Naches River (river km 29.1) where Pacific Lamprey were identified in August, 2017]

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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**

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ABSTRACT

In this report, we summarize our 2017 findings from larval lamprey habitat surveys in the Naches Subbasin (Naches River confluence with the Yakima River at 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, were also documented when encountered. Electrofishing surveys in 50 m reach sites were conducted in the Naches River and five tributary streams; Cowichee, Tieton, Oak (Tieton tributary), Rattlesnake, and Nile. 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.

A total of four index sites (river km 0.0, 14.2, 29.1 and 41.9) were surveyed in the mainstem Naches River in August, 2017. Overall, surveys were primarily conducted in side channel habitats, where Type I habitat was most abundant. Pacific Lamprey were found at 2 of 4 (50%) sites. Pacific Lamprey were not found at river km 41.9 (the upper most site), nor river km 0.0 (the lower most site). Two Pacific Lamprey macrophthalmia (smolt stage with eyes) were found at river km 29.1 (August, 2017). Type I habitat was limited at the mouth (9 m² at river km 0.0). Type I habitat was most abundant at river km 14.2 and 29.1 (120 m² and 100 m², respectively). The highest estimated densities of lampreys (excluding YOY lampreys) were at river km 41.9 and 14.2 (22.6 and 21.3 #/m², respectively). The site near the mouth (river km 0.0) had the lowest density (4.1 #/m²) as well as available Type I habitat. YOY lampreys were found only near the mouth (river km 0.0) with an estimated density of 4.0 #/m², similar to the density of the larger (older) lampreys. The sediment temperature (measured at a maximum of 10 cm below the sediment where the most lampreys were found), was 4.0°C cooler than the plot temperature (taken directly above the sediment) at river km 14.2 and 29.1. At the mouth (river km 0.0), and at the upper most site (river km 41.9), the sediment temperature was cooler than the plot temperature, but to a lesser degree (1.4 and 0.1°C, respectively).

One index site (river km 1.6) was surveyed in Cowichee Creek. No Pacific Lamprey was found in Cowichee Creek, despite the identification of 25 lampreys. The estimated density of lampreys (excluding YOY lampreys) was 17.1 #/m². The estimated density of YOY lampreys was higher (45.0 #/m²). The sediment temperature was 1.4°C cooler than the plot temperature where the most lampreys were found, excluding YOY lampreys. The location with the highest density of YOY lampreys was 2.2°C cooler under the sediment, than the plot temperature.

One exploratory site (river km 5.0) was surveyed in the Tieton River. A large area of Type I habitat was found in the Tieton River at river km 5.0 located in a side channel (300 m²). Overall, however, Type I habitat appears to be limited throughout the Tieton River. The water temperature in the side

channel was 18.1°C. The sediment temperature was 2.3°C cooler than the plot temperature. No larval lampreys were found in the Tieton River despite preferred habitat being present. In Oak Creek (tributary of the Tieton River), a total of three exploratory sites were surveyed to see if larval lampreys were present in Oak Creek. The lower reach was surveyed, where a total of 3 m² of larval habitat was present, but no larval lampreys were found in Oak Creek. Aerial images taken in 2015, showed Oak Creek to have many small log/beaver dams. However, during our visit in 2017, we noticed most of these beaver/log jams were washed away. There was very limited larval lamprey habitat (Type I or Type II habitat) distributed throughout the surveyed sites in Oak Creek.

A total of four exploratory sites were surveyed in a side channel in Rattlesnake Creek. This side channel serves the dual purpose of improving salmonid habitat and providing reliable irrigation water supply (originally built in the early 2000's). The sites were spatially distributed from the inlet (river km 2.1) to the outlet (river km 1.0). Bob Inouye (the landowner that monitors the side channel and the headgate for the irrigation water) was also present and shared his knowledge of the side channel and sites. A total of 28 m² of Type I (preferred) larval lamprey habitat was surveyed in total between the four sites. No larval lampreys were found in the surveyed side channel in Rattlesnake Creek. There was abundant fine sediment throughout the visited sites (approximately 100 m² of Type I habitat in total). The fine sediment was mostly composed of silt and fine sand.

In Nile Creek, one index site (river km 0.6) and one exploratory site (river km 6.8) were surveyed. Lampreys were found at 1 of 2 (50%) sites (found only at river km 0.6). No Pacific Lamprey were found in Nile Creek, despite the identification of 29 lampreys. The density of lampreys (excluding YOY lampreys) was 11.0 #/m² at river km 0.6. The density of YOY lampreys was similar (13.3 #/m²). In Nile Creek, Type I habitat was more abundant than Type II habitat (35 m² Type I habitat and 15 m² Type II habitat in total for both surveyed sites). At the upper most site (river km 6.8) the sediment temperature was 6.1°C cooler than the plot temperature. At river km 0.6, the sediment temperature was 3.1°C cooler than the plot temperature.

INTRODUCTION

Starting in 2010, the Yakama Nation Pacific Lamprey Project initiated electrofishing surveys targeting larval lamprey in the Naches Subbasin. These surveys showed that Pacific Lamprey densities in the Naches River were on the decline. In 2013 and 2014, there was a small release of adult Pacific Lamprey into the Naches Subbasin (by USFWS and Yakama Nation). Since the release of Pacific Lamprey into the subbasin, electrofishing surveys have shown an increase in the distribution and abundance of Pacific Lamprey in the Naches River. Tributary streams of the Naches River are continually monitored for the presence of Pacific Lamprey. In addition to Pacific Lamprey, Western Brook Lamprey (*Lampetra richardsoni*), a more common, primarily resident species, of lamprey are continually documented throughout the Naches Subbasin. This report summarizes our findings from electrofishing surveys in the Naches Subbasin in 2017.

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 (°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 (> 35 mm) 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).

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%).

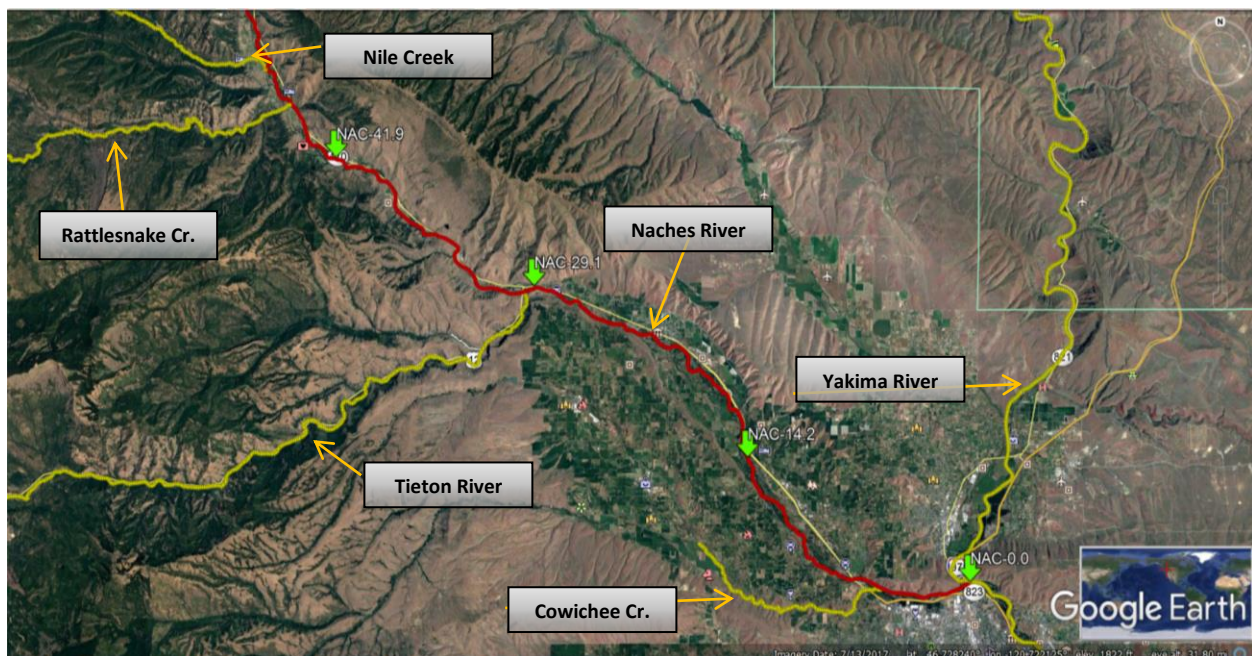
For each survey, and each age class, the total number of observed lampreys was increased (by the percentage listed above) based on the survey’s visibility rank. The adjusted observed value is

represented as “Sampled Estimated Number” in the following report. Survey densities on non-YOY lampreys ($\#/m^2$) 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. An 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

Naches River Mainstem

A total of four index sites were surveyed in the mainstem Naches River (Map 1). The index sites are located at river km 0.0, 14.2, 29.1 and 41.9.



Map 1. Overview of all surveyed sites in the Naches River (red line) in August, 2017, displaying Yakama Nation surveyed index sites (green arrows) where electrofishing occurred. Relevant tributary streams are also labeled accordingly.

Naches River Mainstem Survey Highlights

- Overall, surveys were primarily conducted in side channel habitats. Type I habitat was limited at the mouth ($9 m^2$ at river km 0.0). Type I habitat was most abundant at river km 14.2 and 29.1 ($120 m^2$ and $100 m^2$, respectively).
- The sediment temperature (measured a maximum of 10 cm below the sediment where the most lampreys were found), was 4.0 C cooler than the plot temperature (taken directly above the sediment) at river km 14.2 and 29.1. At the mouth (river km 0.0), and at the upper most site (river km 41.9), the sediment temperature was cooler than the plot temperature, but to a lesser degree (1.4 C and 0.1 C , respectively).

- The highest estimated density of lampreys (excluding YOY lampreys) was at river km 41.9 (22.6 #/m²). A similar estimated density was observed at river km 14.2 (21.3 #/m²). The site near the mouth (river km 0.0) had the lowest area of Type I habitat (9 m²), as well as the lowest density (4.1 #/m²).
- YOY lampreys were found only near the mouth (river km 0.0) with an estimated density of 4.0 #/m², similar to the density of the larger (older) lampreys.
- Pacific Lamprey were found at 2 of 4 (50%) sites. Pacific Lamprey were not found at river km 41.9 (the upper most site), nor river km 0.0 (the lowest most site).
- Two macrophthalmia (eyed Pacific Lamprey, smolt stage) were found at river km 29.1 in August, 2017. Genetic samples were collected from nine Pacific Lamprey, including the one macrophthalmia. Genetic samples were taken for parentage analysis (to see if these larvae match the genetics of any translocated adults into the Naches River, or Yakima River).

Habitat Overview (Naches River)

Table 1. Larval lamprey habitat details for lampreys greater than one year of age from index sites surveyed in the Naches 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”, “Side Ch.” indicates the survey took place in a side channel. Plot temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m ²)	50 m Type II Area (m ²)	50 m Type III 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	Naches	0.0	8/15/2017	9	121	130	> 1 Year	Sand	Silt	Side Ch	20.3	18.9	-1.4	20.3
Index	Naches	14.2	8/18/2017	120	140	260		Sand	Sand	Side Ch	23.0	19.0	-4.0	21.7
Index	Naches	29.1	8/17/2017	100	180	280		Silt	Sand	Side Ch	22.5	18.5	-4.0	21.0
Index	Naches	41.9	8/17/2017	65	120	185		Silt	Silt	Side Ch	17.6	17.5	-0.1	17.2

Table 2. Larval lamprey habitat details for young of year (YOY) lampreys from index sites surveyed in the Naches 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”, “Side Chan.” indicates the survey took place in a side channel. Plot temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

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 °C (Best)	Sed. Temp °C (Best)	Sed. Temp Diff. °C	Thalweg Temp °C
Index	Naches	0.0	8/15/2017	9	121	130	YOY	Sand	-	Side CH	20.3	18.9	-1.4	20.3
Index	Naches	14.2	8/18/2017	120	140	260		-	-	-	-	-	-	-
Index	Naches	29.1	8/17/2017	100	180	280		-	-	-	-	-	-	-
Index	Naches	41.9	8/17/2017	65	120	185		-	-	-	-	-	-	-

Captured Lamprey Details and Estimated Density (Naches 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 Naches River in August, 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	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	Naches	0.0	> 1 Year	Type I	337	6	11	16	4	24	4.1
Index	Naches	14.2			381	12	110	129	4	244	21.3
Index	Naches	29.1			590	12	56	60	5	112	9.3
Index	Naches	41.9			380	10	79	129	2	226	22.6
Index	Naches	0.0	> 1 Year	Type II	404	8	1	2	4	2	0.3
Index	Naches	14.2			283	5	5	7	5	10	2.0
Index	Naches	29.1			220	6	2	2	5	4	0.7
Index	Naches	41.9			261	5	11	16	5	22	4.4
Habitat Summary			> 1 Year	Type I	1688	40	256	334	-	607	14.3
				Type II	1168	24	19	27		38	1.9

Table 4 Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I habitat from index sites surveyed in the Naches River in August, 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 ($\#/m^2$) were calculated using the sampled estimated number and the “YOY Area”.

Site Type	Stream	River KM	Fish Age Class	Habitat Type Surveyed	YOY Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (L/m2)
Index	Naches	0.0	YOY	Type I	1	1	2	5	4	4.0
Index	Naches	14.2			0	-	-	-	-	-
Index	Naches	29.1			0	-	-	-	-	-
Index	Naches	41.9			0	-	-	-	-	-

Lamprey Measurement Details (Naches River)

Table 5. Measurement details of captured lampreys greater than one year old at index sites surveyed in the Naches River in Type I and Type II habitat in August, 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 “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, totals are a sum of presented values, except for “mean weight” and “mean length” which are an average of presented values.

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	Naches	0	> 1 Year	Type I	10	6.335	0.63	33	94	66
Index	Naches	14.2			110	181.1	1.65	70	190	111
Index	Naches	29.1			56	210.5	3.76	55	179	128
Index	Naches	41.9			79	146.3	1.85	41	185	105
Index	Naches	0	> 1 Year	Type II	1	0.71	0.71	72	72	72
Index	Naches	14.2			5	18.25	3.65	83	165	128
Index	Naches	29.1			2	9.01	4.51	72	185	129
Index	Naches	41.9			11	14.84	1.35	40	142	79
Habitat Summary		-	> 1 Year	Type I	255	544	1.97	33	190	103
				Type II	19	43	2.55	40	185	102

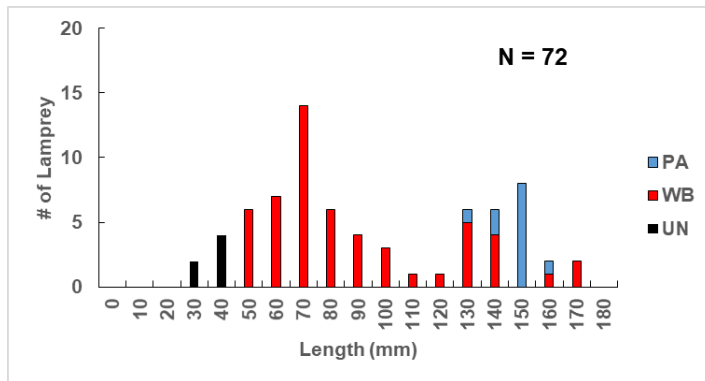


Figure 1. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (black), “WB” Western Brook Lamprey (red), in the Naches River in August, 2017.

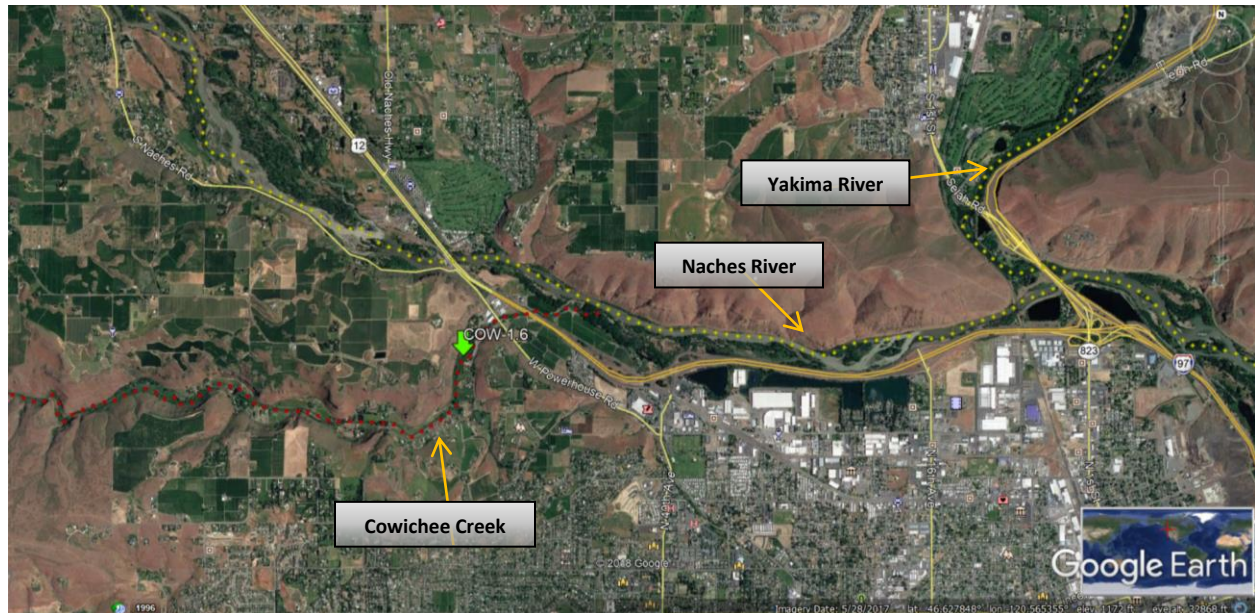
Species Composition and Genetic Samples (Naches River)

Table 6. Species composition of captured lampreys from Naches River index sites surveyed in 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	Naches	0	Type I	12	10	0	-	10	0%	100%	-
Index	Naches	14.2		115	30	1	0	29	3%	97%	7
Index	Naches	29.1		58	56	28	2	28	50%	50%	2
Index	Naches	41.9		90	49	0	-	49	0%	100%	-

Cowichee Creek, Naches River Tributary (confluence with Naches River at river km 4.4)

One index site was surveyed in Cowichee Creek (confluence with the Naches River at river km 4.4). The index site is located at river km 1.6 (Map)



Map 2. Overview of all surveyed sites in Cowichee Creek (red dotted line) in August, 2017, displaying the Yakama Nation surveyed index site (green arrow) where electrofishing occurred. The Naches River and Yakima River are labeled accordingly (also shown by the yellow dotted lines).

Cowichee Creek Survey Highlights

- Type II habitat was more abundant than Type I habitat (35 m² and 24 m², respectively).
- The sediment temperature (measured a maximum of 10 cm under the sediment) was 1.4 C cooler than the plot temperature (measured directly above the sediment) where the most lampreys were found, excluding YOY lampreys (Table 7). The location with the highest density of YOY lampreys was 2.2 C cooler under the sediment, compared to the plot temperature.
- The estimated density of lampreys (excluding YOY lampreys) was 17.1 #/m² (Table 9). The estimated density of YOY lampreys was higher (45.0 #/m²; Table 10).
- No Pacific Lamprey was found in Cowichee Creek, despite the identification of 25 lampreys (Table 13).

Habitat Overview (Cowichee Creek)

Table 7. Larval lamprey habitat details for lampreys greater than one year of age from the index site surveyed in Cowichee 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”, “Side Ch.” indicates the survey took place in a side channel. Plot temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m2)	50 m Type II Area (m2)	50 m Type I/II Area (m2)	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	Cowichee	1.6	8/1/2017	24	35	59	> 1 Year	Sand	-	Edge	21	19.6	-1.4	20.8

Table 8. Larval lamprey habitat details for young of year (YOY) lampreys from the index site surveyed in Cowichee 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”, “Side Chan.” indicates the survey took place in a side channel. Plot temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m2)	50 m Type II Area (m2)	50 m Type I/II Area (m2)	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	Cowichee	1.6	8/1/2017	24	35	59	YOY	Sand	-	Edge	21.5	19.3	-2.2	20.8

Captured Lamprey Details and Estimated Density (Cowichee Creek)

Table 9. Lamprey capture details and estimated lamprey density for lampreys greater than one year of age in Type I habitat from the index site surveyed in Cowichee Creek in August, 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.

				Habitat	Shock	Shock				Survey	Sampled	Estimated
Site		River	Fish Age	Type	Time	Area	# Captu-	#	Observed	Visibility	Esti-mated	Density
Type	Stream	KM	Class	Surveyed	(sec)	(m2)	red			(1-5)	#	(L/m2)
Index	Cowichee	1.6	> 1 Year	Type I	342	6	36	44	2		103	17.1

Table 10. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I habitat from the index site surveyed in Cowichee Creek in August, 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		River	Fish Age	Habitat	YOY	#	Survey	Sampled	Estimated
Type	Stream	KM	Class	Type	Area	Captur-	Observed	Visiblity	Estimated #
				Surveyed	(m2)	ed		(1-5)	
Index	Cowichee	1.6	YOY	Type I	2	4	9	3	90
									45.0

Lamprey Measurement Details (Cowichee Creek)

Table 11. Measurement details of captured lampreys greater than one year old at the index site surveyed in Cowichee Creek in Type I habitat in August, 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 “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.

				Habitat		Total	Mean	Min.	Max.	Mean
		River	Fish Age	Type	#	Weigh-	Weight	Weight	Length	Length
Site Type	Stream	KM	Class	Surveyed		ed	(g)	(g)	(mm)	(mm)
Index	Cowichee	1.6	> 1 Year	Type I	36		38.5	1.07	46	136
										80

Table 12. Measurement details of captured young of year (YOY) larval lampreys from the Cowichew Creek index site surveyed in August, 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	Cowichew	1.6	YOY	Type I	0	-	-	14	20	17

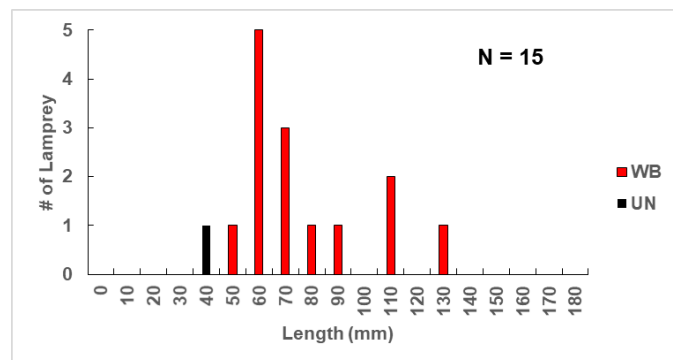


Figure 2. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species “WB” Western Brook Lamprey (red), and “UN”=Unknown Lamprey <50 mm (black), in Cowichew Creek in August, 2017.

Species Composition and Genetic Samples

Table 13. Species composition of captured lampreys from the Cowichew Creek index site surveyed in 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	Cowichew	1.6	Type I	40	25	0	-	25	0%	100%	-

Tieton River, Naches River Tributary (confluence with Naches River at river km 29.5)

One exploratory site was surveyed in the Tieton River (confluence with the Naches River at river km 29.5). The exploratory site is located at river km 5.0 (Map 3).



Map 3. Overview of all surveyed sites in the Tieton River (red dotted line) August, 2017, displaying the exploratory site surveyed at river km 5.0 (white arrow) where electrofishing occurred. The Naches River (yellow dotted line), and the location of Oak Creek (a Tieton River tributary; solid yellow line) are also shown.

Tieton River Survey Highlights

- The Tieton River was surveyed in August, 2017 (Table 14). A large area of Type I habitat was found in the Tieton River at river km 5.0 located in a side channel (300 m²). Overall, Type I habitat appears to be low throughout the Tieton River.
- The water temperature in the side channel was 18.1 C. The sediment temperature under the sediment (a maximum of 10 cm under the sediment) was 2.3 C cooler than the plot temperature (taken directly above the sediment; Table 14).
- No larval lampreys were found in the Tieton River, despite efforts to find them (Table 15). A total of 15 m² of Type I habitat was surveyed.

Habitat Overview (Tieton River)

Table 14. Larval lamprey habitat details from an exploratory site (“Expl.” under “Site Type”) surveyed in the Tieton River. 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”, “Side Ch.” indicates the survey took place in a side channel. Plot temp was taken where the best larval lamprey habitat was estimated to be. Sediment temp was taken where the best lamprey habitat was estimated to be (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m2)	50 m Type II Area (m2)	50 m Type VII Area (m2)	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
Expl.	Tieton	5.0	8/1/2017	300	10	310	Clay	-	Side Ch	18.1	15.8	-2.3	18.1

Table 15. Larval lamprey capture details from an exploratory site (“Expl.” under “Site Type”) surveyed in the Tieton River in August, 2017. Under “Survey Visibility”, “5” indicates that the survey visibility was “very good” during the course of the survey.

Site Type	Stream	River KM	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Sampled Estimated #	Estimated Density (L/m2)
Expl.	Tieton	5.0	Type I	1035	19	0	0	5	-	-

Oak Creek (Tieton River Tributary; confluence at Tieton River, river km 3.8)

In Oak Creek (tributary of the Tieton River, confluence at river km 3.8), a total of three exploratory sites were surveyed to see if larval lampreys were present in Oak Creek (Map 4). The lower reach was surveyed.



Map 4. Overview of all surveyed sites Oak Creek (red line) in August, 2017, displaying the exploratory site surveyed (Site C, D and E; white arrows) where electrofishing occurred. The Tieton River (yellow dotted line) is shown.

Oak Creek Survey Highlights

- No larval lampreys were found in Oak Creek.
- A total of 3 m² of larval habitat was present.
- Aerial images taken in 2015, showed Oak Creek to have many small log/beaver dams. However, our visit in 2017 told a different story.
- There was very limited larval lamprey habitat (Type I or Type II habitat) distributed throughout the surveyed sites in Oak Creek. Sites E and D were old log/beaver dams that had washed out (potentially holding fine sediments before high flows washed them away).

Rattlesnake Creek, Naches River Tributary (confluence at river km 45.4)

A total of four exploratory sites were surveyed in a side channel in Rattlesnake Creek (tributary of the Naches River, confluence at river km 45.4; Map 5). This side channel is man-made (originally built in the early 2000's as a refuge for salmonids). The sites were spatially distributed from the inlet (river km 2.1) to the outlet (river km 1.0). Bob Inouye (is the landowner that monitors the side channel).



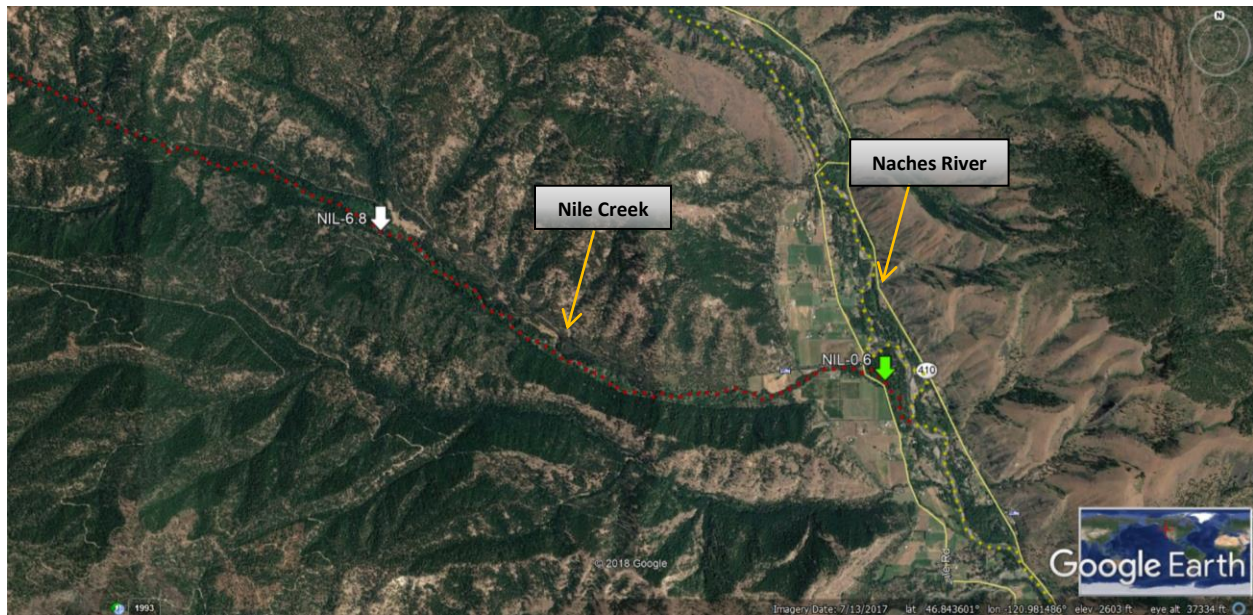
Map 5. Overview of all surveyed sites Rattlesnake Creek (red dotted line) in August, 2017, displaying the exploratory sites surveyed (white arrows) where electrofishing occurred. The Naches River (yellow dotted line) is shown.

Rattlesnake Creek Survey Highlights

- No larval lampreys were found in the surveyed side channel in Rattlesnake Creek.
- A total of 28 m² of Type I (preferred) larval lamprey habitat was surveyed in total between the four sites.
- There was abundant fine sediment throughout the visited sites (approximately 100 m² of Type I habitat in total). The fine sediment was mostly composed of silt and fine sand.

Nile Creek, Naches River Tributary (confluence at river km 47.5)

A total of two sites were electrofished in Nile Creek (Map 6). Of the two sites, one was an index site and one was an exploratory site. The two sites were at river km 0.6 and 6.8 (index and exploratory, respectively).



Map 6. Overview of all surveyed sites Nile Creek (red dotted line) in August, 2017, displaying the index site (green arrow; river km 0.6) and exploratory site (river km 6.8) where electrofishing occurred. The Naches River (yellow dotted line) is shown.

Nile Creek Survey Highlights

- In Nile Creek, Type I habitat was more abundant than Type II habitat (35 m² Type I habitat and 15 m² Type II habitat in total for both surveyed sites).
- At the upper most site (river km 6.8) the sediment temperature (measured a maximum of 10 cm below the sediment) was 6.1 C cooler than the plot temperature (measured directly above the sediment temperature; Table 16). At river km 0.6, the sediment temperature was 3.1 C cooler than the plot temperature.
- Lampreys were found at 1 of 2 (50%) sites. Lampreys were not found at the upper site (river km 6.8; Table 18). The density of lampreys (excluding YOY lampreys) was 11.0 #/m² at river km 0.6. The density of YOY lampreys was similar (13.3 #/m²).
- No Pacific Lamprey were found in Nile Creek, despite the identification of 29 lampreys (Table 20).

Habitat Overview (Nile Creek)

Table 16. Larval lamprey habitat details for lampreys greater than one year of age from an index site and an exploratory site (“Expl.” under “Site Type”), surveyed in Nile 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 temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m2)	50 m Type II Area (m2)	50 m Type I/II Area (m2)	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	Nile	0.6	8/3/2017	10	9	19	> 1 Year	Sand	-	Edge	19.6	16.5	-3.1	21.6
Expl.	Nile	6.8	8/3/2017	25	6	31		Sand	-	Side Ch	17.6	11.5	-6.1	17.6

Table 17. Larval lamprey habitat details for young of year (YOY) lampreys from an index site and an exploratory site (“Expl.” under “Site Type”), surveyed in Nile 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, “Pool” indicates the survey took place in a pool, and “Side Chan.” indicates the survey took place in a side channel. Plot temp was taken where the most lampreys were found. Sediment temp was taken where the most lampreys were found (a maximum of 10 cm under the sediment). “Sed. Temp Diff[erence].” was calculated by subtracting the plot temp from the sediment temp (a negative value indicates that the sediment temperature is cooler than the plot temperature). Thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	50 m Type I Area (m2)	50 m Type II Area (m2)	50 m Type I/II Area (m2)	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	Nile	0.6	8/3/2017	10	9	19	YOY	Sand	-	Pool	19.6	16.5	-3.1	21.6
Expl.	Nile	6.8	8/3/2017	25	6	31		-	-	-	-	-	-	-

Lamprey Capture Details and Estimated Density (Nile Creek)

Table 18. Lamprey capture details and estimated lamprey density for lampreys greater than one year of age in Type I habitat from an index site and an exploratory site (“Expl.” under “Site Type”), surveyed in Nile Creek in August, 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.

Site Type	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 (L/m2)
Index	Nile	0.6	> 1 Year	Type I	360	6	29	49	4	64	11
Expl.	Nile	6.8			415	7	0	0	5	-	-

Table 19. Lamprey capture details and estimated lamprey density for young of year (YOY) lampreys in Type I habitat from an index site and an exploratory site (“Expl.” under “Site Type”), surveyed in Nile Creek in August, 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 (L/m2)
Index	Nile	0.6	YOY	Type I	1	2	4	3	13	13.3

Lamprey Measurement Details (Nile Creek)

Table 20. Measurement details of captured lampreys greater than one year old at an index site surveyed in Nile Creek in Type I habitat in August, 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 “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	Nile	0.6	> 1 Year	Type I	-	-	-	58	120	92

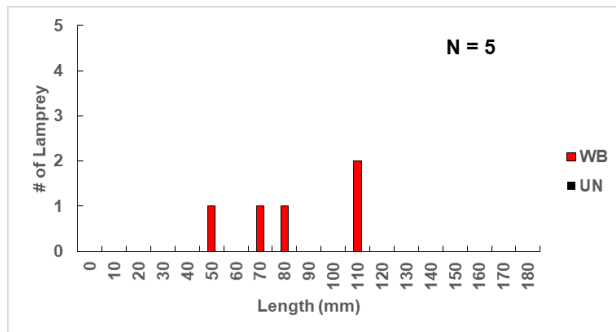


Figure 3. Histogram of measured lampreys (excluding YOY lampreys) captured during electrofishing surveys, separated by species “WB” Western Brook Lamprey (red), and UN”=Unknown Lamprey <50 mm (black), in Nile Creek in August, 2017.

Species Composition and Genetic Samples

Table 21. Species composition of captured lampreys from Nile Creek in 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	Nile	0.6	Type I	31	29	0	-	29	0%	100%	-

APPENDIX: Additional Site Maps and Photos

Naches River



Map A1. Site map of Naches index site at river km 0.0 (surveyed in August, 2017); yellow balloon indicates presence of lamprey of unknown species. The small yellow dots indicate stream distance of 100 m. The displayed image was taken in May, 2017 during a high water event and does not accurately depict the water level at the time of survey.



Photo A1. Naches River index site at river km 0.0; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/silt (right) from 2017 survey.



Map A2. Site map of Naches index site at river km 14.2 (surveyed in August, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m. The displayed image was taken in May, 2017 during a high water event and does not accurately depict the water level at the time of survey.



Photo A2. Naches River index site at river km 14.2; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/silt (right) from 2017 survey.



Map A3. Site map of Naches index site at river km 29.1 (surveyed in August, 2017); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



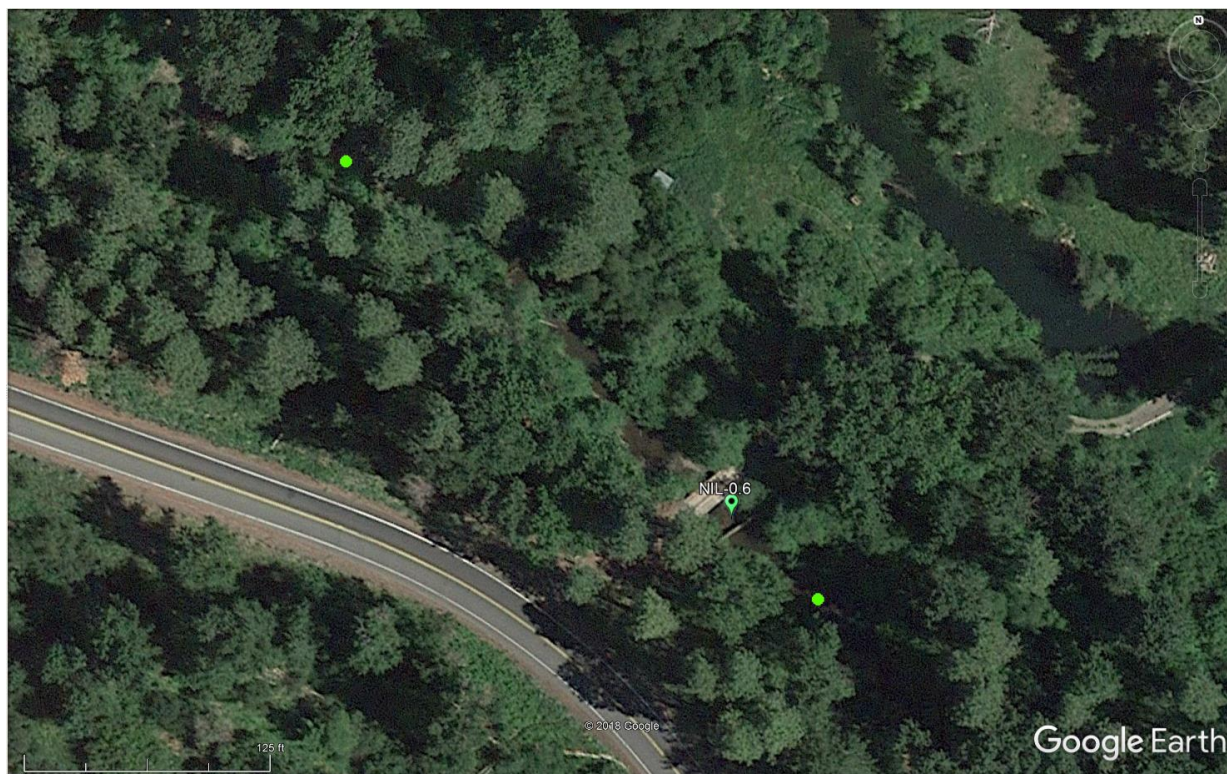
Photo A3. Naches River index site at river km 29.1; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/ (right) from 2017 survey.



Map A4. Site map of Naches index site at river km 41.9 (surveyed in August, 2017); yellow balloon indicates presence of lamprey of unknown species. The small yellow dots indicate stream distance of 100 m.



Photo A4. Naches River index site at river km 41.9; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of silt/ (right) from 2017 survey.



Map A5. Site map of Nile index site at river km 0.6 (surveyed in August, 2017); green balloon indicates presence of Western Brook lamprey. The small green dots indicate stream



Photo A5. Nile Creek index site at river km 0.6; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand (right) from 2017 survey. distance of 100 m.



Map A6. Site map of Nile exploratory site at river km 6.8 (surveyed in August, 2017); white balloon indicates no lamprey found at this site. The small green dots indicate stream distance of 100 m.



Photo A6. Nile Creek exploratory site at river km 1.1; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/ (right) from 2017 survey.



Map A7. Site map of Tieton exploratory site at river km 5.0 (surveyed in August, 2017); white balloon indicates no lamprey found at this site. The small green dots indicate stream distance of 100 m.



Photo A7. Tieton River exploratory site at river km 5.0; overview of Type I habitat (left) and close-up of electroshocking the site (right) from 2017 survey.



Map A8. Site map of Cowichee index site at river km 1.6 (surveyed in August, 2017); yellow balloon indicates presence of lamprey of unknown species. The small green dots indicate stream distance of 100 m.



Photo A8. Cowichee Creek index site at river km 1.6; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of silt/coarse (right) from 2017 survey.