Yakama Nation Pacific Lamprey Project
2018 Annual Report

Project No. 2008-470-00

Report was completed under BPA Contract No. 56662 REL 153

Report covers work performed from: January 2018 – December 2018

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Report Created: March, 2019

Cover Photo: An artificially propagated first feeding Pacific Lamprey larva next to a dime at Prosser Fish Hatchery (Prosser, WA) on June 18, 2018 (photo by Tyler Beals).

This document should be cited as follows:
Lampman, R., T. Beals, D. Lumley, S. Goudy, and R. Rose. 2019. Yakama Nation Pacific Lamprey Project 2018 Annual Progress Report. Prepared for the U.S. Department of Energy, Bonneville Power Administration (Project No. 2008-470-00), Portland, OR (85 pp.)

Bonneville Power Administration P.O. Box 3621, Portland, OR 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

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I. Executive Summary

In accordance with Bonneville Power Administration (BPA) Contract 2008-470-00, the Confederated Tribes and Bands of the Yakama Nation (YN) have prepared this Annual Report for the Yakama Nation Pacific Lamprey Project (YNPLP). This report outlines the most current activities undertaken by the YNPLP from January 1, 2017 through December 31, 2017.

A: WE165 - Environmental Compliance
No additional report is submitted in association with this milestone: see Section III.

B: WE174 – Propagation, Rearing, and Outplanting Plan
One report are submitted in association with this milestone: Appendix B1 (Updated Draft Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research).

C: WE157 – Larval/Juvenile Lamprey Surveys in the Yakima and Mid and Upper Columbia subbasins
Eight reports are submitted in association with this milestone: Appendix C1 (Lower Yakima Subbasin Larval Lamprey Monitoring Report, 2017), Appendix C2 (Upper Yakima Subbasin Larval Lamprey Monitoring Report, 2017), Appendix C3 (Naches Subbasin Larval Lamprey Monitoring Report, 2017), Appendix C4 (Wenatchee Subbasin Larval Lamprey Larval Lamprey Monitoring Report, 2017), Appendix C5 (Methow Subbasin Larval Lamprey Monitoring Report, 2016), Appendix C6 (Klickitat Subbasin Larval Lamprey Monitoring Report, 2017), Appendix C7 (Distribution and Occupancy of Pacific Lamprey in Six Major Columbia River Subbasins within the Yakama Nation Ceded Lands: Summary from 2009-2017 Surveys), and Appendix C8 (Yakama Nation Ceded Lands Larval Lamprey Synthesis Report, 2017).

D: WE28 – Lamprey Survey and Salvage in Irrigation Diversions
Two reports are submitted in association with this milestone: Appendix D1 (Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2017) and Appendix D2 (Intensive Monitoring of Larval/Juvenile Lamprey Entrainment within Dryden Diversion, Wenatchee River, 2017).

E: WE99 – Public Outreach and Education
Two reports are submitted in association with this milestone: Appendix E1 (Yakama Nation Pacific Lamprey Project Outreach and Education, 2017) and Appendix E2 (Participation in the Outplanting of Artificial Propagated Arctic Lamprey Larvae in Noto, Ishikawa, Japan).

F: WE161 – Local and Regional Participation
No additional report is submitted in association with this milestone: see Section III.

G: WE 158 – PIT Tag Adult Lamprey
Three reports are submitted in association with this milestone: Appendix G1 (Translocation of Adult Pacific Lamprey within the Yakima Subbasin, 2016-2017 Broodstock), Appendix G2 (Translocation of Adult Pacific Lamprey within the Wenatchee Subbasin, 2016-2017 Broodstock), and Appendix G3 (Translocation of Adult Pacific Lamprey within the Methow Subbasin, 2016-2017 Broodstock).

H: WE 158 – PIT Tag Juvenile Lamprey
No additional report is submitted in association with this milestone: see Section III.

I: WE196 – Council Step Process for Lamprey Artificial Propagation Activities
No additional report is submitted in association with this milestone: see Section III.

J: WE176 – Research into Artificial Propagation and Juvenile Propagation
No additional report is submitted in association with this milestone: see Section III.

K: WE28 - Trap and Haul Adult Lamprey from Columbia River
One report is submitted in association with this milestone: Appendix K1 (Yakama Nation Adult Pacific Lamprey Collection in the Columbia River Basin, 2017).

L: WE162 – Data Input and Analysis
Three reports are submitted in association with this milestone: Appendix L1 (Columbia Basin Lamprey Identification Guide), Appendix L2 (Larval Lamprey Assessment at the Sunnyside Fish Screening Facility, 2017), Appendix L3 (Summary of Larval Lamprey Hook-and-Line Predator Fish Removal in Chandler Irrigation Diversion [Yakima River, Prosser, WA], 2017), and Appendix L4 (Summary of Freshwater Mussel Observations within the Yakama Nation Ceded Lands from Larval Lamprey Surveys, 2017).

M: WE119 - Manage and Administer Projects
No additional report is submitted in association with this milestone: see Section III.

N: WE141 – Other Reports (Cultural Report)
One report is submitted in association with this milestone: Appendix M1 (Yakama Nation Cultural Oral Interviews on Asum [Lamprey Eels]: Summary and Review Part II [2017]).

O: WE132 – Final Annual Progress Report for CY2017 (Jan 2017 to Dec 2017)
This report was submitted successfully in spring 2017.

P: WE132 – Submit Draft Annual Progress Report for CY2018
This report herein represents the annual report for CY2017.

II. Introduction

The Goal of the Yakama Nation is to restore natural production of Pacific Lamprey to a level that will provide robust species abundance, significant ecological contributions and meaningful harvest throughout the Yakama Nation's Ceded Lands and in the Usual and Accustomed areas (Fig. 1).

Pacific Lamprey (*Entosphenus tridentatus*) has always been important to Native Americans throughout the Pacific Northwest. Since time immemorial, the Fourteen Bands (Palouse, Pisquose, Yakama, Wenatchapam, Klinquit, Oche Chotes, Kow way saye ee, Sk'in-pah, Kah-miltpah, Klickitat, Wish ham, See ap Cat, Li ay was, and Shyiks) who make up the YN, have shared a commonality treating lampreys as a medicine, food source, and cultural icon. These fish are native to the Columbia River Basin, spawning hundreds of kilometers inland within the states of Washington, Oregon, and Idaho (Kan 1975; Hammond 1979; Hamilton et al. 2005).

Over the past three decades the tribes of the Columbia River Basin have noticed drastic declines from the previous era. These trends are now well known and documented within most current literature about Pacific Lamprey throughout their range. In the present day, remnant populations of Pacific Lamprey still migrate up the Columbia River at a fraction of their historical numbers; daytime counts of adult Pacific Lamprey at Bonneville Dam have declined from an estimated 1,000,000 in the 1960's and 1970's to lows of approximately 20,000 in 2009 and 2010 (CRITFC 2011). Pacific Lamprey have been extirpated from many subbasins in the interior Columbia River Basin (Beamish and Northcote 1989; Close et al. 1995; Luzier et al. 2011).

Studies on this disturbing downward trend of Pacific Lamprey populations to date cite various contributors for the decline, including but not limited to hydroelectric / flood control dams, irrigation and municipal water diversions, degraded habitat, water quantity and quality (contamination), increased predation, targeted eradication through the use of rotenone, and host species abundance in the ocean (Close et al. 2005; CRITFC 2011; Luzier et al. 2011; Murauskas et al. 2013). The ecological consequences associated with the decline of these fish in both marine and freshwater environments are also largely unknown. Despite the implementation of various long-term actions intended to address large-scale limiting factors, adult returns remain low in comparison to historical baseline and abundance (CRITFC 2011a; Luzier et al. 2011; Ward et al. 2012).

The purpose of the YNPLP is to 1) collect and report critical information to evaluate status, trends and other biologic characteristics, 2) identify known and potential limiting factors for Pacific Lamprey within Columbia River tributaries, and 3) develop, implement and evaluate the effects of Pacific Lamprey restoration actions within the YN Ceded Lands. All of the Work Elements

described herein (WE165, WE174, WE157, WE28, WE99, WE161, WE158, WE196, WE176, WE162, WE119, WE141, WE132) are oriented toward meeting one of these three project goals.

The primary goals in 2018 were the followings:

- Proceed with the submission of and planning related to the "Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research."
- Continue larval lamprey surveys in Yakama Nation Ceded Lands, focusing on the Yakima Wenatchee, Methow, and Klickitat subbasins.
- Provide synthesis data and information related to larval lamprey distribution, occupancy, and relative abundance.
- Continue salvage and surveys of larval/juvenile lamprey in high priority irrigation diversions, focusing on Wapato, Sunnyside, Wapatox, Bachelor-Hatton diversions in the Yakima Subbasin and Dryden Diversion in the Wenatchee Subbasin.
- Continue adult trap and haul collection from lower Columbia River hydroelectric dams (Bonneville, The Dalles, and John Day dams) as well as upper Columbia River (Priest Rapids Dam).
- Continue adult translocation in the Yakima, Wenatchee, and Methow subbasins as well as mainstem Upper Columbia River and monitor its effectiveness through PIT tagging (migration success), index reach spawning surveys (spawning success), and parentage based genetic tagging (offspring success).
- Expand monitoring on larval/juvenile lamprey passage in the Lower Yakima Subbasin, focusing on Wapato, Sunnyside, and Chandler diversions and tributary monitoring using PIT tagging and acoustic telemetry.
- Develop and refine the science and techniques for the artificial propagation and larval rearing of Pacific Lamprey along with collaborating partners (primarily Confederated Tribes of the Umatilla Indian Reservation, NOAA Fisheries, and USFWS).
- Assess life stage specific limiting factors, critical threats, and knowledge gaps important for the restoration of Pacific Lamprey and test and refine the applicable solutions that are logical and practical, including adult and juvenile passage, flow management, toxicology, and predation.
- Initiate and expand new research related to 1) the development of an improved lamprey identification guide, 2) the temporal changes of larval/juvenile lamprey abundance in irrigation diversions using deep water electrofishing and eDNA, 3) assessment of larval lamprey predation in Chandler Diversion through hook and line methods, and 4) the distribution and siting of freshwater mussels within the Ceded Lands.
- Improve our understanding of Pacific Lamprey in its historical context through Traditional Ecological Knowledge (TEK) by interviewing and pursuing dialogue with tribal elders that grew up harvesting, preparing, and consuming "asum" (Pacific Lamprey in Sahaptin language).

- Engage federal, state, and local partners to further their commitment for Pacific Lamprey restoration and conservation by 1) sharing relevant information related to lamprey biology and monitoring data, 2) proposing new approaches/venues for administering projects to help lamprey or reduce negative impacts, and 3) developing long-term plans with the partners to ensure the commitment for restoration and conservation by all entities is long-lasting.
- Continue rigorous outreach and education for youth/students, teachers, general public, as well as agency biologists and managers to instill a "true" understanding of Pacific Lamprey and its ecological and cultural roles.

Figure 1. Overview of Ceded Lands and Reservation boundaries of the Confederated Tribes and Bands of the Yakama Nation.

III. Deliverables

A. Work Element 165 – Environmental Compliance

Work Element Associated Appendix Report:
Not Applicable

This work element is part of this project's deliverables in relation to environmental laws. This project requires environmental review and compliance assurance prior to contract implementation and we work in close coordination with the BPA Environmental Compliance Officer for this work element and deliverables. This compliance was related to 1) obtaining/renewing applicable local, state, federal, and tribal environmental permits, 2) reporting lamprey observation and catch data to USFWS, 3) documenting public involvement process activities, 4) participating in ESA consultation, and 5) inspection of gear for aquatic invasive species. These milestones were completed successfully in 2018.

B. Work Element 174 – Propagation, Rearing, and Outplanting Plan

Considerable planning has occurred in preparation of pilot propagation and outplanting research activities. The "Framework for Pacific Lamprey Supplementation Research in the Columbia River Basin" was completed in 2014 and the "Synthesis of Threats, Critical Uncertainties, and Limiting Factors in Relation to Past, Present, and Future Priority Restoration Actions for Pacific Lamprey in the Columbia River Basin" was completed in 2017. The 2017 draft of the "Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research" was shared with federal and state agencies involved in Pacific Lamprey management (USFWS, NOAA Fisheries, WDFW, ODFW, and IDFG) for review. The comments were then incorporated to the final draft, which was submitted to both BPA and the Independent Scientific Review Panel of the Northwest Power and Conservation Council for review in March, 2018. See Work Element 174 below for more information. A short summary of the YNPLP work beginning in 2012 is listed below.

<u>Summary of Past YNPLP Work (2012-2018)</u>

Beginning in 2012, the YN succeeded in conducting pilot projects to successfully hold, propagate, incubate, and rear larval Pacific lamprey. Partnership with CTUIR and NOAA each year was very instrumental in ensuring that we have spawn ready male and female Pacific Lamprey for artificial propagation. In 2012, YN investigated the variables for propagation success, tested numerous methods available for incubation (with modification specific for Pacific Lamprey eggs/prolarvae), and assessed larval rearing variables (substrate, feeds). Between 2013 and 2014, YN worked on a variety of investigations, including sexual maturation,

fertilization methods, automation of prolarvae counting, improvements in prolarvae holding, larval rearing, types of feeds, larval/juvenile tagging (VIE, PIT), species identification, and identification of life stage bottleneck for survival.

In 2015, funding was limited and the majority of YN lamprey propagation work was funded by the Bureau of Reclamation. The research focused on the early life stage (YOY) larvae rearing, examining the timing of the bottleneck, the effects of density, and testing of alternative feeds.

- Survival rates from subsampling showed that survival rates was lowest during the first four weeks, but improved after that. Growth rate was consistent during the eight week period and condition factor did not increase or decrease.
- Survival rates were similar across the three density treaments, but growth was consistently higher in the lower density groups.Survival rate was highest in the alfalfa pellet and salmon carcass treatments (followed by the Otohime medium density reference treatment).
- Growth rate (length) was highest in the diversion sediment and spawning mat treatments (followed by the Otohime medium density reference treatment). Growth rate (weight) was highest in the diversion sediment, spawning mat, and wheat flour treatments (followed by the Otohime medium density reference treatment).
- Condition factor was highest in the spawning mat, wheat flour, salmon carcass, and alfalfa pellet treatments (followed by the Otohime medium density reference treatment).
- Weight density was highest in the spawning mat, diversion sediment, and wheat flour treatments (followed by the Otohime medium density reference treatment).

In 2016, experiments were conducted in concert with Mary Moser (CTUIR/NOAA) and the Abernathy Fish Technology Center, and the advantages of sharing resources and findings from both tribal programs were again realized. A key limiting factor was the mortality of larvae at first feeding. To address this, experiments were conducted to assess the role of density and quantity of feeds, feed schedule, and alternative feeds. The primary research focus and results in 2016 were:

- Compensatory feed levels that reflects the increase in larval lamprey density levels appears to offset the reduced growth rates that were previously observed in high density tanks.
- Maintaining a constant feed level from start to end produced better rates of survival and mass density compared to a gradual increase in feed levels.
- The influence of spawning mat was inconclusive – a portion of larvae certainly used the spawning mat for rearing, but it did not affect the survival or growth rates positively or negatively.
- Feeding three times a week compared to twice a week produced better results in terms of survival rates and mass density.

- Due to an operational error, this investigation into "water off" during feeding was compromised and the result was inconclusive. Although turning off water during feeding may indeed help lamprey grow quicker using less feed, there are inherent risks involved in turning the water on and off repeatedly (risk of forgetting to turn the water back on, which can cause large mortalities as demonstrated by our operational accident).
- The most promising alternative additive feed discovered in this investigation was raw chicken eggs (it produced very high rates in survival, growth, and mass density even compared to Otohime A1 group), and further investigation is warranted to try out this feed as an inexpensive nutritious feed.

In 2017, the emphasis was on the early life stage survival bottleneck. Specifically, we answered questions related to: 1) effects of alternative feeds, 2) effects of supplemental feeds, and 3) synergistic effects of alternative and supplemental feeds. The primary research results in 2017 were:

- Average survival rates were high for all groups (87.0-97.7%), but were especially high for Otohime A1, Chicken Egg, and Tetraselmis (95.2-97.7%). Average total length was high for Brown Rice Flour (32.6 mm) and Wheat Flour (32.1 mm) groups as well as Otohime A1 group (31.2 mm). Lamprey specific condition factor was highest for Soy Flour (1.02), Wheat Flour (1.00) and Dark Rye Flour (0.95) groups. Otohime A1, Chicken Egg, and Tetraselmis groups had notably lower condition factor (0.87, 0.84, and 0.85, respectively). Mass density was highest for the Brown Rice Flour group (223 g/m^2; however, only one tank was studied with no replicates) as well as Otohime A1 and Wheat Flour groups (172 and 163 g/m^2).
- Feeds using Otohime A1 or Wheat Flour along with active dry yeast seem to produce positive and reliable results. Further studies to validate the positive results using Brown Rice Flour is also warranted. A mix of grains (such as 10 grain flour) could further diversify the nutritional content and help meet the needs for a balanced nutrition and potentially produce positive results related to survival and growth.
- Certain combinations of additive feed and supplemental feed (alfalfa pellets and salmon carcasses) produced positive results. For example, for feed types that produced minimal growth (e.g. Chicken Egg and Tetraselmis), survival and growth rates increased considerably with the addition of the supplemental feed compared to control (no supplemental feed).
- The fact that additional supplemental feed of salmon carcass and alfalfa pellet primarily resulted in reduced survival and growth for most flour feed tanks indicate that we may be at or approaching the maximum levels of feed that larval lamprey can handle at this stage (a considerable amount of labor will be required to maintain the screens and tank conditions if feed is increased any further).

- Median survival rate was 95.0%, which is a steady improvement not only from last two year's results (86.7 and 72.0%, respectively) but also from the earlier years of research (ranging between 10-50%). Through a variety of refinement and adjustments in the rearing protocols (such as the type of additive feeds and its particle size, ration, tank maintenance methods, and starting density levels), it appears that we essentially resolved the life stage bottle neck problem that was experienced for many years in the laboratory setting.
- Mass density (g/m^2) is a great indicator for success as it incorporates both survival rates and growth rates together. When mass density reaches 100-120 g/m^2, growth appears to diminish significantly (but not necessarily survival rates) from past studies (Lampman et al. 2016). The highest mass density observed from the 2017 study was 223 g/m^2, which is the highest value observed to date; despite this high level of density, survival and growth rates remained at high levels.

In 2018, we focused on: 1) effects of water source and light intensity on adult maturation process, 2) the sensitivity of prolarvae to larvae on transportation stress, 3) effects of sediment depth on larval survival and growth, 4) effects of feed frequency on larval survival and growth, and 5) testing of alternative feeds. Adult maturation studies were conducted in winter/spring season using 2017/2018 adult broodstock and also for the summer/fall season using 2018/2019 adult broodstock. Transportation sensitivity studies were conducted in the summer of 2018. Larval rearing studies were conducted between July and September, 2018. The research results from 2018 are currently being analyzed and will be reported in full detail in the final report in April, 2019.

Work Element Associated Appendix Report:
Not Applicable

C. Work Element 157 – Larval/Juvenile Lamprey Surveys in the Yakima and Mid and Upper Columbia subbasins

Work Element Associated Appendix Reports:
Appendix C1 – Yakama Nation Ceded Lands Larval Lamprey Monitoring Report, 2018

Photo C1. Overview of a larval lamprey survey site on Ahtanum Creek (river km 36.6) where larval Pacific Lamprey were captured in October, 2018.

In the Klickitat River, one site was surveyed immediately upstream of the hatchery weir (river km 69.5; Table C1-1 and Fig. C1-1). 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 #/m^2. 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 #/m^2). 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) (Table C1-2 and Fig. C1-2). 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 #/m^2), followed by Satus (3.7 #/m^2), Toppenish (1.4 #/m^2), Simcoe (1.4 #/m^2) creeks, and Lower Yakima River (0.8 #/m^2). 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 (Table C1-3 and Fig. C1-3). Pacific Lamprey were present at two of the three (60%) Wentachee 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 #/m^2) compared to the Wenatchee mainstem (between 2.0 #/m^2 and 4.1 #/m^2). No lamprey were found at two sites in the Chiwawa River.

In the Entiat River, one site was surveyed (rkm 40.2; Table C1-4 and Fig. C1-4). 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 #/m^2) 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) (Table C1-5). 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).

See **Appendix C1** for more information.

Table C1-1. 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

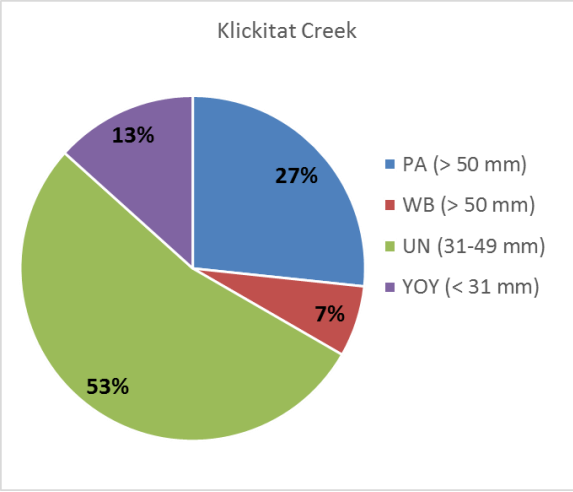


Figure C1-2. Species composition of captured lampreys from the one surveyed site in the Klickitat River (river km 69.5). "PA" stands for Pacific Lamprey, "WB" stands for Western Brook Lamprey, "UN" stands for unknown species lamprey (that are estimated to be over one year of age) and "YOY" stands for young of the year, estimated to be less than one year of age.

Table C1-2. 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	Wenas	0.5	8/8/2018	425	7	2	42	6	0%	2%	0	0
	Index		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	Yakima	13.5	43363	600	10	2	12	3	100%	8%	0	0
	Index		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	Satus	12.9	9/27/2018	693	11	3	141	200	94%	0%	3	0
	Index		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	Toppenish	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		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	Ahtanum	1.1	10/1/2018	673	11	4	94	25	28%	6%	0	1
	Exploratory		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**

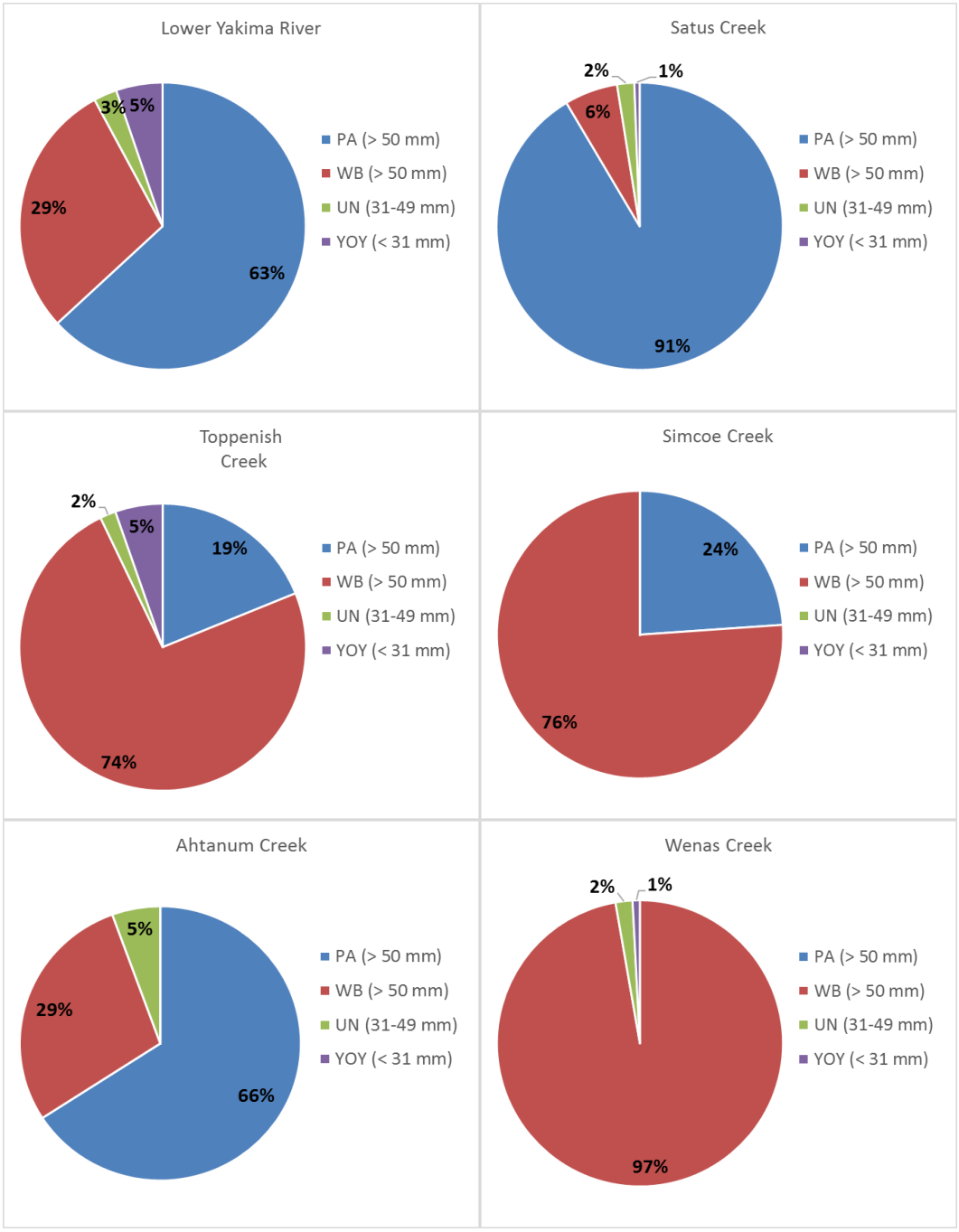


Figure C1-2. Species composition of captured lampreys from each surveyed stream in the Yakima Subbasin. "PA" stands for Pacific Lamprey, "WB" stands for Western Brook Lamprey, "UN" stands for unknown species lamprey (that are estimated to be over one year of age) and "YOY" stands for young of the year, estimated to be less than one year of age. Simcoe Creek is a tributary of Toppenish Creek.

Table C1-3. 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 Time (sec)	Shock Area (m2)	Survey Visibility (1-5)	# Captured	# Missed	% PA	% Unknown	# PA with eyes	# WB with eyes
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

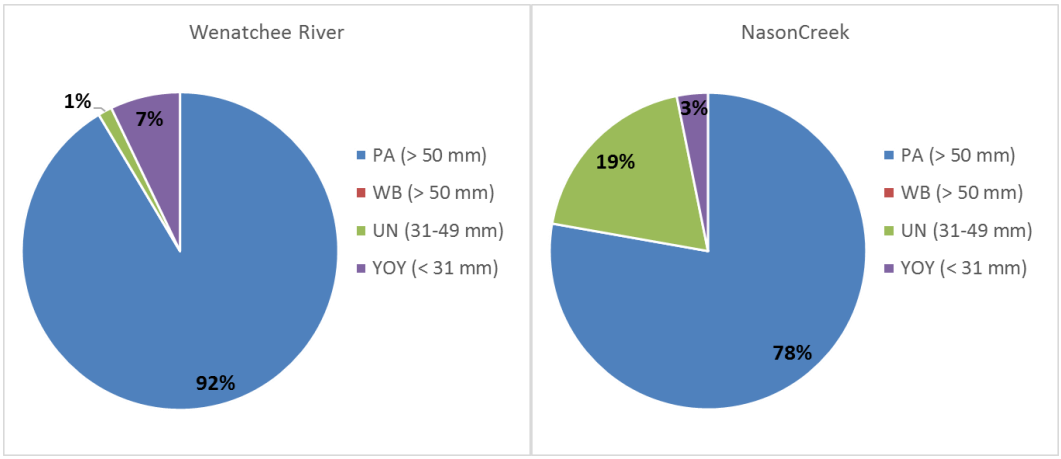


Figure C1-3. Species composition of captured lampreys from each surveyed stream in the upper Wenatchee Subbasin. “PA” stands for Pacific Lamprey, “WB” stands for Western Brook Lamprey, “UN” stands for unknown species lamprey (that are estimated to be over one year of age) and “YOY” stands for young of the year, estimated to be less than one year of age.

Table C1-4. 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

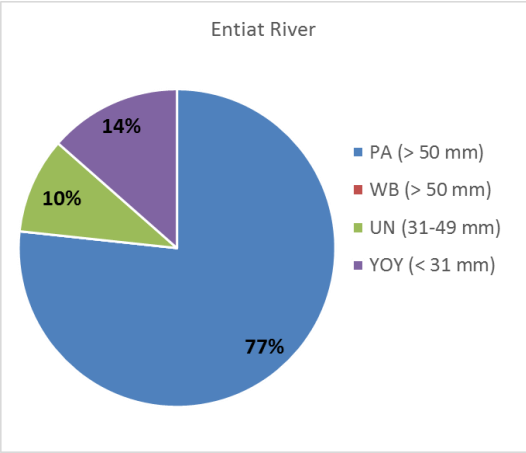


Figure C1-4. Species composition of captured lampreys from each surveyed stream in the Entiat Subbasin (river km 40.2). "PA" stands for Pacific Lamprey, "WB" stands for Western Brook Lamprey, "UN" stands for unknown species lamprey (that are estimated to be over one year of age) and "YOY" stands for young of the year, estimated to be less than one year of age.

Table C1-5. Larval lamprey electrofishing effort and species composition at survey sites within the Methow Subbasin with John Crandall (Methow Salmon Recovery Foundation). "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 with eyes	# WB with eyes
Index	Methow	25.6	8/23/2018	1047	55.2	-	125	10	100%	21%	0	0
Index		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	Chewuch	0.8	8/22/2018	766	50.2	-	129	13	100%	32%	0	0
Index		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

D. Work Element 28 – Lamprey Survey and Salvage in Irrigation Diversions

Work Element Associated Appendix Report:

Appendix D1 – Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakama Basin, 2018

Photo D1. 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.

Appendix D1 summarizes all the surveys conducted by Yakama Nation Fisheries in irrigation diversions during the dewatering season. In 2018, larval lamprey rescue surveys were conducted in 15 Yakima Subbasin irrigation diversions (Table D1-1). 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 (Table D1-2). 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.

See **Appendix D1** for more information.

Table D-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.

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 D1-2. 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. "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 included. **Some of the 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**	

Appendix D2 – Intensive Monitoring of Larval/Juvenile Lamprey Entrainment in the Yakima Subbasin, 2018

Photo D2. Dave'y Lumley (left) and Shekinah Saluskin (right) rescuing larval lamprey trapped above the fish screens of Wapato Irrigation Diversion using a backpack electrofisher and a fine-mesh net.

During the 2018-2019 irrigation dewater season, the Yakama Nation intensively monitored larval/juvenile lamprey entrainment at Sunnyside and Wapato diversions (head gates located at river km 171.4 and 176.2, respectively) (Fig. D2-1 and Fig. D2-2). The following report is divided into two parts: 1) assessment of lamprey abundance and 2) the effects of dewatering rates on lamprey survival. By using a combination of single pass electrofishing and lamprey collection from dry banks, we estimated that a total of 7,249 lampreys were present in Type I habitat immediately downstream of the fish screens at Sunnyside Diversion (Table D2-1). At Wapato Diversion, we estimated the total number of lampreys in Type I habitat immediately upstream of the fish screens to be 10,880 (Table D2-2). From these two diversions, we captured and rescued 6,529 lampreys from wetted habitat. Within these two diversions, we estimated there were 14,546 lampreys in wetted Type I habitat. Although our estimates are likely a conservative estimate of the total number of lampreys in these locations, our data suggest that we removed approximately 45% of entrained lampreys through the 11 combined days of fish rescue efforts.

At Sunnyside Diversion, the maximum incremental dewatering rate was 20.8 cm/hr which lasted for ~155 minutes (Fig. D2-3). At Wapato Diversion, the maximum observed incremental dewatering rate was 27.4 cm/hr and lasted for ~215 minutes (Fig. D2-4). Despite the relatively similar dewatering rates and duration, the rate of mortality was much lower on the first day of dewatering at Sunnyside Diversion (6.8%; 84 of 1,231 lampreys) compared to Wapato Diversion (70.2%; 843 of 1201 lampreys) (Table D2-3 and D2-4). At Sunnyside Diversion, our staff and volunteers were ready to rescue lampreys from the dry banks immediately after dewatering of the critical high density zones began, whereas at Wapato Diversion, our rescue efforts did not start until 2-3 hours after dewatering in the critical high density zones have already progressed. Therefore, it is imperative that the rescue of lampreys trapped on dewatered banks need to occur in a timely manner (only 2-3 hours of delay in rescue can result in a significantly higher rate of mortality).

See **Appendix D2** for more information.

Figure D2-1. Delineated sections of the area downstream of the fish screens at Sunnyside Diversion (grey polygons and blue arrows). Section D2 is located immediately downstream of the fish screens, and Section D1 is located downstream of section D2, extending downstream to the I-82 Highway Bridge. Water flow is moving from left to right.

Figure D2-2. Delineated sections of the area upstream of the fish screens at Wapato Diversion (grey polygons and blue arrows). Sections U1, U2, U3, and U4 divide the area immediately upstream of fish screens. Section U5 surrounds the trashrack, and U6 is located in the upstream canal, reaching 50 m upstream of the trash racks (total upstream canal length is 780 m). Water flow is moving from left to right.

Table D2-1. Total estimated number of lampreys in Type I habitat downstream of the fish screens at Sunnyside Diversion. The estimated number of lampreys for each section, and habitat category, are shown. The blue bold font at the bottom of the table indicates the total estimated number. "First Pass Survey Date" is the date when a first pass electrofishing survey was conducted within the respective section. "Total # Recovered from Dry Banks" is the total number of exposed lampreys removed from dry banks. The "Total Previous # Recovered from Electrofishing" is the number of lampreys opportunistically removed by electrofishing before a first pass in each section was completed.

Section	Type I Habitat Category	First Pass Survey Date	Area of Wetted Type I (m2)	Survey Area (m2) Type I	Total # Captured	Total # Observed	E-Fish Density (#/m2)	Adjusted E-Fish Density (#/m2)	Estimated # (E-Fish)
D1	Edge/Main	11/9/2018	70	10	14	14	1.4	2.8	195
D1	Isolated Pool	11/9/2018	15	12	268	368	30.7	44.7	670
D2	Edge/Main	11/8/2018	119	28	509	739	26.4	36.4	4331
Estimated Total (E-Fish)									**5196**
Total # Recovered from Dry Banks									**1601**
Total Previous # Recovered from Electrofishing									**452**
Total Estimated # in Type I Habitat									**7249**

Table D2-2. Total estimated number of lampreys in Type I habitat upstream of the fish screens at Wapato Diversion. The estimated number of lampreys for each section, and habitat category, are shown. The blue bold font at the bottom of the table indicates the total estimated number of lamprey. "First Pass Survey Date" is the date when a first pass electrofishing survey was conducted within the respective section. "Total # Recovered from Dry Banks" is the total number of exposed lampreys removed from dry banks.

Section	Type I Habitat Category	Initital Survey Date	Area of Wetted Type I (m2)	Survey Area (m2) Type I	Total # Captured	Total # Observed	E-Fish Density (#/m2)	Adjusted E-Fish Density (#/m2)	Estimated # (E-Fish)
U1	Edge/Main	10/19/2018	237	10	5	6	0.6	1.0	237
U2	Edge	10/18/2018	126	11	109	129	11.7	19.8	2505
U2	Main	10/18/2018	90	10	35	45	4.5	7.0	629
U3	Edge	10/18/2018	36	25	327	654	26.2	26.2	952
U3	Main	10/18/2018	73	10	99	199	19.9	19.9	1455
U4	Edge	10/18/2018	17	15	228	456	30.4	30.4	511
U4	Main	10/18/2018	50	9	128	213	23.7	28.4	1417
U5	-	-	0	-	-	-	-	-	-
U6	Edge/Man	10/18/2018	67	10	123	230	23.0	24.6	1645
Estimated Total (E-Fish)									**9350**
Total # Recovered from Dry Banks									**1531**
Total Estimated # in Type I Habitat									**10880**

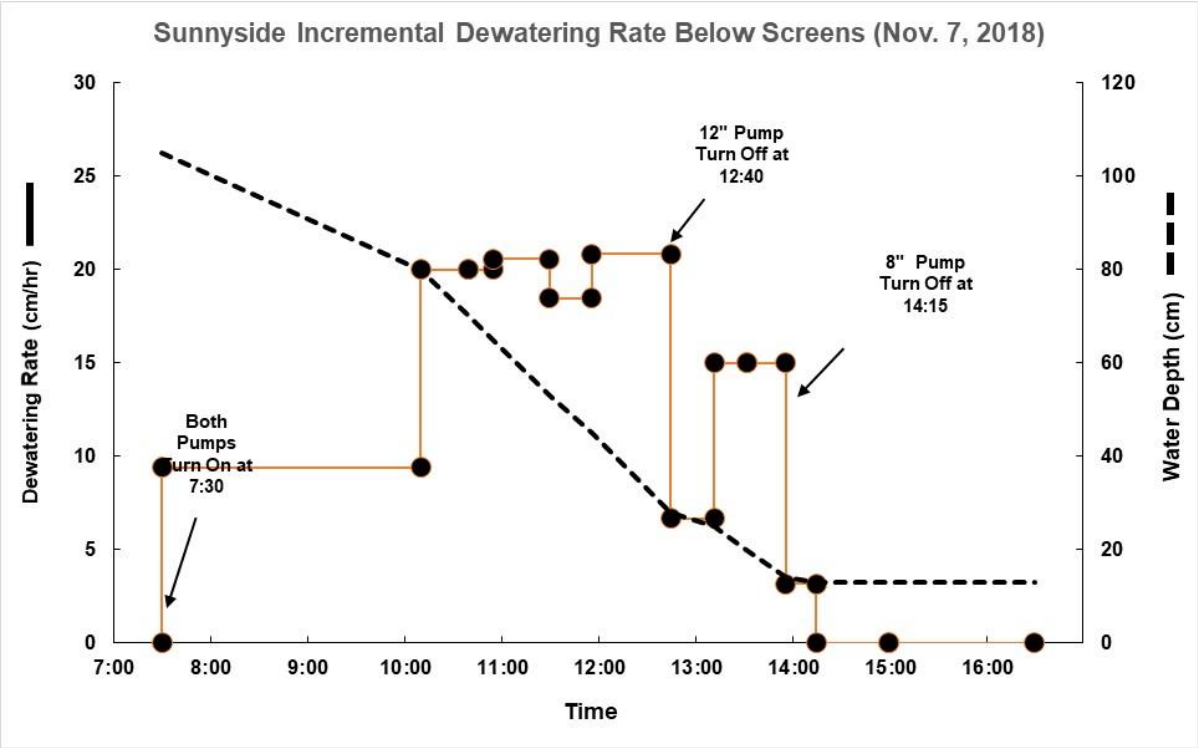


Figure D2-3 Incremental dewater rate observed at Sunnyside Diversion on 11/7/2018. The majority of Type I habitat dewatering downstream of the screens at Sunnyside Diversion occurred on this date. The operating schedule of each pump is also shown. The water depth was measured near a bypass pipe, located immediately downstream of the fish screens near the center of the screen complex.

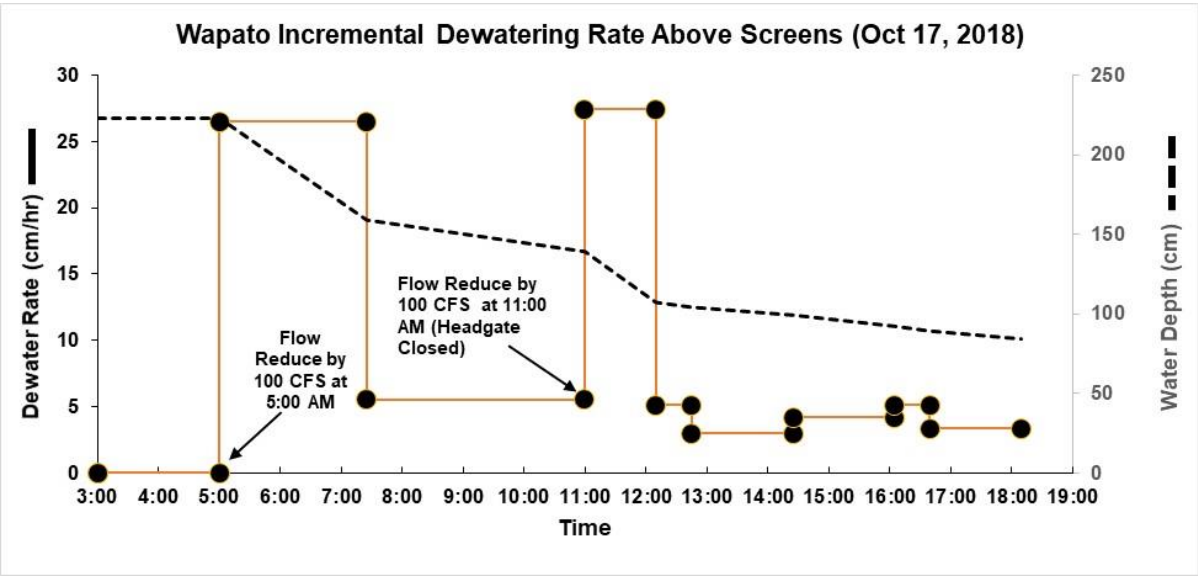


Figure D2-4. Incremental dewatering rate observed at Wapato Diversion on 10/17/2018. The majority of Type I habitat dewatering downstream of the screens at Sunnyside Diversion occurred on this date. The operating schedule of the head gate (and corresponding CFS flow reduction) is shown. The water depth was measured immediately upstream of the fish screens near the bypass wing wall, located near the center of the fish screen complex.

Table D2-3. Summary of daily lamprey capture from dry banks at Sunnyside Diversion downstream of the fish screens. The "Cumml. # of Days Post Water Drawdown" is the number of days after the pumps dropped the water to its lowest level on November 7, 2018.

Survey Date	# of Days Between Surveys	Cummul. # of Days Post Water Drawdown	# Live (Dry Bank)	# Dead (Dry Bank)	# Observed (Live+Dead)	% Dead	Cumml. # Removed (Dry Bank)
11/6/2018	-1	-	76	0	76	0.0%	76
11/7/2018*	1	0	1147	84	1231	6.8%	1307
11/8/2018	1	1	182	36	218	16.5%	1525
11/9/2018	1	2	13	63	76	82.9%	1601
11/13/2018	4	6	0	0	0	-	1601
Total		**-**	**1418**	**183**	**1601**	**11.4%**	**1601**

Table D2-4. Summary of daily lamprey capture from dry banks at *Wapato* Diversion downstream of the fish screens. The "Cumml. # of Days Post Dewatering" is the number of days after the headgate was closed on October 17, 2018.

Survey Date	# of Days Post Previous Survey	Cummul. # of Days Post Dewatering	# Live (Dry Bank)	# Dead (Dry Bank)	# Observed (Live+Dead)	% Dead	Cumml. # Removed (Dry Bank)
10/17/2018	0	0	358	843	1201	70.2%	1201
10/18/2018	1	1	181	93	274	33.9%	1475
10/19/2018	1	2	8	48	56	85.7%	1531
10/22/2018	3	5	0	0	0	-	1531
10/24/2018	2	7	0	0	0	-	1531
10/25/2018	1	8	0	0	0	-	1531
11/16/2018	22	30	0	0	0	-	1531
Total		**-**	**547**	**984**	**1531**	**64.3%**	**1531**

Appendix D3 – Experimental Sprinkler System for Reducing Larval Lamprey Mortality during Irrigation Diversion Dewatering Events: Highlights and Lessons Learned

Photo D3. Sprinkler system set up at Wapato Diversion upstream of the fish screens to help maintain the dewatered fine sediment wet overnight on October 19, 2018.

An experimental sprinkler system was designed by the Yakama Nation Pacific Lamprey Project to provide a supply of water to larval lampreys trapped in dewatered banks. The sprinkler system

was constructed with various sizes of PVC (ranging from 0.5-2 inch diameter), and deployed on dewatered banks at Sunnyside and Wapato diversions on the first day of dewatering (Fig. D3-1 and D3-2). We provide a general overview of the system's construction, coarse cost estimate of the system, as well as our experiences and lessons learned that can be used to make further improvement for the use of this tool in the future.

The sprinkler system was set up and operated at Sunnyside and Wapato diversions immediately after dewatering at each facility. At both facilities, the sprinkler system was ran for 3-4 days after dewatering to provide water to lampreys on or within dewatered banks. An overview of the system at Sunnyside and Wapato diversions are shown in Fig. 3.5-1 and Fig. 3.5-2. The total estimated cost for one system (approximately 30 m in length with 4-6 sprinkler heads) is approximately $1600; $600 for the water supply pump and hose, and $1000 for the PVC sprinkler system itself. This cost can likely be brought down considerably once a design is finalized with a minimal list of supplies/equipment (our estimate includes component purchases stemming from trial and error). This sprinkler system can be extended or scaled down to fit any dewatering scenario. Although this system could certainly be improved further, it is a cheap and an adaptable way to provide life support to lampreys that have a low chance of reaching the water's edge due to dewatering.

Important lessons learned during our operation:

The smaller the diameter of PVC, the easier the system is to maneuver

- The gradual decrease in PVC sizes within our system not only appeared to increase pressure throughout the system, but also made for easy maneuvering around large humps and other obstacles.

Keep the pump electrical connections with the power supply DRY at all times

- Our pump shut off during night operations on several occasions. One probable cause of the system malfunction was moisture reaching the electrical supply (mostly from rain or morning dew). It is imperative that the electrical connection stays dry during this operation.

"Blow-out value" at the end of the sprinkler system is essential

- During the set-up process, sediment became lodged in many of the pipes. The system was first turned on with all sprinkler heads closed, and the blow-out valve was then opened. This effectively pushed out all debris/sediment lodged in the pipes (which would otherwise clog the sprinkler heads).

Focus sprinkler spray on the low gradient dewatered sediment

- We recommend the placement of the sprinkler system on dewatered low gradient fine sediment where lamprey tend to collect in high numbers during the dewatering process. Lampreys tend to have difficulty reaching the water's edge in these locations as the water level drops. On sloped banks, lamprey have a higher chance of "rolling" or "sliding" down the sloped bank to reach the water's edge, so it is more important to keep the sprinkler

system spray focused on these low gradient areas that instigate the most amount of stranding.

Sprinkler spray can provide water to isolated pools

- Isolated pools (pools of water surrounded by dry sediments) can hold large densities of larval lampreys. These pools can dry up quickly over time. The sprinkler system, if set up in proximity with these pools, will keep water in the pool and extend the life of trapped lamprey, thereby allowing future rescue efforts to save them.

See **Appendix D3** for more information.

Figure D3-1. Overview of the sprinkler system operation upstream of the fish screens at Wapato Diversion immediately after dewatering occurred (left photo). In the right photo, the sprinkler spray is submerged to some extent in the large water body because we were not certain how far the water level was going to drop overnight (and what new sediment would become exposed).

Figure D3-2. Overview of the sprinkler system operation downstream of the fish screens at Sunnyside Diversion immediately after dewatering occurred. Part of the sprinkler system covers the high density isolated pools.

Appendix D4 – Implementation of a Simulated Perennial Side Channel Flow Regime in the Wapatox Diversion (Naches River) to Protect High Densities of Larval/Juvenile Lampreys

Photo D4. Downstream view of the Wapatox Diversion irrigation canal (Naches River), immediately downstream of the headgates.

Wapatox Diversion is located in the lower reach of Naches River (headgates at river km 29.0). Wapatox Diversion has a long canal (266 m) between the fish screens and the headgates (Fig. D4-1). There are a set of regulating gates 210 m downstream of the headgates, which during the irrigation season regulate the flow further downstream. Immediately upstream of these regulating gates is a flow return channel, which returns excess flow (and trapped fishes) back to the river. Further downstream (56 m) of the regulating gates are the fish screens and the main fish bypass channel. Annually after dewatering, a high density of lampreys (up to ~50 lamprey/m^2) and a large area of dewatered larval lamprey habitat (up to ~550 m^2) are found between the headgates and regulating gates. In November 2018, the Yakama Nation Fisheries and the Bureau of Reclamation coordinated and managed to maintain sufficient flow year-round in the section upstream of the regulating gates. The availability of regulating gates and the flow return channel at Wapatox Diversion provides the option for water and fishes to return immediately to the river (prior to approaching the fish screens). The canal section downstream of the regulating gates is then left dry, and no water infiltrates the area upstream of the fish screens (preventing damage to the fish screens related to freezing and icing). The operations at Wapatox Diversion to create a perennial side channel has the potential to provide a safe year-round rearing habitat as long as the initial extended dewatering period could be shortened. After a period of dewatering lasting 2-3.5 hours, water was restored into the canal and lampreys stranded in the dried fine sediment regained access to water. However, lampreys can certainly desiccate in even 1-2 hours and either a shorter dewatering period or a break in between the dewatering to allow staff to rescue stranded lampreys is highly recommended to reduce the risk of desiccation. Additionally, accumulated sediment in the canal area downstream of the headgates will need to be dredged using heavy equipment ever few years. This will require more intensive lamprey rescue efforts during those years. In addition to rescue efforts using electrofishing, a lamprey sifting device (to efficiently remove lampreys

from the dredged material) will likely improve the overall lamprey rescue efficiency when the time comes to dredge this high density larval lamprey area.

See **Appendix D4** for more information.

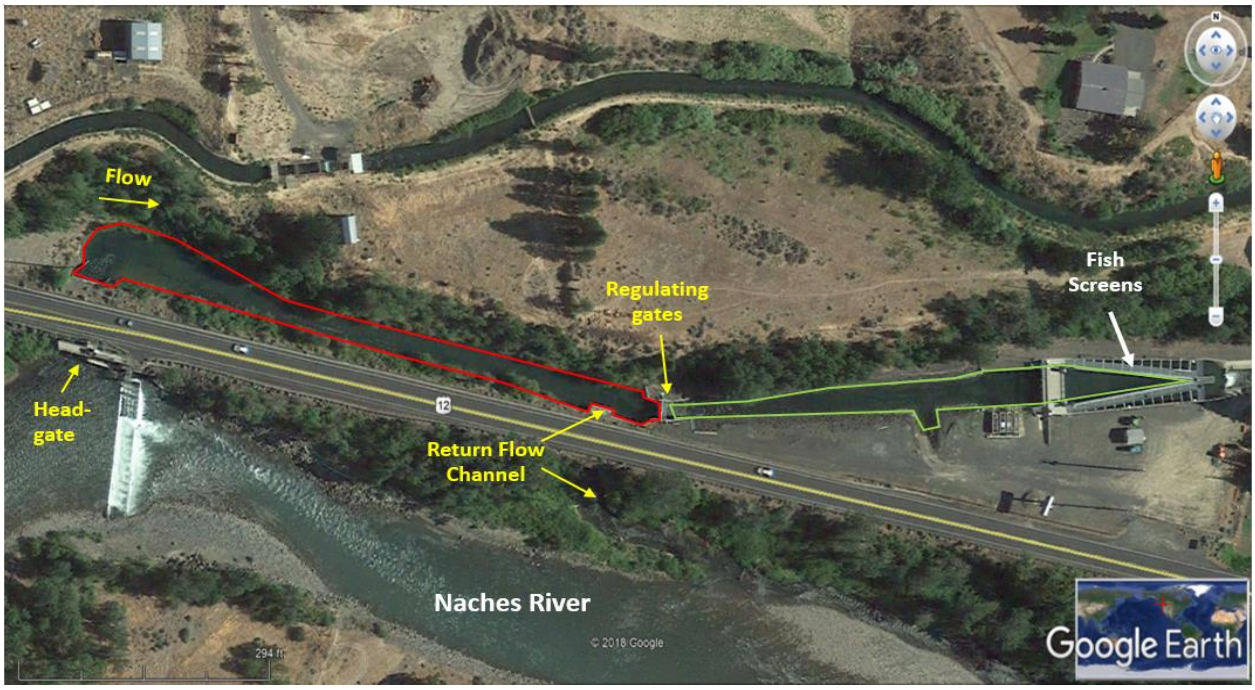


Figure D4-1. Overview of Wapatox Diversion, Naches River (water flow from left to right). The area with 'high' densities of larval lampreys is outlined in red. Larval lampreys are found downstream of the regulating gates (near the fish screens, green outlined area), but in significantly lower densities. On November 1, 2018, immediately after irrigation shutdown, the headgates were left open slightly, and flow was provided between the headgates and regulating gates; in previous years this area was left mostly dewatered during the winter months. The regulating gates were kept shut, to prevent water from going further down the canal. All winter flow re-entered the river via the return flow channel.

E. Work Element 99 – Public Outreach and Education

Work Element Associated Appendix Report:
Appendix E1 – Yakama Nation Lamprey Outreach and Education, 2018

Photo E1. Students from Christian Brothers High School (Sacramento, CA) assisting Yakama Nation staff to monitor adult Pacific Lamprey on March 21, 2018.

Yakama Nation Fisheries Resource Management Program Pacific Lamprey Project (YN PLP) has a duty and responsibility to educate the public and community about Pacific Lamprey and their importance. Pacific Lamprey has become infamous relatively quickly, in part, due to the notoriety of the Sea Lamprey in the Great Lakes. The ecological and cultural significance has become lost among the younger generations. Conservation of this species is critical, and if the public is not educated about the importance of Pacific Lamprey, our efforts will be unsustainable and there will be no focus on their restoration.

For the YN PLP, our primary concern is to restore the Pacific Lamprey to its rightful place in the culture of the Columbia Basin Native Americans. From a tribal perspective, the decline of lamprey equals a loss of a family member, a close friend, and a loss of an important culture. Many young tribal members do not know how to catch and prepare lamprey for cooking and drying, while myths and legends associated with lamprey are being forgotten or lost. We need to dissuade the public of the "River Monster" view of Pacific Lamprey. When we open our hatchery for tours and invite schools, organizations, and the general public to our release events, we have an opportunity to educate them. We have created a variety of visual displays and interactive exhibits. Our team members give presentations about the life cycle, history, cultural significance, medicinal uses of lamprey, and the problems they face. Gaining the support of the public is a vital part of restoring Pacific Lamprey to their rightful place.

We must continue to educate through school presentations, lamprey in the classroom programs, hands-on tours for college students, and reach out to other biologists and fishery managers. At release events, the visitors are able to hold a lamprey and release it into the river. Providing a hands-on experience for people to hold and touch the lamprey is a memorable event for visitors. It can dispel their image of the monstrous creature and many leave with a great respect for this incredible creature.

Last year, through our community events and hatchery tours, we participated and/or organized **31** events, including adult lamprey translocation release events, summer camp hands-on field trips, presentations in classrooms, and hatchery tours (Table E1-1). In this process, we reached out to over **3,931** students, **331** teachers, **245** agency workers, and **905** people from the general public, reaching over **5,412** people combined (Table E1-2).

Our team gives presentations to the scientific community, funding sources, and fisheries managers frequently. In 2018, our biologists and partners sharing YN PLP work gave over **17** presentations at a variety of conferences and meetings, including Upper Columbia Science Conference, California Lamprey Passage Workshop, Annual Lamprey Information Exchange Workshop, and Sitka Whalefest, targeting the scientific and fisheries management community, ranging in locations from Ukiah, California, to Sitka, Alaska (Table E1-1). Through scientific presentations, we reached out to over **272** students, **55** teachers, **1,111** agency workers, and **287** people from the general public, reaching over **1,620** people combined (Table E1-2).

Local news and social network media, and various educational blogs continue to support our outreach efforts and are helping to promote the need to restore Pacific Lamprey (Table E1-1). We take the initiative to announce various outreach events through the local news media and we take the time to provide feedback to reporters and bloggers to ensure they get their stories on Pacific Lamprey written as accurately and correctly as possible. Through these various media outreach, totaling **17** sources, we estimated that we reached out to over **44,441** people from the general public, based on a very conservative estimate (Table E1-2).

For the Pacific Lamprey Project, 2018 was an outstanding year of good publicity with many opportunities to reach out to students, teachers, partners, and the general public (Table E1-1). All together, we reached out to over **4,203** students, **386** teachers, **1,356** agency workers, and **45,633** people from the general public, totaling over **51,578** people (Table E1-2 and Fig. E1-1). We have many opportunities to continue to reach out to the public and all of us on our team will continue to do our best to be the rightful spokesperson and messenger for the Pacific Lamprey, using various means available.

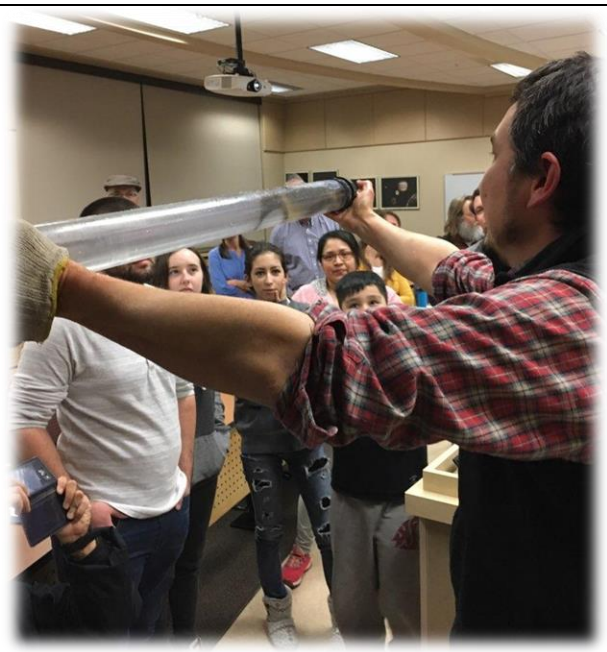
See **Appendix E1** for more information.

Table E1-1. List of 2018 Yakama Nation Pacific Lamprey Project outreach and education activities.

#	Date	Event/Audience	Location	Type of Event	# of Students	# of Teachers	# of Agency Workers	# of General Public	# of People Total
1	2/27/2018	Cowiche Canyon Conservation/Yakima Valley College Biology Lecture Series	Yakima, WA	Outreach	15	5	5	40	65
2	3/14/2018	Oregon Chapter American Fisheries Society Meeting Film Festival	Eugene, OR	Outreach	5	-	50	5	60
3	3/21-22/2018	Christian Brothers High School Volunteer Days	Prosser, WA	Outreach	10	2	-	-	12
4	3/28/2018	Salmon Release Tour (Grandview High School)	Prosser, WA	Outreach	23	3	2	-	28
5	4/6/2018	Sunnyside High School Intern	Prosser, WA	Outreach	1	-	-	-	1
6	4/10/2018	Presentation (Campbell Farm Summer Camp)	Wapato, WA	Outreach	9	2	2	1	14
7	4/10/2018	Presentation (LaSalle High School)	Union Gap, WA	Outreach	11	1	-	-	12
8	4/11/2018	Lower Ahtanum Creek Adult Release (LaSalle High School Students)	Union Gap, WA	Outreach	8	1	-	-	9
9	4/11/2018	Outreach for the World Fish Migration Day	Yakima Valley, WA	Outreach	15	2	10	30	57
10	4/12/2018	Prosser Hatchery Tour (Cheif Kamiakin Elementary School)	Prosser, WA	Outreach	132	19	-	19	170
11	4/13/2018	Methow River Adult Release (Methow students)	Twisp, WA	Outreach	7	2	3	1	13
12	4/21/2018	Prosser Science Expo	Prosser, WA	Outreach	70	5	5	140	220
13	4/21/2018	Lower Yakima River Adult Release (World Fish Migration Day #3)	Prosser, WA	Outreach	25	2	5	20	52
14	4/22/2018	Central Washington University Salmon Run	Ellensburg, WA	Outreach	20	6	-	10	36
15	4/23/2018	Wenatchee River Adult Release (Cascade Middle School)	Leavenworth, WA	Outreach	14	2	4	-	20
16	4/24-25/2018	Benton Conservation District Salmon Summit	Kennewick, WA	Outreach	2,600	130	30	130	2,890
17	4/25/2018	Prosser Hatchery Tour (Mount Hood Community College)	Prosser, WA	Outreach	10	1	1	-	12
18	4/30/2018	Upper Toppenish Creek Adult Release (Mt. Adams School District)	Brownstown, WA	Outreach	30	3	-	-	33
19	5/10/2018	Upper Toppenish Adult Release (NRCS tour)	Upper Toppenish Creek	Outreach	-	-	20	4	24
20	5/12/2018	Aquatic Travelers: Migratory Fishes of the Columbia River (REACH Museum)	Richland, WA	Outreach	125	10	10	75	220
21	6/22/2018	Family Fishing Event at Marion Drain Hatchery	Toppenish, WA	Outreach	100	3	10	30	143
22	7/17/2018	Kittitas Environmental Educational Network Summer Camp	Hellen McCabe State Park	Outreach	24	4	-	-	28
23	7/26/2018	Prosser Hatchery Tour (Yakama Nation Staff)	Prosser, WA	Outreach	-	-	2	-	2
24	8/2/2018	Presentation (Heritage University Salmon Camp)	Prosser, WA	Outreach	24	11	-	-	35
25	8/16/2018	Lamprey Outreach Tabling (Backpack Giveaway)	Toppenish, WA	Outreach	250	20	20	100	390
26	8/16/2018	Upper Toppenish Adult Release (Federal Caucus Group)	White Swan, WA	Outreach	-	-	16	-	16
27	8/20/2018	Presentation (KEEN Camp and Mid-Columbia Fisheries Intern)	Ellensburg, WA	Outreach	10	3	-	-	13
28	10/25/2018	Prosser Hatchery Tour (NRCS Group)	Prosser, WA	Outreach	-	-	10	-	10
29	10/27/2018	SCREECH (REACH Museum)	Richland, WA	Outreach	150	10	20	150	330
30	10/29/2018	Wanapum Archaeology Days at Wanapum Dam	Beverly, WA	Outreach	150	10	20	150	330
31	11/10/2018	Native American Arts/Crafts and Culture Day (Richalnd Public Library)	Richland, WA	Outreach	93	74	-	-	167
1	1/24/2018	Upper Columbia Science Conference Presentation	Wenatchee, WA	Science Pres.	15	-	225	15	255
2	2/7/2018	Rocky Reach Fish Forum Presentation	Wenatchee, WA	Science Pres.	-	-	12	-	12
3	2/15/2018	BPA Master Plan Coordination Meeting Presentation	Portland, OR	Science Pres.	-	-	15	-	15
4	4/19/2018	Lamprey ID Workshop	The Dalles, OR	Science Pres.	2	-	34	2	38
5	5/16/2018	California Lamprey Passage Workshop Presentation	Ukiah, CA	Science Pres.	5	-	85	5	95
6	5/21/2018	Western Division American Fisheries Society Presentation	Anchorage, AK	Science Pres.	20	5	50	5	80
7	6/14/2018	Yakima Basin Science & Management Conference Presentation (Adult)	Ellensburg, WA	Science Pres.	15	5	75	5	100
8	6/14/2018	Yakima Basin Science & Management Conference Presentation (Juvenile)	Ellensburg, WA	Science Pres.	15	5	75	5	100
9	7/10/2018	Northwest Power and Conservation Council Presentation (#1)	Boise, ID	Science Pres.	-	-	40	-	40
10	8/15/2018	Northwest Power and Conservation Council Presentation (#2)	Portland, OR	Science Pres.	-	-	40	-	40
11	11/1/2018	Sitka Whalefest Presentations	Sitka, AK	Science Pres.	150	15	50	200	415
12	11/29/2018	McNary Mitigation Funds Project Proposal Presentation	Wenatchee, WA	Science Pres.	-	-	10	-	10
13	12/12/2018	Annual Lamprey Information Exchange Workshop Presentation (Entrainment)	Portland, OR	Science Pres.	10	5	80	10	105
14	12/13/2018	Annual Lamprey Information Exchange Workshop Presentation (Predation)	Portland, OR	Science Pres.	10	5	80	10	105
15	12/13/2018	Annual Lamprey Information Exchange Workshop Presentation (Juv. Passage)	Portland, OR	Science Pres.	10	5	80	10	105
16	12/13/2018	Annual Lamprey Information Exchange Workshop Presentation (Propagation)	Portland, OR	Science Pres.	10	5	80	10	105
17	12/13/2018	Annual Lamprey Information Exchange Workshop Presentation (Climate Change)	Portland, OR	Science Pres.	10	5	80	10	105
1	2018	Yakama Nation Fisheries (Facebook)	Website	Media	-	-	-	1,981	1,981
2	2018	Prehistoric Species (Facebook)	Website	Media	-	-	-	62	62
3	2018	Kamiakun Fishing (Facebook)	Website	Media	-	-	-	607	607
4	2018	Luna the Lamprey - Collaboration (Facebook)	Website	Media	-	-	-	2,110	2,110
5	2018	Leavenworth Fisheries Complex - Collaboration (Facebook)	Website	Media	-	-	-	1,262	1,262
6	2018	Yakama Nation Fisheries (Agency Website)	Website	Media	-	-	-	1,050	1,050
7	2/8/2018	Columbia Insight: "The amazing ancient lamprey"	Newspaper / Website	Media	-	-	-	230	230
8	2/23/2018	The Columbia Basin Bulletin: "Council Fish/Wildlife Committee Gives..."	Newspaper / Website	Media	-	-	-	2,835	2,835
9	4/18/2018	Sunnyside Sun: "Why release lamprey when salmon runs remain marginal?"	Newspaper / Website	Media	-	-	-	475	475
10	4/18/2018	Tri-City Herald: "See weird fish, robots and scientists at Richland, Prosser..."	Newspaper / Website	Media	-	-	-	8,700	8,700
11	4/18/2018	Yakima Herald: "Outdoors Happenings: April 19, 2018"	Newspaper / Website	Media	-	-	-	2,809	2,809
12	4/25/2018	Daily Sun: "Yakamas release lamprey"	Newspaper / Website	Media	-	-	-	475	475
13	4/25/2018	Prosser Record-Bulletin - "Pacific Lamprey Project"	Newspaper / Website	Media	-	-	-	171	171
14	6/12/2018	Argonaut (UOI newspaper): "The bacon-cheeseburger of the sea"	Newspaper / Website	Media	-	-	-	754	754
15	6/12/2018	My Columbia Basin: "Pacific lamprey returns in record numbers	Newspaper / Website	Media	-	-	-	986	986
16	6/13/2018	The Oregonian: "Pacific lamprey show signs of recovery in Umatilla River"	Newspaper / Website	Media	-	-	-	19,434	19,434
17	6/14/2018	East Orgonian: "Pacific lamprey swarm Umatilla River in best numbers in years	Newspaper / Website	Media	-	-	-	500	500

Table E1-2. Summary of 2018 Yakama Nation Fisheries Pacific Lamprey Project outreach and education activities audience.

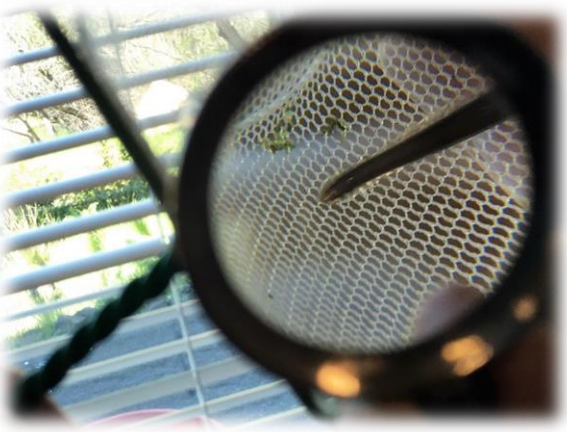
Type of Event	# of Events	# of Students	# of Teachers	# of Agency Workers	# of General Public	# of People (Total)
Outreach	31	3,931	331	245	905	5,412
Science Pres.	17	272	55	1,111	287	1,725
Media	17	-	-	-	44,441	44,441
Total	65	4,203	386	1,356	45,633	51,578




Directed/Edited by:
Ralph Lampman
Video Clips from:
Yakama Nation Fisheries
(Ralph Lampman & Tyler Beals)
USFWS (Ann Grote)
ODFW (Brian Jenkins)
LGL Alaska (Katie Menke)
Ishikawa Prefecture University
(Seiji Yanai)
Gaylord Mink
Music by:
Ryuichi Sakamoto
Respect your "elders,"
especially if they are


TEAM WAHLUKE


Lamprey ID & Tagging Training
???
Ralph Lampman
Tyler Beals
Yakama Nation Fisheries

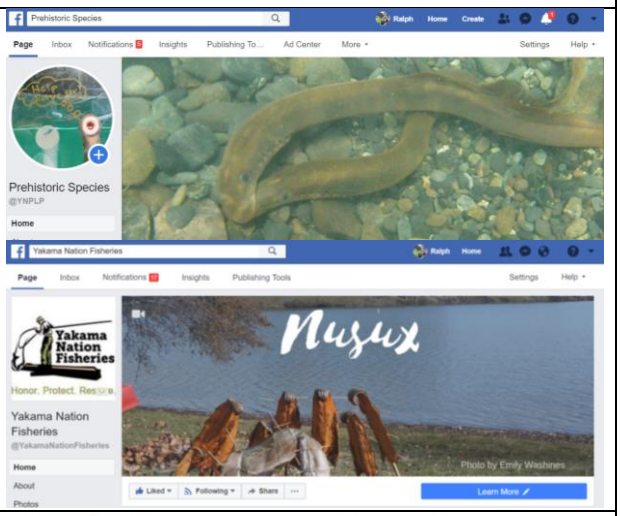


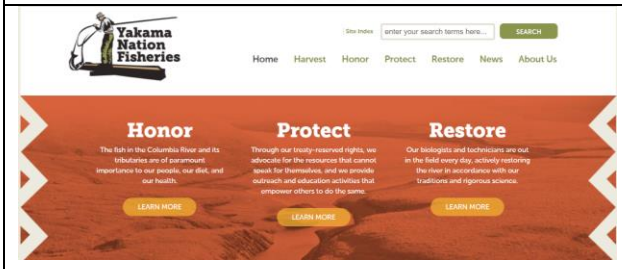

WILLIAM A. EGAN
CIVIC & CONVENTION CENTER


Curious Creatures
SCIENCE SYMPOSIUM
2018
FRIDAY NOVEMBER 2
1PM Leah Zacher
How to Make a Zombie Crab
2PM Ben Burford
Social Behavior Demystifies Squid
3PM Ralph Lampman
Pacific Lamprey - Keeping 450 Million Years of Tradition Alive
SATURDAY NOVEMBER 3
1PM Leslee Matsushige
The Fascinating, Fantastic, Fabulous Family of Fishes Seahorses, Seadragons and Pipefish
2PM Nicholas Pyenson
Beasts of the Northern Wild: Tracing the Evolution and Extinction of High Latitude Marine Megafauna
3PM Casey Clark
I am the Walrus!
SUNDAY NOVEMBER 4
1PM Hans Thewissen
Whales, Superheros, and Midoceanic Ridges
2PM Michael Castellini
Marine Monsters at Home, The Beauty of Life in the Sea
3PM Q&A with all Speakers


Ralph Lamp-rey-man
Indicator Species
Cultural tradition
Food source
Ecosystem engineers
450 Million Years of Adaptation and Wisdom
Big "Step" in Vertebrate Evolution


Reduce Dewatering Rates
Lamprey do not react to changes in head pressure (USGS Study)
The 'sediment level' is the most critical time for lamprey.


Prehistoric Species
@YNPLP
Yakama Nation Fisheries
Nusux
Photo by Emily Washines
Yakama Nation Fisheries
@YakamaNationFisheries


Yakama Nation Fisheries
Home
Harvest
Honor
Protect
Restore
News
About Us
Honor
Protect
Restore
LEARN MORE
LEARN MORE
LEARN MORE


SUNNYSIDE SUN
SPECK
Yakamas release lamprey
YELLOW PAGES

"SINCE 1892" WWW.RECORDBULLETIN.COM APRIL 25, 2018

Pacific Lamprey Project

Photo by Benton Conservation District

(rainbow tie dye shirt) of Yakima releasing a lamprey

Yakima River.

By Victoria Walker

Photo by Dave Hresanits-chuk

Lamprey are usually caught by hand where rapids and waterfalls force them to attach themselves to rocks.

Photo by Benton Conservation District

Grayson Squeochs holds a lamprey poster for his son Remy to pose.

See LAMPREY on page 5

LOCAL

See weird fish, robots and scientists at Richland, Prosser events this weekend

BY ANNETTE CARY

APRIL 18, 2018 07:05 PM, UPDATED APRIL 18, 2018 07:05 PM

Figure E1-1. A collection of photos from Yakama Nation Fisheries Pacific Lamprey Project outreach and education activities in 2018.

F. Work Element 161 – Local and Regional Participation

Work Element Associated Appendix Report:
Not Applicable

Throughout 2018, the YNPLP has continued to maintain a strong presence in supporting and guiding Pacific Lamprey recovery efforts in the Yakima Subbasin and in the Upper and Mid Columbia River basins. The following outlines some of the key activities YNPLP staff are involved with:

<u>Coordination with the Bureau of Reclamation in the Yakima Subbasin</u>
Technical representatives for both the YNPLP and Bureau of Reclamation (the Reclamation) continue to communicate and discuss operations on a regularly basis to coordinate studies and findings on Reclamation facilities, primarily in the lower Yakima River. These meetings have focused primarily on 1) larval/juvenile lamprey salvage/collection in irrigation diversions, 2) intensive monitoring associated with larval/juvenile entrainment in select diversions, 3) juvenile lamprey acoustic telemetry planning, and 4) adult passage improvement planning and implementation. Discussions continue with the Reclamation and irrigation districts about logistics for implementing various components of larval/juvenile lamprey monitoring, salvage, and adult and larval/juvenile passage improvement using funds from Reclamation (Science and Technology Funds), Natural Resources Conservation Service (NRCS) 2015-2020 5-year grant, and McNary Mitigation Funds.

In collaboration with Reclamation and USFWS, the YNPLP continues to work towards implementation of adult Pacific Lamprey passage improvement at Prosser Dam and other lower Yakima River irrigation diversion dams. We are implementing a multi-year passage improvement

project targeted at Prosser, Sunnyside, and Wapato dams and will also focus on Horn Rapids and Roza dams in the near future. A pilot lamprey passage devise (vertical wetted wall) was first installed in 2016 and currently five of these passage structures are installed at Prosser Dam (in all three fish ladders). These discussions will continue over the next couple years with the intent to implement several more structures between 2019 - 2020, including Sunnyside and Wapato diversion dams (funded primarily through NRCS).

Coordination with the Irrigation Districts in the Yakima Subbasin

Due to the need to monitor and salvage larval/juvenile lamprey from irrigation diversions, there is a strong need to build a good relationship with the local irrigation districts. Over the years, we have worked with multiple irrigation districts, including managers and personnel from Sunnyside, Wapato, Congdon diversions and a group of diversions in Ahtanum Creek. We also present and share our research results and updates with the irrigation district managers through the Yakima Basin Joint Board meeting periodically. Since 2016, we have been working closely with Wapato Irrigation Project (WIP) and Sunnyside Valley Irrigation District to discuss short term low cost solutions for mitigating larval entrainment and mortalities. The WIP managers were willing to reduce the dewatering rate in mid-October (shutting down fewer gates at a time and extending the dewatering duration) to reduce the desiccation of lamprey on dry banks; this helped reduce the bank mortality of lamprey significantly in 2016 and provided a great example of the positive outcome from collaboration. In 2018, we experimented with a sprinkler system to keep the dried fine sediment wet and moist so that stranded larval lampreys have a better chance of surviving dewatering during the evening when our staff are not available.

Coordination with the USACE in the Columbia River Basin

Technical representatives of the YN continue to meet quarterly with technical representatives of the USACE with the primary intent to improve juvenile and adult passage conditions through the FCRPS hydro-electric facilities on the mainstem Columbia River. Over the past year the emphasis has been the prioritization of adult passage improvement and juvenile monitoring projects which will incorporate (1) monitoring newly constructed passage structures at Bonneville, John Day and McNary dams, (2) development of a study design for future juvenile research and (3) prioritization of research for both juvenile and adult passage interests. The micro-tag has recently been developed by Pacific Northwest National Laboratory and we are now implementing the second year of a study in the Lower Yakima to test the efficacy of these tags inserted into juvenile lamprey (macrophthalmia). Longer-term planning continues with important priority considerations: implementation vs additional needed research, adult vs juvenile, lower Columbia Projects vs Snake River projects. Many of these considerations are also well coordinated with the USACE sponsored Study Review Work Group (SRWG).

Coordination with the CRITFC in the Columbia River Basin

A considerable amount of planning and coordination continues with the CRITFC in the development of the "Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research," which was submitted to the NPCC in March 2018. There is extensive coordination work associated with genetic sampling for adults and juvenile/larvae, including collection, prioritization, and analysis. The YN policy and technical representatives also continue to meet with the CRITFC Pacific Lamprey Tribal Task Force frequently. Typical agenda items associated with these meetings include the USFWS Conservation Agreement, progress in passage at the FCRPS facilities, progress in adult and juvenile supplementation, coordination for genetic sample analyses, planning for contamination and toxicology studies, and general coordination among the YNPLP and various member tribes for each of our annual project activities. Of primary importance to CRITFC and tribal policy representatives is the ever-present question: When are we going to accelerate the implementation of solutions (instead of short-term stop gap measures)?

Coordination with the USFWS: Regional Conservation Team (CT)

In June, 2011 the USFWS initiated a Pacific Lamprey Conservation Agreement in which the YN is a signatory. Both technical and policy representatives are communicating with the USFWS at multiple administrative levels to strengthen the commitment of this agreement. The YN recognizes that multiple threats exist that limit abundance, productivity and spatial distribution throughout the Ceded Lands subbasins and that multiple agencies, jurisdictions and publics are needed to realize recovery objectives. The YN anticipates working closely with all relevant partnerships to accelerate implementation of various actions at each subbasin scale, within the context of the Conservation Agreement. The forth Lamprey Summit was successfully held in December, 2017, which was also timed with the re-initiation of the 2012 Pacific Lamprey Conservation Agreement. The YN presented and were partners for several separate topics of presentations at the 2nd Information Exchange Workshop in December 2018: 1) juvenile entrainment, 2) juvenile acoustic study, 3) larval/juvenile predation, 4) artificial propagation and larval rearing, and 5) larval lamprey habitat thermal dynamics.

Coordination with the Lamprey Technical Work Group (LTWG)

Technical representatives continue to meet periodically with the LTWG, whose meetings are held biannually focusing on regionally important lamprey coordination / conservation projects. There are also several subgroups that convene meetings more regularly to develop answers and solutions to various specific topics, including critical uncertainties update, adult passage guidelines, best management practice updates, eDNA case study summary, etc. YNPLP staff are currently active in the following subgroups: 1) adult engineering, 2) juvenile engineering and dredging investigations (JEDI), 3) tagging, 4) contaminants, 5) subgroup on other lampreys anadromous and resident (SOLAR).

Coordination with the Mid-Columbia Public Utility Districts

Both YN policy and technical representatives participate and provide significant leadership in implementation of PUD mitigation associated with their FERC licenses. Each of the three Public Utility Districts (Grant, Chelan and Douglas counties) have Pacific Lamprey Management Plans as a component of their FERC licenses. The YN technical representatives regularly attend monthly meetings associated with the implementation of each of the PUD's Pacific Lamprey Management Plans. In collaboration with partners (the Confederated Tribes of the Umatilla Indian Reservation, NOAA Fisheries, and USFWS), we continue to collaborate to investigate the best management practices for rearing larvae/juvenile from artificial propagation, using Chelan County PUD funding allocated for Pacific Lamprey Management.

For activities related to disseminating raw/summary data and results stemming from this project, see Work Element 99 (Outreach and Education) and **Appendix E1**. Each of our team members have taken the time to present our latest findings and results in many local, state, and regional conferences throughout the year in 2018.

G. Work Element 158 – PIT Tag Adult Lamprey

Work Element Associated Appendix Report:

Appendix G1 – Translocation of Adult Pacific Lamprey within the Yakima Subbasin, 2017-2018 Broodstock)

Photo G1. Adult Pacific Lamprey being released above Prosser Dam on Yakima River (river km 76.1) by the general public during an open house release event on April 21, 2018.

Appendix G1 is composed of two parts: 1) summary of all 2017-2018 broodstock adult Pacific Lamprey releases during the spring 2018 migration season within the Yakima Subbasin and 2) analysis of migration data from those adults that were PIT tagged. As part of the translocation release, we have PIT tagged many of the adults released to learn more about their spawning

migration, potential passage barriers, and final spawning destinations. From the Lower Columbia 2017-2018 broodstock (adults collected in summer 2017 that primarily mature in 2018), a total of 531 adult Pacific Lamprey were released within the Yakima Subbasin between March 22 and May 30, 2018 (Fig. G1-1). This is the seventh year that adult Pacific Lamprey were translocated into the Yakima Subbasin. Larval Pacific Lamprey have not been documented upstream of Roza Diversion Dam (river km 210.5) until recently in 2016 (after adult translocation in Upper Yakima occurred in 2015).

From the PITAGIS regional data base (http://www.ptagis.org/), using Query Builder2 Reports, the interrogation data of PIT tagged lamprey were summarized (Fig. G1-2). A total of 126 lamprey (38.8%) out of 324 total PIT tagged lamprey released were detected in at least one PIT array site (Table G1-1). The highlights from the 2017-2018 broodstock adult Pacific Lamprey translocation monitoring in the Yakima Subbasin are the following:

- Sites that detected lamprey the most were ROZ (Roza Diversion Dam Combined; river km 210.5) at 14.6%, PRO (Prosser Diversion Dam Combined; river km 75.7) at 13.4%, Upper Toppenish (river km 55.5) at 4.5%, and Lower Ahtanum (river km 4.0) at 4.1%.
- Adult lamprey holding underneath Prosser Dam fish ladder PIT arrays was an issue in 2017, but this was resolved after vexar plastic mesh was attached to the nearby surface area.
- The number of adults migrating to Prosser Dam in spring 2018 was estimated to be ~2,613 based on a mark recapture study (>58.6% of which are estimated to pass the dam based on PIT tag detections).
- The number of adults passing Roza Dam is still unknown, but PIT tag detections display the behavior of lamprey repeatedly ascending and descending the three weir PIT arrays.

See **Appendix G1** for more information.

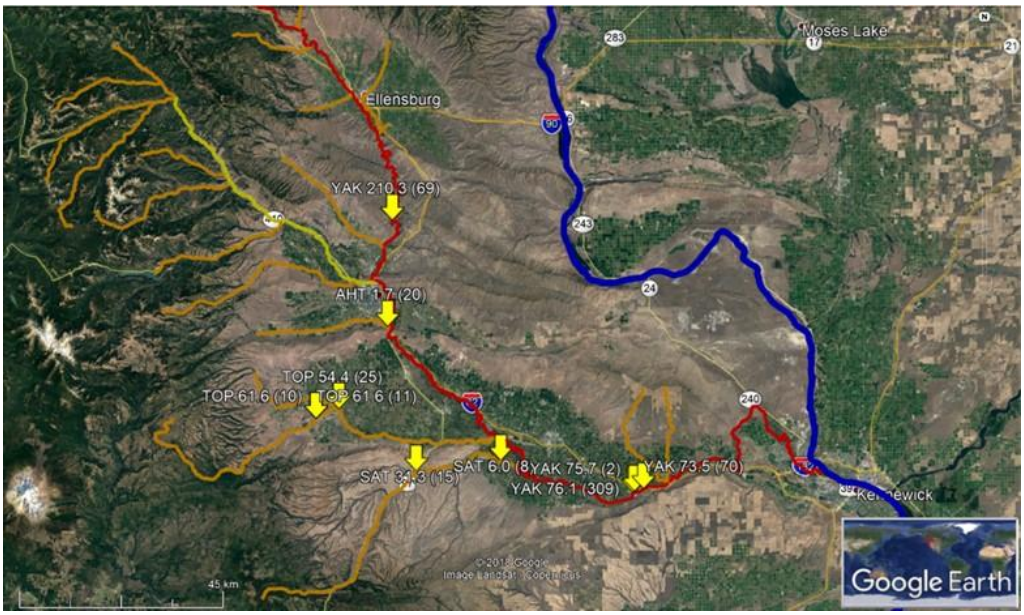


Figure G1-1. Overall aerial map of 2017-2018 broodstock Pacific Lamprey translocation release sites in the Yakima Subbasin. "YAK" stands for Yakima, "SAT" stands for Satus, "TOP" stands for Toppenish, "AHT" stands for Ahtanum, the number next to the stream name is the river km, and the number in parenthesis is the total number of lamprey released. The red line represents mainstem Yakima River, the orange lines represent key tributaries, and the blue line represents the Columbia River.

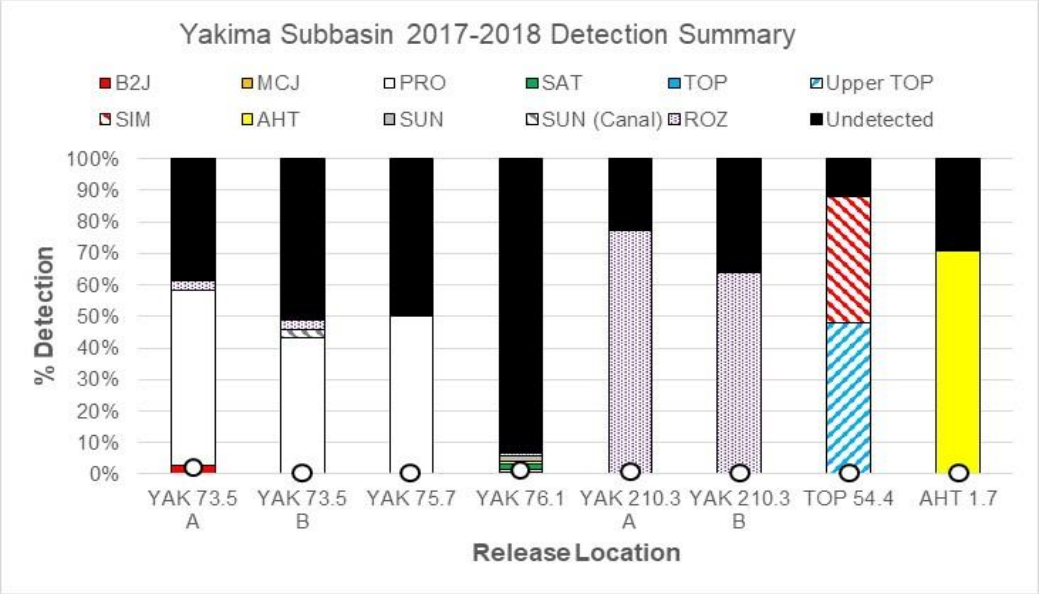


Figure G1-2. Summary of PIT array detections from each release event (with at least one detection event) in the Yakima Subbasin for the 2017-2018 broodstock Pacific Lamprey translocation. For the release location, "YAK" stands for Yakima, "TOP" stands for Toppenish, "AHT" stands for Ahtanum, and the number next to the stream name is the river km (see Part I for more information). The three letter abbreviation assigned by PTAGIS is used for each of the detection site (see Table 1.1-1 for more description of the site). The white circle on the graph indicates the relative location of the release in relation to the respective detection sites (sites above are upstream of the release sites, whereas those below are downstream).

Table G1-1. Summary of 2017-2018 broodstock Pacific Lamprey translocation detection sites from the Yakima Subbasin releases. The three letter abbreviation assigned by PTAGIS is used for each of the detection site and site name provides more description. "Site Name" that start with * indicate that the site is not an official PTAGIS site and hence detection data are not currently available from the PTAGIS website.

Site Subbasin Name	Site Code Value	Site Name	River	River KM	# of Lamprey Detected	% of Lamprey Detected
Lower Columbia-Sandy	B2J	B2J - Bonneville PH2 Juvenile	Columbia	229.5	1	0.3%
Middle Columbia-Lake Wallula	MCJ	MCJ - McNary Dam Juvenile	Columbia	464.9	2	0.6%
Lower Yakima	PRO	PRO - Prosser Diversion Dam Combined	Yakima	75.7	42	13.4%
Lower Yakima	-	*Sunnyside Diversion Canal	Yakima	171.0	1	0.3%
Lower Yakima	SUN	SUN - Sunnyside Instream Array	Yakima	171.1	3	1.0%
Upper Yakima	ROZ	ROZ - Roza Diversion Dam (Combined)	Yakima	210.5	46	14.6%
Lower Yakima	SAT	SAT - Lower Satus Creek	Satus	4.3	2	0.6%
Lower Yakima	TOP	TOP - Lower Toppenish Creek	Toppenish	2.1	4	1.3%
Lower Yakima	-	*Upper Toppenish	Toppenish	55.5	14	4.5%
Lower Yakima	SIM	*Simcoe	Simcoe	8.9	10	3.2%
Lower Yakima	AHT	*Lower Ahtanum	Ahtanum	4.0	13	4.1%
Total Detections	**-**	**-**	**-**	**-**	**138**	**-**
Total # of Lamprey	**-**	**-**	**-**	**-**	**126**	**38.9%**

Appendix G2 – Translocation of Adult Pacific Lamprey within the Wenatchee Subbasin, 2017-2018 Broodstock

Photo G2. Releasing adult lamprey with the general public in Wenatchee River at Jolanda Lake (river km 50.4) on August 31, 2017; Tyler Beals in the background demonstrating electrofishing methods for larval lamprey surveys.

This report is composed of two parts: 1) summary of all 2017-2018 broodstock adult Pacific Lamprey releases within the Wenatchee Subbasin and 2) analysis of migration data from PIT tagged adults. From the Lower Columbia 2017-2018 broodstock (adults collected in summer 2017 that primarily mature in 2018), a total of 275 adult Pacific Lamprey were released at six locations

within the Wenatchee Subbasin between August 31, 2017, and April 23, 2018 (Fig. G2-1). This is the third year that adult Pacific Lamprey were translocated into the Wenatchee Subbasin. Translocation was implemented beginning in 2016 out of concern for the species extinction observed upstream of Tumwater Dam and also to enhance the larval pheromone signal from Upper Wenatchee River to improve adult lamprey attraction. From the PITAGIS regional data base (http://www.ptagis.org/), using Query Builder2 Reports, the interrogation data of PIT tagged lamprey were summarized. Out of 275 PIT tagged lamprey, 143 lamprey (52.0%) were detected in at least one PIT array site within the Columbia Basin (Table G2-1). The highlights from the 2017-2018 broodstock Pacific Lamprey translocation monitoring in the Wenatchee Subbasin are the following:

- Sites that detected lamprey the most were TUF (Tumwater Dam Adult Fishway; river km 49.6) at 25.5%, UWE (Upper Wenatchee River; river km 80.9) at 15.6%, NAL (Lower Nason Creek; river km 0.8) at 11.6%, and LWE (Lower Wenatchee River; river km 2.7) at 10.9%.
- Based on detections at Tumwater Dam from all releases, the estimated number of lamprey that potentially achieved dam passage (i.e. detection at "Weir 18") was estimated to be 12.8% during the summer season and 6.5% during the spring season, which is similar to the estimate provided by us the previous year (6.0%) (Table G2-2). Of these last detected at Weir 18, two lamprey were also detected in the Lower Nason Creek instream array.
- We estimated that 398-602 adult lamprey may have approached Tumwater Dam between 2017 and 2018 based on window count detection efficiency through PIT tagged lamprey and total observed lamprey that passed the dam (Table G2-3).

See **Appendix G2** for more information.

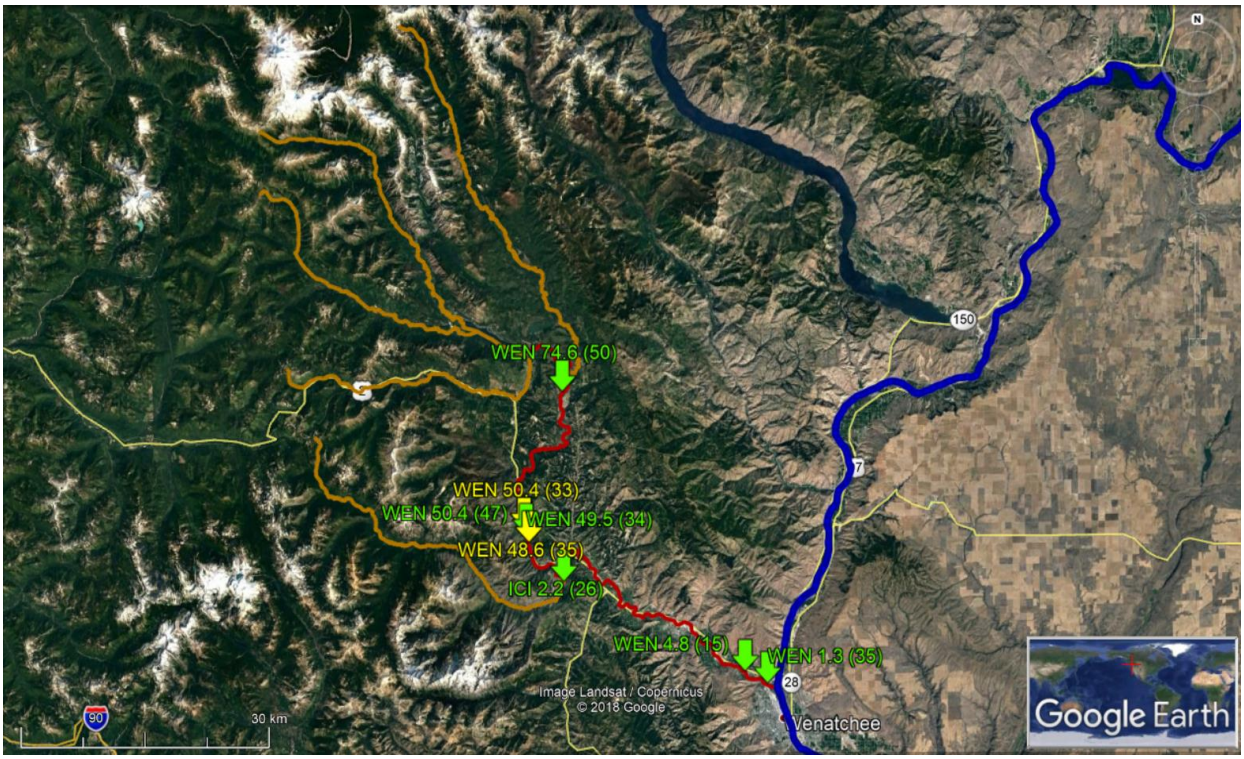


Figure G2-1. Overall aerial map of 2016-2017 broodstock Pacific Lamprey translocation release sites in the Wenatchee Subbasin. "WEN" stands for Wenatchee, the number next to the stream name is the river km, and the number in parenthesis is the total number of lamprey released (green label indicates summer 2017 releases and yellow label indicates spring 2018 releases). The red line represents mainstem Wenatchee River, the orange lines represent key tributaries, and the blue line represents the Columbia River.

Table G2-1. Summary of 2017-2018 broodstock Pacific Lamprey translocation detection sites from the Wenatchee Subbasin releases. The three letter abbreviation assigned by PTAGIS is used for each of the detection site and site name provides more description.

Site Subbasin Name	Site Code Value	Site Name	River	River KM	# of Lamprey Detected	% of Lamprey Detected
Wenatchee	LWE	LWE - Lower Wenatchee River	Wenatchee	2.7	30	10.9%
Wenatchee	TUF	TUF - Tumwater Dam Adult Fishway	Wenatchee	49.6	70	25.5%
Wenatchee	UWE	UWE - Upper Wenatchee River	Wenatchee	80.9	43	15.6%
Wenatchee	ICL	ICL - Lower Icicle Instream Array	Icicle	0.4	4	1.5%
Wenatchee	ICM	ICM - Middle Icicle Instream Array	Icicle	6.8	2	0.7%
Wenatchee	NAL	NAL - Lower Nason Creek	Nason	0.8	32	11.6%
Wenatchee	NAU	NAU - Upper Nason Creek	Nason	19.5	6	2.2%
Total Detections	-	-	-	-	**187**	-
Total # of Lamprey	-	-	-	-	**143**	**52.0%**

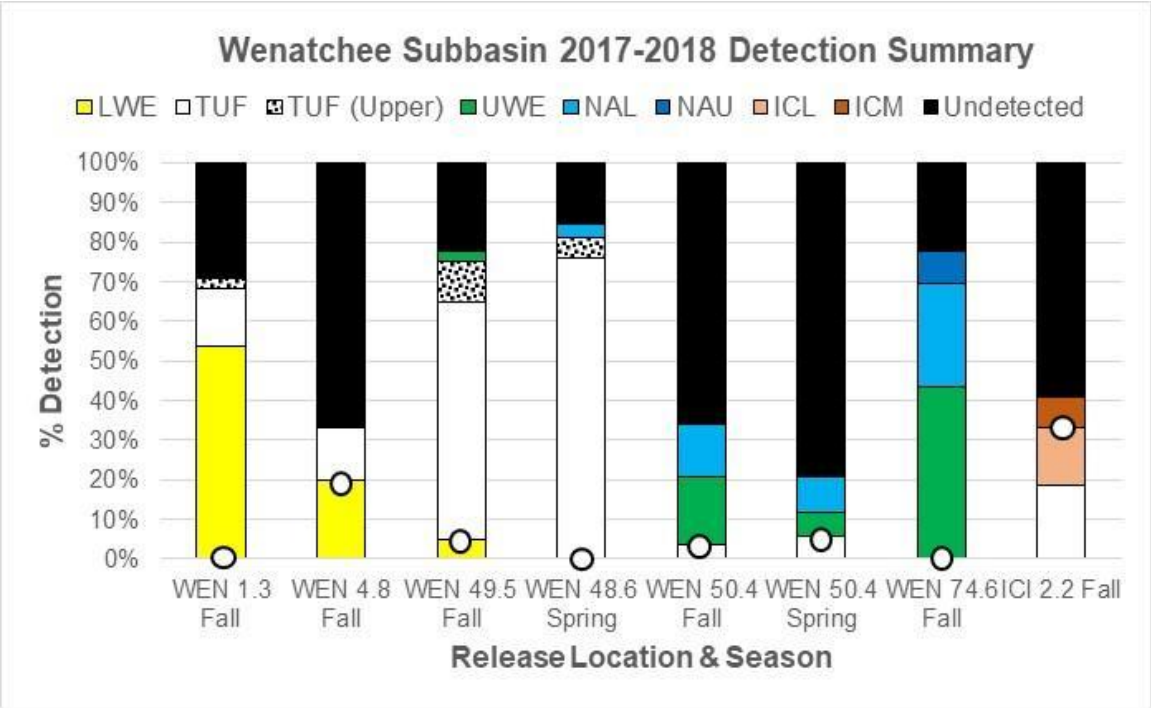


Figure G2-2. Summary of PIT array detections from each release events within the Wenatchee Subbasin for the 2017-2018 broodstock Pacific Lamprey translocation. For the release location, "WEN" stands for Wenatchee River, "ICI" stands for Icicle Creek, and the number next to the stream name is the river km. The three letter abbreviation assigned by PTAGIS is used for each of the detection site (see Table 21 for more description of the site). The white circle on the graph indicates the relative location of the release in relation to the respective detection sites (sites above are upstream of the release sites, whereas those below are downstream).

Table G2-2. Summary of PIT array detections at Tumwater Dam ("TUF") and those that had their last detection at "Weir 18" within Tumwater Dam ("TUF TOP") from all release events within the Wenatchee Subbasin for the 2017-2018 broodstock Pacific Lamprey translocation.

Release \ Site	# Tagged	# TUF	# TUF TOP	%
WEN 1.3 Fall	35	6	1	16.7%
WEN 4.8 Fall	15	2	0	0.0%
WEN 49.5 Fall	34	24	4	16.7%
WEN 50.4 Fall	47	2	0	0.0%
WEN 74.6 Fall	50	-	-	0.0%
ICI 2.2 Fall	26	5	0	0.0%
Overall Fall	**207**	**39**	**5**	**12.8%**
WEN 48.6 Spring	35	29	0	0.0%
WEN 50.4 Spring	33	2	2	100.0%
Overall Spring	**68**	**31**	**2**	**6.5%**

Table G2-3. Summary of all lamprey observations at Tumwater Dam and the corresponding trapping operations since translocation began in 2016 (data from DART Adult Passage Daily Counts for All Species website: http://www.cbr.washington.edu/dart/query/adult_daily). Those that had the same detection date as our PIT tagged lamprey released were noted as "Trap" (if recaptured at the fish hopper trap) or "Video" in the "PIT Lamprey Passage" column. One of the lamprey's PIT tag detection date (September 5, 2018) was one day earlier than one of the passage dates (September 6, 2018); hence, "?" was used in the "PIT Lamprey Passage" column to note this lamprey may potentially be a PIT tagged lamprey.

Passage Date	#	Trapping Operation	PIT Lamprey Passage
8/5/2017	1	6am-4pm Mon-Fri	-
8/10/2017	1	6am-4pm Mon-Fri	-
8/11/2017	1	6am-4pm Mon-Fri	-
8/12/2017	1	6am-4pm Mon-Fri	-
8/13/2017	1	6am-4pm Mon-Fri	-
8/18/2017	1	6am-4pm Mon-Fri	-
8/22/2017	1	6am-4pm Mon-Fri	-
9/1/2017	1	No Trapping	Video
9/2/2017	1	No Trapping	-
9/6/2017	1	No Trapping	?
7/23/2018	1	6am-4pm Mon-Thu	Trap
7/26/2018	1	6am-4pm Mon-Thu	-
7/27/2018	1	6am-4pm Mon-Thu	-
7/29/2018	1	6am-4pm Mon-Thu	-
7/30/2018	1	6am-4pm Mon-Thu	-
8/1/2018	1	6am-4pm Mon-Thu	-
8/6/2018	1	6am-4pm Mon-Thu	-
8/7/2018	1	6am-4pm Mon-Thu	-
8/9/2018	1	6am-4pm Mon-Thu	-
8/11/2018	1	6am-4pm Mon-Thu	-
8/14/2018	1	6am-4pm Mon-Thu	-
8/18/2018	1	6am-4pm Mon-Thu	-
Total	**22**	**-**	**-**

Appendix G3 – Translocation of Adult Pacific Lamprey within the Methow Subbasin, 2017-2018 Broodstock

Photo G3. Outreach event with Methow Valley Independent Learning Center prior to releasing the adult Pacific Lamprey into Upper Methow River on April 13, 2018).

This report is composed of four parts: 1) summary of Lower Columbia 2017-2018 broodstock adult Pacific Lamprey releases within the Methow Subbasin, 2) analysis of migration data from Lower Columbia 2017-2018 PIT tagged adults, 3) summary of Mid-Columbia 2017-2018 broodstock adult Pacific Lamprey releases within the Upper Columbia, and 4) analysis of migration data from Mid-Columbia 2017-2018 PIT tagged adults. Prior to translocation, larval numbers and distribution have steadily decreased in the recent years and the younger age classes were mostly absent, likely as a result of depressed numbers of adults moving into the subbasin. Translocation was implemented in 2015 out of concern for the possibility of species extinction in the near future within the entire subbasin.

From the Lower Columbia 2017-2018 broodstock (adults collected in summer 2017 that primarily mature in 2018), a total of 285 adult Pacific Lamprey were released in the Methow Subbasin and 95 adults were released in the mainstem Columbia just downstream of Methow River confluence (Fig. G3-1). Adults were released at eight locations between September 5, 2017, and April 13, 2018. This is the third year that adult Pacific Lamprey were translocated into the Methow Subbasin. In addition, 314 adult Pacific Lamprey from Priest Rapids Dam were released in the Upper Columbia on August 16, 2017 (136 below Methow River confluence, 129 below Okanogan River confluence, and 49 into Similkameen River), as a result of collaboration between Yakama Nation Fisheries, Colville Tribes Fish and Wildlife, and Douglas and Grant County Public Utility districts (Fig. G3-2). In total, 360 adults were released in mainstem Columbia, 285 in Methow Subbasin, and 49 in Okanogan Subbasin. From the PITAGIS regional data base (http://www.ptagis.org/), using Query Builder2 Reports, the interrogation data of PIT tagged lamprey were summarized. Overall, 42% were detected from the Lower Columbia broodstrock releases (which focused on the Methow Subbasin releases (Table G3-1) and only 18% were detected from the Mid-Columbia broodstock releases which focused on mainstem Columbia releases (Table G3-2). The largest number of detections were from Chewuch River (especially river km 1.6), and very few (n=3) were detected moving into Upper Methow River (upstream of Chewuch River confluence) (Fig. G3-3). As of now, most lamprey migrating in mainstem Upper Columbia appear to be entering Methow River and many of those entering Methow River appear to select Chewuch River as their final destination (Fig. G3-4).

See **Appendix G3** for more information.

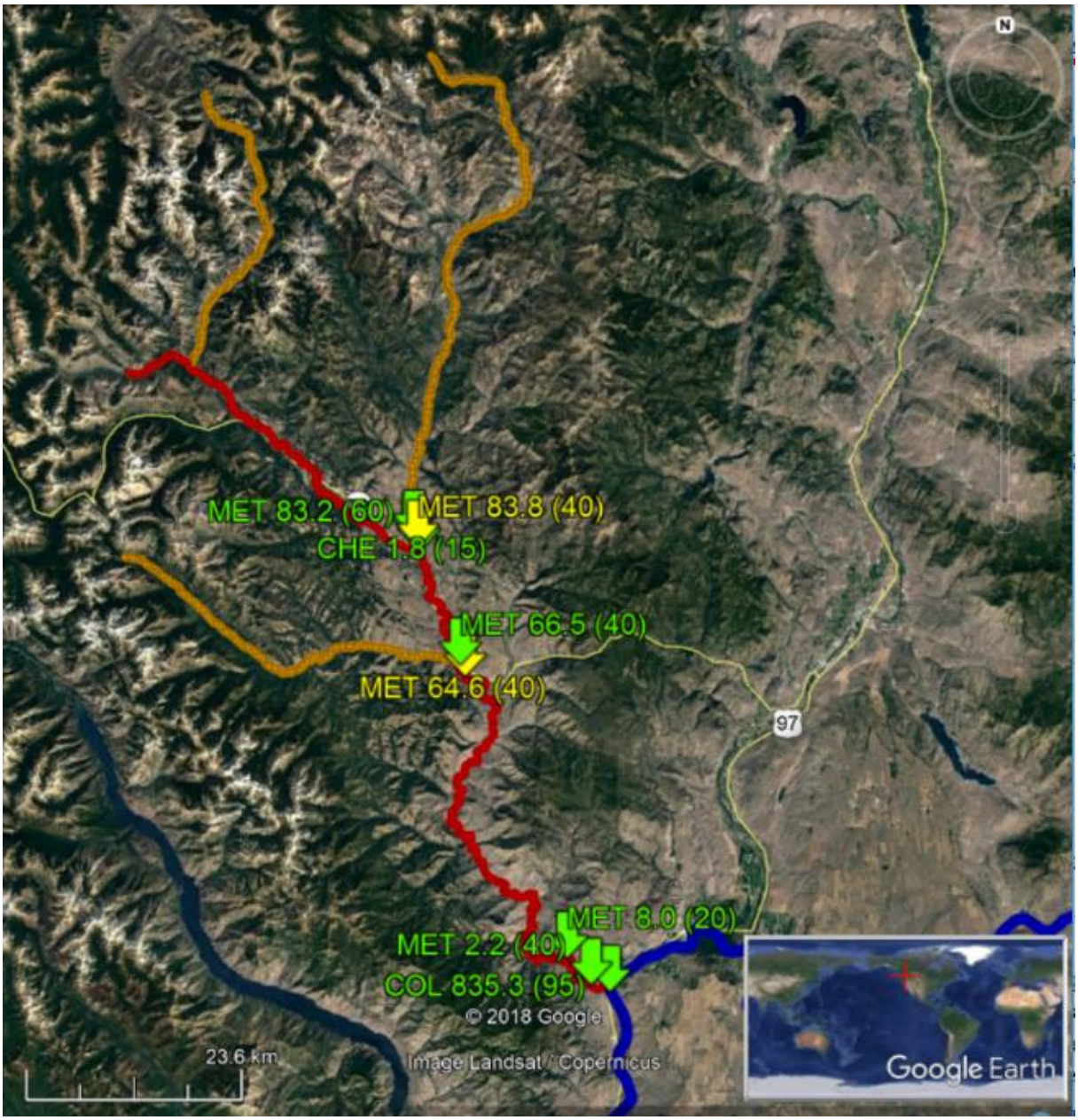


Figure G3-5. Overall aerial map of Lower Columbia 2017-2018 broodstock Pacific Lamprey translocation release sites in the Methow Subbasin (including one Columbia River release site). "MET" stands for Methow, "CHE" stands for Chewuch, "COL" stands for Columbia, the number next to the stream name is the river km, and the number in parenthesis is the total number of lamprey released. The red line represents mainstem Methow River, the orange lines represent its tributaries (Twisp, Chewuch, and Lost rivers from downstream to upstream), and the blue line represents the Columbia River.

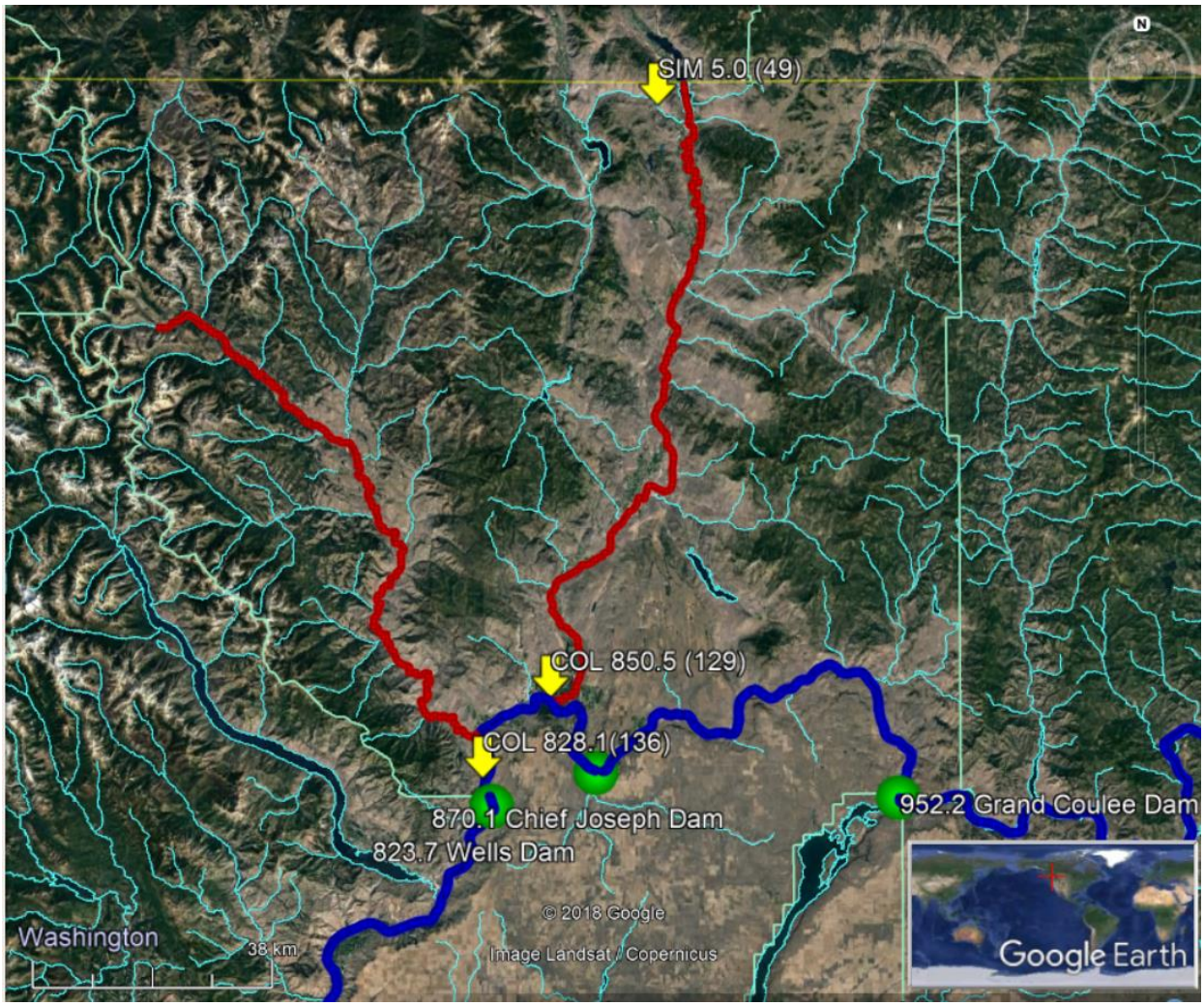


Figure G3-2. Overall aerial map of Mid-Columbia 2017-2018 broodstock Pacific Lamprey translocation release sites in the Upper Columbia Basin (yellow arrows). "COL" stands for Columbia, "SIM" stands for Similkameen, the number next to the stream name is the river km, and the number in parenthesis is the total number of lamprey released. The red line represents Methow (left) and Okanogan (right) rivers and the blue line represents the Columbia River. Upper Columbia River dams and their river km are also displayed (green circles).

Table G3-1. Summary of Lower Columbia 2017-2018 broodstock Pacific Lamprey translocation detection sites from the Methow Subbasin releases (including one Columbia River release). The three letter abbreviation assigned by PTAGIS is used for each of the detection site and site name provides more description.

Site Subbasin Name	Site Code Value	Site Name	River	River KM	# of Lamprey Detected	% of Lamprey Detected
Upper Columbia-Entiat	RRJ	RRJ - Rocky Reach Dam Juvenile	Columbia	755.9	1	0.3%
Chief Joseph	WEA	WEA - Wells Dam, DCPUD Adult Ladders	Columbia	823.7	1	0.3%
Upper Columbia-Entiat	ENL	ENL - Lower Entiat River	Entiat	1.9	2	0.5%
Methow	LMR	LMR - Lower Methow River at Pateros	Methow	3.1	43	11.5%
Methow	MRC	MRC - Methow River at Carlton	Methow	46.4	23	6.1%
Methow	M3R	M3R - 3R side channel Methow River	Methow	78.2	5	1.3%
Methow	MWF	MWF - Whitefish SC in Methow River	Methow	80.2	6	1.6%
Methow	MRW	MRW - Methow River at Winthrop	Methow	88.3	3	0.8%
Methow	CRW	CRW - Chewuch River above Winthrop	Chewuch	1.6	79	21.1%
Methow	CRU	CRU - Upper Chewuch Instream Array	Chewuch	28.1	24	6.4%
Total Detections	**-**	**-**	**-**	**-**	**187**	**-**
Total # of Lamprey	**-**	**-**	**-**	**-**	**158**	**42.1%**

Table G3-2. Summary of Mid-Columbia 2017-2018 broodstock Pacific Lamprey translocation detection sites from the Upper Columbia releases. The three letter abbreviation assigned by PTAGIS is used for each of the detection site and site name provides more description.

Site Subbasin Name	Site Code Value	Site Name	River	River KM	# of Lamprey Detected	% of Lamprey Detected
Wenatchee	LWE	LWE - Lower Wenatchee River	Wenatchee	2.7	1	0.3%
Upper Columbia-Entiat	ENL	ENL - Lower Entiat River	Entiat	1.9	1	0.3%
Chief Joseph	WEA	WEA - Wells Dam, DCPUD Adult Ladders	Columbia	823.7	2	0.6%
Methow	LMR	LMR - Lower Methow River at Pateros	Methow	3.1	15	4.9%
Methow	MRC	MRC - Methow River at Carlton	Methow	46.4	7	2.3%
Methow	MWF	MWF - Whitefish SC in Methow River	Methow	80.2	1	0.3%
Methow	CRW	CRW - Chewuch River above Winthrop	Chewuch	1.6	21	6.8%
Methow	CRU	CRU - Upper Chewuch Instream Array	Chewuch	28.1	2	0.6%
Okanogan	OKL	OKL - Lower Okanogan Instream Array	Okanogan	25.1	4	1.3%
Total	**-**	**-**	**-**	**-**	**54**	**17.5%**

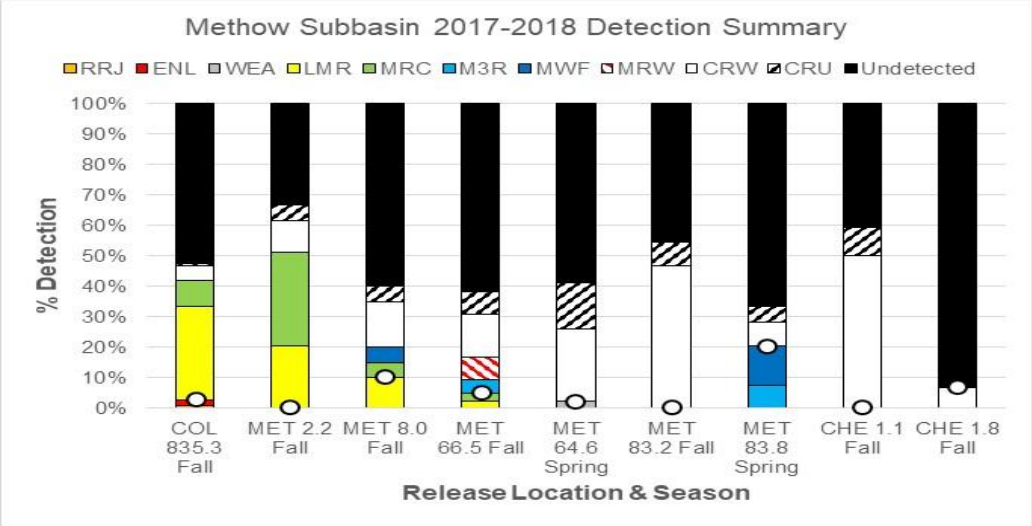


Figure G3-3. Summary of PIT array detections from each release events within the Methow Subbasin

(including one release in Columbia River) for the Lower Columbia 2017-2018 broodstock Pacific Lamprey translocation. For the release location, "COL" stands for Columbia, "MET" stands for Methow, "CHE" stands for Chewuch River, and the number next to the stream name is the river km (see Part I for more information). The three letter abbreviation assigned by PTAGIS is used for each of the detection site (see Table 20 for more description of the site). The white circle on the graph indicates the relative location of the release in relation to the respective detection sites (sites above are upstream of the release sites, whereas those below are downstream).

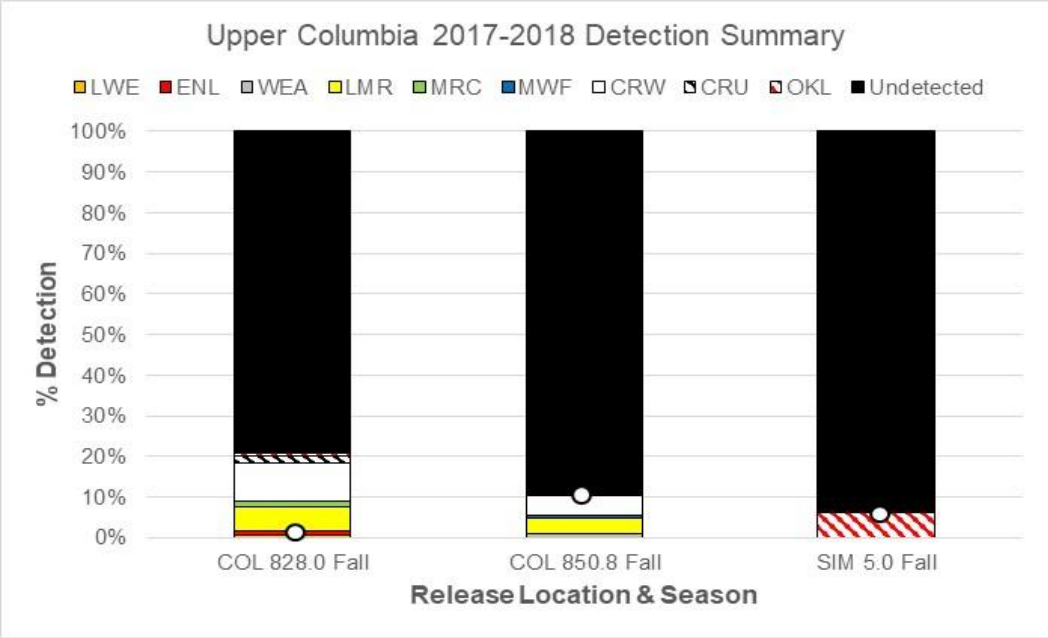


Figure G3-4. Summary of PIT array detections from each release event in Upper Columbia Basin for the Mid-Columbia 2017-2018 broodstock Pacific Lamprey translocation. For the release location, "COL" stands for the Columbia River, "TOP" stands for Toppenish, "AHT" stands for Ahtanum, and the number next to the stream name is the river km (see Part III for more information). The three letter abbreviation assigned by PTAGIS is used for each of the detection site (see Table 27 for more description of the site). The white circle indicates the relative location of the release in relation to the respective detection sites (sites above are upstream of the release sites, whereas those below are downstream).

H. Work Element 158 – PIT Tag Juvenile Lamprey

Work Element Associated Appendix Report:

Appendix H1 – Survival Assessment of Juvenile Pacific Lamprey Implanted with a Dummy Acoustic Tag for a Yakima Basin Acoustic Telemetry Study

Photo H1. The overall aquaria set-up inside Prosser Fish Hatchery lamprey conex building where lamprey were monitored daily (left photo). The removable black mesh we used to cover the tanks and to keep them dark is also displayed (right photo).

Appendix H1 describes the dummy tag holding study that YN conducted in partnership with U.S. Geological Survey. Juvenile Pacific Lamprey (macrophthalmia) were tagged with a prototype acoustic transmitter developed by Pacific Northwest National Laboratory (PNNL, Pasco, WA) to track their migration from the Lower Yakima River to the Lower Columbia River (Bonneville Dam). The small tag is 12 mm in length, weighs 0.08 gram, and has a battery life of 30 days (with a pulse rate of 5 seconds). Reliable analysis of detection data during this study was dependent on a comprehensive understanding of lamprey recovery and overall survival from tag implantation.

To address this uncertainty, a small group of juvenile lamprey were implanted with dummy acoustic tags and closely monitored for a 30-day period (to mimic acoustic tag battery lifespan) in a controlled laboratory environment (10-gallon aquaria; Prosser Hatchery). Dummy tagged lamprey were monitored for survival, surgery recovery, and overall changes in body condition (length and weight) during the 30-day holding period.

In this study, dummy tagged lamprey showed high survival over the 30-day holding period. We observed that incisions healed well over the holding period, with the majority (84.6%) of incisions closed and healed with minimal scarring (Fig. H1-1). Overall survival of dummy tagged lamprey was slightly lower than the control (untagged) lamprey held in the same aquaria (83.9% and 96.2%, respectively) (Fig. H1-2). However, a small portion of dummy tagged lamprey (n=3) were infected with fungus prior to tagging and all died after 19 days. Tagged lamprey that were not infected with fungus at the onset had a comparable survival rate to the control lamprey (96.3% and 96.3%, respectively). We also saw similar body condition changes over the holding period (length/weight) for both dummy tag and control fish, indicating the tag has minimal impact on physiological changes, at least for the 30-day battery life of the tag.

Only 35% met the minimum size threshold of 140 mm that was used for the field study, primarily due to limited availability of large sized juvenile lamprey (Table H1-1). Despite the use of smaller juvenile lamprey, our study showed that the acoustic tag implantation process presumably had

minimal impact on survival. As long as fish infected with fungus prior to tagging are excluded, fungus development was equal for control lamprey and dummy tagged lamprey, indicating that the tag implantation process appears to have no discernable impact on fungal infection occurrences.

See **Appendix H1** for more information.

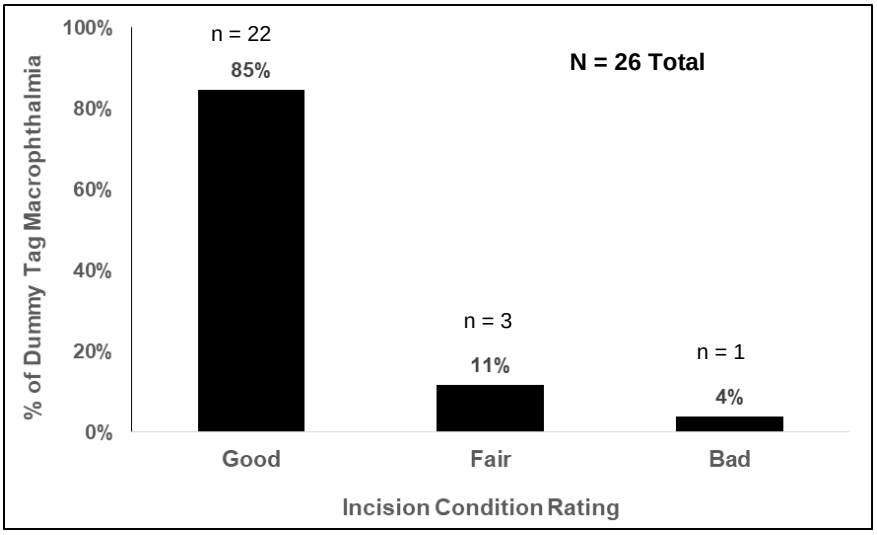


Figure H1-1. Summary of incision condition ratings for dummy tagged lamprey that survived the 30 day holding period. Incisions were rated "Good" when the incision was healed with minimal scarring, "Fair" if the incision was healed, but the scarring was larger and more visible, and "Bad" if the incision was not fully healed.

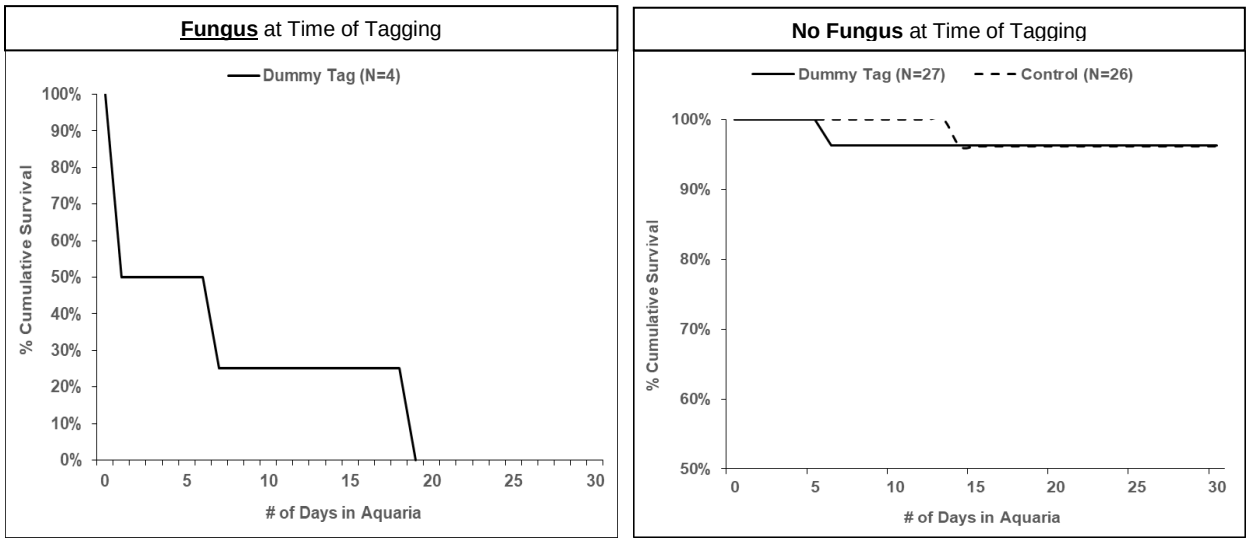


Figure H1-2. Cumulative survival of control and dummy tagged lamprey over the 30 day holding period. The graph on the left shows lamprey that had fungus on their body at the time of tagging (no treatment was received). The graph on the right shows the cumulative survival for all lamprey with no fungus on their body at the time of tagging (some treatment received).

Table H1-1. Biological summary of lamprey that received an acoustic tag, a dummy tag, or no tag (control). Biological data are presented for each tag date by tag type. "% Over 140 mm" shows the number of lamprey over 140 mm (our goal minimum tagging size threshold). The summary rows at the bottom of the table summarize biological data for each tag type from all tagging dates.

Tag Date	Tag Type	# Tagged / Handled	% Over 140 mm	Avg. Length (mm)	Min Length (mm)	Max Length (mm)	Avg. Weight (g)	Min Weight (g)	Max Weight (g)
5/8/2018		20	85%	147	138	173	4.3	3.2	6.4
5/9/2018	Acoustic	24	88%	149	139	164	4.7	3.6	6.5
5/14/2018		54	98%	151	139	176	4.6	3.5	7.4
5/8/2018		6	0%	135	130	138	3.2	2.9	3.6
5/9/2018	Dummy	4	0%	137	136	139	3.7	3.5	3.9
5/14/2018		21	52%	143	132	163	3.9	3.0	5.7
5/8/2018		0	-			-			
5/9/2018	Control	5	0%	125	114	136	2.8	2.0	3.7
5/14/2018		21	19%	137	125	154	3.4	2.2	4.8
	Acoustic	**98**	**93%**	**149**	**138**	**176**	**4.5**	**3.2**	**7.4**
Summary	**Dummy**	**31**	**35%**	**138**	**130**	**163**	**3.6**	**2.9**	**5.7**
	Control	**26**	**15%**	**131**	**114**	**154**	**3.1**	**2.0**	**4.8**

I. Work Element 196 – Council Step Process for Lamprey Artificial Propagation Activities (with CRITFC)

In 2018, Yakama Nation and other CRB tribes continued working though the 3-step process and learning what aspects of this process will be/is relevant to our proposed artificial propagation actions for lamprey. We have been in contact with BPA COTR's and all parties agree that this is a new undertaking and may require a modified strategy to complete this work. We will work closely and collaboratively to insure that this process is completed in a timely manner. The final draft of the "Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research" was submitted in March 2018.

Work Element Associated Appendix Report:

Appendix I1 – Step 1 review of Pacific Lamprey Master Plan by Independent Scientific Review Panel for the Northwest Power and Conservation Council

Photo I1. Collecting eggs from a ripe adult female Pacific Lamprey on June 19, 2018.

Appendix I1 is the Step 1 review of Pacific Lamprey Master Plan we received from the Independent Scientific Review Panel (ISRP) for the Northwest Power and Conservation Council. ISRP has provided a generally favorable review of the Master Plan, which the YN and partners submitted jointly. The scientific review criteria was (generally) met and the document outlines additional questions to review and pursue as we embark on the new collaborative research.

Considerable planning has occurred in preparation of pilot propagation and outplanting research activities. The "Framework for Pacific Lamprey Supplementation Research in the Columbia River Basin" was completed in 2014 and the "Synthesis of Threats, Critical Uncertainties, and Limiting Factors in Relation to Past, Present, and Future Priority Restoration Actions for Pacific Lamprey in the Columbia River Basin" was completed in 2017. The 2017 draft of the "Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research" was shared with federal and state agencies involved in Pacific Lamprey management (USFWS, NOAA Fisheries, WDFW, ODFW, and IDFG) for review. The comments were then incorporated to the final draft, which was submitted to both BPA and the Independent Scientific Review Panel of the Northwest Power and Conservation Council for review in March, 2018.

The Columbia River Tribal Fish Commission (CRITFC), the Confederated Tribes and Bands of the Yakama Nation (YN), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Nez Perce Tribe (NPT) prepared this Master Plan to conceptually address Step 1 review elements of the Northwest Power and Conservation Council's review requirements for artificial propagation projects involving new construction and/or programs that will produce fish for reintroduction. This plan describes ongoing and proposed adult translocation and artificial propagation activities, as well as existing and proposed facilities needed to meet artificial propagation objectives. The plan focuses on activities of the YN and the CTUIR; however, to provide a comprehensive description of supplementation activities in the Columbia River Basin,

the plan also describes ongoing adult translocation activities being conducted by the NPT. Actions described herein will work together and provide synergy with other actions such as improvements to passage, habitat, and water quality to help meet restoration goals for Pacific Lamprey in the Columbia River Basin.

This Master Plan was completed and submitted to initiate experimental larvae/juvenile outplanting in 2019/2020 and will be the basis from which the tribes move forward for additional research and funding towards potential future supplementation and lamprey recovery efforts. It is important to note that all of this planning and coordination work were conducted using Bonneville Power Administration (BPA) funding. However, the new additional funding from BPA associated with the Master Plan will provide a considerable amount of cost-share funding for the "research on life stage bottleneck using artificial propagation" and will help both the YN and the Bureau of Reclamation meet the objectives outlined in this cooperative agreement for the foreseeable future.

See **Appendix I1** for more information.

J. Work Element 176 – Research into Artificial Propagation and Juvenile Propagation

In the last year of Chelan-funded research (2018) we focused on: 1) effects of water source and light intensity on adult maturation process, 2) the sensitivity of prolarvae to larvae on transportation stress, 3) effects of sediment depth on larval survival and growth, 4) effects of feed frequency on larval survival and growth, and 5) testing of alternative feeds. Adult maturation studies were conducted in winter/spring season using 2017/2018 adult broodstock and also for the summer/fall season using 2018/2019 adult broodstock. Transportation sensitivity studies were conducted in the summer of 2018. Larval rearing studies were conducted between July and September, 2018. The research results from 2018 are currently being analyzed and will be reported in full detail in the final report in April, 2019.

Work Element Associated Appendix Report:
Overview of Adult Pacific Lamprey Translocation, Artificial Propagation, and a sexual maturation study (*PowerPoint presentation pdf from 2018 Oregon Chapter American Fisheries Society Meeting) (Chelan County Public Utility District funding)

Photo J1. Two adults from the same 2018-2019 broodstock (collected in 2018 from lower Columbia River hydro dams) with drastically divergent sizes during our monitoring of adults for the sexual maturation study.

Apprendix J1 is a pdf of the YN PowerPoint presentation from the Oregon Chapter American Fisheries Society meeting, and describes the overview of our adult collection, holding, and artificial propagation work (Fig. J1-1, J1-2, J1-3, J1-4, J1-5). It also outlines the preliminary results from the adult sexual maturation study we began this fall (October). During the spawning season in spring/summer (after an overwintering period), we have observed a wide variation in maturation timing from April through July with a portion of them overwintering twice to spawn the following year. Our research question here was "Does the holding water source, temperature, or combination of both affect the maturation of adult Pacific Lamprey?" We have conducted a study using holding tanks consisting of three proportions of water source (river/well ratio of 90/10, 50/50, and 10/90) during the fall and spring seasons using adults that were individually PIT tagged and measured. Well water temperature is fairly stable year around (14-15.5˚C) and river water temperature reflects the Lower Yakima River temperature profile. Currently, the study is ongoing, but results will be available and shared at the meeting. An equal number of tagged fish were placed in each of the treatment tanks and were monitored periodically during the study duration. Interdorsal distance (an indicator for sexual maturation) as well as secondary sexual characteristics were measured and noted for comparing the adults from the three treatment groups. The final results will be available in summer of 2019.

The key take home messages from the preliminary results are the following:

A. Overall, the most shrinkage was seen in the 50% river water treatment (except for length).
B. River water had to be shut down in late February, which altered the water source for all of the three treatment groups; we are not certain the overall impact this change have caused for the final maturation of these adults.
C. Red/yellow mouth index decreased in the 90% river treatment group, while it stayed close to constant or increased in other treatment groups.
D. Temperature fluctuation from Fall 2018 to Spring 2019 was the following:
    1. River water = 4.6-11.5˚C
    2. Well water = 14.1-16.1˚C

Details of this juvenile/larva lamprey PIT tag study will be discussed in more details in the 2018 Annual Progress Report for the Chelan County Public Utility District and Bureau of Reclamation (the primary funding sources for this project).

See **Appendix J1** for more information.

Figure J1-1. Preliminary results showing the changes in interdorsal distance, length, weight, and (lamprey specific) condition factor over time between October, 2017, and February, 2018.

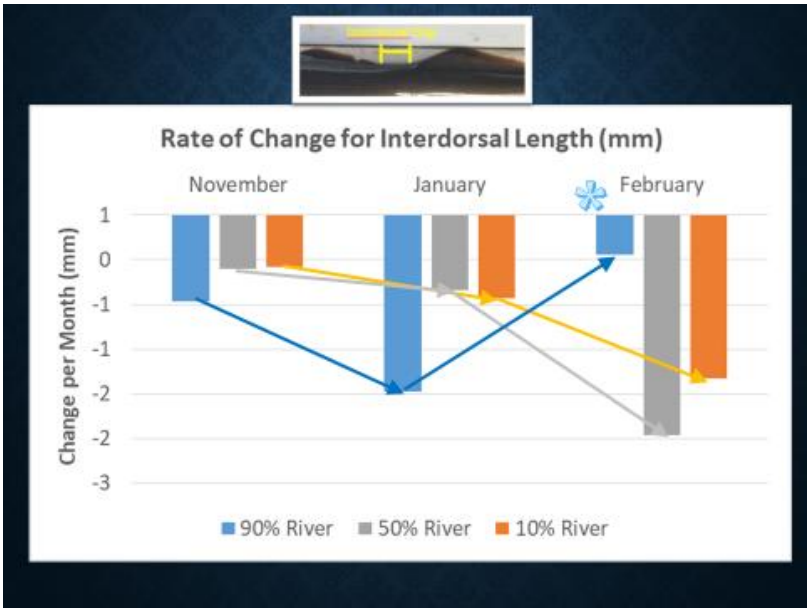


Figure J1-2. The rate of change in interdorsal length (per month) for each of the three treatment groups of lamprey (90% river, 50% river, and 10% river) at the November 2018, January 2019, and February 2019 monitoring.

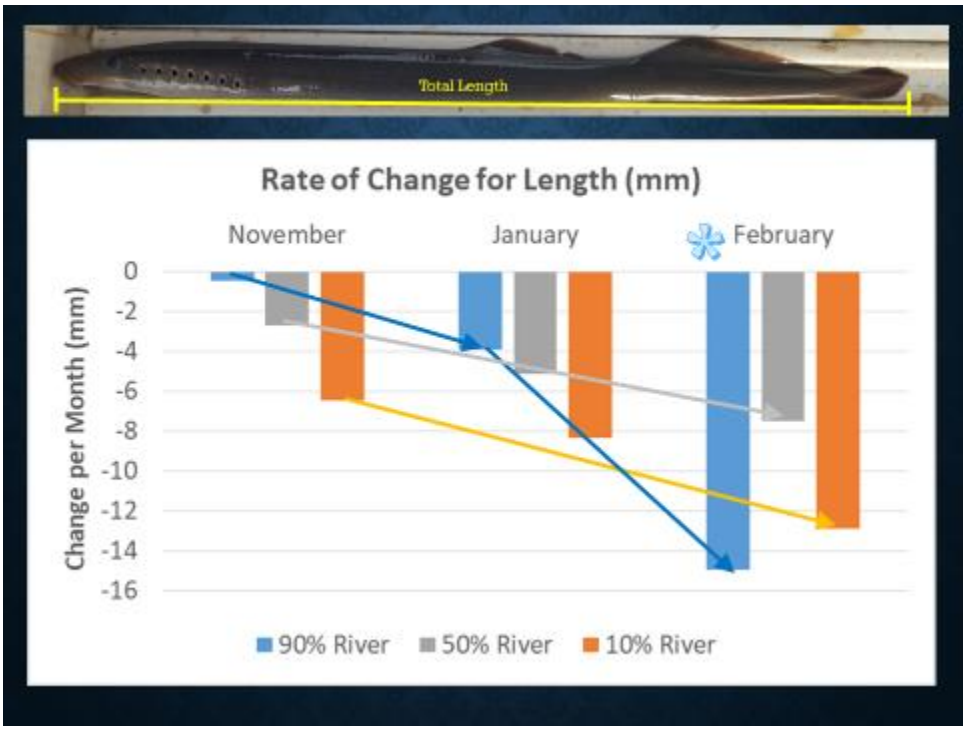


Figure J1-3. The rate of change in total length (per month) for each of the three treatment groups of lamprey (90% river, 50% river, and 10% river) at the November 2018, January 2019, and February 2019 monitoring.

Figure J1-4. The rate of change in weight (per month) for each of the three treatment groups of lamprey (90% river, 50% river, and 10% river) at the November 2018, January 2019, and February 2019 monitoring.

Figure J1-5. The rate of change in lamprey specific condition factor (per month) for each of the three treatment groups of lamprey (90% river, 50% river, and 10% river) at the November 2018, January 2019, and February 2019 monitoring.

E. Work Element 28 – Trap and Haul Adult Lamprey from Columbia River

Work Element Associated Appendix Report:

Appendix K1 – Yakama Nation Adult Pacific Lamprey Collection in the Columbia River Basin, 2018

Photo K1. Lamprey resting boxes installed in front of the public viewing window at Bonneville Dam Washington Shore Ladder with one adult lamprey attaching to the window on June 27, 2018.

Appendix K1 summarizes the adult Pacific Lamprey collection (trapping and transporting) in 2018 from the Lower Columbia River hydroelectric projects, specifically Bonneville, The Dalles,

and John Day dams. The translocation of adult lamprey is part of the "Tribal Restoration Plan for the Columbia River Basin" (Tribal Restoration Plan) by Columbia River Inter-Tribal Fish Commission (CRITFC) and the "Yakama Nation Pacific Lamprey Action Plan" by Yakama Nation Fisheries (YNF). The purpose of translocation is to use it as a tool to help enhance Pacific Lamprey subpopulations in the Yakama Nation Ceded Lands, primarily in the Yakima, Wenatchee, and Methow subbasins.

Allocation each year is based upon the average of the two prior years' estimated Pacific Lamprey run size at Bonneville Dam, as outlined in the Tribal Restoration Plan under "Guidelines for Pacific Lamprey Translocation and/or Artificial Propagation." In 2018, the maximum numbers allocated for Bonneville, The Dalles, and John Day dams were calculated to be 2,060, 1,056, and 829, respectively, totaling 3,945 for each of the four CRITFC member tribes (Table K1-1).

Adult collection for the YNF in 2018 began on June 21, 2018, at Bonneville and John Day dams and was completed on August 13, 2018 (collection continued for all three dams until the last day) (Fig. K1-1 and Table K1-2). In total, 1619 adult lamprey (645 from Bonneville Dam, 173 from The Dalles Dam, and 801 from John Day Dam) were collected, which was within the 2018 allocation guideline number. The peak of the run at Bonneville Dam was late June through mid-July (Fig. K1-2); our collection began just in time before this peak run made its appearance. We had a total of 39 mortalities in 2018 with a mortality rate of 2.4%. Some of the adults were lethargic and appeared to be stressed (white colored belly and sluggish movement and activity), and the majority of these were released immediately upstream of the hydro dam facility where they were collected (to minimize the risk of translocation related mortality). From reviewing the overall run at Bonneville Dam in 2018 in relation to other environmental variables (from DART Adult Passage Graphics and Text website), there was a peculiar relationship between the number of adult lamprey passage and the percent of spill, suggesting a negative correlation (Fig. K1-3).

See **Appendix K1** for more information.

Table K1-1. Total allocation per tribe for 2018 based on updated Tribal Restoration Plan guidelines (*guideline was updated in 2017).

Dam	Allocation
Bonneville	2,060
The Dalles	1,056
John Day	829
Total	**3,945**

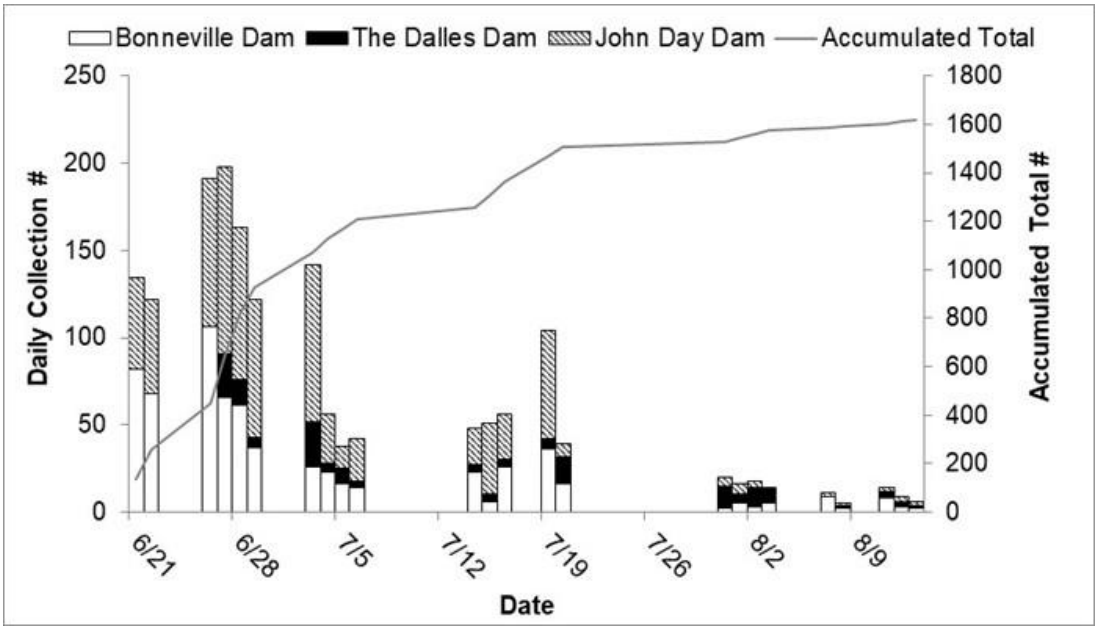


Figure K1--1. Summary of adult Pacific Lamprey collection numbers (daily and accumulated numbers) from 2018 collection.

Table K1-2. Summary of adult Pacific Lamprey collection data from Columbia River hydro dams (John Day, The Dalles and Bonneville dams) in 2018. Bold dates denotes the dates that Yakama Nation actually physically picked up the lamprey. Hyphen in the trap collection sections indicates no trapping (as opposed to capturing zero lamprey).

Date	John Day Dam	The Dalles Dam	Bonneville Dam	Daily Total	Morts	Accumulated Total
6/21/2018	52	-	82	134	-	134
6/22/2018	54	-	68	122	12	256
6/26/2018	85	-	106	191	-	447
6/27/2018	107	25	66	198	18	645
6/28/2018	87	15	61	163	-	808
6/29/2018	79	6	37	122	5	930
7/3/2018	90	26	26	142	-	1072
7/4/2018	28	5	23	56	1	1128
7/5/2018	13	9	16	38	-	1166
7/6/2018	24	4	14	42	3	1208
7/14/2018	21	4	23	48	-	1256
7/15/2018	41	4	6	51	-	1307
7/16/2018	26	4	26	56	-	1363
7/19/2018	62	6	36	104	-	1467
7/20/2018	7	16	16	39	-	1506
7/31/2018	5	13	2	20	-	1526
8/1/2018	6	5	5	16	-	1542
8/2/2018	4	11	3	18	-	1560
8/3/2018	0	9	5	14	-	1574
8/7/2018	2	0	9	11	-	1585
8/8/2018	1	2	2	5	-	1590
8/11/2018	2	4	8	14	-	1604
8/12/2018	3	3	3	9	-	1613
8/13/2018	2	2	2	6	-	1619
Total	**801**	**173**	**645**	**1619**	**39**	**1619**

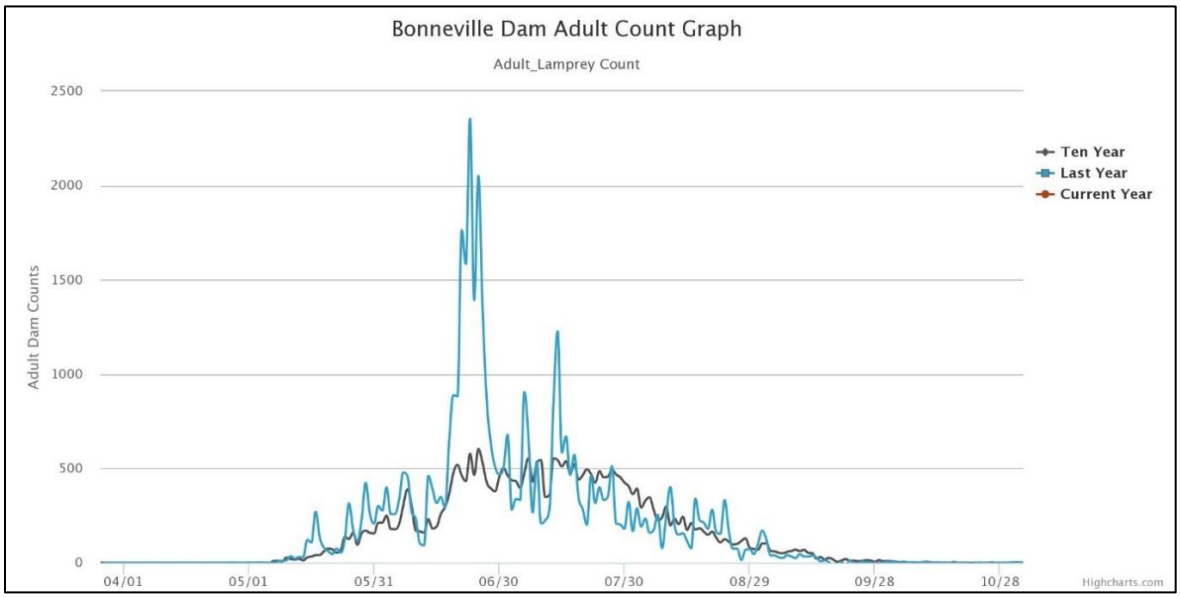


Figure K1-2. Summary of adult Pacific Lamprey counts from Bonneville Dam in 2018 (light blue line) in addition to the 10-year average run between 2009 and 2018 (black line). Data Source: http://www.cbr.washington.edu/dart/query/adult_graph_text.

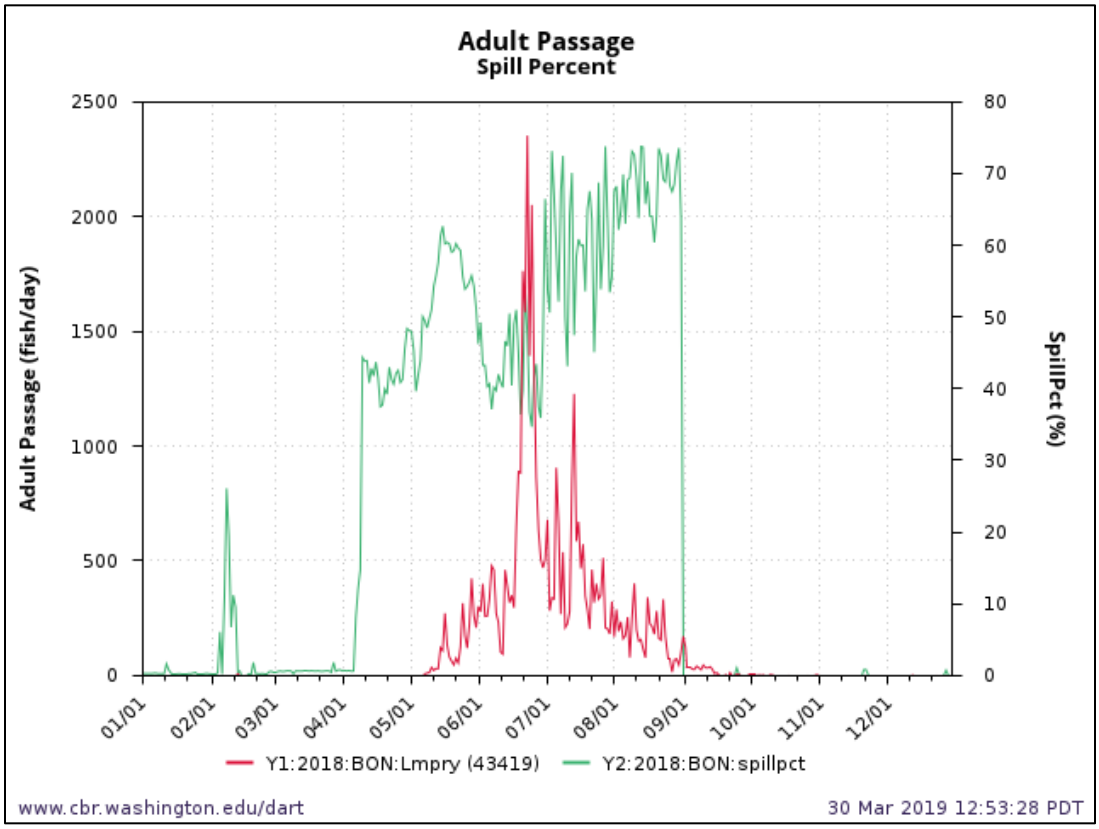


Figure K1-3. Summary of adult Pacific Lamprey counts from Bonneville Dam in 2018 (red line, primary y-axis) in comparison with the percent of spill (green line, secondary y-axis). Data Source: http://www.cbr.washington.edu/dart/query/adult_graph_text.

F. Work Element 162 – Data Input and Analysis

To accomplish the goal of restoring natural production, YNPLP has focused activities on five general objectives: 1) establishing baseline and long term status and trend monitoring data for the presence/absence and relative abundance of Pacific Lamprey, 2) understanding primary limiting factors affecting abundance of local populations, 3) continuously updating subbasin "Action Plans" that identify key activities to promote Pacific Lamprey recovery, and 4) continuing research and development into adult supplementation practice and reintroduce by translocation where local populations have been extirpated or functionally extirpated. Since initiation of the YNPLP in 2008, we have gained a better understanding on program development and prioritizing action plans based upon these objectives. Additional research topics each year have focused on furthering these specific objectives.

Data Depository

All mapping data are currently stored in the Google Earth program and all quantitative data are stored in Microsoft Excel, and all reports are stored in Microsoft Word. All files are backed up on the YN share drive as well as external hard drive regularly. The YNPLP will merge these data together so that they can be stored on a data depository, such as StreamNet, Pacific States Marine Fisheries Commission, and/or other entities (including internal Yakama Nation data depository). We have also scanned all field data sheets from the beginning of the project (2008) to make all hard copy data available in electronic forms. Data depository options were previously discussed with YN GIS specialists (Leon Ganuelas) and StreamNet staff (Van Hare and Michael Banach), and these options will be pursued further in 2019-2020. The USFWS has also set up a data archival recently for ArcGIS map related data as well as other types of documents for lamprey, and this database has the potential to serve as a shared archive for all Pacific Lamprey related data range wide and information contributed by an assortment of collaborating agencies. All of this data / information are available upon request.

Work Element Associated Appendix Reports:

Appendix L1 – Summary of Yakama Nation Fisheries Larval Lamprey Electrofishing Surveys in the Wenatchee Subbasin (2012-2018)

Photo L1. Overview of a larval lamprey survey site in the Wenatchee River at river km 56.8 (7.2 river km upstream of Tumwater Dam), where young of year (< 30 mm) Pacific Lamprey were found in August, 2016.

In the Wenatchee Subbasin, Tumwater Dam (river km 49.8) was recognized as a potential complete passage barrier for upstream migrating adult Pacific Lamprey (prior to adult translocation efforts). In 2016, adult Pacific Lamprey were translocated into both the upper (above the dam) and lower (below the dam) Wenatchee Subbasin, in an effort to recolonize the area upstream of the dam, as well as monitor dam passage and adult migration patterns throughout the subbasin. In this report, we have summarized key information related to the distribution, occupancy and biological trends of larval Pacific Lamprey within the Wenatchee Subbasin using all survey data collected between 2012 and 2018 by Yakama Nation Pacific Lamprey Project.

Within each study reaches, we summarize our larval lamprey data in two parts: 1) distribution and site occupancy, and 2) biological trends at each index site (average length and capture densities). In summary, our electrofishing results suggest that Pacific Lamprey are widely distributed downstream of Tumwater Dam. Site occupancy was near 100% for each of the five survey years (Fig. L1-1), while capture densities have fluctuated from year to year (Fig. L1-2). In Icicle Creek, a tributary of the lower Wenatchee River, no lamprey have been found from all survey attempts since 2012; monitoring will continue to document the offspring production from the 2017 fall translocation in Lower Icicle Creek at river km 2.2. Upstream of Tumwater Dam, larval Pacific Lamprey are increasing in distribution since translocation began in 2016 (0% site occupancy from 2012-2015, 14% in 2016, 100% in 2017, and 67% in 2018; Fig. L1-3). Average length has also increased (26, 66, and 67 mm in 2016, 2017, and 2018, respectively; Fig. L1-4).

Larval Pacific Lamprey were also found in Nason Creek in 2017 (Fig. L1-5), and average length increased here as well (17 and 58 mm in 2017 and 2018, respectively; Fig. L1-6). Overall, the distribution of larval Pacific Lamprey have been increasing steadily since the initial monitoring in 2012 (a 64% increase is documented to date, from 48.8 to 79.8 river km distance; Fig. L1-7). In the upper Wenatchee River, the documented increase in distribution, occupancy, capture density,

and average length indicate that adult translocation appears to be effective for restoring the larval life stage subpopulations in the upper Wenatchee River. No larval Pacific Lamprey have been found in the Chiwawa and White rivers to date, but more surveys are warranted to assess their occupancy as the distribution continues to increase.

See **Appendix L1** for more information.

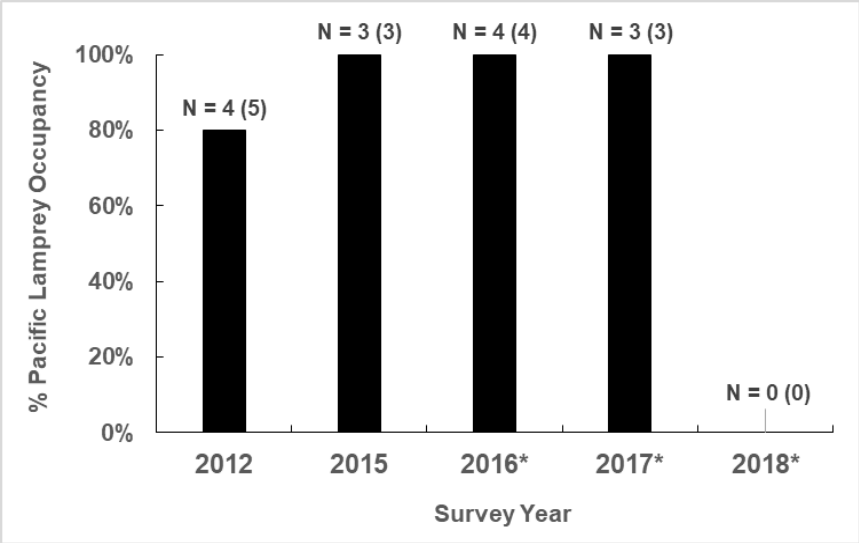


Figure L1-6. Pacific Lamprey site occupancy in the lower Wenatchee River, downstream of Tumwater Dam, river km 49.6. "Percent [%] Pacific Lamprey Occupancy" was calculated by dividing the number of sites occupied with Pacific Lamprey by the number of sites surveyed within the Pacific Lamprey distribution. An asterisk (*) next to a survey year indicates a year where adult Pacific Lamprey were actively translocated into the river. See Table 1 for more details. Sample size (N=) on top of each bar graph displays the number of surveyed sites with Pacific Lamprey present, and in parenthesis the total number of surveyed sites within the distribution is displayed.

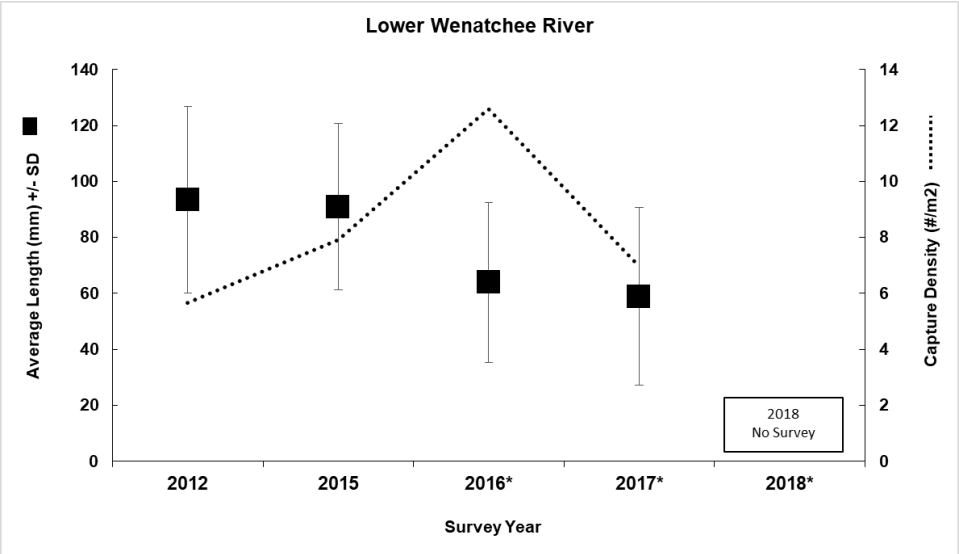


Figure L1-2. Average length and capture densities of Pacific Lamprey from sites surveyed between 2012 and 2018 in the lower Wenatchee River. The yearly average length of measured lamprey (with +/- SD bars) is shown on the primary y-axis (point graph with error bars). Average capture density is shown on the secondary y-axis (line graph). See Table 2 for exact values. An (*) next to a survey year indicates years that adult Pacific Lamprey were actively translocated into the river.

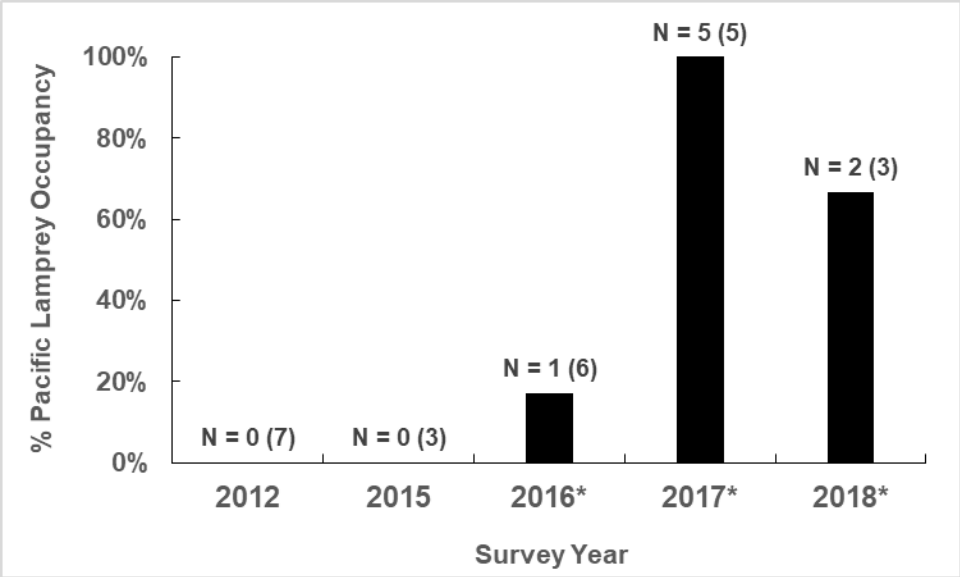


Figure L1-3. Pacific Lamprey site occupancy in the upper Wenatchee River, upstream of Tumwater Dam, river km 49.6. "Percent [%] Pacific Lamprey Occupancy" was calculated by dividing the number of sites occupied with Pacific Lamprey by the number of sites surveyed within the Pacific Lamprey distribution. An asterisk (*) next to a survey year indicates a year where adult Pacific Lamprey were actively translocated into the river. See Table 1 for more details. Sample size (N=) on top of each bar graph displays the number of surveyed sites with Pacific Lamprey present, and in parenthesis the total number of surveyed sites within the distribution is displayed.

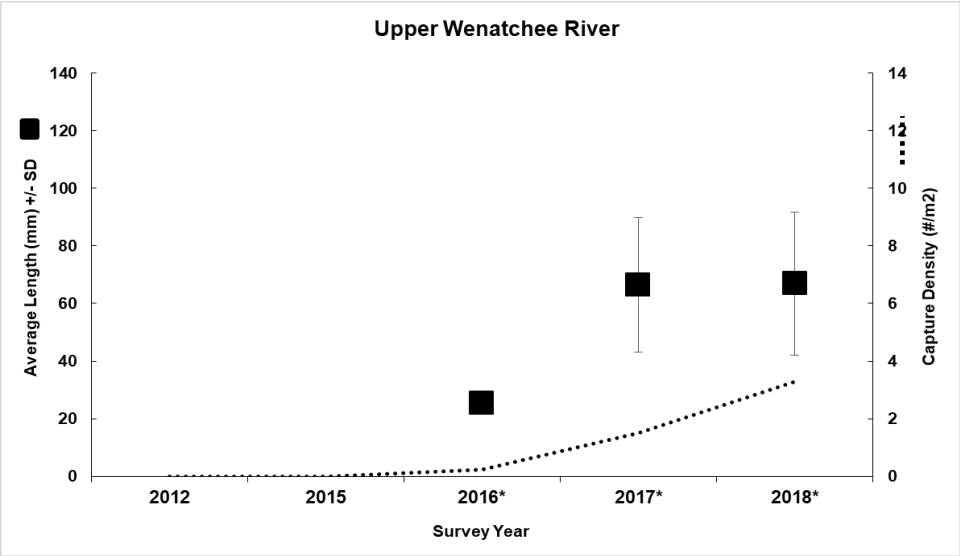


Figure L1-4. Average length and capture densities of Pacific Lamprey from sites surveyed between 2012 and 2018 in the upper Wenatchee River. The yearly average length of measured lamprey (with +/- SD bars) is shown on the primary y-axis (point graph with error bars). Average capture density is shown on the secondary y-axis (line graph). See Table 2 for exact values. An (*) next to a survey year indicates years that adult Pacific Lamprey were actively translocated into the river.

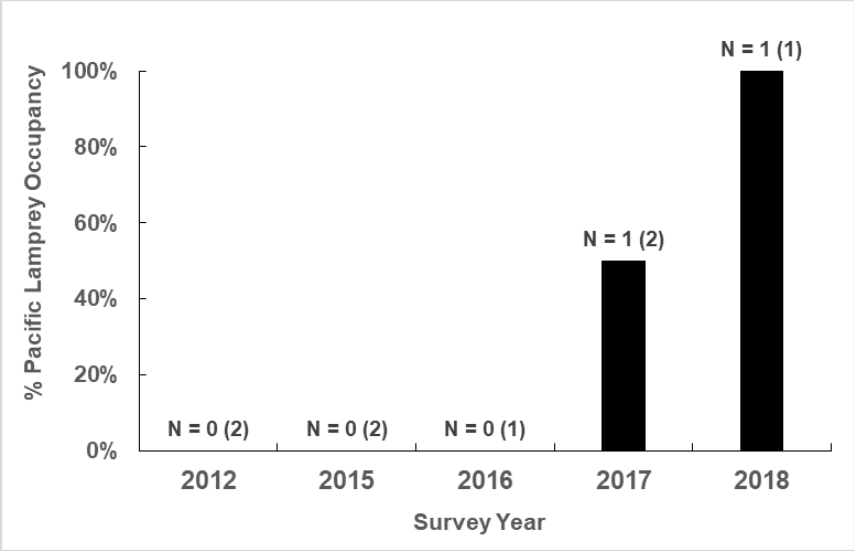


Figure L1-5. Pacific Lamprey site occupancy in the Nason Creek, a tributary of the upper Wenatchee River. "Percent [%] Pacific Lamprey Occupancy" was calculated by dividing the number of sites occupied with Pacific Lamprey by the number of sites surveyed within the Pacific Lamprey distribution. An asterisk (*) next to a survey year indicates a year where adult Pacific Lamprey were actively translocated into the river. See Table 1 for more details. Sample size (N=) on top of each bar graph displays the number of surveyed sites with Pacific Lamprey present, and in parenthesis the total number of surveyed sites within the distribution is displayed.

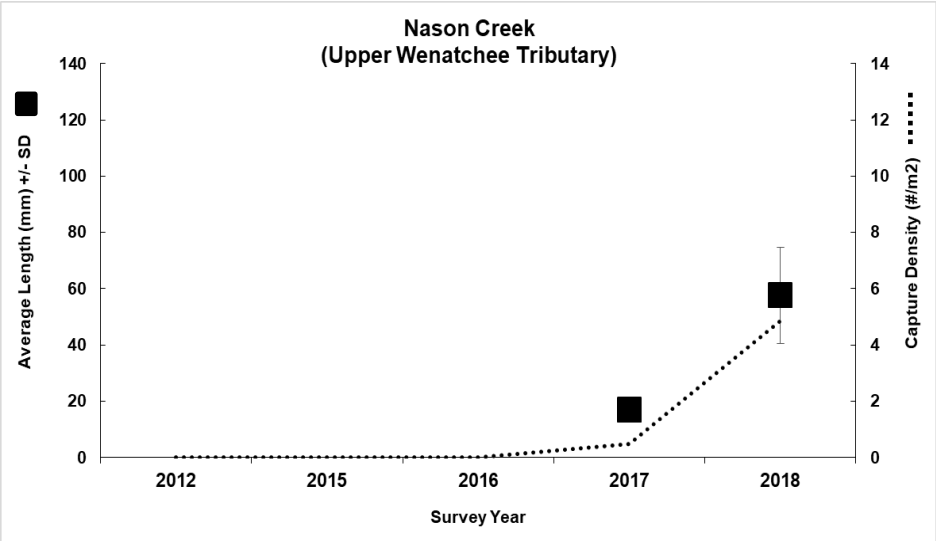


Figure L1-6. Average length and capture densities of Pacific Lamprey from sites surveyed between 2012 and 2018 in Nason Creek (tributary of the upper Wenatchee River). The yearly average length of measured lamprey (with +/- SD bars) is shown on the primary y-axis (point graph with error bars). Average capture density is shown on the secondary y-axis (line graph). See Table 2 for exact values.

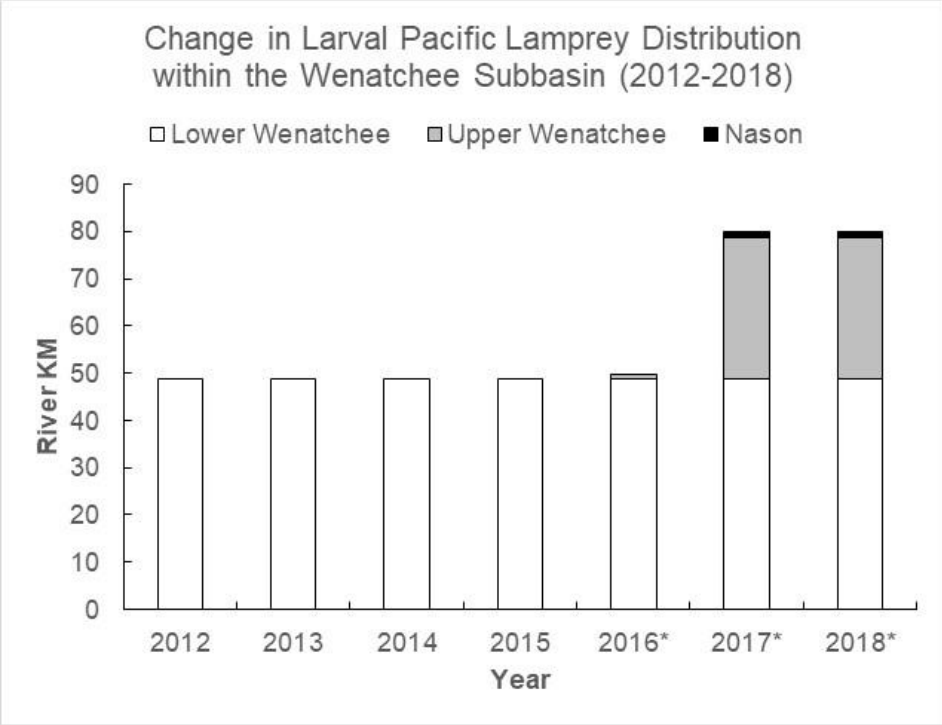


Figure L1-7. Change in larval Pacific Lamprey distribution within the Wenatchee Subbasin between 2012 and 2018 in terms of river km based on electrofishing surveys. The stacked bar graph displays the total river km distribution from the lower Wenatchee River, upper Wenatchee River, and Nason Creek.

Appendix L2 – 2018 Yakima River Lamprey Acoustic Telemetry Updates: Draft Final Results

Photo L2. Juvenile Pacific Lamprey and an accurately scaled image of an acoustic tag designed by Pacific Northwest National Laboratory for use in Pacific Lamprey.

Appendix L2 summarizes the preliminary results from the 2018 Yakima River acoustic telemetry study for juvenile Pacific Lamprey. A final report will be available in April 2019. The overall detection rates from the upper release site were lower than expected within the Yakima River (likely due to a combination of the slow 5-sec burst rate of the tag and the high discharge conditions during release), but the detections from the mainstem Columbia River array sites were very high regardless of the release locations (especially from McNary Dam) (Fig. L2-1). Migration rates were unexpectedly high averaging between 30 and 40 miles / day for both (upper and lower) release groups all the way to Bonneville Dam (Fig. L2-2). Travel time to McNary and Bonneville dams were complete in 5 and 10 days for the lower release group (Lower Yakima) and 7 and 11 days for the upper release group (mid-Yakima), respectively (Fig. L2-3).

See **Appendix L2** for more information.

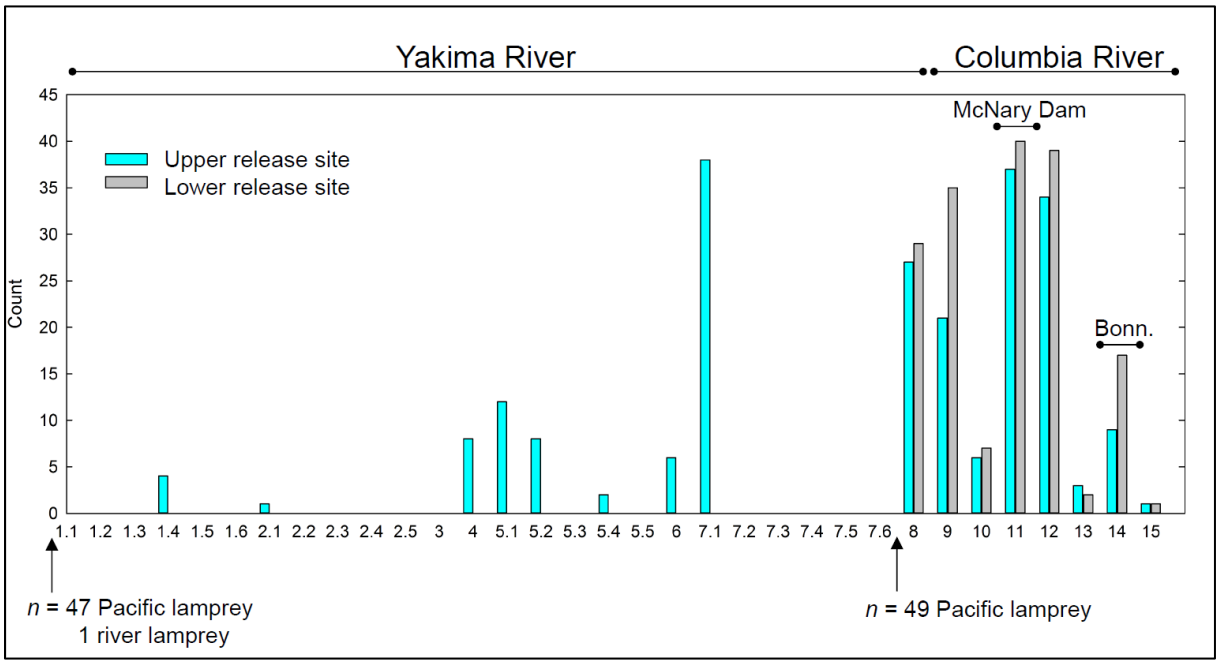


Figure L2-1. Summary of detection data from the acoustic tagged juvenile Pacific Lamprey (plus one Western River Lamprey) released in two locations (Upper and Lower release sites). The number represents the following: 1=Wapato Dam, 2=Sunnyside Dam, 3-4=Wapato Reach, 5=Prosser Dam, 6=Lower Yakima, 7=Horn Rapids Dam, 8-10=Mid-Columbia, 11=McNary Dam, 12-13=Lower Columbia, 14=Bonneville Dam, 15=Lower Columbia. *Preliminary Data.

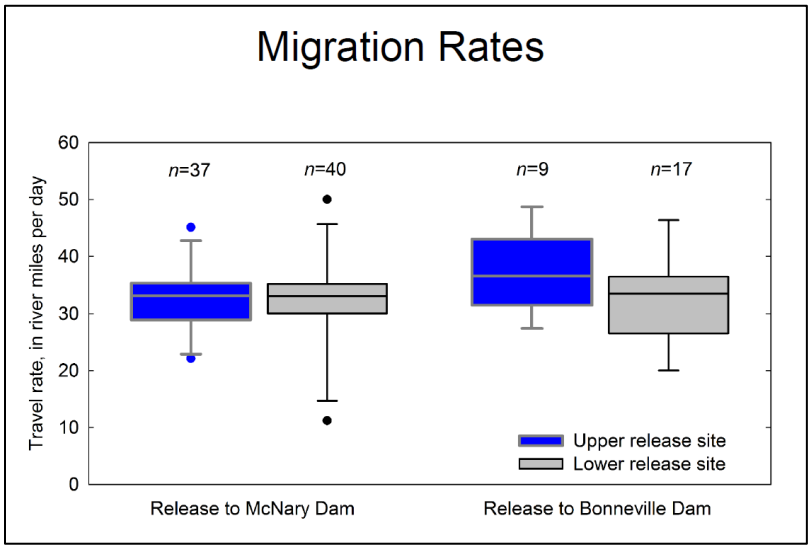


Figure L2-2. Summary of migration rates from acoustic tagged juvenile Pacific Lamprey (plus one Western River Lamprey) released in two locations (Upper and Lower release sites) to McNary and Bonneville dams. *Preliminary Data.

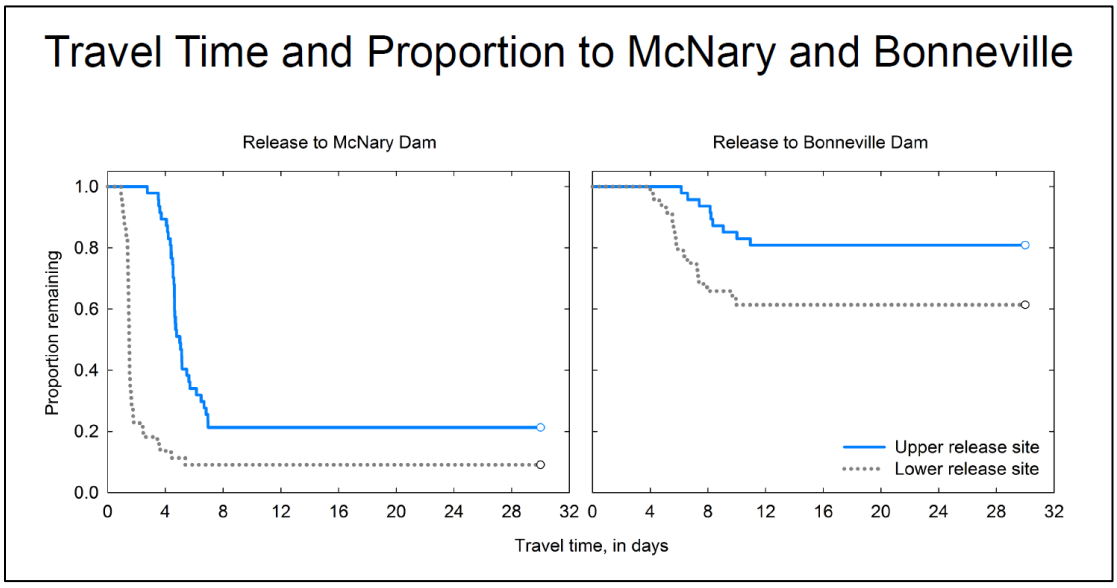


Figure L2-3. Summary of travel time and proportion to McNary and Bonneville dams from acoustic tagged juvenile Pacific Lamprey (plus one Western River Lamprey) released in two locations (Upper and Lower release sites). *Preliminary Data.

Appendix L3 – Summary of Freshwater Mussel Observations within the Yakama Nation Ceded Lands from Larval Lamprey Surveys, 2018

Photo L3. Two live Western Ridge Mussels (*Gonidea angulata*) discovered near the mouth of Ahtanum Creek (river km 1.1), a tributary of the Lower Yakima River.

Freshwater mussels are an underappreciated species that play an irreplaceable ecological role in the rivers and streams of the Columbia River Basin. The Yakama Nation Pacific Lamprey Project (YNPLP) has documented the presence of freshwater mussels (live and/or dead) encountered during larval lamprey electrofishing surveys since 2014. During this time, freshwater mussels were documented within the Yakima and Wenatchee subbasins (Table L3-1). In the Yakima Subbasin, both Western Pearlshell Mussels (*Margaritifera falcate*) and Western Ridged Mussels (*Gonidea*

angulata) were documented. In the Yakima Subbasin, *M. falcate* was confirmed in the following locations: Lower Yakima River mainstem (Sunnyside and Wapato irrigation diversions, river km 171.4 and 176.3, respectively), Toppenish Creek (river km 59.9), Simcoe Creek (river km 9.0), and Wenas Creek (river km 0.5). In Ahtanum Creek, *G. angulata* was confirmed to be present at river km 1.2. In the Wenatchee Subbasin, *M. falcate* was potentially documented in the Upper Wenatchee River, 3.3 river km downstream of Lake Wenatchee. However, identification of these mussels was performed primarily by the YNPLP staff (with the help of local/regional experts) and may not be accurate due to limited knowledge of mussel identification (and appropriate photos are not always present). Although we provide species documentation from a variety of surveyed sites, it is quite possible other mussel species may have also been collected. To improve future documentation efforts, we will add a designated space to our lamprey datasheet to collect the following information; best guess of species, photo of the specimen, general description of the type of habitat where the mussel was found, and the mussel condition (live, fresh mortality, or shell only). The data we collect will be submitted annually to the Xerces Society, which documents freshwater mussel findings throughout the Northwestern United States.

See **Appendix L3** for more information.

Table L3-1. Freshwater mussel observations by the YNPLP in the Yakima and Wenatchee subbasins. Under "Confirmed Species Present" a dash (-) indicates a location where mussel species was not recorded. An asterisk (*) next to a stream indicates that the mussel species listed has not been expertly confirmed, or the sample was too decomposed to get a definitive answer.

Subbasin	HUC4	Stream	RKM	Observing Agency	GPS Coordinate	Site Location Description	Date of Most Recent FW Mussel Sighting	Years FW Mussels Were Sighted	Species Present
Yakima	Lower Yakima	Yakima	171.1	YNPLP	46.518724 -120.478940	Sunnyside Diversion; Canal Downstream of Fish Screens	11/14/2018	2015, 2016, 2017, 2018	Western Pearlshell (*Margaritifera falcate*)
			175.7	YNPLP	46.496552 -120.438836	Wapato Diverison; Canal Upstream of Fish Screens	11/16/2018	2015, 2016, 2017, 2018	Western Pearlshell (*Margaritifera falcate*)
		Toppenish	59.9	YNPLP	46.365937 -120.671330	Upstream of Shaker Church Road, White Swan, WA	7/19/2017	2017	-
		Simcoe (Tributary of Toppenish)	9.0	YNPLP	46.400997 -120.691819	Upstream of Stephenson Road, White Swan, WA	8/24/2018	2015, 2016, 2017, 2018	Western Pearlshell (*Margaritifera falcate*)
		Ahtanum	1.2	YNPLP	46.53685 -120.47417	Downstream of Highway 97 Bridge Union Gap, WA	6/21/2018	2018	Western Ridged (*Gonidea angulata*)
	Naches	Cowichee	1.1	YNPLP	46.627178 -120.581045	Bridge on Powerhouse Road Yakima, WA	2014	2014	-
	Upper Yakima	Wenas*	0.5	YNPLP	46.69724 -120.49537	BOR Land Access off Buchanan Road, Selah, WA	8/8/2018	2018	(*Anodonta sp.*)
Wenatchee	Upper Wenatchee	Wenatchee*	84.0	YNPLP	47.815610 -120.687880	3.3 RKM downstream of Lake Wenatchee	8/29/2018	2016, 2017, 2018	Western Pearlshell (*Margaritifera falcate*)

G. Work Element 141 – Other Reports (Cultural Information)

Work Element Associated Appendix Report:
Appendix M1 – Yakama Nation Cultural Oral Interviews on Asum (Lamprey Eels): Summary Part IV (2018)

Photo M1. Sean Goudy sharing and discussing some of the Pacific Lamprey Project outreach media with Mr. Rex Buck during Wanapum Archeology Days on October 29, 2018.

Within the past several years, the Yakama Nation Pacific Lamprey Project (YNPLP) has interviewed many tribal members, most of whom are tribal elders, to inquire questions related to Pacific Lamprey. We also interviewed some of the young and middle aged tribal members who have strong connections to lamprey related customs, traditional culture, and tribal elder family members. For many of the tribal elders, lamprey have been not only a key food source and medicine but also an integral piece of their culture and tradition, without which there is an indubitable "void" in their very existence.

Between March 2013 and March 2014, an oral interview was conducted with sixteen tribal members (all but two were recorded in full length videos), and 15 key questions were asked related to lamprey status, biology, ecology, culture, as well as human impact. Through this interview process, many insights and revelations were attained related to historical distribution, abundance, run timing, potential threats and impacts, and tradition associated with harvest, preparation, and consumption by Yakama Nation tribal members across the wide-ranging Ceded Lands.

Russel Jim and Elmer Shuster, the two interviewees for which a summary and review was completed in this report, provided unique and intriguing information related to lamprey customs and tradition within the Yakama Nation Ceded Lands. Mr. Jim and Mr. Shuster are Yakama elders born on the Yakama Reservation. They shared their tradition of eel harvest at Celilo Falls and Chief Island, Oregon City-Willamette Falls, Fivemile Creek, Fifteenmile Creek, Tenino to Eightmile Creek in the Dalles, and the John Day and Deschutes rivers. Within the Yakima River

Basin, sites included Horn Rapids-Dam near Richland and Wanawish, Prosser Dam area known as Tup-Tut, Parker-Sunnyside dam, Wapato Dam, and Satus Creek. These areas and many other sites are considered Usual and Accustomed areas according to the YN Treaty of 1855.

The best years the two interviewees can recall for eel harvest was in the 1950s and early 1960s, during which many sacks of eels were harvested per season. However, since the middle 1980s, eel numbers appeared to have declined. Information related to biology, ecology, harvest and cooking methods and "Legends" were discussed. Agricultural development, habitat loss, irrigation/canals, dams (passage), water quality (temperature) and quantity (flow) were considered the primary factors contributing to the decline of Pacific Lamprey according to these two elders. Horseshoe Falls, another name for Celilo Falls, was part of an approximately nine-mile-long tribal fishery that included sites such as the Upper Dalles, the Lower Dalles, Three Mile Rapids, Five Mile Rapids, and Big Eddy. Especially, the construction of The Dalles Dam, which inundated The Celilo Falls – Wyam (Echo of falling water) Village area, took away a crucial harvest site and as a result many of the Yakama Nation tribal members were forced to move and travel longer distances to harvest eels.

See **Appendix M1** for more information.

H. Work Element 132 – Final Annual Report for CY2017 (Jan 2017 to Dec 2017)

Work Element Associated Appendix Report:
Not Applicable

The Final Annual Report (along with associated appendix reports) for the period January 2017 through December 2017 was submitted in spring 2018.

I. Work Element 132 – Annual Report for CY2018 (Jan 2018 to Dec 2018)

Work Element Associated Appendix Report:
Not Applicable

The Annual Report for the period January 2018 through December 2018 refers to this summary report and covers all the work elements that are part of the contract. This report summarizes project goals, objectives, complete and incomplete deliverables, problems encountered, lessons learned, and the information gathered, synthesized, and updated to assist in long term planning.

J. Work Element 119 – Manage and Administer Projects

Work Element Associated Appendix Report:
Not Applicable

This work element is part of this project's deliverables in relation to project administration and management. It covers milestones, such as 1) Federal Information Security Management Act law compliance, 2) final invoice submission for contract closeout, 3) estimate for end of fiscal year accrual, 4) drafting and submission of contract renewal documents, and 5) entry of cost share information. These milestones were completed successfully in 2018.

K. Work Element 185 – Pisces Status Report

Work Element Associated Appendix Report:
Not Applicable

All quarterly Pisces Status Report for the Year 2018 were completed successfully.

IV. References

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V. Appendices

Appendix C1 – Yakama Nation Ceded Lands Larval Lamprey Monitoring Report, 2018

Appendix D1 –Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2018

Appendix D2 – Intensive Monitoring of Larval/Juvenile Lamprey Entrainment in the Yakima Subbasin, 2018

Appendix D3 – Experimental Sprinkler System for Reducing Larval Lamprey Mortality during Irrigation Diversion Dewatering Events: Highlights and Lessons Learned

Appendix D4 – Implementation of a Simulated Perennial Side Channel Flow Regime in the Wapatox Diversion (Naches River) to Protect High Densities of Larval/Juvenile Lampreys

Appendix E1 – Yakama Nation Pacific Lamprey Project Outreach and Education, 2018

Appendix G1 – Translocation of Adult Pacific Lamprey within the Yakima Subbasin, 2017-2018 Broodstock

Appendix G2 – Translocation of Adult Pacific Lamprey within the Wenatchee Subbasin, 2017-2018 Broodstock

Appendix G3 – Translocation of Adult Pacific Lamprey within the Methow Subbasin, 2017-2018 Broodstock

Appendix H1 – Survival Assessment of Juvenile Pacific Lamprey Implanted with a Dummy Acoustic Tag for a Yakima Basin Acoustic Telemetry Study

Appendix I1 – Step 1 Review of Pacific Lamprey Master Plan by Independent Scientific Review Panel for the Northwest Power and Conservation Council

Appendix J1 – Overview of Adult Pacific Lamprey Translocation, Artificial Propagation, and a sexual maturation study

Appendix K1 – Yakama Nation Adult Pacific Lamprey Collection in the Columbia River Basin, 2018

Appendix L1 – Summary of Yakama Nation Fisheries Larval Lamprey Electrofishing Surveys in the Wenatchee Subbasin (2012-2018)

Appendix L2 – 2018 Yakima River Lamprey Acoustic Telemetry Updates: Draft Final Results

Appendix L3 - Summary of Freshwater Mussel Observations within the Yakama Nation Ceded Lands from Larval Lamprey Surveys, 2018

Appendix M1 – Yakama Nation Cultural Oral Interviews on Asum (Lamprey Eels): Summary and Review Part III (2018)