# Summary Assessment of Larval/Juvenile Lamprey Entrainment In Irrigation Diversions within the Yakima Subbasin, 2018

(Cover Photo: Dave'y Lumley and Leona Wapato rescue entrained lampreys with a backpack electrofisher from Sunnyside Diversion, a large irrigation diversion in the middle reach of the Yakima River where many thousands of larval and juvenile lampreys become entrained each year.)

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## Highlights

- A total of 11,703 larval lampreys were collected from 15 irrigation diversions in the Yakima Subbasin, combined for electrofishing efforts in wet areas and collections from dry banks (n=8,628 and 3,076, respectively).
- On average, 69% of the larval lampreys trapped on dewatered banks were found dead, despite our efforts to arrive as close to the dewatering period as possible. However, our pilot sprinkler watering system showed promise in reducing mortality from dry banks.
- The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was highest (93-100%) at three diversions in Ahtanum Creek and was 27% at Sunnyside/Wapato diversions combined.

## Abstract

In 2018, larval lamprey rescue surveys were conducted in 15 Yakima Subbasin irrigation diversions. The number of larval and juvenile lamprey collected from these locations totaled 11,703, combined for electrofishing efforts in wet areas and collections from dry banks (8,628 and 3,076, respectively). Collected lamprey numbers were highest from the Yakima River (n=9,658), followed by Ahtanum Creek (n=1,805), Naches River (n=127), and Toppenish Creek (n=113). Although we did our best to arrive as close to the dewatering period as possible, on average 69% of the larval lampreys trapped on dewatered banks were found dead. At the Wapato and Sunnyside diversions (Yakima River, river km 176.3 and 173.4, respectively), a total of 2,993 lampreys were collected from dry banks, which constitutes 97.4% of the combined total collected from all dry banks (from all 15 diversions). At the Wapato Diversion, bank mortality rates were much higher compared to the Sunnyside Diversion (60% and 11%, respectively). At the Sunnyside Diversion, we were able to be on a standby at the dewatering site as the water level was dropping, allowing for quick recovery of exposed lamprey. In addition, a pilot sprinkler watering system was also setup earlier at Sunnyside Diversion. If developed and refined further, this sprinkler system has the potential to be an effective solution in drastically reducing the dry bank associated mortality we typically observe from desiccation. Larval lampreys were found at 13 (86.7%) of the 15 visited irrigation diversions. Of the diversion where lampreys were found, Pacific Lamprey was present at 8 of the 13 (61.5%) diversions. The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was highest at Upper WIP (100%), Bachelor-Hatton (99%), and Diversion 14 (93%) diversions in Ahtanum Creek (river km 24.8, 31.8 and 32.8, respectively). The ratio of Pacific Lamprey has been increasing steadily since 2010 at Sunnyside and Wapato diversions from approximately 0% from 2010-2013, ~3% in 2013-2014, 7.0% in 2014-2015, 15% in 2015-2016, 33% in 2016-2017, 29% in 2017-2018, and 27% in 2018-2019. Adult lamprey translocation began in 2013 in Ahtanum Creek (which is a tributary to Yakima River upstream of Wapato and Sunnyside diversions) and the ratio of Pacific Lamprey has increased considerably since this restoration project began. Genetic samples were collected from a total of 154 larval/juvenile Pacific Lamprey in order to learn more about translocated adult production throughout the basin.

# Introduction

Pacific Lamprey (*Entosphenus tridentatus*), a species of high cultural and ecological value, is declining in population abundance and distribution throughout the Columbia River Basin. One of the major threats facing Pacific Lamprey are irrigation diversions, many of which provide preferred, yet in effect misleading, refuge habitat to hundreds of thousands of larval/juvenile lampreys moving downstream. When the diversions are dewatered after the irrigation season, the entrained lampreys (which are buried in the fine sediment) are left to dry up unless lamprey-specific rescue efforts are put in place to salvage them. In 2018, larval lamprey rescue surveys were conducted in the Yakima Subbasin with the following primary objectives; 1) efficiently rescue as many larval/juvenile lampreys as possible and return them to their respective stream, 2) check dried banks closely for desiccated lampreys, and 3) understand lamprey species composition as well as distribution upstream and downstream of the fish screens. By understanding the ratio of Pacific lamprey in these diversions each year, we can start to assess the overall impact of irrigation diversions on Pacific Lamprey at the larval/juvenile life stages. Monitoring this impact will be crucial to improving future Pacific Lamprey management and restoration efforts.

# Methods

The Yakama Nation Pacific Lamprey Project surveyed 14 dewatered irrigation diversions within the Yakima Subbasin for larval/juvenile lampreys primarily from October 16, 2018 to November 16, 2018. Electrofishing surveys in dewatered diversions were also conducted in July 2018 in Ahtanum and Toppenish creeks, during the annual shut down time in those streams. Irrigation diversions were surveyed as close as possible to the initial dewatering date to limit additional loss of lampreys from desiccation and/or predation (with the exception of some diversions that require multiple days of dewatering to access optimal lamprey habitat). Diversions which have had relatively high occurrences of entrainment from past surveys were given priority. As in previous years, we focused rescue efforts at two major Yakima River irrigation diversions with known high densities of lampreys; Wapato Diversion (immediately upstream of the fish screens) and Sunnyside Diversion (immediately downstream of the fish screens). In addition to these two diversions, rescue efforts were also focused at Bachelor Hatton Diversion (both upstream and downstream of the fish screens), and Diversion 14 (primarily upstream of the fish screens) due to large numbers of Pacific Lamprey observed in 2015, 2016, 2017. Additional diversions were surveyed based on dewatering schedule and available time.

An AbP-2 Backpack Electrofisher (ETS Electrofishing Systems, LLC, Madison, WI), specifically designed for the sampling of larval lampreys, was used to survey 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). When water temperature was ~10ºC or lower, the voltage was increased to 150-200 volts. Another person, or sometimes several persons, equipped with a fine-mesh hand net was also present to help capture any electrofished

larvae. Type I / II larval lamprey habitat (preferred and acceptable, respectively) was surveyed at each diversion, with Type I habitat given priority (Type II was surveyed primarily when Type I was limited or for subsampling and extrapolation purposes). Specific survey locations in each diversion were determined based larval lamprey density and habitat availability; in most cases we focused on the area immediately upstream and downstream of the fish screens, but if larval lamprey and/or their habitat were relatively abundant, the respective canal areas were also surveyed.

Electrofishing surveys were conducted separately within Type I and Type II larval habitat. Records of survey (electrofishing) time, area surveyed ($m^2$), and total numbers of electrofished lamprey (captured and missed) were recorded separately by habitat type and survey location upstream or downstream of the fish screens. Within each surveyed location, 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). Young of year lampreys (0+ aged; < 36 mm) were tallied separately from the overall group (i.e. not part of the 50 lamprey sample). Missed lampreys were also quantified to determine the total number of observed lampreys per survey area. In addition to electrofishing, dried sediment banks were searched for desiccating or desciccated larval lampreys. Lampreys collected from dry banks were tallied separately from those collected in wet areas. Lampreys found on the bank underwent the same measurement process as those collected from electrofishing, albeit separately. In some cases, identification of lampreys collected from the dry banks was challenging (or virtually impossible) due to decomposition. Rescued lampreys were returned to their native stream, downstream of the respective diversion headgate. In some cases, lampreys were transported to a safe location further downstream, depending on the distribution of habitat and/or diversion facilities (i.e. lack of larval lamprey habitat or close proximity of another diversion intake). Genetic samples on Pacific Lamprey were collected opportunistically from diversions in the Yakima, Ahtanum and Naches rivers/streams. Additional help was provided by the Washington Department of Fish and Wildlife, Washington Conservation Corps, and many other student volunteers from high school to college grade. Rescue efforts were focused primarily upstream of the fish screens, where lamprey were typically most abundant, although at many sites, efforts were also focused downstream of the fish screens in order to understand lamprey entrainment downstream of the fish screens.

Catch per unit effort (CPUE) was calculated from the electrofishing time (minutes) and the number of captured lampreys. The maximum survey CPUE was calculated for each surveyed location (upstream and downstream of the fish screens). Lamprey density (#/$m^2$) was calculated from the total number of observed lamprey (which is a combination of captured and missed lampreys) and the electrofished area ($m^2$). The maximum observed lamprey density is shown for each surveyed location. The percent of Pacific Lamprey is a ratio of the number of Pacific Lamprey to the overall number of identifiable lampreys. The average length of Pacific Lamprey is shown for each surveyed location, and is a combination of Pacific Lamprey lengths from wet area (electrofishing) and dry bank collections. The average length data shown may not fully represent the size distribution of captured Pacific Lamprey, as length data were combined from the two sources (wet

areas and dry banks) and the two groups were given equal weight regardless of the relative abundance from each sources.

## Results

Efforts to rescue larval and juvenile lampreys occurred at 15 irrigation diversions located throughout the Yakima Subbasin; six in the Yakima River, one in Toppenish Creek, six in Ahtanum Creek, and three in the Naches River (Table 1 and 2). Our electrofishing efforts covered a total of 1,026 $m^2$ of larval lamprey habitat, using 1,020 minutes of electrofishing time (Table 1). Our efforts focused primarily upstream of the fish screens; 760 $m^2$ of larval lamprey habitat were surveyed using 781 minutes of electrofishing time, compared to 265 $m^2$ and 239 minutes downstream of the fish screens.

The total number of larval and juvenile lamprey collected from these locations totaled 11,703, combined for electrofishing efforts in wet areas and collections from dry banks (8,628 and 3,076, respectively; Table 1). Collected lamprey numbers were highest from the Yakima River (n=9,658), followed by Ahtanum Creek (n=1,805), Naches River (n=127), and Toppenish Creek (n=113). The maximum CPUE (catch per unit effort) was greatest in an isolated pools downstream of the fish screens at Sunnyside Diversion (34.7 #/min). This location also had the highest observed density (86.7 #/$m^2$). A high CPUE (16.5 #/min) and density (45.9 #/$m^2$) were also observed at Wapato Diversion along a dewatered bank upstream of the fish screens. Although we did our best to arrive as close to the dewatering period as possible, 69% of the larval lampreys trapped on dewatered banks were found dead (Table 1). At Wapato and Sunnyside diversions (Yakima River, river km 176.3 and 173.4, respectively), a total of 2,993 lampreys were collected from the dry banks, which constitutes 97.3% of the total collected from all dry banks (from all 15 diversions). At the Wapato Diversion, bank mortality rates were much higher compared to the Sunnyside Diversion (60% and 11%, respectively).

Out of all captured lampreys, a total of 890 were identified (lampreys > 49 mm in total length), and 44% of those were Pacific Lamprey (Table 2). Upper WIP, Bachelor-Hatton, and Diversion 14 diversions (Ahtanum Creek) had the highest ratio of Pacific Lamprey (100, 99, and 93%, respectively). The ratio of Pacific Lamprey at Sunnyside Diversion and Wapato Diversion, the two diversions in the Yakima Subbasin that entrain the most number of lampreys, was 40% and 14%, respectively. Only one out of three diversions in the Naches River had Pacific Lamprey (Yakima City with 8% Pacific Lamprey). No Pacific Lamprey were found in the upper Yakima River, albeit survey data from Selah-Moxee Diversion were accidentally lost. A total of 24 eyed Pacific Lamprey were collected from Sunnyside and Wapato diversions (21 and 3, respectively). At Sunnyside Diversion, one eyed Pacific Lamprey was found downstream of the fish screens at Sunnyside Diversion, while the remaining 20 were found in the diversion upstream of the fish screens. Genetic (fin clip) samples were collected from 154 Pacific Lamprey.

**Table 1. Summary of larval/juvenile lamprey rescue efforts in dewatered diversions in the Yakima Subbasin. Under survey location, "Upstream" and "Downstream" includes all areas surveyed upstream or downstream of the fish screens, including respective canal areas further away, if surveyed. "Total # Observed (E-Fish)" includes lampreys that were captured during electrofishing and those that were observed but not captured. "Total # Dead on Bank" is the number of dead lampreys collected from dry, dewatered banks. "Total # Live on Bank" is the number of live lampreys collected from dry, dewatered banks. *Although surveys upstream of Sunnyside Diversion fish screens included the use of a Smith Root Electrofisher (salmon settings), only data pertaining to lamprey-specific setting were used. **Survey data are missing from the Selah-Moxee Diversion.**

| Watershed | Stream | Diversion Name | River km of Head-gate | Survey Location | # of Survey Visits | Total Survey Area ($m^2$) | Total Shock Time (min) | Total # Captured (E-Fish) | Total # Observed (E-Fish) | Total # Live on Bank | Total # Dead on Bank | Total # on Bank | % on Bank Dead | Max E-Fish Density (#/m2) | Max CPUE (#/min) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower Yakima | Yakima | Sunnyside | 173.4 | Upstream | 2 * | 10 | 10.1 | 60 | 60 | 31 | 3 | 34 | 10% | 2.6 | 2.6 |
| | | | | Downstream | 5 | 167 | 151.9 | 2177 | 2804 | 1418 | 183 | 1601 | 11% | 86.7 | 34.7 |
| | | Wapato | 176.3 | Upstream | 7 | 528 | 468 | 4334 | 6537 | 543 | 815 | 1358 | 60% | 45.9 | 16.5 |
| | | | | Downstream | 1 | 15 | 16 | 19 | 19 | 0 | 0 | 0 | - | 2.8 | 2.7 |
| | Toppenish | Olney | 73.0 | Upstream | 1 | 25 | 37 | 113 | 134 | 0 | 0 | - | - | 5.6 | 3.5 |
| | | | | Downstream | 1 | 1 | 1 | 0 | 0 | 0 | 0 | | | - | - |
| | Ahtanum | Lower WIP | 16.4 | Upstream | 1 | 10 | 11 | 87 | 106 | 0 | 0 | - | - | 10.6 | 7.8 |
| | | | | Downstream | 1 | 8 | 3 | 0 | 0 | 0 | 0 | | | - | - |
| | | Diversion 14 | 24.8 | Upstream | 3 | 37 | 84 | 929 | 1524 | 0 | 0 | - | - | 37.8 | 19.2 |
| | | | | Downstream | 1 | 3 | 3 | 27 | 37 | 0 | 0 | | | 12.3 | 8.2 |
| | | Bachelor-Hatton | 31.8 | Upstream | 3 | 70 | 92 | 614 | 1368 | 25 | 28 | 53 | 53% | 41.0 | 14.1 |
| | | | | Downstream | 1 | 10 | 9 | 66 | 165 | 0 | 0 | - | - | 16.5 | 7.2 |
| | | Upper WIP | 32.8 | Upstream | 0 | - | - | 0 | 0 | - | - | - | - | - | - |
| | | | | Downstream | 1 | 7 | 7 | 29 | 31 | 0 | 0 | | | 4.4 | 4.5 |
| | | John Cox | ~ 45.0 | Upstream | 1 | 11 | 10 | 0 | 0 | 0 | 0 | - | - | - | - |
| | | | | Downstream | 0 | - | - | - | - | - | - | | | | |
| Upper Yakima | Naches | City of Yakima | 6.0 | Upstream | 1 | 9 | 9 | 32 | 37 | 0 | 0 | - | - | 4.1 | 3.5 |
| | | | | Downstream | 0 | - | - | 0 | 0 | - | - | | | - | - |
| | | Wapatox | 29.0 | Upstream | 1 | 20 | 18 | 45 | 55 | 27 | 0 | 27 | 0% | 9.0 | 18.0 |
| | | | | Downstream | 0 | - | - | 0 | 0 | - | - | - | - | - | - |
| | | Naches-Selah | 32.0 | Upstream | 1 | 6 | 6 | 21 | 21 | 1 | 1 | 2 | 50% | 3.5 | 3.8 |
| | | | | Downstream | 0 | - | - | - | - | - | - | - | - | - | - |
| | Yakima | Selah-Moxee ** | 204.0 | Upstream | 1 | 15 | 15 | 30 | 45 | 0 | 0 | - | - | 3.0 | 2.0 |
| | | | | Downstream | 0 | - | - | - | - | - | - | | | - | - |
| | | Roza | 210.6 | Upstream | 0 | - | - | - | - | - | - | - | - | - | - |
| | | | | Downstream | 1 | 54 | 48 | 36 | 41 | 0 | 0 | | | 2.8 | 2.7 |
| | | Ellensburg Mill | 262.8 | Upstream | 1 | 4 | 4 | 0 | 0 | 0 | 0 | - | - | 0.0 | 0.0 |
| | | | | Downstream | 0 | - | - | - | - | - | - | | | - | - |
| | | New Cascade | 262.8 | Upstream | 1 | 19 | 20 | 9 | 9 | 0 | 0 | - | - | 0.5 | 0.5 |
| | | | | Downstream | 0 | - | - | 0 | 0 | - | - | | | - | - |
| **Total (15 Diversions Surveyed)** | | | | **Upstream** | **24** | **760** | **781** | **6274** | **9896** | **627** | **848** | **1474** | **58%** | **45.9** | **19.2** |
| | | | | **Downstream** | **12** | **265** | **239** | **2354** | **3097** | **1418** | **183** | **1601** | **11%** | **86.7** | **34.7** |
| **Grand Total** | | | | **-** | **36** | **1025** | **1020** | **8628** | **12993** | **2045** | **1031** | **3075** | **69%** | **-** | |

**Table 2. Overview of species composition of captured lampreys from dewatered irrigation diversions in the Yakima Subbasin in 2017-2018. "% Pacific Lamprey" is a ratio of identified Pacific Lamprey to the total number of identifiable lampreys. "Mean Pacific Lamprey Length" is the average length of Pacific Lamprey measured, and "Number of Pacific Lamprey Measured" is the number of Pacific Lamprey measured that contributed to the mean length calculation. "Number Gen. Samp. (Pacific Lamprey)" is the number of Pacific Lamprey genetic samples collected. The summary rows are a sum of presented values (for each respective area), except for "% Pacific Lamprey," which is a weighted average. *Although surveys upstream of Sunnyside Diversion fish screens included the use of a Smith Root Electrofisher (with salmon settings), only data pertaining to lamprey-specific setting were used. **Survey data are missing from Selah-Moxee Diversion.**

| Watershed | Stream | Diversion Name | River km | Survey Location | # of Survey Visits | # Identified | # Western Brook Lamprey | # Pacific Lamprey | % Pacific Lamprey | Mean Pacific Lamprey Length (mm) | # Pacific Lamprey Measured | # of Eyed Pacific Lamprey | # Gen. Samp. (Pacific Lamprey) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower Yakima | Yakima | Sunnyside | 173.4 | Upstream | 2* | 20 | 7 | 13 | **65%** | **102** | 13 | 20 | 26 |
| | | | | Downstream | 5 | 187 | 118 | 69 | **37%** | **59** | 49 | 1 | |
| | | Wapato | 176.3 | Upstream | 7 | 87 | 77 | 10 | **11%** | **85** | 53 | 3 | 34 |
| | | | | Downstream | 1 | 8 | 5 | 3 | **38%** | **113** | 3 | 0 | |
| | Toppenish | Olney | 73.0 | Upstream | 1 | 109 | 88 | 21 | **19%** | **105** | 13 | - | 13 |
| | | | | Downstream | 1 | 0 | - | - | **-** | **-** | | | |
| | Ahtanum | Lower WIP | 16.4 | Upstream | 1 | 71 | 45 | 26 | **37%** | **129** | 15 | - | - |
| | | | | Downstream | 1 | - | 0 | 0 | **-** | **-** | | | |
| | | Diversion 14 | 24.8 | Upstream | 3 | 73 | 5 | 68 | **93%** | **77** | 60 | - | 35 |
| | | | | Downstream | 1 | 15 | 1 | 14 | **93%** | **63** | 14 | | |
| | | Bachelor-Hatton | 31.8 | Upstream | 3 | 68 | 0 | 68 | **100%** | **86** | 56 | - | 31 |
| | | | | Downstream | 1 | 64 | 1 | 63 | **98%** | **66** | 25 | | |
| | | Upper WIP | 32.8 | Upstream | 0 | 0 | 0 | 0 | **-** | **-** | **-** | - | 15 |
| | | | | Downstream | 1 | 32 | 0 | 32 | **100%** | **87** | 25 | | |
| | | John Cox | ~ 45.0 | Upstream | 1 | - | - | - | **-** | **-** | **-** | - | - |
| | | | | Downstream | 0 | | | | | | | | |
| Upper Yakima | Naches | City of Yakima | 6.0 | Upstream | 1 | 26 | 24 | 2 | **8%** | **135** | 2 | - | 0 |
| | | | | Downstream | 0 | - | - | - | **-** | **-** | **-** | | |
| | | Wapatox | 29.0 | Upstream | 1 | 62 | 62 | 0 | **0%** | **-** | **-** | - | - |
| | | | | Downstream | 0 | 0 | 0 | 0 | **-** | | | | |
| | | Naches-Selah | 32.0 | Upstream | 1 | 23 | 23 | 0 | **0%** | **-** | **-** | - | - |
| | | | | Downstream | 0 | - | - | - | - | | | | |
| | Yakima | Selah-Moxee** | 204.0 | Upstream | 1 | - | - | - | - | **-** | - | - | - |
| | | | | Downstream | 0 | | | | | | | | |
| | | Roza | 210.6 | Upstream | 0 | - | **-** | **-** | **-** | **-** | **-** | - | - |
| | | | | Downstream | 1 | 36 | 36 | 0 | **0%** | | | | |
| | | Ellensburg Mill | 262.8 | Upstream | 1 | - | - | - | - | **-** | - | - | - |
| | | | | Downstream | 0 | | | | | | | | |
| | | New Cascade | 262.8 | Upstream | 1 | 9 | 0 | 0 | **0%** | **-** | **-** | - | - |
| | | | | Downstream | 0 | - | 0 | 0 | **-** | | | | |
| **Total (15 Diversions Surveyed)** | | | | **Upstream** | **24** | **548** | **331** | **208** | **38%** | **103** | **212** | **23** | **154** |
| | | | | **Downstream** | **12** | **342** | **161** | **181** | **53%** | **78** | **116** | **1** | |
| **Grand Total** | | | | **-** | **36** | **890** | **492** | **389** | **44%** | **-** | **328** | **24** | |

## Discussion

In 2018, larval lamprey rescue surveys were conducted in 15 Yakima Subbasin irrigation diversions. The number of larval and juvenile lamprey collected from these locations totaled 11,703, combined for electrofishing efforts in wet areas and collections from dry banks (n=8,628 and 3,076, respectively). Collected lamprey numbers (combination of wet and dry) were highest from the Yakima River (n=9,658), followed by Ahtanum Creek (n=1,805), Naches River (n=127), and Toppenish Creek (n=113). The maximum CPUE (catch per unit effort) was greatest in an isolated pool downstream of the fish screens at Sunnyside Diversion (34.7/min). This location also had the highest observed density (86.7/$m^2$).

Although we did our best to arrive as close to the dewatering period as possible, on average 69% of the larval lampreys trapped on dewatered banks were found dead. At Wapato and Sunnyside diversions (Yakima River, river km 176.3 and 173.4, respectively), a total of 2,993 lampreys were collected from the bank, which constitutes 97.3% of the combined total collected from all 15 diversion dry banks. At Wapato Diversion, bank mortality rates were much higher than at Sunnyside Diversion (60% and 11%, respectively). At Sunnyside Diversion, we were able to be at the dewatering site as the water level was dropping, allowing for quick recovery of exposed lamprey. In 2018, we experimented with a pilot sprinkler system, which has the potential to be an effective solution in drastically reducing the high mortality we observe from desiccation, if we develop and refine this tool further.

Larval lamprey were found at 13 (86.7%) of the 15 visited irrigation diversions. Of the diversion where lampreys were found, Pacific Lamprey was present at 8 of the 13 (61.5%) diversions. The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was high at Diversion 14 (93%), Bachelor-Hatton (100%), and Upper WIP (100%) diversions in Ahtanum Creek (river km 24.8, 31.8 and 32.8, respectively). The ratio of Pacific Lamprey has been increasing steadily since 2010 at Sunnyside and Wapato diversions from approximately 0% from 2010-2013, ~3% in 2013-2014, 7.0% in 2014-2015, 15% in 2015-2016, 33% in 2016-2017, 29% in 2017-2018, and 31.5% in 2018-2019. Adult lamprey translocation began in 2013 in Ahtanum Creek (which flows into Yakima River upstream of Wapato and Sunnyside diversions) and the ratio of Pacific Lamprey has increased considerably since this restoration program began. A total of 24 Pacific Lamprey macrophthalmia (juvenile smolt stage with eyes) were collected [21 from Sunnyside (Yakima River) and three from Wapato (Yakima River)]. A portion of these eyed juveniles were implanted with 8 mm pit tags to learn more about their downstream migration patterns.

Genetic samples were collected from a total of 154 larval/juvenile Pacific Lamprey were collected from captured larval/juvenile lamprey from these diversions. Analysis of these samples will provide valuable information related to age composition of Pacific Lamprey throughout the Yakima Subbasin (based on parentage analysis from translocated adults), and other invaluable information related to Pacific Lamprey in the Yakima Subbasin.

# Supplemental Material: Photos

## Lower Yakima Diversions

### Yakima River

*Sunnyside Diversion*

**Figure 1. Overview of downstream area of the drum screens (right), and upstream of the drum screens (left) before dewatering at Sunnyside diversion on October 23, 2018.**

**Figure 2. Overview of downstream area of the drum screens after dewatering at Sunnyside diversion on November 8, 2018.**

*Wapato Diversion*

**Figure 3. Overview of the upstream area above the trash racks (right) and the upstream area below the trash racks (left) taken October 17, 2018.**

**Figure 4. Overview of Sprinkler system setup, taken October 17, 2018.**

## Ahatanum Creek

*Diversion 14*

**Figure 5. Overview of above the drum screen directly by the screen (right) and the upstream section that tapers into the canal (left) from Diversion 14 on Ahtanum Creek, taken on July 3, 2018.**

**Figure 6. Overview of below the drum screen (right) and the water gauge (left) from Diversion 14 on Ahtanum Creek, taken July 3, 2018.**

*Bachelor-Hatton Diversion*

**Figure 7. Overview of above the drum screens (right) and the closed headgate that feeds the canal (left) at the Bachelor-Hatton Diversion on Ahtanum Creek, taken July 19, 2018.**

*Upper WIP Diversion*

**Figure 8. Overview of above the drum screens (right) and an overview of below the drum screens (left) at the Upper WIP Diversion on Ahtanum Creek, taken July 31,2018.**

*John Cox Diversion*
**No photos**

*Lower WIP Diversion*
**No photos**

## Toppenish Creek

*Olney Diversion*
**No photos**

# Naches Diversions

## Naches River

*City of Yakima Diversion*

**Figure 9. Overview of above the screens, below the trash racks (right) and an overview of above the screens, above the trash racks of the City of Yakima Diversion on the Naches River, taken November 1, 2018.**

*Wapatox Diversion*

**Figure 10. Close up of sampling area above the screens (right) and overview just below the head gate looking down the canal at Wapatox Diversion on the Naches River, take November 1, 2018.**

*Naches-Selah Diversion*

**Figure 11. Overview of above the screens, above the trash racks (right) and overview of the dried sediment and isolated pools above the screens, below the trash racks (left) of the Naches-Selah Diversion on the Naches River, taken November 1, 2018.**

# Upper Yakima Diversions

## Yakima River

*Selah-Moxee Diversion*

**Figure 12. Deceased juvenile Chinook Salmon, one with signs of predation (right) and one without (left) from the Selah-Moxee Diversion on the Yakima River, taken October 16, 2018.**

*Roza Diversion*

**Figure 13. Overview of the isolated pools that were sampled below the screens at the Roza Diversion, taken October 23, 2018.**

*Ellensburg Mill Diversion*

**Figure 14. Overview of above the screens, below the trash racks (right) and overview of below the screens at the Ellensburg Mill Diversion on the Yakima River before dewatering, taken October 23, 2018.**

*New Cascade Diversion*

**Figure 15. Overview of below the screens (right) and looking down the canal (left) of the New Cascade Diversion on the Yakima River, taken on October 23, 2018.**