



Yakama Nation Ceded Lands Larval Lamprey Monitoring Report, 2018



[Cover Photo: Overview of a larval lamprey survey site on Ahtanum Creek (river km 36.6) where larval Pacific Lamprey were captured in October, 2018.]

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Highlights

- A total of 26 electrofishing sites were surveyed for larval Pacific Lamprey within the Klickitat (1 site), Yakima (20 sites), Wenatchee (5 sites) and Entiat (1 site) subbasins.
- In the Klickitat River, the estimated density of Pacific Lamprey are present upstream of the hatchery weir. However, seasonal passage efficiency over the weir is unclear.
- In the Yakima Subbasin, larval lampreys were found at 14 of 16 (60%) of surveyed sites. Pacific Lamprey were found at all 14 sites where lampreys were present.
- In the Upper Wenatchee Subbasin (upstream of Tumwater Dam, river km 49.6), Pacific Lamprey densities were highest in Nason Creek (4.5 #/m²), compared to the mainstem Wenatchee River (up to 4.1 #/m²). No lamprey were found in the Chiwawa River.
- In 2018, Entiat River had the highest estimated density of Pacific Lamprey (11.5 #/m²).
- In the Methow Subbasin, young of the year lampreys were found at five of seven index sites suggesting successful spawning of adult Pacific Lamprey translocated into the subbasin in Fall of 2017 and (or) Spring of 2018.

Abstract

In the Klickitat River, one site was surveyed immediately upstream of the hatchery weir (river km 69.5). In 2018, the ratio of Pacific Lamprey (to Western Brook Lamprey) upstream of the weir was high (80%), with estimated lamprey densities (both species combined) of 8.2 #/m². In 2017, surveys downstream of the weir showed a similar ratio of Pacific Lamprey (between 63% and 100%), yet much higher densities of lampreys (20-40 #/m²). The low density of lampreys (and consequently low densities of Pacific Lamprey) upstream of the weir (compared to downstream) suggests only a small proportion of adult Pacific Lamprey maybe able to pass each year.

Throughout the Yakima Subbasin, 16 sites were surveyed in the Lower Yakima Subbasin (3 in the Yakima River, 4 in Ahtanum Creek, 6 in Toppenish Creek, and 3 in Satus Creek), and four sites in the Upper Yakima Subbasin (located in Wenas Creek). In the lower Yakima Subbasin, lamprey were present at 14 of 16 (87.5%) sites. Pacific Lamprey were present at all 14 sites where lampreys were present. The overall average site capture density of Pacific Lamprey was highest in Ahtanum Creek (site average of 4.7 #/m²), followed by Satus (3.7 #/m²), Toppenish (1.4 #/m²), Simcoe (1.4 #/m²) creeks, and Lower Yakima River (0.8 #/m²). No Pacific Lamprey were found in Wenas Creek, although Western Brook Lamprey were present at all four sites.

In the Upper Wenatchee Subbasin (upstream Tumwater Dam on the Wenatchee River, rkm 49.6) five sites were surveyed. Pacific Lamprey were present at two of the three (60%) Wenatchee River mainstem sites, and the one surveyed site in Nason Creek (river km 6.5). The average site capture density was highest in Nason Creek (4.7 #/m²) compared to the Wenatchee mainstem (between 2.0 #/m² and 4.1 #/m²). No lamprey were found at two sites in the Chiwawa River.

In the Entiat River, one site was surveyed (rkm 40.2). All captured lampreys were closely examined, yet only Pacific Lamprey were identified at this site. In 2016, Western Brook Lamprey were found upstream at river km 46.5, suggesting these resident species' distribution appears to be limited to the upper-most reaches. The average site density of Pacific Lamprey (11.5 #/m²) was higher than any of our other survey sites in the Ceded Lands in 2018.

In the Methow Subbasin, we assisted with larval lamprey habitat surveys conducted by John Crandall (Methow Salmon Recovery Foundation). Three previously established index sites were surveyed in the Methow River, and four index sites were surveyed in the Chewuch River (a tributary of the Methow River). Young of the year (YOY) lampreys (< 31 mm) were found at five of the seven surveyed sites, likely indicating successful spawning by adults translocated into the subbasin in Fall of 2017, and (or) Spring of 2018. No Western Brook Lamprey were found, although in 2017 Western Brook Lamprey were identified in the Methow River (at river km 59.3).

Introduction

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 with the primary goal of monitoring Pacific Lamprey in the lower, middle, and upper reaches of watersheds of interest. 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. In the following report, we summarize all electrofishing data collected in 2018 from both index sites and exploratory sites and provide an estimated number and density of both Pacific Lamprey and Western Brook Lamprey residing at these sites within the 50 m reach.

Methods

Field Survey

Surveys were focused on Type I (preferred) and/or Type II (acceptable) habitat to maximize the 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 therefore was not surveyed. Type I and II habitat is generally found in backwater areas, point bars, alcoves, 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 within the site. 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 the Type I habitat. Type II habitat was surveyed in 2018 only as part of the monitoring associated with a concurrent temperature probe study in Lower Yakima sites. 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 the coverage varied depending on available time and survey purpose.

Sediment type (sand, silt or clay) was recorded for the specific area (1 m²) where the most lampreys were observed (separate measurements for 1+ and older larvae vs. 0+ young of the year lampreys). The water depth (cm), plot temperature (°C) and sediment temperature (at 10 cm below the sediment or at the deepest area if shallower than 10 cm) were also recorded at this location. If no fish were observed, plot temperature was taken where the best available habitat was observed. Thalweg temperature was also recorded to represent the main channel temperature.

Electrofishing surveys were conducted with an AbP-2 Backpack Electrofisher (ETS Electrofishing Systems LLC, 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) were recorded. For young of the year (YOY) larvae (<31 mm), we recorded the total area where YOY larvae were observed during the course of the survey. During the course of each electrofishing survey, we estimated the maximum density of both YOY and non-YOY lampreys within a 1 m² area. This is referred to as “max 1+ density” and “max 0+ density” in the following report.

Captured lampreys were separated by habitat type, tallied by life stage, age class (YOY lampreys vs. all other lampreys), and identified to species (if of identifiable length > 49 mm). A minimum of 50 representative 1+ aged lampreys were measured for fish length (nearest 10 mm size class) and identified to species (if of identifiable length, generally > 49 mm). The weight of four individual lamprey of each species were measured to the nearest 0.01 gram (length and weight was generally taken on the largest, smallest and two medium sized larvae relative to the site). 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. YOY lampreys were tallied separately from the overall group (i.e. not part of the 50 lamprey sample). Once separated, five YOY lampreys were measured for representative fish length (largest, smallest, and three medium sizes relative to the collected sample [+/- 1 mm]). Missed lampreys were also quantified separately for both 0+ and 1+ larvae to determine the total number of observed lampreys per survey.

Genetic samples were primarily collected in areas where adult Pacific Lamprey translocation efforts are ongoing, or where the distribution of Pacific Lamprey is uncertain. The samples were collected from Pacific Lamprey (> 50 mm) using scissors or a small (2 mm) hole punch (top or bottom of the caudal fin). The whole body was preserved for YOY larvae (by placement of the whole body on a genetic sheet or preservation in 70% Ethanol), but efforts were made to minimize lethal genetic sampling. Macrophthalmia were generally clipped on the posterior end of the second (rear) dorsal fin with scissors or a small (2 mm) hole punch.

Additionally, genetic samples were collected from Western Brook Lamprey (> 50 mm) with scissors or a small (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 watersheds of interest (representative samples of Class A and Class B). The goal of these samples is 1) to confirm the presence of Western Brook Lamprey in areas where Western Brook Lamprey are thought to be absent, or limited in number and 2) to better understand the genetic variance between these two classes of Western Brook Lamprey throughout the Columbia River Basin.

Data Analysis

First, we calculated the total number of captured Pacific Lamprey and Western Brook Lamprey from each of our surveyed sites. The ratio of Pacific Lamprey and Western Brook Lamprey was extrapolated to include all unidentified lampreys (excluding young of the year lampreys) to get a final number of Pacific Lamprey and Western Brook Lamprey. Next, we divided the final number of Pacific Lamprey and Western Brook Lamprey by the total survey area to get an extrapolated density for each species. In addition to the extrapolated density, we also calculated an extrapolated biomass density based on weight for each species. We extrapolated these species-specific densities over the estimated area of Type I habitat within the 50 m surveyed reach to arrive at an “extrapolated number in 50 m” and “estimated biomass in 50 m” for both Pacific Lamprey and Western Brook Lamprey.

Next, we estimated the total number of lampreys (separated by size class) residing in each of the 50 m reaches. Studies have shown that the capture efficiency of single pass larval lamprey electrofishing is approximately 50% for the number of lampreys captured and 70% for the biomass of lampreys captured (captured lamprey numbers only account for approximately 50% of the total lampreys present whereas captured lamprey biomass accounts for approximately 70% of the total lamprey biomass). To ensure that our abundance estimation accounts for all lampreys present, we doubled the density of captured lampreys to arrive at an “estimated density” of 1+ year old lampreys (excluding YOY). Similarly, to ensure that our biomass estimation accounts for all lampreys present, we divided the biomass by 0.7 to arrive at an “estimated biomass” of 1+ year

old lampreys (excluding YOY). The resulting estimated density, and estimated biomass density, were extrapolated over the area of Type I habitat within the 50 m reach to arrive at a total estimated number and biomass of lampreys (greater than one year of age) residing at each surveyed site.

We took a slightly different approach to estimate the number of YOY lampreys in the 50 m surveyed reach. Due to their small size and sensitivity to electrofishing, we avoided catching all the YOY lampreys that emerged from fine sediment habitat to minimize the potential damage on them from electrofishing. Because of this, the observed number of YOY lampreys (captured plus missed) was used to calculate the survey density (rather than doubling the captured lamprey to arrive at the final number). However, if the number of captured YOY lampreys were greater than the number of missed lampreys (i.e. captured YOY lampreys were more than half of the observed total), we doubled the number of captured YOY lampreys to arrive at the final number and density of YOY lampreys. This estimated YOY density was extrapolated over the available Type I habitat in 50 m to arrive at a total number of YOY lampreys at each site.

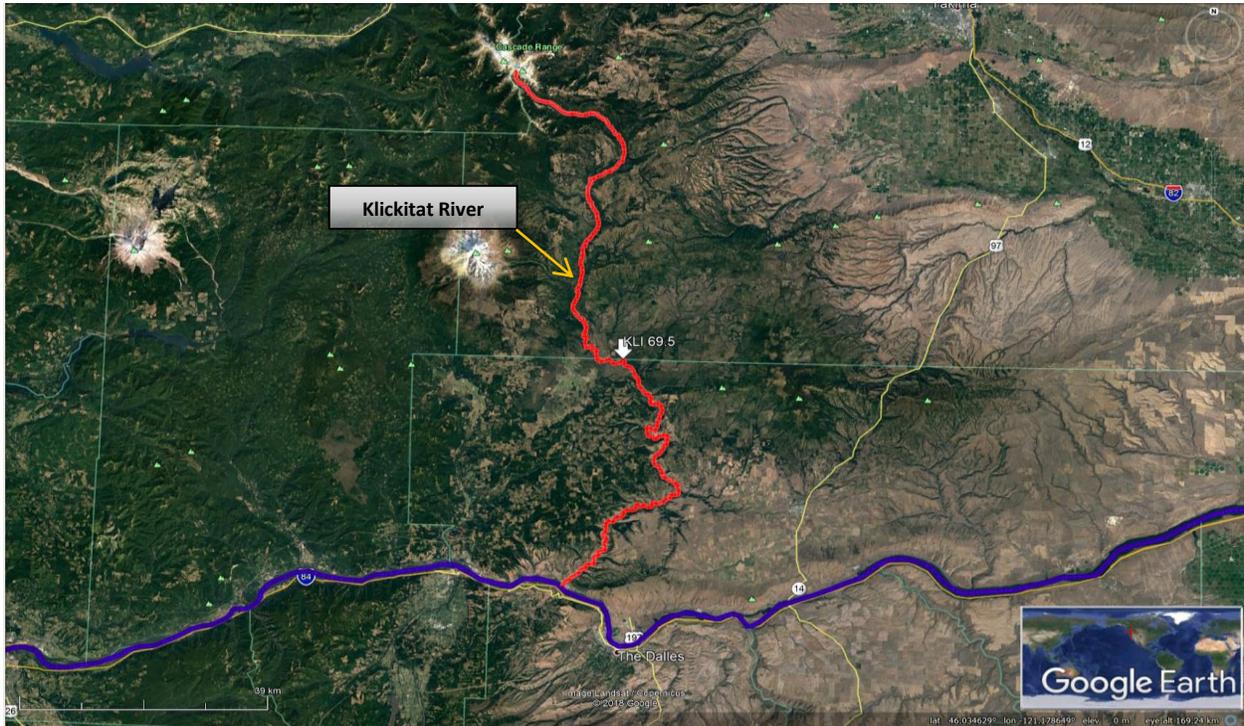
For surveys within the Methow Subbasin, we assisted John Crandall (MSRF) survey long-term status and trend index sites established in the Methow and Chewuch rivers. In the results section, we provide a general summary of the data we helped collect during these surveys; due to the difference in survey methods/protocols, not all values were calculated for the survey sites within the Methow Subbasin.

Results

Klickitat Subbasin

The Klickitat Subbasin was the lower-most subbasin that we surveyed in the Columbia Basin in 2018 (Klickitat River confluence with the Columbia River at river km 287.0). One site was surveyed in the Klickitat River at river km 69.5 (Map 1). The surveyed site is located upstream of the Klickitat Hatchery weir. Type I habitat was limited, with 6m² of Type I habitat observed in the 50 m surveyed reach. Pacific Lamprey and Western Brook Lamprey were both observed at this site, with 80% of the identifiable lamprey being Pacific Lamprey (Table 2). However, over half (60%) were unidentifiable due to their size (<50 mm). YOY larvae were present, which shows active spawning by lamprey upstream of the weir (genetic samples were collected to identify the small lampreys). The presence of Pacific Lamprey at this site demonstrates their ability to successfully pass the weir and spawn, although seasonal adult passage efficiency over the weir is unclear. Estimated lamprey densities upstream of the weir (combined for both species) were low (8.2 #/m²; Table 4) compared to sites downstream of the weir (as high as 30-40 #/m² from 2017 surveys). However, past surveys have shown the ratio of Pacific Lamprey is similar upstream and downstream of the weir. In 2017, between 63% and 100% of identifiable lampreys were Pacific Lamprey at sites downstream of the weir (compared to 80% Pacific Lamprey upstream of the weir

in 2018). The disproportionate density of lampreys upstream and downstream of the weir, and similarly high ratios of Pacific Lamprey suggests maybe only a small proportion of adults are able to pass each year. Further study of passage rates will be explored in 2019.



Map 1. Overview of the one survey site on the Klickitat River (river km 69.5). The one surveyed (electrofished) index site at river km 69.5 (white arrow) is shown. The Klickitat River is a tributary of the Columbia River (blue line).

Habitat Details and General Survey Overview (Klickitat Subbasin)

Table 1. Larval lamprey habitat details from surveyed sites within the Yakima Subbasin. The estimated total area (m²) of Type I and Type II habitat within the surveyed 50 m reach is shown. "Habitat Location in Stream Type" indicates the location within the stream where the survey primarily took place; "edge" along the edge of the main channel.

| Site Type | Stream | River KM | Date | 50 m Type I Area (m ²) | 50 m Type II Area (m ²) | Primary Fine Sediment (Type I) | Habitat Location | Plot Temp °C (Best) | Sed. Temp °C (Best) | Sed. Temp Diff. °C | Thalweg Temp °C |
|-----------|-----------|----------|-----------|------------------------------------|-------------------------------------|--------------------------------|------------------|---------------------|---------------------|--------------------|-----------------|
| | | | | | | | Stream Type | | | | |
| Index | Klickitat | 69.5 | 9/11/2018 | 6 | 1 | silt | Edge | 11.4 | 11.4 | 0 | 11.4 |

Table 2. Larval lamprey electrofishing effort and species composition at survey sites within the Klickitat Subbasin. "Survey Visibility" is an estimated scale of water clarity during the survey (1 is poor visibility, 5 is high visibility). "PA" stands for Pacific Lamprey, and "WB" stands for Western Brook Lamprey. "% PA" is the percent of all captured lampreys (> 49 mm) that were identified as Pacific Lamprey. "% Unknown", is the percent of all captured lampreys < 50 mm in total length that could not be identified to species.

| Site Type | Stream | River KM | Date | Shock Time (sec) | Shock Area (m2) | Survey Visibility (1-5) | # Captured | # Missed | % PA (>50 mm) | % Unknown (<50mm) | # PA with eyes | # WB with eyes |
|-----------|-----------|----------|-----------|------------------|-----------------|-------------------------|------------|----------|---------------|-------------------|----------------|----------------|
| Index | Klickitat | 69.5 | 9/11/2018 | 308 | 6 | 3 | 30 | 10 | 80% | 67% | 0 | 0 |

Lamprey Measurement Details and Genetic Samples (Klickitat Subbasin)

Table 3. Biological data for Pacific Lamprey ("PA") and Western Brook Lamprey ("WB") captured at survey sites in the Klickitat Subbasin. "# of PA" is the number of Pacific Lamprey identified (> 50 mm in length). "Gen." stands for genetic (fin clip) samples.

| Site Type | Stream | River KM | # of PA | PA Mean Weight (g) | PA Mean Length (mm) | PA Min. Length (mm) | PA Max. Length (mm) | # of WB | WB Mean Weight (g) | WB Mean Length (mm) | WB Min. Length (mm) | WB Max. Length (mm) | # Pacific Gen. Sampl. | # WB Gen. Sampl. |
|-----------|-----------|----------|---------|--------------------|---------------------|---------------------|---------------------|---------|--------------------|---------------------|---------------------|---------------------|-----------------------|------------------|
| Index | Klickitat | 69.5 | 8 | - | 67.5 | 60 | 80 | 2 | - | 72.5 | 65 | 80 | 9 | 2 |

Estimated Lamprey Density and Numbers (Klickitat Subbasin)

Table 4. Extrapolated number of Pacific Lamprey ("PA") and Western Brook Lamprey ("WB") within a 50 m reach at each surveyed site within the Klickitat Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age.

| Site Type | Stream | River KM | Extrapolated 1+ PA Density (#/m2) | Extrapolated 1+ WB Density (#/m2) | Extrapolated 1+ PA Mass Density (g/m2) | Extrapolated 1+ WB Mass Density (g/m2) | Extrapolated 50 m 1+ PA # | Extrapolated 50 m 1+ WB # |
|-----------|-----------|----------|-----------------------------------|-----------------------------------|--|--|---------------------------|---------------------------|
| Index | Klickitat | 69.5 | 3.5 | 0.9 | - | - | 21 | 5 |

Table 5. Estimated number of larvae, separated by age class, in a 50 m reach at surveyed sites in the Klickitat Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age. The term "0+" stands for lamprey that are < 31 mm, and are estimated to be less than one year of age. The estimated "max densities" are the maximum estimated density of lamprey observed in one square meter at each site while electrofishing.

| Site Type | Stream | River KM | Estimated 1+ Lamprey Density (#/m2) | Estimated 1+ Max Lamprey Density (#/m2) | Estimated 50 m 1+ # | Estimated 1+ Mass Density (g/m2) | Estimated 0+ Lamprey Density (#/m2) | Estimated 0+ Max Lamprey Density (#/m2) | Estimated 50 m 0+ # | Estimated 50 m 0+ & 1+ # |
|-----------|-----------|----------|-------------------------------------|---|---------------------|----------------------------------|-------------------------------------|---|---------------------|--------------------------|
| Index | Klickitat | 69.5 | 8.7 | - | 52 | - | 1.5 | 4 | 9 | 61 |

Species Composition of All Captured Lampreys (Klickitat Subbasin)

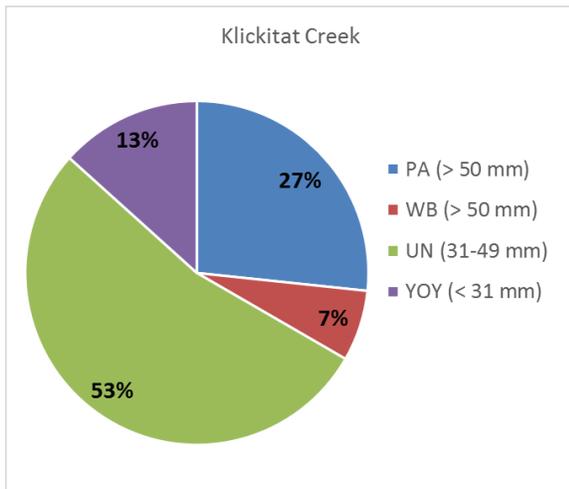
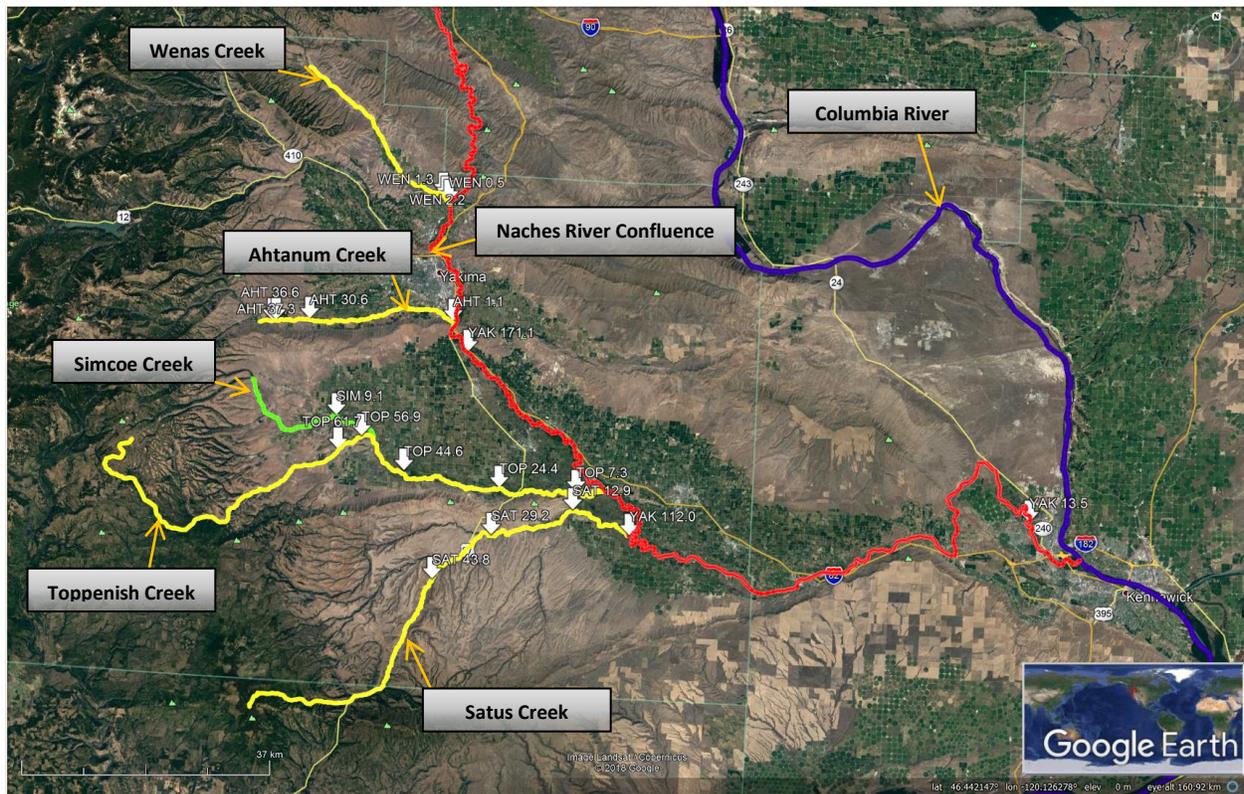


Figure 1. Species composition of captured lampreys from the one surveyed site in the Klickitat River (river km 69.5). “PA” stands for Pacific Lamprey, “WB” stands for Western Brook Lamprey, “UN” stands for unknown species lamprey (that are estimated to be over one year of age) and “YOY” stands for young of the year, estimated to be less than one year of age.

Yakima Subbasin

In total, 16 sites were surveyed in the Lower Yakima Subbasin (3 in the mainstem Yakima, 4 in Ahtanum Creek, 6 in Toppenish Creek, and 3 in Satus Creek; Map 1). The dividing line between the upper and lower Yakima Subbasin is the confluence of the Naches River with the Yakima River at river km 191.8). In the Upper Yakima Subbasin, four sites were surveyed in Wenas Creek. In the Lower Yakima Subbasin, lampreys were present at 14 of 16 (87.5%) sites. Pacific Lampreys were present at all 14 sites where lampreys were present. In sites where larval Pacific Lampreys were present, the average site density of Pacific Lamprey (based on captured numbers and surveyed area), was lowest in the Yakima River (site average of 0.8 #/m²). Ahtanum Creek had the highest average site density of Pacific Lamprey (4.7 #/m²), as well as the highest density between all three Lower Yakima tributaries (3.7 #/m² and 1.4/m² in Satus Creek and Toppenish Creek, respectively). Conversely, Toppenish Creek, which had the lowest average site density of Pacific Lamprey, had the highest density of Western Brook Lamprey (3.8/m² in Toppenish Creek and 4.4 #/m² in Simcoe Creek). In Satus Creek and Ahtanum Creek, the Western Brook average site density was much lower (0.4 #/m² and 0.9 #/m²). The Yakima River had a low average site density of Pacific Lamprey, although it was twice as high as Western Brook Lamprey (0.4 #/m² for Western Brook Lamprey). No Pacific Lampreys were found, or have ever been found, in Wenas Creek.



Map 2. Overview of 2018 survey sites in the Yakima River Subbasin. Yakima River is shown as a red line, and yellow lines indicate tributary streams. The Columbia River is shown in blue. Also shown are surveyed index sites (white arrows) where electrofishing occurred. The location of the Naches River confluence (river km 191.9) is labeled. Tributary streams are also labeled accordingly.

Habitat Details and General Survey Overview (Yakima Subbasin)

Table 6. Larval lamprey habitat details from surveyed sites within the Yakima Subbasin. The estimated total area (m²) of Type I and Type II habitat within the surveyed 50 m reach is shown. "Habitat Location in Stream Type" indicates the location within the stream where the survey primarily took place; "edge" along the edge of the main channel, "main" in the main channel, "side ch" in a side channel, and "alcove" in an alcove.

| | Site Type | Stream | River KM | Date | 50 m Type I Area (m ²) | 50 m | Primary Fine Sediment (Type I) | Habitat | Plot Temp °C (Best) | Sed. | Sed. | Thalweg Temp °C |
|--------------|-------------|-----------|------------|------------|------------------------------------|--------------------------------|--------------------------------|-------------------------|---------------------|----------------|---------------|-----------------|
| | | | | | | Type II Area (m ²) | | Location in Stream Type | | Temp °C (Best) | Temp Diff. °C | |
| Upper Yakima | Exploratory | Wenas | 0.5 | 8/8/2018 | 28 | 60 | silt | Edge | 23.1 | 19.0 | -4.1 | 23.0 |
| | Index | | 0.8 | 8/8/2018 | 220 | 28 | silt | Main | 20.2 | 20.3 | 0.1 | 20.2 |
| | Exploratory | | 1.3 | 8/8/2018 | - | - | silt | Edge | 26.2 | 20.0 | -6.2 | 26.1 |
| | Index | | 2.2 | 8/8/2018 | 13 | 62 | silt | Side Ch. | 25.6 | 21.9 | -3.7 | 25.5 |
| Lower Yakima | Index | Yakima | 13.5 | 9/20/2018 | 400 | 20 | sand | Edge | 18.5 | 14.7 | -3.8 | - |
| | Index | | 112 | 10/2/2018 | 110 | 60 | sand | Edge | 16.3 | 14.9 | -1.4 | 16.0 |
| | Index | | 171.1 | 10/1/2018 | 265 | 1000 | clay | Edge | 15.2 | 14.6 | -0.6 | 15.1 |
| | Index | Satus | 12.9 | 9/27/2018 | 200 | 350 | silt | Edge | 15.5 | 14.8 | -0.7 | 15.1 |
| | Index | | 29.2 | 8/7/2018 | 42 | 95 | silt | Edge | 24.6 | 21.8 | -2.8 | 24.5 |
| | Index | | 43.8 | 8/7/2018 | 15 | 24 | sand | Edge | 20.2 | 17.9 | -2.3 | 19.8 |
| | Index | Toppenish | 7.3 | 9/26/2018 | 800 | 0 | clay | Edge | 18.2 | 18.0 | -0.2 | 18.2 |
| | Index | | 24.4 | 10/11/2018 | 200 | - | clay | Edge | 11.8 | 12.5 | 0.7 | 11.2 |
| | Index | | 44.6 | 8/24/2018 | 43 | 50 | sand | Main | 19.2 | 19.4 | 0.2 | 19.0 |
| | Exploratory | | 56.9 | 10/11/2018 | 11 | - | silt | Side Ch. | - | - | - | - |
| | Index | Simcoe | 61.7 | 7/27/2018 | 7 | 25 | silt | Alcove | 19.6 | 16.8 | -2.8 | 17.8 |
| | Index | | 9.1 | 8/24/2018 | 55 | 100 | silt | Main | 29.1 | 18.2 | -10.9 | 29.1 |
| Index | Ahtanum | 1.1 | 10/1/2018 | 60 | 250 | silt | Edge | 13.8 | 13.8 | -0.1 | 13.8 | |
| Exploratory | | 30.6 | 10/12/2018 | 12 | 7 | silt | Edge | - | - | - | - | |
| Index | | 36.6 | 8/1/2018 | 9 | 18 | silt | Edge | 22.9 | 20.1 | -2.8 | 22.4 | |
| Exploratory | | 37.3 | 8/1/2018 | 3 | 8 | silt | Side Ch. | - | - | - | - | |

Table 7. Larval lamprey electrofishing effort and species composition at survey sites within the Yakima Subbasin. "Survey Visibility" is an estimated scale of water clarity during the survey (1 is poor visibility, 5 is high visibility). "PA" stands for Pacific Lamprey, and "WB" stands for Western Brook Lamprey. "% PA" is the percent of all captured lampreys (> 49 mm) that were identified as Pacific Lamprey. "% Unknown", is the percent of all captured lampreys < 50 mm in total length that could not be identified to species.

| | Site Type | Stream | River KM | Date | Shock Time (sec) | Shock Area (m2) | Survey Visibility (1-5) | # Captured | # Missed | % PA (>50 mm) | % Unknown (<50mm) | # PA with eyes | # WB with eyes |
|---------------------|-------------|-----------|------------|------------|------------------|-----------------|-------------------------|------------|------------|---------------|-------------------|----------------|----------------|
| Upper Yakima | Exploratory | | 0.5 | 8/8/2018 | 425 | 7 | 2 | 42 | 6 | 0% | 2% | 0 | 0 |
| | Index | Wenas | 0.8 | 8/8/2018 | 332 | 6 | 2 | 6 | 0 | 0% | 0% | 0 | 0 |
| | Exploratory | | 1.3 | 8/8/2018 | 422 | 7 | 2 | 58 | 8 | 0% | 4% | 0 | 0 |
| | Index | | 2.2 | 8/8/2018 | 800 | 10 | 2 | 15 | 15 | 0% | 0% | 0 | 0 |
| Lower Yakima | Index | | 13.5 | 43363 | 600 | 10 | 2 | 12 | 3 | 100% | 8% | 0 | 0 |
| | Index | Yakima | 112 | 43375 | 715 | 12 | 2 | 2 | 0 | 50% | 0% | 0 | 0 |
| | Index | | 171.1 | 43374 | 600 | 10 | 1 | 24 | 16 | 55% | 8% | 0 | 1 |
| | Index | | 12.9 | 9/27/2018 | 693 | 11 | 3 | 141 | 200 | 94% | 0% | 3 | 0 |
| | Index | Satus | 29.2 | 8/7/2018 | 600 | 10 | 4 | 168 | 387 | 100% | 5% | 0 | 0 |
| | Index | | 43.8 | 8/7/2018 | 750 | 12 | 4 | 26 | 1 | 54% | 0% | 0 | 0 |
| | Index | | 7.3 | 9/26/2018 | 600 | 10 | 5 | 0 | 0 | - | - | 0 | 0 |
| | Index | | 24.4 | 10/11/2018 | 501 | 8 | 2 | 0 | 0 | - | - | 0 | 0 |
| | Index | Toppenish | 44.6 | 8/24/2018 | 780 | 9 | 2 | 3 | 3 | 33% | 0% | 0 | 0 |
| | Exploratory | | 56.9 | 10/11/2018 | 210 | 4 | 4 | 33 | 10 | 42% | 6% | 1 | 0 |
| Index | | 61.7 | 7/27/2018 | 586 | 7 | 4 | 76 | 24 | 10% | 8% | 0 | 0 | |
| Index | Simcoe | 9.1 | 8/24/2018 | 1200 | 8 | 1 | 46 | 14 | 24% | 0% | 0 | 2 | |
| Index | | 1.1 | 10/1/2018 | 673 | 11 | 4 | 94 | 25 | 28% | 6% | 0 | 1 | |
| Exploratory | Ahtanum | 30.6 | 10/12/2018 | - | 5 | 5 | 19 | 4 | 95% | 0% | 1 | 0 | |
| Index | | 36.6 | 8/1/2018 | 479 | 8 | 4 | 94 | 36 | 100% | 7% | 0 | 0 | |
| Exploratory | | 37.3 | 8/1/2018 | 195 | 3 | 5 | 20 | 50 | 100% | 0% | 0 | 0 | |
| Summary | | Wenas | | | 1979 | 30 | | 121 | 29 | 0% | 2% | 0 | 0 |
| | | Yakima | | | 1915 | 32 | | 38 | 19 | 68% | 6% | 0 | 1 |
| | | Satus | | | 2043 | 33 | | 335 | 588 | 83% | 2% | 3 | 0 |
| | | Toppenish | - | | 3877 | 46 | | 158 | 51 | 28% | 5% | 1 | 2 |
| | | Simcoe | | | 1200 | 8 | | 46 | 14 | 24% | 0% | 0 | 2 |
| | | Ahtanum | | | 1347 | 27 | | 227 | 115 | 81% | 3% | 1 | 1 |

Lamprey Measurement Details and Genetic Samples (Yakima Subbasin)

Table 8. Biological data for Pacific Lamprey (“PA”) and Western Brook Lamprey (“WB”) captured at survey sites in the Yakima Subbasin. “# of PA” and “# of WB” is the number of Pacific Lamprey, and Western Brook Lamprey, identified to species (> 50 mm in length). “Gen.” stands for genetic (fin clip) samples.

| | Site Type | Stream | River KM | # of PA | PA Mean | PA Mean | PA Min. | PA Max. | # of WB | WB Mean | WB Mean | WB Min. | WB Max. | # Pacific | # WB |
|--------------|-------------|-----------|----------|---------|------------|-------------|-------------|-------------|---------|------------|-------------|-------------|-------------|---------------------|-------------|
| | | | | | Weight (g) | Length (mm) | Length (mm) | Length (mm) | | Weight (g) | Length (mm) | Length (mm) | Length (mm) | Lamprey Gen. Sampl. | Gen. Sampl. |
| Upper Yakima | Exploratory | Wenas | 0.5 | 0 | - | - | - | - | 41 | 2.13 | 104 | 70 | 150 | 0 | 0 |
| | Index | | 0.8 | 0 | - | - | - | - | 6 | - | 85 | 80 | 90 | 0 | 0 |
| | Exploratory | | 1.3 | 0 | - | - | - | - | 48 | - | 80 | 60 | 130 | 0 | 0 |
| | Index | 2.2 | 0 | - | - | - | - | 15 | - | 75 | 60 | 90 | 0 | 0 | |
| | Index | 13.5 | 11 | 1.7 | 98 | 84 | 109 | 0 | - | - | - | - | 0 | 0 | |
| | Index | 112.0 | 1 | 2.4 | 115 | 115 | 115 | 1 | 1.54 | 94 | 94 | 94 | 94 | 0 | 0 |
| Lower Yakima | Index | Satus | 171.1 | 12 | 1.3 | 97 | 70 | 123 | 10 | 2.38 | 101 | 50 | 154 | 23 | 0 |
| | Index | | 12.9 | 49 | - | 73 | 50 | 131 | 3 | - | 115 | 90 | 140 | 0 | 0 |
| | Index | | 29.2 | 49 | 0.6 | 86 | 50 | 147 | 0 | - | - | - | - | 25 | 0 |
| | Index | 43.8 | 14 | 5.3 | 144 | 114 | 154 | 12 | 4.28 | 124 | 80 | 185 | 10 | 0 | |
| | Index | 44.6 | 1 | 2.1 | 120 | 120 | 120 | 2 | 1.06 | 78 | 75 | 80 | 0 | 0 | |
| | Exploratory | Toppenish | 56.9 | 13 | - | - | - | 18 | - | - | - | - | - | 1 | 0 |
| | Index | | 61.7 | 5 | 3.0 | 117 | 90 | 144 | 44 | 0.94 | 67 | 50 | 140 | 5 | 0 |
| | Index | Simcoe | 9.1 | 11 | 1.6 | 100 | 80 | 129 | 35 | 1.44 | 89 | 50 | 150 | 0 | 0 |
| | Index | | 1.1 | 13 | 1.3 | 85 | 60 | 126 | 34 | 1.59 | 94 | 60 | 145 | 0 | 0 |
| | Exploratory | Ahtanum | 30.6 | 18 | - | - | - | 1 | - | - | - | - | - | 1 | 0 |
| | Index | | 36.6 | 50 | 1.2 | 89 | 50 | 162 | 0 | - | - | - | - | 16 | 0 |
| | Exploratory | | 37.3 | 20 | - | 79 | 75 | 110 | 0 | - | - | - | - | 0 | 0 |
| Summary | | Wenas | - | - | - | - | - | - | 2.1 | 86 | 68 | 115 | 0 | 0 | |
| | | Yakima | 8.0 | 1.8 | 103 | 90 | 116 | 4 | 2.0 | 98 | 72 | 124 | 8 | 0 | |
| | | Satus | 37.3 | 2.9 | 101 | 71 | 144 | 5 | 4.3 | 120 | 85 | 163 | 12 | 0 | |
| | | Toppenish | 6.3 | 2.5 | 118 | 105 | 132 | 21 | 1.0 | 72 | 63 | 110 | 2 | 0 | |
| | | Simcoe | 11.0 | 1.6 | 100 | 80 | 129 | 35 | 1.4 | 89 | 50 | 150 | 0 | 0 | |
| | | Ahtanum | 25.3 | 1.3 | 84 | 62 | 133 | 9 | 1.6 | 94 | 60 | 145 | 4 | 0 | |

Estimated Lamprey Density and Numbers (Yakima Subbasin)

Table 9. Extrapolated number of Pacific Lamprey (“PA”) and Western Brook Lamprey (“WB”) within a 50 m reach at each surveyed site within the Yakima Subbasin. The term “1+” stands for lamprey that are > 30 mm, and are estimated to be over one year of age. Simcoe Creek is a tributary of Toppenish Creek.

| | Site Type | Stream | River KM | Extrapolated | Extrapolated 1+ | Extrapolated 1+ | Extrapolated 1+ | Extrapolated | Extrapolated |
|--------------|-------------|-----------|----------|----------------------|-------------------|------------------------|------------------------|--------------|--------------|
| | | | | 1+ PA Density (#/m2) | WB Density (#/m2) | PA Mass Density (g/m2) | WB Mass Density (g/m2) | | |
| Upper Yakima | Exploratory | Wenas | 0.5 | 0.0 | 5.9 | - | 12.5 | 0 | 164 |
| | Index | | 0.8 | 0.0 | 1.0 | - | 0 | 220 | |
| | Exploratory | | 1.3 | 0.0 | 7.2 | - | - | - | |
| | Index | 2.2 | 0.0 | 1.5 | - | 0 | 20 | | |
| | Index | 13.5 | 1.1 | 0.0 | 1.9 | - | 440 | 0 | |
| | Index | 112.0 | 0.1 | 0.1 | 0.2 | 0.1 | 9 | 9 | |
| Lower Yakima | Index | Satus | 171.1 | 1.3 | 1.0 | 1.6 | 2.4 | 332 | 277 |
| | Index | | 12.9 | 4.5 | 0.3 | - | 891 | 55 | |
| | Index | | 29.2 | 5.6 | 0.0 | 2.8 | 233 | 0 | |
| | Index | 43.8 | 1.2 | 1.0 | 6.1 | 4.3 | 18 | 15 | |
| | Index | 44.6 | 0.1 | 0.2 | 0.2 | 0.2 | 5 | 10 | |
| | Exploratory | Toppenish | 56.9 | 3.5 | 4.8 | - | 38 | 53 | |
| | Index | | 61.7 | 0.7 | 6.3 | 2.1 | 5 | 44 | |
| | Index | Simcoe | 9.1 | 1.4 | 4.4 | 2.2 | 6.3 | 76 | 241 |
| | Index | | 1.1 | 1.3 | 3.5 | 1.6 | 4.9 | 79 | 208 |
| | Exploratory | Ahtanum | 30.6 | 3.6 | 0.2 | - | 43 | 2 | |
| | Index | | 36.6 | 7.1 | 0.0 | 7.6 | 64 | 0 | |
| | Exploratory | | 37.3 | 6.7 | 0.0 | - | 20 | 0 | |
| Summary | | Wenas | 0.0 | 3.9 | - | 12.5 | 0 | 135 | |
| | | Yakima | 0.8 | 0.4 | 1.2 | 1.3 | 261 | 95 | |
| | | Satus | 3.7 | 0.4 | 4.5 | 4.3 | 381 | 23 | |
| | | Toppenish | 1.4 | 3.8 | 1.2 | 3.1 | 16 | 35 | |
| | | Simcoe | 1.4 | 4.4 | 2.2 | 6.3 | 76 | 241 | |
| | | Ahtanum | 4.7 | 0.9 | 4.6 | 4.9 | 52 | 53 | |

Table 10. Estimated number of larvae, separated by age class, in a 50 m reach at surveyed sites in the Yakima Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age. The term "0+" stands for lamprey that are < 31 mm, and are estimated to be less than one year of age. The estimated "max densities" are the maximum estimated density of lamprey observed in one square meter at each site while electrofishing. Simcoe Creek is a tributary of Toppenish Creek.

| Site | Type | Stream | River KM | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated | Estimated |
|--------------|-------------|-----------|----------|---------------------------|-------------------------------|-----------|-----------|------------------------|-----------|-----------|-----------|-----------|
| | | | | 1+ Lamprey Density (#/m2) | 1+ Max Lamprey Density (#/m2) | | 50 m 1+ # | 1+ Mass Density (g/m2) | | | | |
| Upper Yakima | Exploratory | | 0.5 | 11.7 | 10.0 | 328 | 17.8 | 0.4 | 1 | 12 | 340 | |
| | Index | Wenas | 0.8 | 2.0 | 2.0 | 440 | - | 0.0 | - | 0 | 440 | |
| | Exploratory | | 1.3 | 14.4 | 20.0 | - | - | 0.0 | - | 0 | - | |
| | Index | | 2.2 | 3.0 | 10.0 | 39 | - | 0.0 | - | 0 | 39 | |
| | Index | | 13.5 | 2.2 | 3.0 | 880 | 2.7 | 0.2 | 1 | 80 | 960 | |
| | Index | Yakima | 112 | 0.3 | 1.0 | 37 | 0.5 | 0.0 | - | 0 | 37 | |
| | Index | | 171.1 | 4.6 | 5.0 | 1219 | 5.7 | 0.5 | 1 | 133 | 1352 | |
| | Index | | 12.9 | 9.5 | 40.0 | 1891 | - | 0.0 | - | 0 | 1891 | |
| | Index | Satus | 29.2 | 11.1 | 50.0 | 466 | 4.0 | 0.4 | 5 | 17 | 483 | |
| | Index | | 43.8 | 4.3 | 5.0 | 65 | 14.9 | 0.0 | - | 0 | 65 | |
| | Index | | 44.6 | 0.7 | 2.0 | 29 | 0.7 | 0.0 | - | 0 | 29 | |
| | Exploratory | Toppenish | 56.9 | 16.5 | - | 182 | - | 0.0 | - | 0 | 182 | |
| Lower Yakima | Index | | 61.7 | 14.0 | 20.0 | 98 | 11.5 | 3.7 | 15 | 26 | 124 | |
| | Index | Simcoe | 9.1 | 11.5 | 10.0 | 633 | 12.1 | 0.0 | - | 0 | 633 | |
| | Index | | 1.1 | 9.6 | 16.0 | 574 | 9.3 | 0.0 | - | 0 | 574 | |
| | Exploratory | Ahtanum | 30.6 | 7.6 | - | 91 | - | 0.0 | - | 0 | 91 | |
| | Index | | 36.6 | 14.2 | 40.0 | 128 | 10.9 | 0.0 | - | 0 | 128 | |
| | Exploratory | | 37.3 | 13.3 | - | 40 | - | 0.0 | - | 0 | 40 | |
| | | Wenas | | 7.8 | 10.5 | 269 | 17.8 | 0.1 | 1 | 3 | 273 | |
| | | Yakima | | 2.4 | 3.0 | 712 | 3.0 | 0.2 | 1 | 71 | 783 | |
| Summary | | Satus | | 8.3 | 36.3 | 807 | 9.4 | 0.1 | 5 | 6 | 813 | |
| | | Toppenish | | 10.4 | 11.0 | 103 | 6.1 | 1.2 | 15 | 9 | 111 | |
| | | Simcoe | | 11.5 | 10.0 | 633 | 12.1 | 0.0 | - | 0 | 633 | |
| | | Ahtanum | | 11.2 | 28.0 | 208 | 10.1 | 0.0 | - | 0 | 208 | |

Species Composition (Yakima Subbasin)

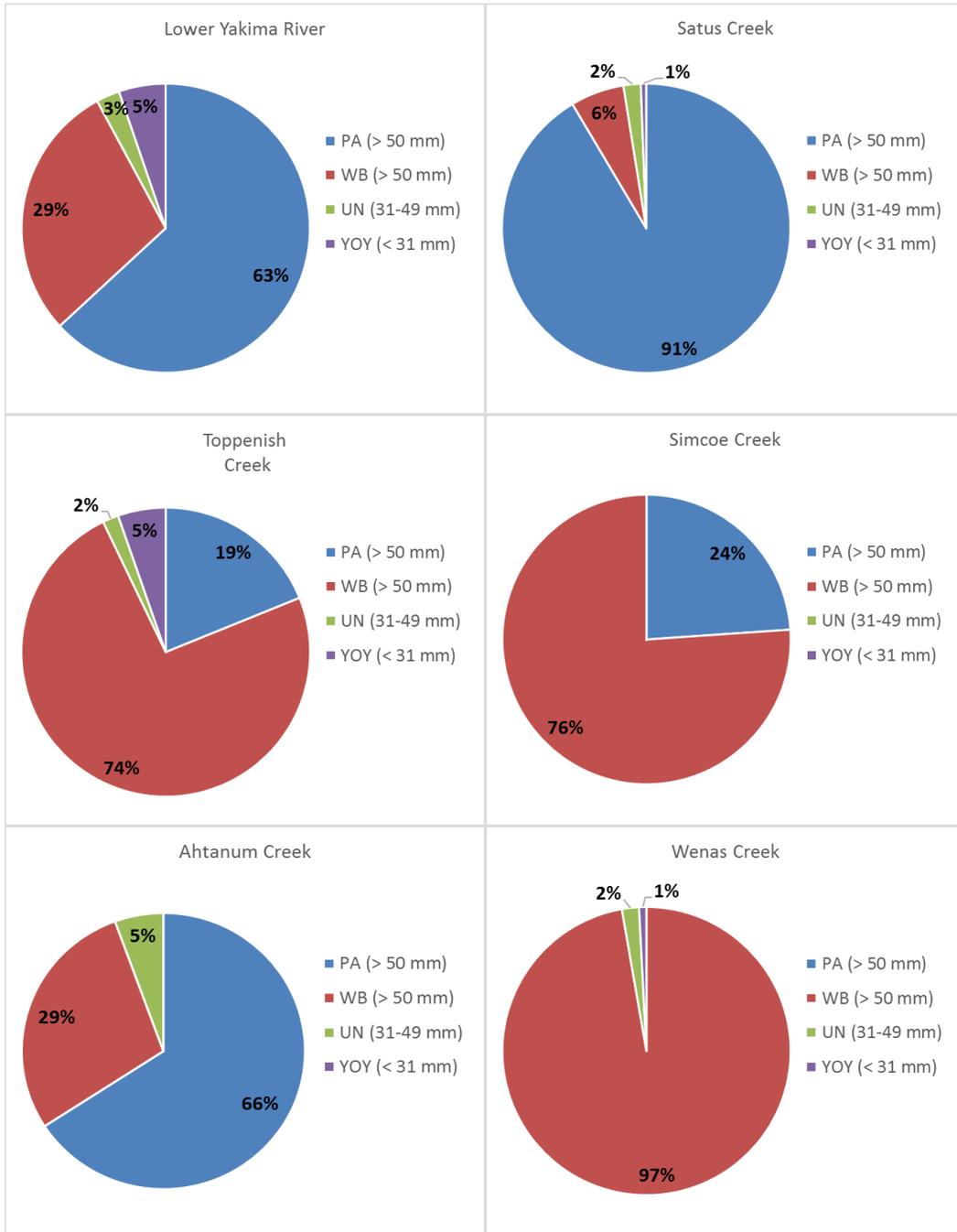
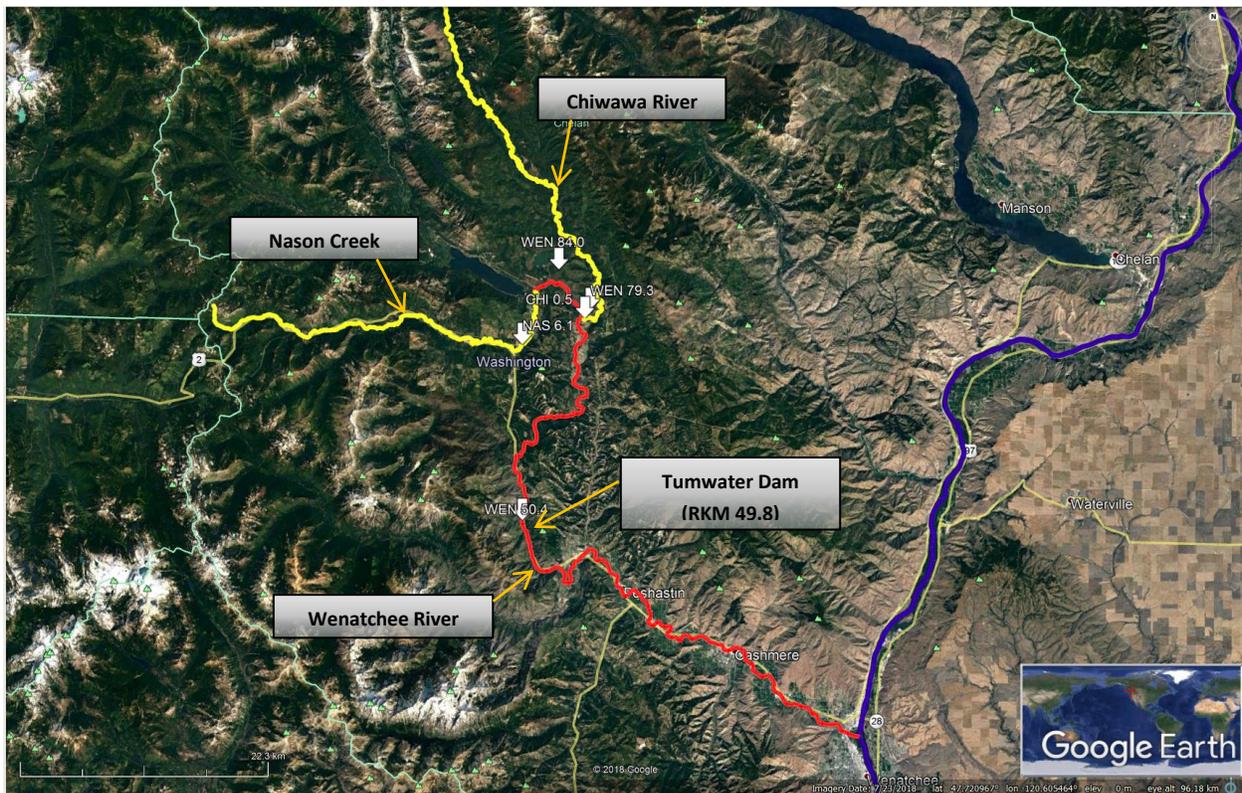


Figure 2. Species composition of captured lampreys from each surveyed stream in the Yakima Subbasin. “PA” stands for Pacific Lamprey, “WB” stands for Western Brook Lamprey, “UN” stands for unknown species lamprey (that are estimated to be over one year of age) and “YOY” stands for young of the year, estimated to be less than one year of age. Simcoe Creek is a tributary of Toppenish Creek.

Wenatchee Subbasin

In the Wenatchee Subbasin, five sites were surveyed in the upper Wenatchee Subbasin (upstream of Tumwater Dam on the Wenatchee River, river km 49.8; Map 3). Electrofished sites were located in the Wenatchee River (3 sites), Chiwawa River (1 site) and Nason Creek (1 site). Pacific Lamprey were present at two of the three (60%) Wenatchee River mainstem sites (Table 2). In the Wenatchee River, Pacific Lamprey were not present at river km 79.3, although present upstream at river km 84.0. Pacific Lamprey were also present at the one site in Nason Creek (river km 6.5). No lamprey were found at the one surveyed site in the Chiwawa River. As in all past years (since 2012), no Western Brook Lamprey were identified in the Wenatchee Subbasin. The average site density was (based on captured numbers and surveyed area) was highest in Nason Creek (4.7 #/m²) compared to the Wenatchee mainstem (between 2.0 #/m² and 4.1 #/m²). YOY lamprey were found at all three sites, suggesting active spawning from recently translocated adults into the Wenatchee Subbasin (2018 or 2017 release years).



Map 3. Overview of 2018 survey sites in the Wenatchee Subbasin. The Wenatchee River is shown as a red line, and yellow lines indicate tributary streams. The Columbia River is shown in blue. Also shown are surveyed index sites (white arrows) where electrofishing occurred. The location of the Tumwater Dam (river km 49.8) is labeled. Tributary streams are also labeled accordingly by name.

Habitat Details and General Survey Overview (Wenatchee Subbasin)

Table 11. Larval lamprey habitat details from surveyed sites within the Wenatchee Subbasin. The estimated total area (m²) of Type I and Type II habitat within the surveyed 50 m reach is shown. "Habitat Location in Stream Type" indicates the location within the stream where the survey primarily took place; "edge" along the edge of the main channel, and "Side Ch" in a side channel.

| Site Type | Stream | River KM | Date | 50 m | 50 m | Primary | Habitat | Plot Temp °C (Best) | Sed. | Sed. | Thalweg Temp °C |
|-------------|-----------|----------|-----------|-------------------------------|--------------------------------|------------------------|-------------------------|---------------------|----------------|---------------|-----------------|
| | | | | Type I Area (m ²) | Type II Area (m ²) | Fine Sediment (Type I) | Location in Stream Type | | Temp °C (Best) | Temp Diff. °C | |
| Index | Wenatchee | 50.4 | 8/28/2018 | 400 | - | silt | Edge | 16.9 | 16.4 | -0.5 | - |
| Exploratory | Wenatchee | 79.3 | 8/29/2018 | 400 | - | silt | Edge | - | - | - | 0.0 |
| Index | Wenatchee | 84 | 8/29/2018 | 300 | 400 | sand | Edge | 17.0 | 17.0 | -0.1 | 16.9 |
| Index | Chiwawa | 0.5 | 8/29/2018 | 40 | 30 | clay | Edge | 17.1 | 14.1 | -3.0 | 13.3 |
| Index | Nason | 6.5 | 8/29/2018 | 85 | 40 | silt | Side Ch. | 17.2 | 15.1 | -2.0 | - |

Table 12. Larval lamprey electrofishing effort and species composition at survey sites within the Wenatchee Subbasin. "Survey Visibility" is an estimated scale of water clarity during the survey (1 is poor visibility, 5 is high visibility). "PA" stands for Pacific Lamprey, and "WB" stands for Western Brook Lamprey. "% PA" is the percent of all captured lampreys (> 49 mm) that were identified as Pacific Lamprey. "% Unknown", is the percent of all captured lampreys < 50 mm in total length that could not be identified to species.

| Site Type | Stream | River KM | Date | Shock | Shock | Survey | # Captured | # Missed | % PA | % Unknown | # PA with eyes | # WB with eyes |
|-------------|-----------|----------|-----------|------------|------------------------|------------------|------------|----------|------|-----------|----------------|----------------|
| | | | | Time (sec) | Area (m ²) | Visibility (1-5) | | | | | | |
| Index | Wenatchee | 50.4 | 8/28/2018 | 623 | 10 | 5 | 21 | 3 | 100% | 10% | 0 | 0 |
| Exploratory | Wenatchee | 79.3 | 8/29/2018 | 821 | 15 | 4 | 0 | 0 | - | - | 0 | 0 |
| Index | Wenatchee | 84.0 | 8/29/2018 | 701 | 11 | 5 | 49 | 41 | 100% | 8% | 0 | 0 |
| Index | Chiwawa | 0.5 | 8/29/2018 | 633 | 15 | 5 | 0 | 0 | - | - | 0 | 0 |
| Index | Nason | 6.5 | 8/29/2018 | 623 | 13 | 4 | 63 | 27 | 100% | 22% | 0 | 0 |

Lamprey Measurement Details and Genetic Samples (Wenatchee Subbasin)

Table 13. Biological data for Pacific Lamprey ("PA") and Western Brook Lamprey ("WB") captured at survey sites in the Wenatchee Subbasin. "# of PA" and "# of WB" is the number of Pacific Lamprey, and Western Brook Lamprey, identified to species (> 50 mm in length). "Gen." stands for genetic (fin clip) samples.

| Site Type | Stream | River KM | # of PA | PA | PA | PA | # of WB | WB | WB | WB | WB | # Pacific Lamprey Gen. Sampl. | # WB Gen. Sampl. | % WB Class B | |
|-----------|-----------|----------|---------|-----------------|------------------|---------------------|---------|---------------------|-----------------|------------------|---------------------|-------------------------------|------------------|--------------|---------------------|
| | | | | Mean Weight (g) | Mean Length (mm) | PA Min. Length (mm) | | PA Max. Length (mm) | Mean Weight (g) | Mean Length (mm) | WB Min. Length (mm) | | | | WB Max. Length (mm) |
| Index | Wenatchee | 50.4 | 19 | 0.7 | 65 | 50 | 111 | 0 | - | - | - | - | 11 | 0 | - |
| Index | Wenatchee | 84.0 | 45 | 0.9 | 72 | 46 | 129 | 0 | - | - | - | - | 20 | 0 | - |
| Index | Nason | 6.5 | 49 | - | 62 | 50 | 88 | 0 | - | - | - | - | 10 | 0 | - |

Estimated Lamprey Density and Numbers (Wenatchee Subbasin)

Table 14. Extrapolated number of Pacific Lamprey (“PA”) and Western Brook Lamprey (“WB”) within a 50 m reach at each surveyed site within the Wenatchee Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age.

| Site Type | Stream | River KM | Extrapolated | Extrapolated | Extrapolated | Extrapolated | Extrapolated 50 m 1+ PA # | Extrapolated 50 m 1+ WB # |
|-----------|-----------|----------|-----------------------------------|-----------------------------------|--|--|---------------------------|---------------------------|
| | | | 1+ PA Density (#/m ²) | 1+ WB Density (#/m ²) | 1+ PA Mass Density (g/m ²) | 1+ WB Mass Density (g/m ²) | | |
| Index | Wenatchee | 50.4 | 2.0 | 0 | 1.3 | - | 800 | 0 |
| Index | Wenatchee | 84.0 | 4.1 | 0 | 3.5 | - | 1227 | 0 |
| Index | Nason | 6.5 | 4.7 | 0 | - | - | 399 | 0 |

Table 15. Estimated number of larvae, separated by age class, in a 50 m reach at surveyed sites in the Wenatchee Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age. The term "0+" stands for lamprey that are < 31 mm, and are estimated to be less than one year of age. The estimated “max densities” are the maximum estimated density of lamprey observed in one square meter at each site while electrofishing.

| Site Type | Stream | River KM | Estimated | Estimated | Estimated 50 m 1+ # | Estimated | Estimated | Estimated | Estimated 50 m 0+ # | Estimated 50 m 0+ & 1+ # |
|-----------|-----------|----------|--|--|---------------------|-------------------------------------|--|--|---------------------|--------------------------|
| | | | 1+ Lamprey Density (#/m ²) | 1+ Max Lamprey Density (#/m ²) | | 1+ Mass Density (g/m ²) | 0+ Lamprey Density (#/m ²) | 0+ Max Lamprey Density (#/m ²) | | |
| Index | Wenatchee | 50.4 | 4.0 | 5.0 | 1600 | 1.8 | 0.2 | 1.0 | 80 | 1680 |
| Index | Wenatchee | 84.0 | 8.2 | 15.0 | 2455 | 5.0 | 3.1 | 5.0 | 927 | 3382 |
| Index | Nason | 6.5 | 9.4 | 15.0 | 798 | - | 1.3 | 10.0 | 111 | 909 |

Species Composition from all captured lampreys (Wenatchee Subbasin)

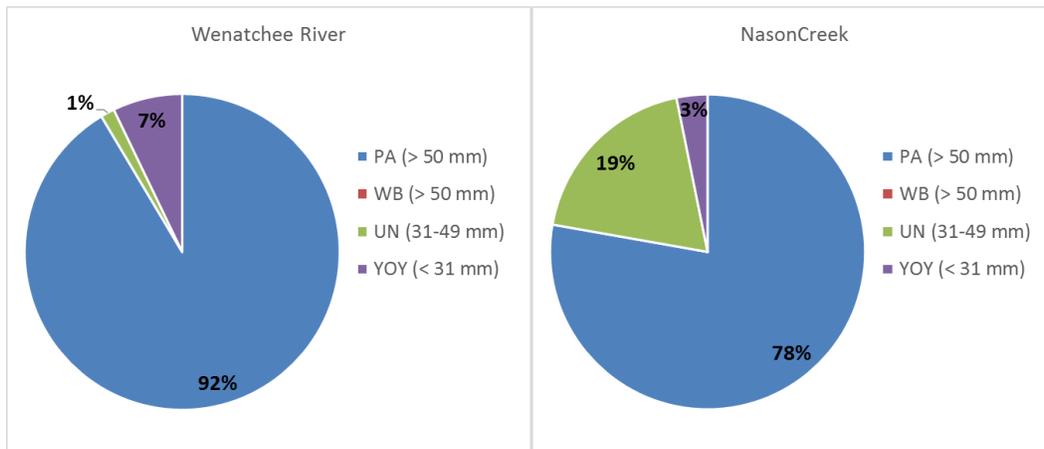


Figure 2. Species composition of captured lampreys from each surveyed stream in the upper Wenatchee Subbasin. “PA” stands for Pacific Lamprey, “WB” stands for Western Brook Lamprey, “UN” stands for unknown species lamprey (that are estimated to be over one year of age) and “YOY” stands for young of the year, estimated to be less than one year of age.

Entiat Subbasin

The Entiat River was the most upstream subbasin we surveyed in the Columbia Basin (confluence of the Entiat River is at river km 771.8 of the Columbia River). One site was surveyed at river km 40.2. Only Pacific Lamprey were present at this site. In 2016, Western Brook Lamprey were found upstream at river km 46.5. Close examination of all captured lampreys at river km 40.2 showed no Western Brook Lamprey here (suggesting their distribution is limited to the upper-most reaches). The Pacific Lamprey density (calculated from captured lamprey and survey area) was higher than any of our other sites in the Columbia Basin in 2018 (11.5 #/m²).



Map 4. Overview of 2018 survey sites in the Entiat Subbasin. The Entiat River is shown as a red line, and yellow lines indicate tributary streams. The Columbia River is shown in blue. Also shown are surveyed index sites (white arrows) where electrofishing occurred. The location of the Naches River confluence (river km 191.9) is labeled. Tributary streams are also labeled accordingly.

Habitat and Survey Detail Overview (Entiat Subbasin)

Table 16. Larval lamprey habitat details from surveyed sites within the Entiat Subbasin. The estimated total area (m²) of Type I and Type II habitat within the surveyed 50 m reach is shown. "Habitat Location in Stream Type" indicates the location within the stream where the survey primarily took place; "Side Ch" indicates the survey primarily took place in a side channel.

| Site Type | River Stream | River KM | Date | 50 m Type I Area (m ²) | 50 m Type II Area (m ²) | Primary Fine Sediment (Type I) | Habitat | Plot Temp °C (Best) | Sed. Temp °C (Best) | Sed. Temp Diff. °C | Thalweg Temp °C |
|-----------|--------------|----------|-----------|------------------------------------|-------------------------------------|--------------------------------|-------------------------|---------------------|---------------------|--------------------|-----------------|
| | | | | | | | Location in Stream Type | | | | |
| Index | Entiat | 40.2 | 9/19/2018 | 265 | 180 | sand | Side Ch. | 10.31 | 9.38 | -0.93 | - |

Table 17. Larval lamprey electrofishing effort and species composition at survey sites within the Entiat Subbasin. "Survey Visibility" is an estimated scale of water clarity during the survey (1 is poor visibility, 5 is high visibility). "PA" stands for Pacific Lamprey, and "WB" stands for Western Brook Lamprey. "% PA" is the percent of all captured lampreys (> 49 mm) that were identified as Pacific Lamprey. "% Unknown", is the percent of all captured lampreys < 50 mm in total length that could not be identified to species.

| Site Type | Stream | River KM | Date | Shock Time (sec) | Shock Area (m2) | Survey Visibility (1-5) | # Captured | # Missed | % PA | % Unknown | # PA with eyes | # WB with eyes |
|-----------|--------|----------|-----------|------------------|-----------------|-------------------------|------------|----------|------|-----------|----------------|----------------|
| Index | Entiat | 40.2 | 9/19/2018 | 578 | 10 | 4 | 133 | 457 | 100% | 23% | 0 | 0 |

Lamprey Measurement Details and Genetic Samples (Entiat Subbasin)

Table 18. Biological data for Pacific Lamprey ("PA") and Western Brook Lamprey ("WB") captured at survey sites in the Entiat Subbasin. "# of PA" and "# of WB" is the number of Pacific Lamprey, and Western Brook Lamprey, identified to species (> 50 mm in length). "Gen." stands for genetic (fin clip) samples.

| Site Type | Stream | River KM | # of PA | PA Mean Weight (g) | PA Mean Length (mm) | PA Min. Length (mm) | PA Max. Length (mm) | # of WB | WB Mean Weight (g) | WB Mean Length (mm) | WB Min. Length (mm) | WB Max. Length (mm) | # Pacific Lamprey Gen. Sampl. | # WB Gen. Sampl. | % WB Class B |
|-----------|--------|----------|---------|--------------------|---------------------|---------------------|---------------------|---------|--------------------|---------------------|---------------------|---------------------|-------------------------------|------------------|--------------|
| Index | Entiat | 40.2 | 102 | - | 89 | 50 | 140 | 0 | - | - | - | - | 0 | 0 | - |

Estimated Lamprey Density and Numbers (Entiat Subbasin)

Table 19. Extrapolated number of Pacific Lamprey ("PA") and Western Brook Lamprey ("WB") within a 50 m reach at each surveyed site within the Entiat Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age.

| Site Type | Stream | River KM | Extrapolated 1+ PA Density (#/m2) | Extrapolated 1+ WB Density (#/m2) | Extrapolated 1+ PA Mass Density (g/m2) | Extrapolated 1+ WB Mass Density (g/m2) | Extrapolated 50 m 1+ PA # | Extrapolated 50 m 1+ WB # |
|-----------|--------|----------|-----------------------------------|-----------------------------------|--|--|---------------------------|---------------------------|
| Index | Entiat | 40.2 | 11.5 | 0 | - | - | 3048 | 0 |

Table 20. Estimated number of larvae, separated by age class, in a 50 m reach at surveyed sites in the Entiat Subbasin. The term "1+" stands for lamprey that are > 30 mm, and are estimated to be over one year of age. The term "0+" stands for lamprey that are < 31 mm, and are estimated to be less than one year of age. The estimated "max densities" are the maximum estimated density of lamprey observed in one square meter at each site while electrofishing.

| Site Type | Stream | River KM | Estimated 1+ Lamprey Density (#/m2) | Estimated 1+ Max Lamprey Density (#/m2) | Estimated 50 m 1+ # | Estimated 1+ Mass Density (g/m2) | Estimated 0+ Lamprey Density (#/m2) | Estimated 0+ Max Lamprey Density (#/m2) | Estimated 50 m 0+ # | Estimated 50 m 0+ & 1+ # |
|-----------|--------|----------|-------------------------------------|---|---------------------|----------------------------------|-------------------------------------|---|---------------------|--------------------------|
| Index | Entiat | 40.2 | 23.0 | 25.0 | 6095 | - | 36.0 | >100 | 9540 | 15635 |

Table 22. Larval lamprey electrofishing effort and species composition at survey sites within the Methow Subbasin with John Crandall (Methow Salmon Recovery). “PA” stands for Pacific Lamprey, and “WB” stands for Western Brook Lamprey. "% PA" is the percent of all captured lampreys (> 49 mm) that were identified as Pacific Lamprey. "% Unknown", is the percent of all captured lampreys < 50 mm in total length that could not be identified to species.

| Site Type | Stream | River KM | Date | Shock Time (sec) | Shock Area (m2) | Survey Visibility (1-5) | # Captured | # Missed | % PA (>49 mm) | % Unknown (<50mm) | # PA eyes | # WB eyes |
|-----------|---------|----------|-----------|------------------|-----------------|-------------------------|------------|----------|---------------|-------------------|-----------|-----------|
| Index | | 25.6 | 8/23/2018 | 1047 | 55.2 | - | 125 | 10 | 100% | 21% | 0 | 0 |
| Index | Methow | 59.3 | 8/23/2018 | 676 | 27.9 | - | 47 | 3 | 100% | 94% | 0 | 0 |
| Index | | 74.7 | 8/22/2018 | 780 | 59.3 | - | 198 | 34 | 100% | 25% | 0 | 0 |
| Index | | 0.8 | 8/22/2018 | 766 | 50.2 | - | 129 | 13 | 100% | 32% | 0 | 0 |
| Index | Chewuch | 22.3 | 8/22/2018 | 687 | 16.1 | - | 26 | 3 | 100% | 0% | 0 | 0 |
| Index | | 28.6 | 8/22/2018 | 934 | 53.8 | - | 4 | 0 | 100% | 25% | 0 | 0 |
| Index | | 16.1 | 8/22/2018 | 1865 | 132.0 | - | 77 | 27 | 100% | 10% | 0 | 0 |

Lamprey Measurement Details and Genetic Samples (Methow Subbasin)

Table 23. Biological data for Pacific Lamprey (“PA”) captured at survey sites in the Methow Subbasin with John Crandall (Methow Salmon Recovery). The mean, min and max length for all measured lampreys is shown for each site (combined for Pacific Lamprey and unknown species lampreys). “Gen. Sampl.” stands for genetic (fin clip) samples.

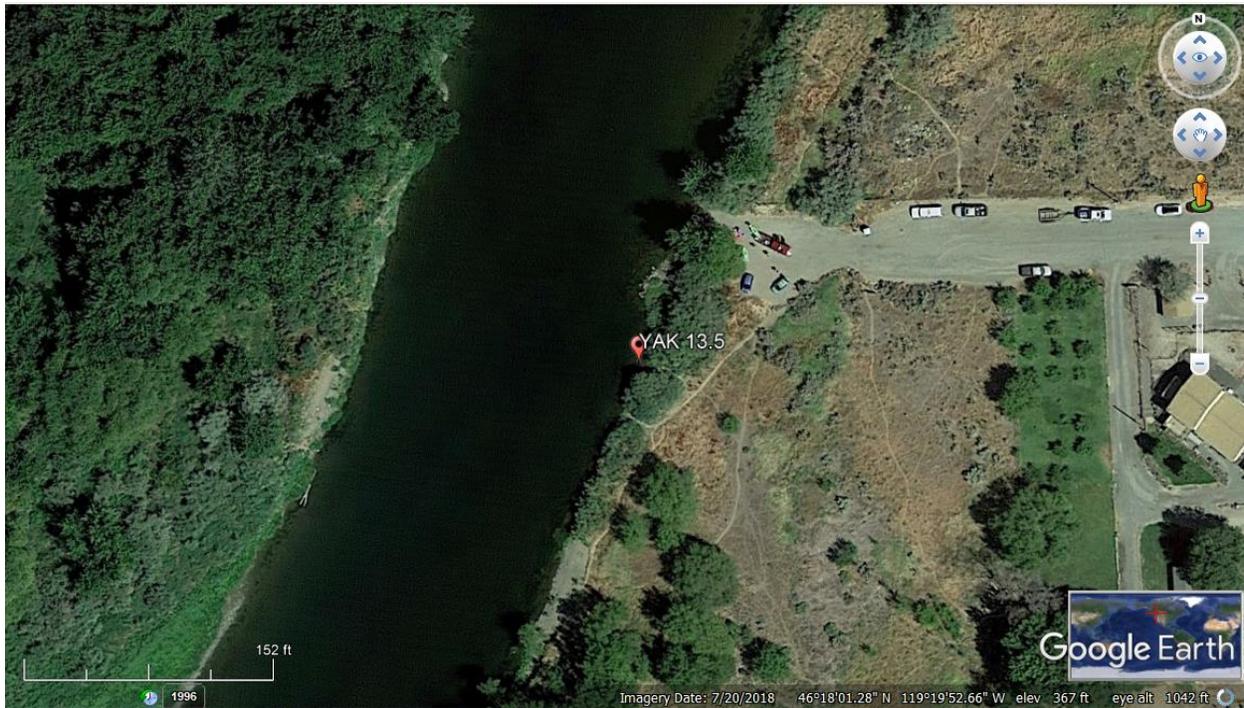
| Site Type | Stream | River KM | # Measured to Length | Mean Length (mm) | Min. Length (mm) | Max. Length (mm) | # Pacific Lamprey Gen. Sampl. |
|-----------|---------|----------|----------------------|------------------|------------------|------------------|-------------------------------|
| Index | | 25.6 | 125 | 68.3 | 18 | 128 | 0 |
| Index | Methow | 59.3 | 47 | 27.7 | 19 | 112 | 0 |
| Index | | 74.7 | 198 | 60.7 | 19 | 114 | 0 |
| Index | | 0.8 | 129 | 64.9 | 39 | 106 | 0 |
| Index | Chewuch | 22.3 | 26 | 74.9 | 58 | 92 | 0 |
| Index | | 28.6 | 4 | 52.5 | 26 | 68 | 0 |
| Index | | 16.1 | 77 | 82.0 | 33 | 134 | 0 |

Estimated Lamprey Density and Numbers (Methow Subbasin)

Not all measurements were collected from Methow Subbasin surveys (slightly different methods/protocols).

Appendix: Additional Site Maps and Photos

Lower Yakima River Mainstem



Map A1. Site map of Yakima index site at river km 13.5 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey.



Photo A1. Yakima River index site at river km 13.5; overview of Type I habitat in August (left) and overview of the same survey area in September (right) from 2018 survey.



Map A2. Site map of Yakima index site at river km 112.0 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A2. Yakima River index site at river km 112.0; overview of Type I habitat in October (left) and overview of the same survey area looking upstream that same day (right) from 2018 survey.



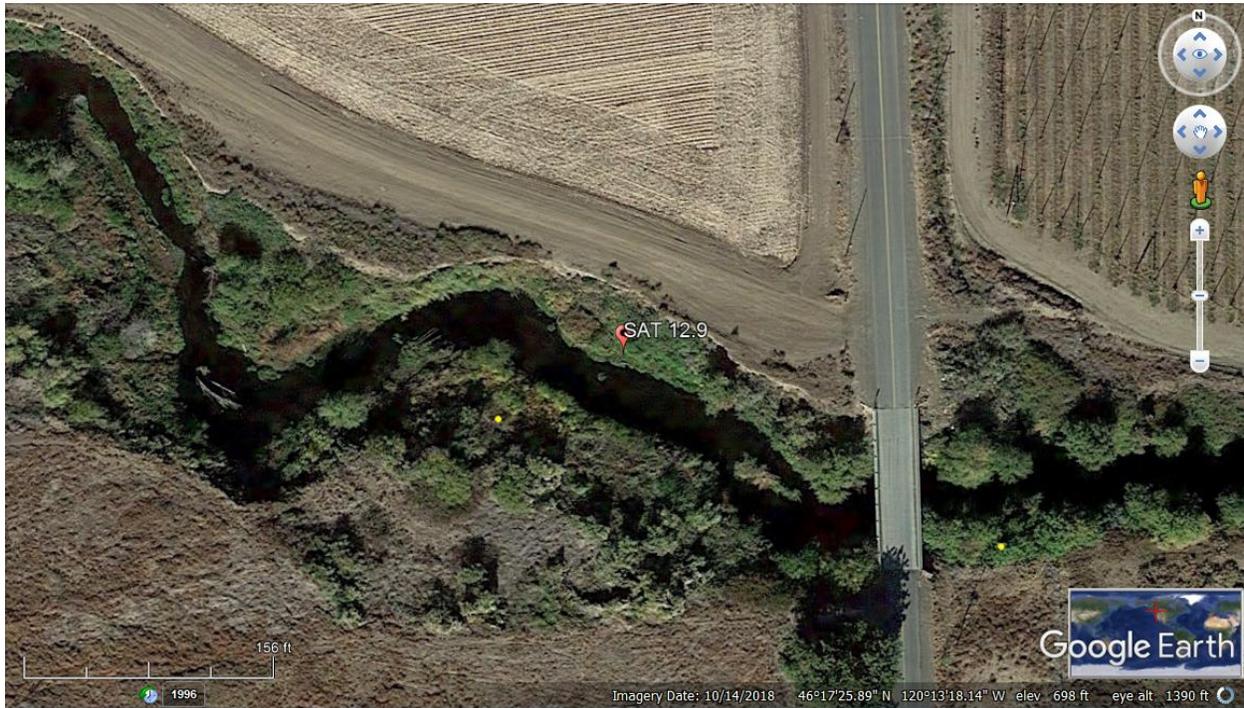
Map A3. Site map of Yakima index site at river km 171.1 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A3. Yakima River index site at river km 171.1; overview of Type I habitat in October (left) and a close up of the silt and fine sand sediment composition (right) from 2018 survey.

Lower Yakima Tributaries

Satus Creek



Map A4. Site map of Satus Creek index site at river km 12.9 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small Yellow dots indicate stream distance of 100 m.



Photo A4. Satus Creek index site at river km 12.9; overview of Type I habitat in June, surveyed in 2018.



Map A5. Site map of Satus Creek index site at river km 29.2 (surveyed in August 2018); 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 29.2; overview of Type I habitat in August (left) and a close up of the fine sand sediment composition in October (right) from 2018 survey.

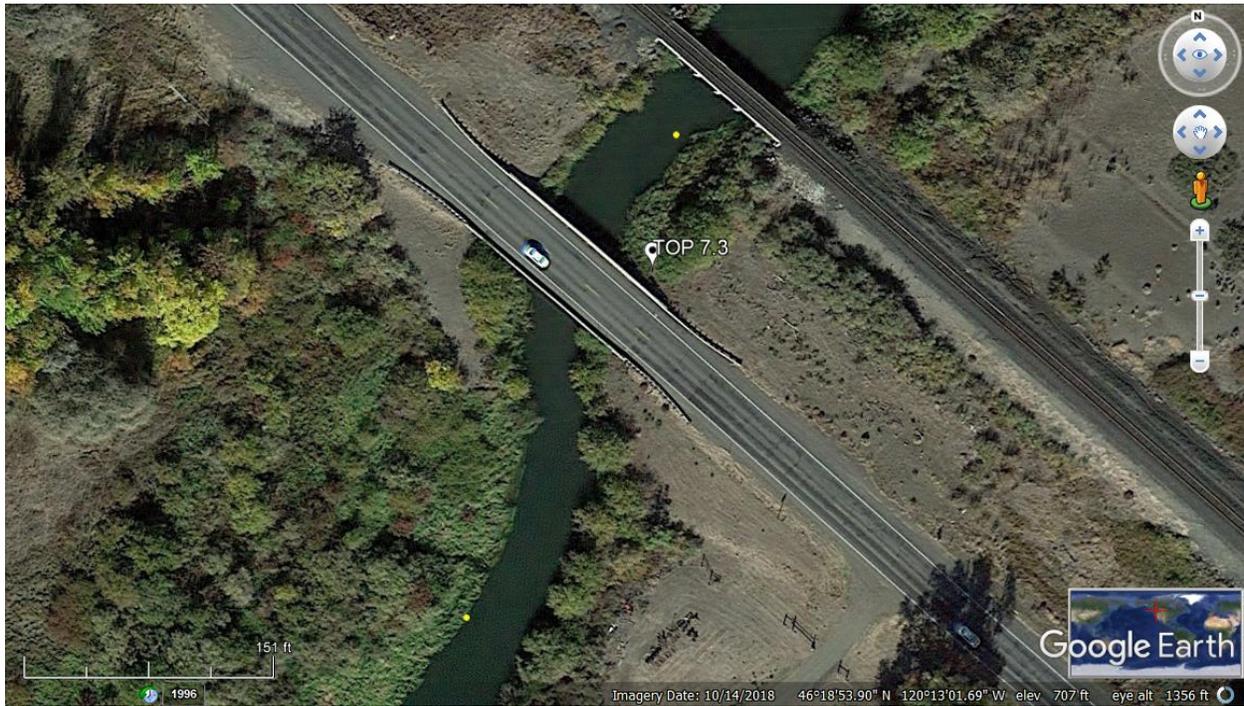


Map A6. Site map of Satus Creek index site at river km 43.8 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A6. Satus Creek index site at river km 43.8; overview of Type I habitat in August (left) and a close up of the fine and coarse sand composition (right) from 2018 survey.

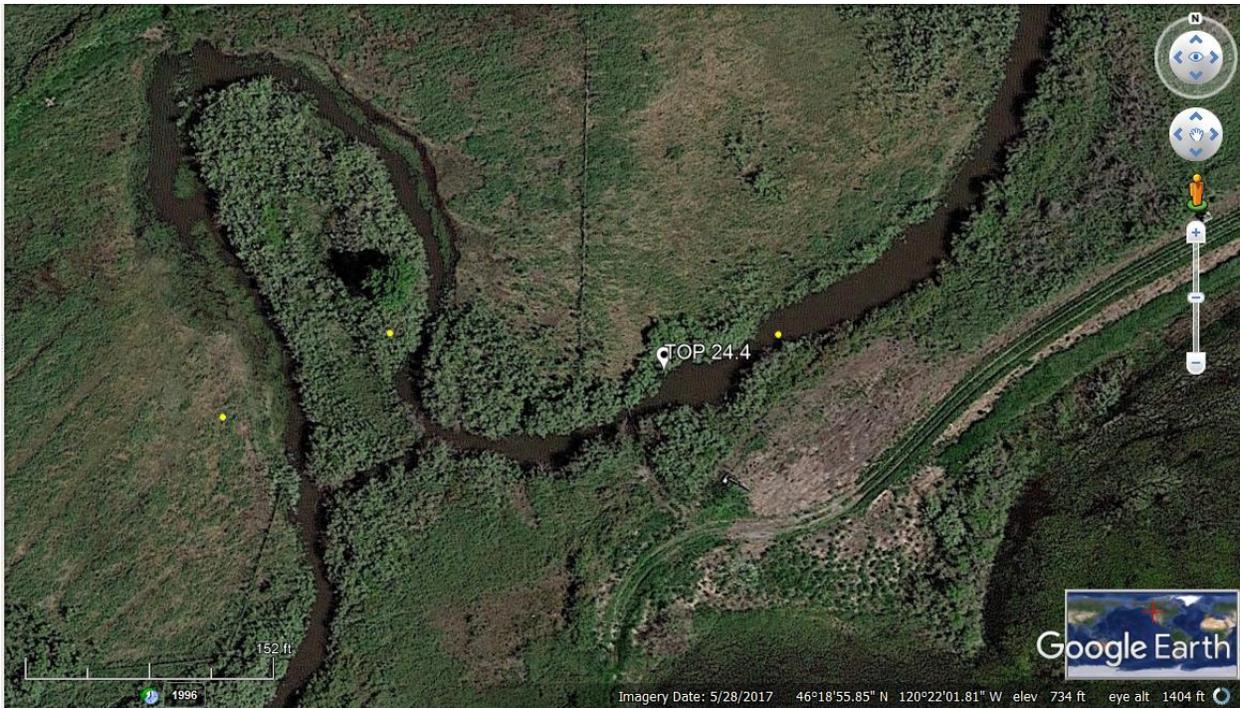
Toppenish Creek



Map A7. Site map of Toppenish Creek index site at river km 7.3 (surveyed in September 2018); white balloon indicates that no lamprey were found at this site. The small yellow dots indicate stream distance of 100 m.



Photo A7. Toppenish Creek index site at river km 7.3; overview of Type I habitat in September (left) and a close up of the silt and fine sand sediment composition (right) from 2018 survey.



Map A8. Site map of Toppenish Creek index site at river km 24.4 (surveyed in October 2018); white balloon indicates that no lamprey were found at this site. The small yellow dots indicate stream distance of 100 m.



Photo A8. Toppenish Creek index site at river km 24.4; overview of Type I habitat in October, surveyed in 2018.



Map A9. Site map of Toppenish Creek index site at river km 44.6 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey.



Photo A9. Toppenish Creek index site at river km 44.6; overview of Type I habitat in located across the stream from a screw trap in June (left) and a close up of the actual surveyed area in October (right) from 2018 survey.



Map A10. Site map of Toppenish Creek exploratory site at river km 56.9 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A10. Toppenish Creek index site at river km 56.9; overview of Type I habitat in October (left) and a close up of the silt and fine sand sediment composition (right) from 2018 survey.



Map A11. Site map of Toppenish Creek index site at river km 61.7 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A11. Toppenish Creek index site at river km 61.7; overview of Type I habitat in July (left) and a close up of the silt and fine sand sediment composition (right) from 2018 survey.



Map A12. Site map of Simcoe Creek index site at river km 9.1 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small green dots indicate stream distance of 100 m.



Photo A12. Simcoe Creek index site at river km 9.1; overview of Type I habitat in October (left) and a close up of the silt, fine sand and aquatic vegetation composition (right) from 2018 survey.

Ahtanum Creek



Map A13. Site map of Ahtanum Creek index site at river km 1.1 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A13. Ahtanum Creek index site at river km 1.1; overview of Type I habitat in October (left) and a close up of the silt, fine sand and aquatic vegetation composition (right) from 2018 survey.



Map A14. Site map of Ahtanum Creek exploratory site at river km 30.6 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A14. Ahtanum Creek index site at river km 30.6; overview of Type I habitat in October (left) and a close up of the actual surveyed area (right) from 2018 survey.



Map A15. Site map of Ahtanum Creek index site at river km 36.6 (surveyed in October 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A15. Ahtanum Creek index site at river km 36.6; overview of Type I habitat in August (left) and a close up of the actual surveyed area (right) from 2018 survey.



Map A16. Site map of Ahtanum Creek exploratory site at river km 37.3 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. . The small yellow dots indicate stream distance of 100 m.



Photo A16. Ahtanum Creek index site at river km 37.3; overview of Type I habitat in August (left) and a close up of the actual surveyed area (right) from 2018 survey.

Upper Yakima

Wenas Creek



Map A17. Site map of Wenas Creek exploratory site at river km 0.5 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. . The small yellow dots indicate stream distance of 100 m.



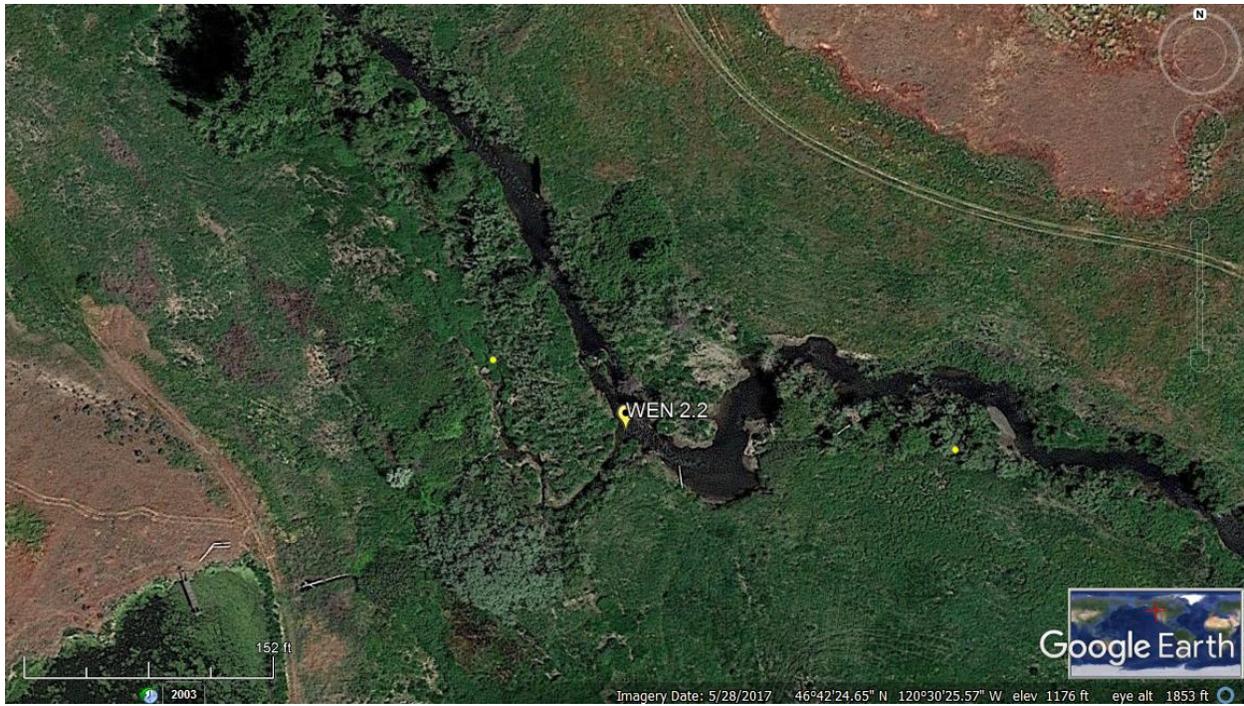
Photo A17. Wenas Creek index site at river km 0.5.



Map A18. Site map of Wenas Creek exploratory site at river km 1.3 (surveyed in August 2018); yellow balloon indicates presence of unidentifiable lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A18. Wenas Creek index site at river km 1.3



Map A19. Site map of Wenas Creek index site at river km 2.2 (surveyed in August 2018); yellow balloon indicates presence of unidentifiable lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A19. Wenas Creek index site at river km 2.2 (Dewey Bill Electrofishing)

Klickitat



Map A20. Site map of the Klickitat River exploratory site at river km 69.5 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.

Photo A20. Klickitat River index site at river km 69.5

No photos available.

Wenatchee



Map A21. Site map of the Wenatchee River index site at river km 50.4 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A21. Wenatchee River index site at river km 50.4



Map A22. Site map of the Wenatchee River exploratory site at river km 79.3 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A22. Wenatchee River exploratory site at river km 79.3



Map A23. Site map of the Wenatchee River index site at river km 84.0 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A23. Wenatchee River index site at river km 84.0

Nason Creek



Map A24. Site map of Nason Creek index site at river km 6.1 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A24. Nason Creek index site at river km 6.5

Chiwawa River



Map A25. Site map of the Chiwawa River index site at river km 0.5 (surveyed in August 2018); red balloon indicates presence of Pacific Lamprey. The small yellow dots indicate stream distance of 100 m.



Photo A25. Chiwawa River index site at river km 0.5

Entiat



Map A26. Site map of the Entiat River index site at river km 40.2 (surveyed in September 2018); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A26. Entiat River index site at river km 40.2