Yakama Nation Pacific Lamprey Project
Annual Progress Report

Project No. 2008-470-00

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Cover photo: Patrick Luke showing an adult Pacific Lamprey to Micah Lampman (3-year-old) prior to its release in Satus Creek (river km 31.3) on April 28, 2015.

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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 Progress Report for the Yakama Nation Pacific Lamprey Project (YNPLP). This report outlines the most current activities undertaken by the YNPLP from January 1, 2015 through December 31, 2015.

A: WE165 - Produce Environmental Compliance Documentation
No report is submitted in association with this milestone: see Section III for more information.

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

C: WE157 - Collect/Generate/Validate Field and Lab Data
Six reports are submitted in association with this milestone: Appendix C1 (Yakima Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2009-2015]), Appendix C2 (Wenatchee Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2012-2015]), Appendix C3 (Entiat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2012-2014]), Appendix C4 (Methow Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2012-2015]), Appendix C5 (Klickitat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2009-2015]), and Appendix C6 (White Salmon Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report [2012-2015]).

D: WE28 - Trap and Haul (Adult Lamprey Collection from Columbia River)
One report is submitted in association with this milestone: Appendix D1 (2015 Adult Pacific Lamprey Collection in the Columbia River Basin).

E: WE 158 – Mark/Tag Animals
Two reports are submitted in association with this milestone: Appendix E1 (Translocation of Adult Pacific Lamprey within the Yakima Subbasin [2014-2015 Broodstock]) and Appendix E2 (2015 Juvenile/Larval Pacific Lamprey Passage Monitoring in Chandler Diversion, Yakima River [Prosser, WA]).

F: WE28 - Trap and Haul (Larval/Juvenile Lamprey Salvage in Diversions)
One report is submitted in association with this milestone: Appendix F1 (2015 Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin).

G: WE162 - Data Input, Analysis and Interpretation

Eight reports are submitted in association with this milestone: Appendix G1 (Distribution and Occupancy of Pacific Lamprey in Six Major Columbia River Subbasins within the Yakama Nation Ceded Lands: Summary from 2009-2015 Surveys), Appendix G2 (2015 Intensive Monitoring of Larval/Juvenile Lamprey Entrainment within the Yakama Subbasin), Appendix G3 (Evaluation of Chandler Diversion Bypass Pathways for Larval/Juvenile Lamprey during the Dewatering Season), Appendix G4 (Larval Lamprey Assessment at Wapato and Sunnyside Fish Screening Facilities), Appedix G5 (Passage of Radio-Tagged Adult Pacific Lamprey at Yakima River Diversion Dams, 2014 Annual Report, Phase 3: Roza and Cowiche Dams), Appendix G6 (The Role of Pacific Lamprey in Yakima River Tributary Food Webs), and Appendix G7 (Influences of Fish Physiology and Habitat Conditions on the Retention Rates of Adult Pacific Lamprey [*Entosphens tridentatus*] Carcasses in Upper Toppenish Creek, a Small Tributary System in South Central Washington, USA) and Appendix G8 (Summary of Pacific Lamprey Salvage Efforts from Dryden Diversion Maintenance Operations).

H: WE161 - Disseminate Raw/Summary Data and Results and Participate in Regional Efforts

No report is submitted in association with this milestone: see Section III for more information.

I: WE99 - Outreach and Education

One report is submitted in association with this milestone: Appendix I1 (2015 Yakama Nation Pacific Lamprey Project Outreach and Education).

J: WE176 - Produce Hatchery Fish / Research into Juvenile

One report is submitted in association with this milestone: Appendix J1 (Evaluation of Pacific Lamprey [*Entosphenus tridentatus*] Life Stage Transition from Prolarva to Larva and Timing of First Feeding).

K: WE119 - Manage and Administer Projects

No report is submitted in association with this milestone: see Section III for more information.

L: WE141 - Other Reports (Cultural Information)

One report is submitted in association with this milestone: Appendix L1 (Yakama Nation Cultural Oral Interviews on Asum [Lamprey Eels]: Summary and Review Part I [2015]).

M: WE132 - Annual Progress Report

This report herein represents the annual progress report.

N: WE185 - Pisces Status Report

No report is submitted in association with this milestone: see Section III for more information.

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 (Figure 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 declines 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 (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, WE158, WE162, WE161, WE99,

WE176, WE119, WE141, WE132, WE185) are oriented toward meeting one of these three project goals.

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 Documentation

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.

B. Work Element 174 – Produce Propagation and Rearing Plan

Considerable planning has occurred in preparation of pilot propagation and outplanting research activities since 2012. In 2012 and 2013, the YNPLP worked closely with the CRITFC and the Umatilla Tribes in the development of a broad scale Research, Monitoring and Evaluation (RME) Framework document towards Pacific Lamprey supplementation generally and artificial propagation specifically. The 2013 draft of the framework document was shared with federal and state agencies involved in Pacific Lamprey management (USFWS, WDFW, ODFW, and IDFG) for review. The comments were then incorporated to the final draft, which was completed in March, 2014.

Work Element Associated Appendix Report:
Appendix B1 – Draft Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research

Photo B1. Pacific Lamprey eggs from 2015 artificial propagation under a dissecting microscope.

The Columbia River Tribal Fish Commission (CRITFC), the Yakama Nation (YN), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Nez Perce Tribe (NPT) prepared a draft Master Plan to address Steps I and II 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 draft Master Plan is scheduled to be completed and submitted to the Independent Scientific Review Panel in spring/summer 2016 to initiate experimental larvae outplanting in fall 2016 and will be the basis from which the tribes move forward for additional research and funding towards potential future supplementation and lamprey recovery efforts. See **Appendix B1** for more information.

C. Work Element 157 – Collect/Generate/Validate Field and Lab Data

Work Element Associated Appendix Reports:
Appendix C1 – Yakima Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2009-2015)

Photo C1. Overview of a Yakima River index site at river km 264.8 from a 2015 survey.

This report covers two assessments within the Yakima Subbasin; 1) the distribution and site occupancy for Pacific Lamprey, *Entosphenus tridentatus*, (primary focus) and all lamprey

species (secondary focus), including Western Brook Lamprey (*Lampetra richardsoni*), and 2) the established index site monitoring for larval lamprey using data from repeat surveys. Both of these assessments (Part I and II) incorporate all Yakama Nation Pacific Lamprey Project survey data collected between 2009 and 2015.

A total of 369 sites were surveyed between 2009 and 2015. The known distribution of Pacific Lamprey in the mainstem Yakima River is river km 73.5 to 195.3. Roza Dam (river km 210.5) is a known passage barrier to Pacific Lamprey passage. The total reach length of Pacific Lamprey distribution within the Yakima Subbasin was 208.4 river km (121.8 and 86.6 river km in the mainstem and tributary streams, respectfully). Pacific Lamprey occupancy (% of surveyed sites with Pacific Lamprey within the known distribution range) was low in the Yakima Subbasin (16.7-50%). Local Pacific Lamprey population segments in the Yakima Subbasin has been functionally extinct in recent years (annual counts of only 0-87 adults at Prosser Dam in Lower Yakima River since 1996), which likely explains why Pacific Lamprey occupancy has been low in this Subbasin. However, occupancy within the Lower Yakima watershed has been increasing steadily between 2011 and 2015 (0%, 12.1%, 25.0%, 36.4%, and 84.6%, respectfully), suggesting that translocation is likely increasing the abundance of Pacific Lamprey.

A total of 45 index sites were established throughout the Yakima Subbasin (Fig. C1-1). These index sites highlight the best, and most accessible, patches of Type I larval lamprey habitat (sand/silt/clay), to attain one of the following monitoring objectives; 1) the distribution and status/ trend of wild Pacific Lamprey (and if present, Western Brook Lamprey), 2) production from ongoing adult Pacific Lamprey translocation efforts, and 3) future production from artificially propagated Pacific Lamprey larvae (first release planned for 2016). Larval lamprey habitat is well distributed across the entire Yakima Subbasin, with habitat almost equally abundant in all three subbasins (Lower Yakima, Upper Yakima, and Naches). However, the high water temperature in lower Yakima River substantially limits lamprey occupation during the summer season. Index site occupancy (% of surveyed sites occupied from repeat surveys) was calculated for Pacific Lamprey and for lamprey species in general using survey data collected between 2009 and 2015.

Sixteen sites (nine groupings) were established in the mainstem Yakima River, with five sites established in the known Pacific Lamprey distribution (river km 73.5-195.3). Within the known distribution, Pacific Lamprey occupancy ranged from 33-67%, while lamprey species occupancy was higher at 67-100%. Translocation has occurred primarily in three tributary streams in the Lower Yakima watershed beginning in 2012 and 2013. As a result, 14 index sites were established in these tributary streams (4, 6, and 4 sites in Satus, Toppenish, and Ahtanum creeks, respectfully), with 8 sites within the known Pacific Lamprey distribution (3, 1, and 4 sites in Satus, Toppenish, and Ahtanum creeks, respectfully) to monitor translocation success. Pacific Lamprey occupancy ranged between 33-100% (Satus 76-100%; Toppenish 50%; and Ahtanum

33-100%) within the known distribution, and lamprey species occupancy ranged between 0-100% (Satus 76-100%; Toppenish 0-100%; and Ahtanum 100%). In the Naches River, five index sites were establishd, with four within the known distribution of Pacific Lamprey. The primary purpose of Naches River index sites is two-folds: 1) to monitor the survival and production from propagated larval outplanting efforts and 2) to monitor the status and trend of wild Pacific Lamprey (and if present, Western Brook Lamprey). Pacific Lamprey occupancy in Naches Subbasin ranged from 0-50% within the known distribution , while lamprey species occupancy ranged from 0-100%. In tributaries upstrem of the known Pacific Lamprey distribution, eight index sites (two sites each in Wenas, Taneum, Swauk, and Teanaway watersheds) were established. Survival and production from Pacific Lamprey larval outplanting (scheduled to start in 2016-2017) will be monitored at Wenas Creek sites, while production from adult translocation efforts upstream of Roza Dam (initiated in March 2015) and overall status and trend will be monitored at the other three tributary streams. See **Appendix C1** for more information.

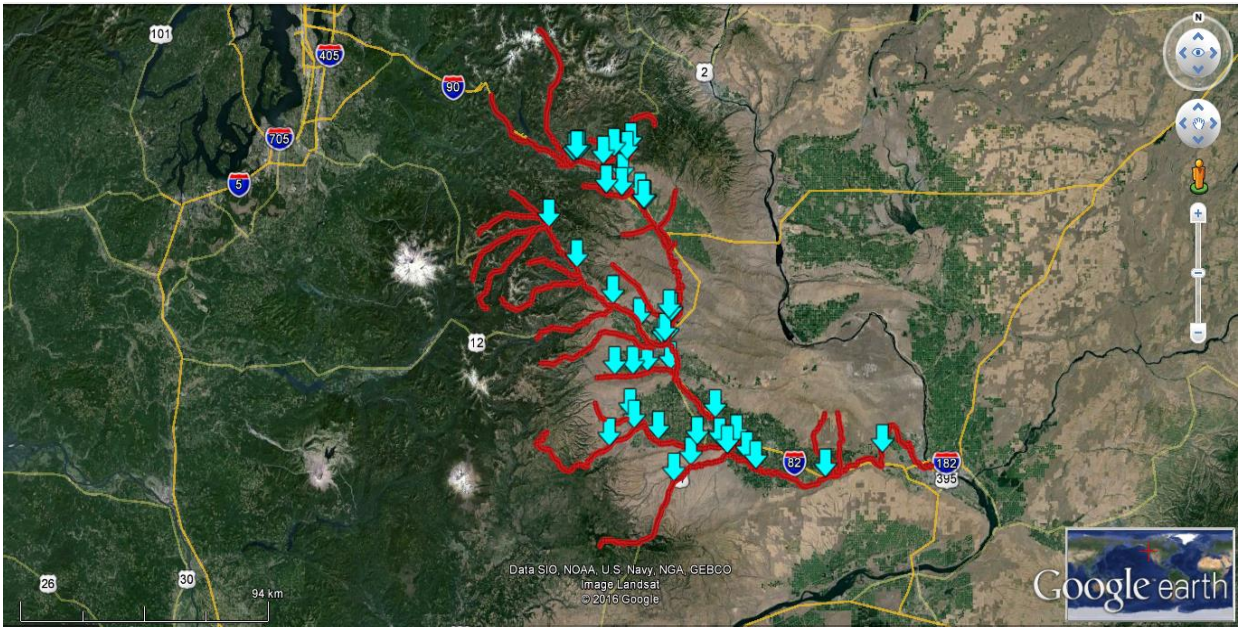

Figure C1-1. Overview map showing the distribution of established index sites in the Yakima Subbasin.

Appendix C2 – Wentchee Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Photo C2. Overview of an index site at river km 63.8 (upstream of Tumwater Dam) from a 2015 survey.

This report covers two assessments within the Wenatchee Subbasin; 1) the distribution and site occupancy for Pacific Lamprey, *Entosphenus tridentatus*, and 2) the established index site monitoring for larval lamprey using data from repeat surveys. Both of these assessments (Part I and II) incorporate all Yakama Nation Pacific Lamprey Project survey data collected between 2012 and 2015.

A total of 36 sites were surveyed for larval lamprey between 2012 and 2015 throughout the Wenatchee Subbasin. The known Pacific Lamprey distribution was determined from all past Yakama Nation survey data, and collaborative distribution information shared by the USFWS. Tumwater Dam (rive km 49.6) is a known passage barrier to Pacific Lamprey. Pacific Lamprey is currently absent upstream of the dam where they have been historically present. Downstream of Tumwater Dam, the known distribution of Pacific Lamprey in the mainstem is river km 1.0-48.8; 47.8 river km of known distribution. Despite its location downstream of Tumwater Dam, no lamprey have been found in Icicle Creek. Although no lamprey were found in any of the Upper Wenatchee watersheds, Pacific Lamprey occupancy (% of occupied sites with Pacific Lamprey) in the Lower Wenatchee River (downstream of Tumwater Dam) was high (87.5%). Because Western Brook Lamprey is known to be absent in the Wenatchee Subbasin, even if no larval lamprey were large enough to confirm species, it was assumed that the small larvae (< 50 mm) were also Pacific Lamprey.

A total of 12 index sites were established throughout the Wenatchee Subbasin (Fig. C2-1). These index sites highlight the best, and most accessible, patches of Type I larval lamprey habitat (fine sand/silt/clay), to attain one, or both, of the following monitoring objectives; 1) the distribution and status/ trend of wild Pacific Lamprey, and 2) production from ongoing adult Pacific Lamprey translocation efforts (initiated in March 2016). In 2016, adult Pacific Lamprey were

translocated both downstream and upstream of Tumwater Dam to recolonize the entire subbasin. Downstream of Tumwater Dam, four mainstem index sites (river km 8.8-40.4) and two tributary index sites (two sites in Icicle Creek, river km 4.0-6.8) were established to monitor the current relative abundance of Pacific Lamprey. Pacific Lamprey occupancy in the mainstem index sites (within the known distribution) is very high (100%) and larval lamprey are present in relatively high numbers. Three mainstem index sites (river km 50.4-84.0) and three tributary index sites (two sites in Nason Creek and one site in White River) were established upstream of the dam to monitor production from translocated lamprey. As of now, occupancy at these index sites is 0%. See **Appendix C2** for more information.

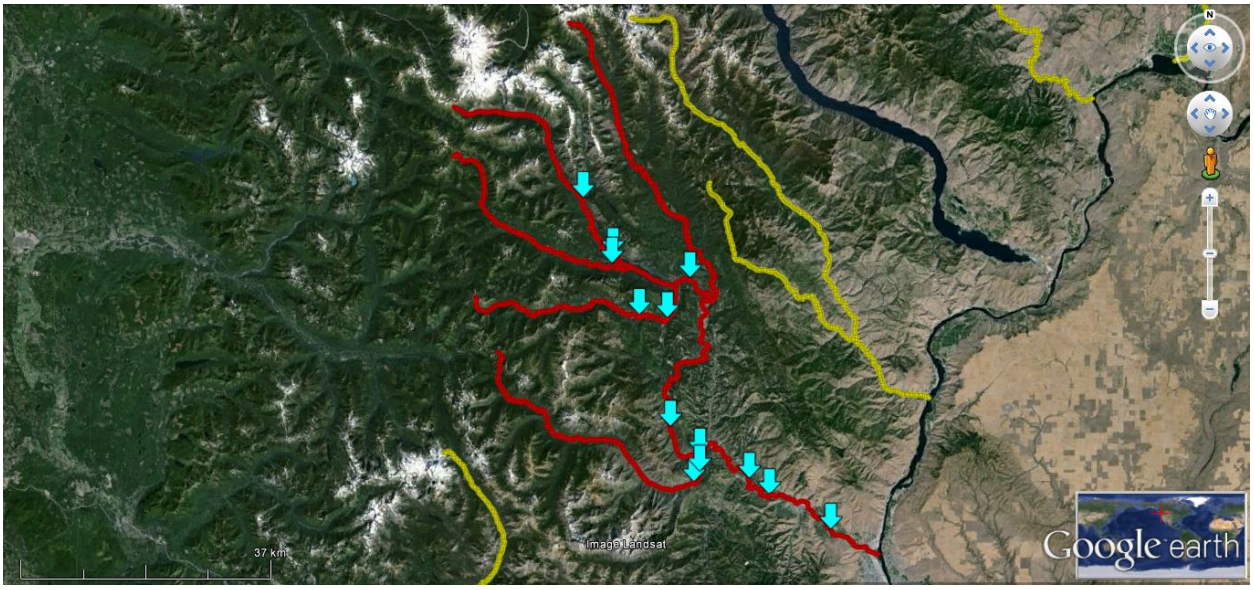

Figure C2-1. Overview map showing the distribution of established index sites in the Wenatchee Subbasin.

Appendix C3 – Entiat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2014)

Photo C3. Overview of an Entiat River index site at river km 27.4 from a 2014 survey.

This report covers two assessments within the Entiat Subbasin; 1) the distribution and site occupancy for Pacific Lamprey, *Entosphenus tridentatus*, and 2) the established index site monitoring for larval lamprey using data from repeat surveys. Both of these assessments (Part I and II) incorporate all Yakama Nation Pacific Lamprey Project survey data collected between 2012 and 2014.

A total of 15 sites were surveyed in the Entiat Subbasin between 2012 and 2014. The known Pacific Lamprey distribution within each subbasin, including tributaries, was determined using all past Yakama Nation survey data, as well as collaborative distribution information shared by the USFWS. The known distribution of Pacific Lamprey in the mainstem Entiat River is river km 1.9-46.4. Occupancy was relatively high in the Entiat Subbasin (88.9%), which may be due to the lack of passage barriers and large-scale irrigation diversions within the subbasin. Larval lamprey habitat is well distributed within the current known distribution of Pacific Lamprey.

A total of four index sites were established throughout the Entiat Subbasin (Fig. C3-1). These index sites highlight the best, and most accessible, patches of Type I larval lamprey habitat (fine sand/silt/clay) to monitor the distribution and status/ trend of wild Pacific Lamprey. Index site occupancy (% of surveyed sites occupied from repeat surveys) was calculated for Pacific Lamprey from all survey data collected between 2012 and 2014. All index sites are located in the mainstem Entiat River (river km 1.5-40.2) and are contained within the known distribution of Pacific Lamprey (river km 1.2-46.4). Occupancy of Pacific Lamprey at index sites, within their known distribution, was very high (100%).
See **Appendix C3** for more information.

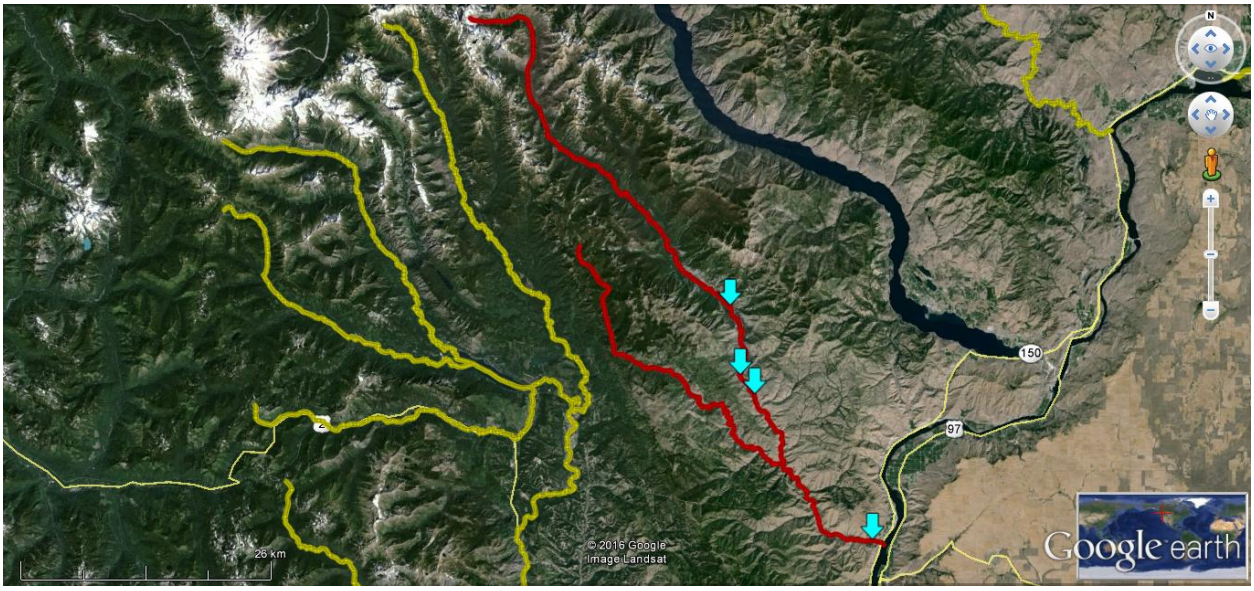

Figure C3-1. Overview map showing the distribution of established index sites in the Entiat Subbasin.

Appendix C4 – Methow Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Photo C4. Overview of a Methow River index site at river km 59.3 from a 2014 survey.

This report covers two assessments within the Methow Subbasin; 1) the distribution and site occupancy for Pacific Lamprey, *Entosphenus tridentatus*, and 2) the established index site monitoring for larval lamprey using data from repeat surveys. Both of these assessments (Part I and II) incorporate all survey data collected by Yakama Nation Pacific Lamprey Project and John Crandall (Methow Salmon Recovery Foundation) between 2013 and 2015.

In recent years, Pacific Lamprey numbers have been declining rapidly in the Methow Subbasin, likely due to the large number of hydroelectric dams lamprey have to pass through to reach the Subbasin (only 0-35 lamprey counted at Wells Dam from 2006-2015). John Crandall (Methow Salmon Recovery Foundation, previously Wild Salmon Conservancy) has been leading surveys for Pacific Lamprey in the Methow Subbasin since 2009, with the Yakama Nation's participation beginning in 2013. A total of 30 sites were surveyed between 2013 and 2015. Only Pacific Lamprey resides in the Methow Subbasin. The known Pacific Lamprey distribution is river km 25.6-81.4. Pacific Lamprey distribution in the Methow Subbasin covers a total of 129.4 river km (78.5 river in the Methow River and 50.9 in the Chewuch River). Pacific Lamprey occupancy (% of occupied sites with Pacific Lamprey) within the Methow Subbasin ranged from 60% to 100%. Pacific Lamprey occupancy was highest in the Chewuch River (60-100%), followed by the mainstem Methow River (66.7-75%). No lamprey are known to reside in the Twisp River (based on WDFW screw trap monitoring and surveys by the Yakama Nation and partners), possibly due to the limited larval lamprey habitat within Twisp River and the limited number of adults that enter the Methow Subbasin.

As a direct result of collaborative monitoring effort, the Yakama Nation established 12 index sites throughout the Methow Subbasin. These index sites highlight the best, and most accessible, patches of Type I larval lamprey habitat (fine sand/silt/clay), to attain both of the following monitoring objectives; 1) the distribution and status/ trend of wild Pacific Lamprey, and 2) production from ongoing adult Pacific Lamprey translocation efforts (initiated in September 2015). Index site occupancy (% of surveyed sites occupied from repeat surveys) was calculated for Pacific Lamprey from all survey data collected between 2013 and 2015.

Six index sites were established in the mainstem Methow River (river km 1.9-96.3); four of these sites are within the known Pacific Lamprey distribution (river km 25.6-81.4) (Figure C4-1). Site occupancy at these four sites ranged from 0-100%. In September 2015, adult Pacific Lamprey were translocated to the mainstem Methow River (initially collected from Lower Columbia River dams and held at Prosser Fish Hatchery) to prevent local extinction, which was eminent based on the most recent larval survey numbers. In addition to monitoring the status of wild larvae, the established index sites (both within and outside of the known Pacific Lamprey distribution) will monitor production of the translocated adults (through genetic analysis of samples taken from captured larvae via parentage analysis). Additionally, six index sites were established in tributary streams (two and one sites in the Chewuch and Twisp rivers, respectfully). The one Twisp River index site was established tentitively at river km 16.5 (site occupancy 0%). In the Chewuch River, all five of the index sites (river km 0.8-49.5) are within the known distribution of Pacific Lamprey (river km 0.8-51.7). Pacific Lamprey occupancy at these sites are between 0-100%. These two rivers will be monitored to track the production from translocated adults in addition to the continued status/trend monitoring of wild Pacific Lamprey numbers. See **Appendix C4** for more information.

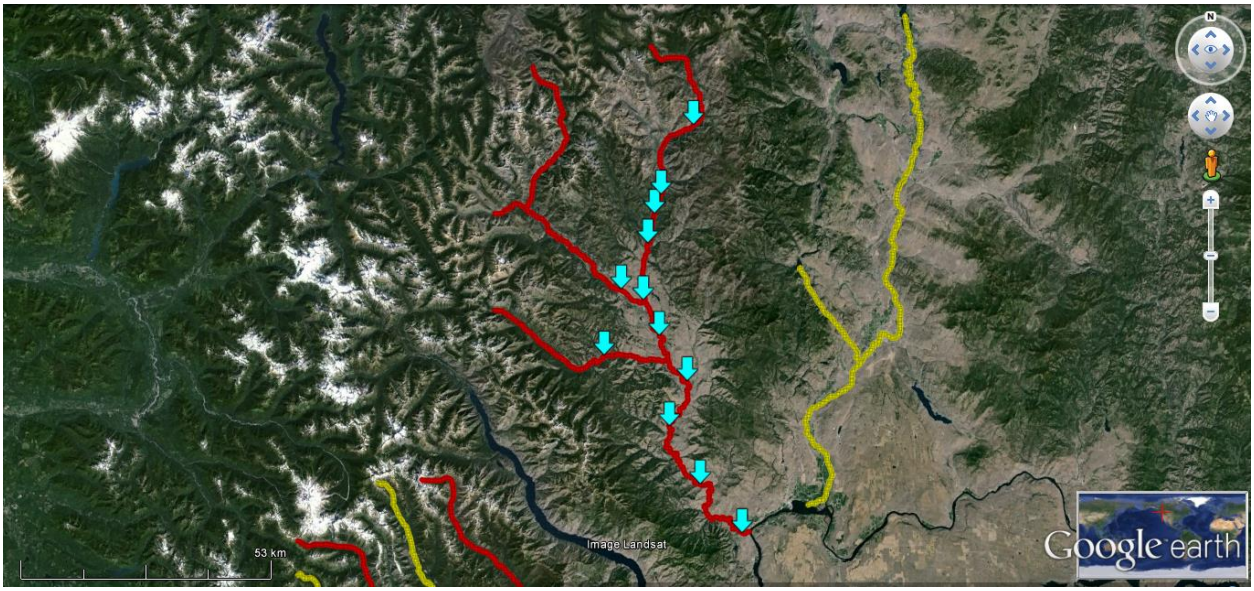

Figure C4-1. Overview map showing the distribution of established index sites in the Methow Subbasin.

Appendix C5 –Klickitat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2009-2015)

Photo C5. Overview of a Klickitat River index site at river km 1.9 from a 2014 survey.

This report covers two parts; 1) Pacific Lamprey distribution and site occupancy (primary focus) and overall lamprey (Western Brook Lamprey and Pacific Lamprey) distribution and site occupancy (secondary focus), and 2) established index site monitoring using data from repeat surveys. Both part one and part two incorporates all Yakama Nation Pacific Lamprey Project survey data collected between 2009 and 2015.

A total of 85 sites were surveyed in the Klickitat Subbasin between 2009 and 2015. The known Pacific Lamprey distribution in the mainstem Klickitat River is river km 0.0 to 69.3 (not extending upstream of the dam at the Klickitat Fish Hatchery at river km 69.4). The distribution of Pacific Lamprey also extends into the Little Klickitat River (river km 0.6-2.8).The total reach length for Pacific Lamprey distribution in the Klickitat Subbasin was 71.5 river km of known distribution (69.3 and 2.2 river km in the Klickitat River and Little Klickitat River, respectfully). Pacific Lamprey occupancy (% of occupied sites with Pacific Lamprey) within the known Pacific Lamprey distribution was high (91.5-100%). The notably high occupancy is potentially due to the relatively high abundance of Pacific Lamprey stemming from close proximity to the ocean and the limited number of hydroelectric dams that fish have to pass through in order to reach the Subbasin. Since both Pacific Lamprey and Western Brook Lamprey are present in the Klickitat Subbasin, larger larvae need to be captured for identification, and more lampreys need to be identified to confirm the presence of Pacific Lamprey. Smaller specimens that cannot be identified to species based on visible features can still be collected, preserved, and identified to species via genetic analysis.

A total of five index sites were established throughout the Klickitat Subbasin (Fig. C5-1). These index sites highlight the best, and most accessible, patches of Type I larval lamprey habitat (fine sand/silt/clay), to monitor both the distribution and status/trend of wild Pacific Lamprey (and if present, Western Brook Lamprey). Index site occupancy (% of survey sites occupied from repeat surveys) was calculated for Pacific Lamprey and for lamprey in general (all lamprey species) from all survey data collected between 2009 and 2015. A total of 4 index sites were established in the mainstem Klickitat River (river km 1.9-69.4), with 3 sites within the known distribution of Pacific Lamprey (river km 0.0-69.3). Occupancy of Pacific Lamprey at index sites, within their known distribution, was quite high (100%), likely due to the relatively high abundance of Pacific Lamprey in the Klickitat Subbasin. Pacific Lamprey distribution does not appear to extend upstream of the dam at the Klickitat Fish Hatchery (river km 69.3). One index site, river km 69.4, is located immediately upstream of the dam to monitor Pacific Lamprey passage over the dam. This site currently holds only Western Brook Lamprey (overall lamprey occupancy is 100%). One index site will be established in the Little Klickitat River (either at river km 0.6 or 1.7). See **Appendix C5** for more information.

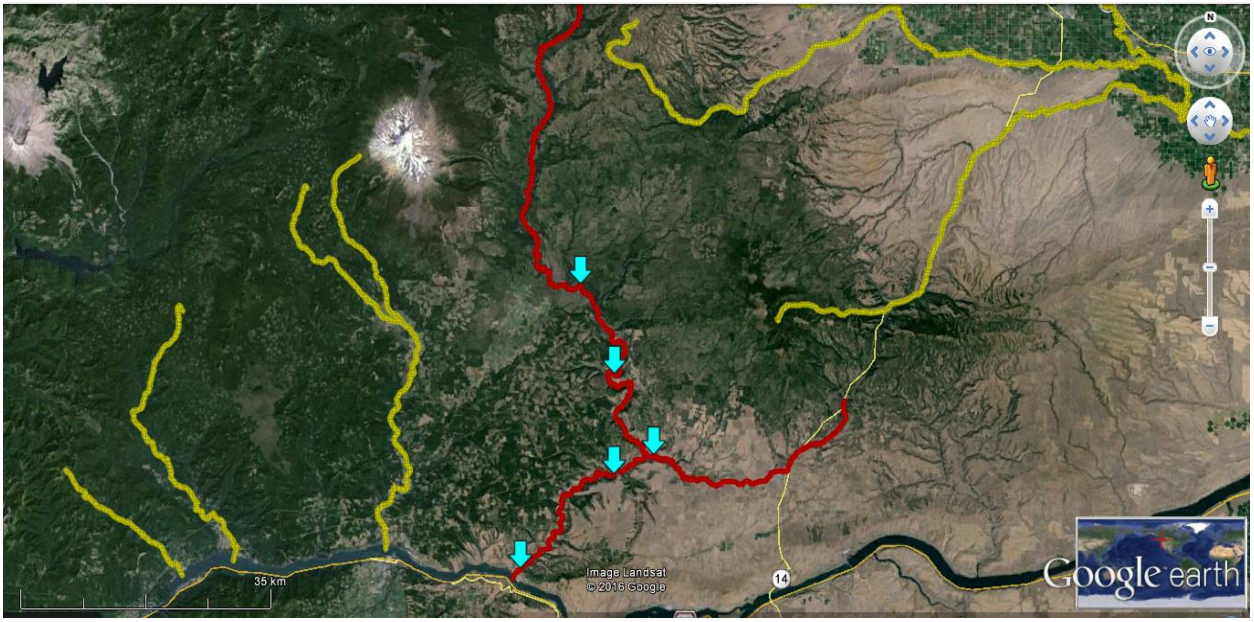

Figure C5-1. Overview map showing the distribution of established index sites in the Klickitat Subbasin.

Appendix C6 – White Salmon Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Photo C6. Overview of a White Salmon River index site at river km 0.8 (near the mouth) from a 2014 survey.

This report covers two parts; 1) Pacific Lamprey distribution and site occupancy (primary focus) and overall lamprey (Western Brook Lamprey and Pacific Lamprey) distribution and site occupancy (secondary focus) throughout the White Salmon Subbasin, and 2) established index site monitoring using data from repeat surveys. Both part one and part two incorporates all Yakama Nation Pacific Lamprey Project survey data collected between 2012 and 2015.

A total of 17 sites were surveyed in the White Salmon Subbasin between 2012 and 2015. The known distribution of Pacific Lamprey in the mainstem White Salmon River is river km 0.8-7.2 (river km 0.8 is located 0.1 km upstream of the Lewis and Clark Hwy Bridge). The total reach length for Pacific Lamprey distribution is 6.4 river km. Pacific Lamprey were absent upstream of Condit Dam (river km 5.9) prior to the dam's removal in 2011. Recent surveys by USFWS in 2015 have shown Pacific Lamprey recolonization up to 1.3 river km upstream of the removal site (river km 7.2). Pacific Lamprey occupancy (% of occupied sites with Pacific Lamprey) within the known Pacific Lamprey distribution was low (25.0%), potentially due to the limited distribution range Pacific Lamprey currently occupy. Overall lamprey occupancy within the known Pacific Lamprey distribution increases substantially to 50.0%. In these Subbasins where both Western Brook Lamprey and Pacific Lamprey are present, larger larvae need to be captured for identification, and more lamprey need to be identified to confirm the presence of Pacific Lamprey.

A total of five index sites were established throughout the White Salmon Subbasin (Fig. C6-1). These index sites highlight the best, and most accessible, patches of Type I larval lamprey

habitat (fine sand/silt/clay). The purpose of these index sites is to monitor 1) the recolonization of Pacific Lamprey as they further recolonize the area upstream of the removal site and 2) the Pacific Lamprey numbers downstream of the removal site. Larval lamprey habitat is considerably limited in mainstem White Salmon River (partly due to the steeper gradient), but Trout Lake Creek has substantially more low gradient wetland habitat, especially near the index site, which are conducive and optimal for Pacific Lamprey larvae (if adults can access the tributary). Index site occupancy (% of survey sites occupied from repeat surveys) was calculated for Pacific Lamprey and for lamprey in general (all lamprey species) from all survey data collected between 2012 and 2015.

A total of four sites were established in the mainstem White Salmon River (river km 0.8-40.5), with one site (river km 0.8) within the known distribution of Pacific Lamprey (0.8-7.2). Pacific Lamprey and overall lamprey occupancy was low (33%) at river km 0.8. Upstream of the removal site, and upstream of Pacific Lamprey distribution, overall lamprey occupancy was much higher at 50-100%. Additionally, one index site was established in Trout Lake Creek (river km 4.2). No Pacific Lamprey have been found to reside in Trout Lake Creek (which is upstream of the Condit Dam removal site), but Western Brook Lamprey have been found here in high abundance (overall lamprey occupancy 100%). See **Appendix C6** for more information.

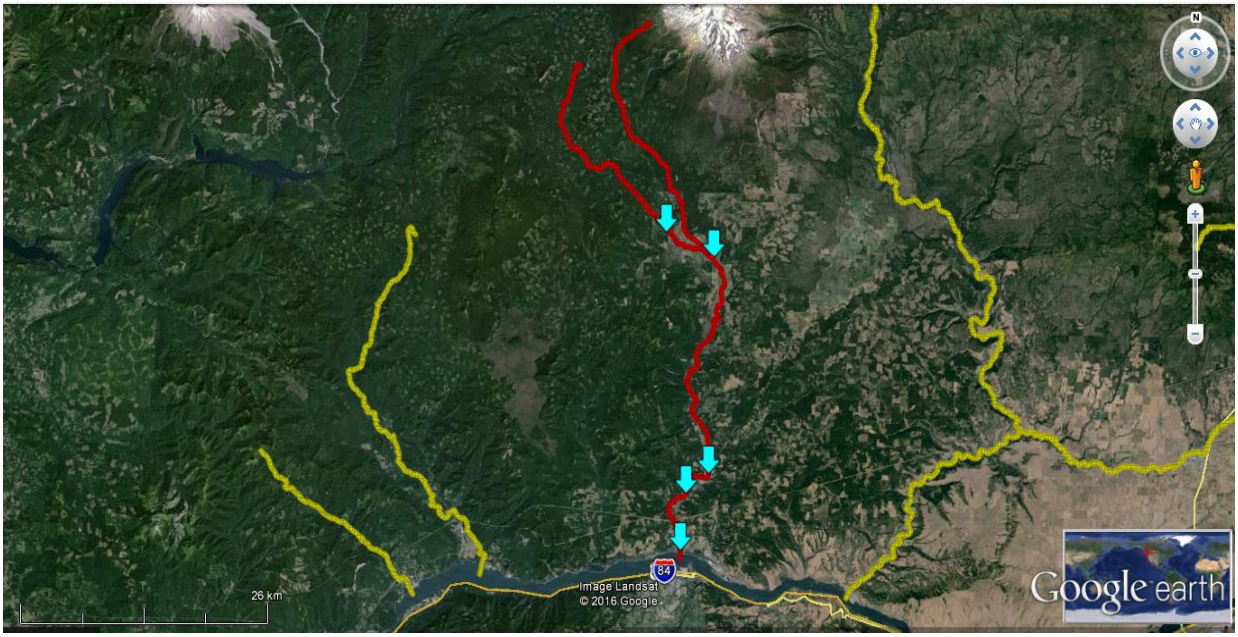

Figure C6-1. Overview map showing the distribution of established index sites in the White Salmon Subbasin.

D. Work Element 28 – Trap and Haul (Adult Lamprey Collection from Columbia River)

Work Element Associated Appendix Report:
Appendix D1 – 2015 Adult Pacific Lamprey Collection in the Columbia River Basin

Photo D1. One of the adult Pacific Lamprey successfully translocated into Lower Satus Creek on March 25, 2015, after collection from the Lower Columbia River.

This report is composed of three parts. The purpose of Part I is to report the summary of events from the 2015 adult Pacific Lamprey collection (trapping and transporting) from the Lower Columbia River hydroelectric projects, specifically Bonneville, The Dalles, and John Day dams. Adult collection for the YNPLP in 2015 began on June 9, 2015, at Bonneville Dam and was completed on August 9, 2015, at John Day Dam. In total, 1068 adult lamprey (289 from Bonneville Dam, 450 from The Dalles Dam, and 329 from John Day Dam) were collected, which was the allocation total for 2015 (Table D1-1, Fig. D1-1, and Table D1-2). We had a total of 23 mortalities in 2015 with a mortality rate of 2.2%. The severe drought and warm season for the region added to the stress experienced by the fish. Part II shows graphs of 2015 lamprey counts and 10-year average counts at Bonneville Dam in relation to various environmental conditions (temperature, spill, flow, dissolved gas, water elevation, and barometric pressure) available through Columbia River Data Access in Real Time (http://www.cbr.washington.edu/dart) (Fig. D1-2 and Fig. D1-3). Part III describes the project area and fish traps used in 2015 to collect lamprey at each of the three facilities (Bonneville, The Dalles, and John Day dams). See **Appendix D1** for more information.

Table D1-1. Total allocation per tribe for 2015 based on Tribal Restoration Plan guidelines.

Project	# of Adults
Bonneville Dam	289
The Dalles	450
John Day	329
Total	**1068**

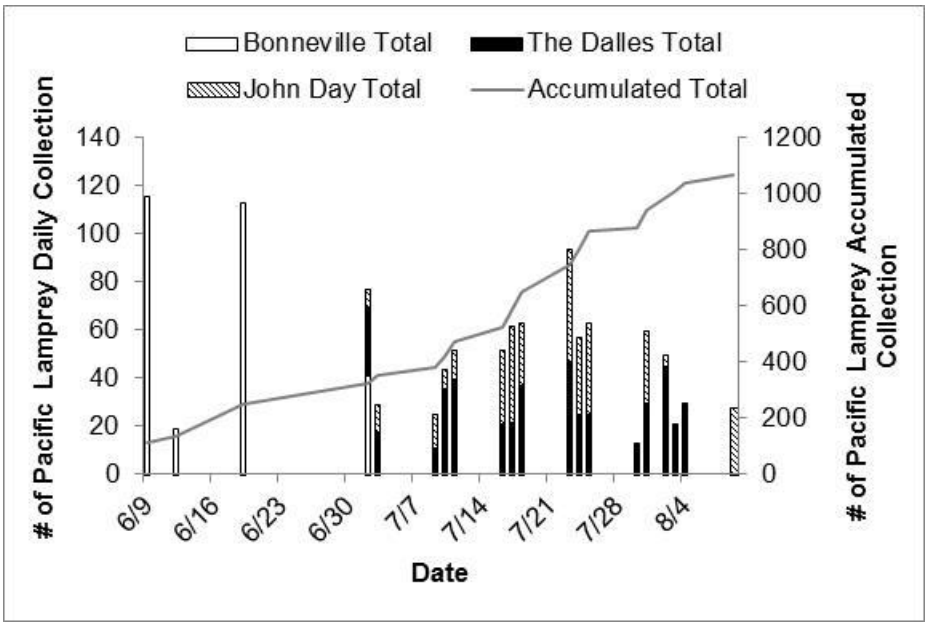

Figure D1-1. Summary of adult Pacific Lamprey collection numbers (daily and accumulated numbers) from 2015 collection.

Table D1-2. Summary of adult Pacific Lamprey collection data from Columbia River hydro dams (John Day, The Dalles, and Bonneville dams) in 2015.

	John Day Dam		The Dalles Dam			Bonneville Dam		Accumulated
Date	North Ladder	South Trap	East Ladder	North Ladder	Rocky Channel	Cascade Island	AFF	Total
6/9/2015	-	-	-	-	-	0	116	116
6/12/2015	-	-	-	-	-	0	19	135
6/19/2015	-	-	-	-	-	0	113	248
7/2/2015	7	0	29	-	-	0	41	325
7/3/2015	11	0	18	-	-	-	-	354
7/9/2015	14	0	11	-	-	-	-	379
7/10/2015	7	1	36	-	-	-	-	423
7/11/2015	11	1	40	-	-	-	-	475
7/16/2015	28	3	21	-	-	-	-	527
7/17/2015	32	8	22	-	-	-	-	589
7/18/2015	26	0	37	-	-	-	-	652
7/23/2015	34	13	47	-	-	-	-	746
7/24/2015	20	12	25	-	-	-	-	803
7/25/2015	31	7	25	-	-	-	-	866
7/30/2015	0	0	13	-	-	-	-	879
7/31/2015	18	12	30	-	-	-	-	939
8/2/2015	3	2	45	-	-	-	-	989
8/3/2015	0	0	21	-	-	-	-	1010
8/4/2015	0	0	30	-	-	-	-	1040
8/9/2015	22	6	-	-	-	-	-	1068
TOTALS	**264**	**65**	**450**	**0**	**0**	**0**	**289**	**-**

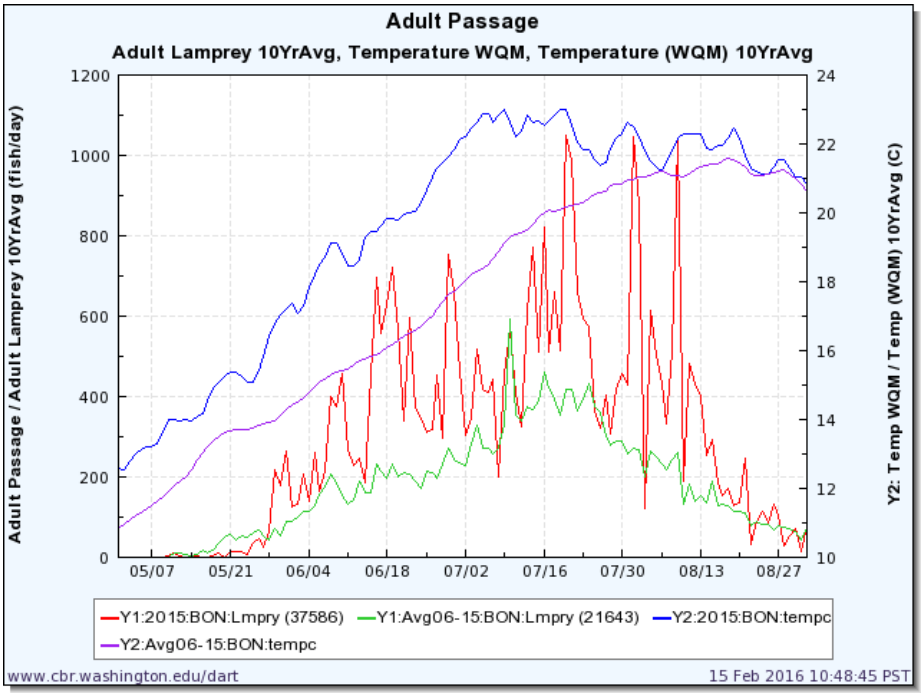

Figure D1-2. Daily adult Pacific Lamprey counts (2015 and 10-year average) in comparison with daily water temperature (2015 and 10-year average) at Bonneville Dam. Increase in water temperature generally results in increase in lamprey counts.

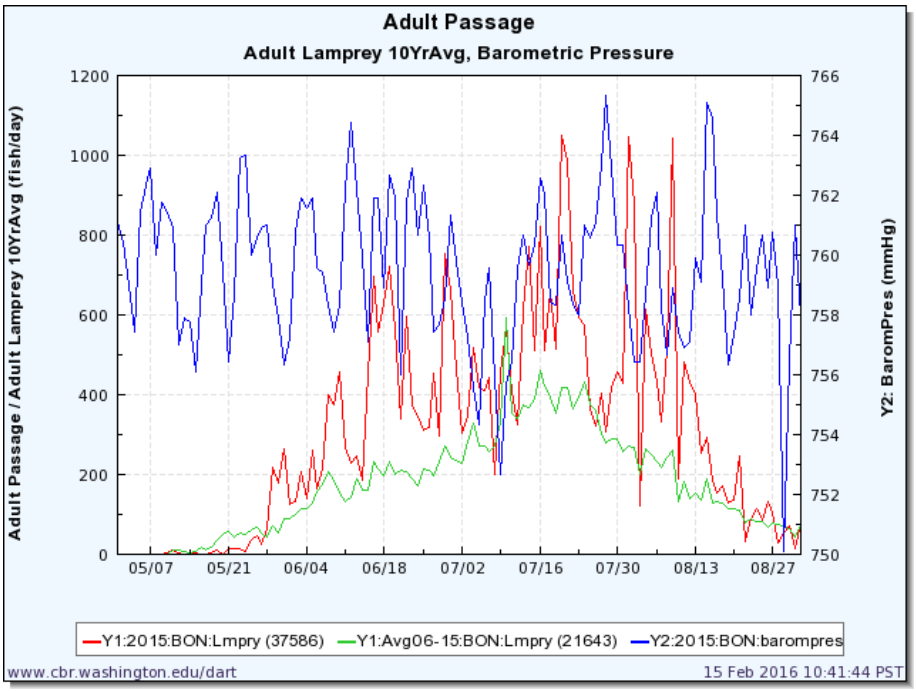

Figure D1-3. Daily adult Pacific Lamprey counts (2015 and 10-year average) in comparison with daily barometric pressure (2015 and 10-year average) at Bonneville Dam. Increase in barometric pressure generally results in increase in lamprey counts.

E. Work Element 158 – Mark/Tag Animals

Work Element Associated Appendix Report:

Appendix E1 – Translocation of Adult Pacific Lamprey within the Yakima Subbasin (2014-2015 Broodstock)

Photo E1. Patrick Luke showing an adult lamprey to Micah Lampman (3-yr-old) prior to its release in Satus Creek (river km 31.3) on April 28, 2015.

This report is composed of two parts: 1) summary of all 2014-2015 broodstock adult Pacific Lamprey releases within the Yakima Subbasin and 2) analysis of migration data from those adults that were PIT tagged. From the 2014-2015 broodstock (adults collected in summer 2014 that primarily matured in 2015), a total of 752 adult Pacific Lamprey were released in three lower Yakima River tributaries (Satus, Toppenish, and Ahtanum) and mainstem Yakima River between summer 2014 and spring 2015 (Fig. E1-1 and Table E1-1). Overall female ratio was 29.0%, PIT tag ratio was 72.6%, and genetic tag ratio was 97.7%. For comparison, up until 2014 the average female ratio has been 36.1%, PIT tag ratio has been 83.0%, and genetic tag ratio has been 94.6%. The accumulated total number of translocated adult Pacific Lamprey in the Yakima Subbasin from 2012-2015 is now 1159 (Table E1-2). Approximately 200 lamprey each were placed in Satus, Toppenish, and Ahtanum creeks, and 123 lamprey were placed in mainstem Yakima River (primarily in Upper Yakima above Roza Diversion Dam).

From the PITAGIS regional data base (http://www.ptagis.org/), we were able to find detection data from 259 individual lamprey (45.9% of the 564 total PIT tagged lamprey released). The vast majority of lamprey released in the lower reaches of Satus, Toppenish, and Ahtanum creeks were confirmed moving upstream after being released (96.3%, 91.4%, and 97.2%, respectfully). This rate (fidelity) has been increasing each year. We also confirmed some adults (5.2%, 6.8%, and 4.3% in Satus, Toppenish, and Ahtanum creeks, respectfully) moving downstream later in the season between April 20 and June 4, 2015, most of which were likely post-spawn downstream drifting while some of the early season downstream detections may be from lamprey exploring other spawning habitat. For example, two lamprey that were originally released in Lower Toppenish Creek migrated out to Yakima River and were detected in Yakima River further upstream; one moved upstream to river km 210.5 (Roza Diversion Dam) and one moved upstream to river km 171.2 (near Sunnyside Dam). The latter one was detected on March 6, 2016, indicating it overwintered twice (constitutes 0.4% of all tags detected). Approximately 64% of the lamprey released in Upper Toppenish (river km 54.3) were detected moving into Simcoe Creek (river km 8.9), while only about 22% of the lamprey that were confirmed moving upstream after being released in Lower Toppenish (river km 1.7) were detected moving into Simcoe Creek; based on this difference, we speculate that diversion dams, such as Unit 2 Diversion Dam (river km 44.6; Fig. E1-2 and Fig. E1-3), may potentially be preventing about two-thirds of the lamprey from moving into Toppenish Creek spawning habitat. From lamprey (n=102) released in Upper Yakima (river km 271.2-286.6), the highest detection was observed at Teanaway River (average of 18.9%) followed by Swauk Creek (average of 5.7%); none were detected in Taneum Creek. One lamprey was also detected at the Upper Teanaway site (river km 19.8). Downstream movements were detected in 25.0% and 75.0% of fish detected moving upstream in Teanaway and Swauk streams, respectfully, between May 31 and June 13, 2015. The fastest upstream migration speed from this 2014-2015 broodstock analysis was 21.5 km/day (Lower Satus Creek) and the fastest downstream drifting speed was 43.3 km/day (from Prosser Dam to McNary Dam). See **Appendix E1** for more information.

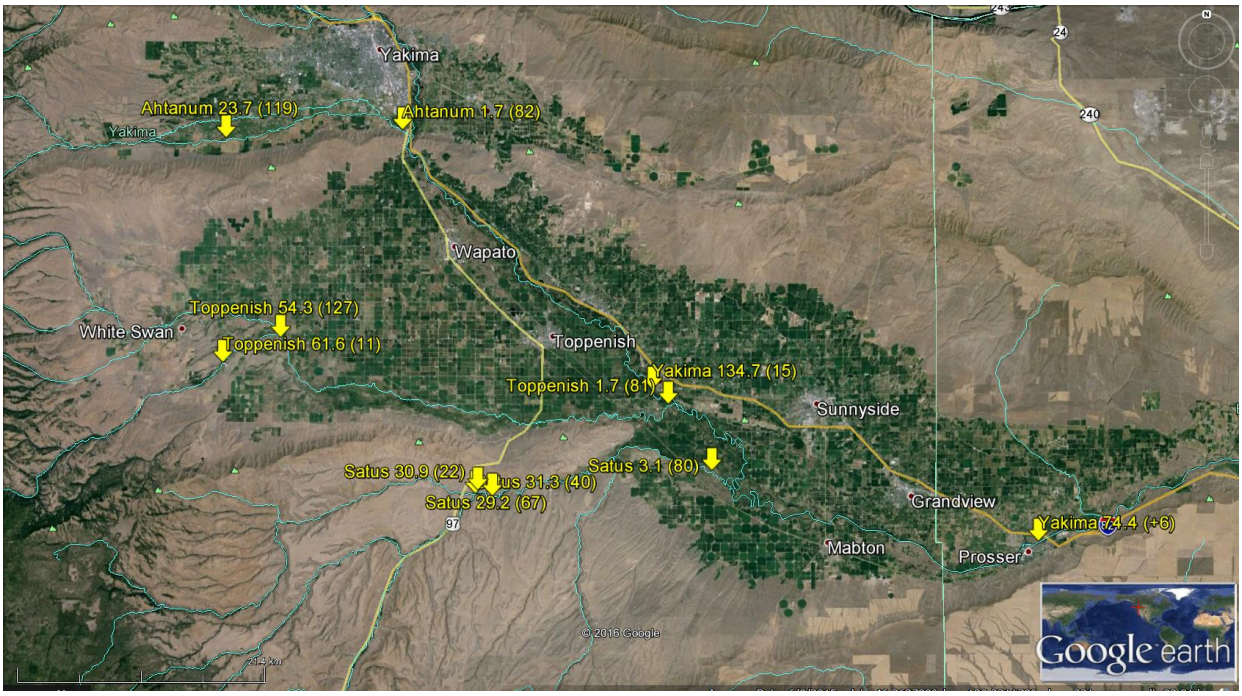

Figure E1-1. Overall aerial map of 2014-2015 broodstock adult Pacific Lamprey translocation release sites (the number next to the stream name is the stream km and the number in parenthesis is the total number of lamprey released).

Table E1-1. Summary of 2014-2015 broodstock adult Pacific Lamprey translocation release information.

Stream	# of Female	# of Male	# of Unknown	# with Pit Tags	# with Genetic Tags	# Total	Female Ratio	Pit Tag Ratio	Genetic Tag Ratio
Satus	70	129	10	168	209	209	35.2%	80.4%	100.0%
Toppenish	55	145	19	194	207	219	27.5%	88.6%	94.5%
Ahtanum	41	154	6	75	197	201	21.0%	37.3%	98.0%
Yakima	35	64	24	109	122	123	35.4%	88.6%	99.2%
Overall	**201**	**492**	**59**	**546**	**735**	**752**	**29.0%**	**72.6%**	**97.7%**

Table E1-2. Summary of all adult Yakama Nation Fisheries Pacific Lamprey translocation (Broodstock 2011-2012 through 2014-2015). *Number with genetic tags from 2012-2013 and 2013-2014 are estimates.

Broodstock Year	# of Female	# of Male	# of Unknown	# with Pit Tags	# with Genetic Tags	# Total	Female Ratio	Pit Tag Ratio	Genetic Tag Ratio
2011-2012	9	6	-	14	15	15	60%	93%	100%
2012-2013	27	110	-	120	*130	137	20%	88%	95%
2013-2014	111	144	-	204	*240	255	44%	80%	94%
2014-2015	201	492	59	546	735	752	29%	73%	98%
Total	**348**	**752**	**59**	**884**	**1120**	**1159**	**32%**	**76%**	**97%**

Figure E1-2. Unit 2 Diversion Dam in Toppenish Creek (river km 44.6), left bank looking downstream, a potential partial passage barrier for upstream migrating adult Pacific Lamprey.

Figure E1-3. Unit 2 Diversion Dam in Toppenish Creek (river km 44.6), right bank looking downstream, a potential partial passage barrier for upstream migrating adult Pacific Lamprey.

Appendix E2 – 2015 Juvenile/Larval Pacific Lamprey Passage Monitoring in Chandler Diversion, Yakima River (Prosser, WA)

Photo E2. Macrophthalmia life stage Pacific Lamprey collected from John Day Dam that were part of this tagging passage study.

Chandler Diversion is a known migration corridor for out-migrating larval/juvenile Pacific Lamprey. In the spring of 2015, we transferred 32 juvenile (macrophthalmia life stage) to Prosser Hatchery that were originally collected in Columbia River (John Day Dam, Smolt Monitoring Facility). These juvenile Pacific Lamprey (combined with one larval Pacific Lamprey collected from Chandler Juvenile Fish Monitoring Facility) were PIT tagged and released within Chandler Diversion to address what overall percentage of lamprey in the diversion will successfully enter the fish bypass. On May 22, 2015, between 9:00 am and 11:30 am, all fish were tagged with 8.4mm Pico full duplex PIT tags at Prosser Hatchery (Fig. E2-1 and Fig. E2-2). Lengths of macrophthalmia averaged 145 mm (between 131 and 159 mm) and the larva was 153 mm.

The release into the diversion occurred at 5:00 pm on March 22, 2015, immediately upstream of the first vehicle crossing bridge, 865 m upstream of the fish bypass (Fig. E2-3). Water temperature was rather high (22.0°C) at the time of the release. There were five PIT tag arrays located within the Chandler Juvenile Fish Monitoring Facility (located within the bypass route) to evaluate downstream passage. Of the 33 tagged Pacific Lamprey that were released upstream of the fish bypass, only one macrophthalmia was detected in the fish bypass (tag arrays A1 and A3). This macrophthalmia was detected at 11:18 pm on the same day of the release (6.31 hours after release). As a result, although all juvenile pit tagged fish migrating back to the river through the bypass channel are supposed to be detected at the pit tag arrays A1, A2, and/or A3, only 3.0% of the macrophthalmia released was ever detected. No other tagged lamprey were detected in the fish bypass as of April 7, 2016 (nearly one year after the initial release).

It is uncertain where the rest of the tagged fish ended up. Some could potentially get lost through predation, although for juvenile salmonids (*Oncorhynchus* species), predation rates are typically

only between 10-30% and usually much lower in the spring when water temperature is still cold. It is known that Smallmouth Bass can feed heavily on larval/juvenile lamprey, and other predatory species within the diversion might pose a threat to migrating lamprey as well. In a pilot laboratory feeding experiment conducted inside a 50-gallon aquarium, a Smallmouth Bass, 65 mm in length, collected from Chandler Diversion was able to consume four larval lamprey, between 34-49 mm in size, within 40 minutes.

There could also be additional screens upstream of the smolt separator, such as at the primary bypass flume, where lamprey may be potentially passing through or getting impinged. There are many factors that may have contributed to the limited percentage of lamprey detected in passing through the fish bypass. A future study with a larger sample size (or alternatively a release closer to the bypass entrance) is needed to further assess passage rates for juvenile/larval lamprey. If the return rates are less than 10-20%, irrigation diversions, such as Chandler Diversion, may pose a serious threat to downstream migrating juvenile/larval Pacific Lamprey in the Lower Yakima River. See **Appendix E2** for more information.

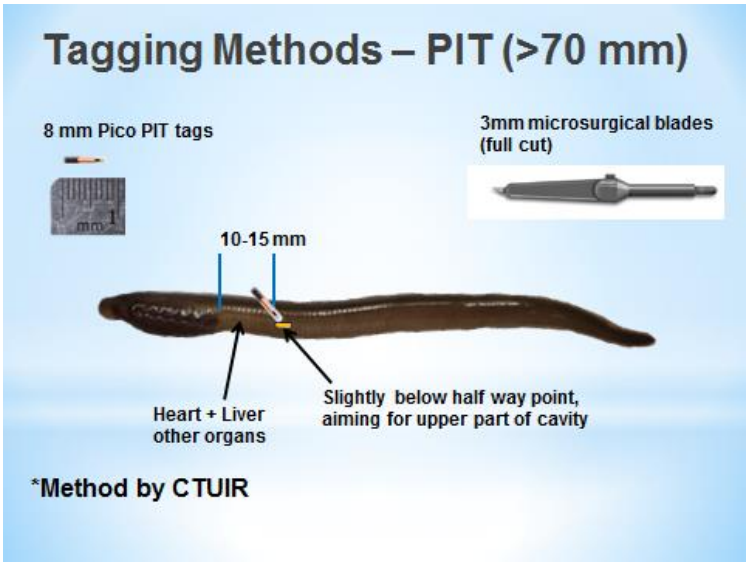

Figure E2-1. Illustration of the Pacific Lamprey PIT tagging methodology, showing insertion location and equipment needed.

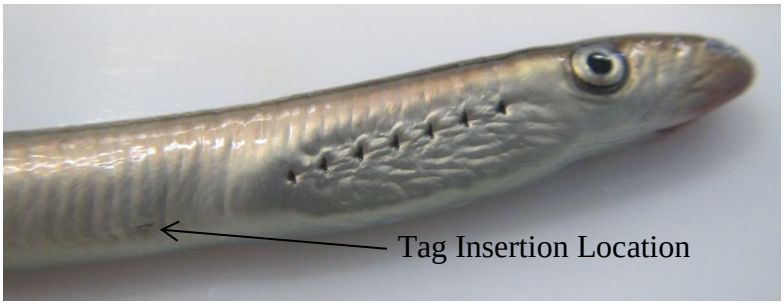

Figure E2-2. Close-up photo of the tag insertion location on juvenile Pacific Lamprey (either side of the body can be tagged).

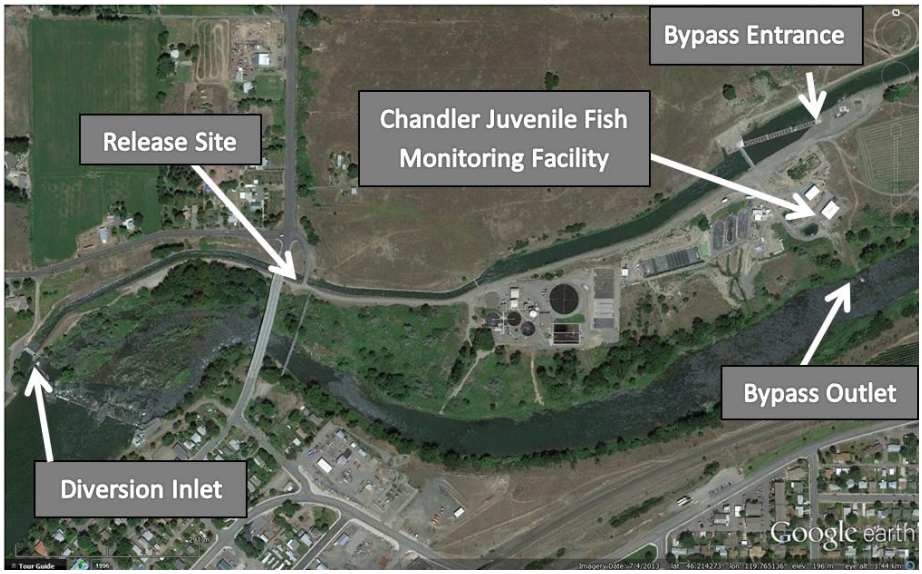

Figure E2-3. Overview map of Chandler Diversion and release site relative to the diversion inlet, fish bypass, and the fish bypass outlet.

F. Work Element 28 – Trap and Haul (Larval/Juvenile Lamprey Salvage in Diversions)

Work Element Associated Appendix Report:

Appendix F1 – 2015 Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakama Basin, Washington, USA

Photo F1. Larval lamprey trapped on the dry bank after dewatering at Wapatox Diversion, Naches River.

A total of 12 irrigation diversions were surveyed in the Yakima Subbasin (6, 2, 1 and 3 in the Yakima River, Ahtanum Creek, Taneum Creek and Naches River, respectively). Irrigation diversions provide preferred, yet in effect misleading, refuge habitat to hundreds of thousands of larval/juvenile lampreys moving downstream. When the diversions are dewatered after the irrigation season, the entrained lampreys are left to desiccate in or on top of dried fine sediment unless salvage occurs. Larval lamprey salvage surveys were conducted with the following objectives; 1) efficiently salvage as many larval/juvenile lampreys as possible and return them to their respective stream downstream of the diversion, 2) check dried banks closely for desiccated lampreys, and 3) understand lamprey distribution and densities upstream and downstream of the fish screens. In addition, we evaluated the ratio of entrained Pacific Lamprey versus Western Brook Lamprey within each of the surveyed irrigation diversion facilities.

In total, 15275 larval/juvenile lampreys were captured and returned to their respective stream (10731, 3252, 1221, and 71 from irrigation diversions in Ahtanum, Yakima, Naches, and Taneum watersheds, respectively) (Table F1-1). Missed lampreys that we could not capture constituted 76.4% of all observed lampreys (79.0% upstream and 39.8% downstream of fish screens). Surveys were conducted in almost equal ratio upstream and downstream of the fish screens (711 m^2 upstream and 703 m^2 downstream). Surveys upstream of the fish screens accounted for 83.3% of the total number of captured lampreys – however, this was primarily driven by the high counts at Bachelor-Hatton Diversion. In facilities where we surveyed both upstream and downstream of the fish screens (n=7), the average ratio of lampreys observed upstream of the fish screens was only 55.3% and densities of lampreys were on average 1.54 times higher compared to those observed downstream of the fish screens. Average density for all sites were 16.0 lamprey/m^2. A total of 2596 dead or nearly dead lampreys (3.8% of total lampreys observed) were found on dewatered banks or on top of partially wetted fine sediment (4.0% and 1.3% upstream and downstream of the fish screens, respectfully).

Pacific Lamprey were present at 7 of the 12 surveyed diversions and on average (by facility) constituted approximately 47% of lampreys identified (Table F1-2). The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was high at Bachelor-Hatton Diversion (97.7%) in Ahtanum Creek (river km 31.8), and Naches-Selah (66.7%) and Wapatox (51.2%) diversions in the Naches River (river km 30.6 and 29.0, respectfully). In the Yakima River, the ratio of Pacific Lamprey ranged from 5.9% (Union Gap Diversion, river km 188.7) to 15.7% (Wapato Diversion, river km 176.3); the ratio at Sunnyside Diversion (river km 171.4) was similar at 14.2%. The ratio of Pacific Lamprey has been increasing steadily since 2011 at Sunnyside and Wapato diversions from approximately 0% in 2012-2013 and 2013-2014, 7.0% in 2014-2015, to 15% in 2015-2016. This indicates that Pacific Lamprey began to appear in large numbers approximately 2.5 years after translocation began in Ahtanum Creek in 2013. See **Appendix F1** for more information.

Table F1-1. Overview of 2015-2016 dewatered irrigation diversion surveys in the Yakima Subbasin. "L" stands for lamprey in the table header.

Watershed	Stream	Diversion Name	River km	Survey Location	# of Survey Days	Survey Area (m^2)	Shock Time (min)	# of L. Captured (E-Fish)	# of L. Missed (E-Fish)	# of L. Observed (E-Fish)	Survey Density (#/m^2)	# of L. Dead	# of L. Observed (Total)
Lower Yakima	Yakima	Chandler	73.4	Upstream	1	24	21	0	0	0	-	0	0
Lower Yakima	Yakima	Chandler	73.4	Downstream	-	-	-	-	-	-	-	-	-
Lower Yakima	Yakima	Sunnyside	171.4	Upstream	1	11	8	40	7	47	4.3	0	47
Lower Yakima	Yakima	Sunnyside	171.4	Downstream	5	472	403	1954	470	2424	5.1	49	2473
Lower Yakima	Yakima	Wapato	176.3	Upstream	3	181	159	992	524	1516	8.4	378	1894
Lower Yakima	Yakima	Wapato	176.3	Downstream	1	50	40	194	110	304	6.1	0	304
Lower Yakima	Yakima	Union Gap	188.7	Upstream	1	24	38	18	10	28	1.2	0	28
Lower Yakima	Yakima	Union Gap	188.7	Downstream	-	-	-	-	-	-	-	-	-
Upper Yakima	Yakima	Roza	210.6	Upstream	1	12	8	5	3	8	0.7	0	8
Upper Yakima	Yakima	Roza	210.6	Downstream	1	50	38	40	14	54	1.1	0	54
Upper Yakima	Yakima	Town	264.7	Upstream	1	23	19	9	12	21	0.9	0	21
Upper Yakima	Yakima	Town	264.7	Downstream	-	-	-	-	-	-	-	-	-
Lower Yakima	Ahtanum	Diversion 14	24.8	Upstream	1	15	15	33	4	37	2.5	0	37
Lower Yakima	Ahtanum	Diversion 14	24.8	Downstream	1	5	5	0	1	1	0.2	0	1
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Upstream	8	281	283	10343	44859	55202	196.4	1510	57132
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Downstream	4	106	98	355	1091	1446	13.6	8	1454
Upper Yakima	Taneum	Taneum	3.7	Upstream	1	19	26	71	15	86	4.5	0	86
Upper Yakima	Taneum	Taneum	3.7	Downstream	-	-	-	-	-	-	-	-	-
Naches	Naches	Congdon	14.1	Upstream	1	4	8	2	2	4	1.1	0	4
Naches	Naches	Congdon	14.1	Downstream	1	10	8	1	0	1	0.1	0	1
Naches	Naches	Wapatox	29.0	Upstream	2	87	101	1212	2335	3547	40.8	651	4198
Naches	Naches	Wapatox	29.0	Downstream	-	-	-	-	-	-	-	-	-
Naches	Naches	Naches-Selah	30.6	Upstream	1	30	16	0	1	1	0.03	0	1
Naches	Naches	Naches-Selah	30.6	Downstream	1	10	12	6	0	6	0.6	0	6
				Upstream	**22**	**711**	**702**	**12725**	**47772**	**60497**	**23.7**	**2539**	**63456**
Total	**-**	**-**	**-**	**Downstream**	**14**	**703**	**605**	**2550**	**1686**	**4236**	**3.8**	**57**	**4293**
				Total	**36**	**1414**	**1307**	**15275**	**49458**	**64733**	**16.0**	**2596**	**67749**

Table F1-2. Overview of species composition from the 2015-2016 dewatered irrigation diversion surveys in the Yakima Subbasin. "L" stands for lamprey in the table header.

Watershed	Stream	Diversion Name	River km	Survey Location	# of Survey Days	# WB L.	# PA L.	% PA L.
Lower Yakima	Yakima	Chandler	73.4	Upstream	1	-	-	-
Lower Yakima	Yakima	Chandler	73.4	Downstream	-	-	-	-
Lower Yakima	Yakima	Sunnyside	171.4	Upstream	1	-	-	-
Lower Yakima	Yakima	Sunnyside	171.4	Downstream	5	399	66	14.2%
Lower Yakima	Yakima	Wapato	176.3	Upstream	3	269	50	15.7%
Lower Yakima	Yakima	Wapato	176.3	Downstream	1	-	-	-
Lower Yakima	Yakima	Union Gap	0	Upstream	1	16	1	5.9%
Lower Yakima	Yakima	Union Gap	188.7	Downstream	-	-	-	-
Upper Yakima	Yakima	Roza	210.6	Upstream	1	4	0	0.0%
Upper Yakima	Yakima	Roza	210.6	Downstream	1	36	0	0.0%
Upper Yakima	Yakima	Town	264.7	Upstream	1	7	0	0.0%
Upper Yakima	Yakima	Town	264.7	Downstream	-	-	-	-
Lower Yakima	Ahtanum	Diversion 14	24.8	Upstream	1	26	0	0.0%
Lower Yakima	Ahtanum	Diversion 14	24.8	Downstream	1	-	-	-
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Upstream	8	5	402	98.8%
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Downstream	4	8	149	94.9%
Upper Yakima	Taneum	Taneum	3.7	Upstream	1	2	0	0.0%
Upper Yakima	Taneum	Taneum	3.7	Downstream	-	-	-	-
Naches	Naches	Congdon	14.1	Upstream	1	1	0	0.0%
Naches	Naches	Congdon	14.1	Downstream	1	0	1	100.0%
Naches	Naches	Wapatox	29.0	Upstream	2	137	144	51.2%
Naches	Naches	Wapatox	29.0	Downstream	-	-	-	-
Naches	Naches	Naches-Selah	30.6	Upstream	1	-	-	-
Naches	Naches	Naches-Selah	30.6	Downstream	1	2	4	66.7%
				Upstream	**22**	**467**	**597**	**56.1%**
Total	**-**	**-**	**-**	**Downstream**	**14**	**445**	**220**	**33.1%**
				Total	**36**	**912**	**817**	**47.3%**

G. Work Element 162 – Data Input, Analysis and Interpretation

To accomplish the goal of restoring natural production, YNPLP has focused activities on five general objectives: 1) establishing baseline information for the presence and absence of Pacific Lamprey, 2) understand 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) continue research, development into adult supplementation practice and reintroduce by translocation where local populations have been extirpated or functionally extirpated and 5) establish long term status and trend monitoring with index sites. Since initiation of the YNPLP in 2008, we have gained a better understanding on program development and prioritizing action plans based upon our Three Phase approach for the last few years.

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 two types of data together so that they can be stored on a data depository, such as StreamNet, and/or shared with other entities. We are also in the process of scanning all field data sheets to make all hard copy data available in an electronic form. 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 2015-2016. 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 is available upon request.

Work Element Associated Appendix Reports:

Appendix G1 – Distribution and Occupancy of Pacific Lamprey in Six Major Columbia River Subbasins within the Yakama Nation Ceded Lands: Summary from 2009-2015 Surveys

Photo G1. Larval lamprey (~ 40 mm) found in a scoop of sandy sediment during a 2015 survey in Lower Wenatchee River (river km 8.8).

Between 2009 and 2015, surveys for larval lamprey were conducted in six major Columbia River subbasins within the Yakama Nation Ceded Lands (Table G1-1 and Table G1-2); White Salmon Subbasin (17 sites surveyed from 2012-2015), Klickitat Subbasin (75 sites surveyed from 2009-2015), Yakima Subbasin (369 sites surveyed from 2009-2015), Wenatchee Subbasin (34 sites surveyed from 2012-2015), Entiat Subbasin (14 sites surveyed from 2012-2014), and Methow Subbasin (31 sites surveyed from 2013-2015). Pacific Lamprey were found in each subbasin. The known Pacific Lamprey distribution within each subbasin, including tributaries, was determined using all past Yakama Nation survey data, as well as collaborative distribution information shared by the USFWS, WDFW, and other local partners (including John Crandall - Methow Salmon Recovery Foundation).

The total reach length for Pacific Lamprey distribution was highest in the Yakima Subbasin with 212.0 river km of known distribution (121.8 and 90.2 river km in the mainstem and tributary streams, respectfully), followed by the Methow (129.4 river km), Klickitat (71.5 river km), Wenatchee (47.8 river km), Entiat (45.2 river km), and White Salmon (6.4 river km) subbasins. Pacific Lamprey occupancy (% of occupied sites with Pacific Lamprey) within the known Pacific Lamprey distribution was generally high in the Upper Columbia tributaries (upstream of the Yakima Subbasin) where Western Brook Lamprey are known to be absent and only Pacific Lamprey reside (75.0-88.9%). Occupancy was highest in the Entiat Subbasin (88.9%). Although no lamprey were found in any of the Upper Wenatchee watersheds, occupancy in the Lower Wenatchee River (up to Tumwater Dam) was high (87.5%).

In the Lower and Mid Columbia subbasins (Yakima Subbasin and downstream), Pacific Lamprey and Western Brook Lamprey are both present. Pacific Lamprey occupancy was highest in the Klickitat Subbasin (80.0-100.0%), potentially due to its higher abundance stemming from

proximity to the ocean and the limited number of hydroelectric dams that fish have to pass through in order to reach the Subbasin. Pacific Lamprey occupancy was low in the White Salmon Subbasin (25.0%), potentially due to the limited distribution range Pacific Lamprey currently occupy (the habitat above the old Condit Dam site became available only since 2011). Pacific Lamprey occupancy was also low in the Yakima Subbasin (16.7-50%). Local Pacific Lamprey population in the Yakima Subbasin has become functionally extinct in recent years (annual counts of only 0-87 adults at Prosser Dam in Lower Yakima River since 1996), which likely explains why Pacific Lamprey occupancy has been low in this Subbasin. However, occupancy within the Lower Yakima watershed has been increasing steadily between 2011 and 2015 (0%, 12.1%, 25.0%, 36.4%, and 84.6%, respectfully), suggesting that translocation may be increasing the abundance of Pacific Lamprey. See **Appendix G1** for more information.

Table G1-1. Summary of Pacific Lamprey distribution and site occupancy for six major Columbia River subbasins within the YN Ceded Lands based on survey data between 2009 and 2015.

Subbasin	Stream Name	# of Survey Sites	River km of Lower-most Site with PA Lamprey	River km of Upper-most Site with PA Lamprey	Total River km with PA Lamprey	# of Sites Downstream of PA Lamprey Distribution	# of Sites Upstream of PA Lamprey Distribution	# of Sites within PA Lamprey Distribution	# of Sites Occupied (PA Lamprey) within PA Lamprey Distribution	% PA Lamprey Occupancy within PA Lamprey Distribution
White Salmon	White Salmon	14	0.8	7.2	6.4	0	10	4	1	25.0%
	Trout Lake	2	-	-	-	-	-	0	0	-
Klickitat	Klickitat	57	0.0	69.3	69.3	0	10	47	43	91.5%
	Little Klickitat	18	0.6	2.8	2.2	0	16	2	2	100.0%
Lower Yakima	Yakima	101	73.5	191.8	118.3	23	0	78	13	16.7%
	Satus	36	12.9	41.2	28.3	9	4	23	7	30.4%
	Toppenish	27	44.6	44.6	0.0	13	12	2	1	50.0%
	Simcoe	12	-	-	-	-	-	0	0	-
	Ahtanum	27	0.9	31.9	31.0	0	4	23	6	26.1%
Upper Yakima	Yakima	94	191.8	195.3	3.5	0	92	2	1	50.0%
	Naches	38	1.7	29.0	27.3	0	16	22	4	18.2%
	Wenas	17	-	-	-	-	-	0	0	-
	Taneum	5	-	-	-	-	-	0	0	-
	Swauk	9	-	-	-	-	-	0	0	-
	Teanaway	3	-	-	-	-	-	0	0	-
Lower Wenatchee	Wenatchee	8	1.0	48.8	47.8	0	0	8	7	87.5%
	Icicle	8	-	-	-	-	-	0	0	-
Upper Wenatchee	Wenatchee	10	-	-	-	-	-	0	0	-
	Nason	7	-	-	-	-	-	0	0	-
	White	1	-	-	-	-	-	0	0	-
Entiat	Entiat	14	1.2	46.4	45.2	2	3	9	8	88.9%
Lower Methow	Methow	11	2.9	81.4	78.5	1	0	10	7	70.0%
	Twisp	1	-	-	-	-	-	0	0	-
Upper Methow	Methow	4	-	-	-	-	-	0	0	-
	Chewuch	15	0.8	51.7	50.9	0	1	14	11	78.6%

Table G1-2. Summary of overall lamprey (all species) distribution and site occupancy for six major Columbia River subbasins within the YN Ceded Lands based on survey data between 2009 and 2015.

Subbasin	Stream Name	# of Survey Sites	River km of Lower-most Site with Lamprey	River km of Upper-most Site with Lamprey	Total River km with Lamprey	# of Sites within PA Lamprey Distribution	# of Sites Occupied (All Lamprey) within PA Lamprey Distribution	% Lamprey Occupancy within PA Lamprey Distribution	# of Sites within Lamprey Distribution	# of Sites Occupied (All Lamprey) within Lamprey Distribution	% Lamprey Occupancy within Lamprey Distribution
White Salmon	White Salmon	13	0.8	41.5	40.7	4	2	50.0%	12	7	58.3%
White Salmon	Trout Lake	2	4.2	4.2	0.0	-	-	-	1	1	100.0%
Klickitat	Klickitat	57	0.0	69.3	69.3	47	45	95.7%	52	49	94.2%
	Little Klickitat	18	0.6	29.8	29.2	2	2	100.0%	15	7	46.7%
Lower Yakima	Yakima	101	73.5	191.8	118.3	78	37	47.4%	78	37	47.4%
	Satus	36	2.9	41.2	38.3	23	10	43.5%	30	14	46.7%
	Toppenish	27	43.3	73.2	29.9	2	1	50.0%	15	12	80.0%
	Simcoe	12	0.1	30.6	30.5	-	-	-	12	10	83.3%
	Ahtanum	27	0.9	38.5	37.6	23	21	91.3%	27	24	88.9%
Upper Yakima	Yakima	94	195.3	328.1	132.8	2	1	50.0%	90	52	57.8%
	Naches	38	1.7	72.3	70.6	22	10	45.5%	37	19	51.4%
	Wenas	17	0.0	19.2	19.2	-	-	-	16	12	70.6%
	Taneum	5	-	-	-	-	-	-	0	0	-
	Swauk	9	0.2	11.7	11.5	-	-	-	9	6	66.7%
	Teanaway	3	0.2	1.2	1.0	-	-	-	2	2	100.0%
Upper Wenatchee	Wenatchee	8	1.0	48.8	47.8	8	7	87.5%	8	7	87.5%
	Icicle	8	-	-	-	-	-	-	0	0	-
Lower Wenatchee	Wenatchee	10	-	-	-	-	-	-	0	0	-
	Nason	7	-	-	-	-	-	-	0	0	-
	White	1	-	-	-	-	-	-	0	0	-
Entiat	Entiat	14	1.2	31.0	29.8	9	8	88.9%	9	8	88.9%
Lower Methow	Methow	11	2.9	81.4	78.5	10	7	70.0%	10	7	70.0%
	Twisp	1	-	-	-	-	-	-	0	0	-
Upper Methow	Methow	4	-	-	-	-	-	-	0	0	-
	Chewuch	15	0.8	51.7	50.9	14	11	78.6%	14	11	78.6%

Appendix G2 – 2015 Intensive Monitoring of Larval/Juvenile Lamprey Entrainment within the Yakama Basin

Photo G2. Overview of the area upstream of the fish screens at Bachelor-Hatton Diversion (Ahtanum Creek, river km 31.8) where over 10,000 larval lampreys were salvaged in 2015.

Total larval lamprey numbers were estimated at three diversions with considerably high lamprey entrainment. The area immediately downstream of the fish screens at Sunnyside Diversion (Yakima River, river km 171.4), the area immediately upstream the fish screens at Wapato Diversion (Yakima River, river km 176.3), and the area immediately upstream and downstream of the fish screens at Bachelor-Hatton Diversion (Ahtanum Creek, river km 31.8) were our primary focus. At each location, surveys were conducted in representative areas of Type I and Type II habitat. The resulting Type I and Type II densities were then extrapolated over the area of the respective habitat type.

At Sunnyside Diversion (in the area immediately downstream of the fish screens), a total of 66 plots were surveyed in representative portions of Type I and Type II habitat between October 29, 2015 and February 25, 2016 covering five survey dates. On average, daily density in Type I habitat ranged between 4.3 and 10.1 lamprey/m^2 (average of 6.9 lamprey/m^2) and that in Type II habitat ranged between 2.1 and 3.3 lamprey/m^2 (average of 2.7 lamprey/m^2). Daily estimated lamprey numbers from electrofishing ranged from as low as 3,146 (December 14, 2015) to as high as 11,075 (October 29, 2015). Throughout the salvage/survey process, a total of 1,954 lampreys were salvaged and returned to the river, with 49 dead lampreys found along the bank (totaling 2,003 lampreys removed). Total estimated numbers (created from the addition of electrofishing estimates, other lamprey observations, and cumulative number of lampreys removed up to the previous survey date) ranged from 4,796 to 11,115. The high estimate was similar to the estimate based on the survey using the deep-water electrofishing platform (12,408) – see Appendix G4 for more information.

At Wapato Diversion (in the area immediately upstream of the fish screens) a total of 12 plots were surveyed in representative portions of Type I and Type II habitat on October 27, 2015. From this, we estimated the total number of larval-juvenile lampreys (from electrofishing densities) to be 6,145 in this area. On average, high density Type I habitat contained 12.9 lamprey/m^2, medium density Type I habitat contained 5.2 lamprey/m^2, and low density Type I habitat near the fish screens contained 2.8 lamprey/m^2. The total estimated number of lampreys in the area immediately upstream of the fish screens at Wapato Diversion was 6,969. If we assume that the high density area potentially had 2 times as many fish at its peak on October 16, 2015, compared to October 27, 2015, based on our observation from electrofishing in high density areas, our estimated number of lampreys in this area increases to 8,075, based on this conservative adjustment (assuming that the density in other areas remained constant). This estimate was similar to the estimate based on the survey using the deep-water electrofishing platform (9,404) – see Appendix G4 for more information.

At Bachelor-Hatton Diversion, surveys were conducted between July 14, 2015 and January 28, 2016. Surveys occurred both immediately upstream and immediately downstream of the fish screens (seven and four survey dates, respectively). From electrofishing efforts, 10,698 lampreys, all live larvae, were captured and successfully returned to Ahtanum Creek. Average electrofishing densities above the fish screens ranged from 42.9-560.0 lamprey/m^2 (July 14, 2015 and October 6, 2015, respectively). Below the fish screens, electrofishing densities ranged from 9.0-25.0 lamprey/m^2 (July 14, 2015 and October 7, 2015, respectively). Identification of 564 larval lampreys (>50 mm in total length) showed that 97.3% were Pacific Lamprey. Also, a total of 1,518 dead (or mostly dead) lampreys were found on dewatered banks (n=8), on top of wetted habitat (n=810), or found on dredged material (n=700). During the dredging operation, which occurred on October 16-17, 2015, two pumps (50 gallon/min and 300 gallon/min pumps) were placed immediately upstream of the fish screens and used to draw down the water level. We estimate that approximately 1,188 larval lampreys have passed through these two pumps during approximately 500 minutes of run time (average of 142 lamprey/hour), resulting in approximately 16-25% mortality (~321 lampreys). At final tally, 13,404 larval lampreys were removed from the diversion (either through electrofishing, mortality, or pump). Upstream of the fish screens, daily total estimated lamprey numbers (sum total of daily electrofished number plus cumulative number of lampreys removed prior to the survey date) ranged from 5,536 (July 14, 2015) to 34,467 (October 17, 2015). Downstream of the fish screens, daily total estimated lamprey numbers ranged between 715 (July 14, 2015) and 1,248 (October 7, 2015).

In reality, these estimated numbers could be considerably larger, even exceeding the high range of our estimated numbers, as we are entirely uncertain how many lampreys remained unseen during the survey period either from survey inefficiency, predation, decomposition, or

concealment in the dredged material. From our 2014 mark-recapture study in Wapato Diversion, we estimated only 19-45% capture efficiency using the standard electrofishing surveys.

The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was comparatively high during the 2015-2016 survey period compared to previous years: At Sunnyside Diversion it was 14.2%, at Wapato Diversion it was 17.1%, and at Bachelor-Hatton Diversion it was 97.3%. It is likely that the offspring from the Ahtanum Creek translocation is contributing to this high ratio at Bachelor-Hatton Diversion and those fish are gradually reaching Wapato and Sunnyside diversions on mainstem Yakima River. During the 2014-2015 survey period, only ~7% were Pacific Lamprey at Sunnyside and Wapato diversions and no Pacific Lamprey were found at Bachelor-Hatton Diversion. See **Appendix G2** for more information.

Table G2-1. Summary of lamprey assessment at Sunnyside Diversion immediately downstream of the fish screens.

Survey Date	Total # of Plots	# Captured (E-Fishing)	# Captured (on Bank)	Daily # Removed	Cumul. # Removed	Daily Est. # Lamprey (E-Fishing)	Daily Est. # Lamprey (Combined)
10/29/15	15	369	40	409	409	11075	11115
11/04/15	12	607	0	607	1016	9661	10070
11/17/15	11	364	0	364	1380	4807	5823
12/14/15	14	261	0	261	1641	3416	4796
02/25/16	15	353	9	362	2003	3545	5195
Total	**67**	**1954**	**49**	**2003**	**-**	**-**	**-**

Table G2-2. Summary of lamprey assessment at Wapato Diversion immediately upstream of the fish screens.

Survey Date	Total # of Plots	# Captured (E-Fishing)	# Captured (on Bank)	Daily # Removed	Cumul. # Removed	Max E-Fish Density (#/m^2)	Daily Est. # Lamprey (E-Fishing)	Daily Est. # Lamprey (Combined)
10/16/15	1	452	372	824	824	60	7703	8075
10/27/15	12	248	0	248	1072	30	6145	6969

Table G2-3. Summary of lamprey assessment at Bachelor-Hatton Diversion. Daily electrofishing estimates are combined with lampreys observed through other means plus the cumulative number of lampreys removed up to the previous surveyed date to arrive at a combined estimated number of lampreys for each survey date at Bachelor-Hatton Diversion.

Survey Date	Survey Location Relative to Fish Screens	# Captured	# Est. Through Pumps	# of Morts	Daily # Removed	Cumul. # Removed	Est. # of Lamprey E-Fish	Daily Est. # Lamprey (Combined)
7/14/15	Upstream	420	-	-	420	420	5536	5536
7/16/15	Upstream	1233	-	-	1233	1653	22638	23058
7/17/15	Upstream	1140	-	-	1140	2793	21085	22738
7/21/15	Upstream	3320	-	410	3730	6523	25285	28488
8/20/15	Upstream	200	-	-	200	6723	-	-
10/6/15	Upstream	2100	1000	300	3400	10123	26656	33679
10/7/15	Upstream	330	86	-	416	10539	24344	34467
10/7/15	Upstream	900	102	800	1802	12341	22731	34127
1/28/16	Upstream	700	-	-	700	13041	10710	23005
7/14/15	Downstream	220	-	8	228	228	707	715
7/17/15	Downstream	106	-	-	106	334	814	1042
8/20/15	Downstream	14	-	-	14	348	-	-
10/7/15	Downstream	15	-	-	15	363	900	1248
Total	**-**	**10698**	**1188**	**1518**	**13404**	**-**	0	**-**

Appendix G3 - Evaluation of Chandler Diversion Bypass Pathways for Larval/Juvenile Lamprey during the Dewatering Season

Photo G3. Overview of Chandler Diversion upstream of fish screens during the dewatered season.

In 2014 and 2015, PIT tagged juvenile Pacific Lamprey were released within Chandler Diversion to evaluate return rates back to the Yakima River. Although the sample size was very small

(2014 = 43, 2015 = 35), we found that detection rates (equivalent to return rates) were very low (3-12%) compared to PIT tagged juvenile salmonids. In an effort to evaluate where the lamprey may be disappearing, we investigated the bypass routes in seven sections from entrance to exit, which are 1) Diversion Above Fish Screens, 2) 1st Bypass Entrance, 3) 2nd Bypass Entrance, 4) 3rd Bypass Entrance, 5) Bypass Confluence, 6) Pump Station inside Vertical Belt Screen Bays, 7) Chandler Juvenile Fish Monitoring Facility.

PIT tagged lamprey were at a minimum 70 mm in length, whose girth are typically over 2.75 mm (Fig. G3-1). Larger juvenile lamprey, ~180 mm in length, typically have a girth near 4.75 mm. Mesh size that meet existing NOAA criteria for salmon are 3/32 inch (2.4 mm) or smaller, so the majority of larger PIT tagged lamprey are not likely to be entrained in fish screens that meet these criteria (including Chandler Diversion fish screens), unless a larger gap exists anywhere on the fish screens. As a result, we searched extensively for gaps and holes that were larger than 2.4 mm in size at the fish screens and within the bypass routes (Fig. G3-2 through Fig. G3-10). The only areas where we found these types of openings were at the Juvenile Monitoring Facility (Fig. G3-6 through Fig. G3-9). Most of the screens used within the upper story segment of the facility were between 3.5 and 4.5 mm – hence, it is possible that a large portion of the lamprey are falling through the screens and being carried back to the river through the alternate return pipes. Also, four large holes (7-18 mm in sizes) were found on the perforated plate (Fig. G3-6); these holes were subsequently sealed with silicon sealant during the winter dewatering season in December to prevent any chances of lamprey escapement through these holes. See **Appendix G3** for more information.

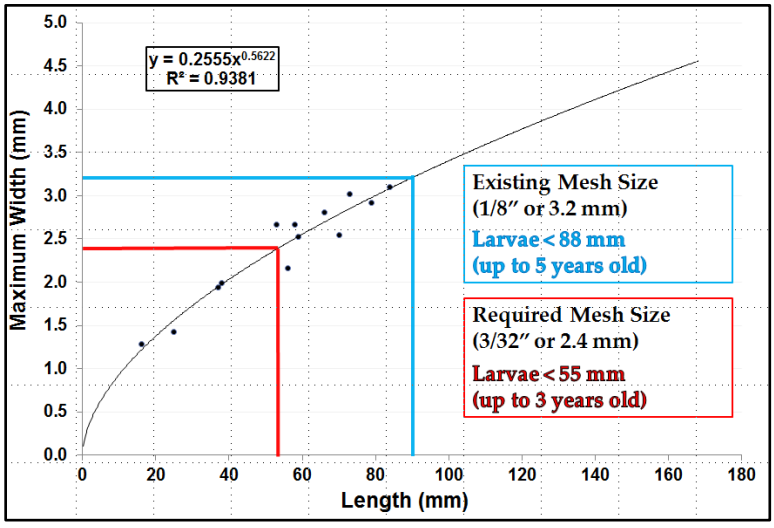

Figure G3-1. The relationship between lamprey total length and maximum body width based on larval/juvenile Western Brook Lamprey and artificially propagated Pacific Lamprey.

Figure G3-2. Location where the three bypass routes converge (looking downstream) - traveling belt screens on the left protecting the pump stations (two bays, four screens).

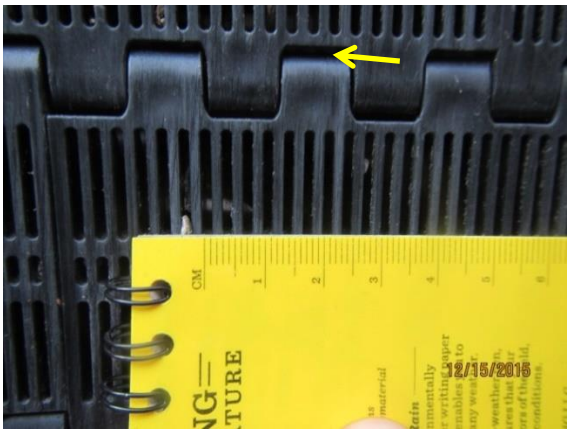

Figure G3-3. Close up of the traveling belt screen (1.5 mm mesh; 2 mm opening at the horizontal locking structure [yellow arrow]).

Figure G3-4. Concrete conduit leading to Chandler Diversion Juvenile Monitoring Facility (looking inside). This entire route was not examined.

Figure G3-5. First segment of CJFMF looking downstream (yellow arrow shows direction of water and fish). Perforated screen is ~20 ft long (upslope), bar screen is ~4 ft (downslope), and the PVC section is ~10 ft long.

Figure G3-6. One of the four large openings (18 mm wide) on the first screen (perforated mesh 4.5 mm) of Chandler Diversion Juvenile Monitoring Facility.

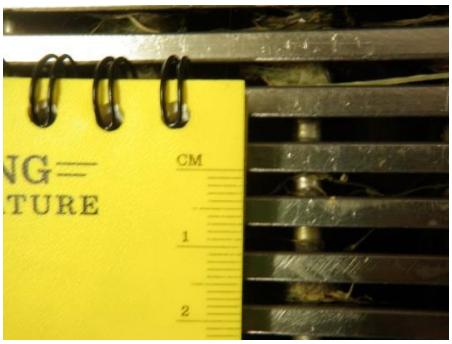

Figure G3-7. Bar screen mesh (screen in the lower part of the photo) has a 3.5~3.8 mm opening.

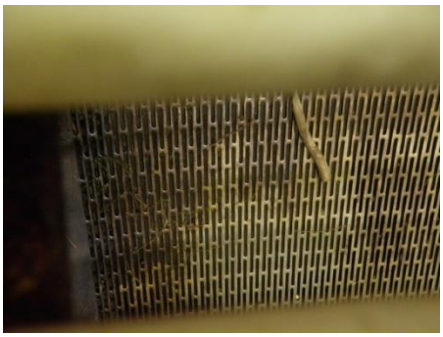

Figure G3-8. Inside view of the area underneath the PVC section of the CJFMF (another type of bar screen shown).

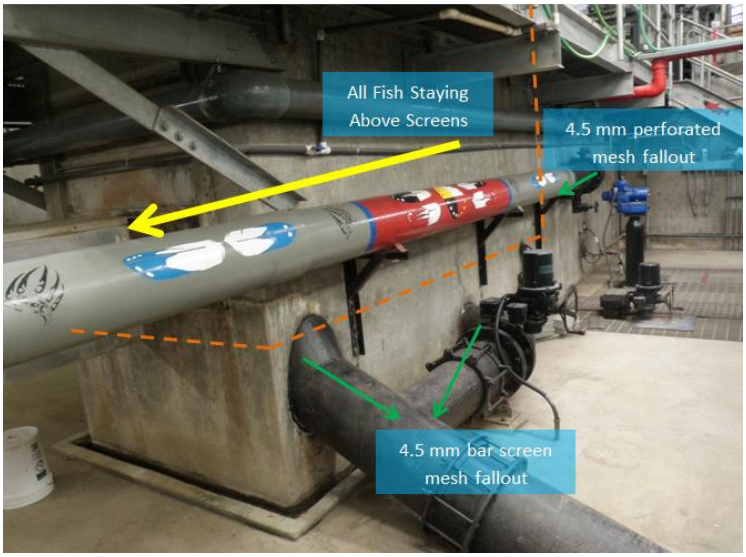

Figure G3-9. The lower story segment of CJFMF. Yellow thick line shows where all the fish that stay above the screens migrate (towards the metal chute with PIT tag reader arrays). The thin green lines show where the path of water (and small organisms) that fall through the screens, which leads directly back to the river.

Figure G3-10. Subsampling holding pool overview (from side). The crowder has a 2.2 mm mesh opening. At the downstream end of the holding pool, there were some 9.5 mm gaps that lead to a dead end opening.

Appendix G4 - Larval Lamprey Assessment at Wapato and Sunnyside Fish Screening Facilities

Photo G4. A video clip image of a larval lamprey during electrofishing event at the Wapato screen forebay (the distance between the two laser points is 14 cm).

Larval Pacific Lamprey surveys were conducted using a deep-water electrofishing platform (DEP) deployed from a small floating platform at Wapato and Sunnyside diversion screens in October 2015 (Fig. G4-1 and Fig. G4-2). Pacific Northwest National Laboratory developed the DEP to document larval lamprey that inhabit water at depths ranging from 1-9 m. The system was deployed from a portable boat which has the capability of surveying in small water bodies where motorboats cannot access. Lamprey are known to enter these regions as larvae and rear in the sediments deposited as water velocities slow near the fish screens. The Yakima Nation in coordination with the Bureau of Reclamation conduct salvage operations to collect larvae in these regions and return to the river to prevent desiccation. Currently no method exists to survey these regions and determine presence/absence, density, and size classes of larvae that are rearing near these facilities.

Within the Sunnyside headgate forebay region (Fig. G4-3), suitable substrates were estimated to be 93.4 m^2 and lamprey density was estimated at 2.5 fish per m^2, which indicate ~232 lamprey occupying this region. The total survey area was 2,870 m^2 downstream of the screens and the total estimated survey area was 10.82 m^2 (Fig. G4-4). Seventy–five lamprey were observed across all size ranges. Within the suitable region (Type I and II substrates), 8.5 m^2 was surveyed with a density of 8.8 fish per m^2 and the total estimated lamprey inhabiting this region was 12,408.

At the Wapato headgate only a small region (3.3 m^2; Fig. G4-5) which was found in the upper portion adjacent to the log boom walkway was found to have suitable substrates. A total of 4 lamprey were observed in this region. Based on the surveyed area and a density of 4.2 fish per

m^2, a total of 14 lamprey might be expected to occur. At the screens forebay region (Fig. G4-6), 50 lamprey were observed across all size ranges. The total survey area polygon was 2,220 m^2 and the total estimated survey area was 10.41 m^2. The suitable region encompassed 1,452 m^2 and an estimated 7.7 m^2 was surveyed with the DEP. The estimated density within the suitable region was 6.5 fish per m^2 and the total estimated lamprey that may be inhabiting this region was 9,404.

This was the first use of a portable electrofishing boat that was designed to be used in small hard to access water bodies. The system performed very well and enable us to surveys these regions effectively and determine relative larval lamprey densities. See **Appendix G4** for more information.

Figure G4-1. Bob Mueller operating the deepwater electrofishing platform at Sunnyside Diversion behind the fish screens.

Figure G4-2. Close up of the electrofishing unit and camera system for the deepwater electrofishing platform.

Figure G4-3. Sunnyside headgate region illustrating total survey region (yellow and blue polygons) and suitable region (blue polygons) from surveys conducted on October 21, 2015.

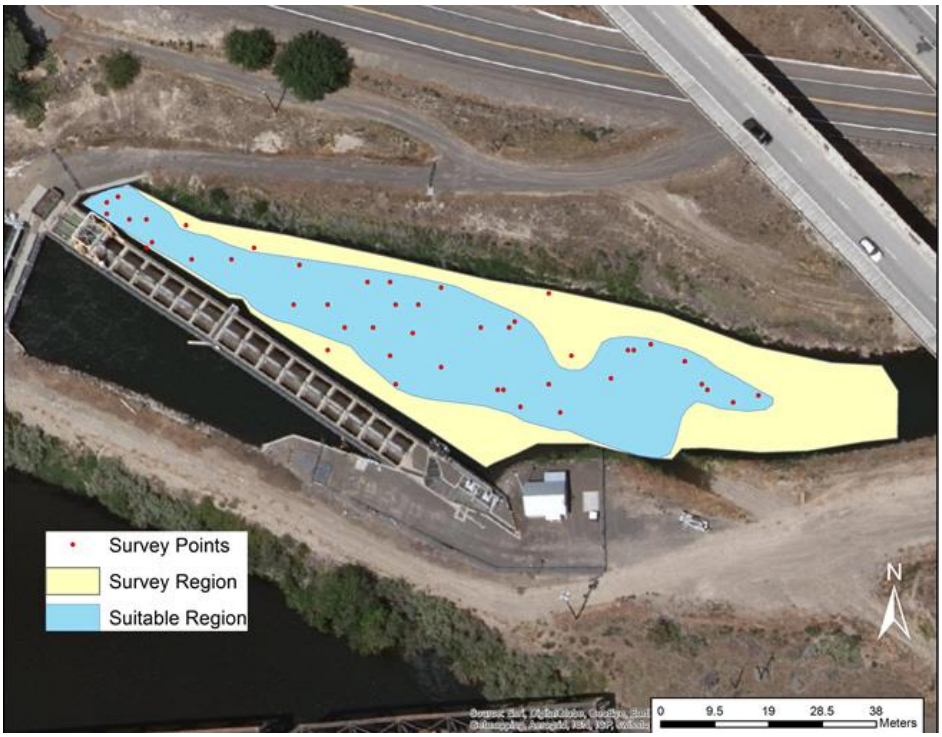

Figure G4-4. Sunnyside screen region illustrating sampling locations (red dots), total survey region (yellow and blue polygons) and suitable region (blue polygons) from surveys conducted on October 21, 2015.

Figure G4-5. Wapato headgate region illustrating total survey region (yellow and blue polygons) and suitable region (blue polygons) from surveys conducted on October 15, 2015.

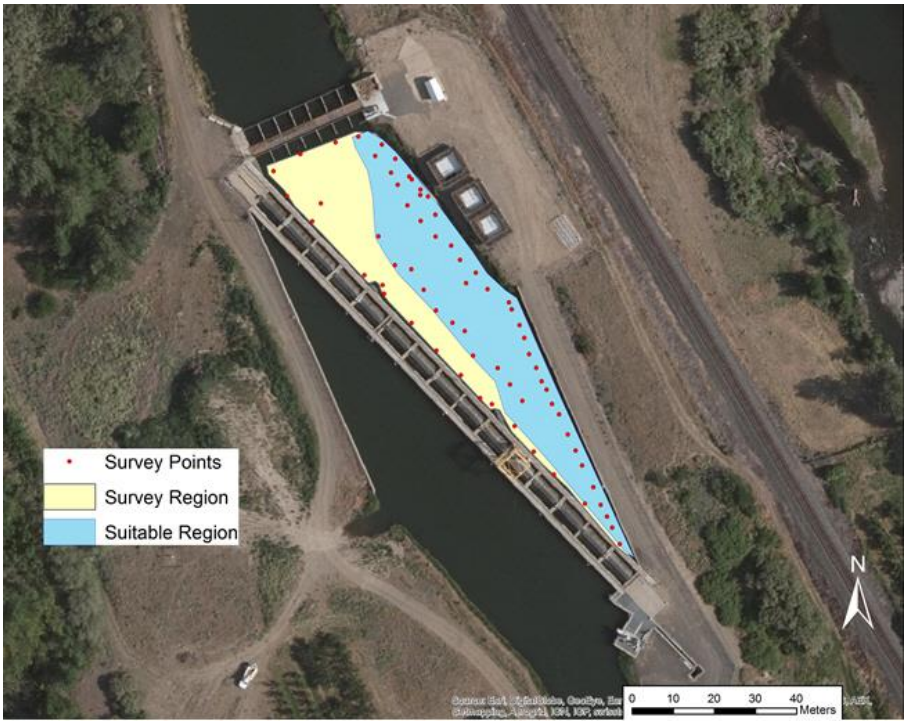

Figure G4-6. Wapato screen forebay region illustrating sampling locations (red dots), total survey region (yellow and blue polygons) and suitable region (blue polygons) from surveys conducted on October 15, 2015.

Appendix G5 - Passage of Radio-Tagged Adult Pacific Lamprey at Yakima River Diversion Dams, 2014 Annual Report, Phase 3: Roza and Cowiche Dams

Photo G5. A radio-tagged adult Pacific Lamprey is released in the lower Yakima River. Photo credit Dave Herasimtschuk, USFWS / Freshwaters Illustrated.

The Pacific lamprey has declined across much of its range in the Pacific Northwest, including in the Yakima River. Several irrigation diversion dams may prevent or delay the upstream migration of adults in the Yakima River, but the total impact on migration and spawning is not known. This report details the third and final phase of a radio-telemetry study designed to determine residence times downstream of dams, passage timing and durations, passage efficiencies, and passage routes of Pacific lampreys at diversion dams on the Naches and Yakima rivers. Eighty-nine adult Pacific lampreys were implanted with radio transmitters and PIT tags and released downstream of Cowiche and Roza dams on September 12, 2013 and April 4, 2014. Overall, combined passage efficiency of all released lampreys was 79% at Cowiche Dam. However, seasonal passage efficiencies at Cowiche Dam were greater for study fish released in the fall (95%) than in the spring (59%) (Fig. G5-1 and Fig. G5-2). This result is consistent with observations from dams studied during Phase 2 (Sunnyside and Wapato Dams) where passage success was also higher for fall-release fish. In contrast, seasonal passage efficiencies were greater for spring-release lampreys at the dams studied during Phase 1 (Wanawish and Prosser dams) and this seasonal difference at neighboring dams may have implications for lampreys that naturally enter and migrate through the Yakima River. At Roza Dam, the overall combined passage efficiency was 0%. While 36 of 44 (82%) tagged lampreys that approached the dam entered the fish ladder, only 5 of 44 (11%) were detected above the ladder in the tunnel and fish

facility (Fig. G5-3 and Fig. G5-4). No tagged lampreys were detected passing the fish facility nor upstream of Roza Dam (see Table G5-1 and Fig. G5-5 for the display of uppermost detection of radio tagged Pacific Lamprey). These results indicate that both the fish ladder and the fish facility obstruct lamprey passage. Thus, as currently built and operated, Roza Dam is a barrier to adult Pacific lamprey migration. Techniques to improve passage at the dam for the short term are discussed (see Fig. G5-6 for an exit hole drilled at the Roza fish facility holding tank). Additional study is needed to identify specific lamprey passage impediments and implement long term solutions at Roza Dam. See **Appendix G5** for more information. See Fig. G5-7 for a summary of passage efficiencies at six dams within the Yakima Subbasin by release season for all three study phases. See Fig. G5-8 for a summary of ratios related to fish ladder entrance, within fish ladder passage, and overall fish ladder passage at five dams within the Yakima Subbasin for all three study phases.

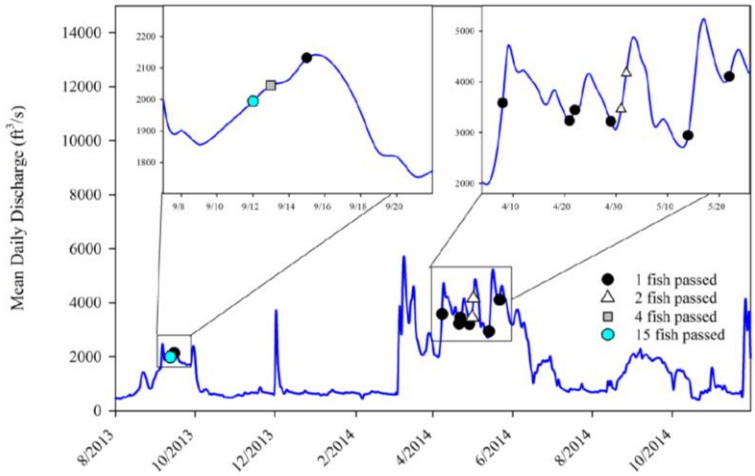

Figure G5-1. Mean daily discharge and passage timing of radio-tagged lampreys at Cowiche Dam on the Naches River, August 2013 through November 2014.

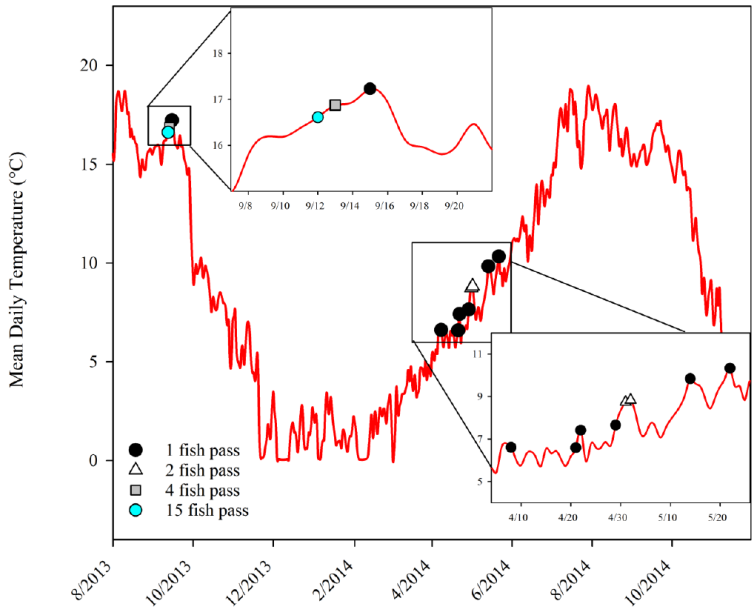

Figure G5-2. Mean daily water temperatures and passage timing of radio-tagged lampreys at Cowiche Dam on the Naches River, August 2013 through November 2014.

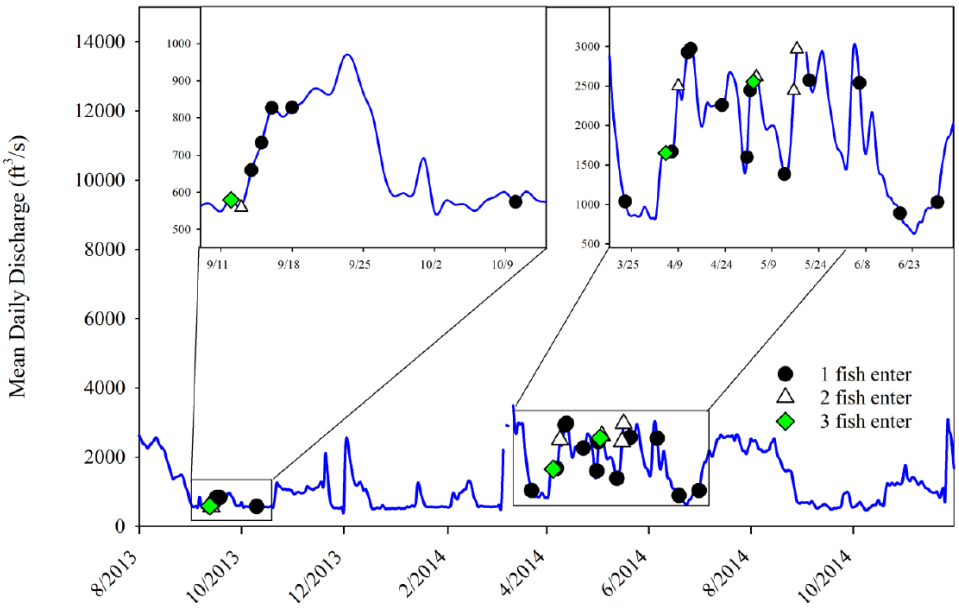

Figure G5-3. Mean daily discharge and timing of first entrance into the fishway for radio-tagged lampreys at Roza Dam from August 2013 through November 2014.

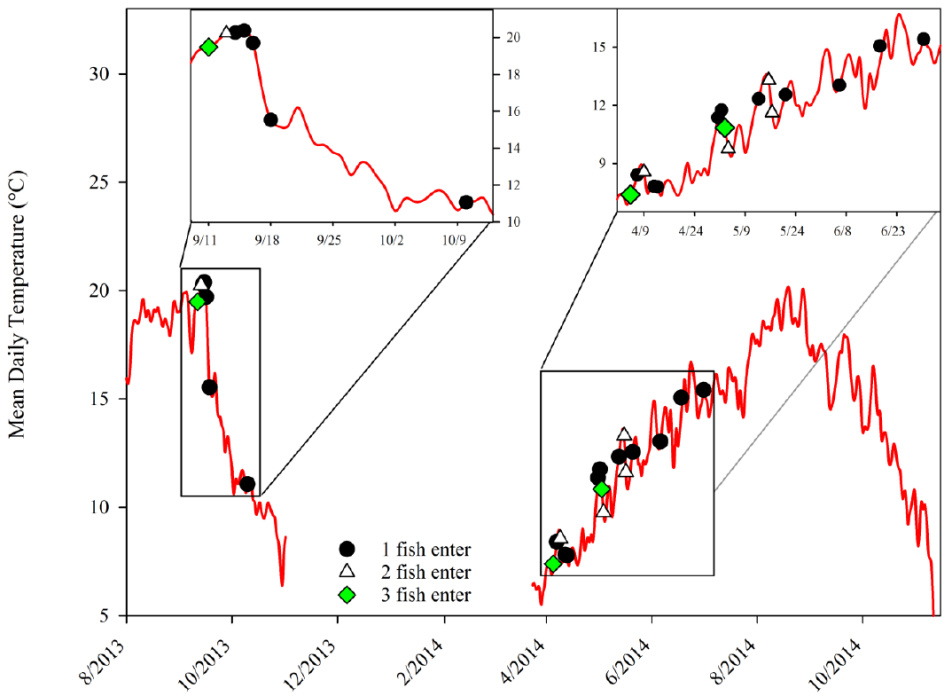

Figure G5-4. Mean daily water temperatures and timing of first entrance into the fishway for radio-tagged lampreys at Roza Dam from August 2013 through November 2014. Roza temperature data are not available from November 2, 2013 – March 23, 2014.

Table G5-1. Summary of last known detection locations (dam or reach) of radio-tagged Pacific lampreys released in Yakima River during fall 2013 and spring 2014.

Reach	Number final detections
Between Sunnyside and Wapato dam	9
Between Wapato Dam and Roza Wasteway #2 Outfall	4
Between Roza Wasteway Outfall and Roza Dam	40
In Roza Dam fishway	4
Between the Naches confluence and Cowiche Dam	9
In Cowiche Creek	2
Between Cowiche Dam and Wapatox Diversion Dam	12
Above Wapatox Diversion Dam	9

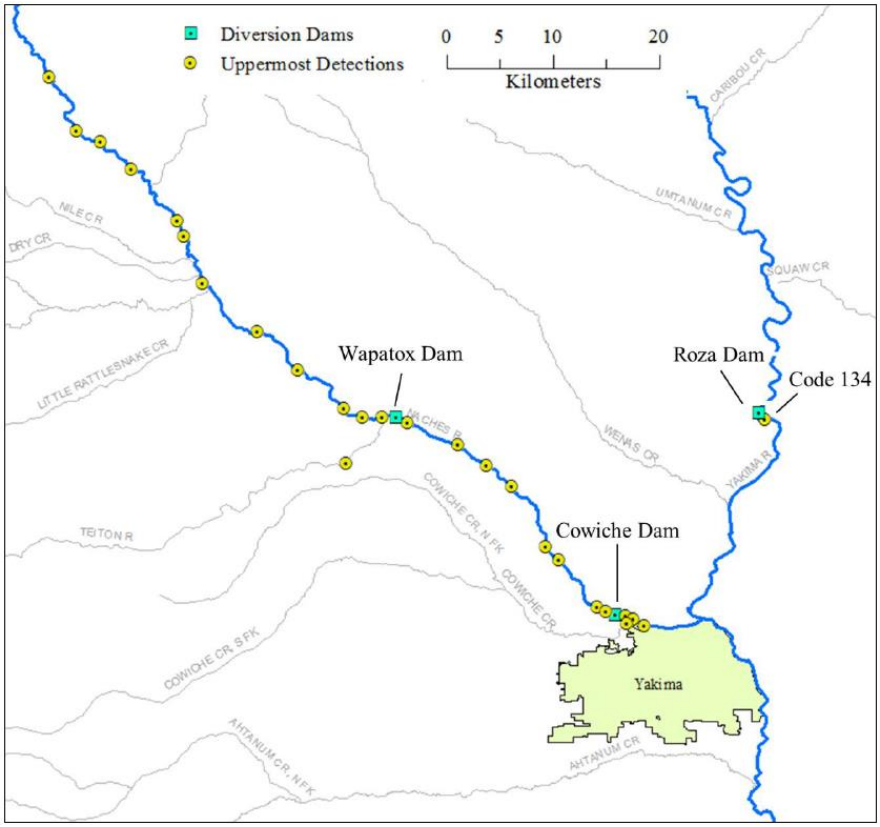

Figure G5-5. Uppermost detection locations of radio-tagged Pacific Lamprey released below Cowiche Dam from September 2013 to November 2014. Note that Code 134 moved downstream out of the Naches River, and eventually approached Roza Dam in the Yakima River system.

Figure G5-6. Exterior view of the lamprey exit hole in the Roza fish facility holding tank during the fall maintenance drawn down of the forebay. The perforated plate visible through the hole is part of the fish crowder.

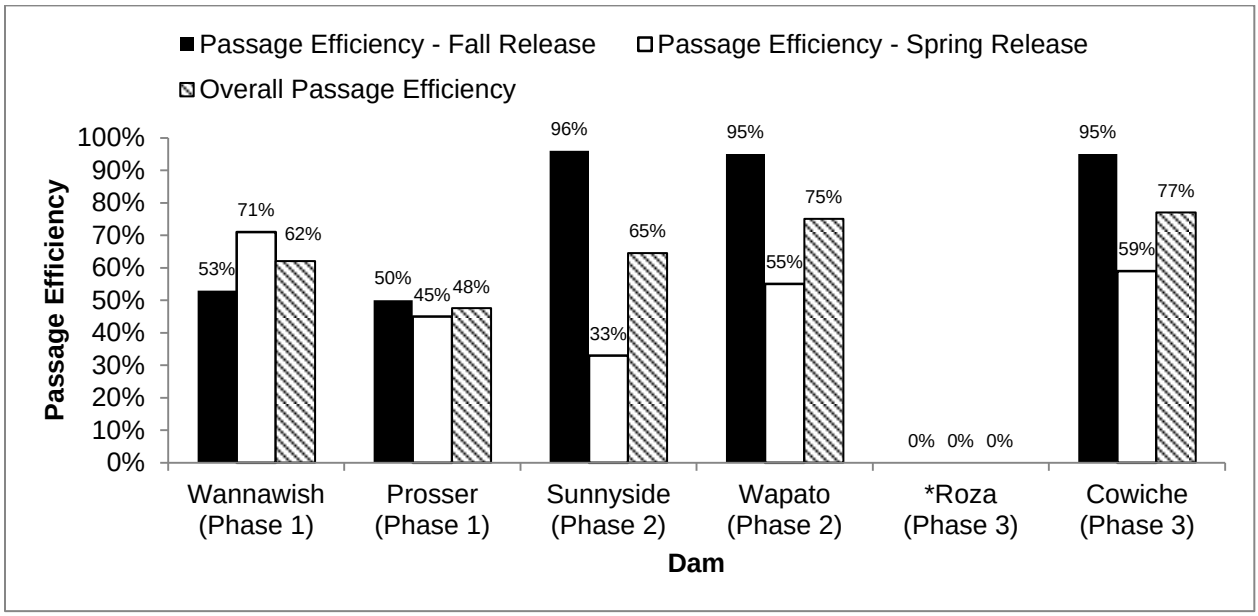

Figure G5-7. Summary of passage efficiency for radio tagged adult Pacific Lamprey at six dams within the Yakima Subbasin from Phase 1 through Phase 3 by release season (fall and spring). Many of the lamprey passing Wanawish and Prosser dams from the fall release group passed during the spring season after overwintering (63% and 43%, respectfully) – all others passed during the same season. *Even though fish ladder passage was detected (see Figure G5-8), no lamprey were detected passing Roza Dam facility for both fall and spring season (lamprey were not detected moving past the fish holding facility at the upper end of the dam).

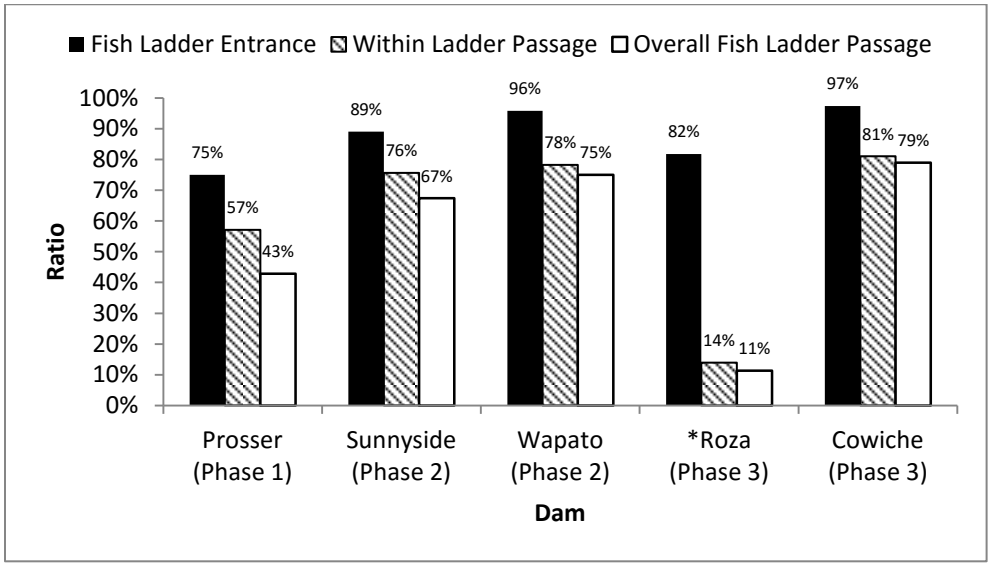

Figure G5-8. Summary of ratios for radio tagged adult Pacific Lamprey fish ladder entrance (vs. detected at dam), within ladder passage (vs. fish ladder entered), and overall fish ladder passage (vs. detected at dam) at five dams within the Yakima Subbasin from Phase 1 through Phase 3 (Wannawish Dam not included due to limited data). *The ratio of within ladder passage and overall fish ladder passage at Roza Dam refers only to the passage of the fish ladder section and does not include passage of the Roza Dam fish facility (lamprey were not detected moving past the fish holding facility at the upper end of the dam).

Appendix G6 - The Role of Pacific Lamprey in Yakima River Tributary Food Webs

Photo G6. Spawned out Pacific Lamprey carcass decaying on mid channel island.

The role of marine-derived nutrients (MDN) delivered by anadromous fish in spawning streams has received significant attention in the literature in the last two decades, but the effect of MDN delivery by Pacific lamprey has been unexamined. In their 2009 review, Mesa and Copeland highlighted several critical gaps in our current understanding of Pacific lamprey ecology, including uncertainties in the behavior and ecological role of adult lamprey in spawning streams.

Over the last two decades, the Columbia River Intertribal Fish Commission (CRITFC) and its member tribes have begun targeted trap-and-translocate programs to increase spawning adult Pacific lamprey numbers in Inland Columbia River basin streams. These efforts have yielded benefits for population density of larval lamprey in these systems, but have been suggested to have the dual benefit of increasing an historic MDN subsidy to these systems. Recent studies have shown the potential significant role of these MDN subsidies in the Inland Northwest, where many streams have been found to be naturally low in nutrients.

Most studies have focused on autumn nutrient additions via spawning salmon; no studies to date have measured the impact of MDN via spring-spawning semelparous Pacific lampreys. In 2015, we assessed the effects of spawning lamprey through 1) the use of a mechanism-based model of stream primary production in response to simulated lamprey spawning; 2) an experiment to assess juvenile salmonid growth in response to artificially added lamprey carcass material; and 3) an observational study of post-spawn carcass fate of adult lamprey translocated into a tributary of the lower Yakima River. We found evidence that lamprey-derived nutrient subsidies may play a significant role in reach-scale primary production under certain conditions and that under all conditions, they may represent a ‘hot spot’ for trophic activity by higher trophic level consumers (i.e., fish) in streams. The preliminary analyses of growth response of juvenile salmonids are on-going for the enclosure experiment, but the average trend suggests greater accrual or retention of mass by juvenile salmon provided lamprey carcass material (Fig. G6-1, Fig. G6-2, and Fig. G6-3). In the observational carcass study, over a third radio tagged of lamprey carcasses were moved

into the riparian zone by riparian_scavengers, while a majority remain in the wetted stream channel to decompose (Fig. G6-4, Fig. G6-5, Table G6-1, and Fig. G6-6). In-stream carcasses were largely entrained by woody debris and found in depositional pools.

Because of their ecologically relevant timing, Pacific lamprey MDN may have once been an essential component of seasonally dynamic subsidies of nutrients into these systems, in-stream carcasses may contribute to fish production through direct consumption pathways, and the frequent removal of carcasses indicates they represent a resource to riparian vertebrates under current conditions (Fig. 6-7). Our studies represent some of the first to explore the food web impact of this species. Future work will expand on these findings and support continued restoration efforts.

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The preliminary analyses of growth response of juvenile salmonids are ongoing for the enclosure experiment, but the average trend suggests greater accrual or retention of mass by juvenile salmon provided lamprey carcass material (Fig. G6-1, Fig. G6-2, and Fig. G6-3). In the observational carcass study, over a third radio tagged of lamprey carcasses were moved into the riparian zone by riparian scavengers, while a majority remain in the wetted stream channel to decompose (Fig. G6-4, Fig. G6-5, Table G6-1, and Fig. G6-6). In-stream carcasses were largely entrained by woody debris and found in depositional pools.

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Figure G6-1. Pacific Lamprey carcass in vexar tube prior to addition to the enclosure within the stream.

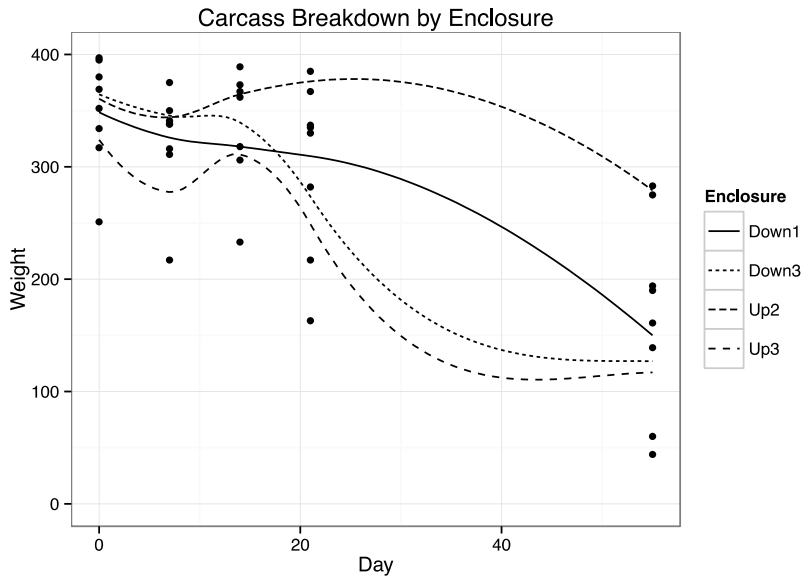

Figure G6-2. Mean carcass breakdown rate by enclosure modeled using a loess smoothing function.

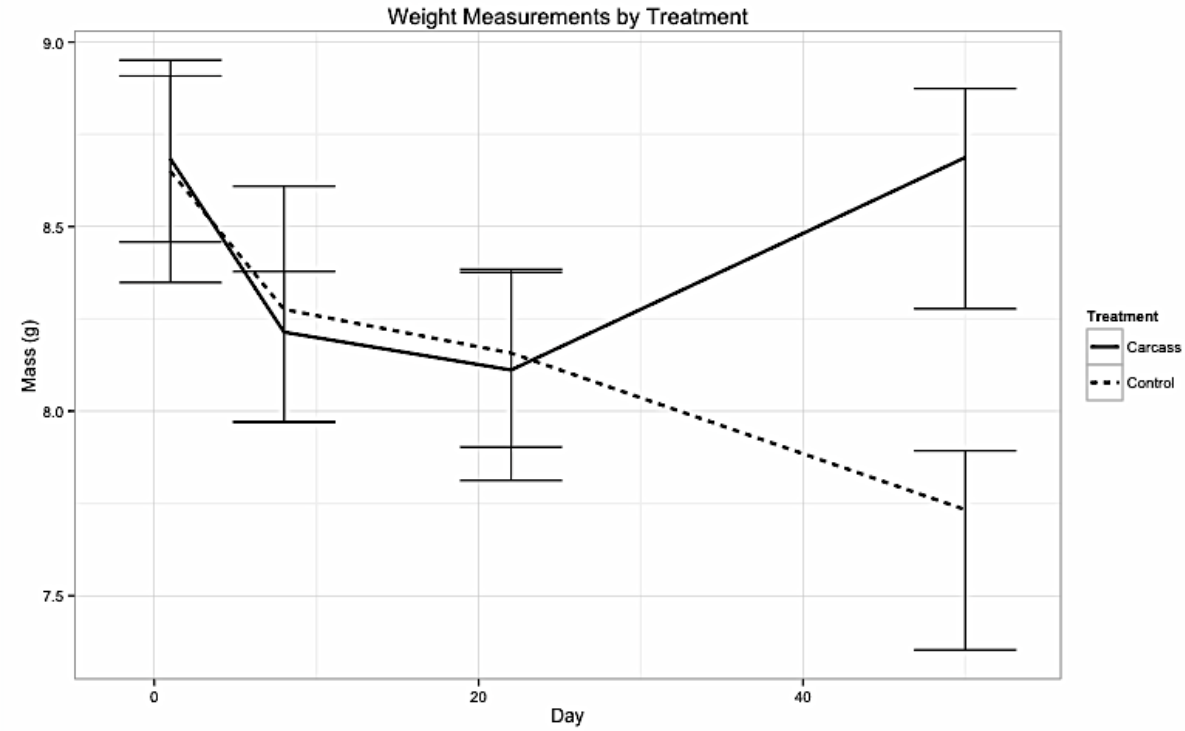

Figure G6-3. Dashed (control) and solid (treatment) lines represent mean mass by enclosure and treatment over time with error bars showing standard deviation from the mean. Thick lines represent the treatment and control means.

Figure G6-4. Example of a Pacific Lamprey redd observed in Satus Creek on June 2, 2015. Note the even spread of cobbles around the nest and the smaller substrate within the nest.

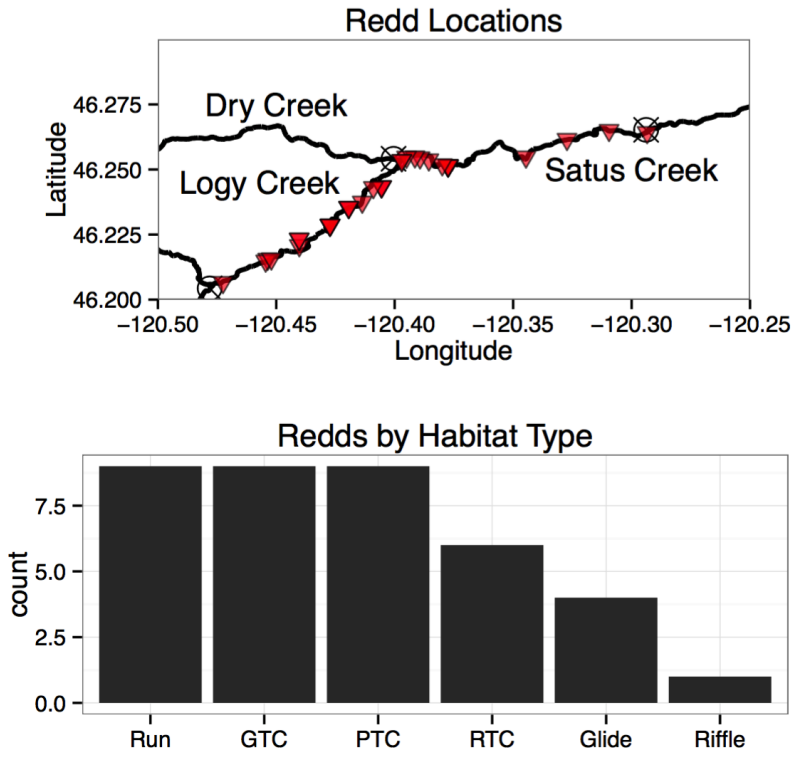

Figure G6-5. Pacific Lamprey red distribution in Satus Creek and habitat types used. GTC, PTC, and RTC are glide-tail crest, pool-tail crest and run-tail crest respectively.

Table G6-1. Summary of final detections of all released radio tagged Pacific Lamprey.

Summary	n
No Detections	8
Bank (covariates not measured)	7
Bank (covariates measured)	14
Assumed Living at last detection	12
In-stream (covariates measured)	21
In-stream (covariates not measured)	3
Pre-release Mortality**	35
Total	100

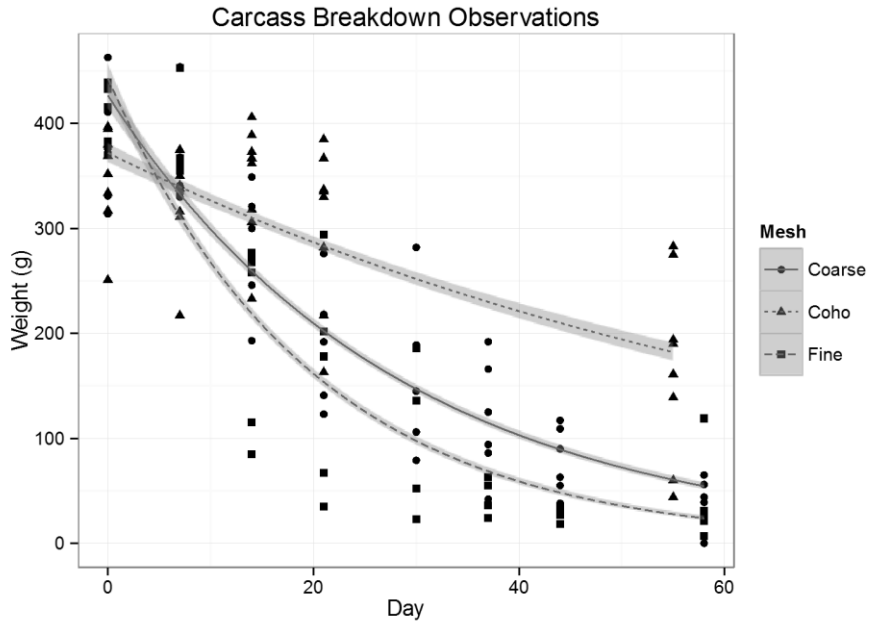

Figure G6-6. Exponential decay models for carcass breakdown by mesh group.

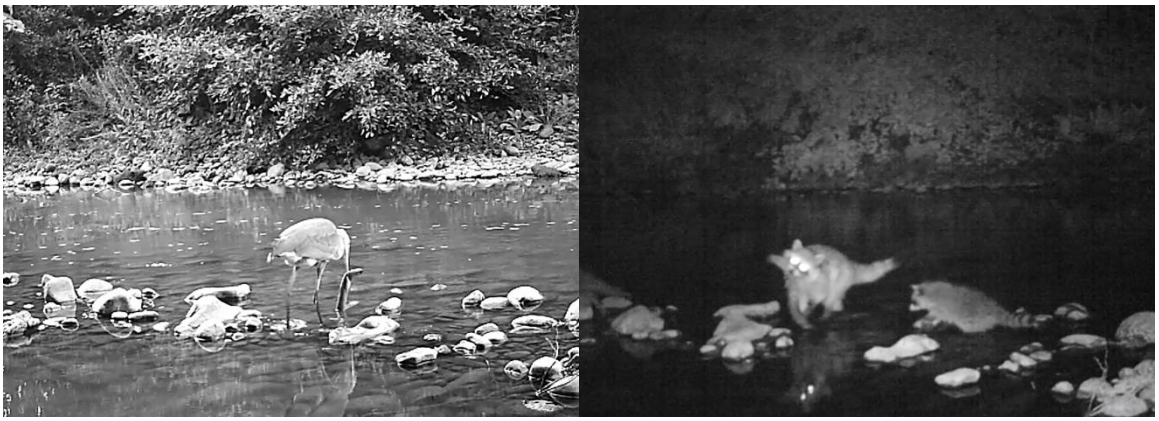

Figure G6-7. Action photos from motion sensing optical game cameras, showing a Great Blue Heron (left photo) and raccoons (right photo) scavenging on spawned out Pacific Lamprey carcasses.

Appendix G7 - Influences of Fish Physiology and Habitat Conditions on the Retention Rates of Adult Pacific Lamprey [*Entosphens tridentatus*] Carcasses in Upper Toppenish Creek, a Small Tributary System in South Central Washington, USA

Photo G7. Example of a female Pacific Lamprey carcass (with some remaining eggs) used in the carcass study in Satus Creek.

Numerous studies have assessed the importance of spawned salmon carcasses for stream and riparian productivity, yet very few studies have examined the roles played by spawned Pacific lamprey carcasses, another anadromous species native to Northwestern USA. We evaluated retention rates of adult Pacific lamprey carcasses in a stream channel in relationship to fish physiology and habitat conditions. On June 19, 2013, a total of 25 adult carcasses uniquely identified with floy tags were released at equal intervals (2m apart) in a 50m reach of Toppenish Creek (a tributary to lower Yakima River in south central Washington, USA) at river-km 59.9. Carcasses movement was monitored over a 24-day study period. Carcasses consisted of 10 males and 15 females, some of which were immature fish lacking mature gametes while others were sexually mature with varying amounts of gametes (milt or eggs). The carcasses placed in the channel margins remained in place at a higher rate in the short-term but were detected less frequently in the long-term compared to those placed in the middle of the channel, indicating potential predation by mammalian species. Carcasses that remained in channel tended to deposit in deep sections of the pools and pool tailouts where fine sediment was more prevalent. Detection frequency was also higher for male fish (vs. female), sexually mature fish (vs. immature), and female fish with less eggs (vs. more eggs), suggesting that female fish with more eggs and immature fresh migrants may be targeted and consumed more by predators in general. See **Appendix G7** for more information.

Influences of Fish Physiology and Habitat Conditions on the Retention Rates of Adult Pacific Lamprey (Entosphenus tridentatus) Carcasses in Upper Toppenish Creek, a Small Tributary Stream in South Central Washington, USA

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AISES Travel Scholarship
EPA

Abstract: Numerous studies have assessed the importance of spawned salmon carcasses for stream and riparian productivity, yet very few studies have examined the roles played by spawned Pacific lamprey (*Entosphesnus tridentatus)* carcasses, another anadromous species native to Northwestern USA. We evaluated retention rates of adult Pacific lamprey carcasses in a stream channel in relationship to fish physiology and habitat conditions.

The carcasses placed in the channel margins remained in place at a higher rate in the short-term but were detected less frequently in the long-term compared to those placed in the middle of the channel, indicating potential predation by mammalian species. Carcasses that remained in channel tended to deposit in deep sections of the pools and pool tailouts where fine sediment was more prevalent. Detection frequency was also higher for male fish (vs. female), sexually mature fish (vs. immature), and female fish with less eggs (vs. more eggs), suggesting that female fish with more eggs and immature fresh migrants may be targeted and consumed more by predators in general.

Photo 1. Aerial overview map of Toppenish Creek study reach area.

Figure 1. Water depth (cm) along longitudinal channel transect (m) in relationship to aerial overview map.

Photo 2. Example of adult carcasses placed in this study.

Photo 3. Tail end of Pool #1 where some adult carcasses were found.

Methods: On June 19, 2013, a total of 25 adult carcasses uniquely identified with floy tags were released at equal intervals (2m apart) longitudinally in a 50m reach of Toppenish Creek (a tributary to lower Yakima River in south central Washington, USA) at river-km 59.9. Carcasses consisted of 10 males and 15 females, some of which were immature fish lacking mature gametes while others were sexually mature with varying amounts of gametes (milt or eggs). The channel transect was divided into five sections and adult carcasses were placed randomly in one of these sections using a random number generator[1]. Habitat types within the 50m reach were classified as pool, riffle, or glide and maximum water depth was measured at each 2m longitudinal interval (Figure 1). The pool area consisted of deep, slow water with predominantly fine substrate (sand/silt/clay), whereas the riffle area consisted of shallow, swift water with chiefly coarse substrate (gravel/cobble). Carcasses movement was monitored primarily every three days over a 24-day study period.

References:

1. http://andrew.hedges.name/experiments/random/original.html

Results:

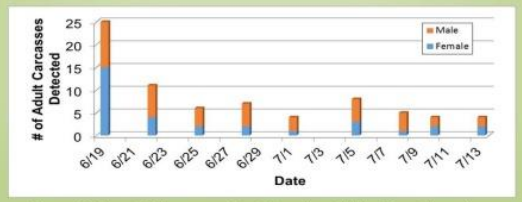

Figure 2. Number of adult carcasses detected over time within the 50m study reach area.

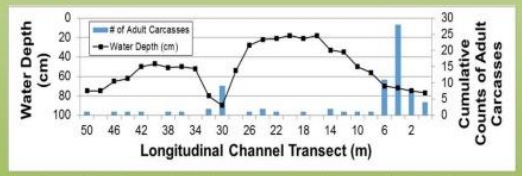

Figure 3. Cumulative counts of adult carcasses (secondary y-axis) along longitudinal channel transect (x-axis) and associated water depth (primary y-axis).

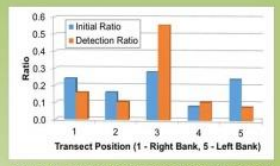

Figure 4. Initial and cumulative detection ratio of adult carcasses by transect position placement.

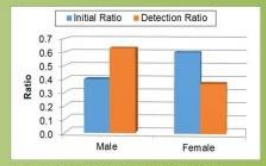

Figure 5. Initial and cumulative detection ratio of adult carcasses by sex.

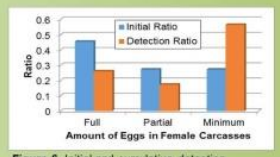

Figure 6. Initial and cumulative detection ratio of adult carcasses by amount of eggs remaining in female carcasses.

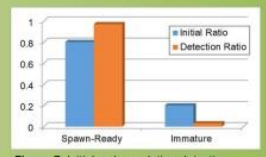

Figure 7. Initial and cumulative detection ratio of adult carcasses by sexual maturation.

Results: Number of detected carcasses was reduced to 44% 3-days post placement and gradually decreased over time to 16%. The majority of carcasses were detected in deep pools. By day 16 (July 5), some of the carcasses were reduced to cartilage, notochords, and skin; by day 24, all were reduced to notochords and skin. Compared to starting initial ratio, cumulative detection ratio was higher for 1) carcasses placed in the center transect position, 2) male carcasses, 3) female carcasses with minimum eggs, and 4) spawn-ready carcasses.

Photo 4. Carcass reduced to head (cartilage), notochords, and skin on July 10, 2013.

Discussion: Predatory consumption of lamprey carcasses by mammal or avian species likely reduced the detection frequency of carcasses placed on the channel margin (position 1 and 5); those carcasses moved the least initially after being placed, yet disappeared within the third day. Female carcasses, especially those with more eggs, appear to be more desirable for predators/consumers than male carcasses. Sexually immature carcasses disappeared more rapidly compared to sexually mature carcasses (overwintered adults), indicating predators/consumers may prefer fresh migrants that hold more lipids and other energy reserves. Finally, the majority of carcasses deposited in fine substrate pool habitat, where larval lamprey typically reside, potentially serving a role in nourishing larval lamprey diet for the next generation.

Figure G-7. Poster titled "Influences of Fish Physiology and Habitat Conditions on the Retention Rates of Adult Pacific Lamprey (*Entosphenus tridentatus*) Carcasses in Upper Toppenish Creek, a Small Tributary Stream in South Central Washington, USA" (see Appendix I1 for the full size poster).

Appendix G8 – Summary of Pacific Lamprey Salvage Efforts from Dryden Diversion Maintenance Operations (Wenatchee River, Dryden, WA)

Photo G8. Salvage of larval/juvenile Pacific Lamprey from the dredged fine sediment (transported from the area upstream of the Dryden Diversion headgate structure) on March 4, 2016.

Dryden Diversion is an irrigation diversion on the Wenatchee River (river km 27.8, 1.75 mm mesh-size fish screens) which entrains many thousands of larval/juvenile Pacific Lamprey each year. The Yakama Nation (YNPLP) assisted with Pacific Lamprey salvage operations 1) when the canal was dewatered (October 12 and 13, 2015) and 2) during dredging operations in the canal forebay area upstream of the headgate (March 4, 2015).

Part I:

Dryden Diversion was dewatered on October 12, 2015 and lamprey salvage efforts in the canal occurred on October 12, 13, and 14, 2015, by Chelan County PUD (CCPUD), the YNPLP, US Fish and Wildlife Service (USFWS), and Washington Department of Fish and Wildlife (WDFW). Through our collective efforts between October 12, 2015, and October 14, 2015, a total of 8999 lamprey (8408 larvae and 591 macrophthalmia) were captured and released back to the Wenatchee River into a small side channel with Type I and II habitat (Table G8-1). Macrophthalmia composed 6.6% of the overall number salvaged. Collective electrofishing efforts (between YNPLP and USFWS) captured a total of 6,750 larval lamprey (79.4% of the total lamprey capture) and 395 macrophthalmia (5.5% of total capture through electrofishing) in 21.5 hours of sample time (332 lamprey/hour). CCPUD primarily salvaged lamprey from dewatered banks (collecting exposed lamprey and digging with shovels), collecting a total of 1,658 larval lamprey and 196 macrophthalmia (20.6% of all life stages) in 15.5 hours of sample time (120 lamprey/hour). Although efforts were made to capture all lamprey we observed, a large number of the lamprey, especially smaller ones, escaped our nets due to high density (missed between 2~4 fish for every fish captured).

To estimate the number of entrained lamprey in Dryden Diversion, we used electrofishing densities from October 12 and 13, 2015. Although on average 2-4 lamprey were missed for every lamprey captured, observed lamprey numbers for each survey (captured and missed) were estimated at twice the number of captured fish to provide a more conservative estimate of lamprey numbers. The resulting densities were used in extrapolating to the overall area within each of the four sections (Fig. G8-1 and Table G8-2).

On October 12, 2015 (the first day of salvage), the highest estimate of lamprey was 47,038 for Section 2 (the high density section within the area upstream of the fish screens). On October 13, 2015 (the second day of salvage), the highest estimate of lamprey was 36,953 within this same section, yet decreased to 15,106 later in the day. Using the combined estimate from the two days of salvage, we estimate the total number of lamprey entrained within Dryden Diversion to be approximately 50,619. Number of lamprey estimated downstream of the fish screens were low (~619), but this estimate only covered a small section immediately below the fish screens.

Part II:
Dredging of fine sediment (primarily silt) occurred in the Dryden Diversion forebay between March 3 and March 11, 2016 (Fig. G8-2). The slow water and fine sediment in the forebay area provides refuge to tens of thousands of larval and juvenile lamprey. The YNPLP aided in lamprey salvage operations on March 4, 2015. The dredged material was immediately placed into a custom dump truck designed to hold water as well as lamprey. The dredged material was then laid out on a large dirt parking lot and the salvage crew searched through the sediment for lamprey. To salvage the lamprey, the salvage crew used fine mesh nets, hands, fire hoses (for breaking up the sediment), and a backpack electrofisher. All lamprey were counted separately by life stage (larvae or macrophthalmia) and approximately 13% of the lamprey were tallied by three size class categories (Table G8-3). In total, 18,746 larval lamprey and 21 macrophthalmia (0.11% of the total) were recovered from approximately 244.5 cubic yards of dredged material (Table G8-4).

In addition to aiding with the salvage operation, the YNPLP provided several recommendations to improve fish health and salvage efficiency. These recommendations include placement of a large tarp between dredged material and dirt parking lot, improved temperature monitoring between holding buckets and river water (+/- 1°C before release), and using the salvage as a means for public outreach and education. Mortalities and injuries were also noted during the diversion dewatering and forebay dredging salvage operations by the YNPLP crew; for instance, during the last release of the day on October 13, 2015, approximately 3.9-7.7% of the larvae/juvenile salvaged were estimated to be dead at the release site. In addition, approximately 24% (62 out of 274) of the larvae salvaged from the forebay dredging operation and transported to Prosser Hatchery died over a period of 11 days after the transfer - majority of these dead

lamprey had various levels of visible bruises on its body. There may also be impacts from rapid changes in water temperature during the salvage operations.

Table G8-1. Summary of larval/juvenile lamprey capture at Dryden Diversion (Wenatchee River) between October 12 and 14, 2016.

Date	Fish Screen Location	Location Description	Agency	Capture Method	# of Captured Larval L.	# of Captured Macro. L.	% of Macro. L.	# of Captured Lamprey	% of Total Capture	Survey Time (Hours)	CPUE (#/hr)
10/12/2015	Upstream	above ecology blocks	Chelan	bank salvage	855	105	10.9%	960	10.7%	4.5	213
10/12/2015	Upstream	below ecology blocks	YN	e-fishing	1976	160	7.5%	2136	23.7%	3.5	610
10/13/2015	Upstream	above ecology blocks	YN	e-fishing	240	1	0.4%	241	2.7%	1.0	241
10/13/2015	Downstream	below fish screens	YN	e-fishing	57	0	0.0%	57	0.6%	0.5	114
10/13/2015	Upstream	below ecology blocks	YN	e-fishing	750	60	7.4%	810	9.0%	3.0	270
10/13/2015	Upstream	below ecology blocks	YN	e-fishing	963	48	4.7%	1011	11.2%	3.0	337
10/13/2015	Upstream	below ecology blocks	YN/FWS/Chelan	e-fishing / bank salvage	2111	60	2.8%	2171	24.1%	13.0	167
10/14/2015	Upstream	below ecology blocks	Chelan	bank salvage	486	73	13.1%	559	6.2%	5.0	112
10/14/2015	Upstream	above ecology blocks	FWS	e-fishing	50	2	3.8%	52	0.6%	0.25	208
10/14/2015	Downstream	below fish screens	FWS	e-fishing	20	0	0.0%	20	0.2%	0.25	80
10/14/2015	Upstream	below ecology blocks	FWS	e-fishing	900	82	8.4%	982	10.9%	3.0	327
			YN/FWS	**e-fishing**	**6750**	**395**	**5.5%**	**7145**	**79.4%**	**21.5**	**332**
Total	**-**	**-**	**Chelan**	**bank salvage**	**1658**	**196**	**10.6%**	**1854**	**20.6%**	**15.5**	**120**
			Total	**-**	**8408**	**591**	**6.6%**	**8999**	**100%**	**37.0**	**243**

Figure G8-1. An overview map showing the four sections of Dryden Diversion.

Table G8-2. Daily estimated number of lamprey by surveyed section.

Date	Start Time	Fish Screen Location	Section #	Total Section Area (m^2)	% Type I Habitat	% Type II Habitat	% Section Wetted	Type I Wetted Area (m^2)	Type I Survey Area (m^2)	Est. Survey Time (min)	E-Fish Time (sec)	# Lamprey Captured	# Lamprey Missed	# Lamprey Observed	Density (#/m^2)	Est. # of Lamprey
10/12/2015	11:00	Upstream	2	2224	90%	10%	75%	1501	16	40	418	231	343	574	35	42511
10/12/2015	13:00	Upstream	2	2224	90%	10%	60%	1201	55	90	3000	979	2937	3916	71	42754
10/12/2015	15:10	Upstream	2	2224	90%	10%	50%	1001	30	65	1863	705	2115	2820	94	47038
10/13/2015	10:40	Upstream	1	458	20%	80%	80%	73	15	46	1380	240	118	358	24	1675
10/13/2015	8:40	Upstream	2	2224	90%	10%	50%	1001	65	180	4321	1200	4800	6000	92	36953
10/13/2015	13:00	Upstream	2	2224	90%	10%	30%	600	140	300	10367	1761	7044	8805	63	15106
10/13/2015	11:40	Upstream	3	1030	100%	0%	50%	515	80	70	2400	100	200	300	4	1288
10/13/2015	16:45	Downstream	4	776	70%	30%	20%	109	20	37	1200	57	30	87	4	619

Figure G8-2. An overview map showing the dredged area in the forebay.

Table G8-3. Lamprey size class subsampling results from Dryden Diversion forebay dredging.

Date	Daily # Captured	Total # Sub-sampled	% Daily # Sub-sampled	# Small (< 50 mm)	# Medium (50-90 mm)	# Large (90+ mm)	% Small (< 50 mm)	% Medium (50-90 mm)	% Large (90+ mm)
3/3/2016	69	69	100%	21	26	22	30%	38%	32%
3/4/2016	3550	411	12%	76	165	170	18%	40%	41%
3/7/2016	3704	489	13%	112	243	134	23%	50%	27%
3/8/2016	4075	436	11%	135	171	130	31%	39%	30%
3/9/2016	2938	375	13%	53	206	116	14%	55%	31%
3/10/2016	1552	290	19%	21	148	121	7%	51%	42%
3/11/2016	2879	357	12%	51	111	195	14%	31%	55%
Total	**18767**	**2427**	**13%**	**469**	**1070**	**888**	**19%**	**44%**	**37%**

Table G8-4. Lamprey salvage details from Dryden Diversion forebay dredging.

Date	Agency	Dredge Site	# of Salvage Days	Material Removed ($Yard^3$)	# Captured Larval L.	# Captured Macro. L.	% Macro. L.	Daily # Captured	# per Cubic Yards	Cumm. # Captured	# Transported by YN	# Returned to River
3/3/2016	Chelan	Debris Booms	1	0.5	66	3	4.3%	69	138	69	0	69
3/4/2016	Chelan/YN	Forebay	2	25	3548	2	0.1%	3550	142	3619	0	3550
3/7/2016	Chelan	Forebay	3	58	3704	0	0.0%	3704	64	7323	0	3704
3/8/2016	Chelan	Forebay	4	61	4073	2	0.0%	4075	67	11398	0	4075
3/9/2016	Chelan	Forebay	5	30	2932	6	0.2%	2938	98	14336	0	2938
3/10/2016	Chelan	Forebay	6	40	1549	3	0.2%	1552	39	15888	0	1552
3/11/2016	Chelan	Forebay	7	30	2874	5	0.2%	2879	96	18767	270	2609
Total	**-**	**-**	**-**	**244.5**	**18746**	**21**	**0.1%**	**18767**	**77**	**18767**	**270**	**18497**

H. Work Element 161 – Disseminate Raw/Summary Data and Results and Participation in Regional Efforts

Work Element Associated Appendix Report:
Not Applicable

Throughout 2015, the YNPLP has continued to maintain a strong presence in supporting and guiding Pacific Lamprey recovery in the Yakima Subbasin and in the Columbia River Basin. The following outlines some of the key activities YNPLP staff is involved with:

Coordination with the Reclamation in the Yakima Subbasin
Technical representative for both the YNPLP and Reclamation continue to meet regularly on an "as-needed" 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, and (2) intensive monitoring associated with larval/juvenile entrainment in select diversions. Discussions continue with the Reclamation about logistics for implementing various components of larval/juvenile lamprey salvage and transport in fine sediment using funds from Natural Resources Conservation Service (NRCS) 2015-2019 5-year grant funding.

In collaboration with Bureau of 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. Progress over the past year has been slower than expected, but we are implementing a multi-year passage improvement project targeted at Prosser and Horn Rapids dams (the two lowermost dams in the Yakima Subbasin) using primarily a USFWS fish passage grant. We have implemented a “Project Alternative Solution Study (PASS)” through Bureau of Reclamation in which over a period of several days, experts from various agencies proposed and assessed a list of alternative solutions for improving adult lamprey passage in the Yakima Subbasin. These discussions are expected to continue over the next couple years with the intent to implement several structures between 2016- 2018, including ones in Sunnyside and Wapato diversion dams (funded through NRCS).

Coordination with the USACE in the Columbia River Basin
Technical representatives of the YN continues 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 in the development of a new 5-10 year planning document which will incorporate (1) monitoring newly constructed passage structures at Bonneville, John Day and McNary dams, (2) design and development of a micro-tag for future juvenile research and (3) prioritization of research for both juvenile and adult passage interests. Many of these

considerations are also well coordinated with the USACE sponsored Study Review Work Group (SRWG) which meets periodically throughout the year to review and recommend priority future lamprey studies. Development and employment of the micro-tag will be fundamental in future work at Reclamation facilities.

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 "Framework for Pacific Lamprey Supplementation Research in the Columbia River Basin" and "Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research." The YN policy and technical representatives met 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, and progress among the YNPLP and various member tribes. Of primary importance to CRITFC and tribal policy representatives is when we are going to accelerate implementation of solutions (such as passage structures).

Coordination with the USFWS: Regional Conservation Team (CT)

In June, 2011 the USFWS initiated a Pacific Lamprey Conservation Agreement in which both the Reclamation and YN are signatories. Both technical and policy representatives are communicating with the USFWS at multiple administrative levels to strengthen the commitment of this agreement. The Yakama Nation representative also serves as the Co-Chair to this CT With respect to the Yakima Subbasin, the YN recognizes that multiple threats exist that limit abundance, productivity and spatial distribution throughout the basin and that multiple agencies, jurisdictions and publics are needed to realize recovery objectives. The YN anticipates working closely with the Reclamation and other relevant partnerships to accelerate implementation of various actions at the subbasin scale, within the context of the Conservation Agreement.

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. With respect to the Yakima Subbasin, one of the primary considerations brought to the LTWG has been with the completion of the "Framework for Pacific Lamprey Supplementation Research in the Columbia River Basin" by the YN and Umatilla Tribes and coordinated by the CRITFC. A significant component of this document outlines both adult and juvenile supplementation research, which will occur within the Yakima Subbasin and includes elements of future research funded through the YN - Reclamation Agreement of 2011.

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 are now conducting a three year (2016-2018) study 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). 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 2015.

I. Work Element 99 – Outreach and Education

Work Element Associated Appendix Report:
Appendix I1 – 2015 Yakama Nation Lamprey Outreach and Education

Photo I1. Lamprey outreach event at Heritage University on November 12, 2015.

Outreach and education is a key, vital component of the Yakama Nation Fisheries Management Program Pacific Lamprey Project. If we are not able to communicate effectively the true understanding of Pacific Lamprey roles (i.e. cultural, ecological, and scientific roles) to the general public, support for lamprey restoration will be futile in the short and long term. Without the active participation by tribal youth in various lamprey events (through harvest, ceremonial,

cultural, and/or school-related activities), the cultural and generational disconnect will only continue to grow related to lamprey. Activities that were a shared, common experience for many of the tribal elders in the old days (1900-1950s), such as lamprey harvest, preparation of lamprey meat, and use of lamprey for various medicinal purposes, are now rarely experienced by the new generation of tribal youth.

There is also a wide spread misconception about lamprey by the general public, owing in large part to the Sea Lamprey invasion of the Great Lakes. It is especially important to clear this misguided stereotypes and inform audiences of Pacific Lamprey's true roles in stream ecology and tribal and world culture. The cultures of the Yakama Nation people have always honored and respected the lands for the many plants and animals it generates; Pacific Lamprey is an epitome of that landscape dynamic and creation. To bring true restoration of Pacific Lamprey, the conception, perception, and image of Pacific Lamprey needs to be retold and re-explained to both the general public and the younger generation, both tribal and non-tribal.

Throughout the year, there are many venues and opportunities to make this type of connection with students and the general public. In total, we estimate that our project have made contact with at least 6,894 students and 20,687 people (general public) through our lamprey outreach activities in 2015 (Table I1-1, Fig. I1-1 through Fig. I1-10). See **Appendix I1** for more information.

Table I1-1. Summary of Yakama Nation Pacific Lamprey Project outreach and education events and activities in 2015.

Date	Event	Venue	Location	Audience	# of Students Reached	# of People Reached (General Public)
1/7/2015	Rocky Reach Fish Forum Lamprey Presentation	Fish Forum	Wenatchee, WA	Biologists / Managers	0	10
2/10/2105	Social Media - Feature Lamprey Cover Photo	Social Media	Online	General Public, Tribal Fishermen	200+	500+
2/13/2015	Hatchery Training for Heritage University Class	Prosser Hatchery	Prosser, WA	Students (College)	6	1
2/27/2015	Prosser Dam Fishermen Meeting #1	Prosser Dam	Prosser, WA	Tribal Fishermen	0	10
3/5/2015	Prosser Dam Fishermen Meeting #2	Prosser Dam	Prosser, WA	Tribal Fishermen	0	5
4/19/2015	Earth Day Family Festival & Salmon Run	Central WA University	Ellensburg, WA	General Public	150+	100+
4/22/2015	Adult Pacific Lamprey Release Event (Earth Day)	Ahtanum Creek	Yakima, WA	Students (High S.), General Public	30	10
4/28/2015	Adult Pacific Lamprey Release Event	Satus Creek	Toppenish, WA	General Public	3	5
4/30/2015	Adult Pacific Lamprey Release Event	Toppenish Creek	White Swan, WA	Students (Middle S.)	50+	10
5/1/2015	Pacific Lamprey Spawning Survey w/ Heritage Uni. students	Satus Creek	Toppenish, WA	Students (College)	5	1
5/7/2015	Salmon Summit (Benton County Event)	Prosser Hatchery	Prosser, WA	Students (Elem.+Middle S.)	100+	10
5/12/2015	Yakama Nation Review News Article	Newspaper Article	Toppenish, WA	General Public	25+	500+
5/13/2015	USDA NRCS Tour + Kittitas County Commissioner	YN Reservation	Toppenish, WA	US Officials, County Dignitaries	0	30+
6/3/2015	USDA Blog by Deputy Under Secretary Ann Milles	v/2015/06/03/preserving-a-wa	Toppenish Creek	General Public	10	100+
6/17/2015	Yakima Basin Science & Watershed Management Conference	Central WA University	Ellensburg, WA	Biologists / Managers	20	80+
Spring/Summer	Prosser Hatchery School Tours	Prosser Hatchery	Prosser, WA	Students (All)	500+	50+
7/13/2015	Hakai Magazine News Article	Magazine Article	Victoria, Canada	General Public	400+	8000+
8/13/2015	Yakama Nation Backpack Giveaway	'akama Nation Cultural Cente	Toppenish, WA	Tribal Members, Students	3000+	1000+
8/17/2015	AFS Annual National Meeting Lamprey Presentation	Convention Center	Portland, OR	Biologists / Managers	15	100+
8/20/2015	AFS Annual National Meeting Lamprey Presentation	Convention Center	Portland, OR	Biologists / Managers	15	100+
9/23/2015	Adult Pacific Lamprey Release Event	Methow River	Winthrop, WA	General Public	15	50+
9/23/2015	Central Washington State Fair	Exhibit	Yakima, WA	General Public	2000+	6000+
10/20/2015	Yakima-Herald News Article	Newspaper Article	Yakima, WA	General Public	200+	4000+
11/12/2015	Yakima School District Education Program (Lamprey Display)	Heritage University	Toppenish, WA	Students (High S.)	50+	5
11/16/2015	Mt. Adams Middle School Assembly	White Swan Middle School	White Swan, WA	Students (Middle S.)	100+	10
-	-	-	-	**Total**	**6894+**	**20687+**

Figure I1-1. Lamprey outreach event at Mt. Adams School District on November 16, 2015.

Figure I1-2. Lamprey outreach event at Prosser Hatchery on May 7, 2015.

Figure I1-3. Adult Pacific Lamprey translocation release in Toppenish Creek on April 30, 2015.

Figure I1-4. Adult Pacific Lamprey translocation release in Toppenish Creek on May 13, 2015. Ann Mills, USDA Deputy Under Secretary for Natural Resources and Environment, hand-carries one of the adult lamprey.

Figure I1-5. Adult Pacific Lamprey translocation release in Satus Creek on April 28, 2015.

Figure I1-6. Adult Pacific Lamprey translocation release in Ahtanum Creek on April 22, 2015 - with La Salle High School students.

Figure I1-7. Adult Pacific Lamprey translocation release in Ahtanum Creek on April 22, 2015 - Patrick Luke holding an adult lamprey in a clear tube display.

Figure I1-8. Adult Pacific Lamprey translocation release in Ahtanum Creek on April 22, 2015 - Emily Washines ready to release one of the lamprey.

Figure I1-9. Adult Pacific Lamprey translocation release in Methow River on September 20, 2015 – Ralph Lampman introduces the audience to one of the lamprey.

Figure I1-10. Adult Pacific Lamprey translocation release in Methow River on September 20, 2015 – an elder from the Coquille Indian Tribe hand-carries one of the adult lamprey.

J. Work Element 176 – Produce Hatchery Fish / Research into Juvenile

Work Element Associated Appendix Report:

Appendix J1 – Evaluation of Pacific Lamprey (*Entosphenus tridentatus*) Life Stage Transition from Prolarva to Larva and Timing of First Feeding

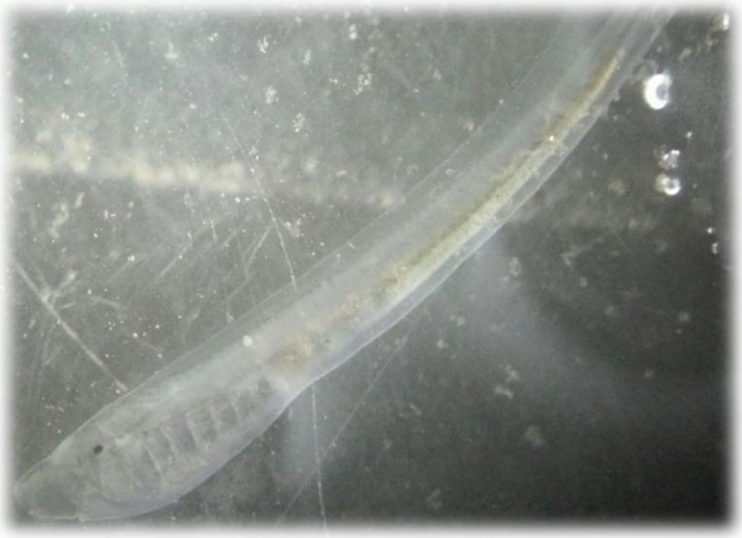

Photo J1. An example of a Pacific Lamprey prolarva in transition to a first-feeding larvae.

Timing of the first feed for propagated fish is a critical element for successful fish production. The most appropriate timing of first feeding for Pacific Lamprey has not been evaluated in depth to date. Propagated prolarvae/larvae were monitored between 24 and 38 days post fertilization at Prosser Fish Hatchery using a dissecting microscope. It appears that anus connection and oral

hood are actively developing between 24-31 days post fertilization (Fig. J1-1 and Fig. J1-2). In synchrony, gall bladder that starts off with a distinct green color loses its color gradually between 27-35 days post fertilization (Fig. J1-3). It is possible that the green gall bladder is an indication of short-term starvation and a sign that they exhausted yolk within its gut and are becoming ready for new feed. As a result, the intersection of the timing between anus connection / oral hood completion and gall bladder discoloration may denote the most suitable timing for first feed, which is approximately 27-30 days post fertilization in a 14 °C holding tank environment (Fig. J1-4, Fig. J1-5, Table J1-1, and Fig. J1-6). See **Appendix J1** for more information.

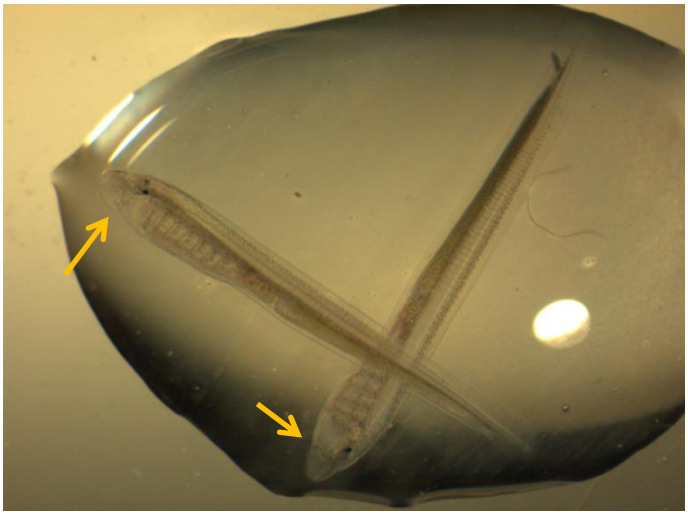

Figure J1-1. Examples of Pacific Lamprey larvae with a complete oral hood – orange arrows (photo credit: J. Barron, USFWS).

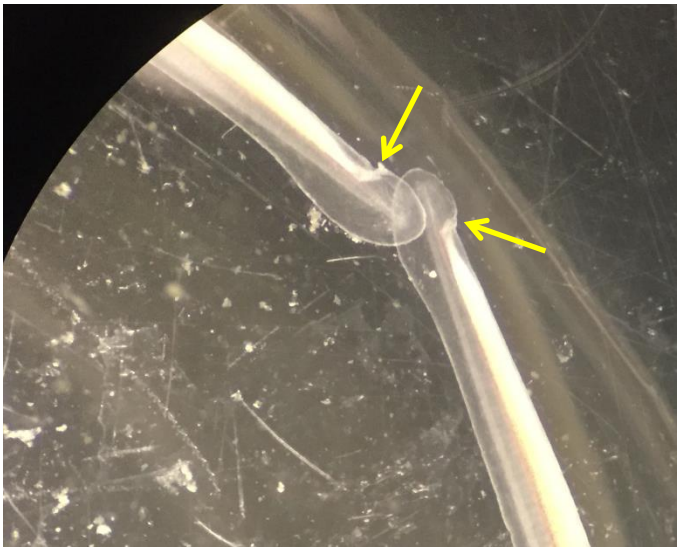

Figure J1-2. Examples of Pacific Lamprey prolarvae with an anus connection/formation – yellow arrows (photo credit: A. Maine, Confederated Tribes of the Umatilla Indian Reservation).

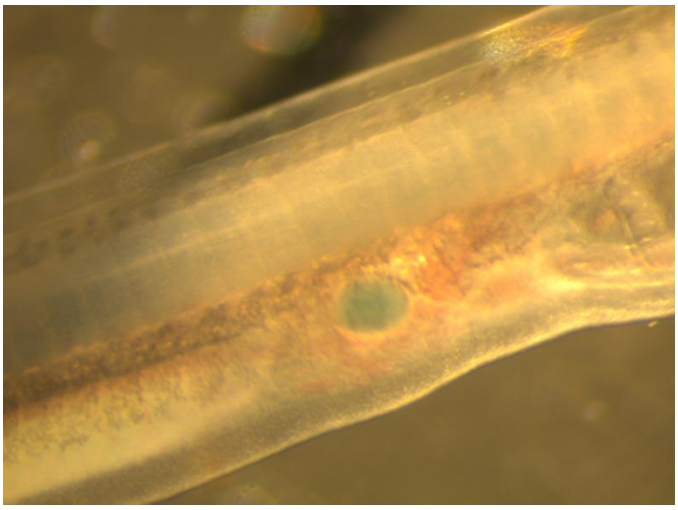

Figure J1-3. An example of a Pacific Lamprey prolarva with a green gall bladder – green arrow (photo credit: J. Barron, USFWS).

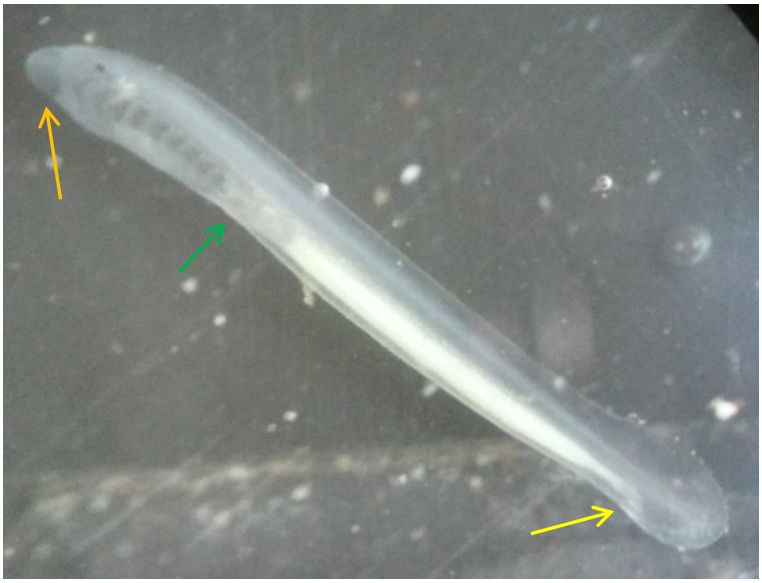

Figure J1-4. An example of a prolarva (27 days post fertilization) with an incomplete oral hood (orange arrow) and an incomplete anus connection (yellow arrow). Indentation is lacking in both areas. Albeit difficult to detect from the photo, the gall bladder was still noted as green in color (green arrow).

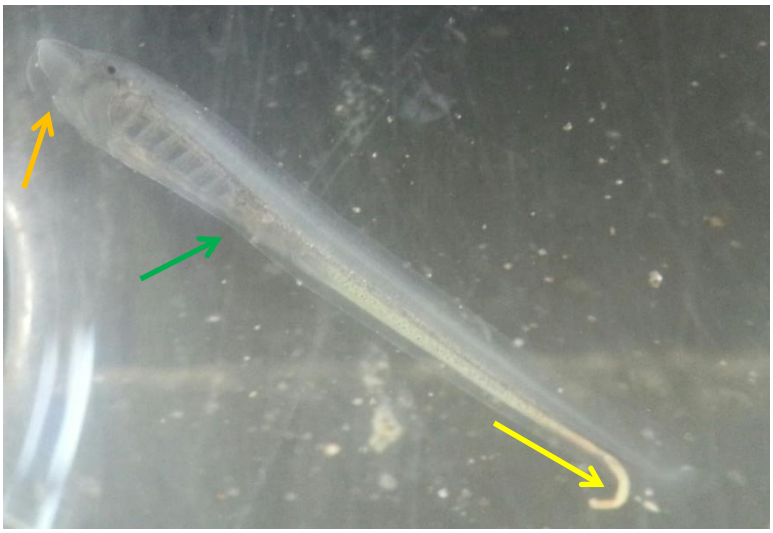

Figure J1-5. An example of a prolarva (31 days post fertilization) with a complete oral hood (orange arrow) and an anus connection (yellow arrow; gut content being pushed out). There is a clear indentation at the oral hood and anus connection. The gall bladder is mostly clear (green arrow), indicating feeding likely began.

Table J1-1. Summary of prolarvae development assessment between July 10, 2015, and July 24, 2015.

Monitoring Date	Spawning Date	Days since Fertilization	Sample Size	Gut Color	Oral Hood Complete	Oral Hood Incomplete	% Oral Hood Complete	Anus Formation Complete	Anus Formation Incomplete	% Anus Formation Complete	Green Gall Bladder	Clear Gall Bladder	% Green Gall Bladder
7/10/2015	6/16/2015	24	10	Creamy Yellow	2	8	20.0%	4	6	40.0%	9	1	90.0%
7/13/2015	6/16/2015	27	7	Whitish Yellow	3	4	42.9%	3	4	42.9%	5	2	71.4%
7/17/2015	6/16/2015	31	9	Faint Yellow	9	0	100.0%	9	0	100.0%	2	7	22.2%
7/21/2015	6/16/2015	35	10	Mostly Clear	10	0	100.0%	10	0	100.0%	0	10	0.0%
7/24/2015	6/16/2015	38	10	Clear/Green	10	0	100.0%	10	0	100.0%	0	10	0.0%

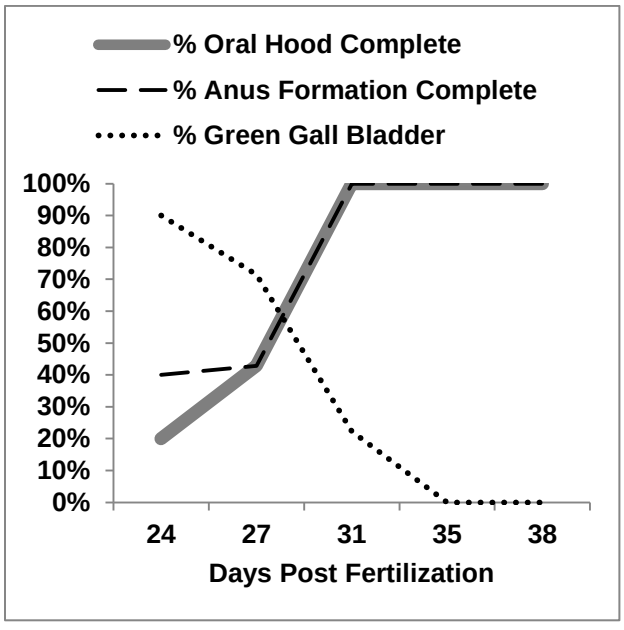

Figure J1-6. Prolarvae conditions in relation to oral hood development, anus formation/connection, and gall bladder color between 24 and 38 days post fertilization.

K. 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 2015.

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

Work Element Associated Appendix Report:
Appendix L1 – Yakama Nation Cultural Oral Interviews on Lamprey Eels: Summary Part I

Photo L1. Two tribal elders having a conversation at one of the Prosser Dam scaffolds on the left bank during a fishers' meeting on April 15, 2016.

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. Leroy Senator and Steve Hoptowit, 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. In addition to harvest within the Yakima Subbasin, Mr. Senator and Hoptowit also shared their tradition of eel harvest in other sites [Lyle Falls (Klickitat River), Fifteenmile Creek, Sherars Falls (Deschutes River), Willamette Falls (Willamette River), and by The Dalles Dam]. Between late 1960s and early 1980s, abundance of Pacific Lamprey within the Yakima River has potentially declined sharply to approximately 8.3-9.1% and eventually 2.2-3.6% of the peak harvest levels from the late 1960s. Information related to biology, ecology, and harvest and cooking methods were also discussed. Water quantity, adult passage, irrigation/canals, and habitat loss were considered as the leading factors contributing to the decline of Pacific Lamprey. See **Appendix L1** for more information.

M. Work Element 132 – Annual Progress Report

Work Element Associated Appendix Report:
Not Applicable

The Annual Progress Report for the period January 2015 through December 2015 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.

N. Work Element 185 – Pisces Status Report

Work Element Associated Appendix Report:
Not Applicable

All quarterly Pisces Status Report for the Year 2015 were completed successfully.

IV. References

Beamish R. J. and T. G. Northcote. 1989. Extinction of a population of anadromous parasitic lamprey, *Lampetra tridentata*, upstream of an impassible dam. Canadian Journal of Fisheries Aquatic Science 46:420-425.

Close, D., M. S. Fitzpatrick, H. W. Li, B. Parker, D. Hatch, and G. James. 1995. Status report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River basin. Report to the Bonneville Power Administration, Contract 9SBI39067, Portland, OR.

Close, D. A., A. D. Jackson, B. P. Conner, and H. W. Li. 2004. Traditional ecological knowledge of Pacific Lamprey (*Lampetra tridentata*) in northeastern Oregon and southeastern Washington from indigenous peoples of the Confederated Tribes of the Umatilla Indian Reservation. Journal of Northwest Anthropology 38:141-161.

Columbia River Inter-Tribal Fish Commission (CRITFC). 2011. Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. CRITFC, Portland, OR.

Hamilton, J. B., G. L. Curtis, S. M. Snedaker, and D. K. White. 2005. Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams – a synthesis of the historical evidence. Fisheries 30:10-20.

Hammond, R. J. 1979. Larval biology of the Pacific Lamprey, *Entosphenus tridentatus* (Gairdner), of the Potlatch River, Idaho. M.S. thesis, University of Idaho, Moscow, ID.

Kan, T. T. 1975. Systematics, variation, distribution, and biology of lampreys of the genus *Lampetra* in Oregon. Doctoral dissertation, Oregon State University, Corvallis, OR.

Murauskas, J. G., A. M. Orlov, and K. A. Siwicke. 2013. Relationships between the abundance of Pacific Lamprey in the Columbia River and their common hosts in the marine environment. Transactions of the American Fisheries Society 142:143-155.

Luzier, C. W., H. A. Schaller, J. K. Brostrom, C. Cook-Tabor, D. H. Goodman, R.D. Nelle, K. Ostrand and B. Streif. 2011. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and Template for Conservation Measures. U.S. Fish and Wildlife Service, Portland, Oregon. 282 pp.

Ward. D. L., B. J. Clemens, D. Clugston, A. D. Jackson, M. L. Moser, C. Peery, and D. P. Statler. 2012. Translocating Adult Pacific Lampreys within the Columbia River Basin: State of the Science. Fisheries 37:351–361.

V. Appendices

Appendix B1 – Draft Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research

Appendix C1 – Yakima Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2009-2015)

Appendix C2 – Wenatchee Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Appendix C3 – Entiat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2014)

Appendix C4 – Methow Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Appendix C5 – Klickitat Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2009-2015)

Appendix C6 – White Salmon Subbasin Larval Lamprey Distribution, Occupancy, and Index Site Monitoring Report (2012-2015)

Appendix D1 – 2015 Adult Pacific Lamprey Collection in the Columbia River Basin

Appendix E1 – Translocation of Adult Pacific Lamprey within the Yakima Subbasin (2014-2015 Broodstock)

Appendix E2 – 2015 Juvenile/Larval Pacific Lamprey Passage Monitoring in Chandler Diversion, Yakima River (Prosser, WA)

Appendix F1 – 2015 Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin

Appendix G1 – Distribution and Occupancy of Pacific Lamprey in Six Major Columbia River Subbasins within the Yakama Nation Ceded Lands: Summary from 2009-2015 Surveys

Appendix G2 – 2015 Intensive Monitoring of Larval/Juvenile Lamprey Entrainment within the Yakama Subbasin

Appendix G3 – Evaluation of Chandler Diversion Bypass Pathways for Larval/Juvenile Lamprey during the Dewatering Season

Appendix G4 – Larval Lamprey Assessment at Wapato and Sunnyside Fish Screening Facilities

Appendix G5 – Passage of Radio-Tagged Adult Pacific Lamprey at Yakima River Diversion Dams, 2014 Annual Report, Phase 3: Roza and Cowiche Dams

Appendix G6 – The Role of Pacific Lamprey in Yakima River Tributary Food Webs

Appendix G7 – Influences of Fish Physiology and Habitat Conditions on the Retention Rates of Adult Pacific Lamprey (*Entosphenus tridentatus*) Carcasses in Upper Toppenish Creek, a Small Tributary System in South Central Washington, USA

Appendix G8 – Summary of Pacific Lamprey Salvage Efforts from Dryden Diversion Maintenance Operations (Wenatchee River, Dryden, WA)

Appendix I1 – 2015 Yakama Nation Pacific Lamprey Project Outreach and Education

Appendix J1 – Evaluation of Pacific Lamprey (*Entosphenus tridentatus*) Life Stage Transition from Prolarva to Larva and Timing of First Feeding

Appendix L1 – Yakama Nation Cultural Oral Interviews on Asum (Lamprey Eels): Summary and Review Part I (2015)