CONFEDERATED TRIBES AND BANDS OF THE YAKAMA NATION

Yakama Nation Pacific Lamprey Project

Annual Progress Report
Project No. 2008-470-00
Contract No. 87336

Performance Period
March 2012 – February 2013

Prepared for:

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I. Executive Summary

In accordance with Bonneville Power Administration (BPA) Contract 2008-470-00 and the Confederated Tribes and Bands of the Yakama Nation (YN) has prepared this progress Annual Report for the Yakama Nation Pacific Lamprey Project (YNPLP). This report outlines the most current activities undertaken by the YNPLP from March 1, 2012 through February 28, 2013.

WE28: The YNPLP collected 300 adult Pacific lamprey (*Entosphenus tridentatus*) from the lower mainstem Columbia River during 2012 and these fish will be and are being used for radio telemetry passage studies, adult translocation projects, and artificial propagation research.

WE115: Of the 12 official sites that were sampled in the Wenatchee River, five sites were located downstream of Tumwater Dam, and eight sites were located upstream of Tumwater Dam. Four out of the five sites contained lamprey downstream of the Tumwater Dam; however, none were found in the seven sites upstream of the dam, validating the claim that no lamprey (Pacific lamprey or otherwise) exist upstream of Tumwater Dam at this point in time.

WE132: The Annual Progress Report for the period March 2011 through February 2012 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 diverables, problems encountered, lessons learned, and the information gathered, synthesized, and updated to assist in long term planning.

WE141: Two elder interviews were recently conducted on March 6, 2013, using a new set of questions we developed and they have shared very interesting historical accounts of Pacific lamprey within the Yakima Subbasin. Based on these two interviews and the information they provided regarding eel harvest within the Yakima basin, we were able to estimate the approximate rate of population reduction within the Yakima basin; by the mid-1970s, the number of adult Pacific lamprey have declined to approximately 8% of the peak numbers since the mid-1960s and dropped further down to 3% of the peak counts after the 1970s, based on harvest information.

WE157: To improve our understanding of the Pacific lamprey population status within the Yakima Basin, the YNPLP have collected, gathered and analyzed existing data by the three major life stages 1) adults, 2) macrophthalmia, and 3) larvae.

WE161: The YNPLP continues to be substantially involved in all local and regional activities associated with Pacific lamprey research and recovery efforts. These include, but are not limited to activities undertaken by the US Army Corps of Engineers, Mid-Columbia Public Utility District FERC license implementation of associated Pacific Lamprey Management Plans, the CRITFC, support and development of the USFWS Pacific Lamprey Conservation Agreement, support and development of Reclamation's Pacific Lamprey Management Plan, and with the Lamprey Technical Work Group.

WE162: In 2012, we surveyed a total of 98 sites using a backback electrofisher designed for larval lamprey in river/stream environment. In addition, there were over 70 other sites that were surveyed quickly (quick assessments) using an electrofisher or a fine-mesh hand net to simply evaluate prescence/absence of juvenile lamprey. Juvenile Pacific lamprey were only found in the Lower Yakima, Naches, Wenatchee, and Entiat Subbasins and the mean ratio of Pacific lamprey (vs. Western brook lamprey) were 13.3%, 5.3%, 100%, and 100%, respectfully. All previous surveys starting in 2009 paint the general same picture for the Yakima Subbasin. That is, Pacific lamprey is rare and primarily limited to the Lower Yakima Subbasin (below Roza Dam) and the majority that we have detected were found in side channels of the Yakima River (primarily in the Wapato reach area) and the lower reaches of major tributaries, including Satus and Ahtanum Creek. Ammocoete habitat and Western brook lamprey, on the other hand, is fairly abundant in the Lower Yakima as well as in the Upper Yakima subbasins. Findings thus far confirm the status of Pacific lamprey is "functionally extinct" in the Yakima Subbasin. Remarkably, the Yakima system has a substantial numbers of Western brook (*Lampetra richardsoni*), especially in the Upper Yakima Subbasin.

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 Nations 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 hundred 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; 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 (WE28, WE115, WE132, WE141, WE157, WE161, and WE162) are oriented toward meeting one of these three project goals.

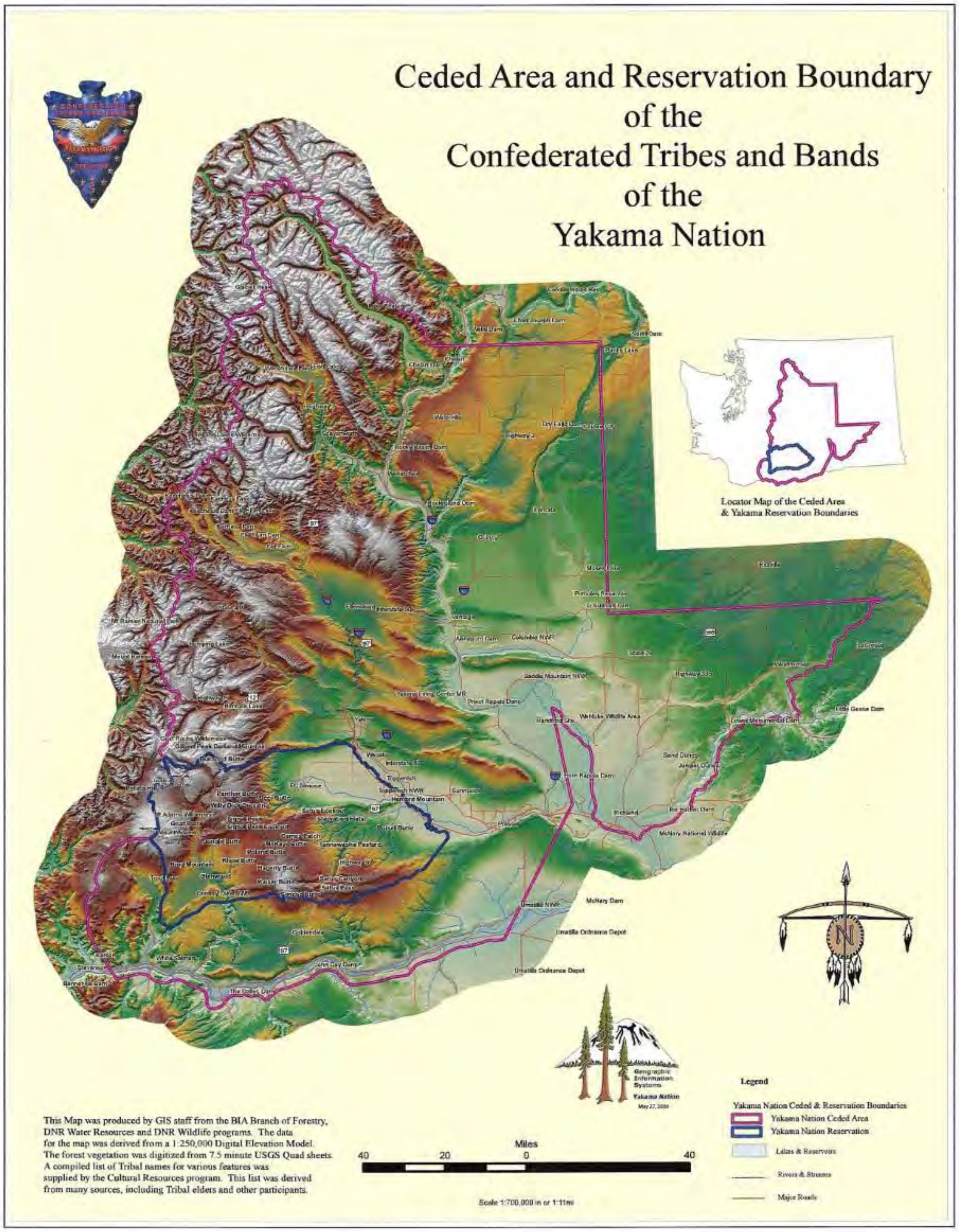

Figure 1. Ceded Lands and Resevation Boundary of the Confederated Tribes and Bands of the Yakama Nation

III. Deliverables

A. Work Element 28 – Adult Pacific Lamprey Trapping and Collection

The YNPLP collected 300 adult Pacific lamprey from the lower mainstem Columbia River during 2012 according to and within the limits set by the Tribal Collection Allocation Guidelines (Table 1 and 2; Figure 2). Collection was closely coordinated with the USACE (Portland District) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). The new collection guidelines, procedures, and more details on the trapping and transportation operations can be found in Appendix A1. Overall mortality rate was 5.1% in 2012. Unfortunately, 14 adults died during and shortly after transportation in late July from a combination of high water temperature, decreased oxygen, and extended transportation time. Ways to reduce this type of mortality was discussed thoroughly among all team members so that this level of mortality will never happen again.

Table 1. Yakama Nation adult Pacific lamprey broodstock collection in 2012

Date	Crew	JD North Ladder	JD South Ladder	John Day Total	TD East Ladder	TD North Ladder	TD Rocky Channel	The Dalles Total	BON Cascade Island	BON AFF	Bonneville Total	Daily Total	Mortality	Accumulated Total
6/13/2012	PL, TB	0	0	0	0	0	0	0	0	80	80	80		80
7/6/2012	PL, TB	4	4	8	3	0	0	3	0	0	0	11		91
7/7/2012	PL, TB	5	3	8	3	0	0	3	0	0	0	11		102
7/8/2012	PL, TB	4	2	6	6	0	0	6	0	0	0	12		114
7/13/2012	PL, TB	6	0	6	0	0	0	0	0	0	0	6		120
7/14/2012	PL, TB	6	4	10	7	0	0	7	0	0	0	17		137
7/15/2012	PL, TB	0	10	10	24	0	0	24	0	0	0	34		171
7/20/2012	RL, TB	35	6	41	3	0	0	3	0	0	0	44	12	203
7/21/2012	PL, TB	3	4	7	6	0	0	6	0	0	0	13	2	214
7/22/2012	PL, TB	0	4	4	33	0	0	33	0	0	0	37		251
7/27/2012	PL, TB	10	11	21	0	0	0	0	0	0	0	21		272
7/28/2012	PL, TB	2	3	5	11	0	0	11	0	0	0	16		288
7/29/2012	PL, TB	0	2	2	12	0	0	12	0	0	0	14	2	300
Total		**75**	**53**	**128**	**108**	**0**	**0**	**108**	**0**	**80**	**80**	**316**	**16**	

Table 2. 2012 Tribal Collection Allocation Guidelines (per Tribe)

Location	Allocation
Bonneville Dam	80
The Dalles	168
John Day	131
Total	**379**

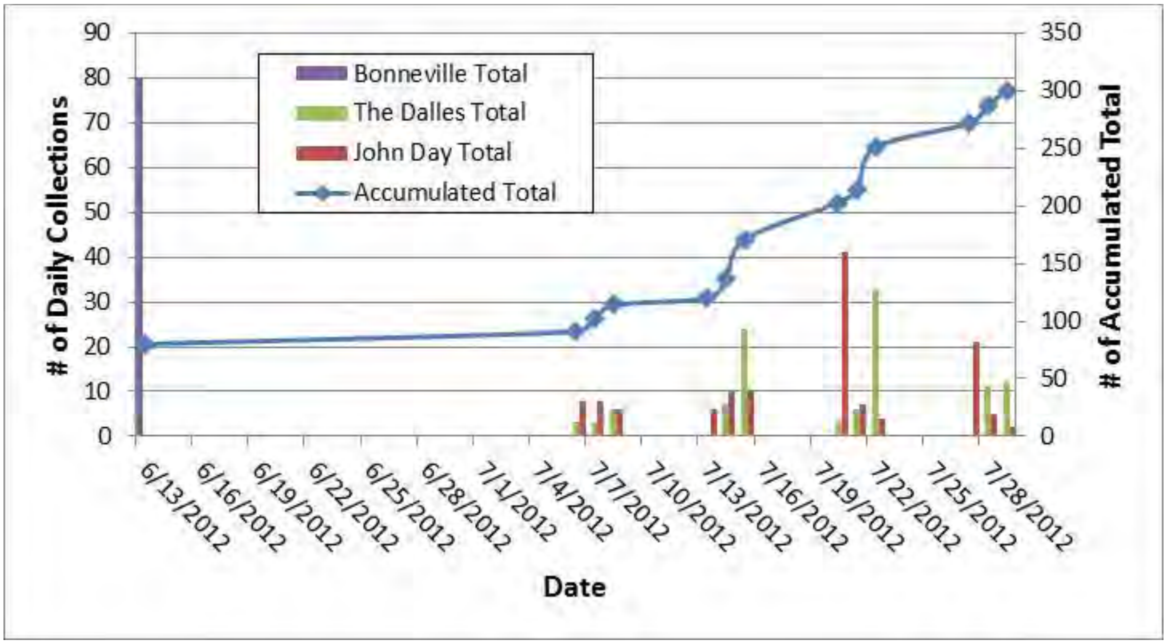

Figure 2. Yakama Nation adult Pacific lamprey broodstock collection in 2012

Approximately $25,000 was spent on planning, staff time, travel and equipment in order to collect these adult lamprey. This is in addition to associated costs incurred by our cost-share partnership with the CTUIR. All costs associated with this collection were charged to the YNPLP - BPA Fish Accords project. The YNPLP is currently planning to undertake a similar collection effort, with the CTUIR, during the summer of 2012.

Approximately 75 of these fish were used in the autumn months (2012) for radio-telemetry studies in the Yakima River with approximately 40 more used in the spring of 2013 for this same study in the mid and upper Yakima River. The remainder of these fish are being used for both pilot / research towards artificial propagation and adult supplementation within the Upper Yakima and Atanum, Satus, Toppenish and Naches watersheds.

The recently released Tribal Pacific Lamprey Restoration Plan (TPLRP) (CRITFC 2011) and the USFWS Lamprey Conservation Agreement each identify the need to develop actions that actively restore Pacific lamprey populations throughout their range. Specifically, the TPLRP 2011 identifies the need for a lamprey Translocation that will guide existing restoration actions and fit within a basin-wide monitoring strategy. Translocations to restore native Pacific lamprey so far have shown positive results by successfully increasing juvenile lamprey numbers in recipient subbasins (Ward et. al. 2012).

In addition, efforts were made to capture adult Pacific lamprey from the lower Yakima River in 2012. This project was implemented under a contract with the Washington Department of Fish and Wildlife (WDFW) under David Hoffarth. The YNPLP staff coordinated with the WDFW to establish schedules and site specific locations on where to deploy the tube traps. Trap setting and transport operation were set up Monday through Friday August 1 through September 30, 2012 (traps were set on Mondays, checked on Tuesdays, Wednesdays and Thursdays, and pulled out of the river on Fridays). Despite the intensive trapping effort primarily near the mouth of Yakima River, no lamprey was captured during this pilot project. The final report from this contract is attached as Appendix A2 and includes trapping summary and recommendations for 2013 field season. In 2013, Horn Rapids Dam will most likely be targeted to trap and collect adult Pacific lamprey within the Yakima Basin. The YNPLP anticipates that this effort will be ongoing through 2014 and will work in close coordination with the USFWS to support the ongoing radio telemetry study with adult lamprey collected from this effort.

Photo of lamprey trapping operation at John Day Dam. From left: Tyler Beals and Frank Spillar

B. Work Element 115 – Wenatchee Rafting Survey

The goal of this project was to evaluate the current distribution and relative abundance of juvenile Pacific lamprey within the Wenatchee Subbasin. No adult or juvenile lamprey has been documented upstream of Tumwater Dam (river km 49.6) in recent years, although historically adults and juveniles were both documented in the upper reaches of Wenatchee Subbasin. In close coordination with the USFWS (Mid-Columbia River Fishery Resource Office), who has conducted some juvenile surveys in recent years, we planned for and conducted juvenile lamprey surveys in the Wenatchee Subbasin. While the USFWS employed a systematic, random approach for their sampling to evaluate mainly presence/absence of larval lamprey, we used a more directed approach focusing on preferred and acceptable larval habitat to assess presence/absence and relative abundance throughout the subbasin. The USFWS and the YNPLP both used 100m reaches for the electrofishing sampling, but the YNPLP electrofished only the Type I (preferred) and Type II (acceptable) habitat, whereas the USFWS electrofished the entire 100m reach (in water <1m deep) including areas considered Type III (unsuitable) habitat. Both of these two sampling protocols have advantages and disadvantages, so we determined that conducting a separate study using these two different protocols will yield different types of results that will most likely complement each other in gaining a better understanding of the current status of Pacific lamprey within the subbasin. At the minimum, we will be able to learn more about the pros and cons of these two distinct sampling protocols by contrasting the results.

Over 40 sites were selected based on ammocoete habitat potential and accessibility. Eighteen sites (12 in Wenatchee, 3 in Icicle, and 3 in Nason) were officially surveyed using our electrofishing and habitat measurement protocol. In several other sites, we conducted quick assessment surveys using either electrofishing or netting (sifting through fine-mesh hand nets) to evaluate presence/absence. We were not able to survey some of the originally planned sites due to low flow conditions (no water in side channels), lack of habitat, or accessibility issues. Most of the sites in Icicle Creek and some of the sites in Wenatchee River were surveyed using a raft over a two-day period. Dave Sulak from the USFWS who had ample prior experience rafting in the subbasin provided much needed help for us to survey these more remote sites efficiently.

Of the 12 official sites that were sampled in the Wenatchee River, five sites were located downstream of Tumwater Dam, and eight sites were located upstream of Tumwater Dam. Four out of the five sites contained lamprey downstream of the Tumwater Dam; however, none were found in the seven sites upstream of the dam, validating the claim that no lamprey (Pacific lamprey or otherwise) exist upstream of Tumwater Dam at this point in time. No lamprey were found in Icicle and Nason Creek, either, despite a large amount of preferred ammocoete habitat being available. For more details and photos of the survey, see Appendix B1. For survey reports from Entiat and White Salmon subbasins, see Appendix B2 and B3. Additional information on the juvenile lamprey survey monitoring (including Wenatchee Subbasin) can be found in Appendix G1.

Photo of electrofishing in lower Wenatchee River. From left: Dan Saluk (USFWS), Patrick Luke (YNPLP), and Tyler Beals (YNPLP)

C. Work Element 132 – The Annual Progress Report

The Annual Progress Report for the period March 2011 through February 2012 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 diverables, problems encountered, lessons learned, and the information gathered, synthesized, and updated to assist in long term planning.

D. Work Element 141 – Other Reports

YNPLP has collected and is still in the process of collecting historical accounts of Pacific lamprey from tribal members. A new set of interview questions that focuses on six elements (biography, abundance, biology, ecology, culture, and human impacts) were developed by the new lamprey research biologist in cooperation with other YN archeologists (see Appendix D1). These interview questions were largely based on interview questions that the Umatilla Tribe has previously conducted to document Traditional Ecological Knowledge (TEK) surrounding Pacific lamprey (Close et al. 2004).

Two elder interviews were recently conducted on March 6, 2013, using this new set of questions and they have shared very interesting historical accounts of Pacific lamprey within the Yakima Subbasin. Detailed answers from these two interviews have been transcribed thoroughly, but a final check-in with the interviewees is warranted to ensure everything is accurate to their understanding before disseminating the information. Based on these two interviews and the information they provided regarding eel harvest within the Yakima basin, we were able to estimate the approximate rate of population reduction within the Yakima basin; by the mid-1970s, the number of adult Pacific lamprey have declined to approximately 8% of the peak numbers since the mid-1960s and dropped further down to 3% of the peak counts after the 1970s, based on harvest information. We will update the cultural report in the near future with the new results from the recent tribal interviews and we plan to work collaboratively with the YN archeologists to add and enhance the report with additional insights from other disciplines.

Pacific Lamprey Action Plan for Yakima Subbasin, a document that describes the current status, primary threats, and restoration plans for the Pacific lamprey population within the Yakima Subbasin can be found in Appendix D2. Basin-specific Pacific Lamprey Action Plans for other basins have not been completed, but we are working directly with all partners that are actively involved in Pacific lamprey management in these other subbasins (Wenatchee, Entiat, Methow, White Salmon, etc.) to determine the primary actions needed for local population recovery. The YN also spearheaded the effort in formulating the "Pacific Lamprey Actions Table," which stemmed from the Lamprey Summit III in 2012. Appendix D3 is a working draft of the Pacific Lamprey Actions Table for the Yakima Subbasin. Actions Table for other subbasins are in the works and are being updated with the help of our partners. After completing these basin-specific Actions Tables, we should be able to produce the basin-specific Action Plans shortly after. Additionally, we will continue regional collaboration towards development of a regional RME framework and continue to develop subbasin specific Action Plans within this "framework".

Photo of the Treaty Day Parade in June showing traditional ways of drying lamprey eels

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

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.

- Phase I has been simply the establishment of the Project, developing general protocols, initiating preliminary surveys throughout several subbasins, and begining a basin wide coordination at a regional scale. For the most part, this effort has been successful. In particular, we have a much higher understanding of the biology, ecology, and distribution of lamprey species within the Ceded Lands of YN. We surveyed and covered lamprey habitat extensively which helps set the stage for our Yakima Subbasin "Action Plan" that is live and ongoing. We have gained cost share partners and have stayed engaged with other agencies and public at both regional and local levels.
- Phase II focuses on adult and juvenile passage issues as well as the establishment of index monitoring sites, from which status and trend is captured over the years to come. These sites include, but are not limited to, Entiat, Klickitat, Methow, Wenatchee, White Salmon, and Yakima subbasins. Based on our current assessment of Pacific lamprey statusnumbers, we conclude that a well thought-out restoration plans and supplementation research activities will provide crucial avenues and directions for long-term lamprey recovery. We will continue to develop Action Plans that focus on key subbasins within the YN Ceded Lands. These activities are taking place in close coordination with Bureau of Reclamation and Yakama Klickitat Fish Project Facilities. YNPLP continues to be engaged and committed to work with the Army Corp of Engineers and the Mid Columbia Public Utility Districts towards the improvement of Columbia River mainstem passage issues. We are also continuing to coordinate closely with the USFWS through the "Conservation Initiative" and the Yakima Basin radio telemetry project and the Columbia River InterTribal Fish Commission through the "Tribal Pacific Lamprey Recovery Plan" and the many projects that stem off of the Plan.
- Phase 3 will focus on implementation of the knowledge we have gained from Phase 1 and 2. Specifically (but not limited to) we anticipate (1) passage and entrainment issues

within the Yakima Basin will begin to be addressed, (2) supplementation research and related management activities will be well defined, developed and initiated in a manner to measure the biological performance of re-introduced local populations, (3) habitat restoration activates oriented primarily towards salmonid recovery will have lamprey habitat needs incorporated, (4) initiate programmatic actions that will reduce toxic chemical levels within juvenile lamprey tissues, (5) fully engage a regional, if not international effort to better understand the ecology of Pacific lamprey within the marine environment, and (6) continued coordination as described in Phase 2.

The YNPLP has spent a considerable amount of time cleaning and organizing current and past data in 2012. Quality control on data has been an issue in the past, but much of the data has been examined for quality control and is ready to be officially stored to data depository, such as StreamNet, and/or shared with other entities. A few meeting was held to discuss data depository options with YN GIS specialists (Leon Ganuelas) and StreamNet staff (Van Hare and Michael Banach) in 2012, and these options will be pursued in 2013.

To improve our understanding of the Pacific lamprey population status within the Yakima Basin, the YNPLP have collected, gathered and analyzed existing data by the three major life stages 1) adults, 2) macrophthalmia, and 3) larvae. Shown below are some highlights of this analysis for adults and macrophthalmia using Prosser Dam and Chandler Fish Counting Station data (see Work Element 162 for updated information on larvae):

Adults:

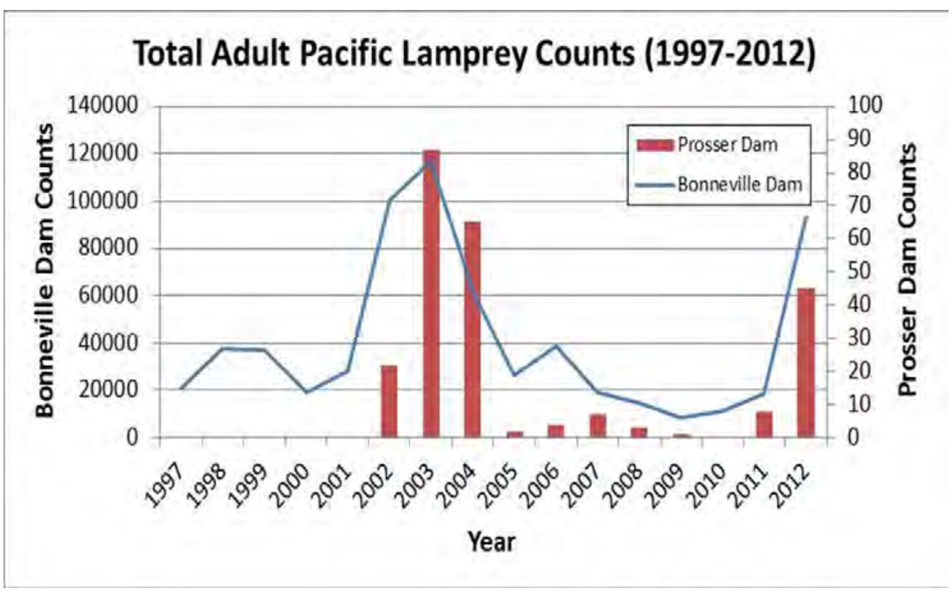

Figure 3. Adult Pacific lamprey counts at Prosser Dam vs. Bonneville Dam between 1997 and 2012 – the general trend in abundance is surprisingly very similar.

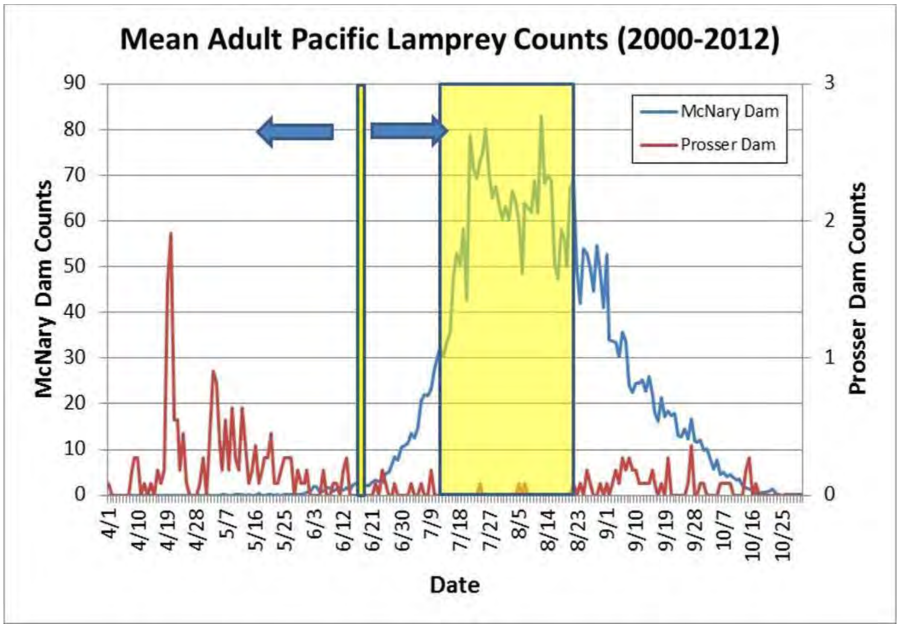

Figure 4. The mean migration timing of adult Pacific lamprey at Prosser Dam vs. McNary Dam based on 13 years of combined data – the majority of migrants at McNary Dam are new migrants (adults that haven't overwintered) while a large number of the Prosser Dam migrants are overwintered migrants (adults that are ready to spawn the same year). The threshold date for the two runs are still unknown, but is most likely in mid-June based on the movement timing of early run lamprey from McNary Dam (yellow line). There is also a large gap in migrants between early July and mid-August at Prosser Dam (yellow box), which may be due to the high water temperature conditions in lower Yakima River during the mid-summer.

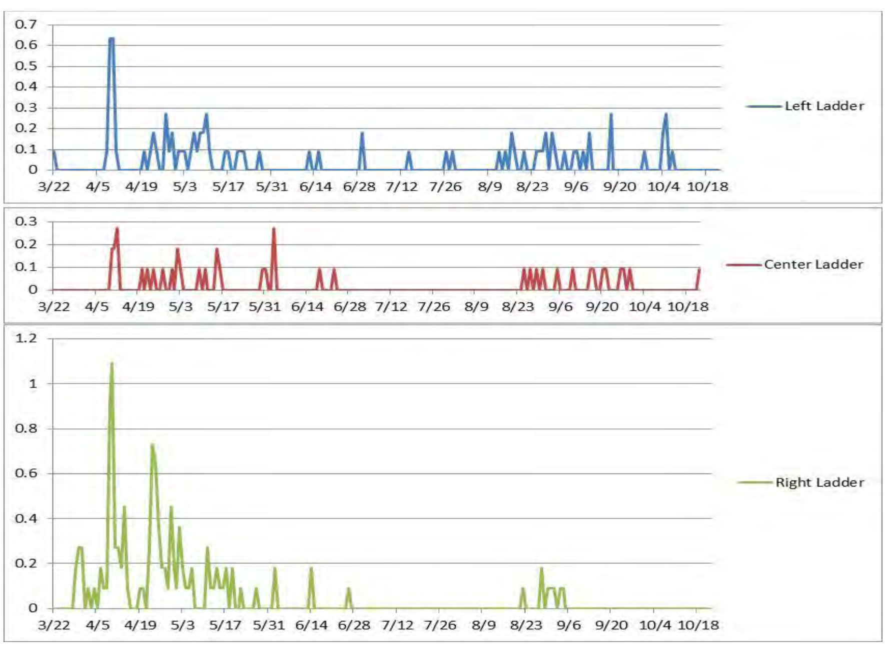

Figure 6. The mean migration timing of adult Pacific lamprey at Prosser Dam based on 13 years of combined data by fish ladder (left, center, and right). This information will help us understand migration behavior of adult Pacific lamprey at the dam by season and flow conditions and will provide crucial input on passage improvement projects.

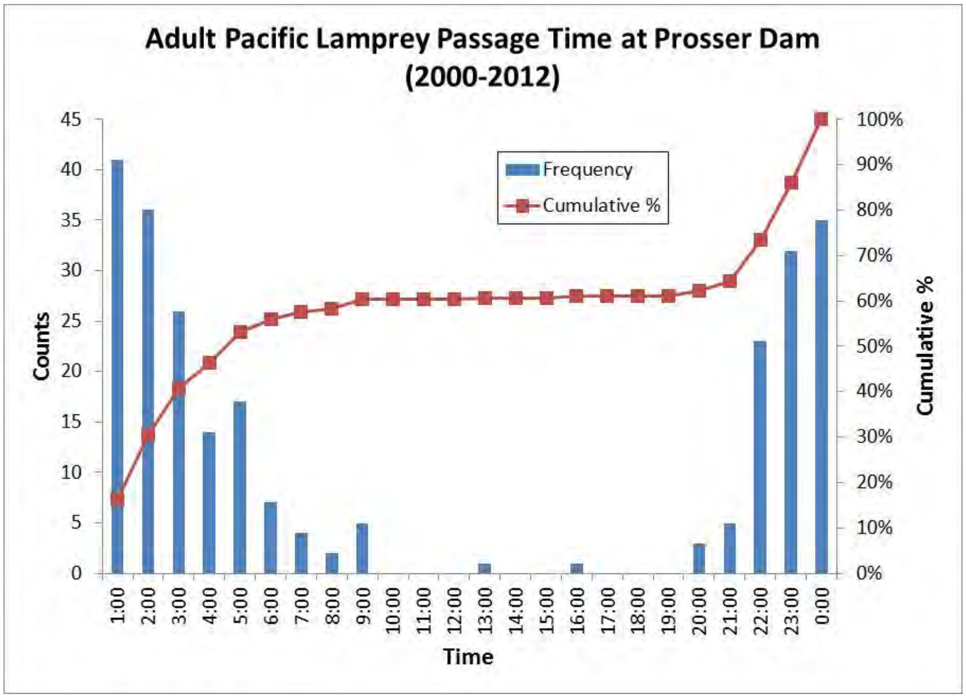

Figure 6. Adult Pacific lamprey passage time at Prosser Dam between 2000 and 2012 – as shown by other studies, the majority of passage was documented in the evening hours between 8pm and 9am.

Macrophthalmia:

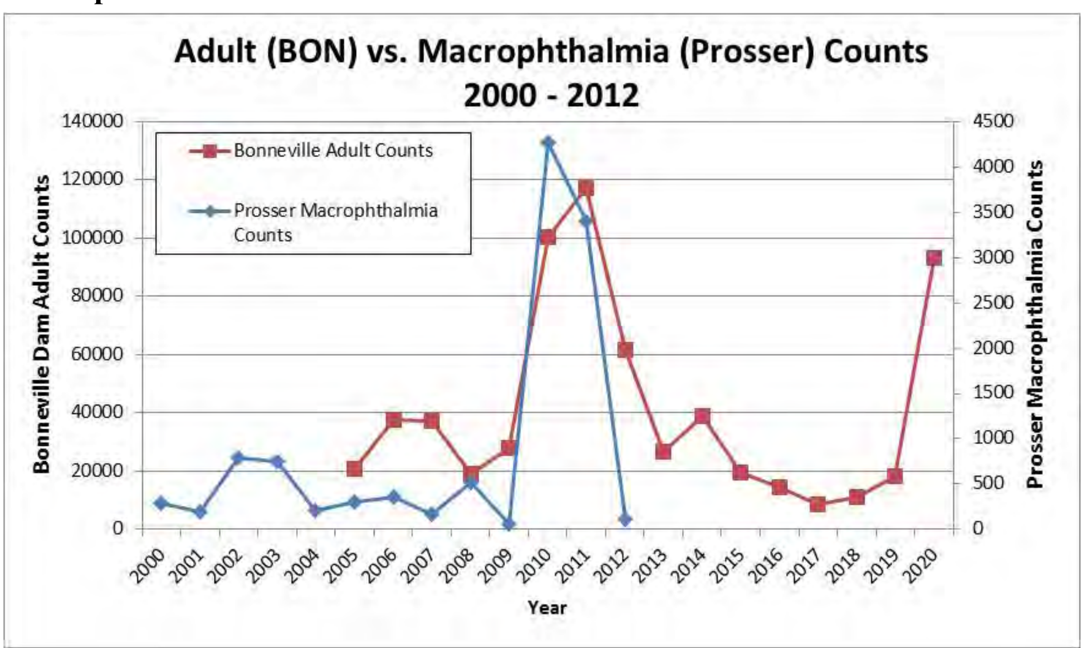

Figure 7. Macrophthalmia counts (extrapolated) from Prosser Dam facility vs. Bonneville adult counts (with 8 year lag) – this indicates that macrophthalmia may be outmigrating as 7 year old juvenile, if the large adult return was responsible for the large outmigrants that was observed at the Prosser Dam facility (Adults overwinter and then spawn, so the 8 year lag will mean that the juveniles are 7 year old).

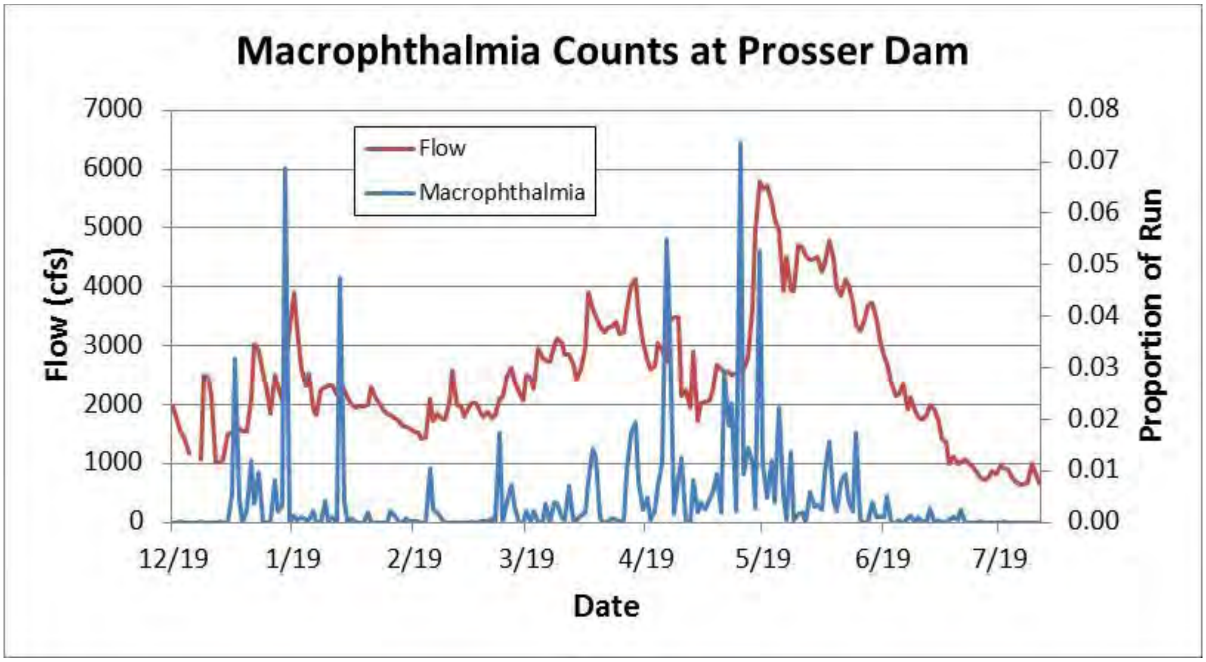

Figure 8. Proportion of the macrophthalmia run (13 years combined) during the juvenile fish collection season. Most of the high counts appear to be triggered by increases in river flow conditions.

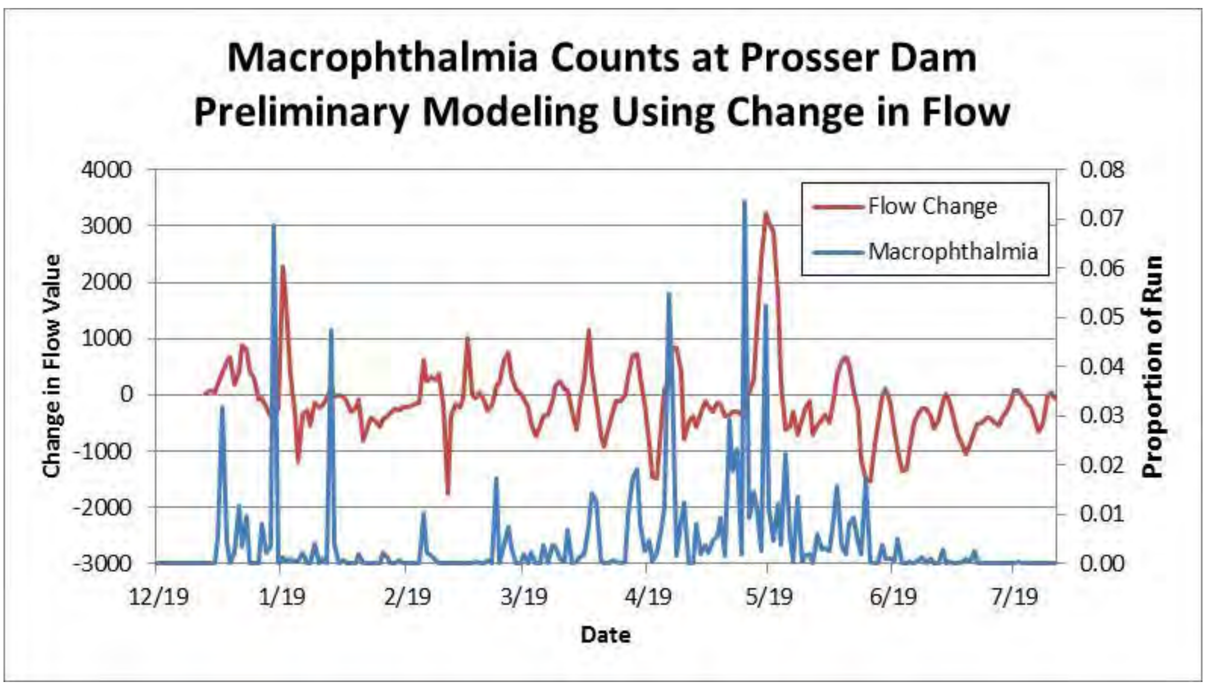

Figure 9. Macrophthalmia counts and preliminary modeling using flow change as a predictor

F. Work Element 161 – Participation in Regional Coordination

The YNPLP continues to be substantially involved in all local and regional activities associated with Pacific lamprey research and recovery efforts. These include, but are not limited to activities undertaken by the US Army Corps of Engineers (both Walla Walla and Portland Districts) associated with adult and juvenile passage at the FCRPS mainstem hydroelectric projects, Mid-Columbia Public Utility District FERC license implementation of associated Pacific Lamprey Management Plans, through all activities within the CRITFC, including the development and submission of the Tribal Pacific Lamprey Recovery Plan (CRITFC 2011), support and development of the USFWS Pacific Lamprey Conservation Agreement, support and development of Reclamation's *Effects on Pacific Lamprey (Lampetra tridentata)* and Reclamation's *Pacific Lamprey Plan,* and with the Lamprey Technical Work Group.

It is important to note that in 2012 a considerable effort has been initiated by the FRMP and CRITFC to develop a Research Monitoring and Evaluation (RME) strategy for the upper Columbia River (at this time, it focuses on Upper Columbia, but we expect to encompass the entire Columbia River over the next few years). This planning effort, with a clear focus on activities within the Yakima River basin, is anticipated to be vetted through the Northwest Power and Planning Council (NPCC) and the Independent Scientific Review Board, such that activities associated with long-term status and trend monitoring and research into potential supplementation activities can move forward through BPA funding. Much of the funds that supported this initial work came from the YN and CRITFC and other large scale cost-share projects. It is anticipated that during 2013, much of this work relevant to the Yakima River basin, will be incorporated in the NPCC tri-annual Amendment Process.

Provided below is a brief summary of various activities that we have been involved with in 2012:

Army Corps of Engineers: The YNPLP meets quarterly with the US Army Corps of Engineers, CRITFC and CRITFC member tribes to evaluate and prioritize adult and juvenile lamprey issue associated with the Federal Columbia River Power System. These meetings are a direct result of the 2008 Fish Accords with the primary issue discussed involving both adult and juvenile passage over these facilities. Another key element of these meetings is the identification and development of additional research topics that the ACE / Tribal workgroup supports through the annual Study Review Work Group for future funding from the Columbia River Mitigation Funds.

Mid- Columbia Public Utility Districts: Each of the three Public Utility Districts (Grant, Chelan and Douglas counties) have Pacific Lamprey Management Plans as a component of their FERC licenses. Although these management plans pertain specifically to the Project Areas of the individual PUDs there is a strong linkage regionally to these activities. The YNPLP meets monthly with each of the PUDs to review progress and to initiate new activities associated with the Management Plan objectives

USFWS Conservation Assessment and Agreement: The YNPLP has worked closely with the USFWS during the development of the Conservation Initiative and more recently with the development and signing of the Conservation Agreement, which was be a primary topic for the upcoming Lamprey Summit, co-sponsored by the CRITFC and the USFWS. The YNPLP will take a leading role in establishing and prioritizing restoration actions within the Yakima Basin and all YN Ceded Lands at large in close collaboration with USFWS and all other partners.

Pacific Lamprey Technical Work Group: The YNPLP is an active member of the Pacific Lamprey Technical Work Group, whose meetings are held biannually focusing on regionally important lamprey coordination / conservation projects. We intend to work closely with this group through the development of the Supplementation Framework discussed above.

Yakima - Umatilla River Rapid Assessments: The YNPLP worked closely with CRITFC and Reclamation in the initial development of a "rapid assessment", with the intention to develop a relatively quick, site-specific evaluation of potential juvenile and adult passage issues at Reclamation irrigation facilities and provide potential alternative solutions. The over-arching objective of this rapid assessment is to anticipate potential funding needs, such that steady progress can be made in correcting passage issues as they are identified. In March, 2012 a team of local and regional biologists and engineers was assembled for approximately two days and evaluated both Prosser and Sunnyside irrigation diversions. These earlier assessments have set the stage for the ongoing adult passage designs currently being explored with the YNPLP, USFWS, BOR engineers, and contractors.

The YNPLP is working closely with the USFWS towards the implementation of an annual radio-tagging study of adult Pacific lamprey. The primary objective of this study is to identify adult movement and passage characteristics within the Yakima River and at irrigation facilities, respectively. The USFWS is primarily responsible for implementation of this study - which is being funded through a cost share agreement between the YN, USFWS and the USACE (Seattle District). The USACE provided to the USFWS approximately $90,000 to implement this study, in addition to direct funding of approximately $50,000 from Reclamation. In addition, the Northern Wasco County Public Utility District contributed $50,000 to purchase the radio tags needed for the ongoing study. A similar arrangement and funding level is anticipated for the years 2012-2013. Interim findings for this study can be found in Appendix E1 “Passage of Radio-tagged Adult Pacific Lamprey at Yakima River Diversions 2012 Annual Report.”

USGS Screening Criteria for Juvenile Lamprey: The YNPLP is working closely with USGS (Dr. Matt Mesa) in furthering our understanding of entrainment mechanism of Pacific lamprey at diversion screens. This investigation will most likely require a combination of both in-the-field investigations and lab-oriented studies (which allows for intensive monitoring with much fewer complications and variables). The USGS lab in Cook, WA, now has a test flume, in which various types of real-life diversion screens (such as drum screens with bypass structure) can be tested for impacts on juvenile lamprey. Efforts will be made in 2013 to take advantage of this great opportunity to advance these studies and strengthen our partnership.

Last but not least, the YN have made a strong effort to educate the public about Pacific lamprey and have participated in a wide variety of outreach venues in 2012. In March, we shared fun information about lamprey with 3-5 year old kids at a Head Start Program in White Swan, WA. The majority of the participating kids were tribal members at this school, but unfortunately the majority had no idea what a lamprey was. In late March, we gave a presentation about lamprey to a group of students from the Central Washington University as part of their science class. Everyone was enthusiastic about learning more about lamprey. We are also currently working with CWU faculty members (Dr. Mark Auslander) to enhance the museum display titled "Life Along the Yakima" by adding lamprey-themed items and planning lamprey-themed activities. Starting in late August, we worked collaboratively with La Salle High School students to monitor the effects of lamprey carcass in the natural stream channel environment for 6 weeks. In this process, we learned with the students what aquatic benthic macroinvertebrates actively feed on lamprey carcasses. In October, we participated in the Yakima Greenway Rivers Festival, which was attended by approximately 250 4th & 5th grade students. We displayed both adult and juvenile (propagated) lamprey in aquarium tanks and discussed a wide variety of topics surrounding lamprey, which both students and parents were fascinated with. Countless people have visited the Prosser Hatchery and many tours were given to biologists, teachers, and people of all other walks of life. We have worked closely and shared a lot of photos and information with Sean Connolly from the USFWS who is spearheading the "Luna the Lamprey" facebook page to effectively reach a wider range of audience that are more tech-savy and participate more in social media through the internet.

Over 10 power point presentations on various aspect of Pacific lamprey (artificial propagation, overall lamprey program, traditional culture, and general outreach) were presented at a wide variety of venues in 2012, ranging from the Chelan Public Utility District Juvenile Lamprey Seminar in August (Wenatchee, WA) where Dr. Beamish and other lamprey experts from across the U.S. gathered, to the Northwest Fish Culture Meeting in December (Portland, OR), which had an audience of 200+ people.

Photos from the Head Start Program outreach event (March, 2012)

Photos from the Yakima Greenway Rivers Festival (October, 2012)

G. Work Element 162 – Field Data Analysis, Interpretation, and Conclusions

Since 2009, the YNPLP has begun conducting juvenile lamprey surveys to document their distribution and relative abundance within the Ceded Area of the YN. Our primary objectives for the juvenile lamprey surveys in project year 2012 were: 1) to assess the presence/absence, distribution, and relative abundance of juvenile Pacific lamprey (primary focus) and Western brook lamprey (secondary focus) and 2) to evaluate the relative abundance of juvenile lamprey habitat and 3) to establish “Index Sites” for long-term status and trend monitoring within the Ceded Area of the YN. Yakima and Klickitat subbasins has been the primary focus of this project since we started in 2009, and in project year 2012, we have expanded this area to include the Wenatchee, Entiat, and White Salmon subbasins (see Appendix B1, B2, and B3 for more information).

In 2012, we surveyed a total of 98 sites using a backback electrofisher designed for larval lamprey. For more details on the juvenile lamprey surveys in 2012, see Appendix G1.
In addition, there were over 70 other sites that were surveyed quickly (quick assessments) using an electrofisher or a fine-mesh hand net to simply evaluate prescence/absence of juvenile lamprey (see Appendix G2 for an example of these surveys). Juvenile Pacific lamprey were only found in the Lower Yakima, Naches, Wenatchee, and Entiat Subbasins and the mean ratio of Pacific lamprey (vs. Western brook lamprey) were 13.3%, 5.3%, 100%, and 100%, respectfully. Within the Yakima Subbasin, we only found Pacific lamprey ammocoetes in the Yakima River, Satus Creek, Ahtanum Creek, and Naches River. The ratio of Pacific lamprey vs. Western brook lamprey in these rivers/streams were 22.0%, 8.3%, 28.6%, 7.7%, respectfully. We did not detect any juvenile lampreys in the lower reaches of the Yakima River until river km 137.6. No juvenile Pacific lamprey have been detected upstream of river km 195.2 in the Yakima River since these surveys began in 2009. On the other hand, Western brook lamprey were detected most frequently in the Upper Yakima Subbasin (73.7% of all sites surveyed) compared to all other subbasins surveyed in 2012.

We also detected an inverse relationship between habitat availability and fish density at the subbasin scale. For instance, Naches Subbasin had the lowest amount of habitat available per site, but the mean fish density was the highest of all the subbasins. This potentially indicates that lack of habitat within the stream/river may force the lamprey to use the habitat at a higher fish density level compared to sites with more larval habitat available, and suggests that density may not be the best indicator for fish abundance and status (i.e. it could be an indication that habitat was limiting).

All previous surveys starting in 2009 paint the general same picture for the Yakima Subbasin. That is, Pacific lamprey is rare and primarily limited to the Lower Yakima Subbasin (below Roza Dam) and the majority that we have detected were found in side channels of the Yakima River (primarily in the Wapato reach area) and the lower reaches of major tributaries, including Satus and Ahtanum Creek. Ammocoete habitat and Western brook lamprey, on the other hand, is fairly abundant in the Lower Yakima as well as in the Upper Yakima subbasins.

Monitoring juvenile lamprey entrainment in the irrigation diversions and canals has also been a key component of our monitoring objectives. The primary activities associated with this objective have been surveys within dewatered irrigation ditches using an electro-shocker and nets to collect juvenile fish samples. From these surveys we have found areas behind fish screens with considerable numbers of lamprey, consisting primarily of Western Brook lamprey and limited numbers of Pacific lamprey in some of the sites (however, many of the captured lamprey cannot be positively identified to species due to its smaller size). Those specimen that appeared as Pacific lamprey were sent to CRITFC for formal identification and validation. We also confirmed that lamprey numbers decreased continuously over the course of a dewatering season at New Rez Diversion from repeat sampling every two weeks, indicating that a large portion of the juvenile lamprey may not survive the dewatering season. We were able to survey many more additional diversion sites in 2012, allowing us to paint a more comprehensive picture of the entrainment issues within the entire Yakima basin, including relative abundance and size class structure. In the following years, we will conduct additional entrainment studies in addition to these canal surveys to determine how lamprey are able to migrate past existing fish screening devices and into the irrigation ditches. This work will be in close coordination with efforts by the USGS Research Station in Cook, WA (Dr. Matt Mesa) in developing screen criteria for juvenile lamprey and being partially funded by Reclamation.

Juvenile survey planning and sampling within Yakima River basin irrigation canals was initiated during the dewatering period in 2011 and is ongoing for 2012 and 2013. Similar to the previous year, planning/coordination meetings between representatives of the YNPLP and Reclamation was held in early October and sampling in 2012 occurred primarily between October 15 and November 28, a period of approximately six weeks. More surveys were conducted again in January to evaluate the status of overwintering lampreys in the canal system.
In 2012, approximately $10,000 - $12,000 dollars were used to fund these activities, including coordination, surveys, equipment, transportation, data analysis and reporting.

A brief summary of findings is provided below (Table 1). Please reference Appendix G3 and G4 for additional information. Lamprey numbers described in the table refer to either of the two species of lamprey present in the basin – Pacific lamprey or Western brook lamprey. In many instances, identification of each individual fish was not possible due to the large number of lamprey being captured and/or size limitations – larger than 50-70mm juveniles generally required for positive identification. Sites where Pacific lamprey-like larvae were detected (these have not been confirmed through genetics analysis yet) include Wapatox (Naches) and New Rez (Yakima) diversions. The percentage of Pacific lamprey (vs. Western brook lamprey) was 25.0% and 16.4% during the survey period in these two sites, respectively. There were a total of 157 and 8 transformers (lamprey with eyes) found above and below screens from all of the diversions, respectively. This amounts to 8.7% and 1.3% of the overall capture numbers above and below screens, respectively. All of the transformers that were examined closely were Western brook lamprey.

Table 1. Summary information of 2012 diversion surveys, differentiating what was captured and observed above vs. below diversion screens.

			Above Screens					Below Screens				
Diverison Name	Stream	River km	Survey Dates	Total Captured	Total Missed	Area	Density (Total / Area)	Survey Dates	Total Captured	Total Missed	Area	Density (Total / Area)
Lower WIP	Ahtanum	16.5	10/24	17	4	3	6.19	10/24	0	0	4	0.00
Upper WIP	Ahtanum	32.8	10/30	0	0	30	0.00	N/A	N/A	N/A	N/A	N/A
Cowiche	Cowiche	0.1	N/A	N/A	N/A	N/A	N/A	10/17	10	5	11	1.42
Wapatox	Naches	28.6	11/1	87	20	77	1.39	11/5	52	9	39	1.55
Taneum	Taneum	3.7	10/15, 10/16	47	6	75	0.71	10/15, 10/16	10	2	52	0.23
Yakima-Tieton	Tieton	23.3	10/17	0	0	71	0.00	N/A	N/A	N/A	N/A	N/A
Toppenish-Satus	Toppenish	7.7	N/A	N/A	N/A	N/A	N/A	10/31	0	0	119	0.00
Unit 2 Feeder	Toppenish	44.6	10/31	0	0	16	0.00	10/31	0	0	20	0.00
Chandler	Yakima	74.3	10/25	0	0	427	0.00	10/25	0	0	390	0.00
Sunnyside	Yakima	171.0	10/30, 10/31	201	36	392	0.60	10/29, 11/21	365	56	518	0.81
New Rez	Yakima	175.5	11/7, 11/8, 11/15, 11/16, 11/28	1118	396	3877	0.39	11/7, 11/14, 11/20	66	23	1616	0.06
Union Gap	Yakima	188.9	10/18	217	50	413	0.65	N/A	N/A	N/A	N/A	N/A
Selah-Moxee	Yakima	203.6	10/24	29	10	261	0.15	N/A	N/A	N/A	N/A	N/A
Roza	Yakima	210.7	10/30	98	25	54	2.28	10/31	125	30	400	0.39
New Cascade	Yakima	262.5	10/23	1	2	29	0.10	10/23	3	1	39	0.10
Westside	Yakima	272.0	10/17	3	0	28	0.11	10/17	1	3	89	0.04
Total				**1818**	**549**	**5753**	**0.41**		**632**	**129**	**3296**	**0.23**

Photo of many dead juvenile lamprey (white lines) in Wapato Diversion after dewatering operations

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V. Appendices

Appendix A1 –Adult Pacific Lamprey Collection in the Columbia River Basin

Appendix A2 – Trapping Adult Pacific Lamprey in the Yakima River (WDFW)

Appendix B1 – Wenatchee Subbasin Juvenile Lamprey Survey Report

Appendix B2 – Entiat Subbasin Juvenile Lamprey Survey Report

Appendix B3 – White Salmon Subbasin Juvenile Lamprey Survey Report

Appendix D1 – Interview Questions for Elders on Eels

Appendix D2 – Pacific Lamprey Action Plan, Yakima Subbasin (Working Draft)

Appendix D3 – Pacific Lamprey Action Table, Yakima Subbasin (Working Draft)

Appendix D4 – Evaluation of the Potential Impacts of "Flip Flop" on Larval Lamprey in the Upper Yakima River Using Photo Documentation and Habitat Assessment

Appendix D5 – Effects of Water Quality on Pacific Lamprey in the Yakima River Basin

Appendix E1 – Passage of Radio-Tagged Adult Pacific Lamprey at Yakima River Diversions: 2012 Annual Report (USFWS)

Appendix G1 – Juvenile Lamprey Surveys in the Yakama Nation Ceded Lands

Appendix G2 – Lower Yakima Juvenile Lamprey Rafting Survey Report

Appendix G3 – Assessment of Lamprey Entrainment in Irrigation Diversions and Canals in the Yakima Basin

Appendix G4 – Repeat Sampling of Juvenile Lamprey in New Rez Diversion (rkm 175.5) within Yakima Basin

Adult Pacific Lamprey Collection in the Columbia River Basin

Yakama Nation Fisheries Resource Management

Pacific Lamprey Restoration Project

Purpose

Effective management for rare species is very important to the Yakama Nation Pacific Lamprey Program (YNPLP). New innovative ways to improve trap efficiency overlaps our interests and goals for least cost-effective ways without doing harm to the fish. Translocation helps migrating adults reach the upper tributaries to over winter safely prespawning. This document summarizes general guidelines for trapping and transporting of adult Pacific Lamprey from the lower hydroelectric projects of Bonneville, The Dalles, and John Day Dams. The objective is to increase the efficiency of collection (time vs. fish number) and diminish lamprey mortality during transport.

Introduction

In the Yakima River Pacific lamprey populations are severely depressed, extirpated in many of their historical range. Prior to translocation the YNPLP lamprey program has three consecutive years of surveying for the presence of larval Pacific lamprey, however many Yakima tributaries were sparse and are endangered. Since 2009, the YNPLP has work collaboratively with CTUIR, Army Corp of Engineers (ACE), Bureau of Reclamation, United States Fish & Wildlife Service (USFWS), and Bonneville Power Administration (BPA) to coordinate translocation of migrating adult Pacific lamprey. This project incentive is to increase natural production of Pacific lamprey just as the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Lamprey program has verified as a viable tool to increase natural spawning. We started with a total of 16 adult's radio tagged then released into the lower Yakima subbasin to help answer passage questions. We are continuing this effort at all the low head dams on the Yakima and is ongoing working with USFWS, Wasco Public Utility District, and BOR.

We know the CTUIR has confirmed a significant increase of Pacific lamprey larvae from natural production from four years of Translocation. Translocation begins with reviewing prior

Bonneville dam adult returns averages subtracting 4% equals the allocation per CRITFC tribes each year. Once allocation is determine gives a target number to catch and bypass the mainstem hydro's, once caught then transported to acclimation sites protecting, monitoring over wintering prior to release. Spring time release sites are based upon historical accounts and habitat surveys of larval lamprey. The preliminary results is a increase in spawning adult's in the Yakima subbasin should then increase the number of juvenile lamprey presence over time. This increase of pheromone may in turn entice even more adult lamprey returns.

The many benefits of Translocation of adult lamprey has enhancement of ecosystems integrity with the reintroduction of ocean nutrients, their progeny biomass helps nutrient cycling for filter feeds and detrivores, herbivores, piscivores, and buffer predators of salmonids during emigration periods.

The rationale is document is to summarized and briefly outline means to improve efficiency (time and money) for collecting adult Pacific lamprey. Current adult collection is guided from the TRIBAL "Guidelines for Pacific Lamprey Translocation and/or Artificial Propagation" RESTORATION PLAN, this documents the work the Yakama Nation is doing at this time.

Translocation Sites

Bonneville Dam

Figure 1 Bonneville Dam

The Dalles Dam

Figure 2 The Dalles Dam

John Day Dam

Figure 3 John Day Dam

Methods

Setting Traps

Site selection for traps is based upon several years of trapping the CTUIR has done. Physical site location to trap adult Pacific Lamprey's are along the bottom of the fish passage floor, along the bulkheads, at the picketed leads fish counting stations. Migrating adult lamprey seek shelter during the daylight hours, tube traps are used provide a shelter. Because of this behavior, the traps are placed at these sites easily accessible. In some cases, the traps are placed next to each other to guide fish into adjacent traps **Figure 4**. The number of funnel traps, and their locations vary depending on each hydroelectric project individually.

When setting traps, remember:

- The cone side always faces downstream

- Weights need to be set in a way that the trap will lay flat on the bottom of the fish ladder.
- Tie off the traps in a way to reduce tangling.
- Check to make sure the bungee cord holding the wood block in place is secure!
- Drop traps slowly but efficiently.
- Set upstream traps first. If traps are to be placed next to each other, place the inside trap first, then move outward with more traps.
- Use a long pole object to push the paralleled traps as close together as possible.
- Once traps are set, revisit the area the next morning to check for fish.

Tube Trap

Figure 4 Two types of tube traps

Checking/Emptying Traps

Bonneville Dam: This project has fixed sites operated and maintain by the Army Corp of Engineers, National Oceanic Atmospheric Administration/National Marine Fisheries Service and the University of Idaho lamprey programs. The Adult Fish way Facility (AFF) fish trap **Figure 5** is the ways and means of capturing adult lamprey for research purposes, when they catch too many they inform the Yakama Nation PLP and we go down and haul their excess fish numbers allowed per day during migrating season. Once the call has been verified to transport this program staff supplies frozen pathogen free ice cubes inside a isolated cooler on hand use to temper warm water to cooler hatchery destination ambient temperatures. Upon arrival to any of the projects always check in with security (physically) and biological staff (phone call). Physical methods each day always know clearly the fish destinations water temperatures (noted data sheet). Fill transport tank up at this project water spout, record tank temperatures, close tank lid. Walk into AFF with 5 gallon bucket lined with black mesh net, take temperatures inside adult lamprey holding tanks record. Coordinate with AFF staff to dip adults and count the number of individuals out of tank into transport buckets the deliver to the truck tank (turn oxygen bottle on .05 on the bubble regulator) after the first fish have been set inside of tote.

Figure 5 Adult Pacific Lamprey Trap AFF

The Dalles & John Day Projects: Upon arrival to any of the projects always check in with security and biological staff. Same watering up protocols occurs at all hydro electric projects. Monitor destination and project temperatures; always have frozen pathogen free ice cubes on hand in isolated coolers backed up with plastic ice packs. Safely walk down to fish counting station, fill buckets up with river water to fill transport tank up **Figure 6**. Fill the 60-gallon isolated tank, using the 5-gallon bucket with attached 25 meter line, approximately 95 percent full of water from the fish ladder. Once filled close lid, return to picketed lead to run traps, have to lift grates up daily (be cautious, very heavy equipment). Refill five-gallon bucket, using a black mesh net mesh liner place it inside bucket with a lid.

Figure 6 Watering up tote, checking traps, resetting traps, tanking adult lamprey to acclimate for translocation

SINGLE SET TRAPS: Observe traps, pull traps slowly in sequence (when resetting - deploy traps same when resetting them).

- Pull trap until it breaks the surface of the water, let water drain out, at the same time feel the lines for wiggling feelings as indicator of fish in the tube traps.

- Gently pull to surface of the grates carefully check the funnel end for fish. If fish are present, don't panic, open the lid of the bucket, open black mesh net, open wood end of the trap.
- Gently wrap the black web around the outlet of the tube trap, tip the funnel end up and spill adult lamprey into the bucket guiding them in as much as possible. Once into the lined bucket loosely twist the top of the net so the adult lamprey does not get away and replace the lid. Secure bucket in the shade as soon as possible. Once complete reset the trap in the order pulled and secure with a clove hitch knot and slip knot for quick release.
- Once all traps are checked, safely walk fish to the tote – gently place into the tote leaving the lid on top for shade.
- It is good to recheck fish trap and hauling adult lamprey tanks, once fish are in the tank take temperatures readings, begin adjusting temperatures to destination temperatures by adding frozen water cubes.
- Next, turn on oxygen aerator valve on with aerator block connecting to hose into the tote. Make sure air is leaving the block and the aerator is set to max **Figure 6**.

SIDE BY SIDE SETS:

- Check this type of set in sequence and reset in sequence then tie off, the outer most or upstream trap should be pulled first to avoid unnecessary tangle with other traps.
- When ready, gently pull a trap straight up to avoid losing any fish. Let the trap drain before hauling it up.
- GENTLY set the trap down and immediately check for the presence of fish:

Running tube traps

Fish Absent:

- Observe while pulling trap up to surface, once in hand check for presence, if none reset in same site.
- When resetting, make sure bungee cord secures wood cover lid is very tight.
- If other traps are in the same spot or nearby to where they could get tangled, set this trap aside, check, then reset the traps back in after all traps have been checked/emptied.

1. When resetting a trap, remember the cone always faces downstream (entrance).
2. Place back into the same spot.

Fish Present:

1. Observe while pulling trap up to surface, once in hand check for presence, if none reset in same site.
2. Carefully place the mesh bag, from the 5-gallon bucket, entirely around the back of the trap, lift the wooden block, and shake the fish into the bag.
3. Remove the bungee cord on the back of the trap, holding the wooden block tight so it will not move freely.
4. Open the mesh net on bucket; gently spill the fish from the trap into the mesh bag, into the 20-gallon bucket.
5. Close the mesh net from around the fish, letting the fish enter the loose fitting mesh bag in the 20-gallon bucket to avoid suffocating the fish and reduce stress.
6. Use two people to carry the 20-gallon bucket plus fish back to the truck/tank.
7. Once all traps are emptied, release all fish into the transportation tank. Make sure the aerator is on.
8. If greater than approximately 20 fish are captured, immediately bring these fish up to the transportation tank, and then return to pull the remaining traps (water up back up buckets for temporary holding).

Transportation Guidelines

Purpose: Help assure ideal water temperature and ample oxygen supply in the transport tank for Pacific lamprey survival.

To cool water temperatures to destination water (i. e., convert warmer water to destination temperatures). The use of frozen 1 liter containers with pathogen free hatchery incubation room water was frozen prior to the day of translocation trapping event (hatchery ice cubes). On the day of transport;

- Fill cooler with the frozen hatchery water with the 1 liter containers.
- Upon arrival to the hydro project check in with staff (hydro biologists), check temperature note into log book.
- Fill transport tank with fresh Columbia river water. After filling the transport tank, the first step to take an initial temperature and note into log book (keeping in mind the destination temperatures).
- This start temperature is baseline what temperature to maintain the fish while at the projects.
- Use destination hatchery ice cubes to keep the temperatures maintain and gradually cool the water to destination temperatures over time slowly by monitoring.
- If low on hatchery ice cubes, as a backup have ice packs to help regulate the tank's temperature (before heading out into the field, it is recommended that the ratio of ice packs per temperature drop is determined for efficient regulation).
- The medical oxygen type tank and aerator help in maintaining oxygen levels, and this is backed up with battery operated portable aerators. Please note as fish respire from stress keeping them comfortable as possible is the goal to maintain homeostasis. Keep in mind, more fish caught more respiration and increase in oxygen is taken up therefore to keep oxygen abundant we recommend not to transport more than 50 adult lamprey at at time in the 60 gallon transport tank.
- Always monitor the behavior of the fish. If they appear stressed (attached onto the side of the tank with most of their head out of the water is natural to them to do this), slight adjustments should be considered, just keep track of both the oxygen and temperatures accordingly (keep in mind high levels of stress will ultimately lead to adult lamprey mortality).
- Before leaving the projects fish ladders, top off the tank with fresh water, and drive carefully to keep the water level as high as possible.
- Revisit destination temperature; take another temperature reading in the lamprey holding tanks. Adjust water temperature of the transportation tank to within 1 °C of the holding tank (see temperature regulation section). Once this is complete, transfer the fish into the holding tank.

Materials:

- (1) 60-gallon fish transportation tank (tote) with a lid
- (1) Aerator stone, hose, attached to medical regulator
- (1) Oxygen tank, crescent wrench, back up regulator
- (1) Thermometer (°C)
- (10) One liter size cubes backed up with freezer icepacks, insulated cooler
- (1) logbook backup with data sheet
- (2) binding strap tie downs to hold tote and oxygen tank in place in the be of the transport vehicle
- (2) hoop nets preferably smelt small mesh nets
- (2) pallets to set oxygen tank on above truck bed

Methods:

Temperature Regulation

Purpose: Help assure ideal water temperature and ample oxygen supply to keep fish healthy as possible.

The idea here is to reduce stress by maintaining water quality and temper adult lamprey to destination temperatures. Cold water, and ample oxygen supply is our guideline, for example, If the initial river temperature is between 15 ºC and 17.5 ºC, then, to increase the level of oxygen available to the fish and decrease stress, the water should be dropped and held constant approximately 1 ºC below the initial temperature. A table showing this correlation for temperature regulation with varying initial river temperatures is shown in Table 1. Further reduction of temperature may be necessary during the transportation process.

Table 1. Correlation between initial river temperature at JDA south fish ladder, and the recommended constant temperature of the transportation tank. Temperature may vary and need to be altered based on number of fish and their behavior.

Initial Water Temp	Temp Reduction	Ideal Tank Temp
14.0 - 17.0 °C	- 1.0 °C	13.0 - 16.0 °C
17.1 - 20.0 °C	- 2.0 °C	15.1 - 18.0 °C
20.1 - 22.0 °C	- 3.0 °C	17.1 - 19.0 °C
22.1 - 24.0 °C	- 4.0 °C	18.1 - 20.0 °C

In order to regulate temperature in the tank, place individual ice cubes and/or packs in a cooler the morning of departure. Use the icepacks to drop the temperature of the water gradually. Do not exceed a temperature drop of 1.5 °C over a ten minute period. Once the desired temperature is reached, use these ice cubes and/or packs to keep as close to this temperature as possible. For cold water, 15 - 17 °C, the water temperature may be dropped 1 °C upon immediate filling of the transportation tank. However, for higher initial temperatures, try to drop it gradually over the course of an hour period, as to ensure a drop less than 1.5 °C over a ten minute period. This should limit the stress on the fish.

In order to properly regulate the temperature, it is necessary to consistently monitor the temperature of the tank water. Check and record the temperature at minimum seven stops between initially filling the tank at the John Day Dam's south fish ladder, and the last stop in Toppenish before heading to the Prosser hatchery. The primary stop locations are shown in Table 2. Just remember to move quickly. Increased time spent at a location may result in fish mortality. Approximate drive times, as well as approximate time spent at each stop is also shown in Table 2.

Table 2. Seven primary stops for fish trapping and transportation from both John Day Dam and The Dalles Dam. The approximate time spent at each location, as well as approximate driving times. Total time for translocating fish from the dams to the hatchery is 345 minutes.

Stop #	Location By Dam	Approx. Time (Min)
1	**JDA South Fish Ladder**	**30**
2	**JDA North Fish Ladder**	**30**
3	**JDA Main Office**	**5**
Driving	JDA to TDA	30
4	**TDA East Fish Ladder**	**35**
5	**TDA North Fish Ladder**	**15**
Driving	TDA to Goldendale	45
6	**Goldendale**	**5**
Driving	Goldendale to Toppenish	60
7	**Toppenish**	**5**
Driving	Toppenish to Prosser	40
Other/ Driving	Between Sites on dams	40
Total Approximate Time: 345 minutes (5 hours , 15 min)		

The medical aerator should ALWAYS be pumping air into the transportation tank at 0.5 and adjust according to the number of adult lamprey in the tank up to 1.5. This too should be checked at every stopping point. If greater than 20 fish are captured, the oxygen tank, hose, and regulator need to be used to provide a proper oxygen supply and adjusted accordingly based on the behavior of the fish. If there are less than 20 fish in the tank, but they show signs of stress (sucking to the wall above the waterline breathing heavily), continue to monitor and note in the transport log book.

Stressed Lamprey

Lampreys that are severely stressed (lampreys that are severely stressed may be very close to dying), can be identified based on two (2) primary behaviors:

1. Lampreys lying on their side at the bottom of the tank.
2. Lampreys sucking to the wall of the tank with their head mostly out of the water with an increased rate of breathing.

Severely stressed lampreys appear like they are trying to ‘escape’ from the tank, or by lying on their side, not sucking to the floor or wall. Consistently monitor and record the behavior of the fish at each of the listed stopping points, as well as any additional stops. The above behavior can lead to mortality, so proper adjustment of stress related variables is needed. These variables include:

- The number of lamprey in the tank
- Water temperature (°C)
- Water level
- Oxygen level

If lampreys are observed to be stressed during transportation, try dropping the water temperature (not exceeding a 1.5 °C temperature drop over a 10 minute period), closely monitoring their behavior. Also, if not already in place, set up the oxygen tank to allow for a greater supply of oxygen to the tank. Ideal lamprey behavior can be identified by:

1. Lampreys are submerged and swimming freely around the tank
2. Lampreys are submerged and sucking to the wall/floor of the tank with a consistent breathing rate.
3. Lampreys brush your hands or gently attach to hand while hand is submerged swim slowly when detached

Acclimation to Hatchery Holding Tank Temperature

Upon arrival at the Prosser Hatchery, the gradual adjustments of water temperature while on transport should match (within 1 °C) to the ambient temperature of the holding tanks.

Acclimation of the fish to the ambient temperature of the holding tank will reduce shock, as well as stress from a large temperature change (over 1°C).

Acclimation Guidelines

1. Park close enough to the tank so that the lamprey can be easily transferred and with enough room to move freely behind the truck.
    - o The tank should be approximately 95% full (of water) upon arrival at the Prosser Hatchery.
    - o Temper transport tank with five 5 gallon buckets of ambient hatchery water for transition let it stand for a few minutes.
2. Remove the plug from the tank, allowing a constant stream of water to leave the tank.
3. Consistently add buckets of water from the holding tank to the transportation tank.
    - o Add roughly 6 buckets of water (30 gallons / approximately half of the initial river water replaced with holding tank water)
    - o Replace plug and let tank sit for 5-10 minutes then read the temperature.
    - o Repeat the process, removing the plug, adding roughly 6 buckets of water (30 gallons/half) so that now most of the water within the tank is holding tank water.
    - o Allow to sit for 10 minutes.
    - o Check the temperature.
    - o If the temperature is within 1 °C, use cotton gloves and individually place each fish into the holding tank. If not, repeat the above process. Be sure to get a final count of the number of lamprey.
    - o Place the fish these newly captured fish into a holding tank that does not already contain fish (pre determined). There is the possibility for the spread of disease.

Adult Pacific Lamprey Inoculation

Prosser Hatchery

The dosage of Oxytetracycline in lamprey treats for furunculosis is 10 mg/kg.

Materials:

- (1) 5-gallon bucket
- (1) Mesh net with extended handle
- MS-222
- $NaHCO_3$ (Sodium Bicarbonate)
- >70% alcohol for cleanliness
- pH readers
- (50) Diabetic Syringes (1 mL)
- Oxytetracycline (as an antibiotic)

- Latex and cotton gloves
- (1) 1m measuring board
- (1) milligram scale
- Hoop nets with soft web to transport inoculated adults to tank
- Camera on hand to document

Methods:

Preparation for Inoculation

- Pre Translocation season USFWS pathologist should be informed of this activity prior to arrival of adult lamprey on the Prosser Fish hatchery grounds.
- Purchase of antibiotics and buffer solution on hand
- Depending on the number of adult lamprey is reliant of how many injections shots will be loaded into the diabetic syringes needed to do for this event.
- Dosage calculation is as follows:
  dosage/drug concentration x kg fish = mL to inject
- Example: 10 mg/mL dosage/300 mg/mL oxytet concentration x 0.42 kg lamprey = 0.014 mL of antibiotic for this lamprey.

Inoculation

Set up MS-222 bath with proper dosage of MS 222 and $NaHCO_3$ into a 10 liter container. Same set up for the recovery bath. Have destination tank prepared in prior planning protocols. Once fish are tempered to acclimation site, grab one at a time and submerge into the 10 liter bath and time the event until the fish is completely anesthesized visually. Once down, take total lengths and weights and photo of the fish. Once taken, grab the dosage of Oxytetracycline and inject 25 mm anterior of the vent and inject antibiotics. Once complete rub slime over the injection pin point and place into recovery buckets, once back to conscience state place into adult holding tanks.

Appendix

Collection outline

1. *Tribal Adult Lamprey Collection Plan from each participating Tribe*
    a. Annual collection numbers are preplanned
        i. Collection Permits, letters for Access to the Projects, adult holding facilities
        ii. Tribal collection protocols and numbers would follow "Guidelines for Pacific Lamprey Translocation and/or Artificial Propagation"
            1. Annual tribal total = 4% of two-year average of expanded counts (day, night, LPS) at Bonneville dam
                a. 1% per CRITFC member tribe
    b. Monitor Fish Passage Web Site
    c. Trapping locations and effort
        i. At all existing locations
            1. Deploy 3 x 12 and 3 x 8 funnel traps
            2. Entrances facing down stream
            3. Checked daily (mornings)
            4. Holding tank is watered up with existing project water with aerator
            5. Fish extracted and placed into bucket lined with fine mesh netting
            6. Fish is then gently placed into insulated tanks (temperature taken)
    d. Infrastructure aerated insulated transport tanks
        i. Monitor temperature, have nonchlorated pathogen free ice cubes to temper water down to holding facilities ambient temperatures
        ii. Each individual adult lamprey anesthetized in 70ml/l of MS-222 buffered with $NaHCO_3$ to pH 7, then inoculated with a dosage oxytetracycline at 0.1cc /ml/live weight.
    e. Collection personnel
        i. USACE project biologist, fish counters, juvenile bypass personal, and tribes lamprey crews
            1. Systematic collection of adult lamprey within facilities

Materials

Washington and Yakama Nation Scientific Collectors & Project permits

- Safety course for each project, first aid, and project protocols

- Approved hardhat to be worn at all times while at each of the project sites
- Security badges (Bonneville, The Dalles, John Day)
- Tube traps 3' x 10" and 3' x 8"
- (3) 5-gallon buckets with 1 attached line (rope) ~ 10 meters in length
- (2) Fine mesh nets to line buckets for fish transport
    - (1) for loose fitting within the 5-gallon bucket
    - (1) for loose fitting within the 20-gallon bucket

- Cotton Gloves (to be worn at all times while handling fish from traps)
- (1) 60-gallon fish transportation tank (green totes) with outlet plug
- Medical oxygen tank with bubble valve for aeration of holding tank/portable aerator bubblers
- Data Sheet(s) for daily take and personal computer to down load daily.

Trapping Adult Pacific Lamprey in the Yakima River

A Cooperative Project

between the

Yakama Nation,
Washington Department of Fish and Wildlife
and the
Bureau of Reclamation

Performance Period: August 1, 2012 – September 30, 2012

Submitted by

Paul Hoffarth
Washington Department of Fish & Wildlife
Region 3, District 4 Fish Management

October 4, 2012

Introduction

The Yakama Nation Fisheries Resource Management Program (FRMP) is actively engaged with research into passage of adult Pacific lamprey over irrigation dams in the Yakima River that are owned or operated by the U.S. Bureau of Reclamation. It is believed that adult lamprey movement is hindered or denied by these dams and/or associated fishways. The primary research tool is the use of radio-telemetry. Small radio transmitters are surgically implanted into adult lamprey, which are released into the river and monitored via multiple radio receivers located above and below certain irrigation dams. This ongoing study is anticipated to continue through Year - 2013, and is possible through collaboration with the U.S. Bureau of Reclamation and the U.S. Fish and Wildlife Service.

Within the past few years, very few adult lamprey have been counted at the Prossor Dam fish counting facility, operated by the Yakama Nation Yakama-Klickitat Fish Program. As such, it is believed that very few adult lamprey enter into the Yakima River which makes a study to evaluate adult passage difficult. Many adult lamprey used for this study will need to be transported from collection sites on mainstem Columbia River dams. However, use of these fish may compromise the study. It is not clear to researchers if these lamprey are inclined, or at all motivated to continue an upstream migration in the Yakima River once taken from the Columbia River. Thus, it is difficult to interpret if passage at the dams is actually a problem and an artifact of the dam itself.

To relieve this potential issue, the FRMP is proposing to capture and use lamprey that volitionally enter into the Yakima River. Based on adult lamprey counts at McNary Dam and Priest Rapids Dam, it is well established that lamprey migrate past the Yakima River during July and August. It is possible that lamprey enter into the Yakima River, but do not necessarily proceed upstream due to elevated water temperatures, Horn Rapids Dam or other reasons.

Objectives & Tasks

The purpose of this Pilot Program is to 1) capture approximately 20-30 Pacific lamprey adults in the Yakima River, if possible and to 2) learn how to capture adult lamprey in the future in the most cost-effective manner as possible. This work would be implemented using WDFW staffs located in Pasco, WA. and supervised by Mr. Paul Hoffarth, District 4 Fish Biologist. Approximately 25 specially designed lamprey traps, to be built by staff from the Yakama Nation Pacific Lamprey Project, will be set and retrieved daily (5 days per week) at various locations in the lower Yakima River, below Horn Rapids Dam (specific sites to be determined). It is likely that traps will also be set at the mouth of the Yakima River, within the currents of the Columbia River. Trapping would commence in early August and proceed for approximately four weeks but could potentially continue through September, if funding permits.

Tasks

1) In coordination with the Yakama Nation FRMP staffs, WDFW will establish and implement a weekly schedule for lamprey trapping. It is anticipated that traps will be inspected and reset five days per week, preferably in the early morning hours.

2) FRMP will provide to WDFW Region 3 staffs all traps and related equipment needed to capture lamprey from a boat. FRMP will also assist and educate WDFW staff for a minimum of two days in proper setting and hauling traps and proper handling and care of captured lamprey. WDFW will provide the boat, fuel and any equipment necessary to retrieve traps from the water.

3) FRMP Staffs will establish facilities for holding captured adult lamprey. These facilities will include a vessel to be used on the boat as well as a land-based holding facility. This facility will be located in Prosser, WA. or at a location nearer to trapping sites.

4) Trapping sites will initially be determined by FRMP staffs, in coordination with WDFW. As the trapping efforts proceed, it is anticipated that WDFW will learn and identify additional sites that may provide for better opportunities for capture of adult lamprey.

5) Once adults are captured, WDFW staffs will contact FRMP staffs for notification. As a standard protocol, WDFW will put all lamprey into appropriate storage locations unless otherwise directed by FRMP. FRMP will make all possible efforts to support WDFW in transport of capture lamprey to the Yakama Nation Prosser Fish Hatchery in order to help save WDFW expenses in travel time.

Schedule

Trap and transport operations (Monday-Friday)……………………………August 6 - August 31

> Traps will be set on Mondays; checked and reset on Tuesday, Wednesday, and Thursday; and checked and pulled on Fridays

Lamprey Traps

WDFW staff along with Ralph Lampman and Patrick Luke from the FRMP assembled and set the first lamprey traps in the Yakima River delta on August 9, 2012. Each trap consisted of two eight inch perforated PVC pipes 36 inches in length attached to each other and weighted to hold to the bottom of the river (Figure 1). A funnel with a two inch diameter opening was attached at one or both ends of the pipe. Three double tube traps were set each night of fishing from August 9 through August 21. On August 22 two bicycle traps and one additional double tube traps were included during trapping operations. The bicycle traps were 36 inches in length and 16 inches in diameter (Figure 2). The traps were anchored with the funnel end facing downstream.

Figure 1. Double-tube lamprey trap.

Figure 2. Bicycle lamprey trap.

Location
Traps were primarily located at the mouth of the Yakima River where the warmer more turbid water from the Yakima River water mixed with the Columbia River (Figure 3). This area was selected as the biologists believed that the adult lamprey would stage in the cooler water of the Columbia before entering the Yakima River. Traps were set on two nights, August 28 and 29, approximately one mile upstream and at the Highway 240 Bridge. Traps were set at depths ranging from one to seven meters in depth and over a wide range of velocities. River velocities in the Yakima River were relatively low during the time period traps were set. Flows averaged 2,369cfs during the month of September, range 2,060 to 2,640cfs. River velocities in the Columbia River at the confluence are relatively fast. Flows averaged 82,020cfs, range 35,100 to 154,000cfs.

Figure 3. Lamprey trapping locations in the Yakima River delta.

Temperature data loggers were placed in the Yakima River delta at Bateman Island and in the Columbia River at the Interstate 182 bridge from August 27 through August 30. Water temperatures averaged 1.4°C cooler in the Columbia River and were more stable than the Yakima River (Figure 4). Water temperatures in the Columbia River averaged 19.2°C over the three day period, range 18.8°C-19.5°C. Water temperature in the Yakima River delta averaged 20.6°C and ranged from 19.5°C to 22.1°C.

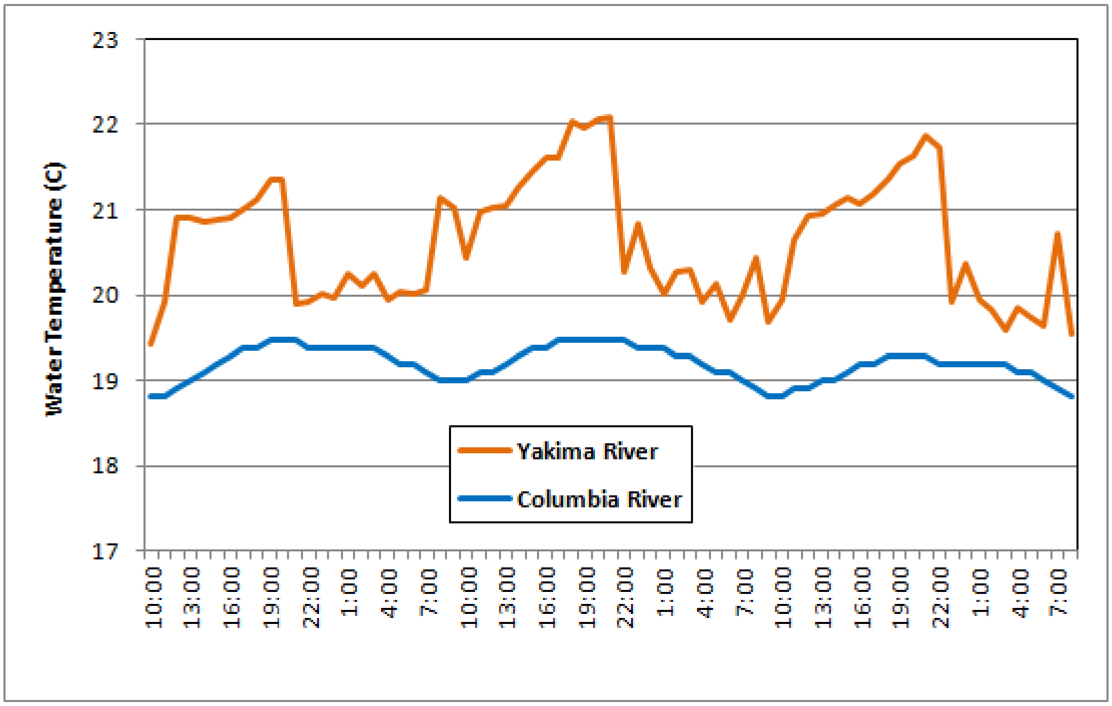


Figure 4. Hourly water temperature in the Yakima River delta and the Columbia River, August 27 – 30, 2012.

Trapping Summary

The traps were set on twelve nights between August 9 and August 29. Three double-tube traps were set on the first seven days of trapping operations (21 trap nights). For the next five nights beginning August 22, two bicycle traps and four double tube traps were set for a total of 51 traps set, 41 double-tube traps and 10 bicycle traps.

No lamprey were collected during trapping in August 2012. The only species captured were two sculpins (Cottus sp) and one crayfish. Only 11 adult lampreys were counted passing through the Prosser fishway during the time period when traps were set

The double-tube and bicycle traps were not effective at capturing adult lamprey in 2012. This may have been a function of the low numbers of lamprey in the river, the locations of the traps, timing of the trapping, or ability of the traps to attract and capture lamprey.

Recommendations

In 2012 the low flows were not sufficient to allow the 18-19ft boats access to the river beyond the lower four miles. The river is relatively broad with low water velocities in the areas that were accessible by boat in 2012. Future trapping operations may want to considering trapping at or below the two diversion dams, Wanawish (Horn Rapids) and Prosser, in the lower Yakima River.

Juvenile Lamprey Surveys within the Wenatchee Subbasin
Part I

Yakama Nation FRMP, Pacific Lamprey Project

Surveys conducted on 8/23/2012 and 8/24/2012
by Patrick Luke, Ralph Lampman, and Tyler Beals
with the help of Dan Sulak (USFWS)

Summary of Findings:

The goal of this rafting trip was to explore and survey potential lamprey habitat in an approximate 8.8 km section of the Wenatchee River mainstem above Tumwater Dam, as well as a section within and below Icicle Creek. Both a mesh (1mm) net and an e-fisher (AbP-2 e-shocker designed for larval lamprey sampling) were used to survey any accessible Type I habitat (fine sediment mixed with organic debris) or Type II habitat (fine sediment mixed with rock) at during both rafting trips.

For the survey above Tumwater Dam, sediment was found primarily at the confluences (rarely at the outlets) of side channels or in small pockets of backwater located along the main channel. The river level was low, and water swift, with the main channel consisting primarily of large and small cobble. There were several riffles with ideal spawning sediment (a mixture of fine sand, cobble, and gravel), yet a limited amount of type 1 habitat for larval lamprey. The type 1 habitat that was present appeared to have very little decomposition, which is important for the survival of larval lamprey. This is assumed due to the lack of odor of the sediment. In the past, Pacific Lamprey were found above Tumwater Dam. However, since more recent modifications to the dam, the presence of Pacific Lamprey has not been confirmed above the dam. No lamprey were found, which supports the assertion that no lamprey reside above Tumwater Dam. In addition to dam passage issues for adults, the lack of type 1 habitat could be one of several causes for the absence of Pacific Lamprey in this area.

For Icicle Creek and downstream of the confluence, we covered 2.5km of the Wenatchee River mainstem downstream of the Icicle Creek confluence surveying for larval lamprey. Due to the expertise of our guide, and short travel distance, we were able to sample a large percentage of the accessible type 1 habitat, limited only by private property postings. No fish were found in Icicle Creek and a total of 40 larvae were observed in this sampled reach of the Wenatchee River. The majority of accessible habitat in Icicle Creek was observed along the edges of the main channel, and at the base of bridges. The only side channel present along Icicle Creek provided a minimal amount of fine sediment at its confluence. There were spawning, and carcasses of, adult Chinook Salmon throughout the creek. In the Wenatchee River, side channel outlets and confluences were the primary location of abundant type 1 habitat, with pockets of type 1 habitat also observed along the mainstem and in areas of backwater.

Of the 40 larval lamprey that were observed, a total of 10 were captured and those of identifiable size (>50 mm required for proper identification of Western Brook or Pacific Lamprey) were identified as Pacific Lamprey. The larval lamprey that were spotted, not captured, ranged greatly in size (from <20mm to >100mm). The range of Western Brook Lamprey is believed to not extend above the Yakima River Basin, and our findings support this belief.

Mainstem Wenatchee Above Tumwater Dam

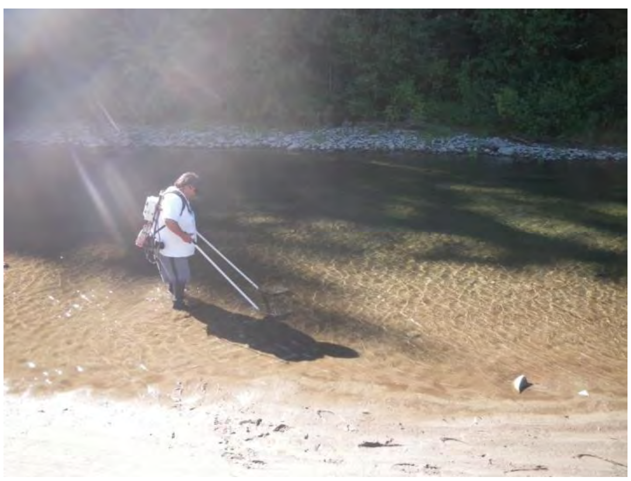
Beginning our journey at 9:05am from private property at the end of Meacham Road

Site 1 (WE46) – 13.4^{0}C; Pocket of backwater off of main channel; abundant type 2 habitat with type 1 habitat towards the back of the pool

Type 2 habitat survey at Site 1; approximately only 1/3 of the available habitat was type 1

Site 2 (WE45.5) – 16.9^{o}C; Confluence of side channel

Patrick Luke e-fishing at Site 2 (type 1 habitat extended up to 3m from sandy bank)



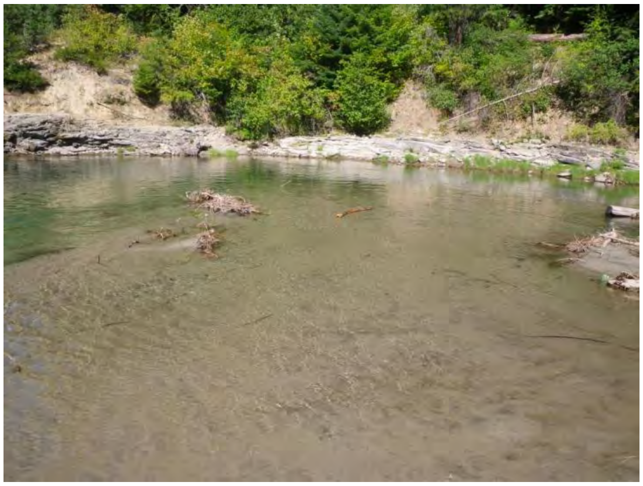
Caddis Fly and fine sand sediment at Site 2

Site 3 (WE43.5) – Spot checked here on right bank of river

Site 4 (WE42) – 14.7^{0}C; Largest area of type 1 habitat; backwater and deep pool (upstream view)

Another view out from backwater area of Site 4 (downstream view)

View into backwater area of Site 4 showing abundant organic debris and fine sediment



Site 5 (WE41.5) – Ralph Lampman spot checking at mouth of side channel

Site 6 (WE41.5B) – Ralph Lampman spot checking site on left bank of main channel

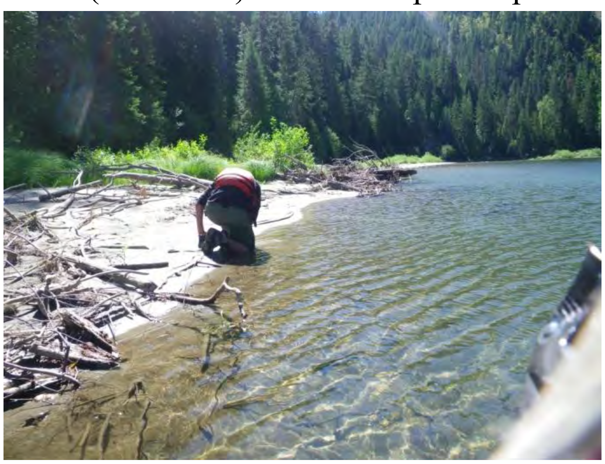
This area showed signs of high animal activity, including bear and deer!

Site 7 (WE41.5C) – 15.2^{0}C; The crew sampling an area of backwater; only e-fished site to produce aquatic worms

Sediment found at Site 7 (this was present at all previous locations sampled)

Site 8 (WE41.5D) – Ralf Lampman spot checking at confluence of small side channel left bank of river

Site 9 (WE41.5E) – Ralf Lampman spot checking sediment on right bank of river.



Site 10 (WE41.5) – Small area of backwater along main channel right bank of river

Icicle Creek and Mainstem Wenatchee River

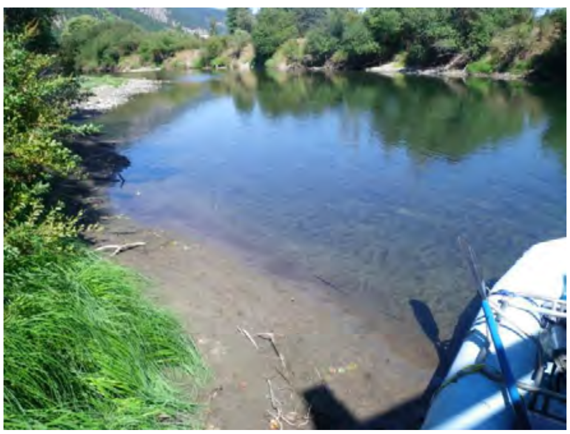
Icicle Creek

Site 1(Right bank main channel) – 16.6^0; Abundant fine sediment mixed with organic debris

Sediment composition at Site 1

Site 2 (Confluence of side channel) – Spot checked with mesh net yielded no lamprey

Site 3 (Right bank main channel) – 14.0^{0}CPrimarily course sand beach with woody debris



The crew with Patrick Luke shocking good type 1 habitat under E. Wenatchee Rd. bridge at Site 3.

Close-up of course sand substrate at Site 3

Site 4 (Left bank main channel) – 14.3^{0}C; Abundant sediment along bank of deep pool, Tyler Beals e-fishing

Substrate located at Site 4

Site 5 (Left bank of main channel) – spot check with mesh net near woody debris

Site 6 (Left bank of main channel) – Spot check with mesh net on sand bar

Site 7 (Confluence with Wenatchee R.) – Spot check at downstream end coarse sandy beach, right hand bank

Wenatchee River

Site 1 (Confluence of side channel) – 14.6^{0}C; Primarily detritus; **2** lamprey larvae found; 1 Pacific and 1 unknown (<50mm) were found by e-fishing, Patrick Luke e-fishing

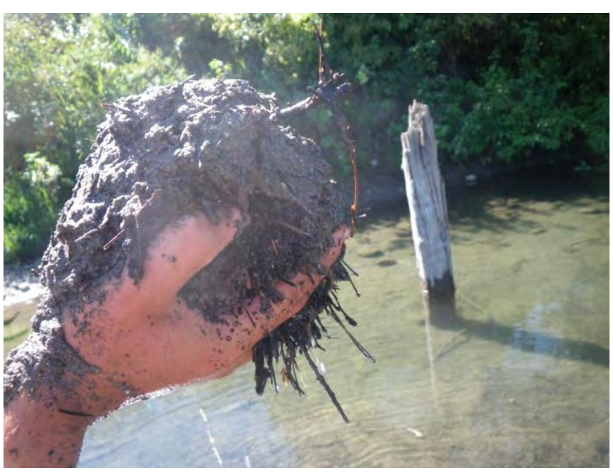
Tail of Pacific Lamprey (aprox. 65mm) found at Site 2 (caudal ridge is clear in the middle and the rest of the body not clear)

Detritus substrate at Site 1

Site 2 (Outlet of side channel) – 17.3^{0}C; Hotspot with 37 fish observed and 8 caught by e-fishing , fish observed sized below 20mm to above 100mm. Ralf Lampman e-fishing

Larval lamprey captured at Site 2 and identifiable fish were Pacific Lamprey

Sediment at the hotspot Site 2 side channel, primarily organic debris with fine sand



Site 3 (Side channel) – Ralf Lampman spot checking on left bank of side channel

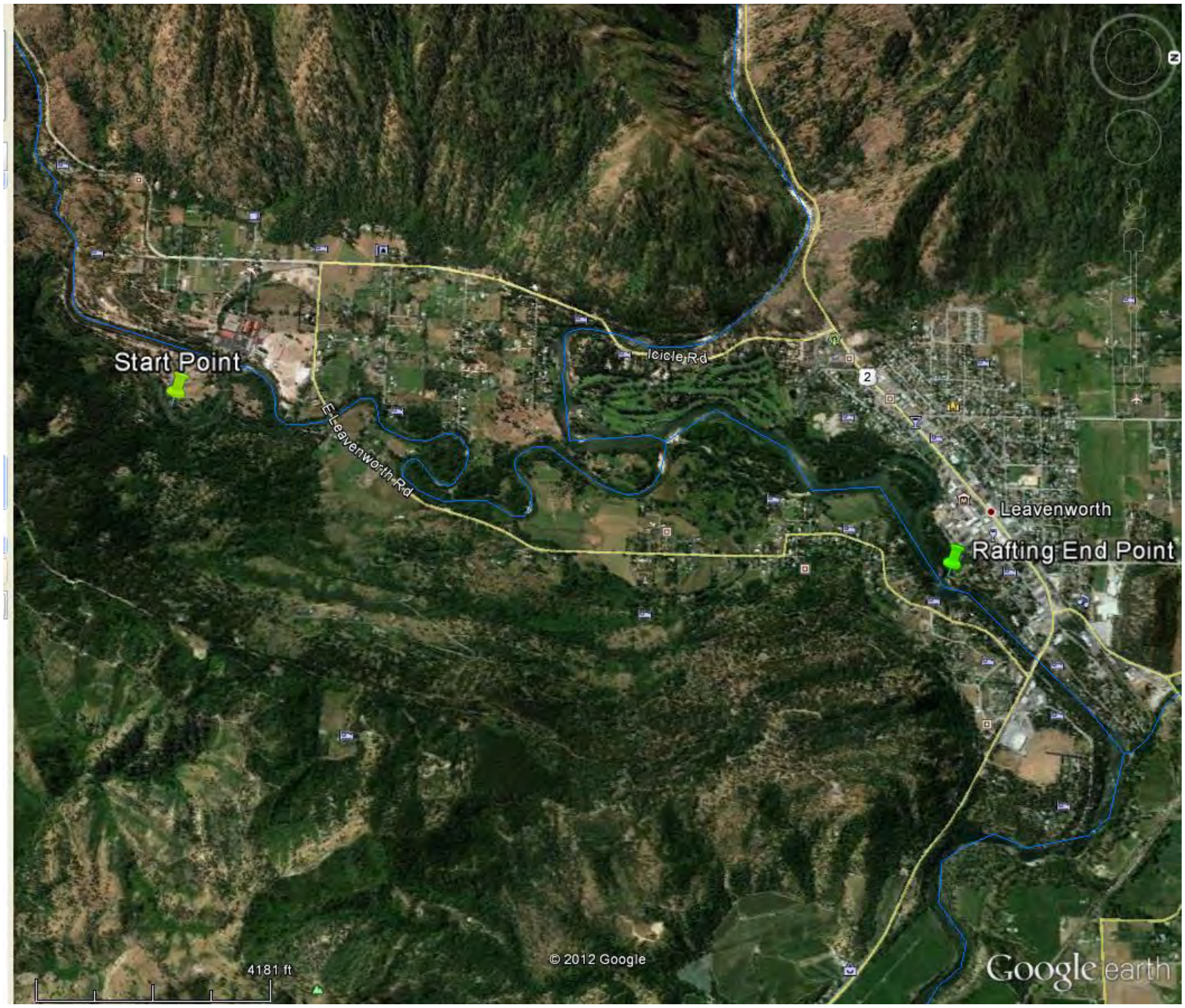
Larval lamprey below 20mm found while spot checking at Site 3

Site 4 (Confluence of side channel) – 17.6^{0}C; Patrick Luke e-fishing popular beach; only one fish (>100mm) observed, orgainic debris only present in displayed backwater area

Site 5 (Left bank of main channel) – Spot checked at sandy beach near takeout point; several larvae below 20mm were caught

Google Earth Maps

Icicle Creek and Mainstem Wenatchee River



Start Point
IC1
IC2 SP
IC3
844 ft
© 2012 Google
Google earth

IC2 SP
IC3
IC4
IC5 SP
Prowell St
Shore St
Old Bridge Rd
Tegernseer Strausse
E Leavenworth Rd
Dempsey Rd
855 ft
© 2012 Google
Google earth


Icicle Rd
WE1
WE2
IC7
Wilson St
IC6
IC5 SP
E Leavenworth Rd
912 ft
© 2012 Google
Google earth


WE2
WE3 SP
WE4
WE5
Rafting End Poi
2
971 ft
© 2012 Google
Google earth

Wenatchee River Mainstem Above Tumwater Dam


WE43.5
729 ft
© 2012 Google
Google earth

WE43.5
WE42
NF-7906
WE41.5 SP
WE41.5B
WE41.5C
WE41.5D SP
WE41.5E SP
1184 ft
© 2012 Google
Google earth


WE41.5B
WE41.5C
WE41.5D SP
WE41.5E SP
Raft End Point
WE41 SP
2
738 ft
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Google earth

Juvenile Lamprey Surveys within the Wenatchee Subbasin Part II

Yakama Nation FRMP, Pacific Lamprey Project

Surveys conducted on 9/4/12 to 9/6/12
by Dave'y Lumley, Markeyta Pinkham, and Tyler Beals

Summary of Findings:

During this sampling trip we surveyed the lower and mid Wenatchee River and Nason Creek, a tributary to Wenatchee River, using a combination of fine mesh (1mm) netting and electro-fishing (AbP2 e-shocker designed for larval lamprey sampling). We were able to check all 14 sites on the Wenatchee River (WE7, WE7.5, WE9, WE15, WE16, WE19, WE31, WE32, WE33, WE35, WE36, WE37, WE38, WE50), but we were able to conduct an official survey in only three sites (WE31, WE35, and WE50) due to the lack of available Type I or II habitat (preferred and acceptable ammocoete habitat). Due to accessibility and time constraints, we were not able to sample all the sites that we originally scheduled in Nason Creek. However, many sites did not contain potential Type 1 or II habitat.

WE7 was along the bank of a public boat launch and was composed of fine sand, soft silt and a mix of cobble with some woody debris. The temperature was 18.3 °C and 61 lamprey larvae were found here, 30 of which were identified as Pacific lamprey. We examined WE7.5 which is right above the park that WE7 was located at but the channel was dried up and is just off of Hwy 97. The next area we sampled was WE31, which is located off of Hwy 2, and is at a public turnoff that leads directly to the river. There was a small beach composed mostly of coarse sand mixed with small amounts of fine sand. The temperature was 16.0 °C and no lamprey larvae or fish / macroinvertebrates / wildlife tracks were found here. The next site sampled was WE35, which is located off of Hwy 2 next to the Alps Shoppe in Jolanda Lake above Tumwater Dam. Downstream of this building was a small beach composed of thick clay and small amounts of fine sand and silt layered on top. The temperature was 14.1°C and there were many bird and small animal tracks all over the area. There were some aquatic grasses in and outside the water and no lamprey larvae were found at this site. The last site sampled on the Wenatchee River was

WE50 and was located downhill from a public camping area by County Hwy 22. The part of the river we sampled in was in a small backwater area just off of the mainstem at its bend and the temperature was 15.5^{0}C. This site was composed of this clay with small amounts of silt and broken down debris layered on top and also mixed with tall grasses protruding from the water. There were aquatic insects and small juvenile fish observed but no lamprey larvae were found. The rest of the sites had no surveyable habitat and were mainly composed of large boulders, cobble, gravel, and deep pools. Photos and temperatures were taken throughout the Wenatchee River and had an average temperature of 15.3^{0}C.

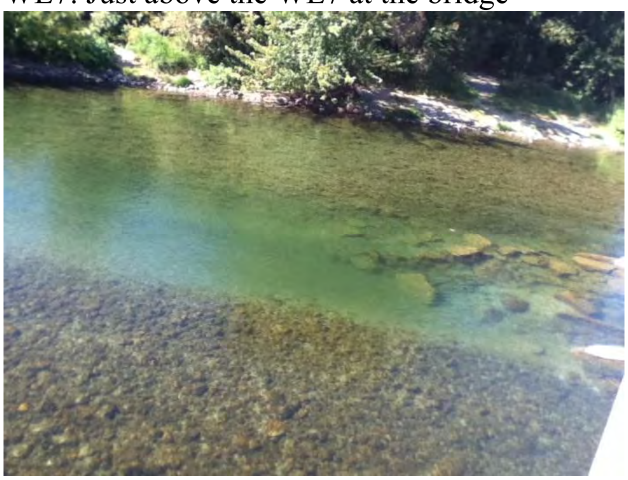
The next set of sites that were surveyed was in Nason Creek which is a tributary of the Wenatchee River. The list of sites included NA1, NA16, NA17, NA19, NA20, and NA21. We checked out all the sites but were only able to survey NA16 and NA20. NA16 was located off of Hwy 207 in a public turnoff. This whole area is composed of gravel, cobble, and boulder but in a small corner of a side channel, there was habitat available to survey. This area was mostly coarse and fine sand mixed with some woody debris. The temperature was 16.4^{0}C and no lamprey larva was found. The next site was NA20 and was located at a washout bridge. The area that we sampled was next to the outlet of a small pond that flowed into the creek and had deposited fine and coarse sand. When electro-fishing no lamprey larvae were found but when digging with the net a variety of small insects and clams were found. The temperature of this area was 15.6^{0}C. We were not able to survey in all sites due to the lack of habitat or inaccessibility but photos and temperatures were taken and the average temperature of Nason Creek was 15.0^{0}C.

Overview Map (Part II)


WE7.5
Main St
97
2
McKee Ln
WE7
Warehouse Rd
© 2012 Google
287 m
Google

WE7: Dried up side channel

WE7: Just above the WE7 at the bridge



WE7: Just above the WE7 at the bridge

Old Monitor Rd
Allyn Rd
Allyn Ln
WE7.5
Main St
97
Monitor
Warehouse Rd
McKee Ln
2
Fairview Canyon Rd
WE7
© 2012 Google
288 m
Google

WE7.5: located upstream of the bridge at the public boat launch area

WE7.5: Close up of sample area composed of fine sand, soft silt and woody debris

WE7.5: Close up of substrate

WE7.5: Close up of caught lamprey in bucket

WE7.5: Close up of lamprey

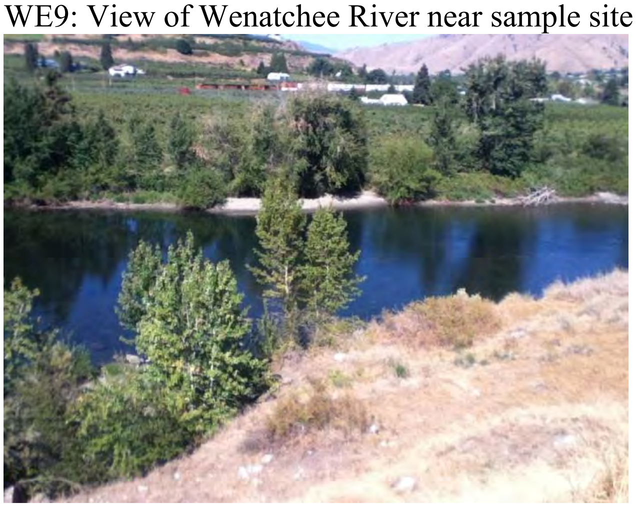
WE7.5: Close up of lamprey in net


WE9
97
© 2012 Google
287 m
Google

WE9: View of site, inaccessible with shocker and no habitat

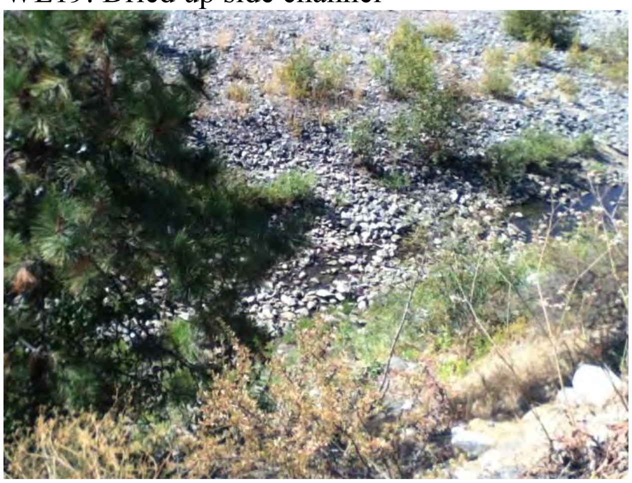
WE9: Sample site located in side channel

WE9: View of Wenatchee River near sample site



WE19: Steep hills above sample site, no habitat to survey

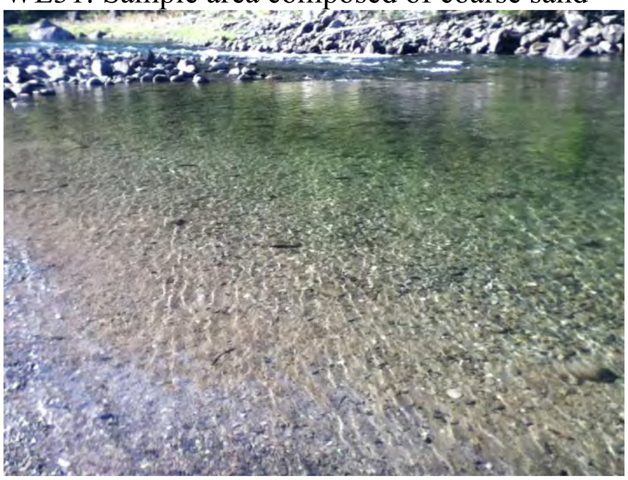
WE19: Dried up side channel



WE19: Small amounts of stagnant water located in side channel

WE31: View of sample area

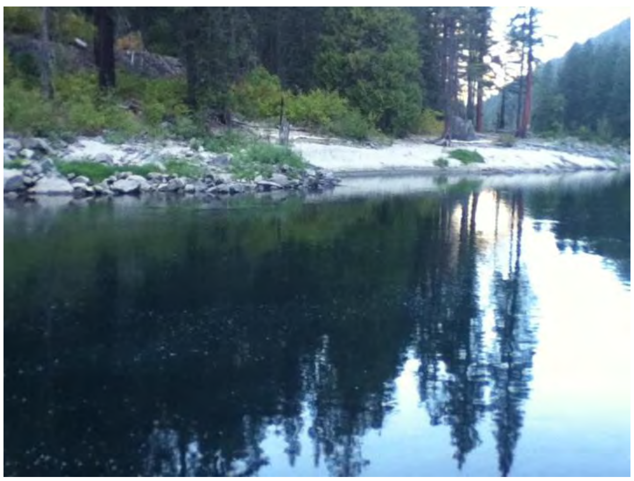
WE31: Sample area composed of coarse sand



WE31: Close up of sediment

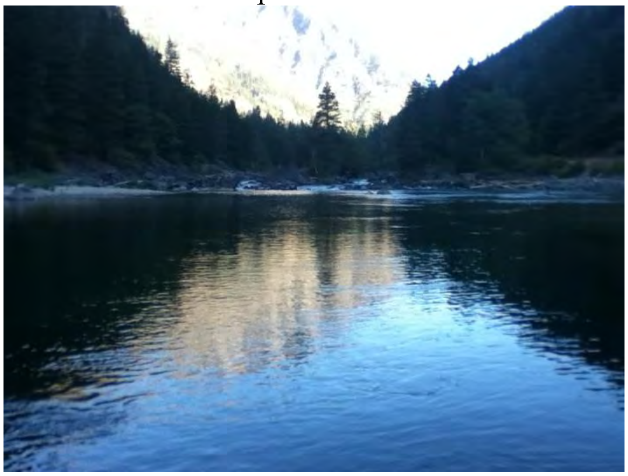
WE32: View of sample area and lack of habitat, Temp. 16.0^{0}C

WE32: Possible habitat across the river

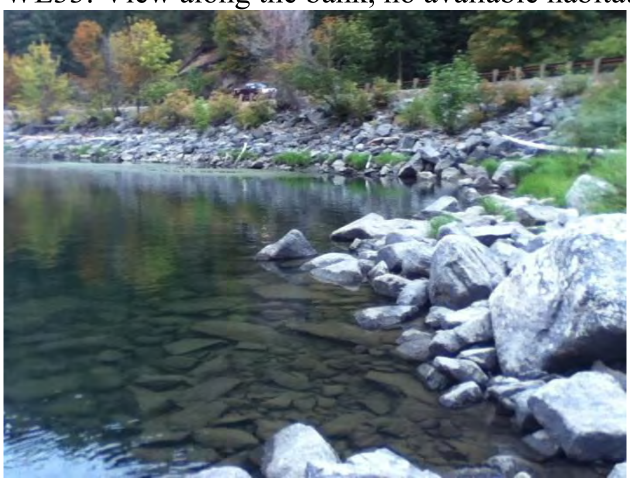


WE32: Area composed of cobble and deep pools

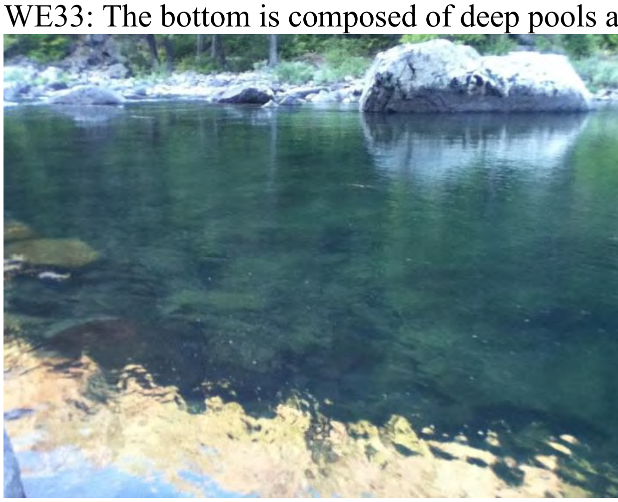
WE33: View of sample area on Wenatchee River



WE33: View along the bank, no available habitat



WE33: The bottom is composed of deep pools and boulders

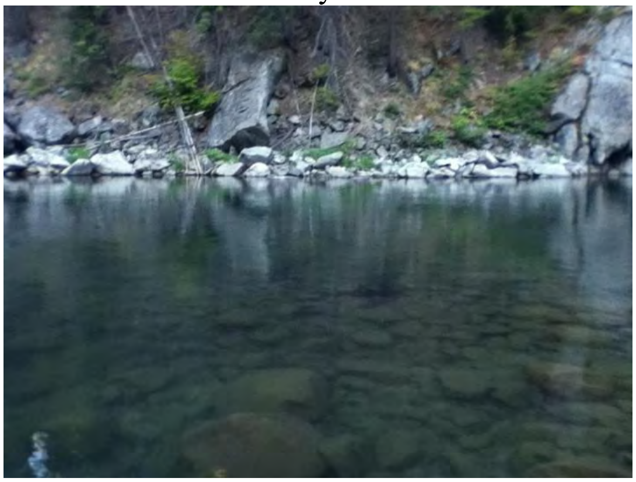


WE35: View of bank full of many bird and small animal tracks

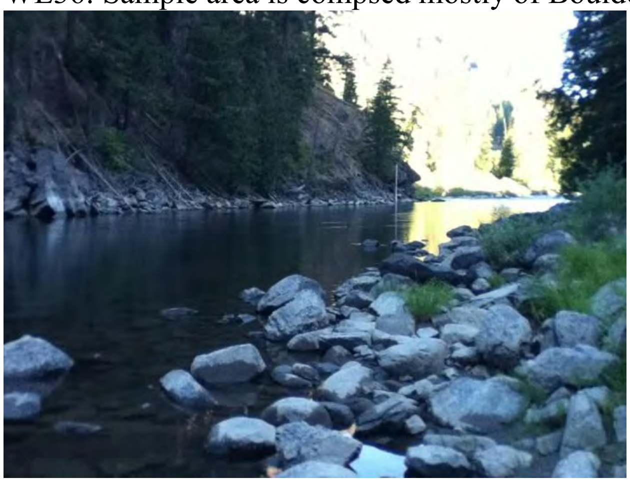
WE35: close up of sample area

WE35: Close up of the thick clay sediment

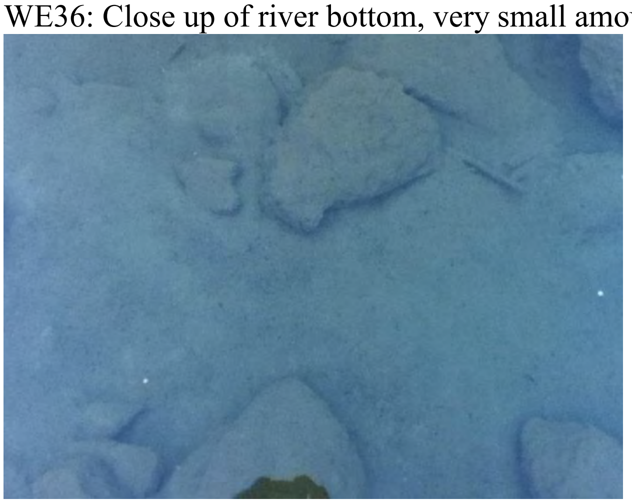
WE36: View of the rocky bottom



WE36: Sample area is compsed mostly of Boulders and cobble



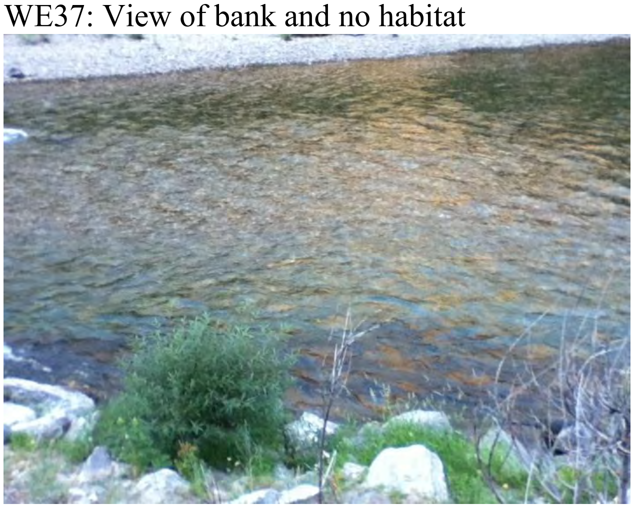
WE36: Close up of river bottom, very small amounts of silt in between some of the cobble



WE37: View of sample area and rocky island in the middle of the river

WE37: Possible habitat located on other bank but water was too swift to cross

WE37: View of bank and no habitat



WE38: There was a very thin layer of sand on top of gravel located in a small section of the bank

WE38: The area was spot-checked but no lamprey larvae were found

WE38: The sediment consisted of fine sand

WE50: Backwater area from the river formed a shallow pond full of small juvenile fish and insects

WE50: View of the outlet of the pond to the river

WE50: Close up of the substrate

NA16: Gravel bottom of the creek near sample site

NA16: Rocky bank of Nason Creek

NA16: Close up of sediment composed of fine sand and woody debris

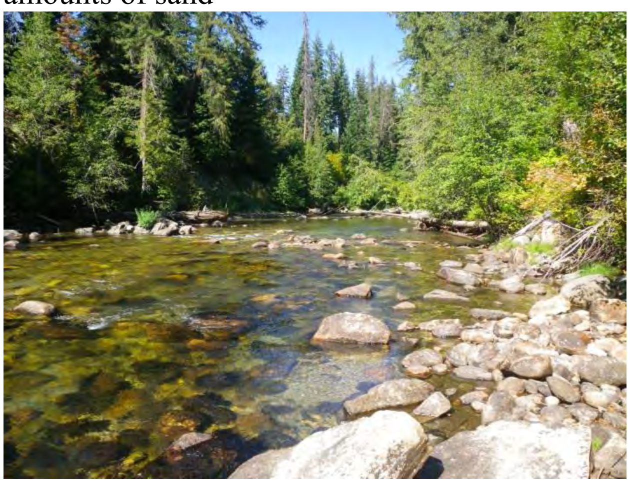
NA17: Sample area composed of gravel and cobble

NA17: The water was too deep and swift to cross

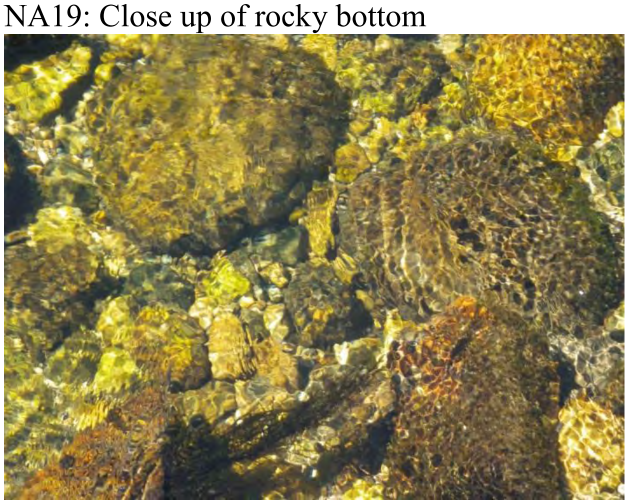
NA17: This rocky island split the creek

NA19: Upstream of Nason Creek, mostly composed of boulders and cobble

NA19: Downstream of Nason Creek, mostly composed of boulders and cobble with small amounts of sand



NA19: Close up of rocky bottom



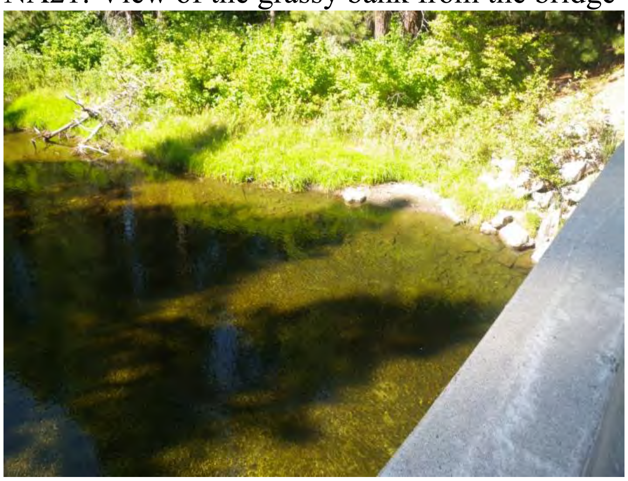
NA20: The middle of the creek was mostly gravel

NA20: There was fine sand that collected along the bank, we sampled but found not lamprey larvae

NA20: Close up of sediment

NA21: This area had no habitat and was composed mostly of gravel and some cobble

NA21: View of the grassy bank from the bridge



NA21: View of the rocky bank from the bridge

Juvenile Lamprey Surveys within the Wenatchee Subbasin
Part III

Yakama Nation FRMP, Pacific Lamprey Project

Survey Conducted on 9/12/12 and 9/13/12
by Dave'y Lumley, Markeyta Pinkham, and Frank Spillar

Summary of Findings:

During this sampling trip we surveyed the lower and mid Wenatchee River and also Nason Creek which is one of its tributaries using a combination of fine mesh (1mm) netting and electro-fishing (AbP-2-e-shocker designed for larval lamprey sampling). We surveyed WE35 extensively, which is just above Tumwater Dam in the Jolanda Lake (Wenatchee River). There is a large island located in the middle of the lake and is full of cobble, tall grasses, small trees, woody debris, and lots of fine sediment. We used our rafts to access the island and although the habitat was abundantly available, no lamprey larvae was found. The water temperature was 16.1^{0}C and the island bank contained a mixture of Type I and Type II habitat throughout the area. We checked all channel margins and also along both banks of Jolanda Lake. There was some habitat located across the river from HWY 2 but all in deep water that would be inaccessible with the electro-shocker and no place to stand along the bank due to the thick brush and trees. The next area that was surveyed was Dryden Dam in the beginning of the canal. The canal was all channelized with no available habitat along its steep banks. There was, however, small amounts of sediment located mid-channel in the deep water, which will be accessible during dewatering events. The temperature was 12.2^{0}C and of what was observable, the sediment was a mixture of coarse and fine sand surrounded with gravel, cobble, and some boulders. We visited the rest of the sites on the Wenatchee River, including WE1, which was being used as the Incident Base for the Fire Fighters at the time, so we were not able to enter the area. WE7 and WE13A were not accessible to survey, either; water was dried up at the time of the survey. In Nason Creek, we were only able to survey NA15 and examine NA5 due to time constraints. When sampling NA15, no lamprey were detected (10.9^{0}C water temperature). The creek has a vast amount of Type I and Type II habitat located within it. NA5 was located further

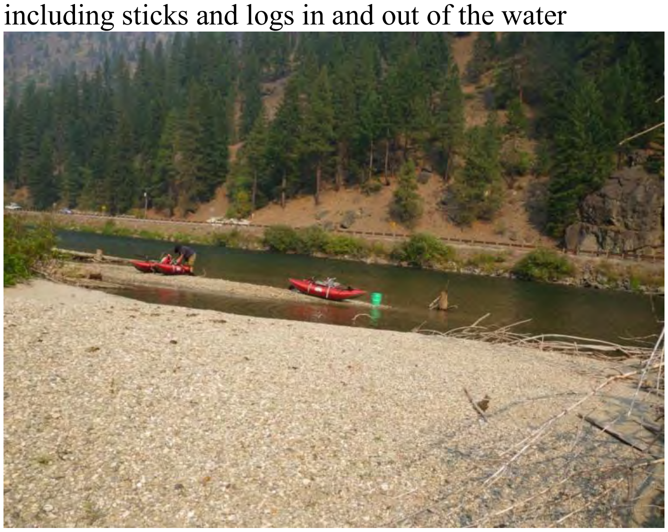
upstream and in a side channel that was almost completely dried up except for a few water puddles that were full of green and orange algae and aquatic weeds in its stagnant water.

Overview Map (Part III)


Jolanda Lake
WE35 Island
2
© 2012 Google
lat 47.620645° lon -120.729172° elev 604 m

WE35: Jolanda Lake, Markeyta Pinkham in a raft, Temperature 16.1^{0}C

WE35: Jolanda Lake, abundant fine and coarse sediment with little gravel and plenty of woody debris including sticks and logs in and out of the water

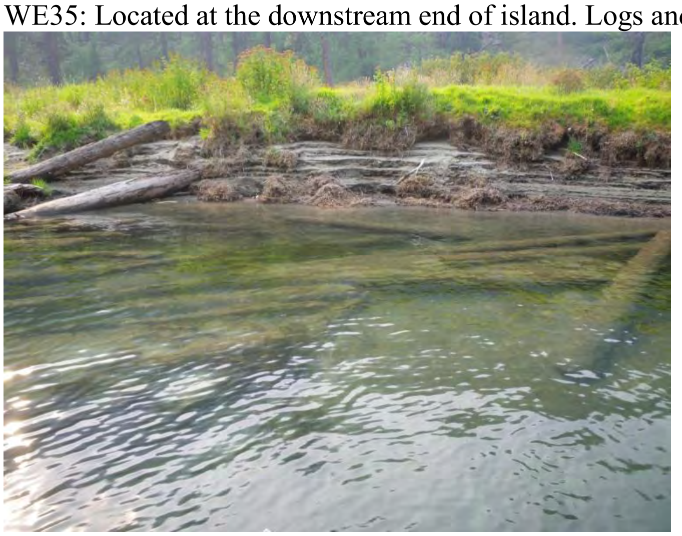


WE35: Close up of available habitat, composed of fine and coarse sand mixed with woody debris

WE35: Close up of available habitat with woody debris

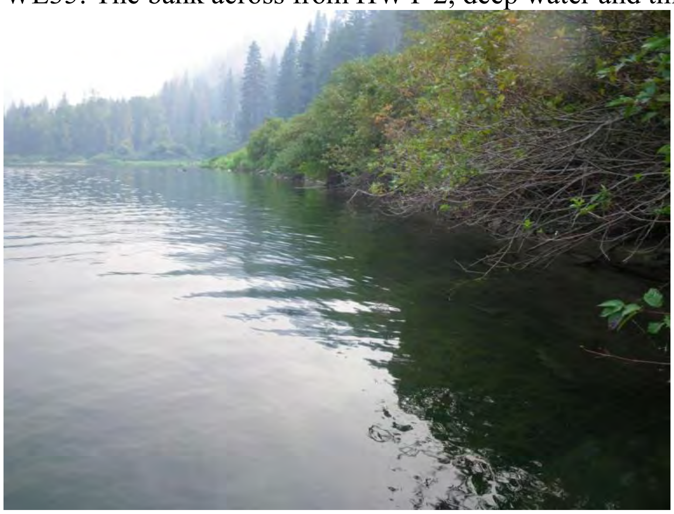
WE35: Close up of available habitat with a tire in the sediment

WE35: Located at the downstream end of island. Logs and sediment located along bank



WE35: Located at the downstream point of the island, composed of an abundance of coarse sand

WE35: The bank across from HWY 2, deep water and thick brush along bank

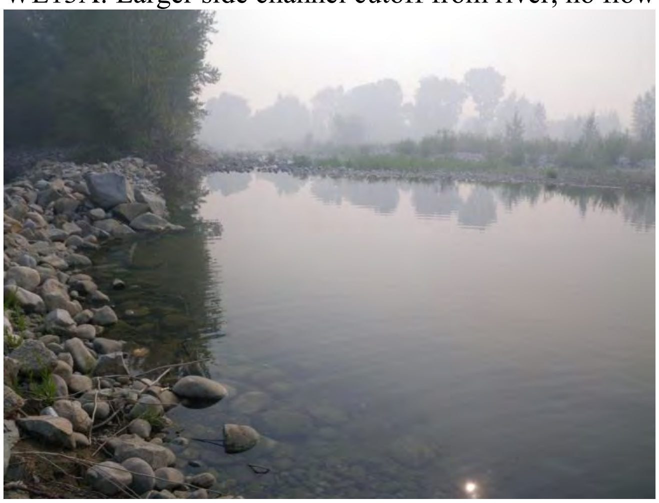


WE35: Very little sediment along with deep water

WE13A
N Cashmere Rd
2
Miller Dale
W Prospect St
Prospect St
W Pleasant Ave
E Pleasant Ave
McGill St
N Division St
River St
pendence Way
Cottage Ave
Mill Rd
Sunset Hwy
Mission Ave
S Division St
Railroad Ave
Chapel St
Foster St
Washington St
© 2012 Google
Angier Ave
402 m
lat 47.523628° lon -120.476602° elev 242 m
Lincoln St

WE13A: Small dried up side channel that traveled along the river before reconnecting

WE13A: Larger side channel cutoff from river, no flow



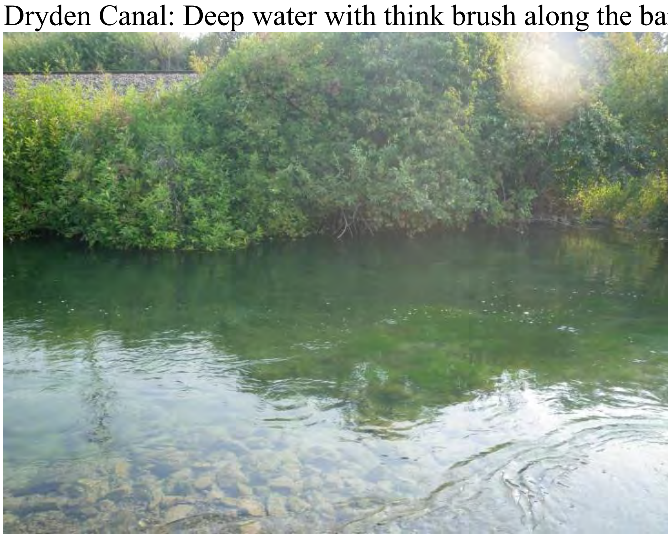
WE13A: small Sediment Island composed of coarse sand located along bank, thickly mixed with cobble and gravel. Markeyta Pinkham spot-checking


Drydin Dam Canal
Smith
Otis Rd
2
Motel Rd
Scheble Rd
© 2012 Google
370 m
lat 47.552148° lon -120.571730° elev 295 m

Dryden Canal: channelized canal, temperature 12.2^{0}C

Dryden Canal: very little amounts of silt along bank mixed with gravel

Dryden Canal: Deep water with think brush along the bank sides

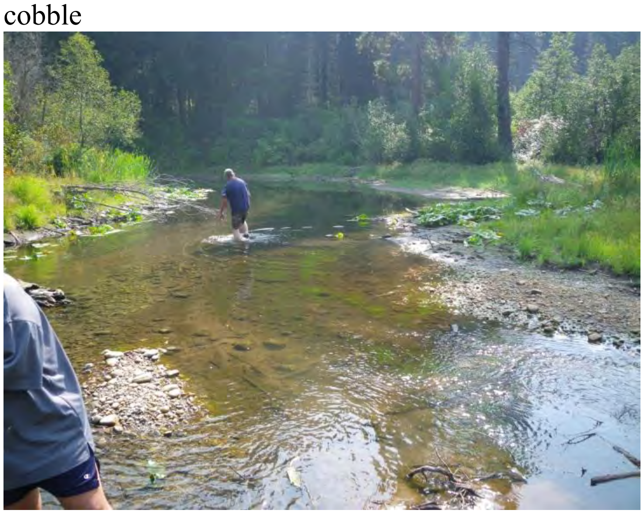


207
NA15
Rieche Rd
© 2012 Google
322 m
lat 47.764939° lon -120.723825° elev 600 m

NA15: Nason Creek had braided small channels intertwining

NA15: Markeyta Pinkham holding sediment for a close up, this area was composed of soft silt mixed with small amounts of woody debris

NA15: Frank Spillar walking down Nason Creek, this area was composed of this coarse sand, gravel and cobble



NA15: Markeyta Pinkham holding sediment, this sediment was composed of thick, deep coarse sand

NA15: This section of Nason Creek was composed of fine sand mixed with sticks and smaller woody debris and the bank consisted of lush greenery

NA15: Markeyta Pinkham holding up thick fine sediment

NA5: Side channel on Nason Creek, cut off from main stem and composed of stagnant water with algae growing inside

Larval Lamprey Survey within the Entiat Subbasin

Yakama Nation FRMP, Pacific Lamprey Project

Surveys conducted on 10/2/12 through 10/4/12

By Tyler Beals, Dave'y Lumley, and Frank Spillar

<u>Summary of Observations:</u>

Pacific Lamprey are documented in the Entiat River, as well as the Entiat Hatchery sedimentation pond. However, their distribution within the basin has not been documented in detail to date. Our goal was to supplement information regarding lamprey distribution, and document Pacific Lamprey distribution within the basin. We traveled to Entiat to survey an approximate 42 km section of the Entiat River from the mouth to upper reaches. Both a mesh (1mm) hand net and an electro-fisher (AbP-2 e-shocker designed for larval lamprey sampling) were used to survey any accessible Type I habitat (fine sediment mixed with organic debris) or Type II habitat (fine sediment mixed with cobble/gravel). A total of 24 sites were predetermined using aerial photos, with accessibility available to 13 of the sites.

The lower section had an abundance of Type I and Type II habitat but very few sites had deposition of detritus in addition to the fine sediment. Windy conditions during the time of sampling may have also reduced our ability to detect lamprey here. At site 4, we captured 31 larval lamprey and at site 15 we captured 6 larval lamprey. No other lamprey were captured during this survey. Spot checking with the hand net yielded sightings of lamprey at site 13. All identifiable larval lamprey (larval lamprey greater than 60 mm) captured were identified as Pacific Lamprey. Areas with an abundance of detritus were observed to hold primarily the larger fish. Shallow water conditions (and a puncture hole in one of the pontoons) made it unfavorable to raft above Site 4. Sites 5 through 11B did not appear to have larval lamprey habitat. Most of these sites had shallow water with large cobble and boulders, based on observations from the access roads. Larval lamprey were concentrated near areas of accumulated organic debris, even when extended areas of Type I habitat (without the debris) was present around this debris. Overall, the most amount of habitat was present in the lower section of the river between the mouth and Entiat 4. The upper section was cold (~ 5.5 °C), deep, and had Type I habitat along the main channel. However, detritus deposits that appeared to produce high density rearing were

limited and patchy. Side channels, especially their confluences and inlets, provided the majority of the observed Type I habitat. We conclude that Pacific Lamprey are present, but their distribution is limited due to swift, shallow water in most of the river, limiting the accumulation of fine sediment. Our observations suggest that habitat with a combination of small woody debris / organic matter and fine sediment is limited and patchy in the upper river, potentially limiting Pacific Lamprey distribution.

October 2, 2012

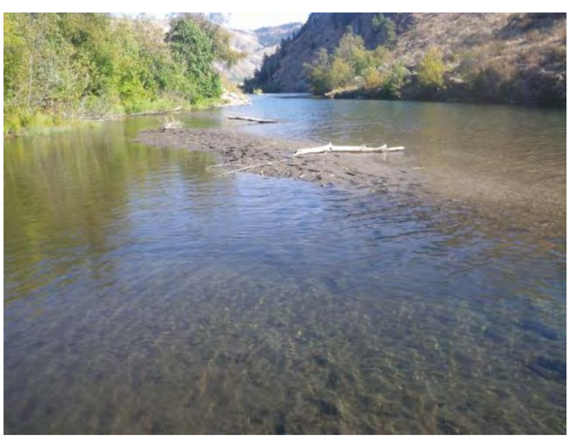
Site 1 (Near confluence with Columbia River) – 17.0 ^{o}C; A submerged sand bar was present between the main channel and backwater area; fine sand and aquatic plants present; backwater was deep and lacked sediment. E-shocked and no fish were found.

Sediment composition at Site 1

Site 2 (Outlet of small side channel) – 15.4 ^{o}C; Abundant fine sand sediment and aquatic plants. Spot checked on right bank (looking upstream) and no fish were found.

Sediment composition found at site 2.

Site 3 (Outlet of small side channel) – 16.0 ^{o}C; Small exposed sandbars were present between the mouth of the side channel and the main stem Entiat. Sediment was fine sand mixed with small organic matter. E-shocked and only one fish (>50mm) was observed.



Sediment composition found at site 3.

October 3, 2012

Site 4 (Side channel) – 9.8 ^{o}C; Fine sediment located throughout the center of the side channel. Areas of white sand present (free of detritus), as well as sand mixed with organic matter (leaves/wood/detritus). E-shocked and caught 31 fish; many small larvae observed (< 30mm). Primarily Type II habitat with pockets of type 1. Fish were found in both habitat types.

Type 2 habitat located at site 4.

Close-up of habitat located at Entiat 4. The primary mix of sediment was fine and course sand and a top layer of organic debris (including leaves).

Pacific Lamprey captured at on the Entiat River at site Entiat 4. A total of 31 fish were captured ranging in size from <30mm to >150mm.

Site 5 (Main channel) – No habitat was observed from bridge. "No Trespassing" signs were present, limiting access to the river. All observable substrate was boulder/cobble.

Site 6 (Main channel) – 14.3 ^{o}C; Shallow water/riffles, with cobble/boulders as the only substrate observed from this Co. Highway 19 bridge (both upstream and downstream).

Site 6B (Main channel) – 10.6 ^{o}C; Shallow water/riffles with cobble/boulders as the only substrate observed from bridge of Dinkelman Canyon Road (both upstream and downstream.)

October 4, 2012

Site 11C (Main channel) – 6.5 ^{o}C; Boulders/cobble were present throughout the channel. No fine sediment was observed.

Boulder/cobble substrate located in a deep pool at site 11C.

Chinook salmon observed in a deep pool below site 11C.

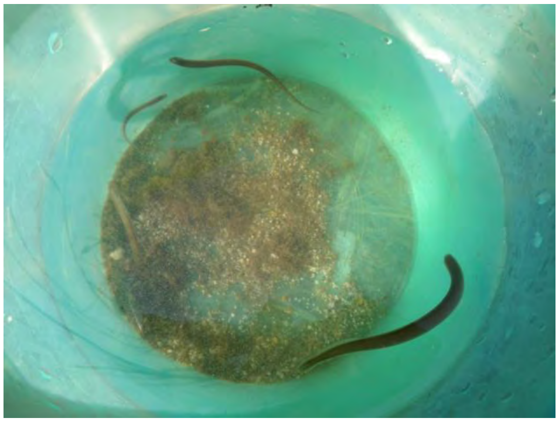
Site 13 (Backwater area off main channel) – 5.8 ^{o}C; Very fine sand with small woody debris (branches/sticks). We spot checked here and observed two (2) fish swim away from the net.

Sediment composition found at site 13.

Site 15 (Sandbar off of main channel) – 5.3°C; Electro-fished site. This sandbar consisted of fine and course sand. Patchy woody debris was present and fish were concentrated around them. Six (6) fish were captured, and identifiable fish (≥70mm) were identified as Pacific Lamprey.

Sediment composition found at site 15.

Ammocete lamprey found at site 15. Lamprey (>70 mm) were identified as Pacific Lamprey.



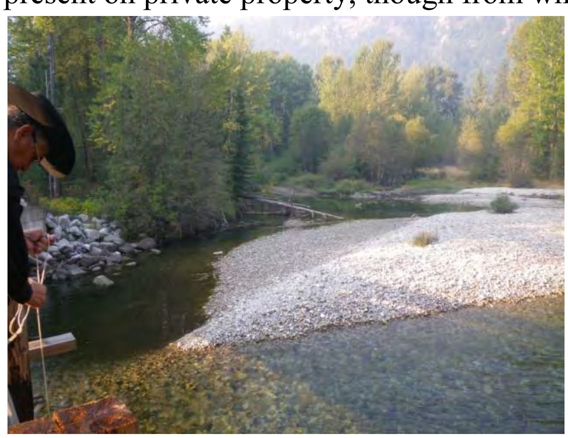
Site 15B (Side channel outlet) – 5.4°C; There was abundant fine sediment (fine/course sand) located on the margins of this small side channel. Abundant woody debris was visible. We did not sample this area due to inaccessibility from the roadway.

View facing upstream along the side channel at site 15B.

Fine sediment and woody debris observed at site 15B.

Site 15C (Main channel) – 5.4ºC; Large boulders and abundant cobble present along main channel. No fine sediment visible within, above, or below, this site.

Site 19 (Backwater off main channel) – 5.0ºC; Most upstream site visited. Backwater area present on private property, though from what we could see, it coarse and lacked fine sediment.



Small amount of fine sediment was located under the bridge at site 19, but appeared to be too coarse for larval lamprey.

Aerial Maps


Entiat 19
Manson
Entiat 15C
Entiat 15B
Entiat 15
Entiat 13
Entiat 11C
Entiat 6B
Entiat
Entiat 6
Entiat 5
Entiat 2
Entiat 1
4.27 mi
© 2012 Google
Google earth

State Rd
Sunset Ct
Hillcrest Dr
Dunn St
Hagen St
Entiat Way
2nd St
Co Hwy 19
State St
Entiat 3
Entiat 2
Entiat 1
97
© 2012 Google
454 ft
Google earth


Entiat 4
Enitat 3
Entiat 2
508 ft
© 2012 Google
Google earth


Co Hwy 19
Keystone Dr
Entiat 5
482 ft
© 2012 Google
Google earth

Entiat 6
479 ft
© 2012 Google
Google earth


Entiat 6B
388 ft
© 2012 Google
Google earth


Entiat 11C
302 ft
© 2012 Google
Google earth


Entiat 15
Entiat 13
278 ft
© 2012 Google
Google earth


Entiat 15B
334 ft
© 2012 Google
Google earth

N
Entiat 15C
© 2012 Google
329 ft
Google earth

Entiat 19
305 ft
© 2012 Google
Google earth

Larval Lamprey Surveys within the White Salmon Subbasin

Yakama Nation FRMP, Pacific Lamprey Project

Survey Conducted on 9/24/12 to 9/26/12
by Dave'y Lumley, Tyler Beals, and Frank Spiller

Summary of Findings:

We surveyed habitat in the White Salmon River and two of its tributaries (Rattlesnake and Tout Lake creeks) using a combination of fine mesh (1mm) hand-netting and electro-fishing (AbP-2 electro-shocker designed for larval lamprey sampling). Due to accessibility and time constraints, we were not able to survey all the scheduled sites. Many of the sites visited did not contain Type I or II habitat (ammocoete habitat consisting of fine substrate and organic matter). The two main goals for surveying the White Salmon Basin were to: 1) supplement the USFSW larval lamprey surveys and to 2) document good potential lamprey habitat where we could release translocated or propagated lamprey in the near future.

The first water body we surveyed was Rattlesnake Creek which is a tributary of the lower White Salmon River. There was no suitable habitat that we could find or have access to and the flow was too low to raft in at the time of the survey. We investigated three sites (RS1, RS2, RS5), but was not able to access two other sites (RS3 and RS4). RS1 was located just below the building of Wet Planet Rafting and Kayaking Co. under the HWY 141 Bridge in Husum and there was no potential habitat, only a low flow stream with a streambed consisting of gravel, cobble, and boulders. We traveled up the creek to access RS2 and the habitat was virtually the same with no fine substrate. To access the next site we traveled on Indian Creek Rd. RS3 and RS4 were on private property and we were unable to contact the landowners. RS5 was located further up the road at the Staats Rd. crossing and there was also no potential habitat to survey (no fine sediment deposits on the streambed). However crayfish and microinvertebrates were relatively abundant here. The average water temperature was 13.9 C^0 in Rattlesnake Creek during the survey.

Trout Lake Creek, which is a tributary of the upper White Salmon River, was also surveyed. We were able to access all six sites but not all were surveyable and the creek was too low to raft in. TL1 was located inside town and was composed of deep pools and rocky banks. TL2 was located in the Trout lake area and lamprey has been found here in the past so we only

spot-checked in this area; however, no larval lamprey were found. TL3 and TL4 were located in the Trout Lake Natural Area Preserve so we contacted the Trout Lake Ranger Station (USFS) and got permission to cross the land and were given a key for locked gates for full access. TL3 was a .45 mile hike in and had very good depositional habitat. Due to our time constraints, we were only able to spot-check several areas here, but no lamprey was found. Cold water temperature (10 C^0) may inhibit lamprey from using this habitat. TL4 was a .13mile hike-in to the creek and there was a small amount of sediment in a small backwater area. Sediment was primarily fine and coarse sand with a small amount of clay, silt and detritus. No lamprey was found here but a variety of other organisms were observed, including caddis-flies, may-flies, small aquatic beetles, and a long horsehair worm. TL5 was located behind a locked gate which the USFS key opened and led to a small campground. The site was composed of mostly swift water with cobble and large boulders, and no survey was conducted due to lack of habitat. The site for TL6 was located off of a steep cliff and we were unable to travel down, so instead we traveled a short distance downstream to a bridge crossing to survey. This area was also composed of fast moving water and large rocks from what we could see. No lamprey were found in Trout Lake creek and the average water temperature was 10.3 C^0.

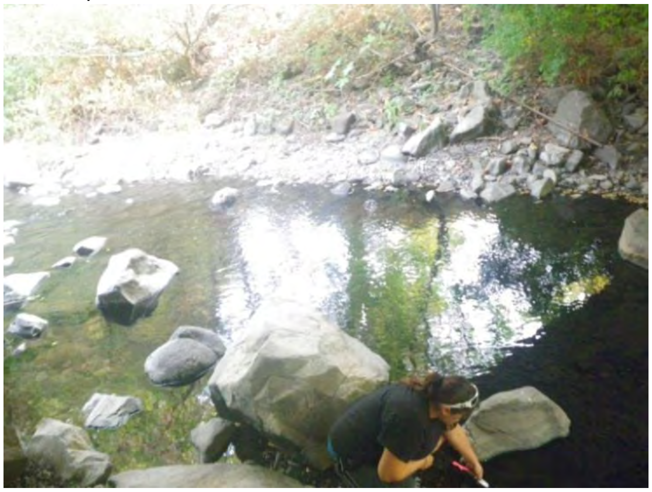
Finally, mainstem White Salmon River was surveyed, which is a tributary of the Columbia River. Not all areas was accessible and those that were had little to no ammocoete habitat. In the areas that we visited, we were unable to find areas that were suitable to raft down (with a cataraft), but we did speak with Mark Zollor of "Zollor's Outdoor Odysseys" and he offered to take us down the river in a rafting trip in the future. WS2 was located on private property "Riggleman Fruit" and we were unable to contact the landowners. WS3 and WS4 were located at Northwestern Park which used to be known as Northwestern Lake until the Condit Dam was removed. After the dam removal, this park changed dramatically and the entire reservoir is dried up leaving behind a canyon-like landscape. There were multiple signs of "No Access Areas" due to the re-vegetation of the entire reservoir area, which will be in progress till August 2013. The only area to access the river was down a new ramp that led down the hill. Once at the bottom, the only available habitat we could find was type II habitat (very thin layer of coarse, dark colored sand on top of gravel). The area was spot-checked but nothing was found. WS5 was located on private property of the Stevenson Land Company, so only photos were taken remotely (we were unable to contact them). This part of the river was located in a deep canyon and was difficult to access, if not inaccessible. WS6 was also located on private land but we were able to travel a short distance down the road to a bridge on Sunnyside Rd. However, the river was also inaccessible here as a result of being in a deep canyon. Habitat was mostly deep pools surrounded by tall walls of bedrock. WS6B was located off of River Rd. and was also composed of deep pools and large boulders with no habitat available to survey. This area is a public fishing and recreational area, so there is high traffic. WS7 contained no habitat to survey with primarily swift water and coarse sediment covered streambed. WS8 had a very similar habitat. A thin layer of coarse sand that collected on top of bedrock was surveyed, but no lamprey was found at this site. Flow was also swift at WS9 in the upper White Salmon River, where only coarse substrate remained in the system. There were patches of exposed rock that accumulated woody debris and a very thin layer of sediment collected around the debris but not large enough to allow larval rearing. During this survey, we found very little depositional areas and no larval lamprey was found.

RS1: The sample area was composed of gravel and cobble with very small amounts of sediment present

RS1: A mixture of cobble and gravel represented the area

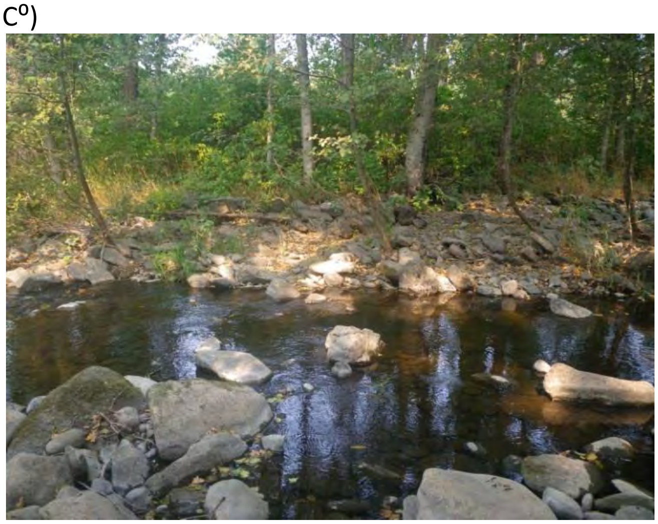
RS1: There was very little fine sediment available and the water level was too low to raft

RS1: We accessed the creek under the bridge near the Wet Plant Rafting and Kayaking Co. (water temp. 13.9 C^{o})



RS2: Downstream view of area, all gravel, cobble, and boulder with no fine sediment (no sample taken).

RS2: The bank was lined with bushes, trees, grasses, fallen leaves and woody debris (water temp. 14.0 C^{o})



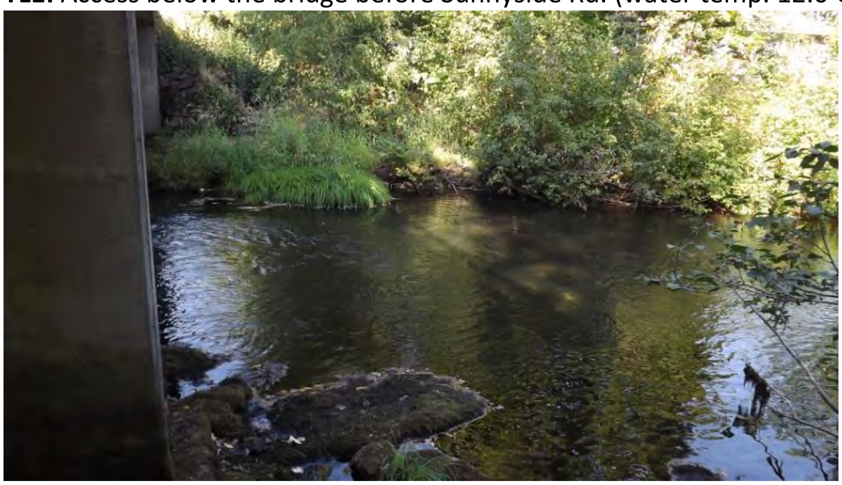
RS2: Upstream view of area showing gravel, cobble, and boulder sediment mixture

RS5: Area composed of gravel, cobble, and boulders - no sample taken (water temp. 13.9 C^o)

RS5: Only water skippers and crayfish were observed in this area

TL1: There was no habitat to sample, only cobble along the bottom

TL1: Access below the bridge before Sunnyside Rd. (water temp. 12.0 C^{o})



TL1: Right bank (looking downstream) was lined with trees, bushes and tall grasses and the other side was private property

TL2: This area had suitable habitat and was spot-checked in multiple areas but no lamprey were found

TL2: Close up of sediment in one area - a mixture of gravel and coarse sand **(**water temp. 10.7 C^{o})

TL2: Close up of sediment in another area (a mixture of small gravel and fine sediment)

TL2: Close up of sediment which was composed of small gravel, coarse sand, and clay with very small amounts of woody debris mixed in

TL3: No access through this gate, but we got permission to cross (from the Trout Lake Ranger Station). We had to hike in about a mile from here.

TL3: The bank was lined with tall grasses, bushes, and some fallen trees (water temp. 10.3 C^{o})

TL3: Close up of sediment composed of fine and coarse sand

TL3: Close up of sample area, spot-checked in multiple areas - no lamprey were found but it was one of the best depositional area we observed

TL3: This sample area was composed of good habitat along the bottom of a deep pool

TL3: Close up of sediment sample composed mostly of coarse sand mixed with small amounts of fine sand

TL4: This area was a preserve and we got permission to enter from the Trout Lake Ranger Station, it was about a half mile hike in to the site

TL4: Small amounts of sand that collected in a backwater area (water temp. 11.0 C^{o})

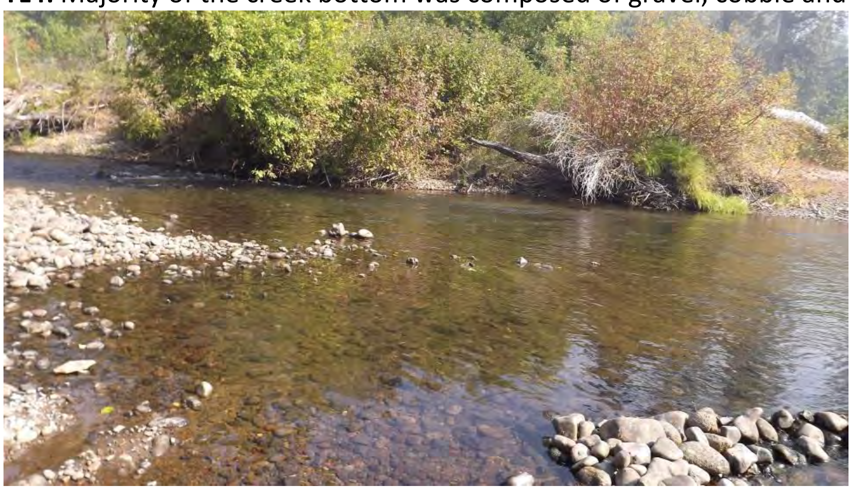
TL4: We spot-checked the area and no lamprey was found

TL4: Close up of sediment composed mostly of coarse sand and small gravel

TL4: A variety of organisms was observed including water skippers, small aquatic beetles, caddis flies, may-flies, and this horsehair worm

TL4: Small rocky shelf, most likely man-made, along the side of a small backwater area

TL4: Majority of the creek bottom was composed of gravel, cobble and boulders



TL4: There is dry sediment further up on the bank, if we were there earlier in the year there could have been more area to sample

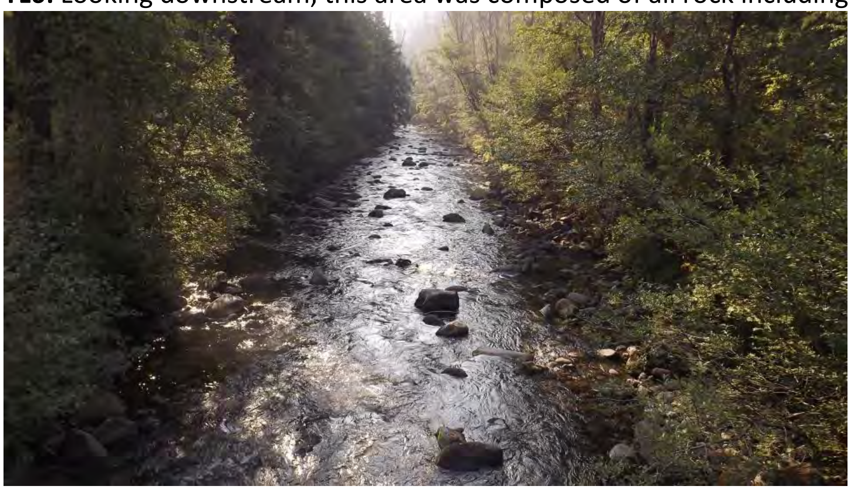
TL5: This area was gated off but we got permission to enter from the Trout Lake Ranger Station and was given a key

TL5: This area was composed of cobble and boulders with no available habitat

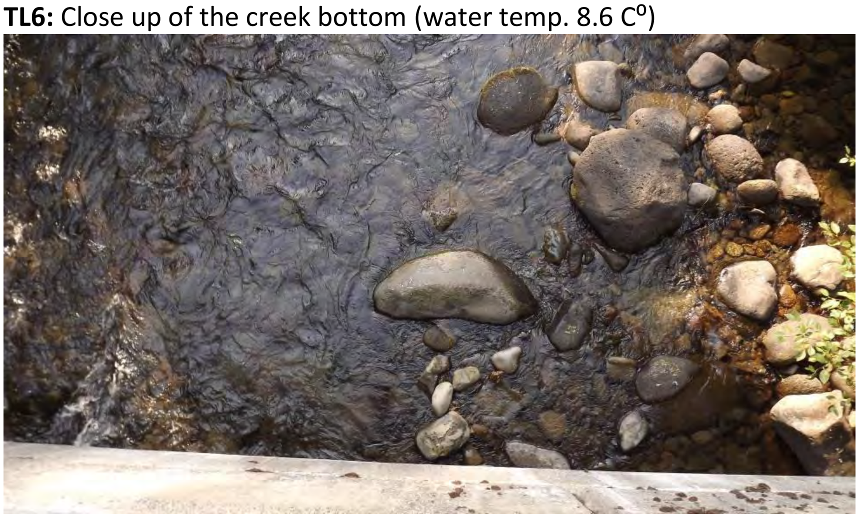
TL5: This site was located along the side of campgrounds (water temp. 9.8 C^{o})

TL6: The site was inaccessible so we traveled downstream to a bridge just below this point

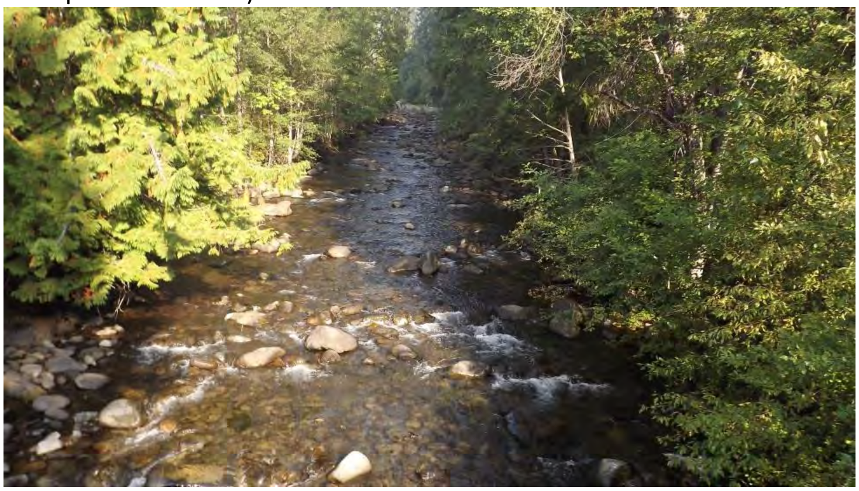
TL6: Looking downstream, this area was composed of all rock including cobble and boulders



TL6: Close up of the creek bottom (water temp. 8.6 C^o)



TL6: Looking upstream, the bank was lined with trees, bushes, grasses, and rocks along the creeks (lack of depositional fines)



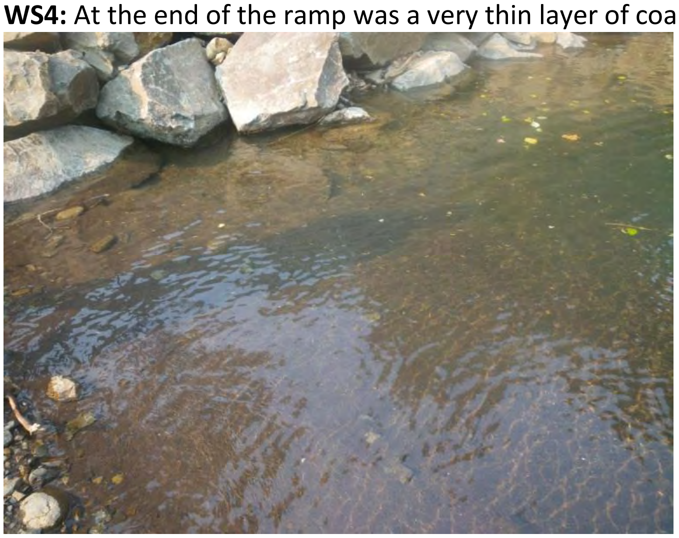
WS3: No access due to the Dam removal earlier this year

WS4: There were many signs posted that there is a re-vegetation process going till August 2013 and there will be no access till then unless in the designated areas

WS4: View of the river showing more inaccessible land

WS4: The only access to the river without crossing over the re-vegetated area was down a small ramp

WS4: At the end of the ramp was a very thin layer of coarse dark sand on top of gravel



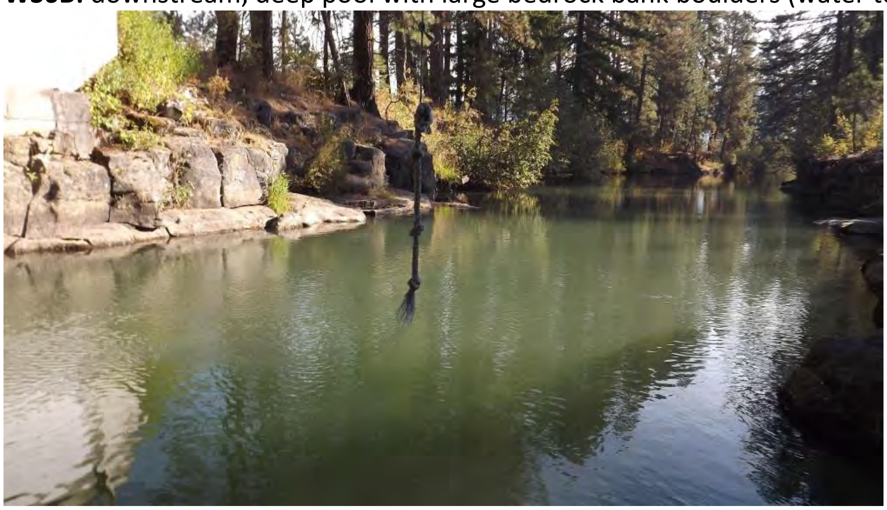
WS4: Close up of the thin layer of sand over gravel (water temp. 15.0 C^{0})

WS5: Stevenson Land Company (No Trespassing sign)

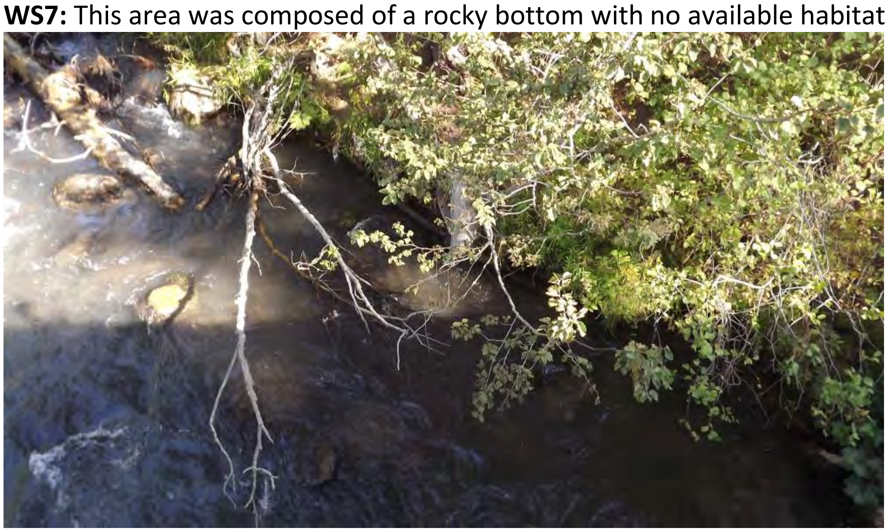
WS5: Without crossing onto the property, photos were taken of the area and showed it to be inaccessible with steep canyon walls

WS6B: Upstream, this area was composed of a deep pool surrounded by large bedrock banks with no sediment to sample

WS6B: downstream, deep pool with large bedrock bank boulders (water temp. 8.2 C^{o})

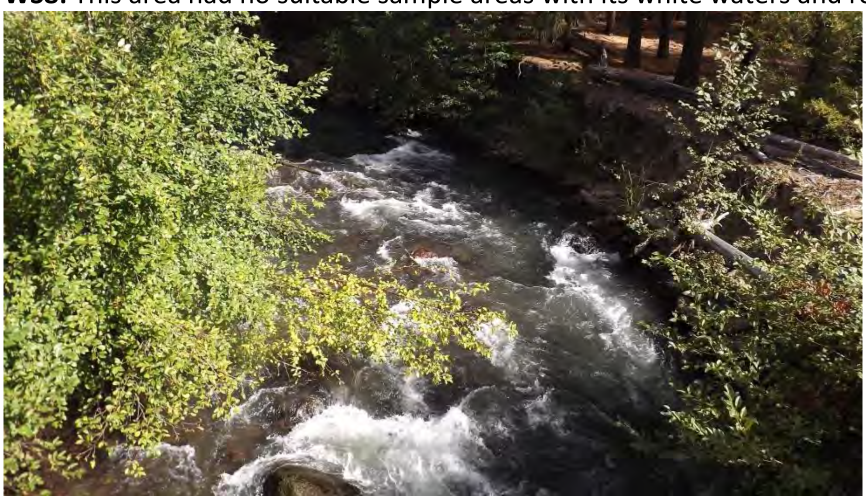


WS7: This area was composed of a rocky bottom with no available habitat (water temp. 8.4 C^{o})



WS7: Looking upstream, the bottom is a mixture of cobble and boulders lined with trees, bushes and grasses on the bank

WS8: This area had no suitable sample areas with its white waters and rocky bottom



WS8: Visible bottom area was all exposed coarse substrate (boulders, etc)

WS8: The only fine sediment found was in small patches along the bank (water temp. 8.0*)

WS8: Found a thin layer of sediment on top of a small section of bedrock

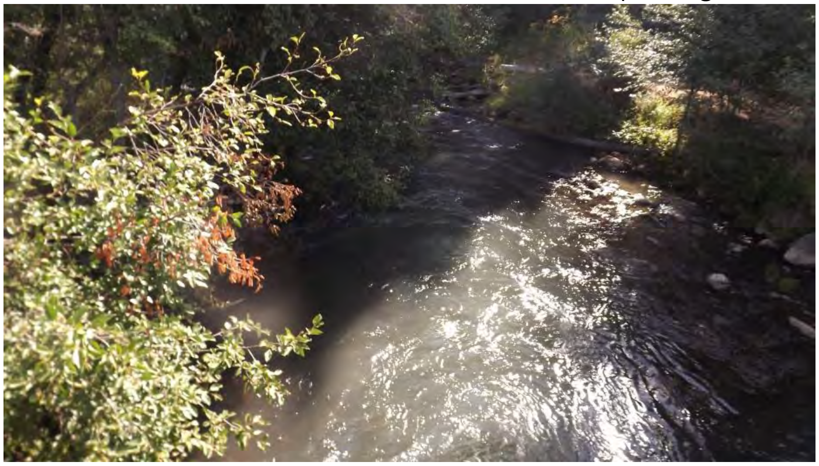
WS8: The sediment was composed of dark coarse sand

WS9: This area only had swift water and a rocky bottom which didn't allow for sediment to collect

WS9: There was some woody debris that collected along the rocks but very little to no fine sediment

WS9: Close up of the rocky bottom, (water temp. 8.0*)

WS9: water was calmer but still no suitable habitat (looking downstream)



Interview Questions for Elders on Eels (Pacific Lamprey)

1. Biography
   a. What year were you born? Did you grow up in the Yakima Basin?
   b. How long have you (or someone you know) fished for eels? If not, do you remember observing them anywhere? How long ago was it?
   c. Which river or stream did you (or others) harvest (or see) eels? (If you are comfortable in sharing more about the site, we certainly appreciate it – such as lower reach, upper reach, or site name). Where any of the fishing sites in the Yakima Basin?
   d. What forms of gear did you use to harvest eels (general answer is fine, but details are great, too)?

2. Harvest / Abundance
   a. When do you think were the best years for lamprey harvest (specific year or range of years)? What was the abundance like, if you were to describe it in words?
   b. How many lamprey did you (or your family) catch per day (or per week, season, etc.) when the harvest was good?
   c. How many people would you say fished this area with you (in a day or over the season)? Did members from other tribes (Non-Yakama) also fish there?
   d. In the area that you harvested eels, when did Pacific lamprey appear to decrease significantly?
   e. How many lamprey did you (or your family) catch per day (or per week, season, etc.) when the harvest was low more recently?

f. How many people would you say fished this area with you (in a day or over the season) when the harvest was low more recently?
g. When was the last time you (or someone you know) fished for eels?
h. If lamprey were still abundant, would you go fishing for them?

3. Biology
   a. How long did the eel runs (or harvest timing) last (range of months)? What about peak harvest timing (month)?
   b. Was there more than one season or run of eels per year? Dark vs. light eel, for instance.
   c. Were eels that were harvested back then different from the current eels in terms of color, size, etc.?
   d. Did you ever see or hear of areas where eels spawned? (or any other life stages, such as larva and transformers) What about resident lamprey (Western brook lamprey)?

4. Ecology
   a. Were there any seasonal signs indicating run/harvest timing (stream conditions, flowers, fruits, roots, etc.)?
   b. What other animals/fish were abundant back when the eels were running?
   c. Did you ever observe other animals feeding on eels? (blue heron, hawks, seals, bears, etc.) Did they take large numbers?

5. Culture
   a. How was lamprey important to you (or your family) in terms of diet or medicine? How often did you eat them? How were the eels prepared after they were caught?
   b. Are there other uses for eels besides food or medicine?
   c. Do you have any photos (or art work) of lamprey (or related to lamprey) that you don't mind sharing with us?

6. Human Impact
   a. Out of the following nine factors, which factor(s) do you think played the largest factor in lamprey decline in your area (of fishing)? 1. Passage (Adult / Juvenile), 2. Irrigations/Canals, 3. Habitat Loss, 4. Water Quantity, 5. Water Quality (Temperature, Toxicants, etc.), 6. Predation, 7. Disease, 8. Ocean Conditions, 9. Others.

7. Wrap-Up
   a. Do you know of any other information about eels that we have not discussed today?
   b. Could we contact you later for follow-up questions? Is there anyone else that you know that we could talk to about eels?

	What	*What &Why*	*Where*		*When*		*Who*	
ID #	**Threats / Actions**	**Description of Actions**	**Subbasin / Watershed**	**Geographic Scale**	**Timing**	**Feasibility**	**Potential Funding Source**	**Implementing Entity**
Threat #1	**Adult Migration**							
Action 1.1	**Passage Improvement**	initial focus (2013-2015) is on four lower dams (fix) and start assessments of upstream projects in near future. Also continue focus on radio telemetry to evaluate passage.	Lower Yakima (lower 4 dams), Upper Yakima (Roza Dam, Town Canal Dam)	**Point**	2 release groups [summer (September) and spring (March)] to monitor movement year round	High	BOR / BPA / USACE	Yakama Nation / USFWS
Action 1.2	**Prevention of Canal Access**	Prevent adults from entering canal (both inlets & outlets), which could be a significant issue considering the high level of pheromone attraction steming from canal waters.	Lower Yakima, Upper Yakima, Naches?, Others?	**Point**	*future project - during spawning migration (March - October)	High	BOR	Yakama Nation / BOR
Action 1.3	**Lack of Information on Status and Trend**	Limited info exist on where the historical and existing Pacific lamprey population migrate to and spawn within the Yakima Basin. Take advantage of existing radio telemetry to study their current distribution. Historical info could be supplied from elder interviews. If adult usage is hard to confirm, larval presence could be used as an indicator for assessment as well.	Region-wide	**Region**	year round	High	BOR / BPA	Yakama Nation / USFWS
Threat #2	**Downstream Passage - Entrainment**							
Action 2.1	**Determining New Screening Criteria for Larval/Juvenile Lamprey**	Support USGS in defining new lamprey screening criteria from laboratory research.	Region-wide	**Region**	year round (lab study)	High	BOR	Yakama Nation / USGS
Action 2.2	**Monitoring of Entrainment Impacts**	Continue canal surveys to document entrainment and implement new monitoring that showcase precisely how lamprey are being entrained ("when", "how", "where", etc.). Focus is on four lower dams at this time, but expand as needed.	Lower Yakima (lower 4 dams), Upper Yakima (Roza Dam, etc.), and diversions in supplementation sites (Ahtanum, Naches, Toppenish)	**Point**	winter (October - March)	High	BPA / BOR	Yakama Nation / BOR
Action 2.3	**Reduction of Dewatering Mortality Associated with Canals**	Identify ways to reduce mortality of lamprey during dewatering periods (desiccation & predation)	Lower Yakima (lower 4 dams), Upper Yakima (Roza Dam, etc.), and diversions in supplementation sites (Ahtanum, Naches, Toppenish)	**Point**	early winter (October - November)	High	BOR	Yakama Nation / BOR
Action 2.4	**Characterize Juvenile Out-Migration**	Use Chandler (Prosser) juvenile facility to help characterize juvenile migration. Thousands of macrophthalmia (juvenile) lamprey have been documented passing through this facility during winter months (January~February) and we could effectively estimate outmigration numbers using pit tagging and other methods.	Lower Yakima (Prosser Dam)	**Point**	late winter (January - March)	High	BPA / USACE	Yakama Nation

	What	*What &Why*	*Where*		*When*		*Who*	
ID #	**Threats / Actions**	**Description of Actions**	**Subbasin / Watershed**	**Geographic Scale**	**Timing**	**Feasibility**	**Potential Funding Source**	**Implementing Entity**
Threat #3	**Stream and Floodplain Degradation**							
Action 3.1	**Restoring Natural Deposition of Fine Sediment and Organic Matter**	Reduce fine sediment & organic matter (food source) collection in canals OR find ways to transport fine sediment & organic matter back into the flowing rivers at the end or beginning of the irrigation season. Also, need to refute the current paradigm which asserts that fine sediment is detrimental to stream health (in fact they are vital to stream health.	Basin wide, but focusing on: Lower Yakima (lower 4 dams), Upper Yakima (Roza Dam), and diversions in supplementation sites (Ahtanum, Naches, Toppenish)	**Point**	*future project - pilot project in 2013	Medium	BOR / SRFB	Yakama Nation
Action 3.2	**In-Channel Restoration**	Implementation of pilot in-channel restoration projects that focuses on restoring lamprey habitat & associated effectivness monitoring. For mainstem Yakima, restoration focusing on side channels may be most effective.	Lower Yakima (Wapato Reach), potentially in Taneum, Toppenish, Satus, and/or Ahtanum	**Watershed**	*future project - pilot project in 2013	High	SRFB	Yakama Nation
Action 3.3	**Riparian/Floodplain Restoration**	Restoration of natural, functioning riparian, floodplain, and side channels is a plus, but hard to find specific remedies that can fix this at a large scale (beyond what has already been done for salmon restoration). However, including lamprey as a "target species" for riparian/floodplain restoration activities is plausible.	Lower Yakima (focus on Wapato reach)	**Region**	*future project - pilot project in 2013	Medium	SRFB	Yakama Nation
Action 3.4	**Inclusion into "Target Species" for Other Restoration Activities**	Include lamprey as a "target species" for various restoration activities, including SRFB, so that exisiting salmon restoration activities could further enhance lamprey habitat needs	Region-wide	**Region**	*future project - start in 2013	High	SRFB	Yakama Nation / USFWS
Action 3.5	**Lack of Information on Status and Trend**	Survey for larval lamprey in high potential habitat and conduct index surveys in key locations to determine status and trend within the basin. These surveys will also aid evaluation of adult passage and effectiveness monitoring from supplementation activities.	Region-wide	**Region**	summer (June - Octoboer)	High	BPA	Yakama Nation / USFWS
Threat #4	**Water Quality - Temperature**							
Action 4.1	**Monitoring of Larval Survival in High Temperature Conditions**	Continue to document presence / absence in high water temperature reaches (to find temperature thresholds for survival). High temperature is a known problem, but remedy is difficult to find.	Lower Yakima (mainstem, lower Toppenish, lower Ahtanum, etc.), Upper Yakima (lower Wenas)	**Watershed**	summer (June - August)	High	BPA	Yakama Nation / USFWS

	What	*What &Why*	*Where*		*When*		*Who*	
ID #	**Threats / Actions**	**Description of Actions**	**Subbasin / Watershed**	**Geographic Scale**	**Timing**	**Feasibility**	**Potential Funding Source**	**Implementing Entity**
Action 4.2	**Monitoring of Flow Management on Thermal Dynamics during Spawning Season**	"Flip Flop" flow management can affect thermal dynamics of the river and considering that this happens during the spawning season (most critical period), it is important to understand the potential impact of this.	Upper Yakima & Naches	**Subbasn**	*future project - spring - summer (May - July)	Medium	BOR	Yakama Nation
Threat #5	**Water Quality - Contaminants & Chemistry (DO, BOD, pH etc)**						BOR	Yakama Nation
Action 5.1	**Monitoring of Water Chemistry Effects**	No known existing threat (limited monitoring currently), but beneficial to at least monitor conditions in art. prop. / translocation areas to document potential influence	Focusing on supplementation sites	**Watershed**	summer (June - July)	Medium	BOR	Yakama Nation
Action 5.2	**Monitoring of Contaminants Effects**	Monitor areas that are more heavily contaminated (usually lower in the River) and document the effects on Pacific lamprey (at all life stages)	Lower Yakima (Prosser), Toppenish, Ahtanum, Naches, Satus, Lower Wenas	**Watershed**	summer (June - july -> in 2012, it was collected in late October and early November to capture samples from canals)	High	BOR	Yakama Nation / USGS
Threat #6	**Water Quantity - Dewatering and Stream Flow Management**							
Action 6.1	**Minimize Flow Management Impacts**	Find solutions to ameliorate impacts from "Flip Flop" (flow management that balance water between Upper Yakima and Naches reservoirs). This happens during summer which coincides with the migration, spawning, and egg hatching period, which is a critical period for lamprey.	Upper Yakima & Naches	**Subbasn**	summer (May - September)	Medium	BOR	Yakama Nation
Threat #7	**Predation**							
Action 7.1	**Predation Reduction**	Support projects (such as salmon related ones) that reduce the abundance of predacious and/or invasive species that prey on juvenile, larval lamprey at a rate much higher than the historical background rates.	Lower Yakima (lower 4 dams), and expanding as needed	**Point**	*future project - year round (as opportunity arise)	Medium	BPA / BOR	Yakama Nation
Action 7.2	**Providing Refuge in Areas of High Predation**	Provide overwintering / refuge habitat to reduce predation risks for adults	Lower Yakima (lower 4 dams), and expanding as needed	**Point**	*future project	Medium	BPA / BOR	Yakama Nation
Threat #8	**Disease**							
Action 8.1	**Disease Monitoring**	Work in conjunction with fish pathologists during the process of art prop. and translocation activities.	Lamprey holding facilities (Prosser Hatchery, etc.)	**Point**	year round (at the hatchery)	High	BPA	Yakama Nation / USFWS
Threat #9	**Harvest**							
Action 9.1	**Harvest Monitoring**	As far as we know, no harvest is taking place within the Yakima Basin currently, but ammocoete harvest (for use as a fish bait) may be taking place in some places	Region-wide	**Watershed**	*future project - year round	Medium	BPA / WDFW	Yakama Nation / WDFW
Threat #10	**Small Effective Population Size**							

	What	What &Why	Where		When		Who	
ID #	Threats / Actions	Description of Actions	Subbasin / Watershed	Geographic Scale	Timing	Feasibility	Potential Funding Source	Implementing Entity
Action 10.1	Supplementation Using Adult Translocation (Satus Cr)	Supplement local populations by translocating 50 adults annually from lower Columbia River dams to Satus Creek in two locations to overcome the small effecitve population size (virtually no water diversion in the system)	Lower Yakima: Satus (rkm 13 [Plank Rd] & rkm 31 [below Dry Cr confluence])	Stream	spring - summer (May - July)	High	BPA	Yakama Nation
Action 10.2	Supplementation Using Adult Translocation (Toppenish Cr)	Supplement local populations by translocating 75 adults annually from lower Columbia River dams to Toppenish Creek in two locations and Simcoe Creek (main trib. to Toppenish Cr) in one location to overcome the small effecitve population size and document canal entrainment	Lower Yakima: Toppenish (rkm 37 & 57), Simcoe (rkm 2)	Stream	*future project - spring - summer (May - July)	High	BPA	Yakama Nation
Action 10.3	Supplementation Using Adult Translocation (Ahtanum Cr)	Supplement local populations by translocating 75 adults annually from lower Columbia River dams to Ahtanum Creek in three locations to overcome the small effecitve population size and document canal entrainment	Lower Yakima: Ahtanum (rkm 4 [La Salle High School], rkm 17 [Lower WIP], & rkm 30 [Mission])	Stream	*future project - spring - summer (May - July)	High	BPA	Yakama Nation
Action 10.4	Supplementation Using Adult Translocation (Naches River)	Supplement local populations by translocating 75 adults annually from lower Columbia River dams to Naches River in three locations to overcome the small effecitve population size and document canal entrainment and flow management impacts	Naches: Naches (rkm 4 [below Cowiche confluence], rkm 22 [Naches City Bridge], rkm 40 [above Tieton confluence])	Stream	*future project - spring - summer (May - July)	High	BPA	Yakama Nation
Action 10.6	Supplementation Using Artificial Propagation (Eschbach Park)	Supplement local populations by implanting 50,000 artificially propagated larval lamprey (between 0+ & 1+ age) in Naches River side channel by Eschbach Park. Also, conduct effectiveness monitoring by evaluating survival, growth, density, dispersion and habitat density	Naches: Naches (rkm 13.9 [Eschbach Park])	Stream	*future project - fall (October - November)	High	BOR	Yakama Nation
Action 10.7	Supplementation Using Artificial Propagation (Holmes Acclimation Pond)	Supplement local populations by implanting 50,000 artificially propagated larval lamprey (between 0+ & 1+ age) in the Holmes Coho Acclimation Pond. Also, conduct effectiveness monitoring by evaluating survival, growth, density, dispersion and habitat density	Upper Yakima: Yakima (rkm 261.0 [Holmes Acclimation Pond])	Stream	*future project - fall (October - November)	High	BOR	Yakama Nation

	What	*What &Why*	*Where*		*When*		*Who*	
ID #	**Threats / Actions**	**Description of Actions**	**Subbasin / Watershed**	**Geographic Scale**	**Timing**	**Feasibility**	**Potential Funding Source**	**Implementing Entity**
Action 10.8	**Supplementation Using Artificial Propagation (Cle Elum Hatchery Side Channel)**	Supplement local populations by implanting 50,000 artificially propagated larval lamprey (between 0+ & 1+ age) in the side channel by the Cle Elum Hatchery. Also, conduct effectiveness monitoring by evaluating survival, growth, density, dispersion and habitat density	Upper Yakima: Yakima (rkm 303.1 [Cle Elum Hatchery])	**Stream**	*future project - fall (October - November)	High	BOR	Yakama Nation
Action 10.5	**Supplementation Using Both Adult Translocation & Artificial Propagation (Wenas / Taneum / Teanaway Cr)**	Supplement local populations by using both adult translocation and larval supplementation in Wenas, Taneum, and/or Teanaway creeks. Also, conduct effectiveness monitoring by evaluating survival, growth, density, dispersion and habitat density	Upper Yakima (lower 11 km on Wenas, lower 5 km on Taneum, lower 20 km on Teanaway)	**Stream**	*future project - fall (October - November)	High	BOR / BPA	Yakama Nation
Action 10.9	**Supplementation Using Both Adult Translocation & Artificial Propagation (Cle Elum River)**	Supplement local populations by using both adult translocation and larval supplementation in Cle Elum River. Also, conduct effectiveness monitoring by evaluating flip flop impacts, survival, growth, density, dispersion and habitat density	Upper Yakima: Cle Elum (lower 12 km)	**Stream**	*future project - fall (October - November)	High	BOR / BPA	Yakama Nation
Action 10.10	**Monitoring Spawning Behaviour (probably need to choose one from the three)**	Monitor adult spawning and recruitment of larval lamprey using the coho spawning channel located above the Holmes Coho Acclimation Pond. This monitoring will help us understand spawning/recruitment relationships in Pacific lamprey.	Upper Yakima: Yakima (rkm 261.1 [Holmes Acclimation Pond])	**Stream**	*future project - spring - summer (May - July)	Medium	BPA / BOR	Yakama Nation
Action 10.11	**Monitoring Spawning Behaviour (probably need to choose one from the three)**	Monitor adult spawning and recruitment of larval lamprey using the spawning channel located at the Cle Elum Hatchery. This monitoring will help us understand spawning/recruitment relationships in Pacific lamprey.	Upper Yakima: Yakima (rkm 303.1 [Cle Elum Hatchery])	**Point**	*future project - spring - summer (May - July)	Medium	BPA / BOR	Yakama Nation
Action 10.12	**Monitoring Spawning Behaviour (probably need to choose one from the three)**	Monitor adult spawning and recruitment of larval lamprey using the spawning channel located at the Prosser Hatchery. This monitoring will help us understand spawning/recruitment relationships in Pacific lamprey.	Lower Yakima: Yakima (rkm 74.5 [Prosser Hatchery])	**Point**	*future project - spring - summer (May - July)	Medium	BPA / BOR	Yakama Nation
Threat #11	**Lack of Awareness**							

	What	What &Why	Where		When		Who	
ID #	Threats / Actions	Description of Actions	Subbasin / Watershed	Geographic Scale	Timing	Feasibility	Potential Funding Source	Implementing Entity
Action 11.1	Outreach and Education	Outreach activities through student / community events.	Region-wide	Region	year round	High	BPA / BOR	Yakama Nation / USFWS
Action 11.2	Community Involvement in Restoration	Student / community involvement during restoration activities. As a result of translocation and art. prop supplementation projects, there will be many opportunities to involve local students in these activities (fish release, monitoring, etc.)	Lower Yakima (Wapato k-12), Toppenish (White Swan / Harrah / Toppenish k- 12), Ahtanum (La Salles, West Valley, Ahtanum k-12), Naches (Naches k-12), Taneum (Thorp k-12), Cle Elum (Cle Elum k-12), Wenas (Selah k-12)	Subbasn	year round	Medium	BPA / BOR	Yakama Nation
Action 11.3	Larval Lamprey in Classrooms	Lamprey (larval) in the classroom using aquarium tanks, etc. Providing more chances for students to have hands-on experiences with lamprey will greatly enhance awareness of lamprey (and potentially how they decide to interact with lamprey in the future in whatever careers they choose.	Lower Yakima (Wapato k-12), Toppenish (White Swan / Harrah / Toppenish k- 12), Ahtanum (La Salles, West Valley, Ahtanum k-12), Naches (Naches k-12), Taneum (Thorp k-12), Cle Elum (Cle Elum k-12), Wenas (Selah k-12)	Subbasn	*future project - year round except summer months (September - June)	High	USFWS / BPA / BOR	Yakama Nation
Threat #12	Climate Change							
Action 12.1	Assessing Climate Change Impacts on Species Distribution	Assess climate change impacts (in terms of temperature and flow dynamics, etc.) within the Yakima Basin to further our understanding on how that may affect future lamprey distribution within the	Lower Yakima (mainstem, lower Toppenish, lower Ahtanum, etc.), Upper Yakima (lower Wenas)	Region	*future project	Low	BPA	Yakama Nation

Evaluation of the Potential Impacts of "Flip Flop" on Larval Lamprey in the Upper Yakima River Using Photo Documentation and Habitat Assessment: Summer 2012

Yakama Nation FRMP
Tyler Beals and Ralph Lampman

Photos and surveys performed on 8/14/2012, 9/10/2012 and 9/12/2012
With the help of Markeyta Pinkham

Summary of Observations

The Yakima Basin has undergone a regulated flow regime known as "Flip Flop" during the late summer since 1982. This operation switches the source of flow augmentation in September away from the upper Yakima Basin over to the Naches Basin to prevent spring Chinook from spawning in the drying channel margins. This rather swift reduction in water level generally starts in late August and lasts 2-3 weeks, often resulting in exposure of fine sediment in channel margins throughout the upper Yakima River between Cle Elum and the Naches River confluence. Larval lamprey are highly vulnerable to dewatering events and are often found desiccated on dried up banks during events, such as flow modification at dams, culvert replacement, and canal dewatering (from "Best Management Practices to Minimize Adverse Effects to Pacific lamprey" USFS, USFWS, and BLM 2010; also see Figure 19).

We surveyed a total of nine sites throughout the upper Yakima River between Cle Elum and Roza Dam (rkm 300.9 to rkm 214.9), attempting to assess the potential effects of Flip Flop on larval lamprey habitat. During the course of the Flip Flop period, we observed a total habitat area of 1,536 m^2 becoming unavailable to larval lamprey in these nine sites. Larval habitat in two sites was completely (100%) dried up whereas the remaining five sites lost larval habitat by 40 - 70 % (overall mean of 67%). Also, the habitat that remained in water (33% on average) after the water level had dropped tended to be shallower and harder, indicating inferior habitat quality compared to what was dried up. If we make a rough estimate that what we surveyed represents 5% of the total larval habitat area available in this reach, the total habitat loss is estimated to be 30,000 m^2 (7.5 acres); in all likelihood it represents less than 5%, and in that case the total habitat loss would be even higher.

A fine mesh net was used to spot check for larval lamprey at five sites within the remaining habitat, and we detected lamprey in all five sites (both Pacific lamprey and Western brook lamprey were identified). Side channel connections and backwater eddies, which tended to have larger habitat areas, also appeared to experience greater habitat loss compared to others. These types of habitat generally have a flatter slope compared to mainstem habitat, resulting in greater loss of habitat when subjected to the same level of water drop. Furthermore, after dewatering, the flow of these side channels were greatly reduced, resulting in a small trickle or dried up inlets and outlets, making lamprey susceptible to isolation from the mainstem river water. A high density of wildlife (raccoons, river otters, etc.) and avian track marks by the dewatered sand bars were observed at these sites, indicating potential predation of desiccated larval lamprey. Whether the rate of flow reduction for Flip Flop is gradual enough for larval lamprey to escape in time from dried up banks and isolated side channels will require further investigation. Furthermore, the impact of Flip Flop operation on adult and newly hatched lamprey could potentially be devastating in both Upper Yakima and Naches Basin and we recommend further analysis.

Methods

Photographs were taken on 8/24/2012, before the Flip Flop, and 9/10/2012 and 9/12/2012, roughly two weeks after the beginning of the Flip Flop. Sites were selected between Cle Elum and Roza Dam based on previously sampled sites where lamprey were found as well as new sites that had optimal habitat. Habitat was generally found in channel margins, backwater eddies, side channel connections, periphery of vegetative islands, and some boat launches. Photographs of available habitat were taken pre and post Flip Flop in identical locations to show the amount of habitat loss at each site. On 9/12/12, measurements were taken at each site to estimate the amount of habitat loss for rearing larval lamprey. The total area of larval lamprey habitat [Type 1 (preferred habitat with fine sediment and organic matter) and Type 2 (usable habitat with a combination of fine and coarse sediment)] that was available during the first visit but dried up completely or lost connection to flowing water as a result of the dewatering event was measured.

Results

See below:

UY 18 (rkm 300.9) – So. Cle Elum Way, Cle Elum, WA

Habitat in this side channel is located mostly on the right bank (looking upstream) and on the channel margin of a pool (Figure 1 and 2). The exposed habitat was primarily Type 1 habitat, with small areas of Type 2 habitat also exposed. Habitat loss consisted of fine and coarse sand, detritus, and small woody debris (Figure 2). Type 2 and to a lesser degree Type 1 habitat with some fine organic matter was still present after the water drop. The majority of the surrounding substrate is gravel, cobble and boulder. Both the inlet and outlet of the side channel were greatly reduced by 9/12/2012, and appeared absent during a later visit on 9/17/2012. The drop in water level exposed an estimated *24* m^2 of habitat (50% of the *48* m^2 total habitat area).

Before ***After***

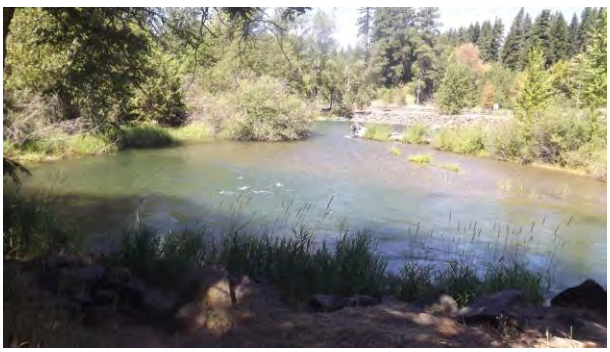


Figure 1. Inlet of the side channel (main channel in the background). Cobble and boulders was also abundant. Prime habitat present in the lower right corner of the photo near channel margin.

Before ***After***

Figure 2. Showing the water level drop and woody debris still mixed with available habitat at the side channel margin. Prime habitat was located here.

UY 32 (rkm 266.1) – Highway 10 west of Ellensburg, WA (across from Red Hawk Ranch)

One stretch of habitat was present at the inlet of a side channel on the right bank. The habitat loss was primarily Type 1 with patches of Type 2. The exposed Type 1 sediment consisted of small amounts of detritus mixed with fine and coarse sand. There was some available Type 1 habitat after the water drop. Figure 3 shows an overview of the water drop in this area with habitat visible in the bottom left of the photo. The inlet and outlet of the side channel was constricted to a trickle flow after dewatering. No sediment was found at any other point at this site. The water level drop caused approximately *6 m*^{2} of habitat loss (40% of the *15 m*^{2} total habitat area) (Figure 6).

Before ***After***

Figure 3. Water level overview at mouth of side channel. No sediment was found near the pictured log jam or further at any accessible points downstream within the side channel.

Before ***After***

Figure 4. Water level drop showing both lost and available Type 1 habitat.

UY 33 (rkm 264.8) – west of Ellensburg, WA along Highway 10 (Upstream of Town Diversion Dam)

This area is the confluence of a side channel. The site has an abundance of Type 1 habitat with aquatic plants and algae present mainly in the side channel. Habitat, both lost and still available after the water drop, was all Type 1 and consisted of fine organic matter, aquatic plants, clay and fine sand. The sediment within the side channel was soft and "fluffy" to the touch when under water, and up to knee deep in places. The sediment of the main channel backwater was a mix of coarse and fine sand. After dewatering, the side channel had much reduced flow, with minimum flows at the inlets and outlets. An overview of the side channel confluence is shown in Figure 5 and an access point to the side channel in Figure 6. We estimated a habitat loss of *1115* m^2 after dewatering (70% of the *1586* m^2 total habitat area).

Before ***After***

Figure 5. Overview of confluence of side channel above Town Diversion Dam.

Before ***After***

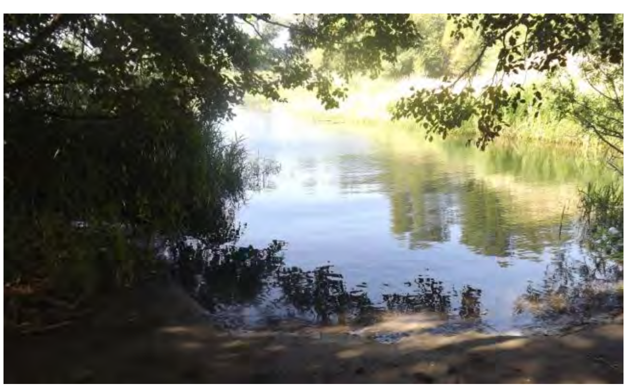


Figure 6. Small access point to the side channel. Beaver dam and some reduced habitat still present further upstream.

UY 39 (rkm 261.1) – west of Ellensburg, WA along Eastbound I-90

Side channel located off of Eastbound I-90 towards Ellensburg. Both available and lost habitat was primarily Type 1 habitat. Habitat constisted of fine sand and some organic matter. The sediment was shin deep in places and accumulated behind logs and boulders. There were several pockets of Type 1 sediment visible in this area (Figure 7 and 8). The total estimated loss of habitat was *29 m*^{2} (50% of the *58 m*^{2} total habitat area).

Before

After

Figure 7. Overview showing logs and boulders located along the right bank. Patches of sediment visible between.

Before

After

Figure 8. Sediment located between a inclined log on the left bank (looking upstream) of the side channel.

UY 42 (rkm 255.7) – KOA Campground, Ellensburg, WA (Camp Site # T9)

This small island, accessible from the KOA Campground in Ellensburg, has available habitat located from near the center to its downstream end. Both Type 1 and Type 2 habitat were present, with Type 2 being most predominant. Type 1 habitat consisted of fine organic matter, fine sand, and clay, while Type 2 had the addition of gravel and cobble (Figure 9). The habitat was completely covered by water before the Flip-flop, but afterwards, the entire island as well as the side channel inlet and outlet were dry and habitat was completely lost (Figures 9 and 10). An estimated *10 m²* of habitat was lost at this site (100% of the total habitat area).

Before

After

Figure 9. Looking downstream from upstream end of island showing complete water loss over the island.

Before

After

Figure 10. Type 1 and Type 2 habitat dried up after Flip Flop. Photo taken near center of island.

UY 52 (rkm 235.7) – Canyon Rd. south of Ellensburg (edge of River by rock pile)

Area downstream of one of many rock piles along Canyon Road between Ellensburg and Selah. The sediment at the upstream end of the island was soft and mixed with clay and fine organic matter, while sediment on the island immediately surrounding the vegetated island was primarily fine sand. The habitat, both available and lost, would be considered Type 1. The back side of the island was not photographed so water level was hard to pinpoint for habitat loss estimates (hence not included). There was stagnant, warm water with an overgrowth of vegetation present after the water level dropped (Figures 11 and 12), and this area was included in the loss of habitat estimation. The photographed loss of habitat was estimated at *243* m^2 (70% of the *347* m^2 total habitat area) (Figure 11).

Before ***After***

Figure 11. Water level change before and after Flip-flop. Sediment is present on downstream end of island as well, but was not included in habitat loss estimation. Stagnant water present.

Before ***After***

Figure 12. Loss of habitat and stagnant water. There is a definite edge where the water was before the water level drop.

UY 53 (rkm 235.5) – Canyon Rd. south of Ellensburg, WA (edge of River by rock pile)

This is the downstream end of another rock pile downstream of UY 52 between Ellensburg and Selah along Canyon Road. The remaining habitat, both available and lost, was Type 1, consisting of fine sand and some coarse sand (Figure 13 and 14). Due to accessibility issues, we were not able to measure the habitat loss on the ground. However, through previous observations, and analysis of photos, the habitat loss was estimated to be between *80 and 100* m^2 (50% of the total habitat area).

Before

After

Figure 13. Overview of habitat loss below rock pile. All Type 1 habitat.

Before

After

Figure 14. Close-up of available habitat close to rock pile on the downstream end.

UY 56 (rkm 229.7) – Canyon Rd. Ellensburg, WA (Umtanum Recreation Boat Launch Site)

The only visible habitat at this site was at the boat launch at the Umtanum Recreation site off of Canyon Road between Ellensburg and Selah. The habitat here is primarily Type 2 with a patch of Type 1. The sediment was not very deep, consisting of fine sand on top of coarse rock, or on top of the root wad in Figure 15. All available habitat was lost after dewatering began. This is a high traffic area, so the accumulation of sediment may be displaced/disturbed considerably during the summer months. Figure 16 shows an upstream overview of the Yakima River, showing the water level drop in this area. No available habitat was observed upstream or downstream from this site. The amount of habitat loss was estimated at *3 m*^{2} (100% of the total habitat area).

Before

After

Figure 15. View of boat launch from the foot bridge. Sediment primarily present on upstream side of boat launch.

Before

After

Figure 16. View from the foot bridge. No habitat viewable either upstream or downstream. Here the water change is noticeable on the right side of the river.

UY 62 (rkm 214.9) – Canyon Rd. south of Ellensburg, WA (pullout off southbound roadside)

This was an access point to the river between Big Pines Recreation site and the Roza Recreation site off of Canyon Road. There is a small foot trail that leads to this location from a WDFW access site. There is abundant fine sediment consisting mainly of fine sand with a mix of course sand and small woody debris (Figure 17 and 18). Remaining habitat after dewatering was more shallow compared to habitat that dried up, but still appeared to consist of primarily Type 1 habitat. All habitat loss consisted of Type 1 habitat. This was the only pocket of fine sand visible at this site. Habitat loss was estimated as *11* m^2 (40% of the *28* m^2 total habitat area).

Before

After

Figure 17. Access site off of small paved trail.

Before

After

Figure 18. Water level drop facing downstream from the access site.

Table 1. Summary of habitat loss for the nine sites that was evaluated.

Site Name	**RKM**	**Total Habitat Area (m^2)**	**Habitat Loss (m^2)**	**% Loss**
UY18	300.9	48	24	50
UY32	266.1	15	6	40
UY33	264.8	1600	1120	70
UY39	261.1	58	29	50
UY42	255.7	10	10	100
UY52	235.7	347	243	70
UY53	235.5	~180	~90	50
UY56	229.7	3	3	100
UY62	214.9	28	11	40
Overall	***86.0***	***2289***	***1536***	***67***

Figure 19. Photo of desiccated larval lamprey from a dam dewatering event in North Umpqua River (Southern Oregon) in 2009. Hundreds of larval lamprey are visible in this small 0.5 m^2 area. Within a couple days, various avian and wildlife predators cleaned up virtually all of these lamprey morts, making them disappear rather quickly.

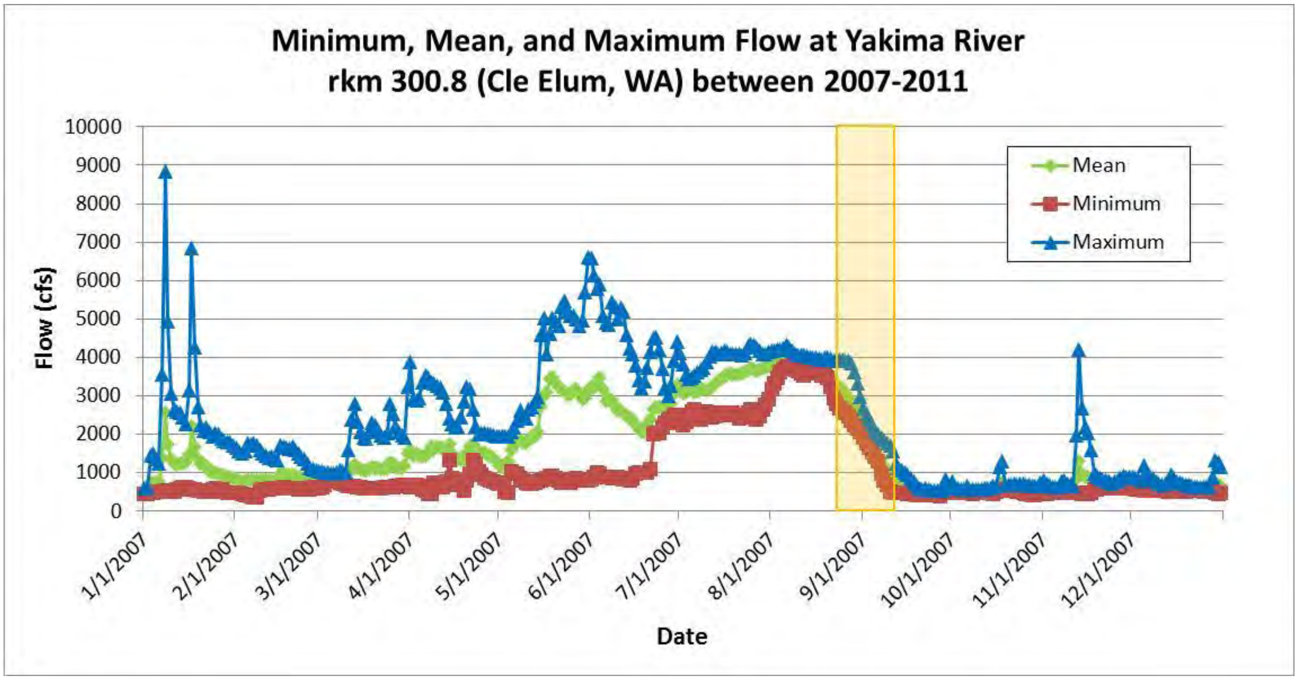


Figure 20. Graph of Yakima River (rkm 300.8) annual flow fluctuations with the Flip Flop dewatering period highlighted in orange. During this 3-week dewatering period, water level drops by approximately 2,750 cfs (mean daily drop of 130 cfs).

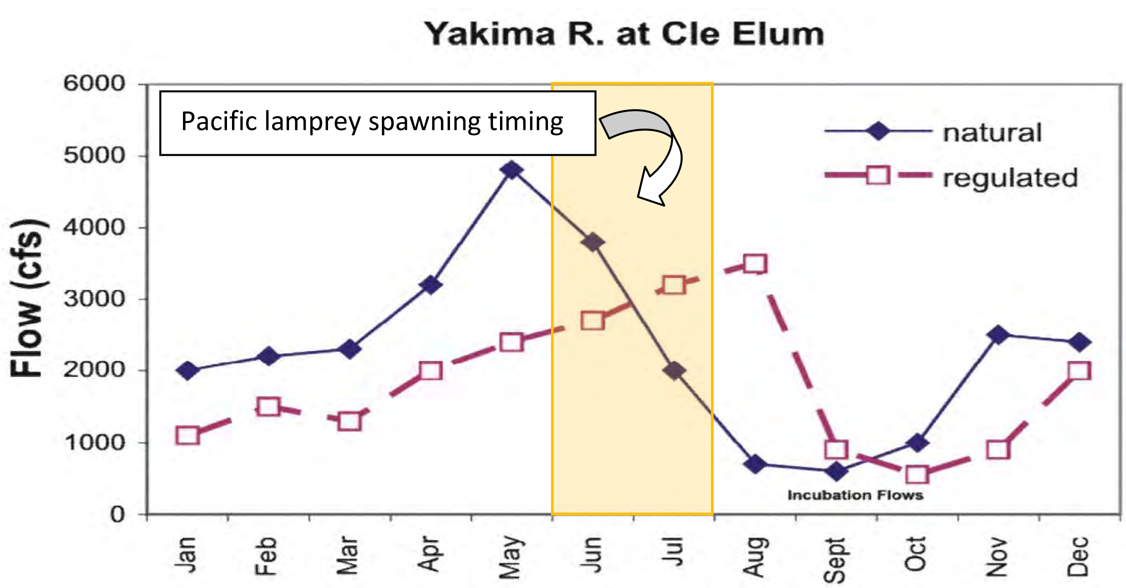


Figure 21. Graph of regulated and natural Yakima River (rkm 300.8) annual flow fluctuations (inserted from "Evaluation of the Effects of 'Flip-Flop' Operations on Spring Chinook Production in the Yakima Basin" Cramer Fish Sciences 2007). The area highlighted in orange shows the Pacific lamprey spawning timing in Upper Columbia Basin.

Under the natural flow regime, the flow reduction takes place over a longer period compared to the regulated flow regime (~90 days compared to ~21 days), hence the rate of flow reduction is much reduced (~45 cfs/day compared to 130 cfs/day) (Figure 20 and 21). In addition, the spawning timing of Pacific lamprey in Upper Columbia Basin is generally between June and July in synchrony with the onset of the reduction in snow melt high flow water. Under the regulated flow regime, this reduction in flow is not observed until late August, which is considerably past their natural spawning timing and Pacific lamprey may miss an important environmental cue to successfully spawn. In 2012, with overwintered adult lamprey in holding tanks, we found that those that did not sexually mature by the following July never showed any signs of spawning readiness all summer/fall, potentially indicating that if they miss the window of opportunity to spawn between this time period, they may be simply incapable of spawning that year (or indefinitely). Even if they were able to spawn in late summer, the rate of flow reduction could likely desiccate eggs as well as newly hatched larvae that have not had the chance to migrate out of the redds. As a result, the impacts of Flip Flop operation on adult and newly hatched lamprey requires serious consideration (in Naches Basin as well).

Larval Lamprey Spot Checks / Photographs

Spot checks using a mesh net (5 mm) were performed at five sites within available habitat still present after the water drop (two sites lost all the larval habitat). Lampreys were found at all the sites that were sampled. Both Western brook lamprey and Pacific lamprey larvae were identified. At two of the sites, lamprey were only observed swimming away from the net and were not captured. Captured larvae were all above 50 mm (including a transformed Western brook lamprey that was >100 mm) (Figure 22-26) whereas all those that were only observed were estimated to be under 50 mm.

Table 2. Summary of sites where lamprey were captured or observed. Sites that did not have habitat or sites that could not be spot checked are also listed.

Larvae Captured	UY18, UY33, UY52
Larvae Only Observed	UY32, UY39
No Remaining Habitat	UY42, UY56
No Sampling	UY53, UY62

Figure 22. Larval lamprey (>50mm) found at site UY 18. This was the only lamprey found at this site. The middle of the caudal ridge was clear and suggests Pacific lamprey, though identification is not certain.

Figure 23. Photograph of a Western brook lamprey (>100mm and eyes present) found at UY 33 confluence of side channel. The wildlife and avian track marks can be seen in the background.

Figure 24. Photograph of the same Western brook lamprey showing one of its newly developing eyes.

Figure 25. Tail of a larval Pacific lamprey found at confluence of side channel at site UY 33.

Figure 26. Tail of a larval Pacific lamprey captured at UY 52 on the main channel side of the island.

Aerial Maps

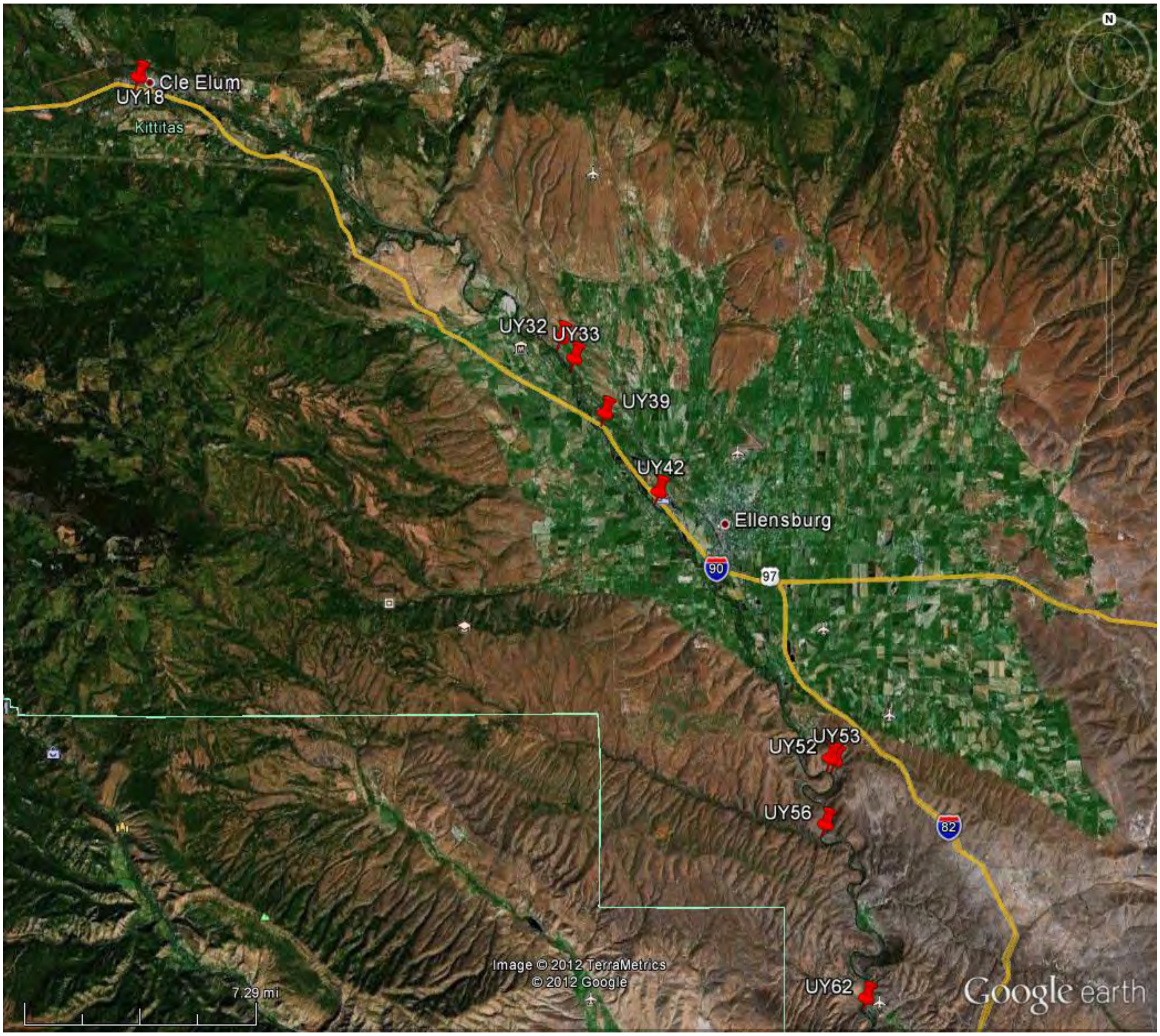


Figure 27. Google Earth overview of all (9) sites monitored before and after the Flip Flop.

Figure 28. Close-up map of Site UY18.

Figure 29. Close-up map of Site UY32 and UY33.

Figure 30. Close-up map of Site UY39.

Figure 31. Close-up map of Site UY42.

Figure 32. Close-up map of Site UY52 and UY53.

Figure 33. Close-up map of Site UY56.

Figure 34. Close-up map of Site UY62.

Effects of Water Quality on Pacific Lamprey in the Yakima River Basin

Yakama Nation FRMP, Pacific Lamprey Program

Prepared by Ralph Lampman

June 6, 2012

Background:

Although Yakima River Basin has undergone many in-depth water quality investigations in the past decades, examining the prevalence, abundance, and distribution of contaminants as well as their effects on fish, macroinvertebrates, and algal communities, hardly any information exists related to the effects of water quality on lamprey species in the basin.

Recommended Actions:

- Establish water quality sampling sites in the Yakima River Basin that are known to have water quality issues. Literature suggests that levels of contaminants (whether it be pesticide, insecticide, herbicide, or eutrophication) are high in agricultural tributaries and lower reaches of the mainstem river. We are also interested in the levels of contaminants along the river continuum from upper reaches to lower reaches. Therefore, we recommend the following nine sites along the Yakima River: 1) Roza Dam, 2) Selah, 3) Wapato Diversion, 4) Wapato Reach, 5) Granger, 6) Prosser Dam, and 7) Horn Rapids Dam (Figure 1). We also included two tributary sites: 1) Lower Naches and 2) Marion Drain (selected due to its use in the near future as a potential lamprey propagation facility).
- At a minimum, fish tissues from larval samples (whether it be Pacific lamprey or resident lamprey) will be analyzed for contaminants (such as pesticide, steroids, and other chemicals of interest). Bed sediment samples will also be taken to evaluate the correlation with the contamination from the fish tissue (*The Granger and Prosser Dam are near existing water testing sites that Washington Dept. of Ecology monitors regularly, so we will check to make sure that these samples are not duplicated anywhere else; if other agencies are already conducting these tests, we will utilize their data).
- Timing of sampling would occur sometime between late May and late June, which appears to correspond to the peak levels in various contaminants from year to year (due to the irrigation flow management). Coincidentally, this also corresponds to the spawning season of Pacific lamprey, and we suspect that this could be detrimental to adult lamprey (physiologically and behaviorally). If we are able to locate adult lamprey within the basin (through tagged lamprey that are translocated, for instance), we will also sample the fish tissue from these individuals after they are spent and/or spawned out. Larval lamprey migrate year round, but there appears to be a distinct peak in movement observed immediately before the spawning season (data from various smolt traps in

Oregon and Washington). The fact that larval lamprey are migrating actively in the water column during these peak periods for contaminants may also be detrimental to their health and growth.

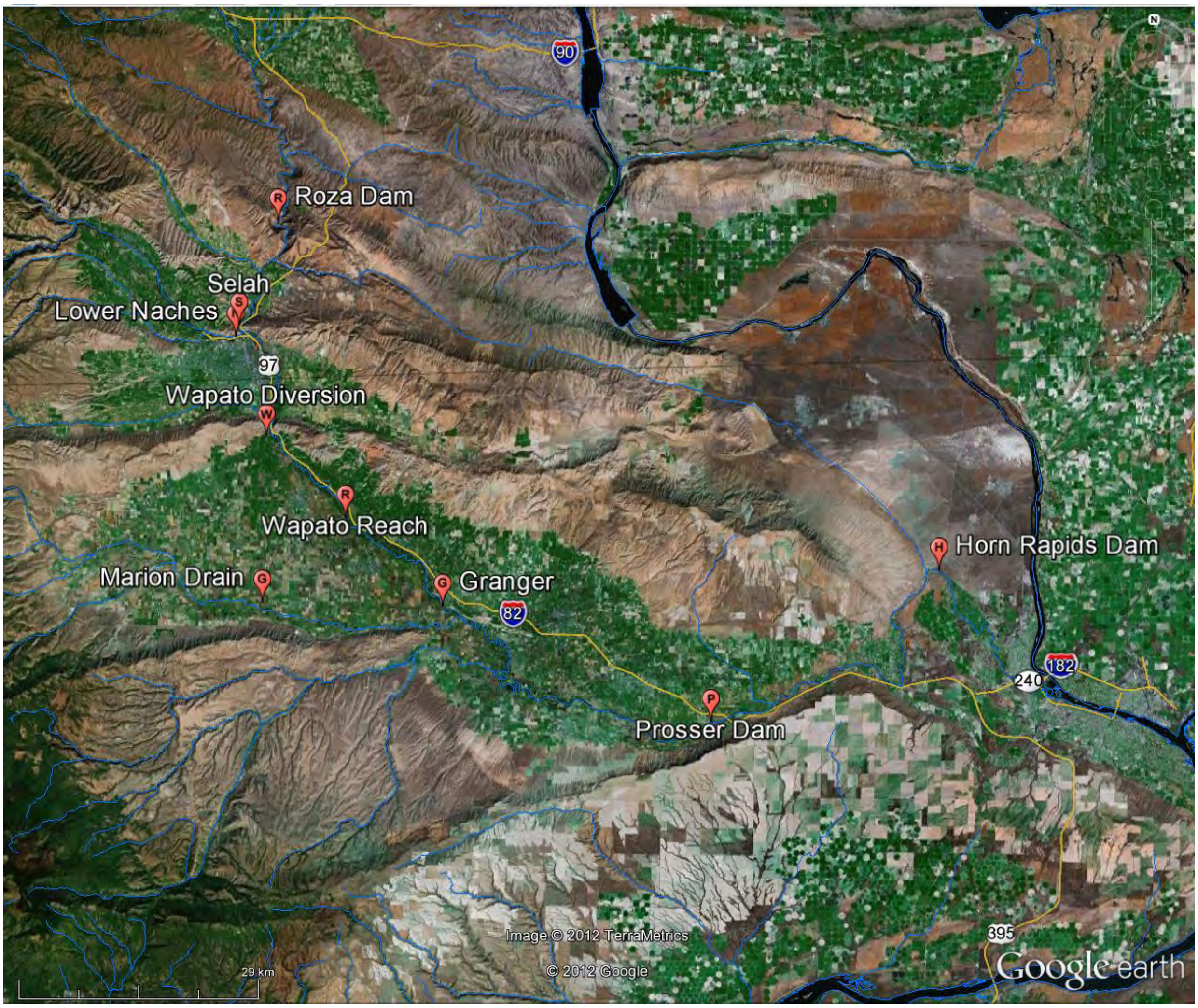


Figure 1. Nine sampling sites for water quality measurements in the Yakima River Basin.

- We also recommend that summer temperature profiles be established in seven sites within the Yakima Basin to better understand how temperature may influence lamprey rearing (Figure 2).
- The Hydromet (Bureau of Reclamation) water temperature monitoring sites provide year around temperature data and are distributed widely across the Yakima River and Naches watershed. However, there is a large gap in data collection between the Grandview and Parker sites and a considerable gap between the Parker and Roza Dam sites. The lower Yakima River near the mouth also not being monitored.
- We will establish five sites between Grandview and Parker sites, one site between Parker and Roza Dam sites, and one site near the mouth of Yakima River.

- Furthermore, USGS is also working cooperatively with BOR to model water temperature in the reaches between Roza Diversion Dam and Prosser Dam, which would provide useful data for furthering our understanding of how these reaches are used by lamprey.

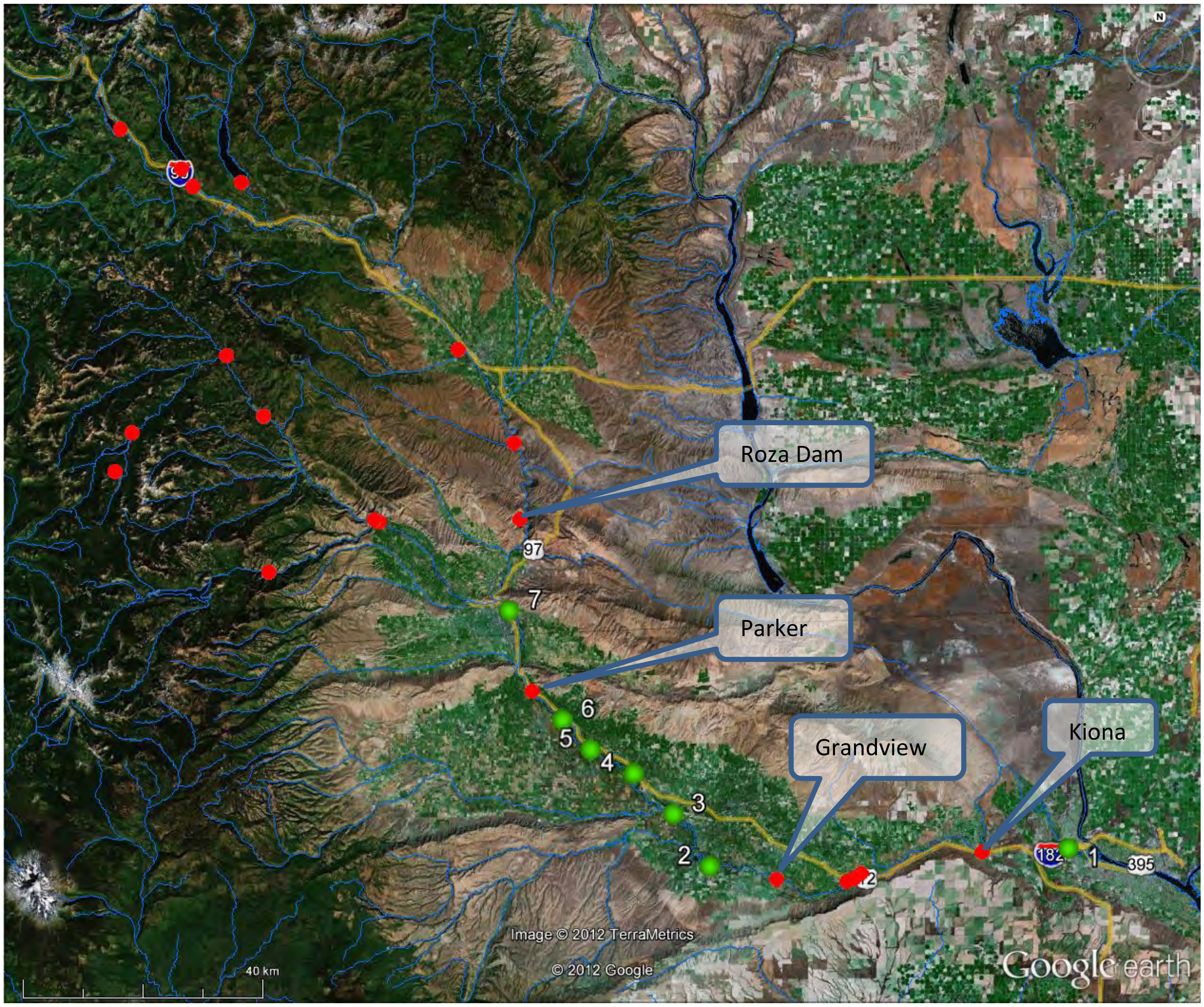
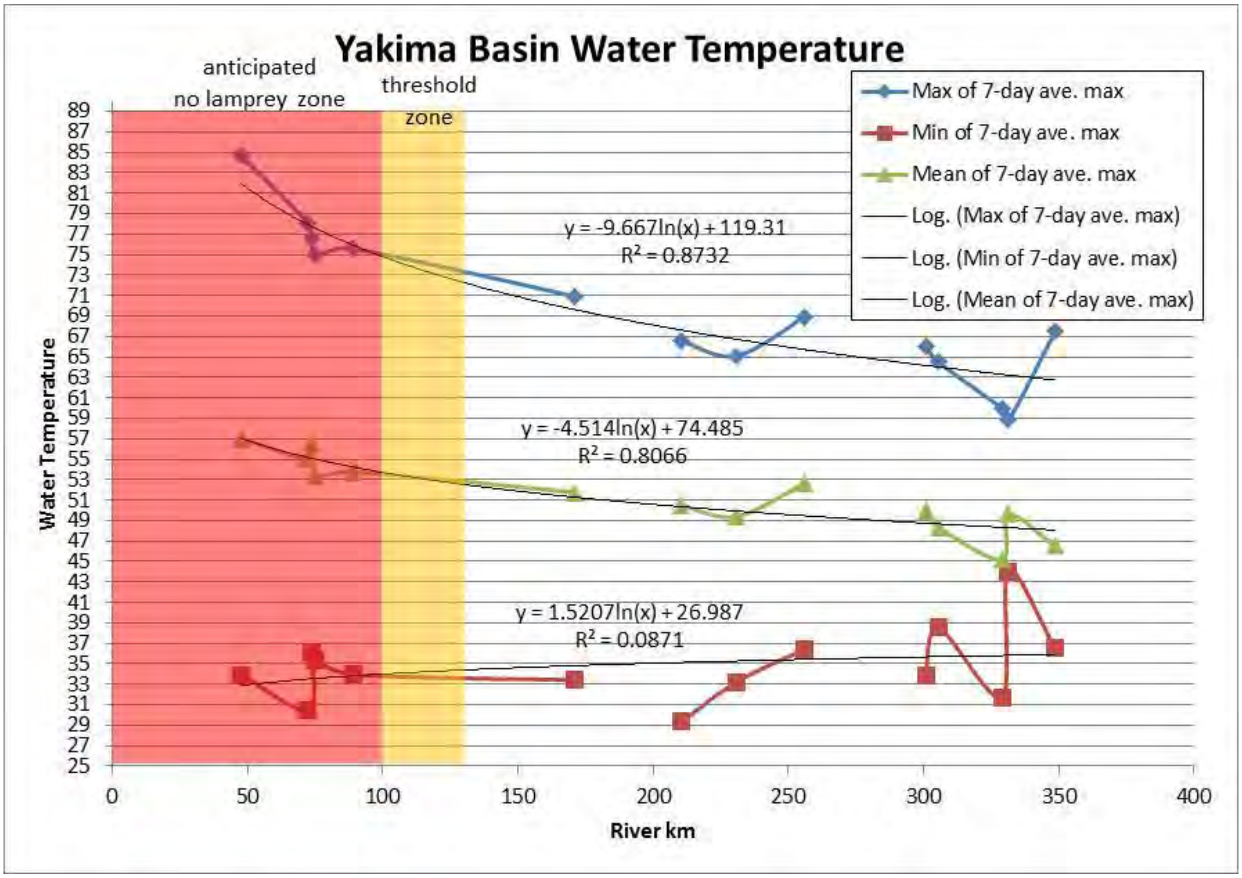


Figure 2. Seven sampling sites for summer water temperature measurements in the Yakima River Basin (shown as green circles). The Hydromet (Bureau of Reclamation) all-season water temperature monitoring sites are shown as red circles.

- Based on the Hydromet temperature data analysis using the previous five years of data (2007-2011), we anticipate that larval lamprey may not be present in the lower Yakima River (0 – 100 river km) during peak summer temperatures as they normally exceed 75 F (Meeuwig et al. 2005 showed a large increase in larval lamprey mortality in 72 F).
- By focusing our temperature monitoring in the reaches between Parker (rkm 171) and Grandview (rkm 89) sites, we will be able to get a better understanding of the thermal thresholds for larval lamprey in this lower reach of the river.



Yakima Basin Water Temperature
anticipated
no lamprey zone
threshold
zone
Max of 7-day ave. max
Min of 7-day ave. max
Mean of 7-day ave. max
Log. (Max of 7-day ave. max)
Log. (Min of 7-day ave. max)
Log. (Mean of 7-day ave. max)
y = -9.667ln(x) + 119.31
R² = 0.8732
y = -4.514ln(x) + 74.485
R² = 0.8066
y = 1.5207ln(x) + 26.987
R² = 0.0871
Water Temperature
River km

Key Literature Sources:

Cuffney, T. F., M. R. Meador, S. D. Porter, and M. E. Gurtz. 1997. **Distribution of fish, benthic invertebrate, and algal communities in relation to physical and chemical conditions, Yakima River Basin, Washington, 1990.** U.S. Geological Survey Water-Resources Investigations Report 96-4280, 94 p.

- Physical, chemical, and biological indicators of water-quality conditions showed that the Cascades and Eastern Cascades site group had the fewest impaired sites and that impairment was only moderate (some metals, but not a significant factor in fish community)
- Sites in the Columbia Basin site group were all moderately or severely impaired with the exception of two reference sites (Umtanum Cr. & Satus Cr. below Dry Cr.). Three sites were heavily affected by agriculture (Granger Drain, Moxee Drain, and Spring Creek) and were listed as severely impaired by most of the physical, chemical, and biological condition indices. Stimulation of algal growth by nutrients and possible toxicological effects of pesticides combine to cause major shifts in the food base for invertebrates and fish.
- Larger-river sites located downstream from the city of Yakima had moderate to severe levels of impairment. Severe impairment of fish communities at these sites was associated with high levels of pesticides in fish tissues and the presence of external anomalies on fish (also found at Granger Drain). Assessment of fish community conditions and the concentrations of pesticides in fish tissues were better indicators of site conditions.
- The data suggests that invertebrates and algae exhibit a threshold effect at relatively low levels of agricultural intensity (fish communities showed more of a linear effect).
- Contamination in filtered water and suspended sediment reflected the value in bed sediment (highly correlated). These values were also highly correlated with NPAI (index for intensity of agriculture). NPAI was also highly correlated with amount of nutrients and degree of embeddedness.
- Granger Drain, Moxee Drain, Spring Creek were highly impaired (Cherry Creek, too)
- Satus Creek has a high level of algae

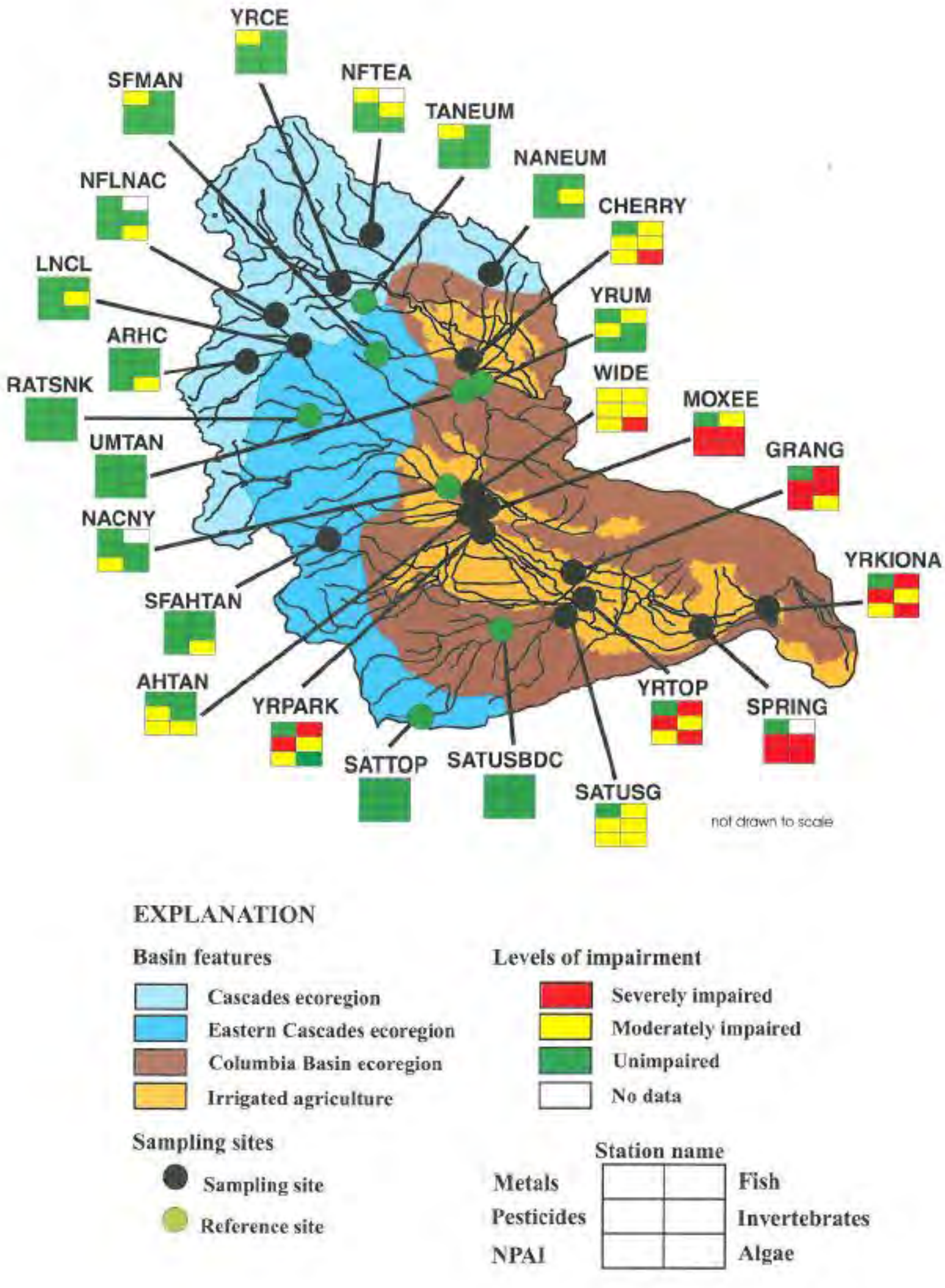


Figure 17. Map showing site condition ratings based on fish, invertebrate, and algal community condition indices and indices of metals enrichment, agricultural intensity, pesticides contamination, and disturbance. (Site abbreviations are listed in table 1.)

Table 8. Summary of site conditions determined from indices that characterize metals enrichment, agricultural intensity (NPAI index), pesticide contamination, and disturbance within the Yakima River Basin, Washington

[Thresholds for high (red) levels of metals, agricultural intensity (NPAI index), pesticides in filtered water, pesticides in suspended sediment, pesticides in fish tissues, abd disturbance indices are: > 20, >100, > 30, > 100, > 20, and > 20. Thresholds for low (green) levels are < 4, < 12, < 6, < 10, < 10, and < 4. Conditions were assigned to the moderate (yellow) level if they did not fall in either the high or low category. Missing values precluded the determination of site conditions based on pesticides in bed sediment. HC, Hells Crossing; NF, North Fork; SF, South Fork; Cr, Creek; nr, near; blw, below; YR, Yakima River; N, North; —, index could not be estimated.]

Very high

USGS station number	Site	Site condition indices: Metals index	NPAI index	Index of pesticide concentrations in: Filtered water	Suspended sediment	Bed sediment	Fish tissue	Disturbance index
Cascades site group								
12479750	NF Teanaway	9.6	2.6	3.0 [a]	4.0 [a]	4.2	0.1	1.6
12481900	Taneum Creek	5.4	2.8	3.0 [a]	4.0 [a]	4.4	0.1	1.2
12483750	Naneum Creek	2.3	6.4	3.0 [a]	4.0 [a]	4.5	0.1	1.3
12488250	American River at HC	3.5	4.3	3.0 [a]	4.0 [a]	1.8	0.1	1.2
12497200	NF Little Naches River	2.2	3.0	3.0 [a]	4.0 [a]	—	0.1 [b]	1.0
Eastern Cascades site group								
12483190	SF Manastash Creek	4.0	8.7	3.0 [a]	4.0 [a]	4.6	0.1	1.6
12487200	Little Naches River	2.5	7.1	3.0 [a]	4.0 [a]	4.2	0.4	1.4
12489100	Rattlesnake Creek	2.9	4.0	3.0 [a]	4.0 [a]	1.0	0.1	1.1
12500900	SF Ahtanum Creek	1.4	11.4	3.0 [a]	4.0 [a]	5.4	0.1 [b]	1.6
12507594	Satus Cr nr Toppenish	2.8	9.0	1.3	3.7	—	0.2	1.4
Columbia Basin site group								
12484440	Cherry Creek	4.0	70.7	19.0	88.8	147.2	1.9	14.8
12484550	Umtanum Creek	2.2	9.4	1.6	4.9	1.2	1.3	1.6
12500430	Moxee Drain	1.7	108.1	58.7	138.1	105.2	16.4	26.3
12500442	Wide Hollow Creek	4.8	79.0	11.0	20.6	26.4	13.1	10.5
12502500	Ahtanum Creek	2.4	60.6	6.2	15.8	—	6.0	7.4
12505460	Granger Drain	2.2	200.0	41.2	504.6	89.7	36.5	63.8
12508500	Satus Cr blw Dry Cr	1.7	8.7	3.0 [a]	4.0 [a]	5.0	0.4	1.4
12508620	Satus Cr at gage	2.6	72.5	22.1	30.6	—	2.4	10.6
12509710	Spring Creek	2.2	144.4	18.2	304.8	—	7.7	38.8
Large-river site group								
12479500	YR at Cle Elum	6.2	3.4	1.4	8.0	—	1.7	1.7
12484500	YR at Umtanum	2.9	16.2	5.8	7.7	7.6	4.8	3.0
12499000	Naches R. at N. Yakima	3.2	6.8	1.5	1.7	—	12.7	2.1
12503950	YR at Parker	3.2	27.5	7.2 [c]	9.8 [c]	89.2 [c]	21.9	5.7
12507525	YR blw Toppenish	2.9	50.5	12.5 [d]	50.4 [d]	—	24.9	11.5
12510500	YR at Kiona	2.8	48.0	17.2	49.3	15.3	27.8	11.8

[a] Estimated from data collected at Cooper River.
[b] Estimated from concentrations measured at Cascade and Eastern Cascade sites.
[c] Estimated from data collected at Yakima River above Ahtanum Creek at Union Gap.
[d] Estimated from data collected at Yakima River at RM 72.

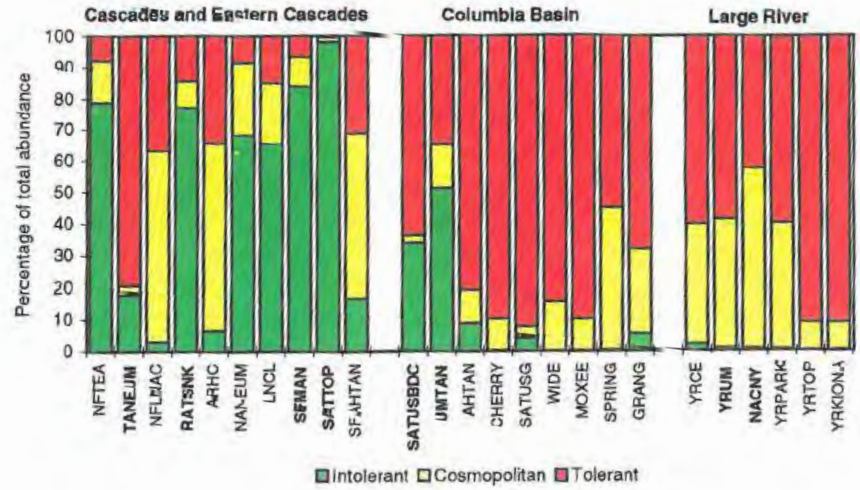


Figure 7. Algal community composition based on autecological classifications described in the literatu abbreviations are given in table 1. Reference sites are shown in bold type.)

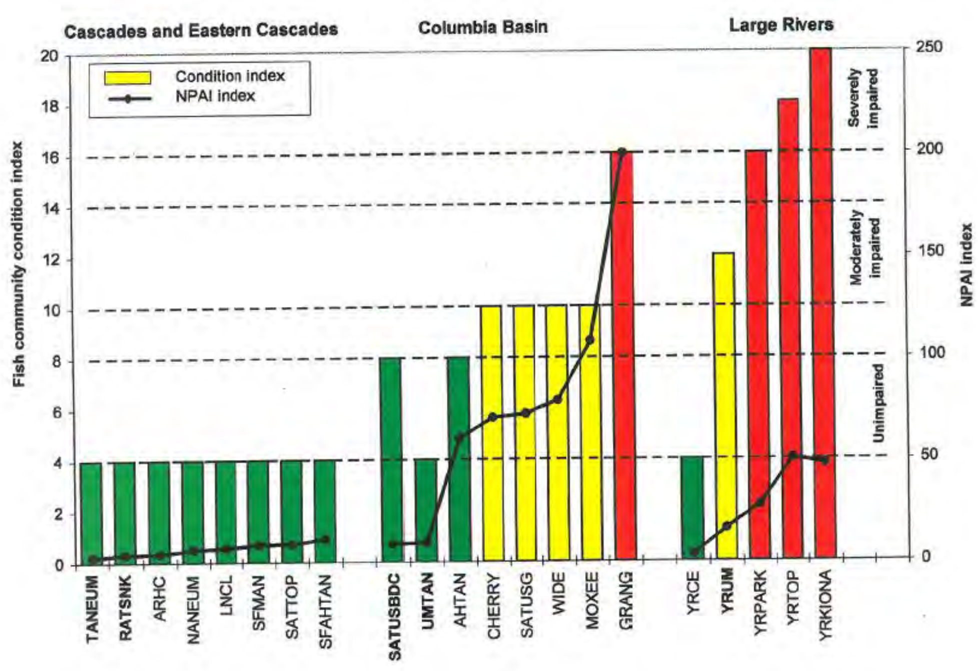


Figure 11. Relation between the multimetric fish community condition index and the non-pesticide agricultural intensity (NPAI) index, Yakima River Basin, Washington, 1990. (Site abbreviations are listed in table 1; reference sites are shown in bold type.

Ebbert, J. C. and S. S. Embrey. 2002. **Pesticides in surface water of the Yakima River Basin, Washington 1999-2000 – Their occurrence and an assessment of factors affecting concentrations and loads.** U.S. Geological Survey Water-Resources Investigations Report 01-4211, 49 p.

- A total of 25 pesticides compounds were detected in samples collected during the study. Detection frequencies ranged from about 1% for ethalfluralin, ethoprophos, and lindane to 82% for atrazine. Maximum concentrations of azinphos-methyl, carbaryl, diazinon, para,para'-dichlorodiphenyldichloroethylene (p,p'-DDE), and lindane exceeded chronic-toxicity guidelines for the protection of freshwater aquatic life. Atrazine was the most widely detected herbicide; azinphos-methyl was the most widely detected insecticide.
- The highest detection frequencies and concentrations of pesticides generally occurred during irrigation season, which is from mid-March to mid-October. Pesticides are applied during irrigation season, and runoff of excess irrigation water from fields transports them to surface water.
- Ground-water discharges also transport some pesticides to surface water (atrazine, deethylatrazine, and simazine detected when there was little or no surface runoff)

Table 9. Estimates of agricultural pesticide usage in the Yakima River Basin, Washington, during 1999 and detection rates of the pesticides in Yakima River at Kiona, Washington, May 1999 through January 2000

[Usage data are only for pesticides listed in table 1; I, insecticide; H, herbicide; %, percent;detection rates are based on 16 samples collected from Yakima River at Kiona; percentages for usage may not total to 100 because of rounding]

Pesticide	Type	Amount of active ingredient applied (pounds)	Percent detections	Primary uses
Azinphos-methyl	I	294,600	50	Apples 88%, pears 7%, cherries 4%
Chlorpyrifos	I	162,900	12	Apples 73%, cherries 11%, pears 8%
Carbaryl	I	116,200	75	Apples 71%, cherries 19%, asparagus 4%, pears 3%
Propargite	I	49,900	0	Hops 95%, wine grapes 3%, mint 2%
Malathion	I	43,400	38	Cherries 48%, apples 23%, timothy hay 12%, cattle 6%, asparagus 4%
EPTC	H	39,900	19	Corn grain 30%, alfalfa 26%, sweet corn 23%, corn silage 12%
Disulfoton	I	39,000	0	Asparagus 100%
Metolachlor	H	20,200	31	Corn grain 32%, sweet silage 27%, sweet corn 25%, peas and beans 14%
Metribuzin	H	18,900	0	Alfalfa 84%, asparagus 11%, other nonorchard 9%, potatoes 5%
Alachlor	H	16,600	12	Corn grain 36%, corn silage 31%, sweet corn 28%, peas and beans 5%
Carbofuran	I	12,700	0	Wine grapes 83%, other nonorchard 22%, potatoes 8%, alfalfa 6%
Diazinon	I	12,000	6	Hops 52%, pears 17%, apples 12%, cherries 12%, cattle 5%
Terbacil	H	11,500	62	Alfalfa 55%, mint 45%
Simazine	H	8,400	69	Juice grapes 30%, asparagus 28%, pears 28%, wine grapes 13%
Methyl parathion	I	8,400	0	Apples 92%, sweet corn 5%
Atrazine	H	7,600	94	Corn grain 36%, corn silage 31%, sweet corn 29%, pasture 3%
Pendimethalin	H	7,000	0	Mint 96%, peas and beans 4%
Acetachlor	H	6,200	0	Corn silage 95%, corn grain 5%
Trifluralin	H	5,700	19	Asparagus 61%, hops 15%, juice grapes 9%, potatoes 7%, mint 4%
Phorate	I	2,500	0	Potatoes 92%, corn grain 5%, corn silage 4%
Ethoprophos	I	2,500	0	Potatoes 100%
Linuron	H	2,100	0	Asparagus 100%
Terbufos	I	2,000	0	Corn grain 50%, corn silage 43%, sweet corn 7%
Butylate	H	1,900	0	Corn grain 54%, corn silage 46%
Cyanazine	H	1,600	0	Corn silage 74%, corn grain 15%, sweet corn 11%
Fonofos	I	700	0	Asparagus 41%, sweet corn 22%, corn grain 20%, corn silage 17%
Triallate	H	520	0	Peas and beans 100%
Ethalfluralin	H	110	0	Peas and beans 100%
Lindane	I	10	0	Cattle 100%

Also detected: deethylatrazine 81%, *p,p'*-DDE 19%, prometon 6%, tebuthiuron 6%

Ebbert, J. C., S. S. Embrey, and J. A. Kelley. 2005. **Concentrations and loads of suspended sediment and nutrients in surface water of the Yakima River Basin, Washington, 1999-2000 – With an analysis of trends in concentrations.** U.S. Geological Survey Water-Resources Investigations Report 03-4026, 100 p.

- In years of ample water supply, canal water, which is diverted from either the Yakima or Naches River, makes up more of the flow in drains and streams carrying agricultural return flows, diluting the nutrients discharged to the river downstream.
- Concentrations of total nitrogen in drains increase after irrigation season because nitrate, which constitutes much of total nitrogen, continues to enter the drains from subsurface drains and shallow ground water. Concentrations of phosphorus and suspended sediment often decrease, because they are transported to the drains in runoff of irrigation water from fields.
- Loads of nutrients in the Yakima River at Kiona were similar during irrigation and non-irrigation season because average streamflows and concentrations of nutrients were similar between the two seasons.
- Decreased transport of sediment and associated phosphorus to streams and drains likely results from increased use of agricultural best management practices that reduce runoff from cropland.

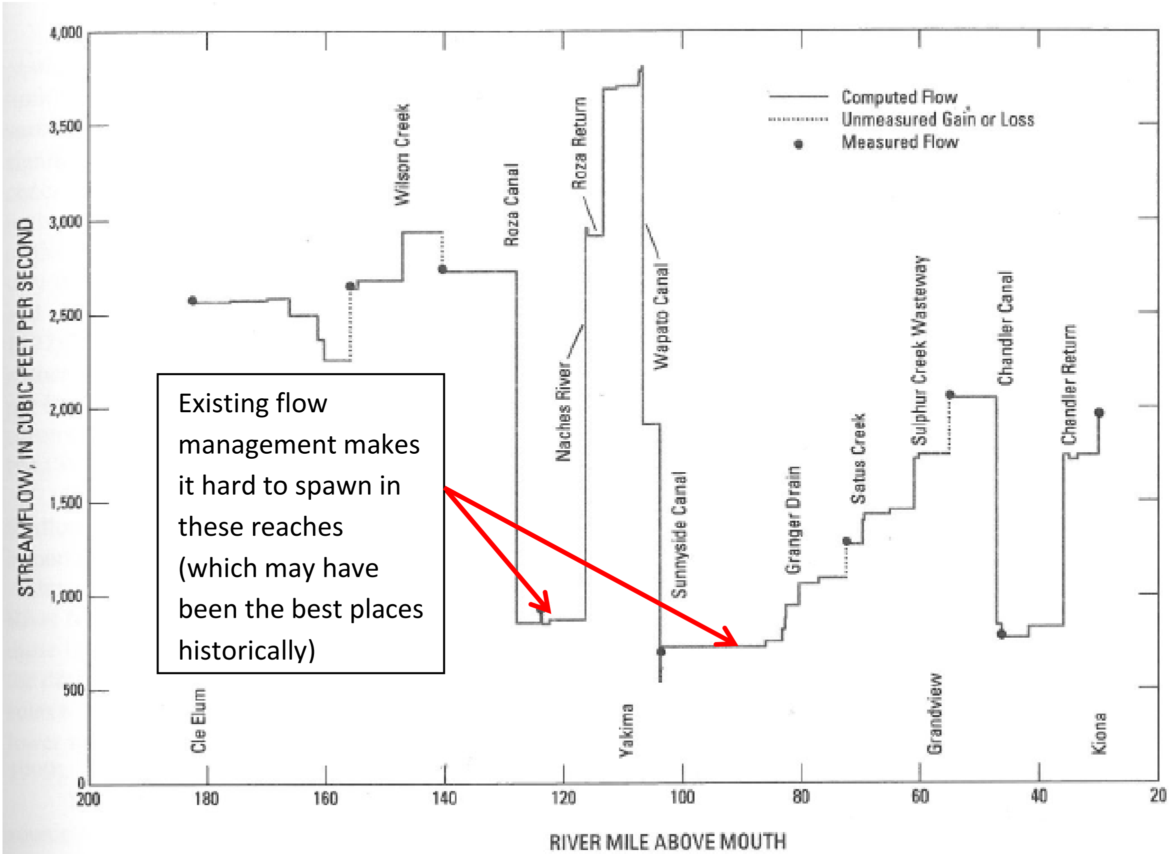
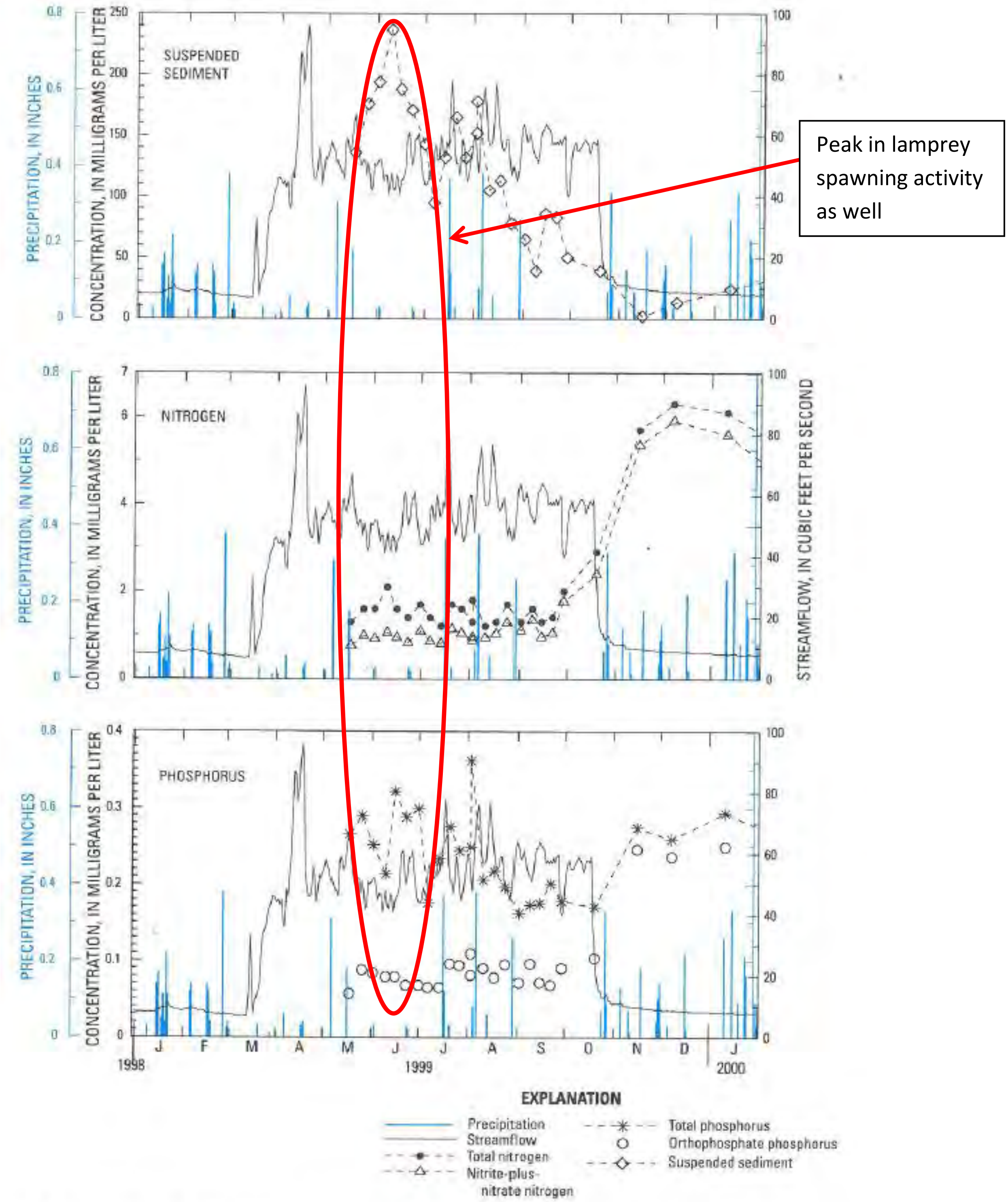


Figure 2. Streamflow in the Yakima River during irrigation, August 2-6, 1999.



***A.* Moxee Drain at Birchfield Road near Union Gap**

Figure 7. Daily streamflow and concentrations of suspended sediment, total and nitrite-plus-nitrate nitrogen, total phosphorus and orthophosphate (as P) in samples collected from selected surface-water sites in the Yakima River Basin, Washington, May 1999-January 2000

Fuhrer, G. J., J. L. Morace, H. M. Johnson, J. F. Rinella, J. C. Ebbert, S. S. Embrey, I. R. Waite, K. D. Carpenter, D. R. Wise, and C. A. Hughes. 2004. **Water Quality in the Yakima River Basin, Washington, 1999-2000.** U.S. Geological Survey Circular 1237, 34 p.

- Nitrate and orthophosphate (both highly soluble) were the dominant forms of nitrogen and phosphorus found in the basin and its agricultural tributaries. Concentrations in some agricultural drains were high enough to support nuisance-level growths of algae.
- The majority of the agricultural streams and drains sampled exceeded the WA state fecal-coliform bacteria standard for multiple water uses (none from the Yakima River exceeded the standard).
- Arsenic (human carcinogen) detected in agricultural drains when ground water is the primary source of streamflow.
- Concentrations of azinphos-methyl (guthion), an insecticide heavily used on orchard in the Yakima Basin (highly toxic to fish and benthic invertebrates), routinely exceeded the USEPA freshwater chronic-toxicity criterion for the protection of aquatic life. The insecticides carbaryl, diazinon, and malathion and the herbicide metribuzin infrequently exceeded auatic-life guidelines.
- Shallow ground water underlying agricultural areas contribute soluble pesticides (mostly herbicides, such as atrazine) and nutrients (such as nitrate) to streams all year.
- Transport of a pesticide to streams depends, in large part, on its tendency to dissolve in water or adhere to soil (as reflected by K_{OC}).
- The dominant types of algae found in agricultural streams and drains were those that prefer or require high concentrations of nutrients and alkaline conditions.

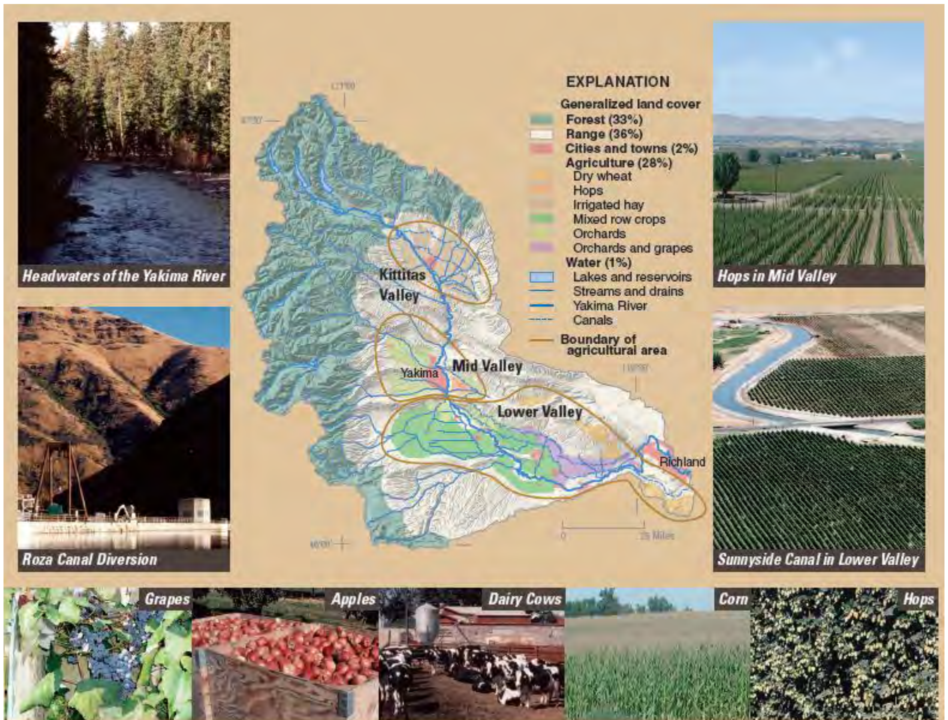


Figure 1. The Yakima River integrates many landscapes and ultimately yields most of its flow to canals that supply water for irrigation.

May be interesting to monitor these endocrine disruptors, which have not been monitored very much

Low levels of steroids and other organic wastewater contaminants have been detected in the Yakima River

In the first round of sampling for pharmaceuticals, hormones, steroids, personal care products, and other wastewater contaminants in U.S. streams, 8 chemicals were detected in the Yakima River downstream from intense agricultural activities [28].

Chemical	Use
Cholesterol	Plant/animal steroid
Coprostanol	Fecal steroid
N,N-diethyl toluamide	Insect repellent
Triclosan	Antimicrobial disinfectant
Tri(2-chloroethyl) phosphate	Fire retardant
Tri(dichloroisopropyl) phosphate	Fire retardant
Carbaryl	Insecticide
Naphthalene	Polyaromatic hydrocarbon

Concentrations of all these compounds were low and were comparable to national data. The first five chemicals listed above were among the most frequently detected in the Nation. Except for carbaryl and naphthalene, which did not exceed drinking-water health advisories, aquatic-life guidelines or drinking-water standards have not been established for the chemicals listed above .

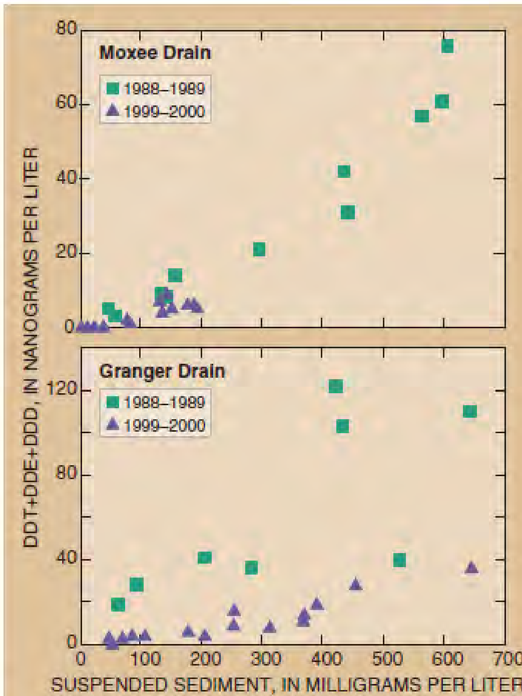


Figure 16. Since 1988–89, the relation between total DDT and suspended sediment has changed in Moxee and Granger Drains. The suspended sediment is now less contaminated with total DDT.

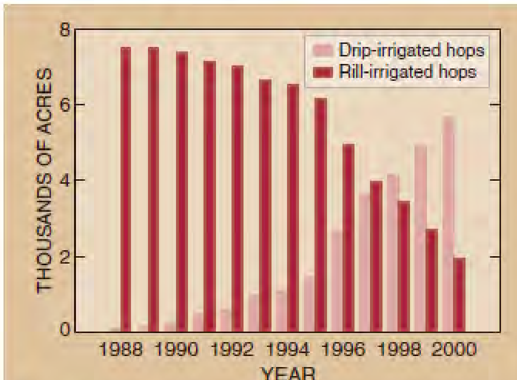


Figure 17. Conversion of rill irrigation to less-erosive drip irrigation has probably resulted, in large part, in the sharp decrease in concentrations of suspended sediment and total DDT in Moxee Drain (see figure 16).

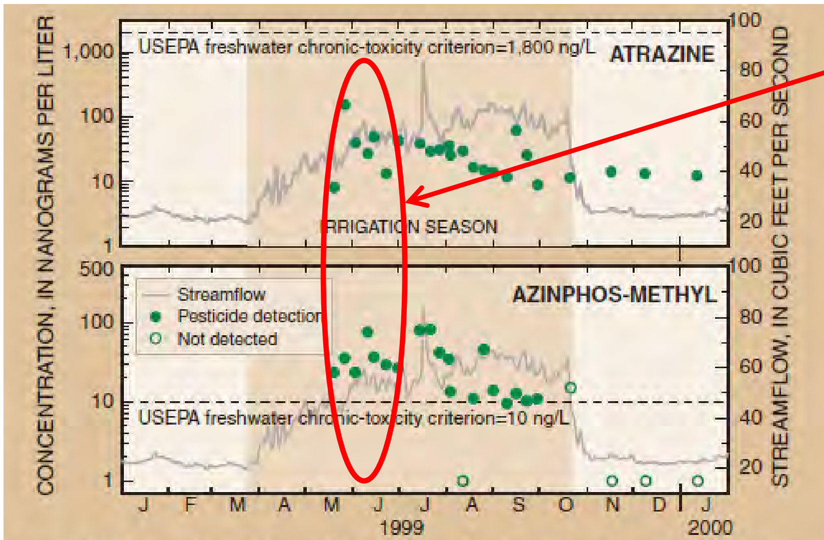


Figure 20. Because soluble pesticides like atrazine can percolate to the ground water, they are detected not only during the irrigation season when they are applied, but also during the nonirrigation season when ground water discharges to Granger Drain. In contrast, azinphos-methyl is detected only during the irrigation season, but almost always at levels exceeding the aquatic-life criterion.

Again, spawning season corresponds to the peak levels in contaminants

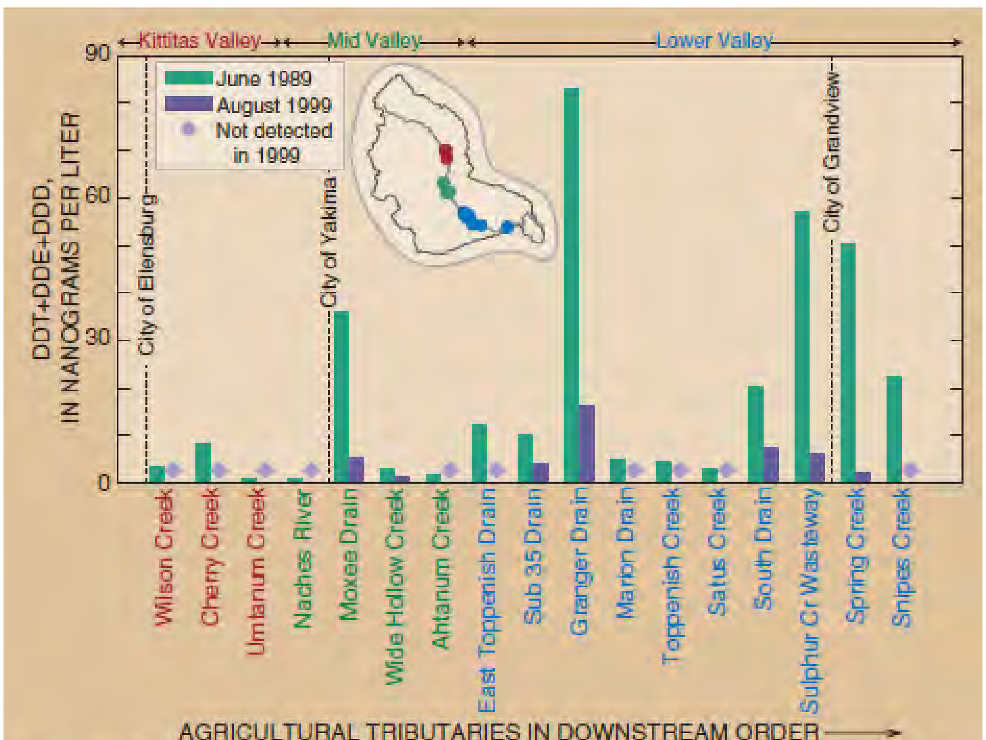


Figure 12. Concentrations of total DDT in water samples from major tributaries to the Yakima River decreased sharply between 1989 and 1999.

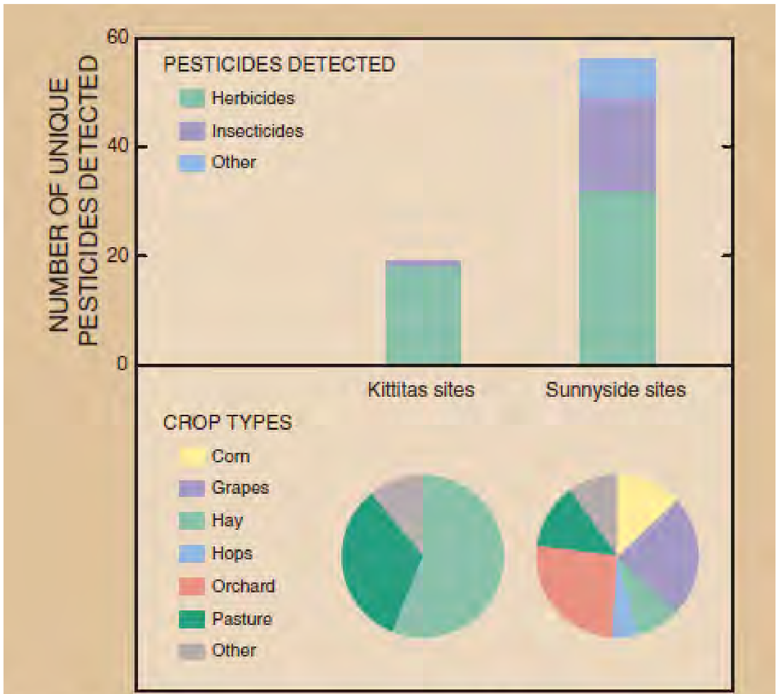


Figure 22. Many more pesticides were detected in the Lower Valley near Sunnyside than in the Kittitas Valley. This difference can be explained by the high diversity of crops grown in the Lower Valley compared with the Kittitas Valley, which is dominated by hay and pasture.

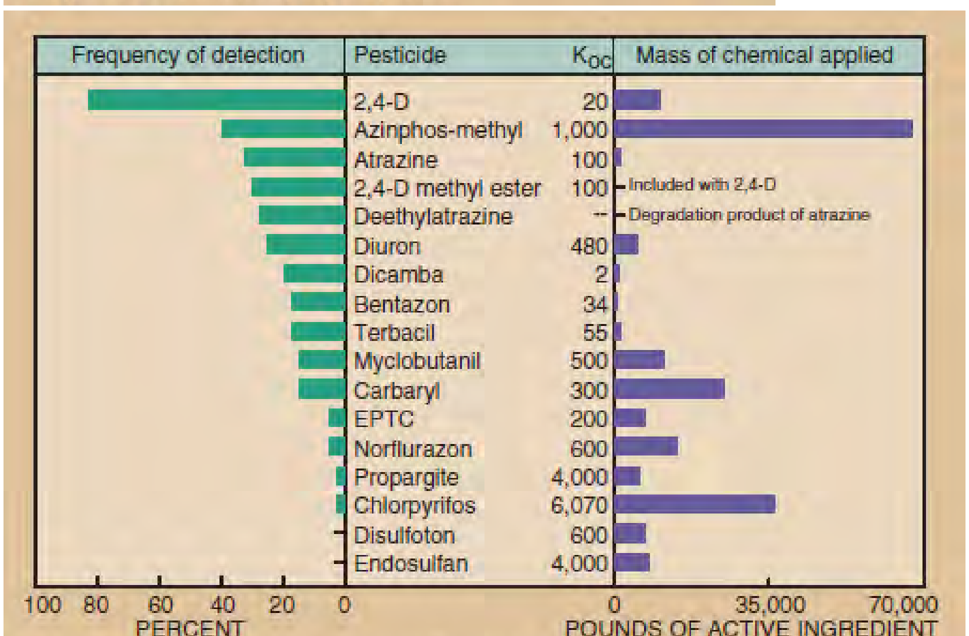


Figure 24. Pesticides in irrigation runoff were not always detected in proportion to the quantity applied to agricultural land. Other factors, including the degree to which certain pesticides adhere to soil, affected how often pesticides were detected in agricultural runoff (see explanation of K_{oc} in box on page 22).

Johnson, A., K. Carmack, B. Era-Miller, B. Lubliner, S. Golding, R. Coots. 2010. **Yakima River Pesticides and PCBs Total Maximum Daily Load: Volume 1. Water Quality Study Findings.** Washington Department of Ecology Publication No. 10-03-018.

- Highest level of toxicity found during the 1st half of irrigation season (late March~June) from return flow
- Urban storm discharges also contribute a high level of toxins, too
- Fruit packer & veg. processor and WWTP effluent contributes some toxins, but is much less significant compared to the major two sources (above)
- Key toxins in the basin to consider are:
    - Legacy pesticides (no longer used), such as PCBs, Toxaphene (not listed, but high), DDE, DDT, dieldrin, dioxin, chlordane, and chlorpyrifos
    - Insecticides (still being used), such as chlorpyrifos and endosulfan
- PCBs = endocrine disruptors, widespread and found throughout WA (not necessarily a problem restricted to Yakima)
- DDT = detected at high level, but has shown improvement in recent years. Toppenish and Sulphur subbasin wells had high level of DDT.
- dieldrin = chlorine related pesticide and is currently coming from primarily ground water sources
- dioxin = has been a concern but excluded from study because human consumption criterion was met or close to being met
- insecticides = still being applied in spring and fall, has low bioaccumulation risk, but a high amount was detected in bottom feeders like carp (lamprey was not tested, but suspect they will also have a high amount)
- Suspended sediment is a good relative measure of overall toxins, and it really increases below Moxee Drain confluence in the mainstem
- Some of the return flows with high toxin levels in general were: Wilson Cr, Moxee Drain, Granger Drain, Sulphur Cr. Wasteway, Spring Cr
- All of these sites are included in the routine monitoring sites, except Wilson Cr. Yakima River at Kiona (Benton City Bridge) also has a high level of toxins and is one of the routine monitoring sites.
- Routine monitoring is conducted in spring (mid-May) and fall (November) so would be great to add on the lamprey tissue sampling during this period (especially spring).
- One of the reasons that the DDT level has decreased recently is from the "use of PAM (polyacrylamide) in the flocculation and sedimentation of fine-grained, organically enriched soil particles that tend to sorb total DDT." PAM was discovered in the 1970s and has become a standard practice for water conservation in recent years. The residual monomer (acrylamide) are neurotoxin to humans. PAM are also resistant to microbial attacks in general. Besides the fact that it enhances the absorption of toxins in sediment (to reduce the suspended sediment in water), if it resists all the microbes that are naturally

in the detritus in the sediment that lamprey feed on, sounds like this chemical can be quite problematic for larval lamprey. There are two types of PAM and the cationic PAM are very toxic to wildlife/aquatics, but are still very effective as a flocculant. PAM eventually breaks down, but are much more stable compared to other soil polymers.

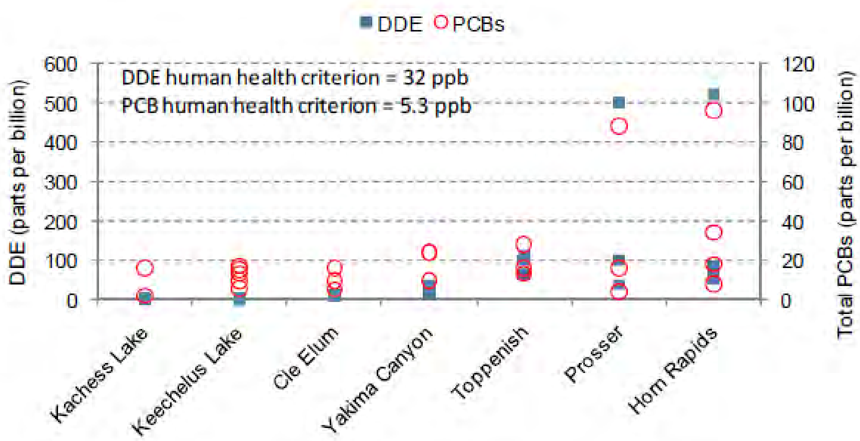


Figure ES-2. DDE and PCB Levels in Yakima River Fish Collected in 2006.

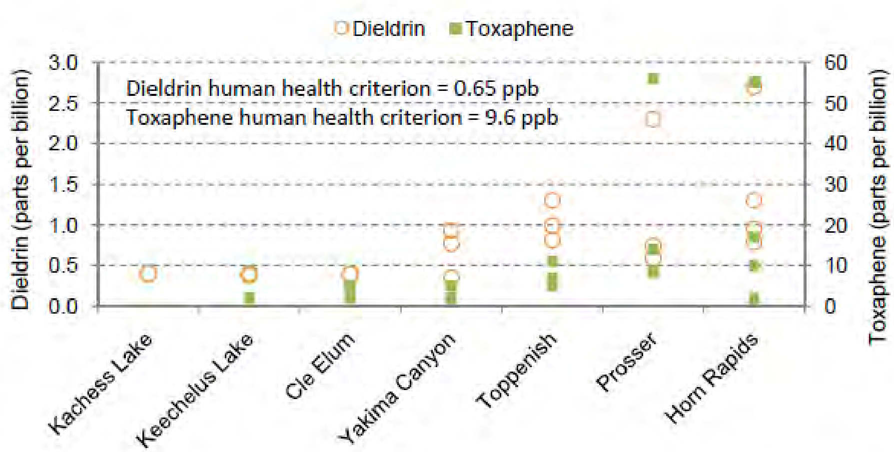


Figure ES-3. Dieldrin and Toxaphene Levels in Yakima River Fish Collected in 2006.

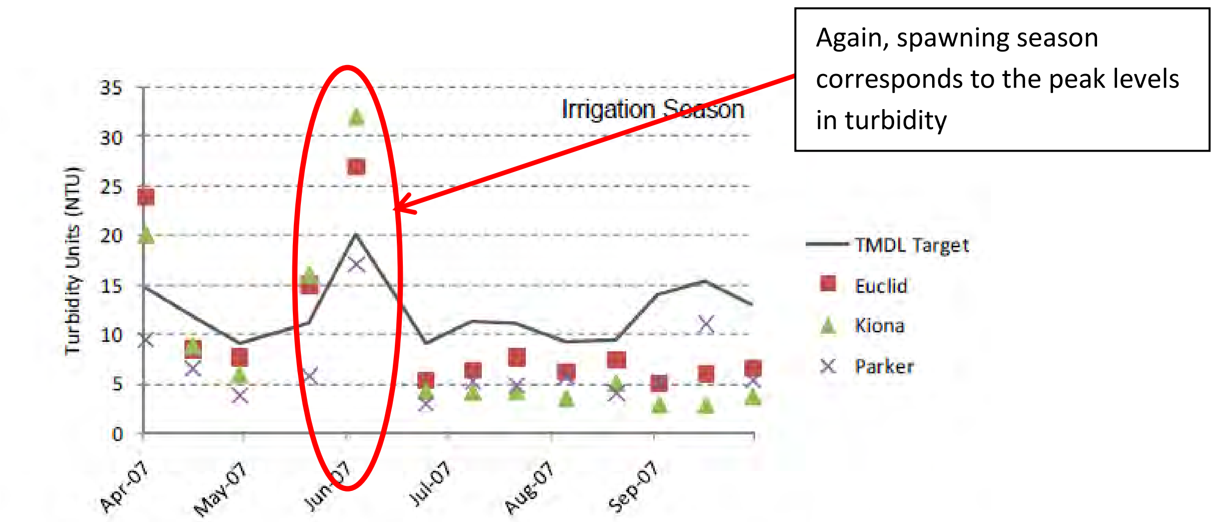


Figure ES-4. Turbidity in the Lower Mainstem Yakima River during the 2007 Irrigation Season.

Figure 4 is a schematic of the drainage, showing the relative position of selected tributaries, diversions, return flows, and other features of interest in the present study.

Feature	Inflow or Outflow	River Mile
Keechelus Lake	→	214.5
Kachess Lake	→	203.5
Cle Elum Lake	→	185.6
Wilson Creek	→	147.0
Umtanum Stream-gaging Station	–	140.5
Roza Diversion Dam	←	127.9
Naches River	→	116.3
Roza Power Return	→	113.3
Wide Hollow Creek	→	107.4
Moxee Drain	→	107.3
Ahtanum Creek	→	106.9
Wapato Canal		106.7
Sunnyside Diversion Dam	←	103.8
Parker Stream-gaging Station	–	103.7
Marion Drain	→	83.2
Granger Drain	→	82.8
Toppenish Creek	→	80.4
Satus Creek	→	69.6
Sulphur Creek Wasteway	→	61.0
Euclid Stream-gaging Station	–	55.0
Chandler Diversion Dam @ Prosser	←	47.2
Spring Creek/Snipes Creek	→	41.8
Chandler Power Return	→	35.8
Kiona Stream-gaging Station	–	29.9
Horn Rapids Diversion Dam	←	18.0
Columbia River Confluence	–	0

Figure 4. Relative Position of Selected Tributaries, Diversions, Irrigation Returns, and Other Features on the Yakima River.

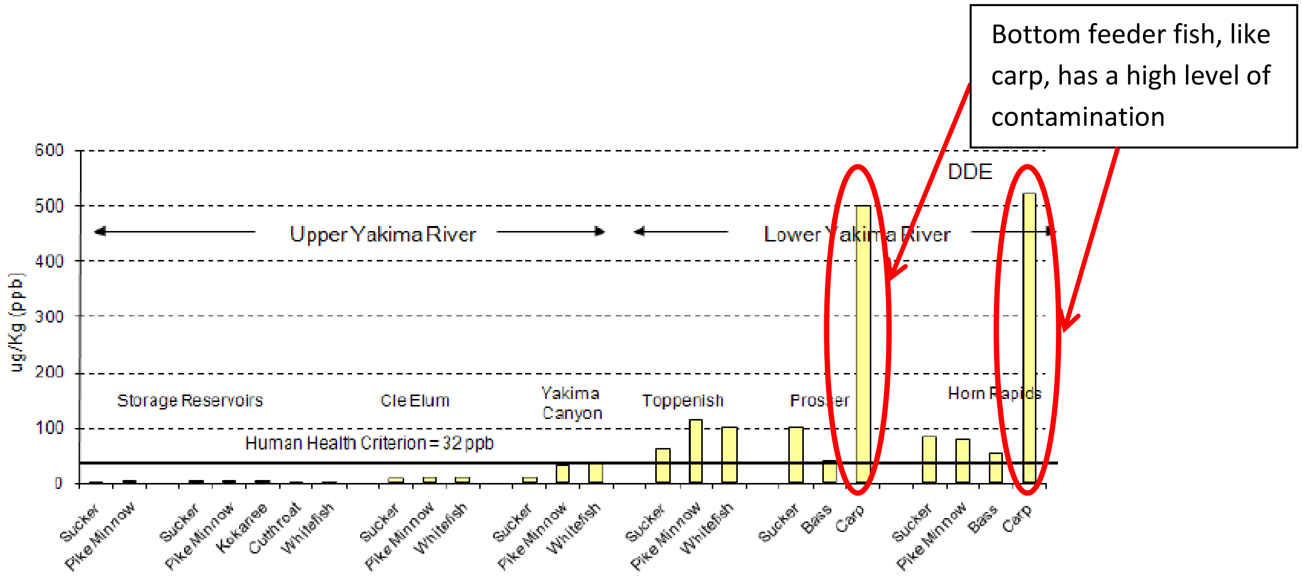


Figure 5. Mean DDE Concentrations in Yakima River Fish Fillets Collected in 2006 *(parts per billion, wet weight).*

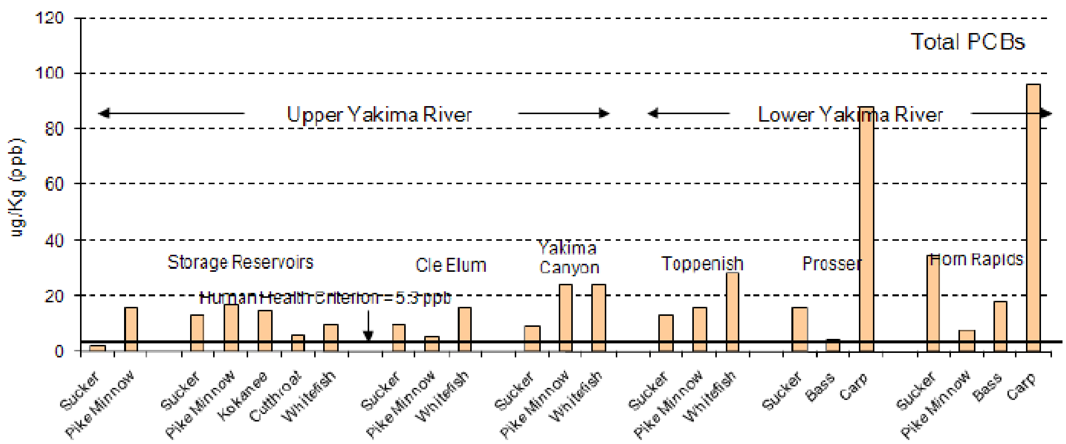


Figure 6. Mean Total PCB Concentrations in Yakima River Fish Fillets Collected in 2006 *(parts per billion, wet weight).*

Wise, D. R., M. L. Zuroske, K. D. Carpenter, and R. L. Kiesling. 2009. **Assessment of eutrophication in the lower Yakima River Basin, Washington, 2004-07.** U.S. Geological Survey Scientific Investigations Report 2009-5078.

- The Zillah reach (RM 116 – 72) had abundant periphyton growth and sparse macrophyte growth, the lowest nutrient concentrations, and moderately severe summer dissolved oxygen and pH conditions in 2005.
- The Mabton reach (RM 72-47) had sparse periphyton and macrophyte growth, the highest nutrient conditions, but the least severe summer dissolved oxygen and pH conditions in 2005.
- The Kiona reach (RM 47 – 4) had abundant macrophyte (stargrass) and epiphytic algae growth, relatively high nutrient concentrations, and the most severe summer dissolved oxygen and pH conditions in 2005.
- The metabolism associated with periphytic algae and macrophytes growth caused large daily flucturations in dissolved oxygen concentrations and pH levels that exceeded the WA state water-quality standards between July and September in 2004-2007. \
- Nutrients also come from ground water, making it hard to manage the nutrient load.
- In general, higher flow could mitigate the eutrophication (from turbidity and scouring) except in the Kiona reach, stargrass can still uptake nutrient from the substrate.

Information from Scott Ladd (Yakama Nation) on chemicals of concern:

1. Acrolein (systematic name: propenal) = simple unsaturated aldehyde
    a. Used by irrigation farmers as a herbicide to control floating weeds & algae in canals
    b. Immediately reacts with other products (instable and toxic)
    c. 6 day phase out required before the chemical reaches streams
    d. Has a piercing, disagreeable, acrid smell (burnt fat) – glycerol by product
    e. Requires NPD permit?
2. Endothal
    a. Aquatic herbicide
    b. Toxic to some species of fish
    c. Disappears from soil in 7-21 days
    d. Half life ~7 days
3. Copper sulfates
    a. Fungicide and used to control aquatic plants and snails
    b. Highly toxic to fish
    c. Inhibits growth of bacteria

Bob's recommendation for sites:

Roza, Selah, Roza, Wapato, Reach, Granger, Marion Drain, Prosser, Horn Rapids

Julia Unrein:

- Water quality, sediment analysis done by Columbia Analytical Services (Kelso, WA) – cost? Only contractor (Stratus Consulting knows). April Smith had to do her own – ask.
- Important to deprivate (2-3 days) to remove the sediment that may not get digested (use glass balls or cotton balls) to avoid overestimating the contaminent.
- PCB, PAH, heavy metal [causes lesions, cancer, etc.], DDT were the main concerns (diesel, psuedoestrogen [from pulp mill], too)
- Used mason sand (medium size), playground sand is good, too (clean) from landscape companies. Also used wood chips (for air space).
- 1 l/min for the large 5 ft circular tank (flows from one end to the other) – 1.5' deep, 6" water, 6" sand. Turn off water during feeding (how long?). margins were a bit anaerobic (hydrogen sulfide).
- 0.12 l/min for the small circular tanks (larvae survived for 60 days just fine) - 4" sand, 6-8" water above.
- Undergravel filter (polystyrene with ~ 1cm opening) – 2x2' but can cut to whatever size

Passage of Radio-tagged Adult Pacific Lamprey at Yakima River Diversion Dams

2012 Annual Report

Andy Johnsen, Mark C. Nelson, Daniel J. Sulak, Cal Yonce, and R.D. Nelle

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
Leavenworth, WA

On the cover: Pacific lamprey code 69 attempting to climb the closed headgate in the right fishway at Prosser Dam, April 30, 2012. Photograph by Cal Yonce, USFWS.

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2012 Annual Report

Passage of Radio-tagged Adult Pacific Lamprey at Yakima River Diversion Dams

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U.S. Bureau of Reclamation

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January 9, 2013

Disclaimers

PASSAGE OF RADIO-TAGGED ADULT PACIFIC LAMPREY
AT YAKIMA RIVER DIVERSION DAMS
2012 ANNUAL REPORT

Andy Johnsen, Mark C. Nelson, Daniel J. Sulak, Cal Yonce, and R.D. Nelle

Final Report

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Rd.
Leavenworth, WA 98826

Abstract- The Pacific lamprey *Entosphenus tridentatus* is an anadromous fish native to the Pacific Northwest. Information about Pacific lampreys in the Yakima River is very limited. Several irrigation diversion dams exist on the Yakima River that may prevent or delay the upstream migration of adult Pacific lampreys; however, the total impact of these dams on adult Pacific lamprey migration and spawning is not known. We used radio telemetry to determine approach timing, residence time, fishway routes, other passage routes, and migration rates at the diversion dams on the lower Yakima River. Wanawish, Prosser, Sunnyside, and Wapato dams were equipped with multiple antenna telemetry stations. Seven additional stations were established to monitor tributaries and the boundaries of the study area. Seventy-six Pacific lampreys, collected from lower Columbia River dams in summer 2011, were radio-tagged and released near Wanawish and Prosser Dams on October 4, 2011 and March 28, 2012. Seventy-four lampreys made upstream movements with sixty-eight approaching at least one dam. Overall passage success at the dams varied from a low of 39% at Sunnyside Dam to a high of 62% at Wanawish Dam. Only two lampreys passed all four dams. All passage events occurred in October and April-June. At all four dams combined, the average residence time for lampreys that passed in the fall was 5.45 d with a fishway passage time of 2.2 h. Lampreys that passed in the spring had an average residence time of 23.7 d and a fishway passage time of 3.4 h. Fall passage occurred during discharges between 500 and 2,500 ft^3/s. Average discharge during spring passage events was highest at Wanawish with 8,300 ft^3/s and lowest at Prosser Dam with 5,200 ft^3/s. The majority (78%) of passage occurred when water temperatures were between 12 and 15 °C. The average migration rate between dams was 10.1 km/day with most movements past stations occurring at night. Fishway entrance velocities at all four dams ranged between -4.61 and 10.09 ft/s. To date, our results indicate the diversion dams on the Yakima River are impeding the upstream migration of Pacific lampreys. We suggest several different modifications that may increase lamprey passage including a lamprey passage system (LPS), reduced fishway velocities, and modifications to fishway entrances.

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Introduction

The Pacific lamprey *Entosphenus tridentatus* is an anadromous fish native to the Columbia River Basin and many of its tributaries, including the Yakima River (Patten et al. 1970). Over the last decade the number of adult Pacific lampreys returning to the Yakima River has been minimal, with counts at Prosser Dam (river kilometer 75) ranging from 0 to 87 individuals per year (DART 2011). These low counts are consistent with the declines observed at Columbia River dams (Kostow 2002, DART 2011). Several factors including construction and operation of hydroelectric and diversion dams, river impoundment, water withdrawals, stream alteration, habitat degradation, elevated water temperatures, pollution, and ocean conditions have likely contributed to this decline (Luzier et al. 2011).

Telemetry studies of Pacific lamprey movements within the Columbia River have documented that hydroelectric dams cause major delays and difficulties for the upstream migration of Pacific lampreys, resulting in less than half of tagged fish successfully passing upstream through the fishways (Moser et al. 2002, Johnson et al. 2009, Keefer 2009). Several diversion dams exist in the Yakima River Basin and may be impediments for adults migrating to suitable spawning areas, however, details on upstream migration, timing, spawning, and distribution of Pacific lamprey in the Yakima River are not well understood. Results from the pilot year of this study indicate dam passage success rates as low as 25%, however, the sample size was small and more detailed information about passage and residence time at the dams is needed (Johnsen et al. 2011).

The objective of this multi-year radio telemetry study is to determine adult Pacific lamprey passage at the Yakima River diversion dams, including approach timing, residence time downstream of dams, passage routes, time in the fishways, total time spent at the dams, and migration rates between dams. In addition, areas where Pacific lamprey over-winter and spawn in the Yakima River will be located if possible. Information from this study will help guide management recommendations for improving passage at the dams in the Yakima River.

This annual report presents the results of our study for the 2011 migratory year, from September 13, 2011 through August 31, 2012. Because of the increased interest and urgency for actions to conserve Pacific lamprey we also make some preliminary recommendations in this report.

Background

Similar to summer steelhead *Oncorhynchus mykiss,* Pacific lamprey enter freshwater a year prior to spawning, migrate upstream to overwinter, and then access spawning tributaries or areas the following spring. It is thought Pacific lampreys do not home to their natal streams, unlike many anadromous fishes, but instead may utilize the “suitable river strategy” in which returning adults are attracted to streams inhabited by larval lamprey or ammocoetes (Waldman et al. 2008). Recent genetic studies indicate Pacific lampreys are panmictic (Goodman et al. 2008 and Docker 2010) and support the hypothesis of no natal homing in Pacific lamprey. Adults typically return to the Columbia

River from February to June (Kostow 2002) and begin to arrive at McNary Dam (67 kilometers downstream of the Yakima River confluence) in early June with the peak of migration in late July or early August (DART 2011). During a migratory year, lampreys are not observed at Prosser Dam until mid to late August and only a few are counted through the fall. Most of the returning adults are observed the following spring with the majority counted during April and May (DART 2011). However, radio telemetry studies conducted in tributaries such as the John Day River (Bayer et al. 2000), the Willamette River (Clemens et al. 2011), and the Methow River (Nelson et al. 2009) found that Pacific lamprey entered these spawning tributaries in late summer and completed about 85% of their migration to spawning areas before overwintering. Thus it appears there has been a shift in migration timing in the Yakima River that differs from other tributaries and may be related to temperature differences between the Yakima and Columbia rivers. During July and August, temperatures in the lower Yakima River are on average almost 4 °C higher than in the Columbia River (mean 23.8 °C vs. 20.0 °C, 2002 to 2009 data-USBOR 2011; DART 2011). This appears to create a thermal barrier that either encourages lampreys to migrate past the Yakima River and continue upstream in the Columbia River or discourages lampreys from entering the Yakima River until later in the fall after temperatures equilibrate. Lampreys may also be overwintering in the Columbia River and entering the Yakima River the following spring. Radio-tagged Pacific lampreys translocated to the Yakima River exhibited the same migratory behavior as those that entered the river naturally (Johnsen et al 2011), supporting both the hypothesis of no natal homing and shifted migration timing within the Yakima River.

Investigation of the potential thermal barrier and its effect on lamprey migration in the Yakima River is beyond the scope of our current study. However, because it appears to shift the majority of the migration to the spring, we designed our study to test passage at the dams during both the fall and spring of the lamprey migration year. Accordingly, we tagged and released a portion of our study fish in the fall and held the others over winter before tagging and releasing them in the spring in order to mimic both the timing of the "natural" run and the condition of the lampreys during their migration in the Yakima River.

Methods

Study Area

The Yakima River flows for 344 km, from the headwaters at Keechelus Lake in the Cascade Mountains to the confluence with the Columbia River at river kilometer (rkm) 539, and drains an area of approximately 15,941 km^2 (Figure 1). Annual mean discharge at the Kiona Gage Station (rkm 48.1) is 3,479 cubic feet per second (ft^3/s) (range 1,293 – 7,055 ft^3/s), with the highest daily mean discharge of 59,400 ft^3/s recorded on December 24, 1933 and the lowest daily mean discharge of 225 ft^3/s recorded on April 4, 1977 (USGS 2011). The main tributaries include Satus Creek, Toppenish Creek, Naches River, Taneum Creek, Teanaway River, and Cle Elum River.

A complex irrigation network, managed in large part by the U.S. Bureau of Reclamation, makes the Yakima River Basin one of the most intensely irrigated areas in the United States, and has served to make it a leading producer of tree and vine fruit as well as other diverse agricultural products. Six lakes and reservoirs, with a total active storage capacity of 1.07 million acre-feet, hold the spring and summer snowmelt in the mountains for delivery to irrigation districts between April and October (Fuhrer et al. 2004). Irrigation water is distributed throughout the network via rivers, creeks, and man-made canals. Irrigation diversion dams include Wanawish, Prosser, Sunnyside, Wapato, Roza, and Easton on the Yakima River and Cowiche and Wapatox on the Naches River (Figure 1).

Surface water diversions are equivalent to about 60% of the mean annual stream flow from the basin (Fuhrer et al. 2004). In spring, the stream flow reflects the quantity of water stored in the mountain snowpack, while during the dry summer months it reflects the quantity of water released from the basin’s storage reservoirs. During summer, return flows from irrigated land account for 50 to 70% of the flow in the lower Yakima River (Fuhrer et al. 2004).

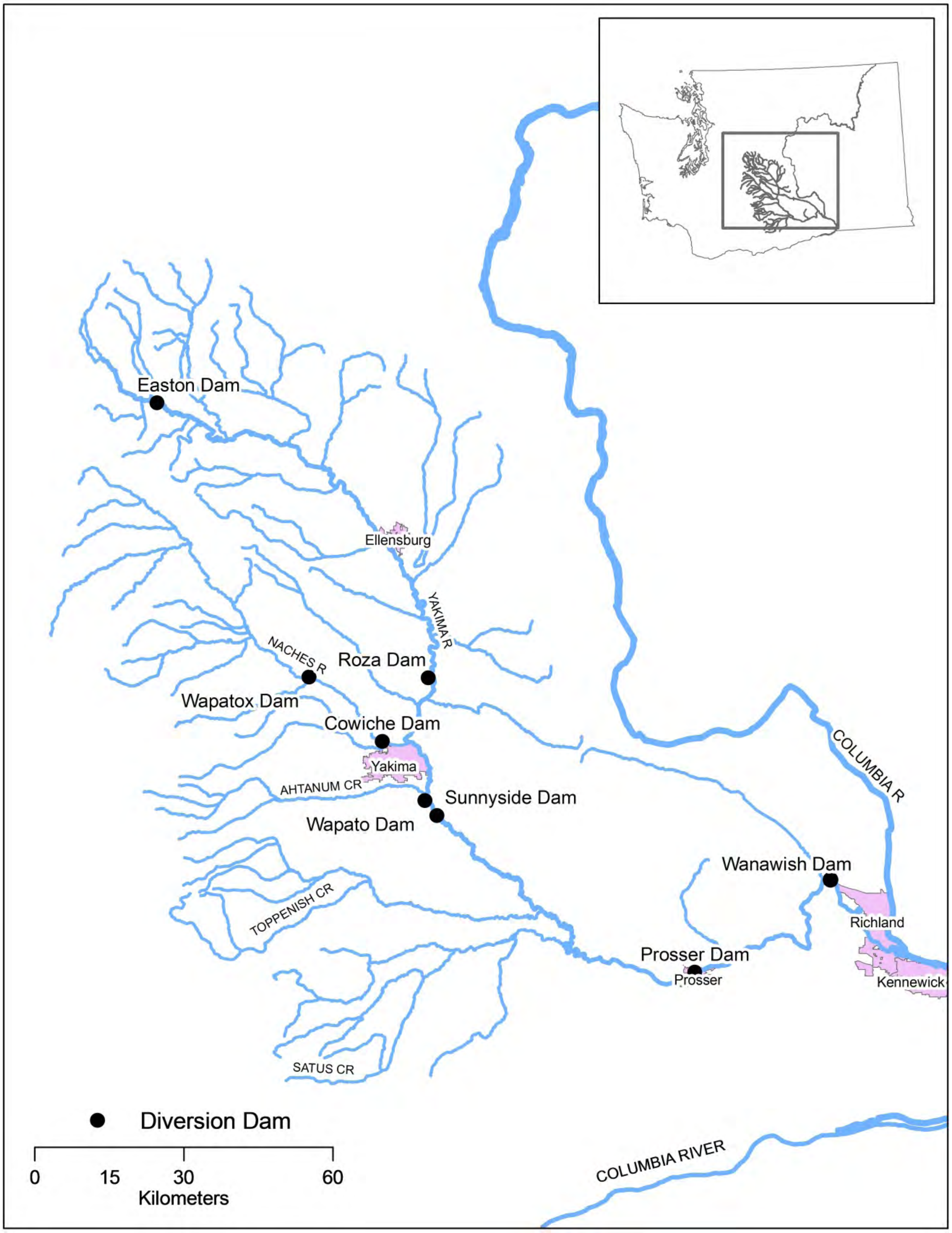

Figure 1. Map of the Yakima River watershed, showing the locations of the major diversion dams.

Fixed Stations

Fixed telemetry stations were set up at six diversion dams, in three tributaries, at the outfall of an irrigation diversion, and near the mouth of the Yakima River (Figure 2). The basic layout at a diversion dam consisted of aerial antennas that monitored downstream of the dam, the face of the dam, and upstream of the dam. Underwater antennas monitored pools at the entrance, middle, and exit of each fishway. Aerial antennas were four element Yagi-type and underwater antennas were constructed of coaxial cable with 100 mm of the inner wire bared at the end. Hanging antennas were added to the arrays during the spring of 2012 and were the same design as the underwater antennas except they were suspended above the waterline. Aerial antennas were mounted on masts, underwater antennas were suspended on chains, and hanging antennas were zip-tied to rails and posts. Data recording telemetry receivers (Lotek SRX-400A), equipped with an antenna switching unit (Grant Engineering Hydra) programmed on a "master-slave" cycle, were housed in a metal box at each station. AC power, when available, was used to charge the external 12v battery that powered the receiver at each diversion station. Solar panels were used as a back-up power system in case AC power was lost and as the primary power source at stations with no available AC power.

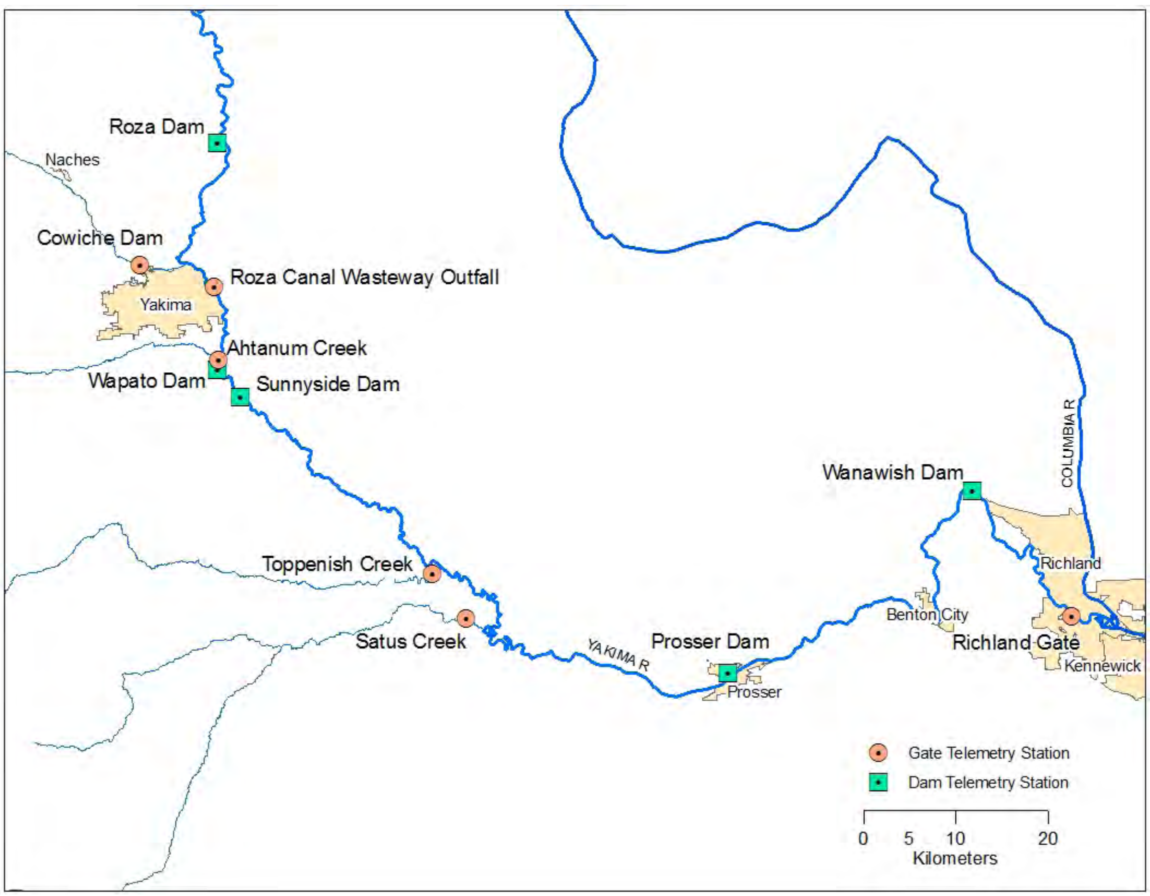

Figure 2. Map of the lower Yakima River basin showing the locations of fixed telemetry stations in 2012.

Wanawish Dam

Wanawish Dam, constructed in 1892 at rkm 29 near Horn Rapids, is a rock filled timber crib dam with a concrete face. It is 160 m long and approximately 2 m high and diverts water into canals on both banks of the river. Fishways, consisting of an entrance pool and 4 vertical slot pools, are located on each bank at the dam, with the fishway exit near the mouth of each canal (Figure 3). Each entrance pool has a high flow and low flow gate that were operated in relation to river flow. Both fishways at the dam had one aerial antenna facing downstream, one upstream, and one across the face of the dam. Underwater antennas were located at the entrance, middle, and exit pool of each fish ladder, as well as the entrance to the irrigation canal on river left. Hanging antennas were placed in the entrance of the right bank irrigation canal and in each corner where the face of the dam meets the bank (Figure 3).

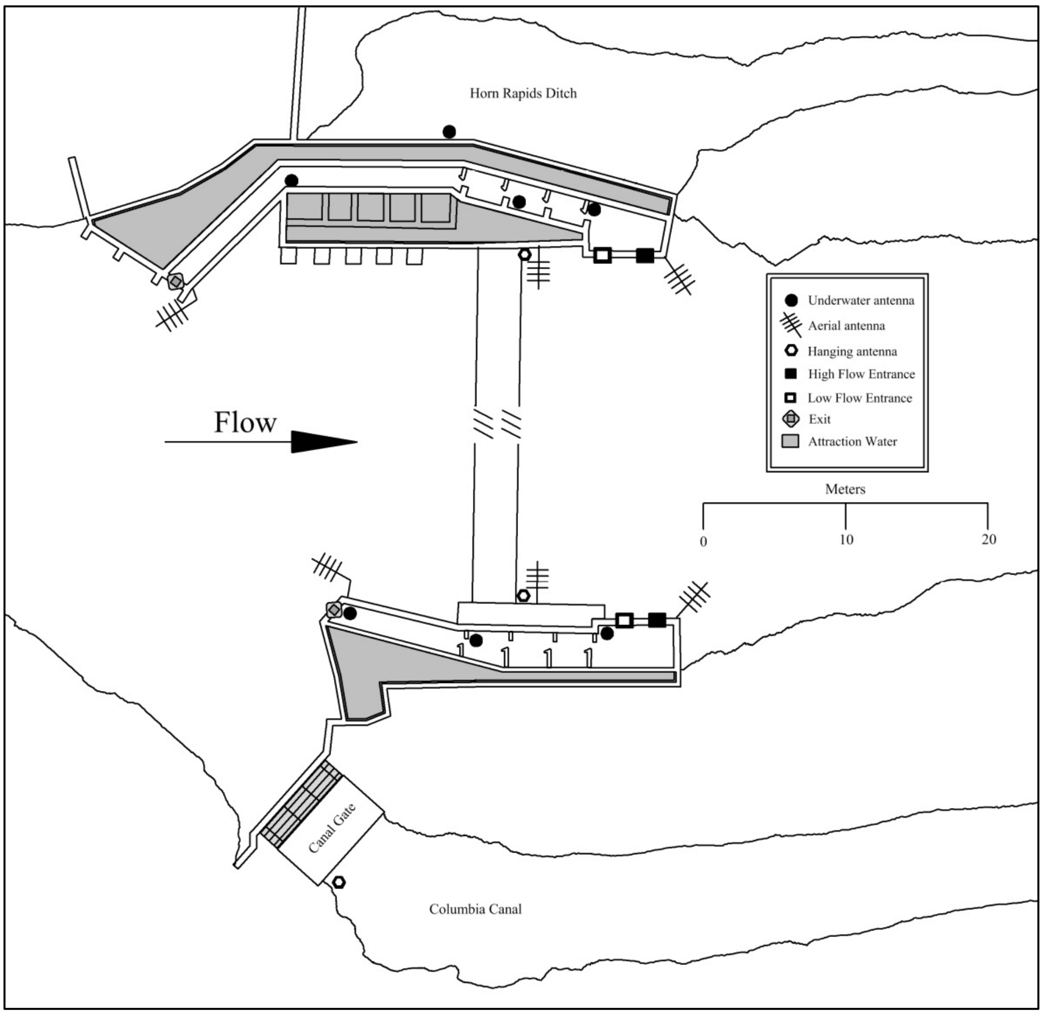

Figure 3. Locations of telemetry antennas on right and left bank fishways at Wanawish Dam, 2011 to 2012.

Prosser Dam

Prosser Diversion Dam, constructed in 1904 by private interests and now operated by the U.S. Bureau of Reclamation, is located at rkm 75. The facility consists of a concrete weir structure (2.7 m tall, 201 m long), an irrigation canal (1,500 ft^3/s capacity) on the left bank, an adult sampling facility (in the right bank fishway), three vertical slot type fishways (one on the right bank and two mid-river "islands" on the dam), and a juvenile bypass and sampling facility (downstream at the canal screen structure). The left island entrance pool has four gates: two high flow and two low flow. The center island fishway entrance pool has high flow and low flow gates on each side. The right bank fishway has an upper entrance with high and low flow gates and a lower entrance with one high/low flow gate (USBOR 2011). The right bank fishway had one aerial antenna monitoring downstream and one upstream; underwater antennas were located at the high water entrance, low water entrance, middle, and exit pools of the fish ladder. A hanging antenna was placed near an outflow pipe located at the most downstream end of the dam (Figure 4). The center island fishway had one downstream aerial antenna and two upstream aerial antennas (combined as one unit); underwater antennas were at both entrance pools and the exit pool of the fish ladder. Hanging antennas monitored where the face of the dam met the left and right sides of the island (Figure 4). The left island fishway was equipped with aerial antennas monitoring upstream, downstream, and across the face of the dam to the left and right of the island; underwater antennas were located within the entrance, middle, and exit pool of the fish ladder. Hanging antennas were placed on the outside of each fish ladder entrance gate and where the face and the left side of the island meet (Figure 4).

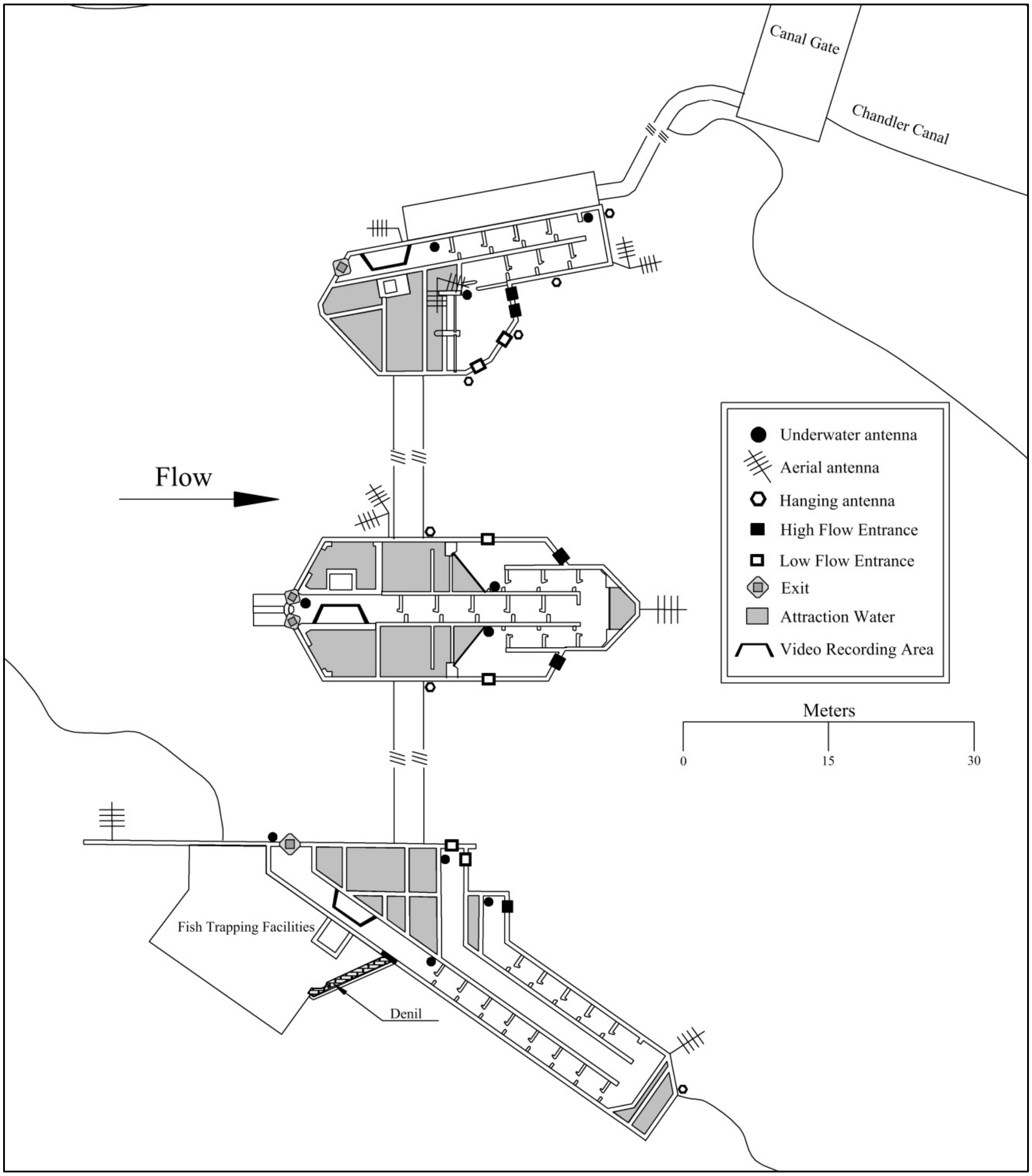

Figure 4. Locations of telemetry antennas on right, center, and left fishways at Prosser Dam, 2011 to 2012.

Sunnyside Dam

Sunnyside Diversion Dam, located at rkm 167, was completed in 1907. It is a concrete ogee weir with embankment wing and a canal (1,320 ft^3/s capacity) on the left bank. The structural height is 2.4 m and the weir crest length is 152 m (USBOR 2011). Fish passage facilities consist of three stair step ladders, one on each bank and one near the center of the dam. The left and right bank fishways have one high flow and one low flow gate. The center island has two high flow and two low flow gates; one located on each side. The left bank fishway had one upstream aerial antenna and two downstream aerial antennas (combined as one unit); underwater antennas were located in the entrance, center, and exit pool of the fish ladder. Hanging antennas monitored the sluiceway and the corner where the structure met the face of the dam (Figure 5). The center island fishway was equipped with a total of four aerial antennas: two (combined as one unit) monitored downstream and two monitored upstream on either side; underwater antennas were located in both entrance pools and a middle pool of the fish ladder. Hanging antennas were placed in the corners of the island and the face of the dam (Figure 5). The right bank fishway was equipped with three aerial antennas: one downstream, one across the face of the dam, and one upstream; underwater antennas were located in the entrance, middle, and exit pools of the fish ladder. One hanging antenna monitored where the right bank structure and the face of the dam met (Figure 5).

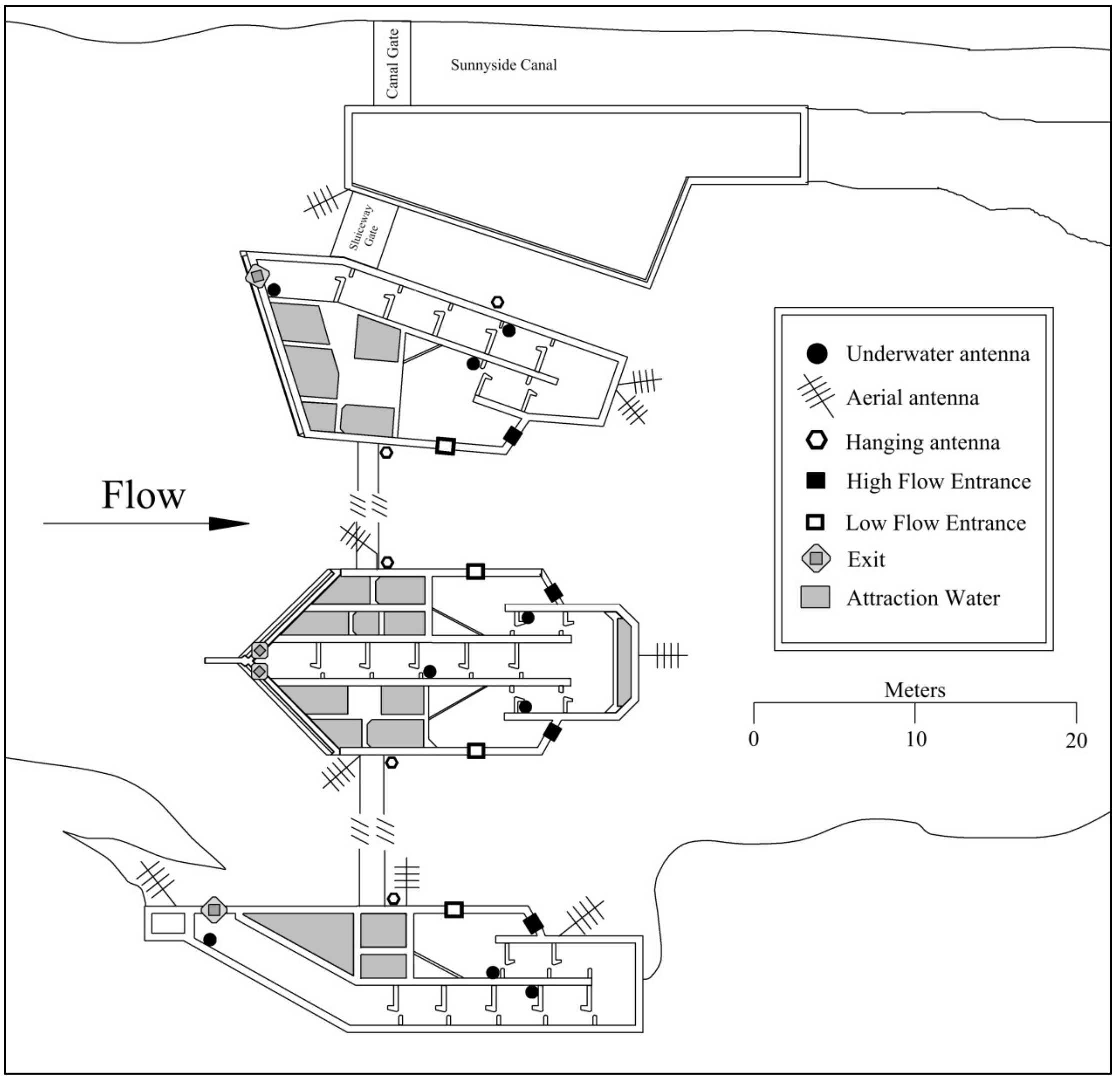

Figure 5. Locations of telemetry antennas on the right, center and left bank fishways at Sunnyside Dam, 2011 to 2012.

Wapato Dam

Wapato Dam (rkm 171.5) consists of two separate structures in two channels connected by a natural island. The west channel structure has one fishway located on a center island with a diversion canal on the right bank. The east channel structure has fishways on both the center island and on the right bank. All the fishways consist of serpentine vertical slot pools with high and low flow gates in the entrance pool. The east channel structure center island was equipped with three aerial antennas: one downstream, one upstream, and one monitoring the face on the river left side of the island. Underwater antennas were located in the entrance, middle, and exit pools of the fish ladder. A hanging antenna was located on the right side of the island near the face of the dam (Figure 6). The right bank of the east channel structure utilized three aerial antennas: one downstream, one upstream, and one across the face of the dam. Underwater antennas were positioned in the entrance, middle, and exit pools of the fish ladder. One hanging antenna was placed in the corner where the face and left bank structure met (Figure 6). The west channel structure was equipped with four aerial antennas: one downstream, one upstream, and one across the face of the dam on either side of the center island. Underwater antennas were located in the entrance, middle, and exits pools of the fish ladder (Figure 7).

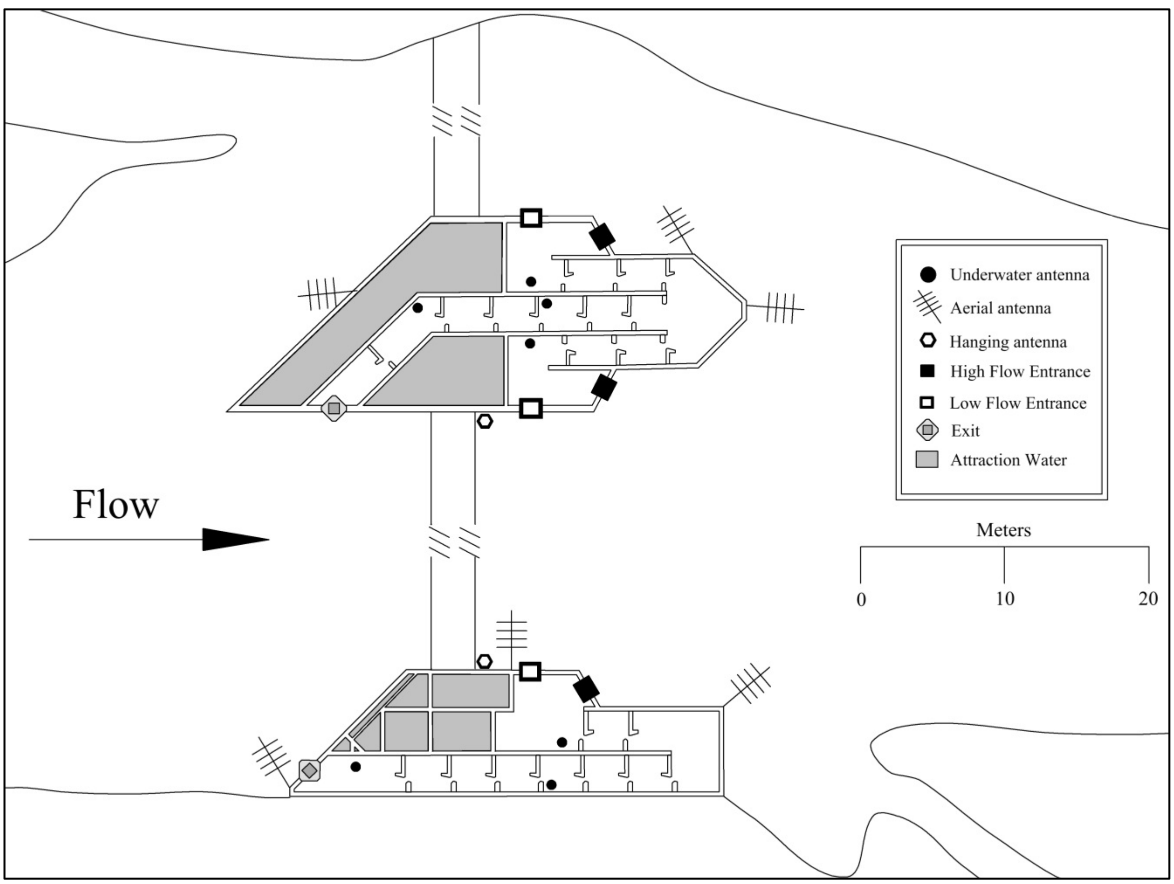

Figure 6. Locations of telemetry antennas on the left island and right bank of the east structure of Wapato Dam, 2011 to 2012

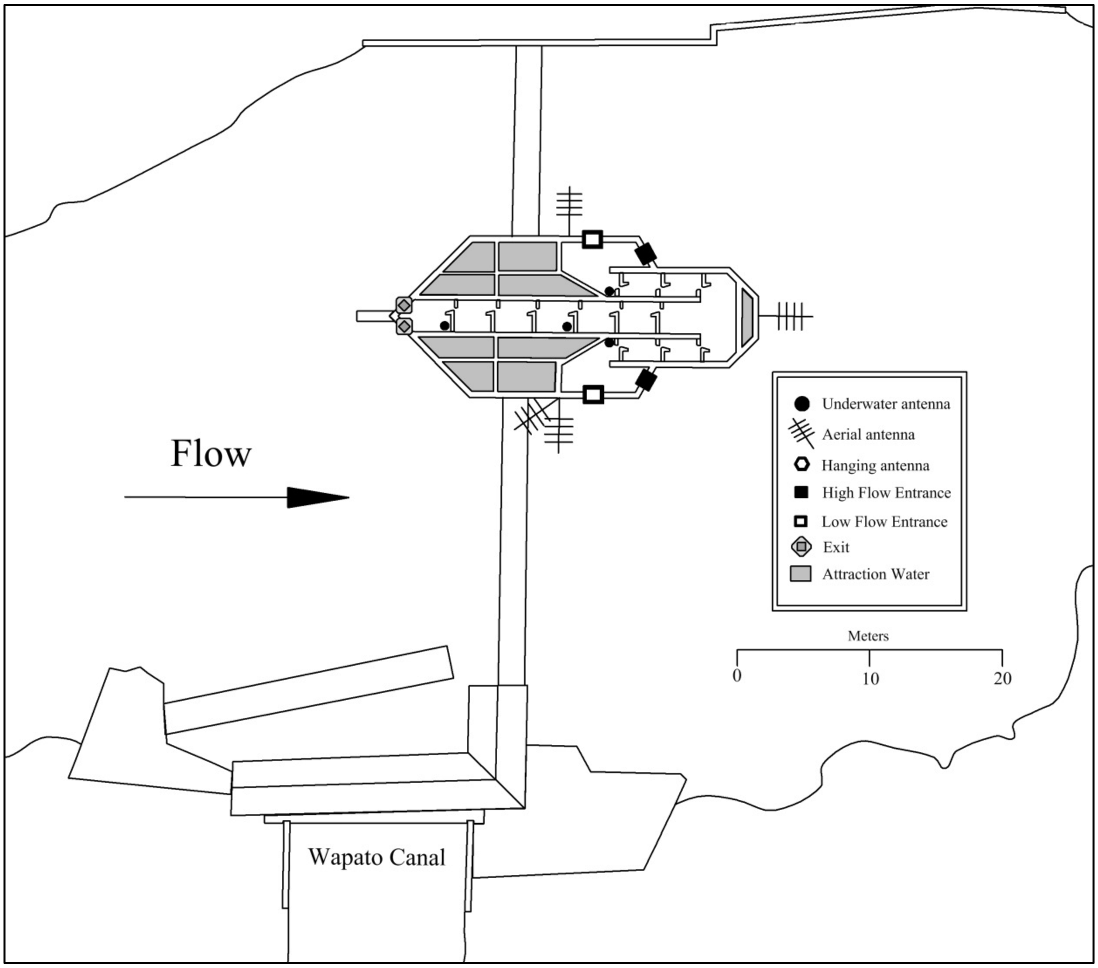

Figure 7. Locations of telemetry antennas on the center island of the west structure of Wapato Dam, 2011 to 2012.

Cowiche Dam

Cowiche Dam (rkm 6) on the Naches River is a concrete ogee spillway structure. It is approximately 65 m in length, with a 1.5 m crest, a 6.4 m ogee spillway, and a 6.4 m apron (George and Prieto 1993). A fish ladder consisting of vertical slot pools is located on the river left of the dam. A diversion canal and fish screen is located on the river right portion of the dam. The dam was equipped with three aerial antennas: one downstream, one across the face of the dam, and one upstream (Figure 8).

Roza Dam

Roza Dam (rkm 205) was originally built in 1939 and is operated by the U.S. Bureau of Reclamation. It is a concrete weir with a movable crest structure. The dam stands 20.4 m tall and is 148 m in length (USBOR 2011). Water is diverted into an irrigation canal on the river right of the dam. The fishway utilizes a vertical slot pool design with entrances on both banks. These entrances merge into a single ladder on the left bank. A simple telemetry station consisting of one downstream antenna was installed at Roza Dam to detect if any tagged Pacific lampreys migrated that far upriver (Figure 2). No solar power backup was utilized at Roza Dam.

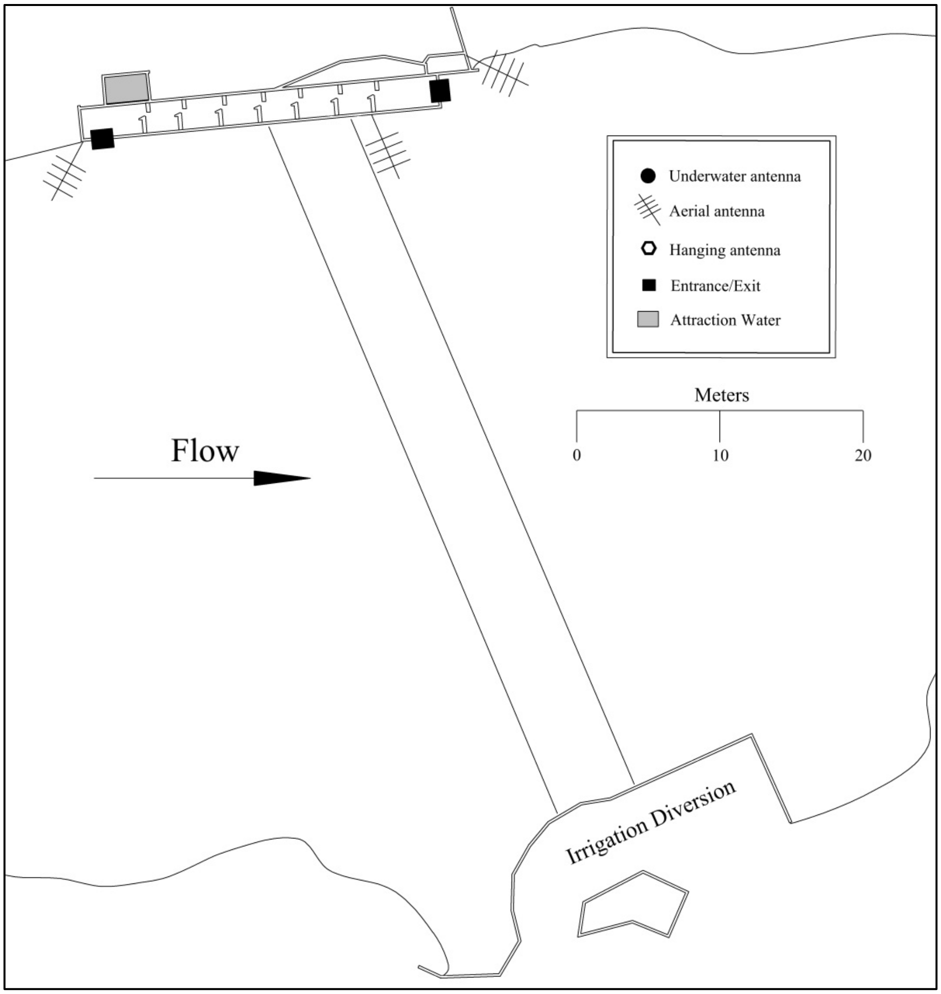

Figure 8. Locations of telemetry antennas on Cowiche Dam, 2011 to 2012.

Gate Stations

"Gate" stations were set up to determine if any tagged lampreys left the study area or entered tributaries (Figure 2). A station near the mouth of the Yakima River (rkm 6.9) was set up to determine if Pacific lamprey moved downstream to the Columbia River. This fixed station consisted of one aerial antenna aimed across the river, a SRX400A receiver, and a car battery charged by AC power provided by the landowner. Gate stations were also set up on Satus and Toppenish creeks to determine movement into these tributaries. These stations each had one antenna facing upstream and one facing downstream combined together as one unit. The receivers at these stations were powered by solar panels. A station using solar power and a single downstream facing antenna monitored movement into Ahtanum Creek (Figure 2). A station at the Roza irrigation canal wasteway outfall near the city of Yakima (rkm 182) was also set up to aid in upstream migration detections. This station was equipped with a single upstream facing antenna and was AC powered.

Telemetry Data Analysis
For descriptive purposes, the definitions of *left* and *right* were referenced to the downstream or river flow direction, and applied to the river banks as well as the island fishways at the dams. *First approach* was defined as the first detection recorded on an aerial antenna at a fixed telemetry station. *Below dam residence* was calculated as the difference between the first downstream detection at the dam and the first detection of entry into the fishway during a passage event. *Below dam residence* was further separated into three segments based on activity: *fall residence*, *over-winter*, and *spring residence*. *Fall residence* was defined as the time a lamprey spent actively moving at a dam in an attempt to pass. *Over-winter* was calculated as the time of inactivity during the winter months in which a lamprey did not move or attempt to pass a dam. *Spring residence* was calculated as the difference between when movement commenced after the over-winter period and when a lamprey either entered a fishway on a passage event or moved downstream from the dam. *Fishway passage* was calculated as the elapsed time between the first fishway entrance detection and the last fishway exit detection during a passage event. *Above dam residence* was defined as the difference between the last fishway exit detection and the last upstream aerial antenna detection at the dam. Diurnal movements were described as occurring either during day or night hours. Civil twilight, as noted at the town nearest to each dam (www.sunrisesunset.com), was used to differentiate between day and night hours. *Migration time* was calculated as the difference between the last detection as the lamprey moved from one station to the first detection at the next station. *Migration rate* was as defined the distance between stations divided by migration time.

Collection
Adult Pacific lampreys were supplied by the Yakama Nation Fisheries Program from lampreys collected at Bonneville Dam, The Dalles Dam, and John Day Dam on the lower Columbia River between June 24 and August 18, 2011. Fish were captured in funnel traps at the picketed leads of the fish counting stations on both sides of the dams and transported to the Yakama Nation Prosser Hatchery facility and held until tagged. All were injected with 0.15 cc of Oxytetracycline to prevent the spread of disease (Patrick Luke, Yakama Nation Fisheries Program, pers. comm.). Holding facilities consisted of flow-through metal stock tanks supplied with river and/or well water.

Radio Transmitter Implantation
Implantation surgeries took place in the spawning shed at the Yakama Nation Prosser Hatchery facility. The surgical procedure was modified from methods described in Moser et al. (2002) and Nelson et al. (2007). Tools and transmitters were chemically disinfected with Benz-All®. Fish were anesthetized in a bath of 80 ppm tricaine methanesulfonate (MS-222) buffered with sodium bicarbonate to match the pH of the river water. After 8 to 10 minutes the fish was removed from the bath and total length (mm), interdorsal base length (mm), girth (mm), and weight (g) were measured and recorded. The lamprey was then placed on a cradle made from PVC pipe and the head and gills were immersed in a 15 L bath of 40 ppm of buffered MS-222. Wet sponges were placed in the cradle to prevent the lamprey from sliding and to assist in incision placement. Using a number 12 curved blade scalpel, a 25 mm incision was made 1 cm off the ventral midline with the posterior end of the incision stopping in line with the anterior end of the first dorsal fin. A

catheter was inserted through the incision and out the body wall approximately 4 cm posterior to the incision. The antenna was threaded through the catheter and the individually coded radio transmitter (Lotek NTC-6-2, 9 x 30 mm, 4.3 g, 441 d battery life or Lotek NTC-4-2L, 8 x 18 mm, 2.1 g, 162 d battery life) was inserted into the incision. Using a 19 mm needle the incision was then closed with 3-4 braided absorbable sutures. The lamprey was then transferred to a holding tank until release.

Release

Release dates were chosen in an attempt to mimic the movements of the natural run in the river. Release sites were located upstream and downstream of both Wanawish Dam and Prosser Dam. Release sites were chosen by accessibility and relative close proximity to each dam. Individuals were chosen for each release site by removing them from the holding tank at random. The code of each fish was then recorded prior to release.

Tracking

Fixed telemetry stations were downloaded on a weekly schedule. Test beacons were activated during downloads at each station to ensure the antennas and receivers were operating and recording properly. In addition to the data recorded at fixed stations, mobile tracking was opportunistically conducted to determine exact locations at the dams as well as approximate locations between the dams. Mobile tracking was conducted by foot, truck, boat, and airplane.

Temperature

Stream temperatures were monitored at Wanawish, Prosser, Sunnyside, and Wapato dams. Electronic data loggers (HOBO® U22 Water Temp Pro v2, Onset Computer Corp.) were calibration checked for accuracy with an NIST-tested thermometer and only units that agreed to within 0.2 °C were deployed. The data loggers were housed in perforated PVC pipe (40 mm dia.) and tethered to wire cable suspended into the river from one fishway at each dam. Data loggers were programmed to record once every hour. Data were downloaded into a shuttle, offloaded, and saved to a desktop computer. Mean, minimum, and maximum daily water temperatures were calculated with the Hoboware® Pro software package.

Discharge

Stream discharge was obtained from the USBOR Pacific Northwest Region Hydromet website (http://www.usbr.gov/pn/hydromet/yakima/yakwebarcread.html). Average daily flow (QD) was queried for the Yakima River stations at Kiona (KIOW), Prosser (YRPW), and Parker (PARW). Discharge is reported in ft^3/s.

Velocity

Velocities at the entrances to the fishways were measured during weekly downloading of the telemetry stations. Measurements were taken when the velocity meter was available for use and when time allowed. Velocities were measured using a Marsh McBirney Flo-Mate™ 2000 portable flow meter. The sensor and mount were attached to an extension pole so measurements could be taken from the deck of the dam. Measurements occurred on the downstream side of all open entrances to the fishways. The meter was placed approximately 0.5 m into the water column, though this varied between fishways and levels of discharge. Three measurements were taken and the median velocity was recorded in feet per second (ft/s). For analysis purposes, each island fishway had velocities of all its open gates averaged and reported as one. Statistical analyses of entrance velocities were performed using a single factor analysis of variance. The field measurements of entrance velocity are recorded in Appendix B.

Results

Tagging

Tagging and release occurred during two time periods; one in the fall 2011 and the other in the spring 2012. For the fall releases, a total of 42 adult Pacific lampreys were radio tagged September 13-15, 2011 (Table 1). Weights ranged from 356 to 825 g (mean 509.5 g), lengths from 624 to 780 mm (mean 685 mm) and girths from 100 to 135 mm (mean 116.5 mm). For the spring release, 35 lampreys were tagged on March 21-22, 2012 (Table 2). Weights ranged from 276 to 499 g (mean 361.8 g), lengths from 532 to 687 mm (mean 595.7 mm), and girth ranged between 95 and 123 mm (mean 106.2 mm) (Figures 9 and 10).

Holding

Lampreys tagged in the fall were held for 3 weeks before release. Lampreys tagged in the spring were held for one week. One lamprey shed its tag during the fall holding period. No mortalities occurred during holding.

Releases

Fall release- A total of 41 tagged lampreys were released on October 4, 2011. Five were released from the left bank 1.2 km upstream of Wanawish Dam; sixteen were released 0.45 km downstream of the dam, eight on each bank (Figure 11). The upstream release location was in a slow water area consisting of submerged grasses and an undercut bank. The downstream release locations were in areas consisting of various sized cobbles. Sixteen lampreys were released on the left bank 0.30 km downstream of Prosser Dam amongst large boulders in a slow, deep pool. Four lampreys were released 1.1 km upstream of the dam on the right bank in a slow water area with boulders and floating debris (Figure 12).

Spring release- A total of 35 Pacific lampreys were released on March 28, 2012 at the same locations used in the fall. Seven lampreys were released on each side of the river downstream of Wanawish Dam and four were released upstream of the dam. Thirteen tagged fish were released downstream of Prosser Dam and 4 upstream of the dam.

Table 1. Weight, total length, girth, dorsal base length, and release location of radio-tagged adult Pacific lampreys released in the Yakima River on October 4, 2011.

Code	Total Length (mm)	Weight (g)	Girth (mm)	Dorsal Base Length (mm)	Release Location
4	710	587	135	34	Wanawish Left d/s
11	669	570	122	35	Wanawish Left d/s
21	644	377	103	26	Wanawish Left d/s
27	780	665	128	44	Wanawish Left d/s
18	642	420	108	30	Wanawish Left d/s
22	654	466	115	45	Wanawish Left d/s
35	662	425	110	35	Wanawish Left d/s
43	657	450	115	38	Wanawish Left d/s
6	715	571	128	47	Wanawish Right d/s
7	726	644	125	40	Wanawish Right d/s
10	724	525	113	43	Wanawish Right d/s
14	716	581	123	36	Wanawish Right d/s
19	675	444	105	45	Wanawish Right d/s
23	661	473	119	38	Wanawish Right d/s
28	719	598	124	44	Wanawish Right d/s
12	664	475	118	55	Wanawish Right d/s
13	720	825	127	38	Wanawish u/s
20	700	479	114	39	Wanawish u/s
32	669	464	119	32	Wanawish u/s
45	669	445	112	31	Wanawish u/s
40	660	461	111	40	Wanawish u/s
5	732	596	115	44	Prosser d/s
9	739	647	125	41	Prosser d/s
15	678	476	113	39	Prosser d/s
17	653	392	105	50	Prosser d/s
26	690	514	116	34	Prosser d/s
29	703	530	122	44	Prosser d/s
31	649	420	109	38	Prosser d/s
34	754	676	127	55	Prosser d/s
37	640	437	111	29	Prosser d/s
39	719	558	119	41	Prosser d/s
41	687	470	113	39	Prosser d/s
42	684	470	116	36	Prosser d/s
8	680	544	119	41	Prosser d/s
16	732	600	124	47	Prosser d/s
33	666	468	118	31	Prosser d/s
46	683	540	120	35	Prosser d/s
30	675	475	114	34	Prosser u/s
38	624	367	104	29	Prosser u/s
36	632	356	100	31	Prosser u/s
44	684	462	109	38	Prosser u/s
24	668	456	121	34	shed during holding

Table 2. Weight, total length, girth, dorsal base length, and release location of radio-tagged adult Pacific lampreys released in the Yakima River on March 28, 2012.

Code	Total Length (mm)	Weight (g)	Girth (mm)	Dorsal Base Length (mm)	Release Location
56	571	327	98	20	Wanawish Left d/s
67	572	315	102	18	Wanawish Left d/s
69	625	408	109	30	Wanawish Left d/s
71	620	348	97	40	Wanawish Left d/s
78	595	391	112	30	Wanawish Left d/s
85	622	387	106	30	Wanawish Left d/s
88	605	354	106	27	Wanawish Left d/s
55	542	297	105	12	Wanawish Right d/s
59	589	352	104	22	Wanawish Right d/s
60	625	445	113	18	Wanawish Right d/s
61	562	395	123	18	Wanawish Right d/s
65	638	377	103	30	Wanawish Right d/s
68	600	349	116	34	Wanawish Right d/s
77	602	371	103	25	Wanawish Right d/s
57	561	352	115	30	Wanawish u/s
72	532	276	95	17	Wanawish u/s
89	555	320	102	15	Wanawish u/s
82	553	293	98	15	Wanawish u/s
62	610	405	112	27	Prosser d/s
63	687	499	117	40	Prosser d/s
64	598	354	107	30	Prosser d/s
66	592	362	102	32	Prosser d/s
75	612	427	112	25	Prosser d/s
76	646	444	110	34	Prosser d/s
79	582	323	105	27	Prosser d/s
81	635	401	110	23	Prosser d/s
83	655	434	110	32	Prosser d/s
84	585	337	101	21	Prosser d/s
86	580	322	101	24	Prosser d/s
87	593	329	100	22	Prosser d/s
58	575	305	95	25	Prosser d/s
70	592	332	97	27	Prosser u/s
73	555	290	100	23	Prosser u/s
74	600	340	115	26	Prosser u/s
80	582	403	115	32	Prosser u/s

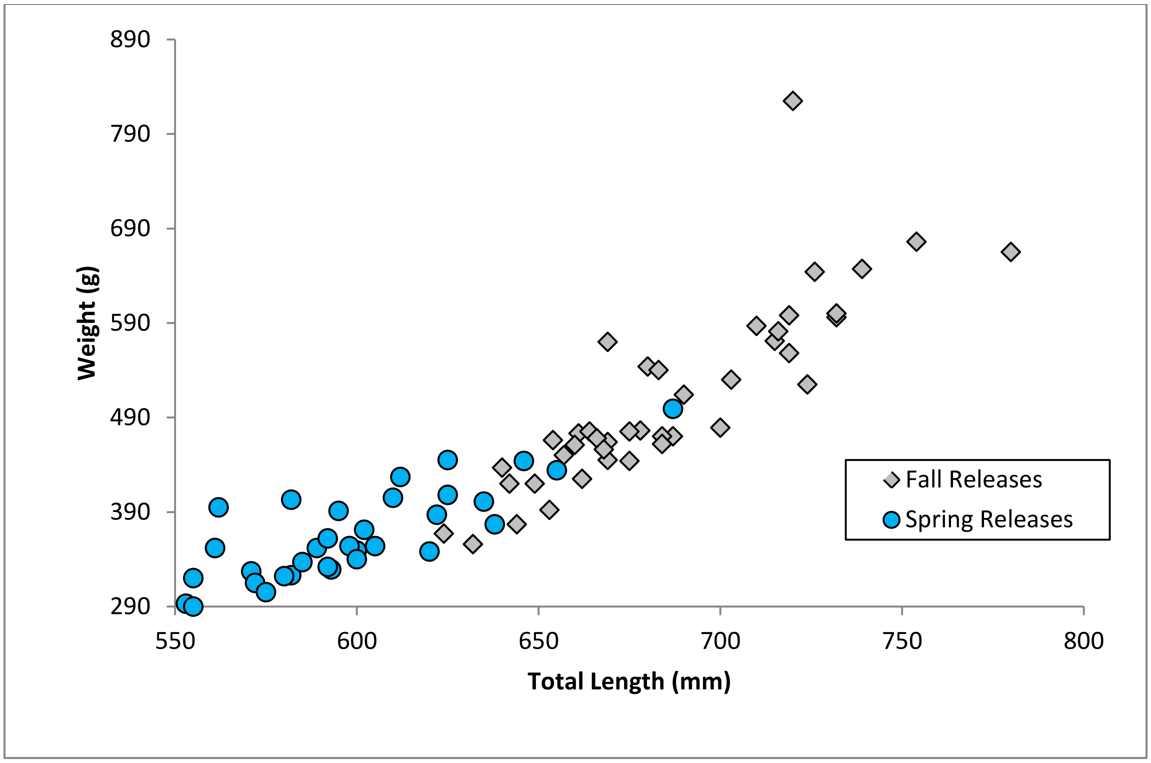

Figure 9. The lengths and weights of radio-tagged Pacific lampreys released into the Yakima River on October 4, 2011 and March 28, 2012.

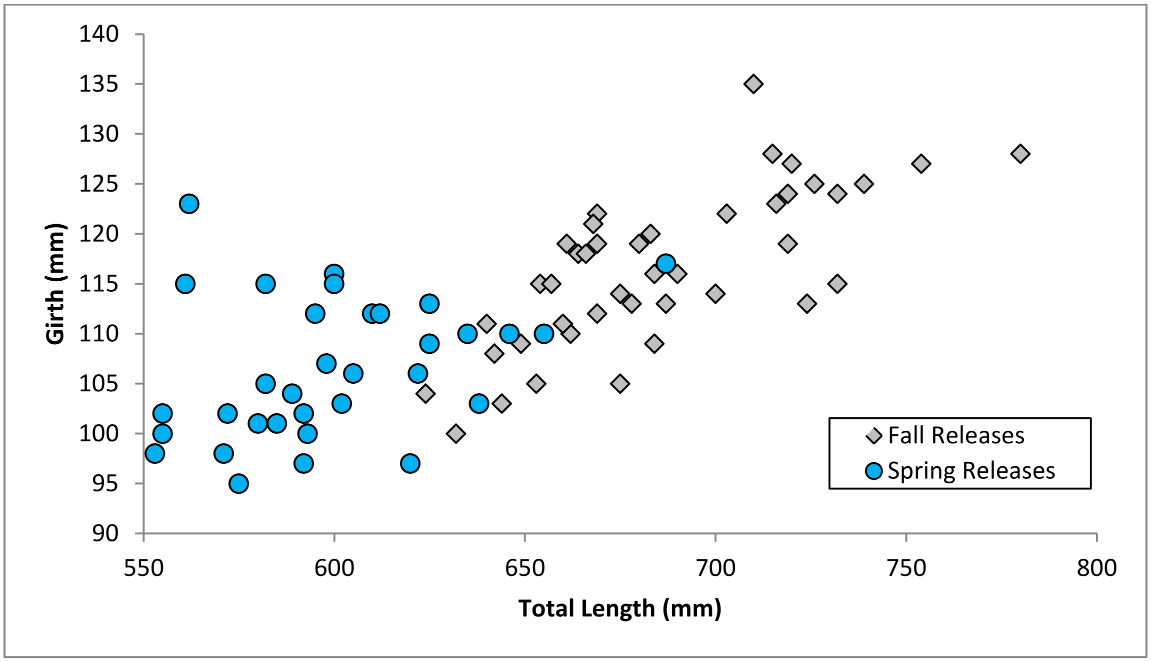

Figure 10. The girths of radio-tagged Pacific lampreys released into the Yakima River on October 4, 2011 and March 28, 2012.

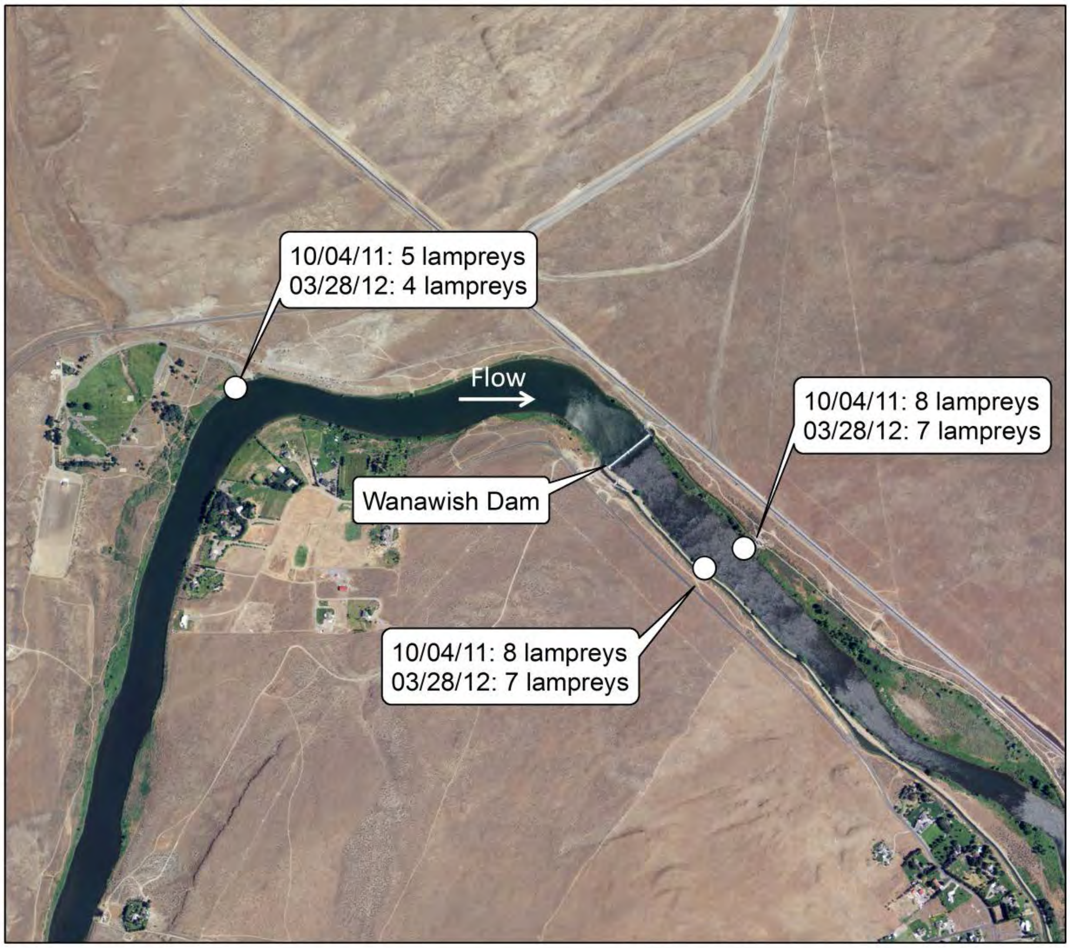

Figure 11. Aerial photograph showing the release locations of radio-tagged adult Pacific lampreys in the vicinity of Wanawish Dam on October 4, 2011 and March 28, 2012.

Figure 12. Aerial photograph showing the release locations of radio-tagged adult Pacific lampreys in the vicinity of Prosser Dam on October 4, 2011 and March 28, 2012.

Movements
A total of 73 (96%) Pacific lampreys moved upstream from their release sites. Two moved downstream from their release sites and one never moved. The tag of this latter individual was later determined to be on the bank, indicating either predation or scavenging had occurred. First approaches of a dam were made between October 4, 2011 and July 7, 2012. A total of thirteen lampreys resided at the dams through the winter. The movements of radio-tagged lampreys at each dam are described in the following sections.

Wanawish Dam
First approach of fall release- Sixteen tagged lampreys were released downstream of the dam on October 4 and first approach detections of individuals ranged from October 4 to December 20, with a second pulse from January to April 2012 (Table 3). Nine lampreys (56%) approached in October, one individual approached in December, five (31%) approached in the following spring, and one moved downstream from its release location. Detections of first approaches were on the downstream aerial antennas, with 62% near the left bank while the rest were near the right bank.

First approach of spring release- Fourteen tagged lampreys were released on March 28 and detections of first approach of individuals at the dam ranged from March 28 to April 24, 2012. One hundred percent of the spring released lampreys were detected approaching the dam.

Below Dam Residence- Total residence time below Wanawish Dam ranged from two hours and forty-five minutes to nearly 219 days (Table 3). Ten lampreys approached the dam before overwintering. Three passed the dam in October and had an average fall residence of 8 days (range 0.11-13.1 d). The remaining seven had an average fall residence of 12 days (range 1.7-19.7 d) before they stopped actively moving. These lampreys remained at the dam throughout the winter before continuing their upstream migration. Overwinter residence averaged 132 days, though one lamprey only overwintered for 55.5 days. Spring residence time of fall released lampreys averaged 33.9 days (range 21.3-50.9 d) for those who passed the dam and 58.1 days (range 29-82 d) for those that were unsuccessful in migrating past the dam. Successful spring released lampreys had an average residency time of 30.8 days (range 23-50 d) (Figure 13). All twenty-nine lampreys that approached Wanawish Dam were detected on each side of the dam at least once (Figure 14). Holding areas for lampreys were not localized to a pool or corner of the dam and instead were distributed across the width of the river, most commonly in middle of the river close to the face of the dam and along the banks just downstream of the dam. The mortality of one lamprey was indicated at Wanawish Dam on May 4 when code 19 stopped moving. On May 10 it was detected out of the river on the right bank 250 m downstream of the dam, but recovery of the transmitter was not possible and it is unknown if the lamprey was depredated or scavenged.

Table 3. Wanawish Dam approach and residence data: first and last detection dates and total number of days that adult radio-tagged Pacific lampreys resided below the dam before entering a fishway or moving downstream, October 2011 through August 2012.

Code	1st Station Detected	1st Detection Date	Last Detection Date	Days	Enter Fishway?
11	Left Bank	10/04/11 19:34	05/07/12 16:18	215.9	No
35	Left Bank	10/04/11 19:51	10/04/11 22:36	0.1	Yes
22	Left Bank	10/04/11 19:57	10/15/11 21:25	11.1	Yes
6	Left Bank	10/04/11 22:26	04/21/12 22:01	200	Yes
12	Right Bank	10/10/11 19:35	10/23/11 21:04	13.1	Yes
27	Left Bank	10/10/11 21:29	05/16/12 20:24	219	Yes
19	Left Bank	10/15/11 19:34	05/04/12 00:51[A]	201	No
4	Left Bank	10/18/11 19:46	04/22/12 20:58	187.1	Yes
18	Right Bank	10/22/11 19:21	04/15/12 21:33	176.1	No
14	Right Bank	12/20/11 22:45	04/23/12 00:15	124.1	Yes
21	Left Bank	02/24/12 03:34	05/06/12 09:01	72.2	No
7	Left Bank	02/26/12 02:05	05/18/12 02:23	82	No
43	Left Bank	03/17/12 13:53	04/27/12 15:50	41.1	No
23	Left Bank	03/17/12 14:32	05/18/12 05:06	61.6	No
60	Right Bank	03/28/12 16:01	04/23/12 00:09	25.3	Yes
65	Right Bank	03/28/12 20:03	04/24/12 01:26	26.2	Yes
71	Left Bank	03/28/12 20:18	05/08/12 22:53	41.1	Yes
88	Left Bank	03/28/12 20:41	05/17/12 18:50	49.9	Yes
69	Left Bank	03/28/12 21:00	04/21/12 21:18	24	Yes
78	Left Bank	03/28/12 23:51	04/22/12 20:38	24.9	Yes
28	Left Bank	03/31/12 14:15	04/21/12 22:06	21.3	Yes
77	Right Bank	04/01/12 18:45	04/24/12 21:30	23.1	Yes
68	Right Bank	04/10/12 20:40	04/22/120 8:28	11.5	No
59	Right Bank	04/12/12 19:39	05/14/12 19:04	31.9	Yes
55	Right Bank	04/21/12 21:31	08/21/12 00:37[B]	121.1	No
67	Left Bank	04/22/12 21:21	05/19/12 18:19	26.9	No
61	Right Bank	04/23/12 03:41	04/25/12 22:46	2.8	No
85	Left Bank	04/24/12 02:58	unknown	unk	Yes
56	unknown	unknown	05/28/2012 22:39	unk	Yes

[A] last date of movement

[B] date radio tag battery died

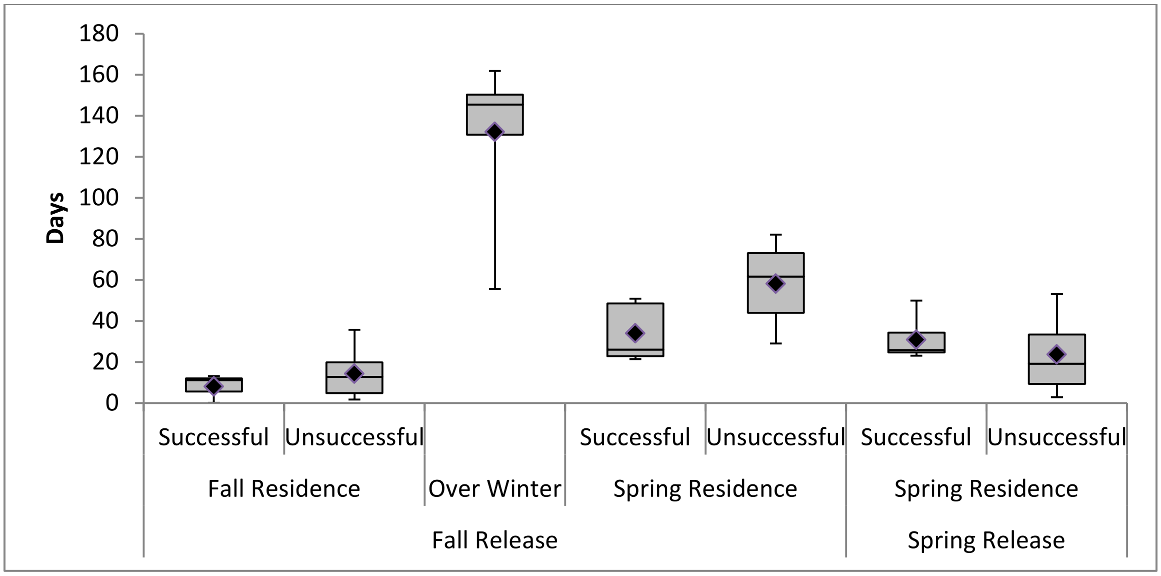

Figure 13. Periods of below dam residency for radio-tagged Pacific lampreys at Prosser Dam that were successful and unsuccessful in passing upstream of the dam, October 2011 through July 2012. Box plots show median and quartiles. The diamonds indicate the means.

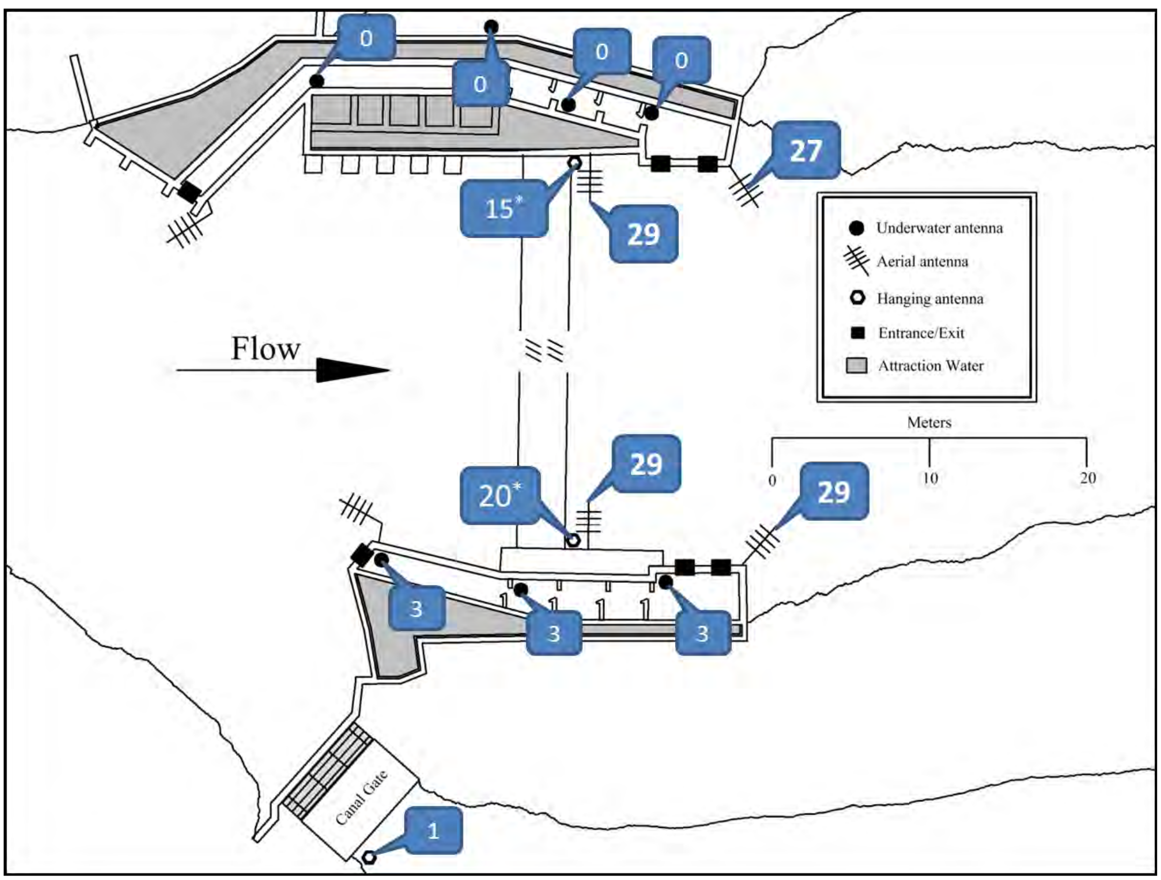

Figure 14. Number of radio-tagged Pacific lampreys detected on downstream and in-ladder antennas at Wanawish Dam, October 2011-July 2012. Antennas with a (*) were installed on March 27, 2012.

Fishway Passage- Of the 29 Pacific lampreys that approached the dam, 18 (62%) were ultimately successful in passing upstream (Table 4). Three fall released lampreys passed Wanawish Dam in October and five were successful in the spring months for a total fall release success rate of 53%. Ten of the fourteen spring released lampreys passed, for a success rate of 71%. All passage events took place in October, April, and May; half of which occurred between April 21 and 24. The right bank fishway was definitively used by three lampreys. Two lampreys were last detected passing the dam on the left bank antennas but there were no detections on the antennas within the fishway. The remaining 13 were detected passing the dam on the river right station. Data suggest that these individuals did not use the fishway but instead climbed over the dam using a ledge in between the fishway and the face of the dam (Figure 15). Passage time within the fishway ranged from 0.03 to 0.27 hours. The time it took to pass the dam using the ledge ranged from 0.18 to 2.98 hours (average 1.08 hours). Nine lampreys never passed the dam and instead moved back downstream. One individual remained at the dam until the transmitter battery died near the end of the study period. The status of that lamprey is not known.

Table 4. Wanawish Dam fishway data: dates of entry, exit and total time in fish ladder or passage area, and water temperature at passage for radio-tagged adult Pacific lampreys from October 2011 to July 2012.

Code	Release Site/Period	Fishway or Area	Entered Ladder or Area	Exited Ladder or Area	Time in Ladder or Area (hr)	Temp °C
35	WAN Fall Dn	L. Bank	10/04/11 22:36	10/05/11 02:45	4.15	15.4
22	WAN Fall Dn	Ledge	10/15/11 21:25	10/15/11 22:39	1.23	14.0
12	WAN Fall Dn	Ledge	10/23/11 21:04	10/23/11 22:08	1.07	14.0
69	WAN Spr Dn	Ledge	04/21/12 21:18	04/21/12 21:36	0.3	11.9
6	WAN Fall Dn	Ledge	04/21/12 22:01	04/21/12 22:27	0.43	11.9
28	WAN Fall Dn	R. Ladder	04/21/12 22:06	04/21/12 22:20	0.23	11.9
78	WAN Spr Dn	Ledge	04/22/12 20:38	04/22/12 21:36	0.97	13.3
4	WAN Fall Dn	Ledge	04/22/12 20:58	04/22/12 21:26	0.47	13.3
60	WAN Spr Dn	Ledge	04/23/12 00:09	04/23/12 00:28	0.32	14.3
14	WAN Fall Dn	R. Ladder	04/23/12 00:15	04/23/12 00:17	0.03	14.3
65	WAN Spr Dn	Ledge	04/24/12 01:26	04/24/12 01:53	0.45	14.7
77	WAN Spr Dn	Ledge	04/24/12 21:30	04/24/12 21:41	0.18	14.7
71	WAN Spr Dn	Ledge	05/08/12 22:53	05/08/12 23:09	0.27	13.3
59	WAN Spr Dn	L. Bank	05/14/12 19:04	05/14/12 19:32	0.47	15.1
27	WAN Fall Dn	Ledge	05/16/12 20:24	05/16/12 23:23	2.98	16.4
88	WAN Spr Dn	R. Ladder	05/17/12 18:50	05/17/12 19:06	0.27	15.3
56	WAN Spr Dn	Ledge	05/28/12 22:39	05/28/12 23:03	0.4	14.5
85	WAN Spr Dn	Ledge	unknown	05/13/12 15:06	unk	13.9

Figure 15. The ledge on the right bank of Wanawish Dam that it appears most Pacific lampreys used to pass upstream. The flow is approximately 5,500 ft^3/s in the left picture and 10,500 ft^3/s on the right. The entrance to the fishway is just out of the picture on the left hand side.

Discharge-

Pacific lampreys passed Wanawish during two distinct discharge levels. The three that passed in October 2011 did so at flows below 2,600 ft^3/s. Lampreys passing during the spring months did so at flows between 6,610 and 10,400 ft^3/s. The majority of passage events occurred during periods of increasing discharge (Figure 16).

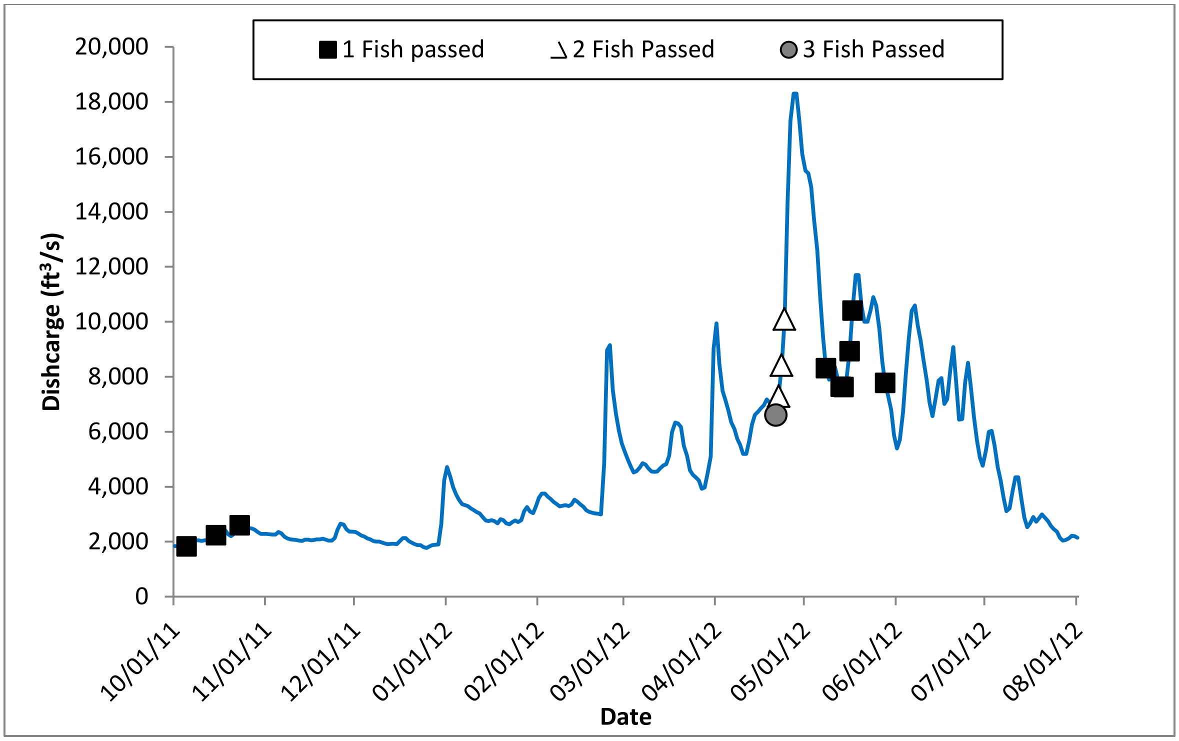

Figure 16. Graph showing the discharge and passage timing of radio-tagged Pacific lampreys at Wanawish Dam on the Yakima River, October 2011 through July 2012.

Velocity at Fishways- Fishway entrance velocities were recorded between April 5 and August 7, 2012 (Figure 17 and Appendix B). Velocities for the right bank fishway ranged between -0.81 and 6.92 ft/s. Several negative velocities were recorded for both fishways. The left bank fishway was inoperable during most of the study period. Its velocities are therefore representative of the velocity of the river as it passes the fishway entrance and not those of the fishway itself.

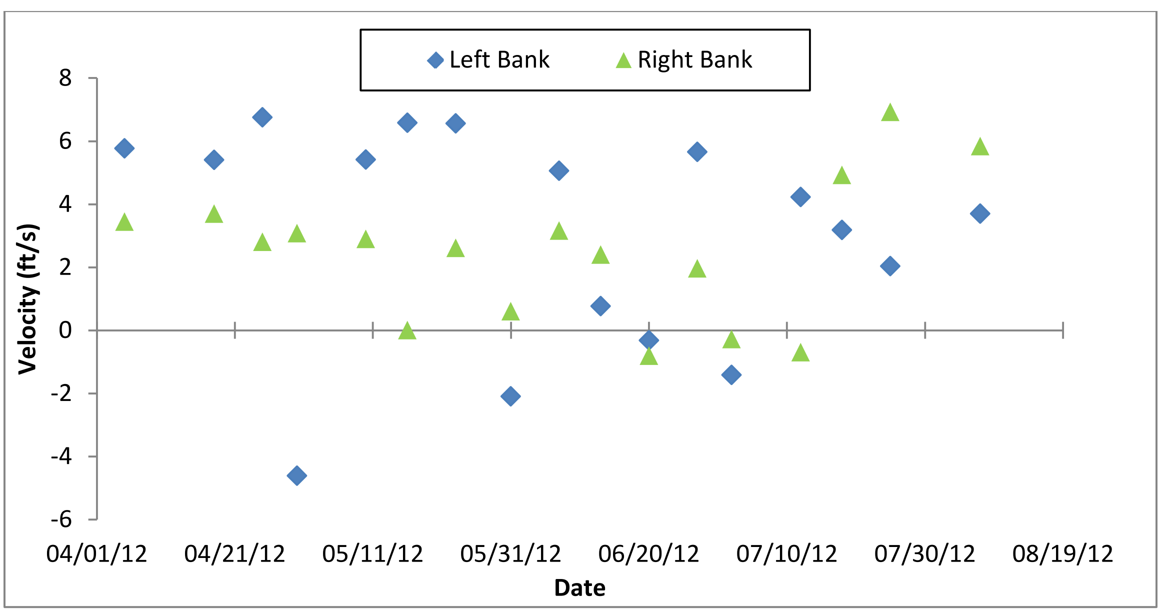

Figure 17. The entrance velocities at Wanawish Dam fishways between April and August, 2012.

Temperature- Water temperatures of the Yakima River were recorded at Wanawish Dam between October 1, 2011 and September 1, 2012 (Figure 18). Daily averages varied from 0 to 25 °C. Lamprey passage occurred during daily mean temperatures of 11.9 to 16.4 °C with the majority (78%) passing between 13.4 and 14.7 °C (Figure 18, Table 4). In the fall, water temperatures rapidly declined to less than 10 °C after the last lamprey passed the dam and movements below the dam generally ceased for the remainder of the fall.

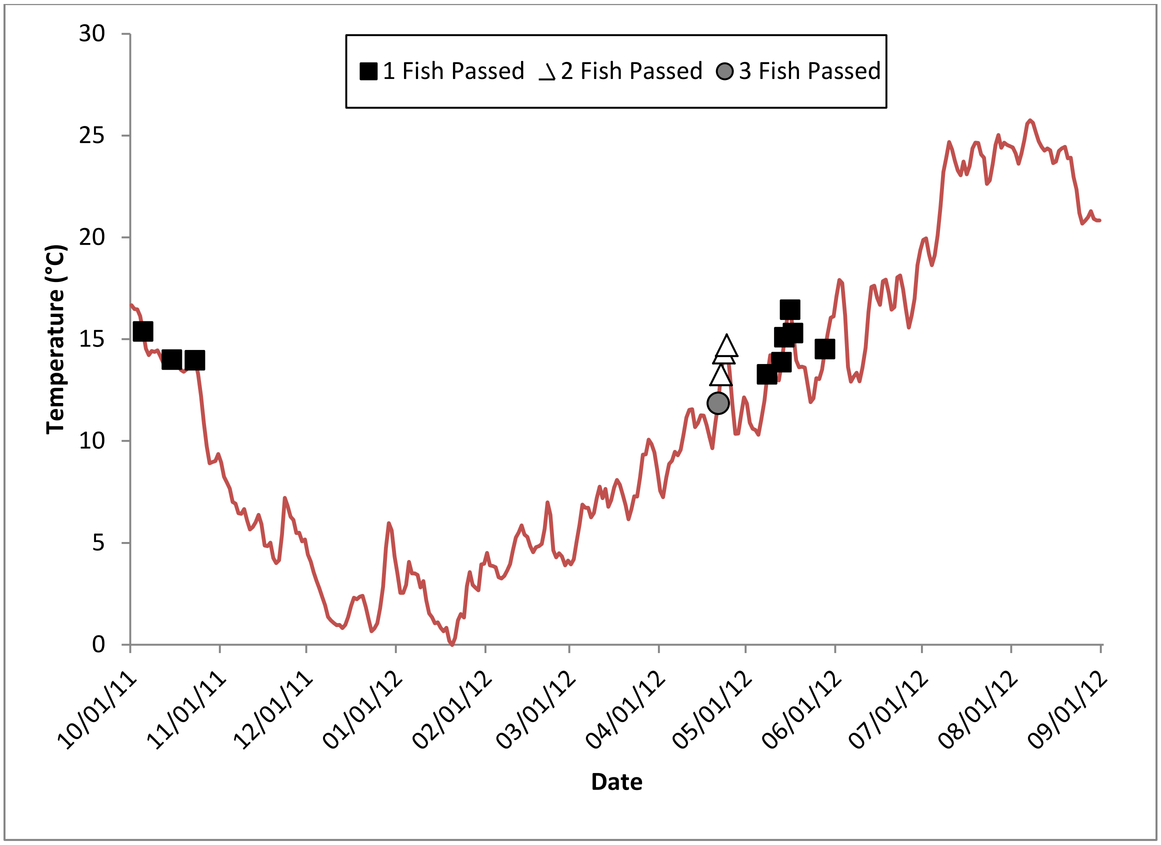

Figure 18. Average daily water temperatures of the Yakima River and dates of lamprey passage at Wanawish Dam between October 1, 2011 and September 1, 2012.

Above Dam Residence- On May 10, one lamprey (code 71) was detected in the right bank Columbia Irrigation District Canal after it had passed the dam. It stayed approximately 20 m downstream of the canal entrance for 58.1 days. It then exited through the upstream end of the canal and continued its upstream movement. No other lamprey resided more than a few minutes at the dam once it had successfully passed upstream of it.

Prosser Dam

First Approach- Pacific lampreys from both releases downstream of Prosser Dam began to approach on the evening of their release (Table 5). Twenty-eight of the 29 lampreys released downstream of the dam were detected approaching it. Twelve fall released lampreys first approached between October 4 and November 24, 2011 before overwintering. The remaining four approached between February 22 and May 28, 2012. Spring released lampreys approached the dam between March 28 and May 20, 2012. One spring released lamprey never approached the dam and instead moved downstream from the release site. Of the five lamprey released upstream of Wanawish Dam in the fall, one approached Prosser Dam in October. Three others overwintered before approaching between March 17 and April 11. Only one of the four lampreys released upstream of Wanawish in the spring approached Prosser Dam. It did so on April 7. Fifteen (83%) of those lampreys that successfully passed Wanawish Dam migrated upstream to Prosser Dam and approached it. One fall released lamprey approached on October 15, while the rest of the approaches from both release groups occurred between March 17 and May 28. Prosser Dam therefore had an overall approach rate of 84%. First approaches were made near the left bank 62% of time and the right bank 34% of the time. Only two lampreys were first detected on the downstream antenna on the center island.

Below Dam Residence- Average fall residence for lampreys that were successful in passing Prosser Dam was 0.5 days (Figure 19). Three lampreys approached the dam in the fall and moved downstream before over-wintering. These lampreys all spent less than two hours at the dam before moving downstream. Lampreys that remained at the dam and were unsuccessful in passing during the fall had an average fall residence of 23.5 days (range 24-77 d). These individuals stopped moving and over-wintered at the dam for an average of 120 days (range 87-152 d). Fall released lampreys that began moving again in the spring and ultimately passed Prosser Dam resided at the dam for an average of 45.8 days while those that were unsuccessful resided for an average of 59.4 days. Spring released lampreys had the most variable residence times at Prosser Dam: Lampreys that passed in the spring had an average residency of 27.4 days (range 0.04-93 d) while those that did not pass averaged 81.6 days (range 12-130.3 d) of residency at the dam.

Table 5. Prosser Dam approach and residence data: first and last detection dates and total number of days that adult radio-tagged Pacific lampreys resided below the dam before entering a fishway or moving downstream, October 2011 through August 2012.

Code	1st Station Detected	1st Detection Date	Last Detection Date	Days	Entered Fishway?
16	Left Island	10/04/11 19:46	10/04/12 20:16[C]	0.02	Yes
29	Right Bank	10/04/11 20:02	10/04/11 20:20	0.01	No
39	Right Bank	10/04/11 20:25	10/4/11 21:51[C]	0.06	Yes
8	Right Bank	10/04/11 20:26	10/05/11 22:46	1.1	Yes
42	Right Bank	10/04/11 20:33	10/04/11 22:06	0.06	No
17	Center Island	10/04/11 20:40	04/23/12 22:34	202.1	No
46	Right Bank	10/04/11 20:40	10/12/11[B]	7	No
26	Right Bank	10/04/11 21:14	5/29/12 23:39	238.1	Yes
9	Right Bank	10/04/11 21:22	10/04/11 21:23	0.00	No
31	Right Bank	10/04/11 22:41	10/17/11[B]	12	No
41	Right Bank	10/05/11 04:45	04/15/12 12:03	193.3	No
34	Right Bank	10/15/11 20:28	10/15/11 21:57	0.06	Yes
35	Right Bank	10/15/11 20:57	03/22/12[A]	158	No
13	Right Bank	10/21/11 21:32	10/22/11 06:04	0.4	Yes
37	Left Island	02/22/12 06:18	05/16/12 08:00	84.1	No
15	Left Island	03/17/12 00:23	06/03/12[A]	78	No
12	Left Island	03/17/12 20:26	06/03/12 23:00	78.1	No

Table 5 Continued

Code	1st Station Detected	1st Detection Date	Last Detection Date	Days	Entered Fishway?
40	Left Island	03/17/12 20:56	05/08/12 21:01	52.0	Yes
20	Left Island	03/25/12 23:55	06/05/12 11:29	71.5	Yes
66	Left Island	03/28/12 20:50	05/29/12 22:15	62.1	Yes
76	Left Island	03/28/12 22:10	06/29/12 22:41	93	Yes
63	Right Bank	03/29/12 01:10	08/06/12 07:45	130.3	No
75	Left Island	03/29/12 21:46	07/25/12[B]	117	No
33	Left Island	03/30/12 21:10	05/09/12 22:24	40.1	Yes
22	Right Bank	03/31/12 03:57	06/30/12 04:34	91	No
84	Left Island	03/31/12 05:18	04/12/12 20:30	12.6	Yes
58	Left Island	04/02/12 21:12	07/25/12 20:21	114	No
86	Left Island	04/03/12 02:35	07/12/12 04:59	100.1	No
83	Left Island	04/03/12 18:27	04/10/12 22:56	7.2	Yes
79	Left Island	04/05/12 02:15	04/22/12 22:33	17.9	Yes
89	Left Island	04/07/12 22:12	04/10/12 18:58	2.9	Yes
81	Left Island	04/09/12 22:37	06/09/12[A]	60	No
32	Left Island	04/11/12 02:32	05/15/12 23:38	34.9	Yes
5	Left Island	04/22/12 04:29	05/13/12 21:19	21.7	Yes
87	Left Island	04/23/12 12:43	08/25/12 18:04	124.2	No
28	Left Island	04/23/12 23:37	04/24/12 00:29	0.04	Yes[D]
69	Left Island	04/24/12 01:58	04/24/12 02:51	0.04	Yes
4	Left Island	04/25/12 00:05	07/14/12 22:11	80.9	Yes
78	Left Island	04/25/12 00:43	06/02/12 01:22	38	Yes
6	Center Island	04/28/12 00:18	05/08/12 21:25	10.9	Yes
14	Right Bank	05/01/12 02:25	06/01/12 22:08	31.8	Yes
77	Left Island	05/01/12 02:50	05/28/12 23:59	27.9	Yes
65	Left Island	05/08/12 21:19	08/03/12 14:27	86.7	No
59	Right Bank	05/19/12 00:22	05/31/12 00:05	12	No
85	Left Island	05/20/12 05:35	06/02/12 01:07	12.8	Yes
27	Left Island	05/28/12 12:09	06/29/12 22:28	32.4	Yes
62	Left Island	06/02/12 23:53	07/25/12[B]	52	No
60	Left Island	04/30/120 4:32	05/25/12 11:10	25.3	No

[A] last date of movement
[B] date tag was recovered
[C] last detection before power failure
[D] entered and went up left fishway on 4/24 when headgate was closed and backed down 1 hour later

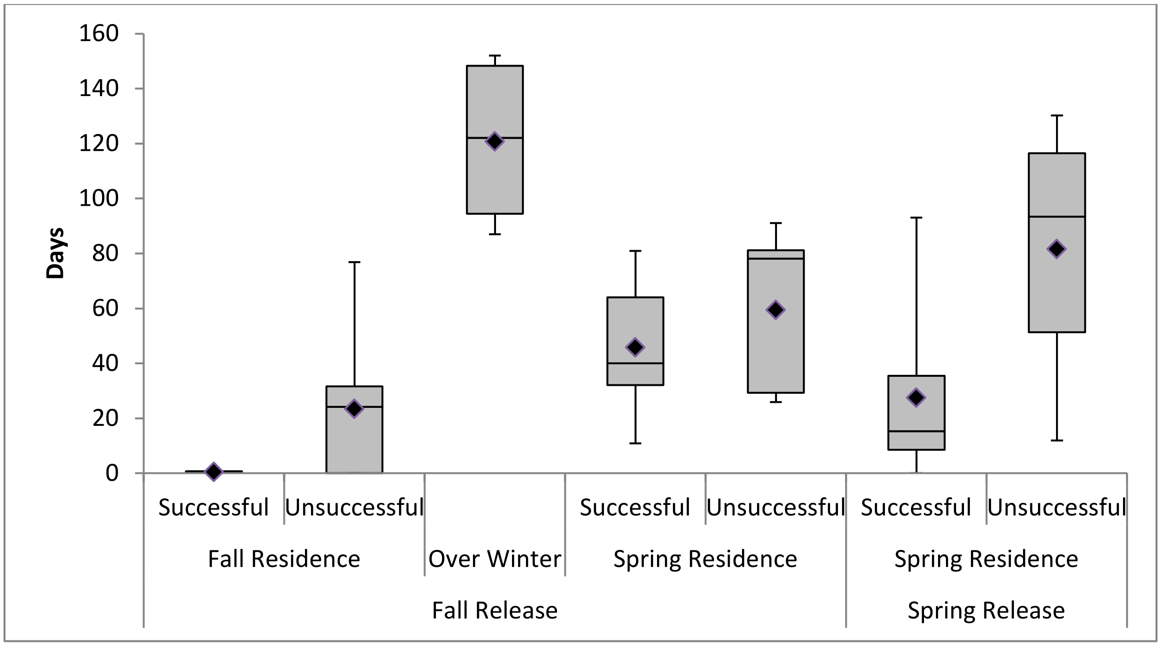

Figure 19. Periods of below dam residency for radio-tagged Pacific lampreys at Prosser Dam that were successful and unsuccessful in passing upstream of the dam, October 2011 through July 2012. Box plots show median and quartiles. The diamonds indicate the means.

Lampreys were detected on all three stations at Prosser Dam while they searched for upstream passage with the greatest number occurring on the left island antennas (Figure 20). Unlike at Wanawish Dam, lampreys spent little time near the face of Prosser Dam during holding periods or daylight hours, residing instead just downstream of the bedrock ledge the dam was built upon. The greatest concentration occurred in a pool along the left bank (Figure 21). This area included a boulder filled pool and areas of whitewater coming off the face of the dam. Pacific lampreys were consistently detected in this area during both day and night hours. Night observations during July showed tagged lampreys attempting to climb over the dam using the bedrock at face of the dam along the left bank (Figure 22). High velocities over the dam and the overhanging crest prevented these lampreys from being successful in their attempts.

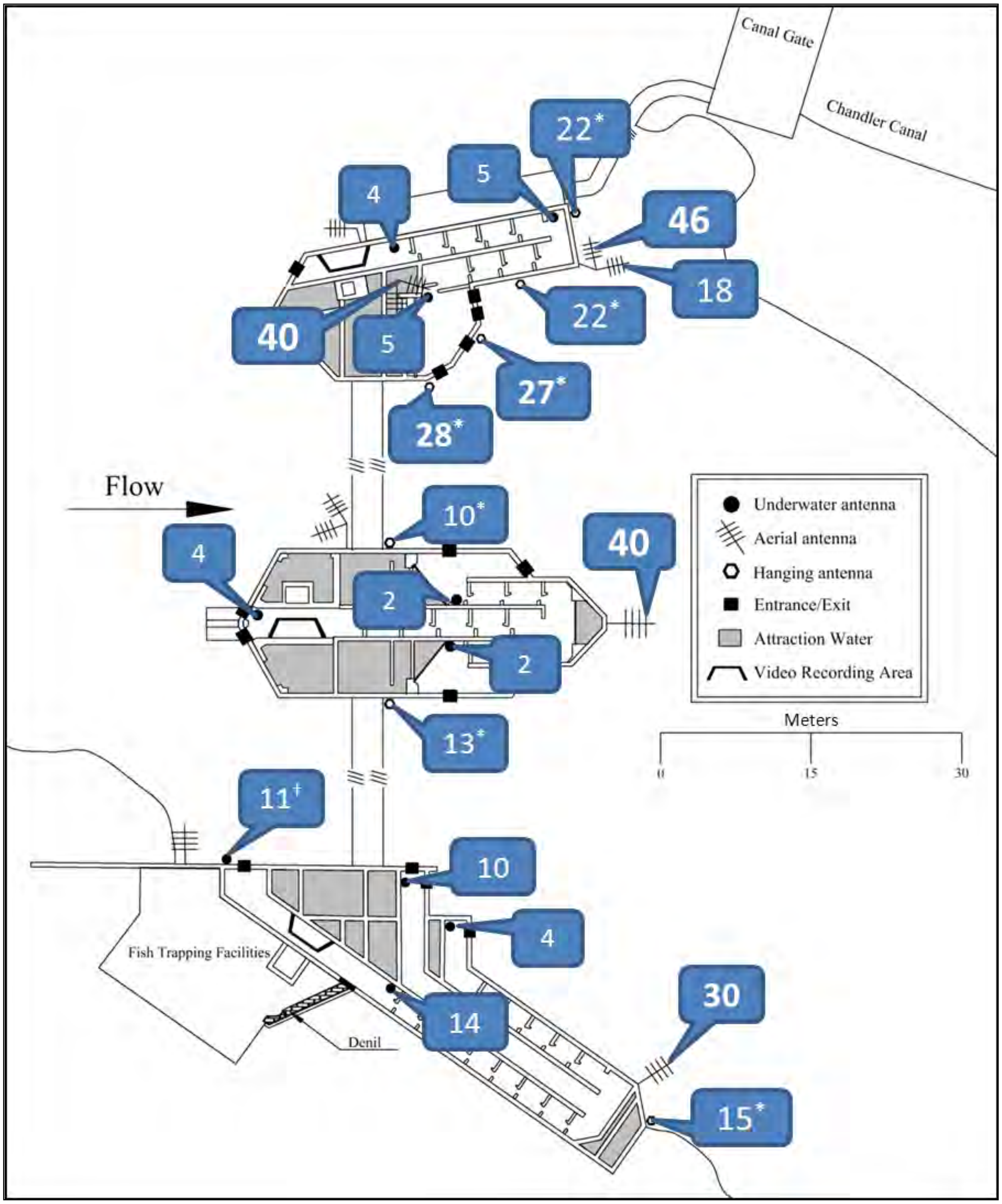

Figure 20. Number of radio-tagged Pacific lampreys detected on downstream and in-ladder antennas at Prosser Dam, October 2011-July 2012. † indicates two additional lampreys were not detected but were detected upstream by mobile tracking. Antennas with a (*) were installed on March 27, 2012.

Four tags were recovered at Prosser Dam. On October 12, 2011 a tag was recovered left of river center downstream of the dam. The tag was in a grassy area with approximately 5 cm of water covering it. The antenna appeared to have bite marks in it, but it is not known if predation or scavenging occurred. On October 17, 2011 a deceased radio-tagged lamprey was found in the drain pipe of the trap tank in the adult salmonid trapping facility on the right bank. This drain empties into the river along the bank downstream of the fishway. It is assumed that the lamprey swam up the 4 inch PVC drain pipe as it was not detected moving up the fishway. On July 25, 2012, two tags were recovered from the left bank downstream of the dam. Both were on the bank above the waterline in areas of grass and mud. Neither showed teeth marks, however, their presence on dry land indicate some type of predation or scavenging had occurred. Three lampreys ceased moving and were still at the dam at the end of the study period. It was determined from several foot tracking occasions that these individuals were in the river but visual observations of the lamprey or tag were not possible and their fates are not known.

Figure 21. Pool and whitewater along the left bank of Prosser Dam where the majority of Pacific lampreys held during the day and night hours.


Figure 22. Radio-tagged Pacific lampreys (circled in red) attempting to climb over Prosser Dam by way of the dam face and exposed bedrock, July 3, 2012.

Fishway Passage- A total of 23 tagged lampreys passed Prosser Dam, for an overall passage success rate of 48%. Five lampreys (22%) passed in October, two of which used the right bank fishway during adult salmonid trapping operations. Both lampreys successfully moved up the ladder and around or through the picket gate used to direct salmon into the denil and trapping facility. The remaining eighteen (78%) passed the dam between April 10 and July 14. Thirteen of the 23 (57%) passage events occurred in the right bank fishway (Table 6). Four lampreys used the center island fishway and four were known to have used the left island fishway. An additional two lampreys passed the dam during a power outage and we deduced they used the left fishway: Prior to losing power both were detected on the left island antennas; video recorded two lampreys in the fishway that night; both tagged lampreys were detected upstream of the dam the next day during mobile tracking. Passage time for Prosser Dam fishways ranged between 0.55 and 29.48 hours with an average of 5.05 hours (Table 6). One lamprey (code 69) entered the right bank fishway on April 24 at which time the fishway headgate was closed due to high flows. It remained near the headgate for several days attempting to pass (Figure 23). On May 2 it moved downstream within the ladder and was detected on the underwater center antenna near the gate blocking the entrance to the denil. The gate was lifted between May 6 and May 8 while the denil was in operation. On May 10, code 69 was foot tracked and located in the body of water beneath the denil. This area collects spillage from the denil but has no entry or exit for fish when the denil is not operating. Code 69 remained in this location for the remainder of the study as it had no way to exit. A lamprey also entered the left island fishway on April 24. The headgate in this fishway was also closed. Code 28 remained in the fishway for approximately an hour before returning downstream. It entered the fishway a second time on June 19 for approximately an hour and a half before once again returning downstream. On July 1 it moved downstream from the dam.

Table 6. Prosser Dam fishway data: dates of entry and exit, total time in the fish ladder, and water temperature at passage for radio-tagged adult Pacific lampreys, October 2011 through July 2012.

Code	Release Site/Period	Fishway	Entered Ladder	Exited Ladder	Time in Ladder (hr)	T °C	Video?
16	PRO Fall Dn	Left	10/04/11[A]	10/05/11[A]	unk	15.6	yes
39	PRO Fall Dn	Left	10/04/11[A]	10/05/11[A]	unk	15.6	yes
8	PRO Fall Dn	Right	10/05/11 22:46	10/05/11 23:28	0.71	15.1	no
34	PRO Fall Dn	Right	10/15/11 21:57	10/15/11 23:18	1.34	13.6	no
13	WAN Fall Up	Center	10/22/11 06:04	10/22/11 15:25	9.36	13.3	yes
89	WAN Spr Up	Right	04/10/12 18:58	04/10/12 23:15	4.29	10.6	no
83	PRO Spr Dn	Right	04/10/12 22:56	04/11/12 02:45	3.82	10.6	no
84	PRO Spr Dn	Right	04/12/12 20:30	04/13/12 07:06	10.6	10.7	no
79	PRO Spr Dn	Right	04/22/12 22:33	04/23/12 00:47	2.23	12.5	no
40	WAN Fall Up	Right	05/08/12 21:01	05/09/12 00:10	3.15	12.9	no
6	WAN Fall Dn	Right	05/08/12 21:25	05/09/12 03:20	5.92	12.9	no
33	PRO Fall Dn	Right	05/09/12 22:24	05/10/12 00:49	2.42	13.7	no
5	PRO Fall Dn	Right	05/13/12 21:19	05/14/12 01:48	4.48	13.2	yes
32	WAN Fall Up	Left	05/15/12 23:38	05/16/12 00:55	1.28	15.4	no
77	WAN Spr Dn	Center	05/28/12 23:59	05/29/12 02:56	2.95	14.0	no
66	PRO Spr Dn	Center	05/29/12 22:15	05/30/12 04:50	6.58	14.8	no
26	PRO Fall Dn	Center	05/29/12 23:39	05/31/12 05:08	29.48	14.8	yes
14	WAN Fall Dn	Right	06/01/12 22:08	06/02/12 03:06	4.97	15.8	yes
85	WAN Spr Dn	Right	06/02/12 01:07	unknown	unk	17.0	yes
78	WAN Sp rDn	Right	06/02/12 01:22	unknown	unk	17.0	no
27	WAN Fall Dn	Left	06/29/12 22:28	06/29/12 23:24	0.93	17.8	yes
76	PRO Spr Dn	Left	06/29/12 22:41	06/29/12 23:14	0.55	17.8	yes
4	WAN Fall Dn	Left	07/14/12 22:11	07/14/12 23:09	0.97	22.3	yes

[A] exact time of day unknown due to power outage

Figure 23. Radio-tagged Pacific lamprey code 69 attempting to exit the right bank fishway at Prosser Dam by climbing the closed headgate, April 30, 2012.

Discharge-

River discharge at Prosser Dam varied between 588 and 18,705 ft^3/s. In October 2011, three tagged lampreys passed the dam at flows of 1,460 ft^3/s or less. The other successful lampreys passed between April and July when flows ranged from 1,080 to 11,750 ft^3/s (Figure 24). Passage occurred primarily on increasing flows or during transitions between decreasing and increasing flows.

Velocity at Fishways- Velocities at the Prosser Dam fishway entrances were recorded between April 5 and August 7, 2012 (Figure 25 and Appendix B). Velocities varied between -0.9 and 9.5 ft/s. All three fishways had average velocities between 4 and 6 ft/s and did not differ significantly ($p=0.21$). Due to river conditions on several occasions, measurements were not taken at the Prosser Dam right bank upper fishway entrance. Large differences between the upper and lower fishways during the peak period of passage led us to analyze these two entrances separately.

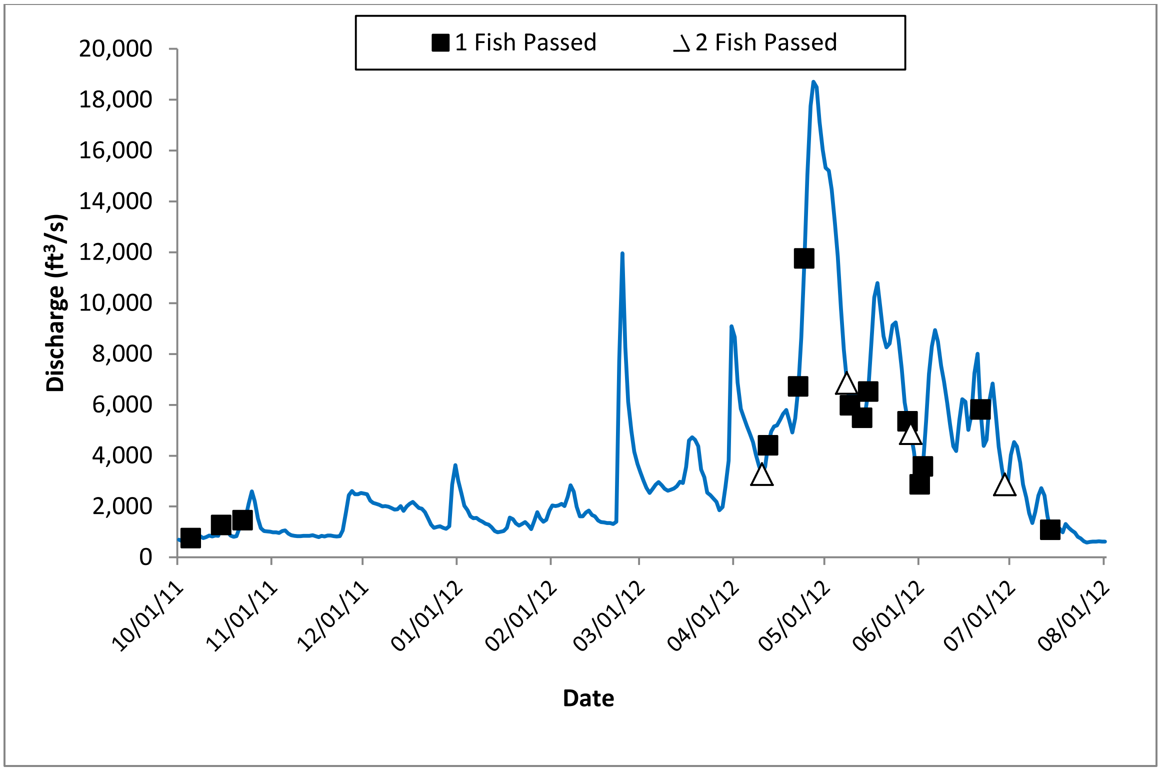

Figure 24. Graph showing the discharge and passage timing of radio-tagged Pacific lampreys at Prosser Dam on the Yakima River, October 2011 through July 2012.

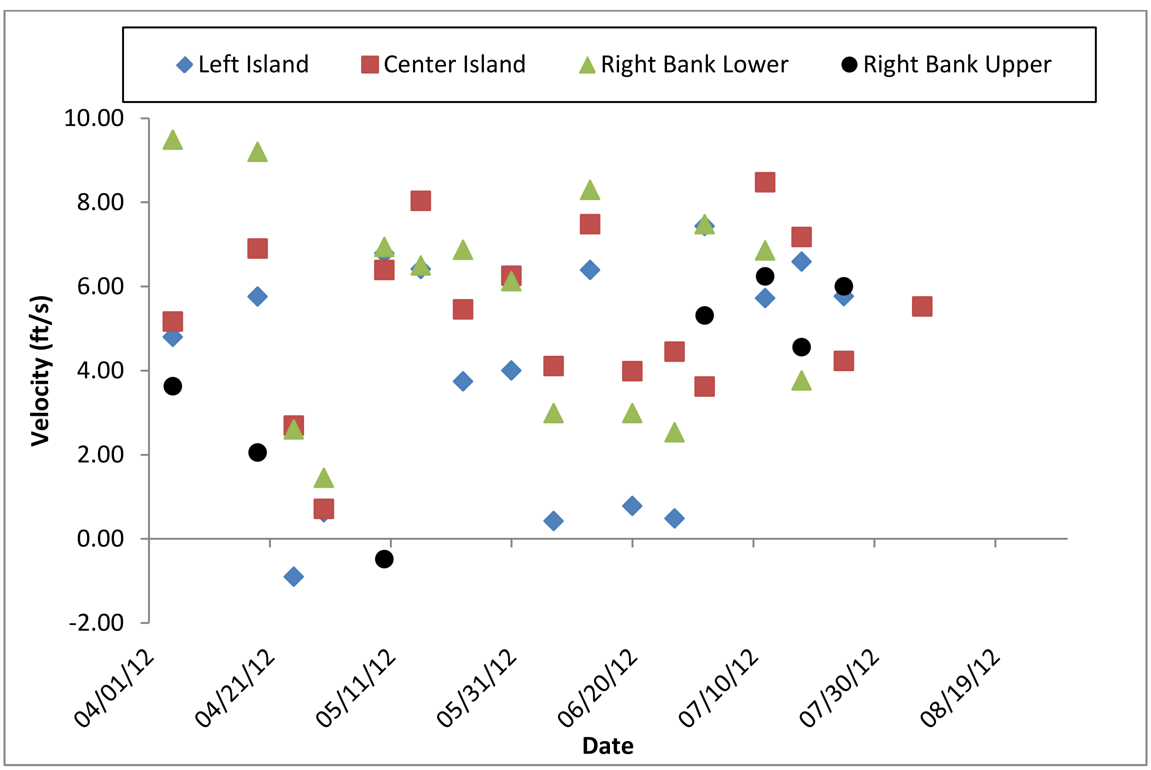

Figure 25. The entrance velocities at the Prosser Dam fishways between April and August, 2012.

Temperature- River water temperature was recorded at Prosser Dam from October 1, 2011 to September 1, 2012 (Figure 26). Daily averages ranged from 0.3 °C to 24 °C. The majority of tagged lampreys passed the dam at mean daily water temperatures between 12 °C and 15 °C, however, the last lamprey passed at 22.3 °C. In the fall after the 3 lampreys passed the dam water temperatures decreased rapidly and passage ceased for the winter.

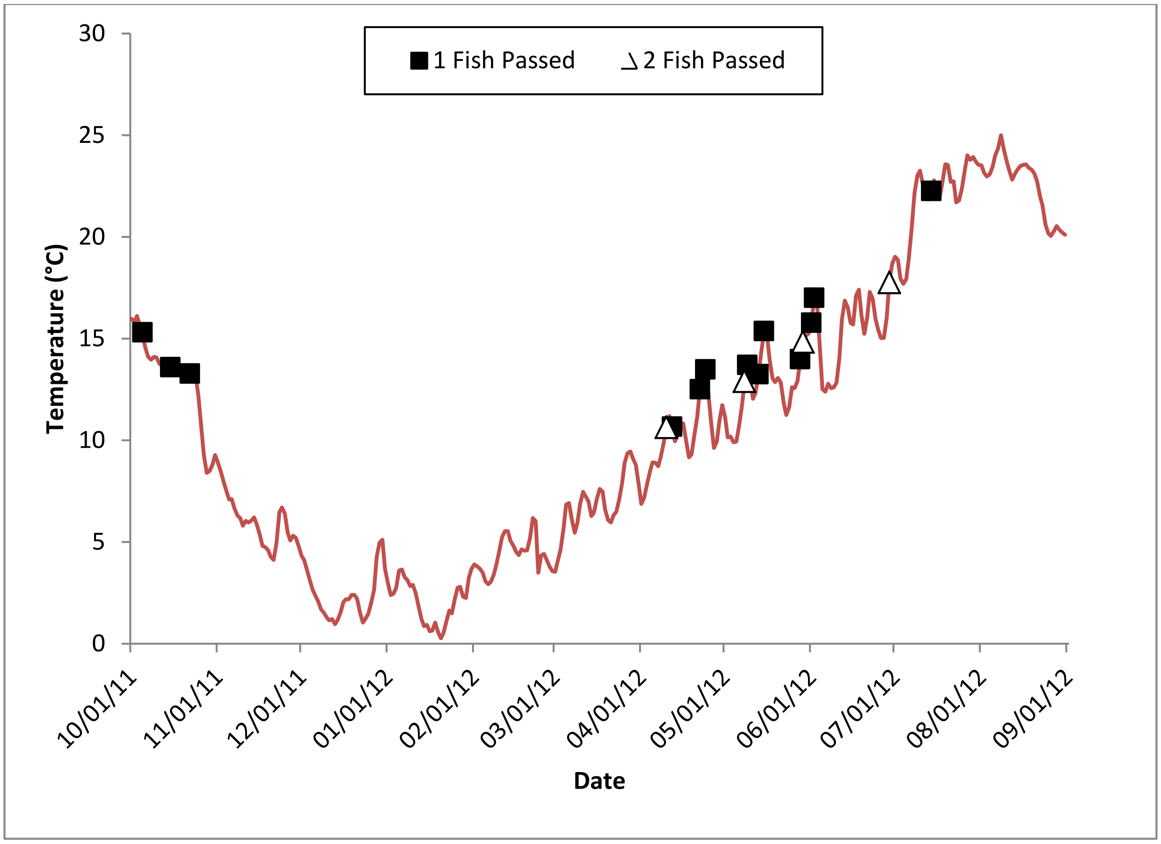

Figure 26. Average daily water temperatures of the Yakima River and dates of radio-tagged lamprey passage at Prosser Dam, October 2011 through August 2012.

Above Dam Residence- The lampreys that successfully passed Prosser Dam spent little time in the vicinity before continuing their migration. Two individuals spent 3.33 and 16.83 hours respectively while the rest spent less than 10 minutes before moving upstream.

Video counts of lampreys at Prosser Dam- Between August 22, 2011 and July 1, 2012 a total of 41 lampreys were observed on the video recorders within the fishways at Prosser Dam, 10 of which were radio-tagged. Thirteen tagged lampreys passed that were not detected on the video counts (Table 6 and Figure 27). Video recording was not operational for the time periods of March 31-April 2 and also April 23-May 7 and only one tagged lamprey passed Prosser Dam during these time periods. Thus during the times that the videos were recording, 12 of the 22 tagged lampreys (55%) were not observed or counted while passing in the fish ladders at Prosser Dam.

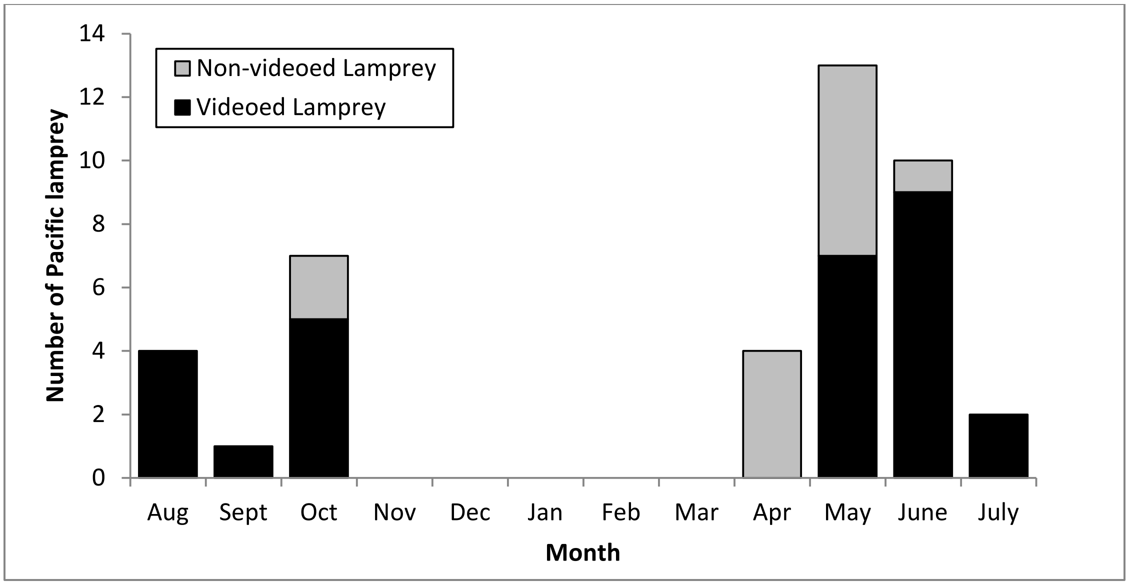

Figure 27. Video counts of upstream migrating adult Pacific lampreys at Prosser Dam, August 2011 to July 2012.

Sunnyside Dam

First Approach- The first detections at Sunnyside Dam were all on the aerial antennas of the center island station (Table 7). Thirty-one lampreys had either been released above Prosser Dam or had successfully passed above Prosser Dam and 18 (58%) migrated upstream to Sunnyside Dam. Three lampreys first approached the dam in October 2011. Approaches made during the spring months occurred from March 28 to July 3, 2012 with the majority in April (Table 7).

Below Dam Residence- Pacific lampreys that were successful in passing Sunnyside Dam had an average residency of 9.3 days before entering a fishway. The shortest residency occurred on June 16, 2012 and lasted just over 2.5 hours while the longest was 20.7 days (Table 7). The average residency time for those individuals who were not successful and ultimately moved downstream was 40 days (range 0.1 to 112.7 d). Only one lamprey (code 34) over-wintered at Sunnyside Dam. It attempted to find passage from its arrival on October 24 until December 29. It then over-wintered for 90 days until it began moving again on March 28. Its spring residence at the dam lasted for 81 days until June 17 when it stopped moving. It is not known if the tag was shed, the lamprey died, or it was still holding. Lampreys utilized holding areas across the width of the river downstream of the dam; however, the majority of lampreys used the area between the center island and the right bank for holding during daylight hours (Figure 28). A large log stuck on the face of the dam provided a break in the flow over the dam and lampreys were routinely detected beneath it.

Table 7. Sunnyside Dam approach and residence data: first and last dates of detection and number of days that radio-tagged adult Pacific lampreys resided below the dam before entering a fishway or moving downstream, October 2011 to August 2012.

Code	1st Station Detected	1st Detection Date	Last Detection Date	Days	Entered Fishway?
44	Center Island	10/16/11 01:32	10/23/11 20:04	7.8	Yes
38	Center Island	10/17/11 03:32	10/17/11 6:20	0.1	No
34	Center Island	10/24/11 04:10	06/17/12[A]	237	No
13	Center Island	03/28/12 01:16	05/24/12 04:00	57.1	No
30	Center Island	04/11/12 23:32	04/29/12 16:22	17.7	No
70	Center Island	04/14/12 06:04	06/15/12 02:17	61.8	No
73	Center Island	04/15/12 21:14	04/23/12 02:47	7.2	No
84	Center Island	04/22/12 17:31	06/06/12 02:14	44.4	No
83	Center Island	04/23/12 04:04	08/13/12 21:08	112.7	No
39	Center Island	04/24/12 03:18	06/21/12 16:23	58.6	No
8	Center Island	04/24/12 06:11	05/14/12 22:19	20. 7	Yes
79	Center Island	05/10/12 01:12	05/15/12 22:59	5.9	Yes
6	Center Island	05/17/12 02:24	05/28/12 00:53	10.9	Yes
36	Center Island	05/17/12 21:35	05/17/12 23:17	0.07	No
32	Center Island	06/03/12 22:50	06/17/12 22:28	14	Yes
14	Center Island	06/15/12 22:10	7/17/12[A]	30.1	No
77	Center Island	06/16/12 22:28	06/17/12 01:05	0.1	Yes
5	Center Island	07/03/12 07:05	07/09/12 00:43	5.7	Yes

[A] last date of movement

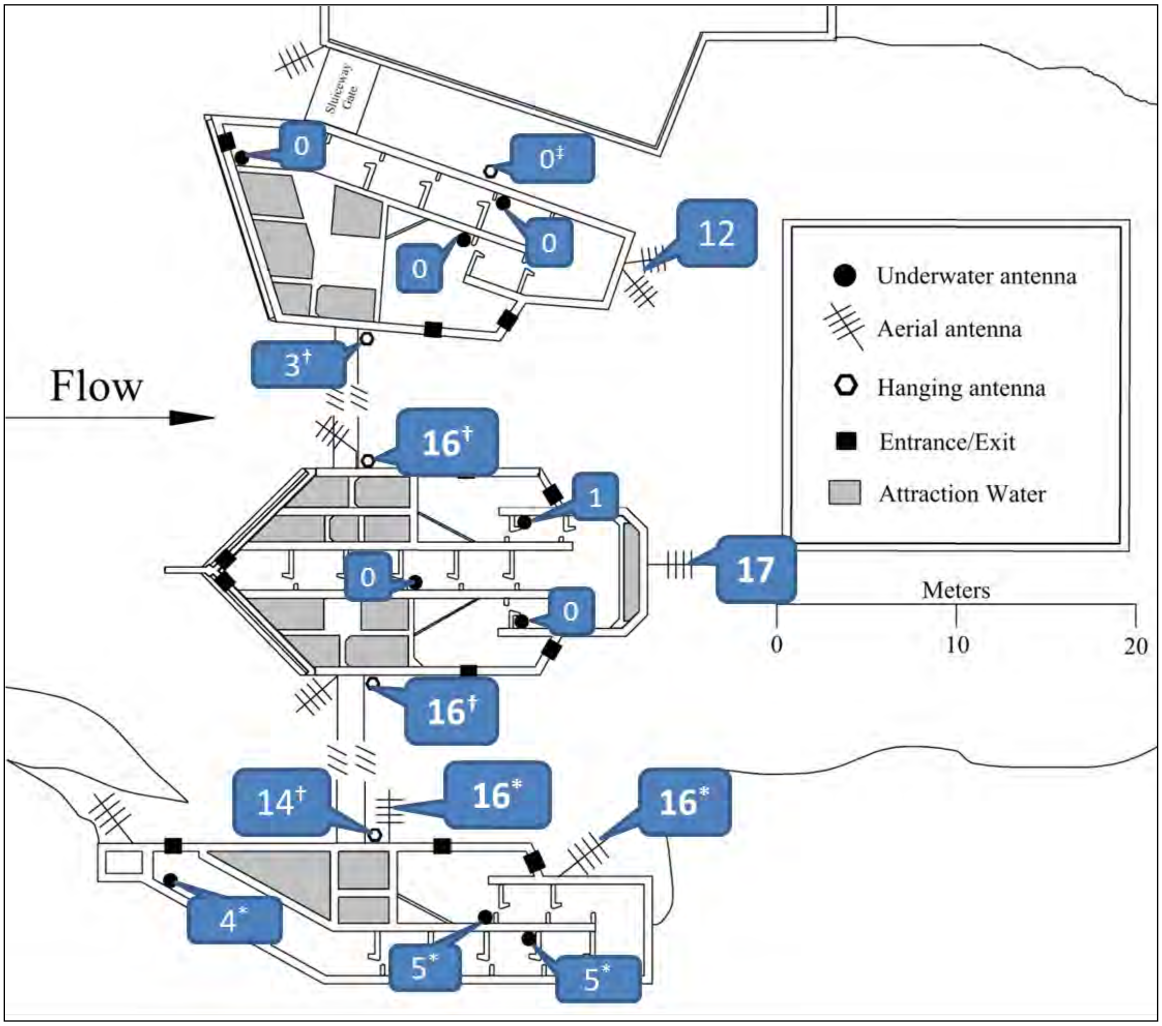

Figure 28. Number of radio-tagged Pacific lampreys detected on downstream and in-ladder antennas at Sunnyside Dam, October 2011-July 2012. Antennas with a (*) were installed on December 2, 2011. The † indicates antennas installed on April 5, 2012 and a ‡ indicates an installation date of April 30, 2012.

Fishway Passage- Seven of the eighteen (39%) lampreys that approached Sunnyside Dam successfully passed upstream using one of the fishways (Table 8). Of the fish released in the fall, 5 (42%) passed the dam while two (33%) from the spring release were successful. The first lamprey passed Sunnyside Dam on October 23, 2011, before the right bank fishway antennas were installed. Because it was not detected on any underwater antennas within the left and center island fishways, based on the data from aerial antennas we concluded it passed in the right bank fishway. Six lampreys passed upstream between May 14 and July 9, 2012; five using the right bank fishway and one using the center island fishway. Two lampreys were detected in the right bank fishway but did not successfully negotiate the ladder or pass the dam. Passage through the fishways ranged between 0.27 to 3.85 hours with an average of 1.09 hours.

Table 8. Sunnyside Dam fishway data: dates of entry and exit and total time in the fish ladder for radio-tagged adult Pacific lampreys from October 2011 to August 2012.

Code	Release Site/Period	Fishway	Entered Ladder	Exited Ladder	Time in Ladder (hr)	Temp °C
44	PRO Fall Up	Right	10/23/11 20:04[A]	10/23/11 21:14[A]	1.17	12.5
8	PRO Fall Dn	Right	05/14/12 22:19	05/14/12 22:35	0.27	11.9
79	PRO Spr Dn	Right	05/15/12 22:59	05/15/12 23:23	0.40	12.2
6	WAN Fall Dn	Right	05/28/12 00:53	05/28/12 01:39	0.77	12.3
77	WAN Spr Up	Right	06/17/12 01:05	06/17/12 01:50	0.75	14.6
32	WAN Fall Up	Right	06/17/12 22:28	06/17/12 22:58	0.50	14.6
5	PRO Fall Dn	Center	07/09/12 00:43	07/09/12 04:34	3.85	17.8

[A] based on center island aerial antennas

Discharge- Discharge at Sunnyside Dam ranged from a low of 586 ft^3/s on July 26, 2012 to a high of 18,924 ft^3/s on April 25, 2012. The one lamprey that passed in October did so at a discharge of 1,807 ft^3/s. The lampreys that passed in the spring did so at flows between 2,839 and 8,410 ft^3/s. The majority of passage events occurred during increases in the hydrograph (Figure 29).

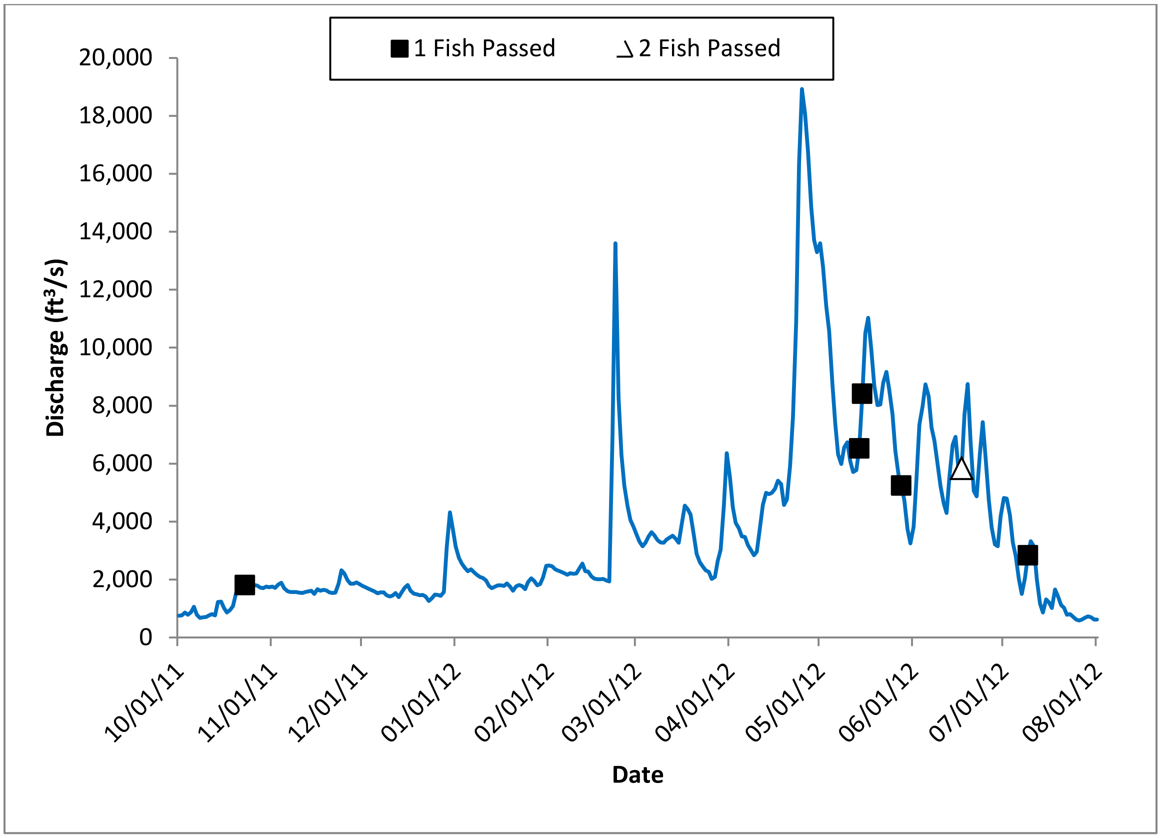

Figure 29. Graph showing the discharge and passage timing of radio-tagged Pacific lampreys at Sunnyside Dam on the Yakima River from October 2011 to August 2012.

Velocity at Fishways- Fishway entrance velocities were recorded at Sunnyside Dam between April 5 and August 7, 2012 (Figure 30 and Appendix B). Velocities at the dam ranged from -0.53 to 10.09 ft/s. The right bank fishway was the slowest with an average velocity of 4.7 ft/s. The center island fishway averaged 7.3 ft/s and the left island fishway had a slightly higher average of 7.5 ft/s. There were no significant differences between the left and center islands (p=0.5), however, the right bank velocities were significantly different than both the left and center island fishways (p=0.0005, p=0.01).

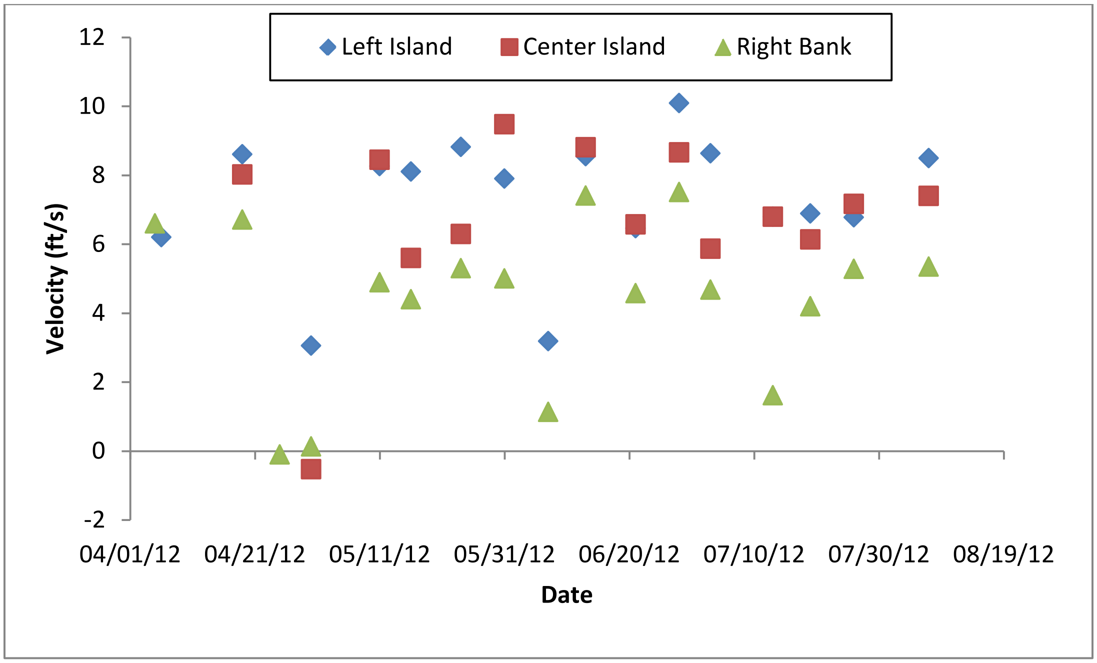

Figure 30. Entrance velocities at Sunnyside Dam fishways between April and August, 2012.

Temperature- Water temperature was recorded at Sunnyside Dam from October 1, 2011 through Sept 1, 2012 and mean daily temperature ranged from 0 to 18.3 °C (Figure 31). Six out of seven lampreys passed when temperatures were between 12 and 15 °C, including both fall and spring passage events. One lamprey passed the dam when the water temperature was 17.8 °C.

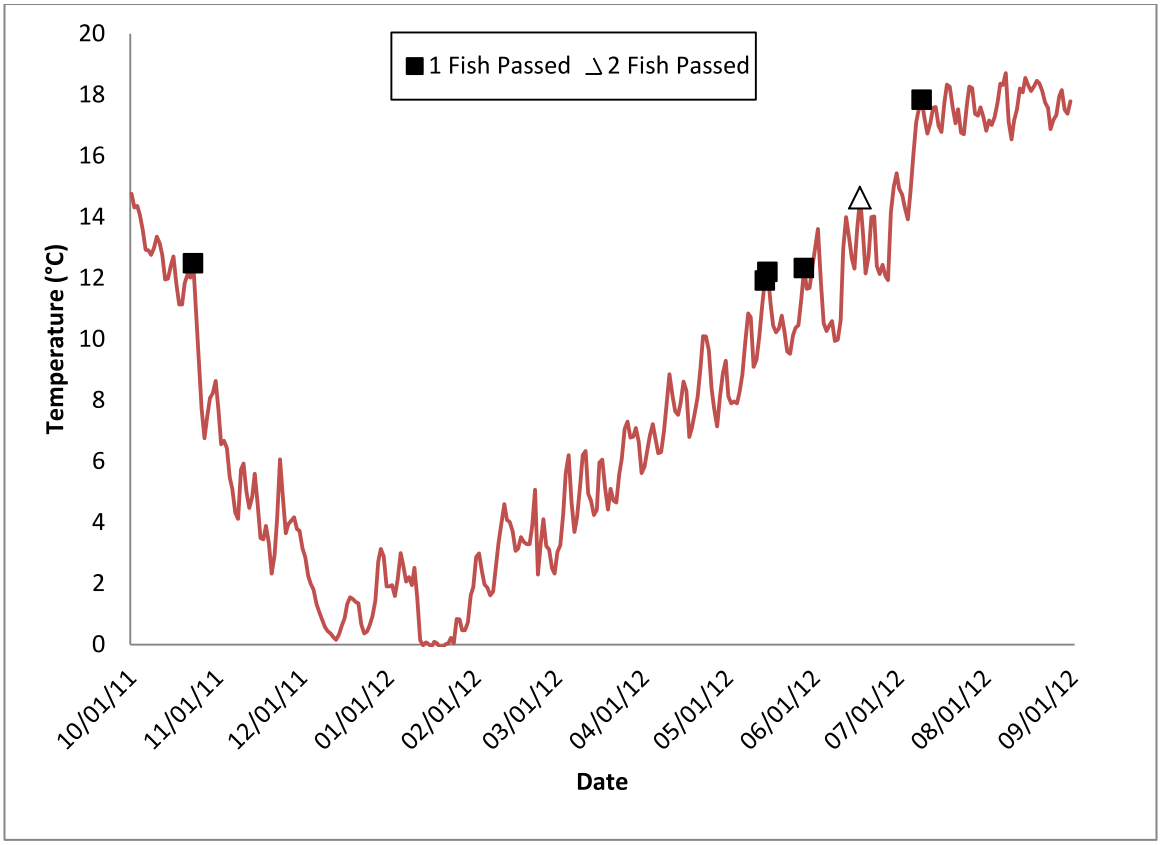

Figure 31. Average daily water temperatures of the Yakima River and dates of lamprey passage at Sunnyside Dam between October 1, 2011 and September 1, 2012.

Above Dam Residence- Only one lamprey was detected for more than a few minutes after successfully passing through Sunnyside Dam- code 5 spent 18.5 hours in the upstream vicinity of the dam before continuing its migration.

Wapato Dam
First Approach- All seven Pacific lampreys that passed Sunnyside Dam migrated upstream to Wapato Dam (Table 9). One approach occurred in the fall on November 2, 2011. The remaining six approached the dam in the spring between May 15 and July 11, 2012. Two approached using the west channel and five used the east channel. All of those in the east channel were first detected on the center island downstream aerial antenna.

Below Dam Residence- One lamprey (code 44) over-wintered at Wapato Dam in the east channel. Its fall residence at the dam lasted 26.1 days before it moved approximately 200 m downstream and over-wintered near a rock cross vane. On March 10, after an overwintering period of 102.6 days, it resumed actively trying to pass the dam. On June 5 it moved downstream and was subsequently detected passing downstream of Sunnyside as well. Its total residence time at Wapato was 216.34 days. The residence time of those that were successful in passing the dam ranged between 1.81 and 33.9 days with an average of 11.02 days. These fish were detected during daylight hours holding near the face of the dam as well as along the bank just downstream of the dam though antenna detections indicate movements occurred across the entire dam (Figures 32 and 33). Two lampreys were still residing at Wapato at the end of the study period, one in each channel.

It is not known whether these fish were holding, no longer alive, or if the tags had been shed. They were the last two fish detected approaching the dam.

Table 9. Wapato Dam approach and residence data: first and last dates of detection and number of days that radio-tagged adult Pacific lampreys resided below the dam before entering a fishway or moving downstream, October 2011 to August 2012.

Code	1st Station Detected	1st Detection Date	Last Detection Date	Days	Entered Fishway?
44	E. Center Island	11/02/11 09:13	06/05/12 17:27	216.3	No
8	E. Center Island	05/15/12 04:13	06/18/12 01:51	33.9	Yes
79	W. Center Island	05/17/12 02:57	05/18/12 22:18	1.8	Yes
6	E. Center Island	05/28/12 23:31	06/02/12 04:32	4.2	Yes
77	E. Center Island	06/17/12 23:32	06/22/12 03:33	4.2	Yes
32	E. Center Island	06/18/12 02:56	07/19/12[A]	30.9	No
5	W. Center Island	07/11/12 03:59	07/24/12[A]	12.8	No

[A] last date of movement

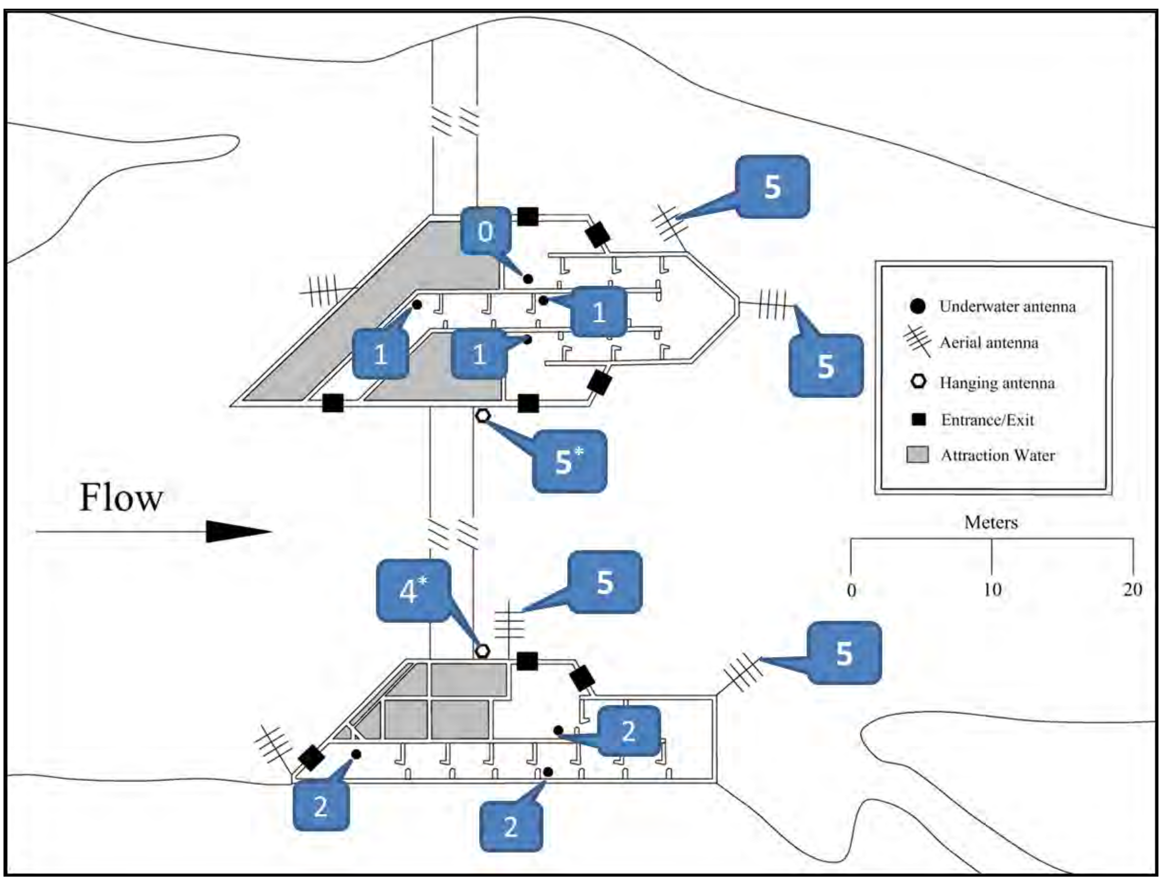

Figure 32. Number of radio-tagged Pacific lampreys detected on downstream and in-ladder antennas in the east channel at Wapato Dam, October 2011-July 2012. A (*) indicates an antenna installation date of April 5, 2012.

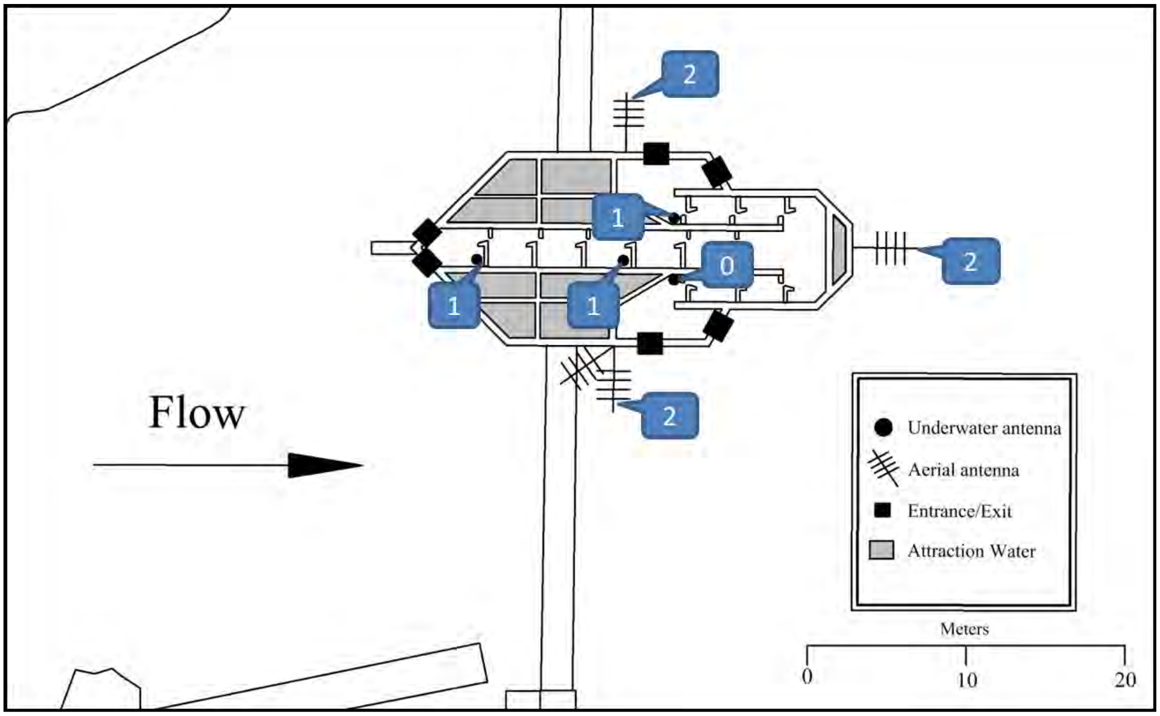

Figure 33. Number of radio-tagged Pacific lampreys detected on the downstream and in-ladder antennas in the west channel of Wapato Dam, October 2011-July 2012.

Fishway Passage- Of the seven Pacific lampreys that approached Wapato Dam, 4 (57%) successfully passed upstream using one of the fishways (Table 10). Two of the five fall-released lampreys were successful while both spring-released lampreys that made it to Wapato successfully passed it. No passage occurred during October of 2011. All passage events occurred between May 20 and June 22, 2012. One lamprey passed using the west channel island fishway, one passed in the east channel island fishway, and two lampreys passed in the east channel right bank fishway. Passage times for the lampreys in the east channel were 50 minutes or less while the lamprey that passed in the west channel took 1.4 days (Table 10).

Table 10. Wapato Dam fishway data: dates of entry and exit and total time in the fish ladder for radio-tagged adult Pacific lampreys from October 2011 to August 2012.

Code	Release Site/Period	Fishway	Entered Ladder	Exited Ladder	Time in Ladder (hr)	Temp °C
79	PRO Spr Dn	W. Center Island	05/18/12 22:18	05/20/12 08:31	34.22	10.2
6	WAN Fall Dn	E. Center Island	06/02/12 04:32	06/02/12 05:22	0.83	13.4
8	PRO Fall Dn	E. Right Bank	06/18/12 01:51	06/18/12 02:38	0.78	13.4
77	WAN Spr Dn	E. Right Bank	06/22/12 03:33	06/22/12 04:12	0.65	14.0

Discharge- Discharge at Wapato Dam ranged from a low of 586 ft^3/s on July 26, 2012 to a high of 18,924 ft^3/s on April 25, 2012. Lampreys that passed the dam did so during flows of 4,873-9,908 ft^3/s. Passage events all occurred after peak flows and like the other dams tended to be on an increase in the hydrograph (Figure 34).

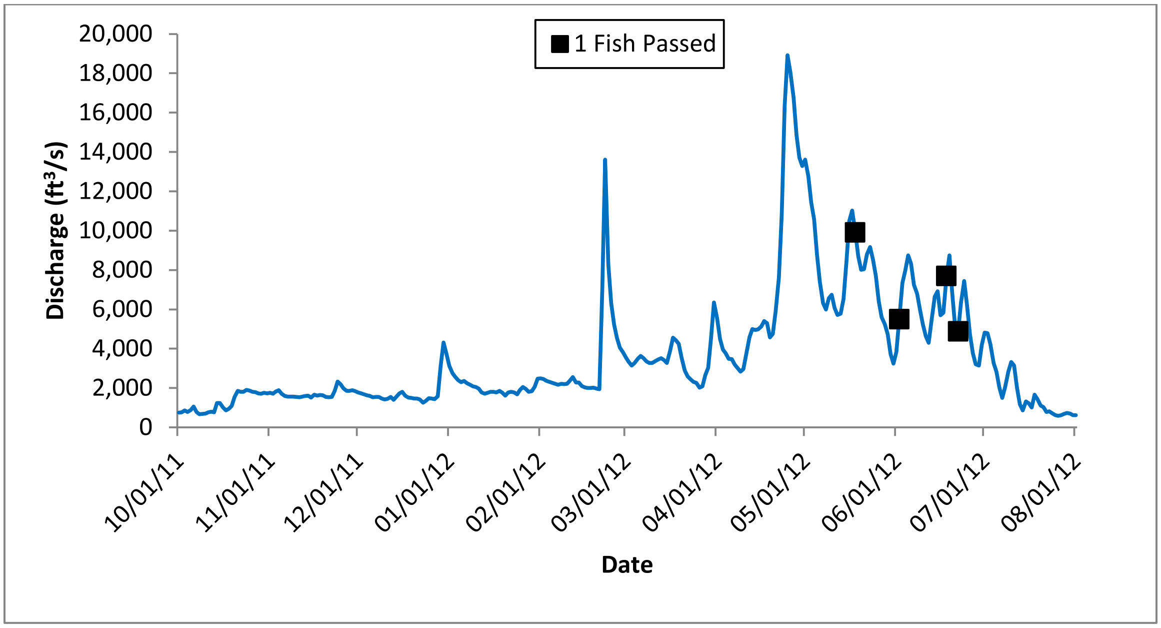

Figure 34. Graph showing the discharge and passage timing of radio-tagged Pacific lampreys at Wapato Dam on the Yakima River from October 2011 to August 2012.

Velocity at Fishways- Velocities at the Wapato Dam fishway entrances were recorded between April 6 and August 7, 2012 (Figure 35 and Appendix B). The differences in velocities between each fishway were significant (p=0.0004). The east channel center island fishway consistently had velocities below 3 ft/s. The east channel right bank and west channel center islands fishways were much more varied in their velocities. The highest velocity, 6.69 ft/s, occurred July 19 in the east channel right bank fishway while the lowest, 0.79, occurred in the west center island fishway on July 3, 2012. No negative velocities were recorded at Wapato Dam. Attraction water did not appear to be in operation at the east channel center island.

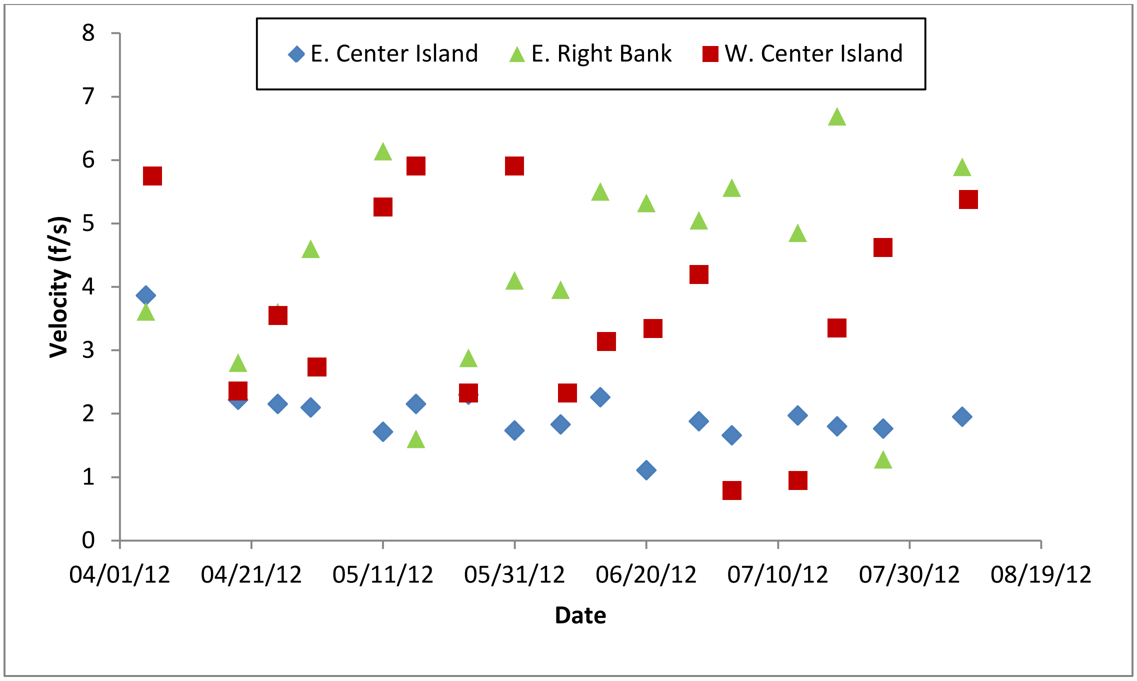

Figure 35. Entrance velocities at Wapato Dam fishways between April and August, 2012.

Temperature- River water temperatures were recorded at Wapato Dam between November 4, 2011 and September 1, 2012 (Figure 36). Temperatures were not available for the time period between June 8 and July 13, 2012. The average daily temperature varied from 0 to 18.1 °C. Lamprey passage occurred at temperatures between 13 and 15 °C with the exception of one passing at 10 °C. Two fish did pass during the time period when temperature data was not available. The temperatures during these passage events were determined using those from nearby Sunnyside Dam.

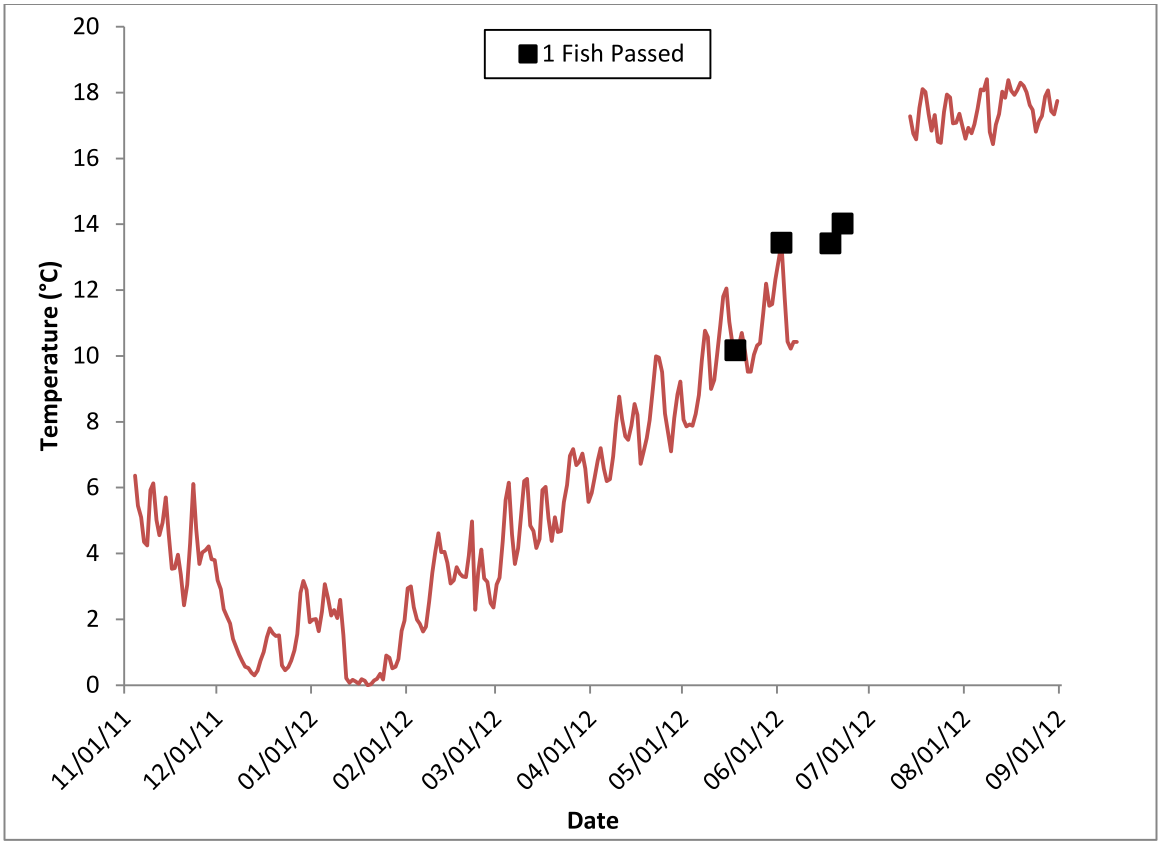

Figure 36. Average daily water temperatures of the Yakima River and dates of lamprey passage at Wapato Dam between November 4, 2011 and September 1, 2012. Data was not available for the time period between June 8 and July 13, 2012.

Above Dam Residence- The four lampreys that successfully passed Wapato Dam had above dam residence times between 32 minutes and 17 hours. There did not appear to be any correlation between fishway passage time and the length of above dam residence.

Diurnal Period of Movement

Upstream movements of Pacific lampreys past fixed stations occurred almost exclusively at night (Figure 37). First approaches to the dams and movements into the fishways both occurred at night with a frequency of greater than 75%. Lampreys initiating successful passage of a dam did so nearly all during night hours; only two entering a fishway during daylight hours. Both of these movements occurred within the last two hours of daylight. Movement downstream from the dams occurred evenly between day and night hours.

Figure 37. Diurnal periods that adult radio-tagged Pacific lampreys were active during downstream movement, upstream movement, and entry into fishways during the time period of October 2011 to August 2012.

Migration Rates between Stations

Fall Releases- Fall released Pacific lampreys had an average migration rate of 11.1 km/d (range 4 to 23 km/d) to move the 46.7 kilometers from Wanawish Dam to Prosser Dam. Migration rates for fall released lampreys between Prosser Dam and Sunnyside Dam- a distance of 92 km- averaged 7.7 km/day ranging from 1.8 to 12.7 km/day. The average migration rate for fall released lampreys between Sunnyside and Wapato dams (5 km) was 15.5 km/d, ranging from 4.2 to 30.9 km/d (Figure 38).

Spring Releases- Lampreys released in the spring migrated upstream from Wanawish Dam to Prosser Dam (46 km) at an average rate of 11.1 km/d (range 3.1 to 21.6 km/d). From Prosser Dam to Sunnyside Dam (91.4 km) lampreys averaged 7 km/d (range 4.9 to 9.9 km/d). The two spring released lampreys that migrated from Sunnyside Dam to Wapato Dam (5 km) averaged 5 km/d (range 4.1 to 30.9 km/d) (Figure 38).

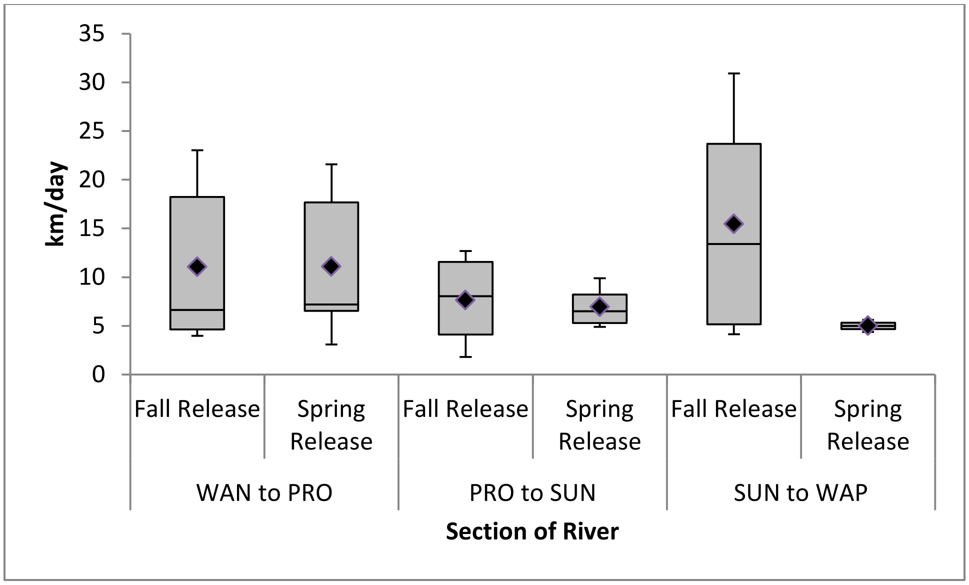

Figure 38. Kilometers traveled upstream per day by radio-tagged Pacific lampreys in the Yakima River, October 2011 to July 2012. Box plots show median and quartiles. The diamonds indicate the means.

Multiple Dam Passage

Lampreys having passed at least one dam had success rates of 39% at Prosser Dam, 50% at Sunnyside Dam, and 57% at Wapato Dam. When separated by release dates the fall group decreased in success from 50% at Prosser to 40% at Wapato while the spring group increased greatly from 30% to 100%. The numbers of lampreys passing these dams however was small. A total of five (7%) lampreys succeeded in passing two dams from all releases combined. Only two lampreys made it through three dams, one from each release group. Of the 30 lampreys released downstream of Wanawish, only two (7%) successfully passed all four diversion dams; one from each release group (Table 11).

Table 11. Release site, period, and number of radio-tagged Pacific lampreys that passed the lower four diversion dams on the Yakima River during fall 2011 and spring 2012.

		Number of Passage Events							
Release Site And Period	**n**	**WAN Fall**	**WAN Spring**	**PRO Fall**	**PRO Spring**	**SUN Fall**	**SUN Spring**	**WAP Fall**	**WAP Spring**
WAN Fall Up	5			1	2		1		
WAN Fall Dn	16	3	5	0	4		1		1
WAN Spr Up	4				1				
WAN Spr Dn	14		10		3		1		1
PRO Fall Up	4					1			
PRO Fall Dn	16			4	3		2		1
PRO Spr Up	4								
PRO Spr Dn	13				5		1		1
Totals	***76***	***3***	***15***	***5***	***18***	***1***	***6***	***0***	***4***

Dropouts between Dams

Not all lampreys that passed a dam continued their migrations upstream to the next dam. These "dropouts" consisted of both lampreys that passed a dam and never arrived at the next and also those that were unsuccessful at passing a dam and ultimately moved back downstream. Last known locations between dams were obtained for thirty of these individuals. Eight lampreys were present between the mouth of the Yakima River and Wanawish Dam (Figure 39). Eight lampreys were between Wanawish and Prosser dams (Figure 40), including six that approached Prosser Dam and then moved downstream and two that moved upstream from Wanawish but never reached Prosser Dam. In the reach between Prosser Dam and Sunnyside Dam a total of fourteen last known locations were recorded (Figure 41). Six were lampreys that had moved downstream from Sunnyside Dam. Eight ceased their upstream migrations and never reached Sunnyside Dam. No lampreys were in between Sunnyside and Wapato dams at the end of the study period. In addition to these known locations, another twenty-six lampreys dropped out in the reaches between the lower four dams (Table 12). Lampreys released in the spring upstream of Prosser Dam had the highest rate of dropouts with 100%. Percentages for all other releases were between 69% and 80%.

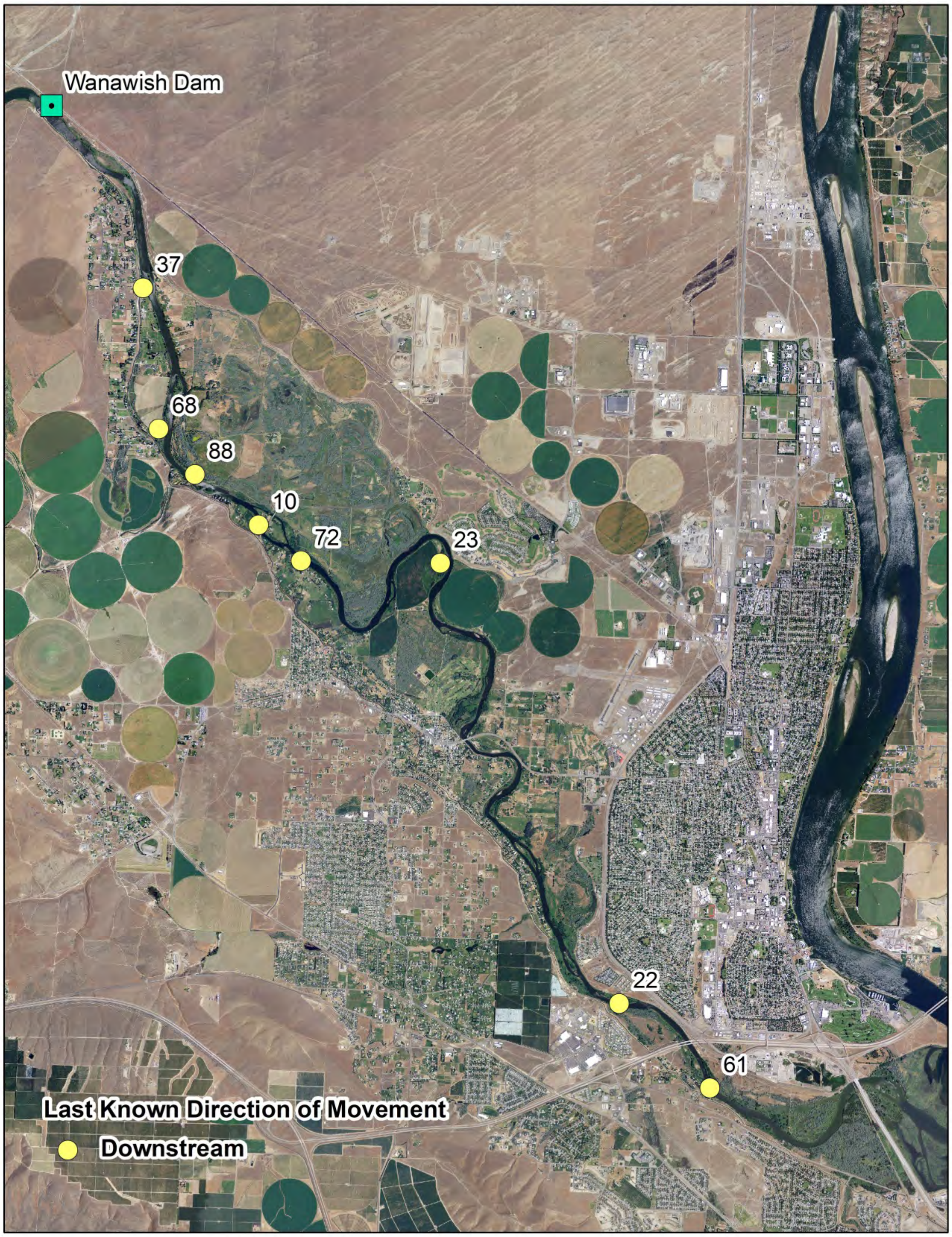

Figure 39. The last known locations of radio-tagged Pacific lampreys downstream of Wanawish Dam on the Yakima River, 2011-2012. The number represents the code of each radio tag.

Figure 40. The last known locations of radio-tagged Pacific lampreys between Wanawish Dam and Prosser Dam on the Yakima River, 2011-2012. The number represents the code of each radio tag.

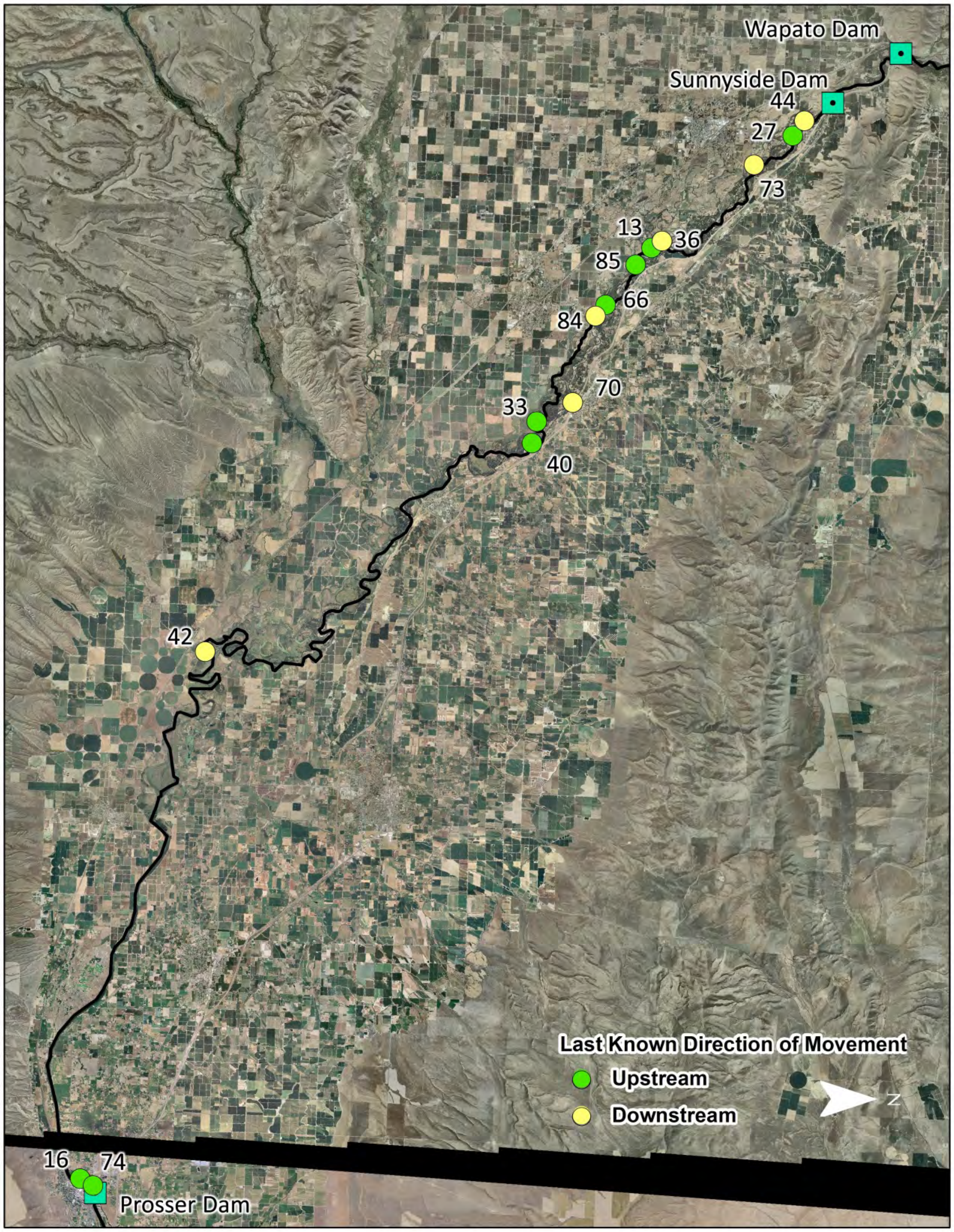

Figure 41. The last known locations of radio-tagged Pacific lampreys between Prosser Dam and Sunnyside Dam on the Yakima River, 2011-2012. The number represents the code of each radio tag.

Table 12. The number of radio-tagged Pacific lampreys that remained in between the lower dams on the Yakima River, 2011-2012.

Release Site/Period	D/S WAN n Dropouts/ n in Reach	WAN to PRO n Dropouts/ n in Reach	PRO to SUN n Dropouts/ n in Reach	Total (%)
WAN Fall Up		2/5 (40%)	2/3 (67%)	4/5 (80%)
WAN Fall dn	7/16 (44%)	3/8 (38%)	2/4 (50%)	12/16 (80%)
WAN Spr up		2/4 (50%)	1/1 (100%)	3/4 (75%)
WAN Spr dn	3/14 (21%)	6/10 (60%)	2/3 (67%)	11/14 (79%)
PRO Fall up			3/4 (75%)	3/4 (75%)
PRO Fall dn		6/16(38%)	4/7 (57%)	10/16 (63%)
PRO Spr up			4/4 (100%)	4/4 (100%)
PRO Spr dn		5/13 (38%)	4/5 (80%)	9/13 (69%)

Gate Stations

No Pacific lampreys were detected entering Satus or Toppenish creeks. Lampreys were not detected on the gate stations at the Roza Canal Wasteway outfall, Cowiche Dam on the Naches River, or at Roza Dam. No lamprey were detected on the station near the mouth, however, one lamprey was detected via truck tracking upstream of the station just out of its range.

Discussion

A total of 76 Pacific lampreys were radio-tagged, released, and tracked in the Yakima River during the 2011 migration season. Nearly all the tagged lampreys actively moved upstream and attempted to pass the diversion dams. Overall, about 50% of each release group failed to pass a dam and 25 to 40% of the lamprey that successfully passed each dam subsequently dropped out from the migration before reaching the next dam. Thus, during the 2011 migration season, only about 5% of the tagged lampreys were able to pass above Wapato Dam, the fourth diversion they encounter on the lower Yakima River.

Less than 50% of radio-tagged Pacific lampreys successfully pass each hydroelectric dam on the lower Columbia River (Moser et al. 2005; Keefer et al. 2009) and at Willamette Falls Dam on the Willamette River (Clemens et al. 2011). During our study to date, success rates for each of the lower Yakima River dams varied between 39% and 62%. Thus, although main stem Columbia River dams and the Willamette Falls Dam are much larger and more complex, our results indicate that small diversion dams on the lower Yakima River are similarly impeding and obstructing the migration of Pacific lampreys.

Dams with low passage rates and localized lamprey holding areas are prime candidates for lamprey passage structures (LPS) (Moser et al. 2006). Installed at Bonneville Dam on the lower Columbia River, LPS provide a series of ramps and pools which a lamprey can utilize to bypass the fishways and pass the dam (Moser et al. 2011, Reinhardt et al. 2008). At Prosser Dam tagged lampreys had a strong preference for residing in the pool at the corner along the left bank, which is essentially a dead end with no direct access to a fishway. Lampreys were detected residing in this pool during daylight hours and attempting to find passage across the width of the dam during night hours. Night observations showed tagged lampreys in this corner attempted to pass the dam via the exposed bedrock at the face of the dam. Velocities over the face appear to have been too swift as lampreys were unable to make the transition from bedrock to face without being swept downstream. Even if velocities were low, the overhanging lip at the crest of the dam is probably an insurmountable obstacle. Thus, this area appears to be an ideal place to install a LPS at Prosser Dam (see Appendix A for our conceptual design).

Wanawish Dam had the highest rate of passage (62%) but the average delay at the dam during the spring was 32.4 days. If there were no dams on the Yakima River, and lamprey were able to freely and naturally migrate at the overall mean speed of 7.7 km/d exhibited by our tagged lampreys between dams, after 32.4 days they would be 250 km upriver and into presumably suitable spawning areas above Roza Dam in the upper Yakima or Cowiche Dam in the Naches. Thus it is imperative that measures are developed to simultaneously reduce delays and increase passage rates at all of the dams. Any potential measures need to incorporate lamprey behavior and physiology while also considering the requirements for salmonid passage and the human factors of operation and maintenance.

At Wanawish Dam, for example, very few lampreys actually used one of the fishways. Instead, use of a concrete ledge along the right side of the dam appeared to account for the majority of passage events. This ledge extends approximately 6.5 m downstream from the face of the dam and is covered in water when flows are approximately 6,000 ft^3/s or higher. It is likely that the lampreys climbed over this ledge like a waterfall, although no passage events were witnessed. Only three lampreys passed Wanawish Dam at flows less than 6,000 ft^3/s. None of these were detected as moving through a fishway and it is possible that at lower flows lampreys are capable of climbing over the face of the dam. The left bank fishway was also closed for much of the spring season as attraction water was not flowing due to a broken gate. Miscommunications between maintenance staffs caused disruption in the routine cleaning of the trash rack at the exit of the fishway. These factors significantly reduced the amount of flow exiting the fishway. This may have inhibited the lampreys from finding the entrance and using the fishway despite the fact that more than half the lampreys first approached the dam on river left. Operating procedures however are to close both entrance gates when discharge is expected to exceed 4,000 ft^3/s for a week or longer (NMFS 1987). Discharge at Wanawish Dam exceeded this from February 23 to July 6, thereby encompassing the entire spring migration. Had the fishway been operated as normal it would still have been inaccessible to lampreys. Opening the left fishway during higher flows may increase lamprey passage so long as velocities do not significantly increase. One modification that may reduce delay and increase passage is adding rounded steps to the ledge which would allow for shorter climbing distances over a wider range of flows. Note that any modifications done to the ledge should be minor and not interfere with a lamprey's ability to use it. Any large scale modifications such as a metal ramp LPS should be done on the left bank, which receives the greatest number of first approaches.

Yakima River diversion dam fishways are much smaller and simpler than those of the main stem Columbia River. Tagged lamprey spent on average of 4.2 hours in the ladders at Yakima River dams compared to McNary Dam where tagged lampreys took an average of 67.2 hours to pass through a fishway (Boggs et al. 2008). Residence time downstream of the Yakima dams, however, was longer than for Columbia River dams (Boggs et al. 2008; Keefer et al. 2009). This suggests that finding or entering a fishway at the Yakima diversions may be more of an obstacle than the fishway itself. The fishways were designed for salmonids that swim higher in the water column. Pacific lampreys tend to be bottom oriented and the elevation of the fishway entrance may affect their ability to find and enter the ladder. This warrants additional attention and if it is an issue, we suggest the construction of "mounds" connecting the river bottom to the elevated fishway entrance to guide the lamprey to the opening (see Appendix A).

Water velocity is known to affect lamprey entry and passage in the ladders. Given the variation in the recorded velocities, particularly at Prosser Dam, we cannot be certain what the exact entrance velocities were when a lamprey entered, but most probably passed in the range of 2 to 7 ft/s. Johnson et al. (2009) found that reducing entrance velocities below 4 ft/s increased the number of Pacific lamprey entering a fishway. Moser et al. (2002) however, saw no increase in entry when velocities were reduced from 8 ft/s to 4 ft/s. Provided that adequate surfaces are available to attach for resting, it is possible for Pacific lampreys to pass through velocity barriers up to a maximum of 9 ft/s using burst swimming, though few are able to so (Moser et al. 2002; Keefer et al. 2010). Velocities at Prosser Dam's right bank lower entrance exceeded this maximum on several occasions and use of this entry did not occur until velocities dropped below approximately 3 ft/s. A reduction in velocities may encourage more entries by lampreys, particularly in the spring months when most passage occurs. Techniques to reduce velocities and still provide passage for salmonids should be investigated. If reduction of velocities is not possible, other techniques such as rounding the corners of the cement walls at the entrances and in the vertical slots have proven effective in increasing passage (Moser et al. 2002).

A wide range of velocities were recorded at the fishway entrances. Some entrances such as the center island in the east channel at Wapato Dam and the center island at Sunnyside Dam had nearly constant velocities throughout the study period. Others such as those at Prosser Dam were very inconsistent and often had negative values. High discharge and water levels made it difficult to standardize the measurement methods as the entrances were not visible. This often prevented accurate determination of where in the water column the probe was in relation to the entrance as well as keeping the probe in a constant location within the flow exiting the fishway. Large eddies formed near the entrances at high discharge and appeared to interfere with the velocity readings. Very low discharge also interfered as the water level was too low to reach and adequately submerge the probe. Daily operation of the fishways directly influenced the flow and velocity at the entrances. Fishways were closed during high discharge events to protect equipment. Attraction water was also closed at Wapato Dam's east channel center island and Wanawish Dam's left bank. The cleaning schedules of the fishway trash racks also impact the velocities. Velocity measurements were taken during weekly downloading of the telemetry stations, therefore the recorded entrance velocity was often two or three days prior to or after a passage event. Installing a more sophisticated velocity meter with a standard depth and recording schedule at the entrances is needed to precisely determine the velocity when a lamprey enters the fishway. This system would provide feedback and assist in the development of modifications of the operations to reduce velocity to increase passage of lamprey.

Fish counts at Prosser Dam are done with video recording equipment in each fishway. These data indicate that Pacific lampreys pass upstream primarily during the spring period of the migration, mostly in April and May but a few pass earlier in the migration during the previous late summer and fall period. Our results are consistent with these observations, with over half of the passage events occurring in April and May and a smaller number passing the previous October. Fifty-five percent of our tagged lampreys successfully passed through a fishway when the video cameras were operational but were not recorded. This indicates that a significant portion of lampreys are passing in the fishways at the dam without being counted. Alterations of the video procedure or the counting area may be needed if more accurate counts of Pacific lampreys are desired. Picketed leads are used to direct salmon past the counting window to increase detection and species identification. It is likely that adult Pacific lamprey pass through the 22 mm space between the bars in the leads so reducing that gap may force the lamprey to pass in front of the counting wall and increase the video detections. However, care should be taken that any changes do not make it more difficult for them to pass this area. For example, lampreys move in the ladders at night and may be passing through the leads behind the counting wall to avoid the bright electric lights used to illuminate the counting area. Decreasing the space between the bars may inadvertently delay or prevent many from passing the counting area.

Pacific lamprey telemetry studies on Columbia River tributaries (Baker et al. 2012, Courter et al. 2012) have shown that movement around dams also occurs almost exclusively at night. Pacific lampreys in the Columbia River are more likely to move during the day in areas of low gradient or low risk (reservoirs) than in high gradient or high risk areas such as fishway entrances (Keefer et al. 2012). Our results are consistent with these in that almost all entrances into a fishway occurred at night and half of the downstream movements during daylight hours. A similar proportion of daylight downstream movements occurred during the pilot year of this study (Johnsen et al. 2011).

Spawning areas of Pacific lamprey in the Yakima River basin have not yet been definitively identified. Only one lamprey was detected above Wapato Dam during mobile tracking. It was found under a logjam in a reach with potential spawning substrate but no indications of spawning were observed in the immediate area. Lampreys were also detected during aerial, truck, and boat tracking throughout the reaches between the lower four dams. Most of these reaches do not appear to hold much suitable spawning habitat, but we were unable to make in-river observations of these individuals and do not know if they were attempting to spawn. No entries into Satus, Toppenish, or Ahtanum creeks were detected despite the presence of larval Pacific lamprey and western brook lamprey *Lampetra richardsoni* (Reid 2012; Patrick Luke, Yakama Nation, pers. comm.) and the availability of likely spawning areas. The next phase of our study will include releasing lampreys at Sunnyside and Wapato dams, resulting in a greater number of individuals gaining access to potential spawning areas farther up in the basin. We will continue to monitor lamprey movements within these reaches and attempt to document reproductive behavior.

Insights from the pilot study (Johnsen et al. 2011) were incorporated into our study design. Solar power backup was added to all stations at the dams and kept the telemetry receivers operating when AC power at the dams was turned off during high flow events. Based on data from the pilot study, hanging antennas were added this year and resulted in additional information on finer scale movements and holding areas at the dams. Cowiche Dam and Roza Dam were not originally part of this year's study plan; however manpower and resources were available to equip them with telemetry stations, which reduced the amount of effort required to monitor migrations upstream of Wapato Dam. Future phases of our study will include additional antennas at these dams to better understand their impacts on Pacific lamprey passage.

Aerial tracking of our tagged lamprey was conducted on one occasion by Yakama Nation Fisheries personnel during their steelhead telemetry study. The flight detected lampreys between the dams, including many that never arrived at the next dam, and provided information we likely would not have otherwise collected. Aerial tracking will be used if possible for next year's study.

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Appendix A: Conceptual designs for improving Pacific lamprey passage at Prosser Dam

To date, our telemetry study has identified several methods that may improve passage efficiency for adult Pacific lamprey at Prosser Dam. Four concepts are developed and discussed in this appendix.

Lamprey Passage Structure

A lamprey passage structure (LPS) pumps water through a series of metal ramps and holding tanks to allow lampreys to pass over dams (Moser et al. 2006). These systems are used effectively at other dams including Bonneville Dam on the Columbia River (Moser et al. 2011) and Three Mile Falls Dam on the Umatilla River (Jackson and Moser 2012).

Justification

Telemetry data show that lampreys gather and hold in the pool area at the left bank of the dam. Adults have been observed attempting to move upstream by climbing the bedrock there (Figure A-1).

Figure A-1. Pacific lamprey (circled in red) climbing bedrock on left bank at base of Prosser Dam.

Placement and Construction

The area on the river-left side of the dam would be the best place to build a LPS for adult lamprey passage. The ramp would start at the bedrock on the downstream side of the dam between the canal and the river (A-2). The ramp would then angle up and over the dam in the space between the gatehouse wall at the head of the canal and a wall at the end of the dam (Figure A-3).

Figure A-2. Proposed site of LPS on the left bank of Prosser Dam at low flow.

Figure A-3. Prosser dam and the head of the Chandler Canal. The ramp would be placed in the space (circled in red) between the gate house and the slanted wall at the left bank of the dam.

The entire system would consist of a covered ramp, a pump, and either a collection box at the top end of the ramp or an outlet into the river above the dam (Figure A-4). Water would be pumped from the river on the upstream side of the dam to the highest section of the ramp and then flow down the ramp, out the entrance, and over the bedrock. At base flows, this pumped water would be the only attraction water in the area.

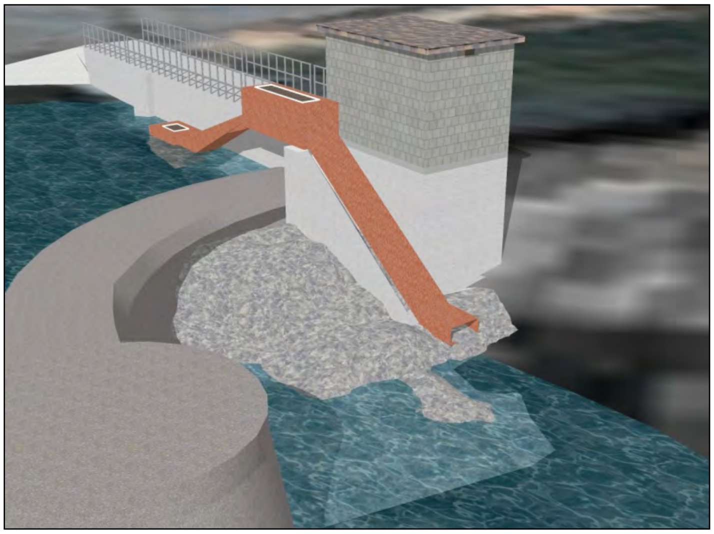

Figure A-4. Concept of proposed LPS on the left bank at Prosser Dam. The existing structures of the dam are shown in grey with the proposed lamprey ramp in red.

Advantages

The LPS at this site has several advantages. The system would be protected from floating logs and debris as the proposed site is sheltered between two concrete walls. AC power is available in the gate house at the location and water for the ramp would be pumped and regulated, allowing for constant velocities and operation regardless of river flow. The system could also be used as an adult trapping facility to aid in collection of lampreys for propagation or future studies. Finally, building the ramp here would not require any modifications to the dam structures or river channel.

Disadvantages

The ramp system relies on water being pumped from the river to the higher elevation of the ramp. Thus, the system requires electricity and potentially more maintenance than passive systems. The outfall ramp of the LPS needs to be carefully positioned in order to avoid entrainment of lampreys back over the dam or down the canal.

Underground Lamprey Passage Structure

Telemetry identified another possible location for a LPS on the right bank of the river. One radio tagged lamprey entered and traveled up the existing drain pipe into the fish trapping facility, suggesting that lampreys looking for passage would find a LPS ramp entrance in the area.

Placement and Construction

The ramp would begin on the downstream side of the dam near the drain outflow pipe and then proceed underground to exit upstream of the dam (Figure A-5). By placing the LPS in a concrete trough under ground-level, the structure would not interfere with access to the right bank facilities or with operations of the trap and the fish ladder.

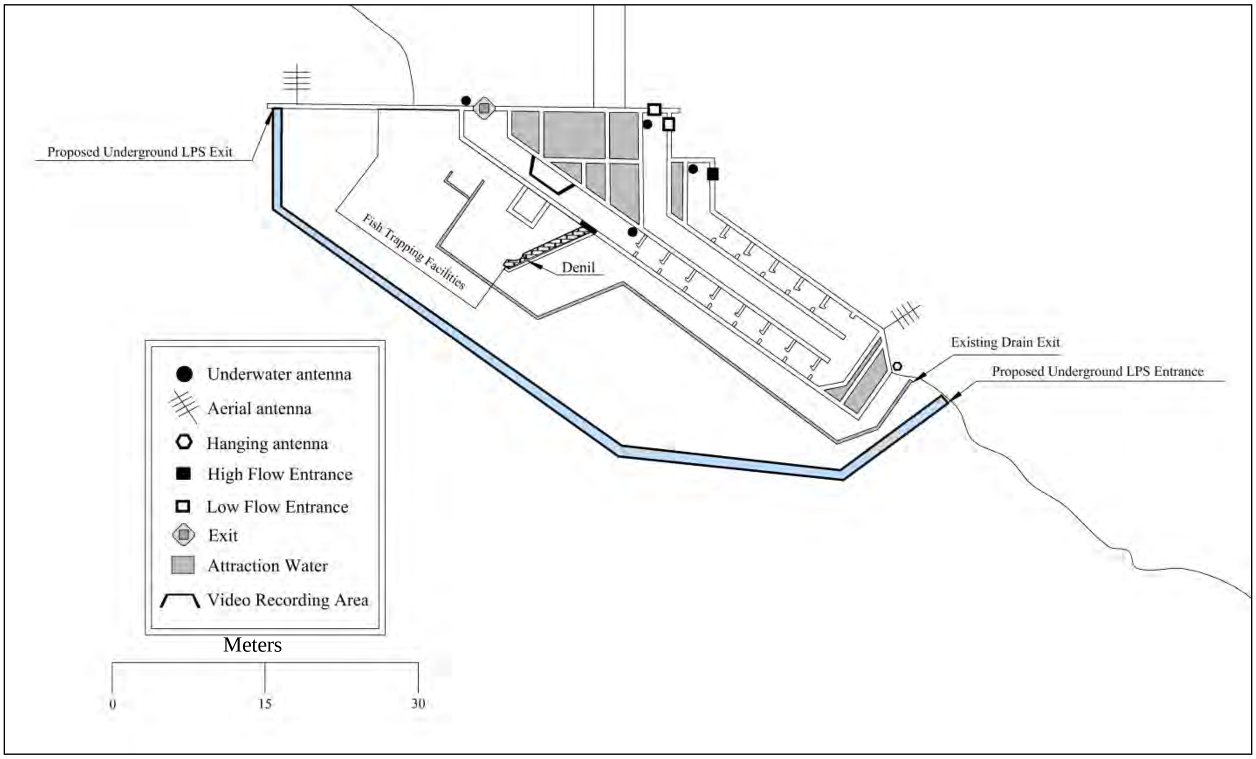

Figure A-5. Proposed site and concept for an underground LPS on the right bank of Prosser Dam.

Rock Ladder

A "natural" pile of rocks extending from the crest of the dam to the river bed on the downstream face of the dam could provide passage for up-migrating adult Pacific lamprey.

Justification

Provided suitable surfaces to hold onto, Pacific lampreys have the ability to climb over steep and turbulent sections of river. For example, Pacific lampreys are known to climb Willamette Falls (Clemens et al. 2011). We observed lampreys at Prosser Dam attempting to move upstream by climbing natural bedrock but the rock does not extend up to the dam crest (Figure A-6).

Figure A-6. Pacific lamprey climbing bedrock at the base of Prosser Dam.

Placement and construction

The bedrock on the left bank of Prosser Dam is the best location for the rock ladder (A-7). Lampreys have been observed climbing bedrock in the area and telemetry data show that lampreys congregate there. Additionally, a log boom just upstream of the dam in the area reduces debris going over the dam face at that location.
The construction of a rock ladder would require placing large rocks and boulders at the base of the dam and building them up to the crest. This construction would use the bedrock as a base with the added rocks cemented or otherwise secured to ensure that they stay in place during high flow events. The rock ladder needs to be designed so that there are areas of varying velocities and that water is flowing over the rocks at a wide range of discharges. This would provide a variety of paths for the lampreys to take over the dam as conditions change.

Figure A-7. Proposed site at Prosser Dam of rock ladder showing bedrock at low flow. The head of the Chandler Canal is just right of the edge of the frame.

Advantages

The rock ladder holds several advantages over other potential systems. First, the rock ladder is passive and does not require water to be pumped, eliminating the need for personnel to monitor and maintain a pump. Second, the base of the ladder could be quite large to make it easier for lampreys to find a place to start climbing. This may increase passage compared to a single ramp with a small entrance. Finally, as lampreys recover and are once again plentiful in the future, a rock ladder would better serve as a tribal fishery location where lampreys could be captured using traditional methods.

Disadvantages

A rock ladder may be prone to catching tree trunks, branches, or other debris and it may be necessary to clear the area at times. Construction would likely be a regulatory challenge requiring permits to do work in the river and on the dam. The proposed site of the rock ladder is dry at base flows, so the dam crest may need to be modified to keep water flowing over the rocks. Finally, lampreys using an open and uncovered system such as this may be more susceptible to predation or illegal harvest before a fishery is established.

Fish Ladder Modification: Entrance Mounds

Mounds could be built at the base of the entrances to the existing fish ladders (Figure A-8). These structures would slope down on all three sides from the lower edge of the entrance to the river bed.

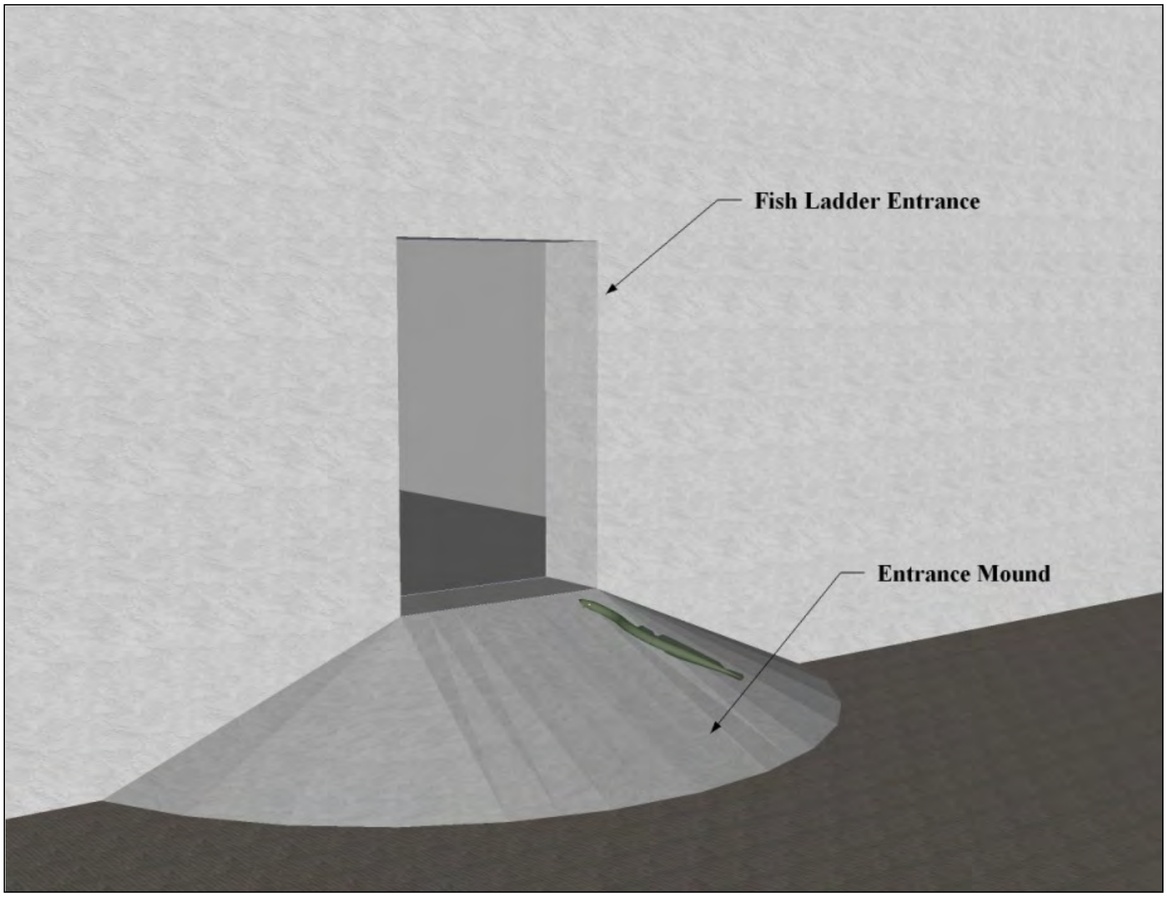

Figure A-8. Concept of proposed fish ladder entrance mound.

Justification

One factor contributing to the difficulty faced by lampreys in using the existing fishways may be an inability to find the ladder entrances. The ladders were designed for salmonids that swim in the water column, but Pacific lampreys move close to the river bed, often anchoring themselves to rocks. Thus, lampreys may not be swimming high enough in the water column to discover those ladder entrances that may be located above the river bed. Entrance mounds could guide lampreys to the entrances and provide an attachment surface to negotiate higher velocities (Figure A-8).

Placement and construction

Modifications would be made to the existing fish ladder entrances. Initially, a single ladder could be modified in order to test the effectiveness of mounds and then other ladders could be modified later if the changes increase passage. The river left ladder could be changed first as telemetry data suggest lampreys congregate in the area. Passage through the ladder is monitored by video, so effectiveness of modifications could be quantified.

The construction of concrete mounds would require coffer dams and diverting water from the base of the ladder. Concrete would be used to form mounds sloping to the river bed from the bottom of the ladder entrances. This new concrete would need to be secured in place, possibly using rebar or by excavating in front of the entrances so that it is sufficiently buried. Permits would be needed for working in the river and on the dam.

Advantages
Adding mounds to the fish ladder entrances would be a relatively simple modification to an existing fish passage system. Constructing the mounds may be cheaper than constructing an entirely new system for lamprey passage. The system is passive and it should not require any maintenance beyond what is currently required to keep fishways clear. Finally, the modifications could be undertaken as a trial, and if proven effective could be implemented at other dams that have similar fishway entrances.

Disadvantages

Constructing mounds at fish ladder entrances would require working in the river and modifying the dam structures. Permits and various agency approvals would be needed. Also, it is currently unknown by us how many entrances are elevated and whether it makes it more difficult for lampreys to find the ladder or if other factors are preventing them from entering (e.g. high water velocities or squared edges at fishway entrances).

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Appendix B: Water velocities at the entrances of fish ladders at Yakima River diversion dams during 2102.

The following tables contain the velocities of water flowing out of fish ladder entrances at Wanawish Dam (Table B-1), Prosser Dam (Table B-2), Sunnyside Dam (Table B-3), and Wapato Dam (Table B-4). Velocities at open gates were measured with a portable flow meter (Marsh McBirney Flo-Mate™ 2000). Gate labels for each entrance (NMFS and BOR 1992a-e) are shown in Figures B-1 through B-5.

Table B-1. Water velocities (ft/s) measured at fish ladder entrances on Wanawish Dam during 2012.

Date	Left Bank G1*	Right Bank G2
4/5/2012	5.77	3.34
4/18/2012	5.4	3.7
4/25/2012	6.75	2.8
4/30/2012	4.61	3.08
5/10/2012	5.41	2.89
5/16/2012	6.85	
5/23/2012	6.56	2.61
5/31/2012		0.6
6/7/2012	5.06	3.16
6/13/2012	0.76	2.4
6/20/2012	-0.325	-0.81
6/27/2012	5.66	1.96
7/2/2012	-1.42	-1.17
7/12/2012	4.22	-0.7
7/18/2012	3.18	4.92
7/25/2012	2.03	6.92
8/7/2012	3.7	5.84
9/12/2012	3.5	3.63

*The fishway entrances appeared to be closed during the study and the measured velocities represent the speed of the river current moving across the ladder opening.

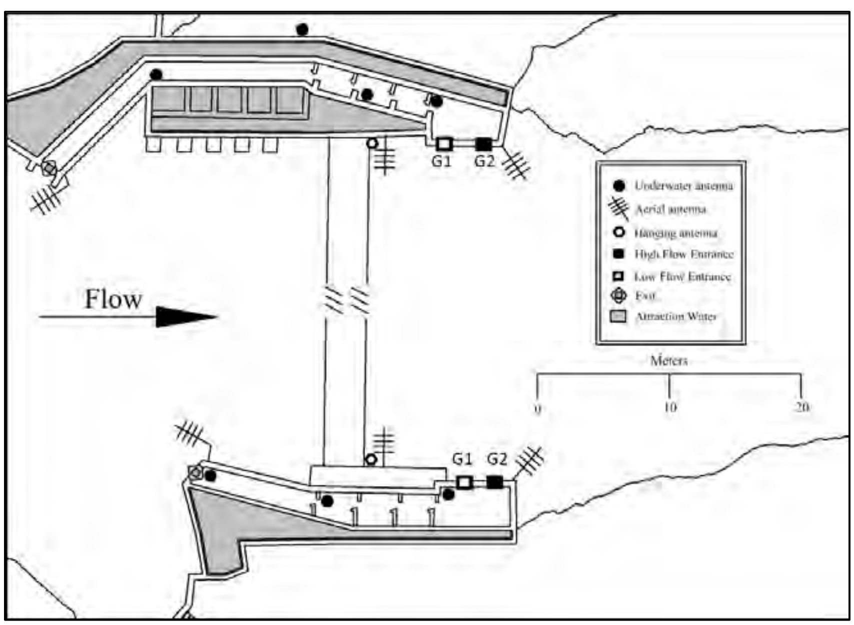

Figure B-1. Wanawish Dam fishway gate labels.

Table B-2. Water velocities (ft/s) measured at fish ladder entrances on Prosser Dam during 2012.

	Left Island				Center Island				Right Bank		
Date	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3
4/5/2012			4.7	4.7		6.4		3.9	3.6		9.6
4/19/2012			6.39	5.14		7.23		6.57	2.05		9.2
4/25/2012			-0.9	-0.9		7.65					2.6
4/30/2012			0.93	0.99		1.76		-0.33			1.45
5/10/2012			7.05	6.53		6.89		5.9	-0.48		6.94
5/16/2012						8.18		7.9			6.5
5/23/2012						4.68		6.23			6.87
5/31/2012			3.79	4.22		6.27		6.25			6.13
6/7/2012						4.58		3.64			2.99
6/13/2012			6.67	6.12		8.24		6.73			8.3
6/20/2012		-0.74	1.1	0.47		4.19		3.78			2.99
6/27/2012		-0.63	0.14	0.83		4.63		4.28			2.53
7/2/2012		4.83	9.86	7.62	2.34		4.91			5.31	7.48
7/12/2012		4.32	7.32	5.53			8.48			6.24	6.86
7/18/2012			6.36	6.82						4.56	3.77
7/25/2012					4.23		7.18		6.27	5.74	
8/7/2012	5.77				5.03		6.02			5.01	5.51
9/6/2012					6.32		6.52			6.51	4.88
9/12/2012					7.67		6.46		0.4		6.7

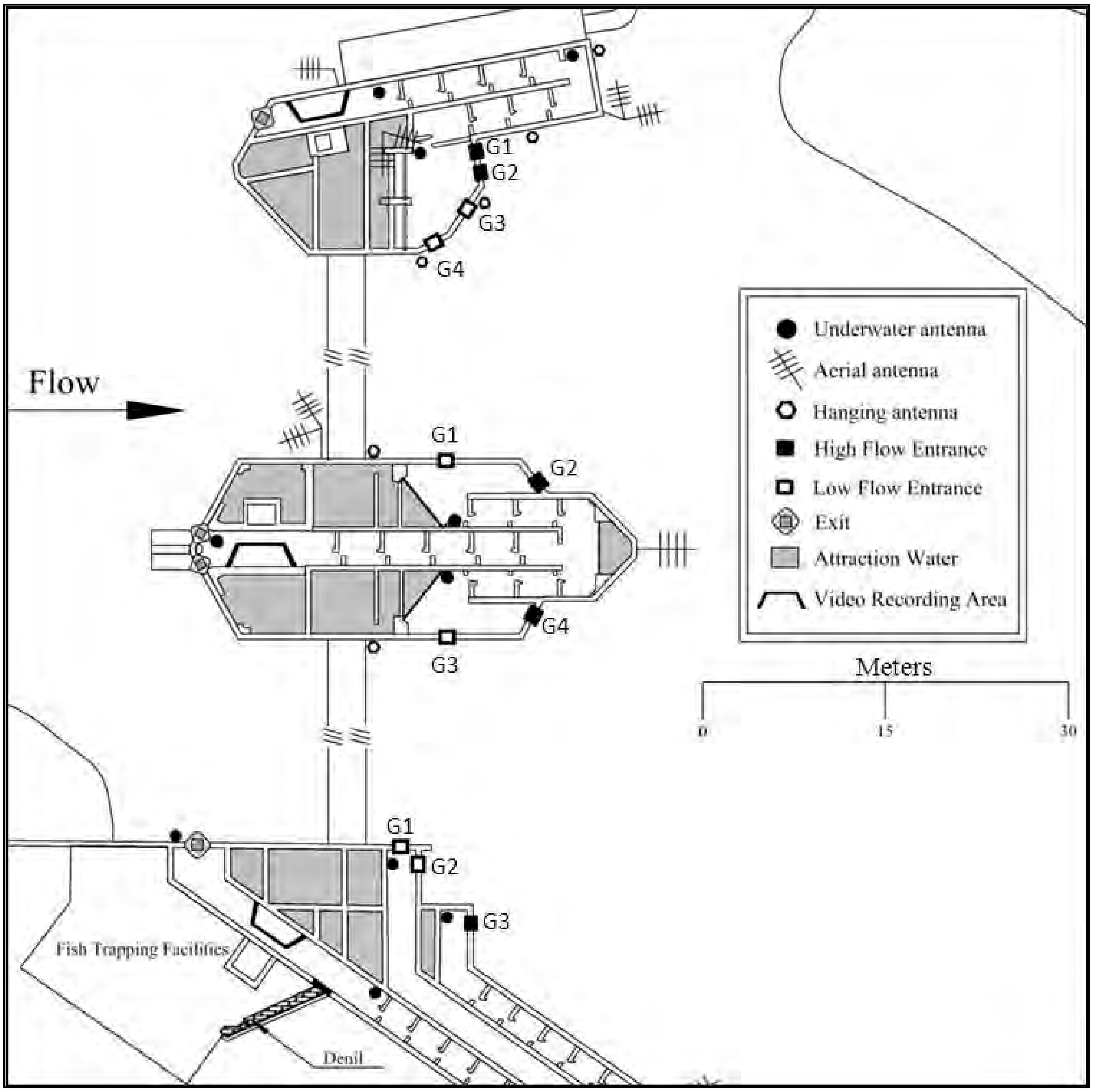

Figure B-2. Prosser Dam fishway entrance gate labels.

Table B-3. Water velocities (ft/s) measured at fish ladder entrances on Sunnyside Dam during 2012.

	Left Island		Center Island				Right Bank	
Date	G17	G18	G11	G12	G13	G14	G3	G4
4/5/2012								6.6
4/6/2012		6.33						
4/19/2012		8.6		7.81		8.23		6.71
4/25/2012								-0.1
4/30/2012		3.05		-0.52		-0.53		0.13
5/11/2012		8.26		7.22		9.67		4.89
5/16/2012		8.1		6		5.2		4.4
5/24/2012		8.82		6.17		6.41		5.3
5/31/2012		7.9		9.67		9.28		5
6/7/2012		3.18						1.13
6/13/2012		8.55		8.99		8.62		7.41
6/21/2012		6.46		6.71		6.44		4.58
6/28/2012		10.09		8.39		8.93		7.51
7/3/2012		8.63		5.2		6.54		4.68
7/13/2012		6.79	6.63		6.95		1.62	
7/19/2012		6.89	6.17		6.1		4.2	
7/26/2012		6.78	7.31		7.02		5.28	
8/7/2012		8.49	7.57		7.22		5.35	
9/5/2012	7.81		6.93		7.97		8.02	
9/13/2012	7.95		4.35		6.58		4.92	

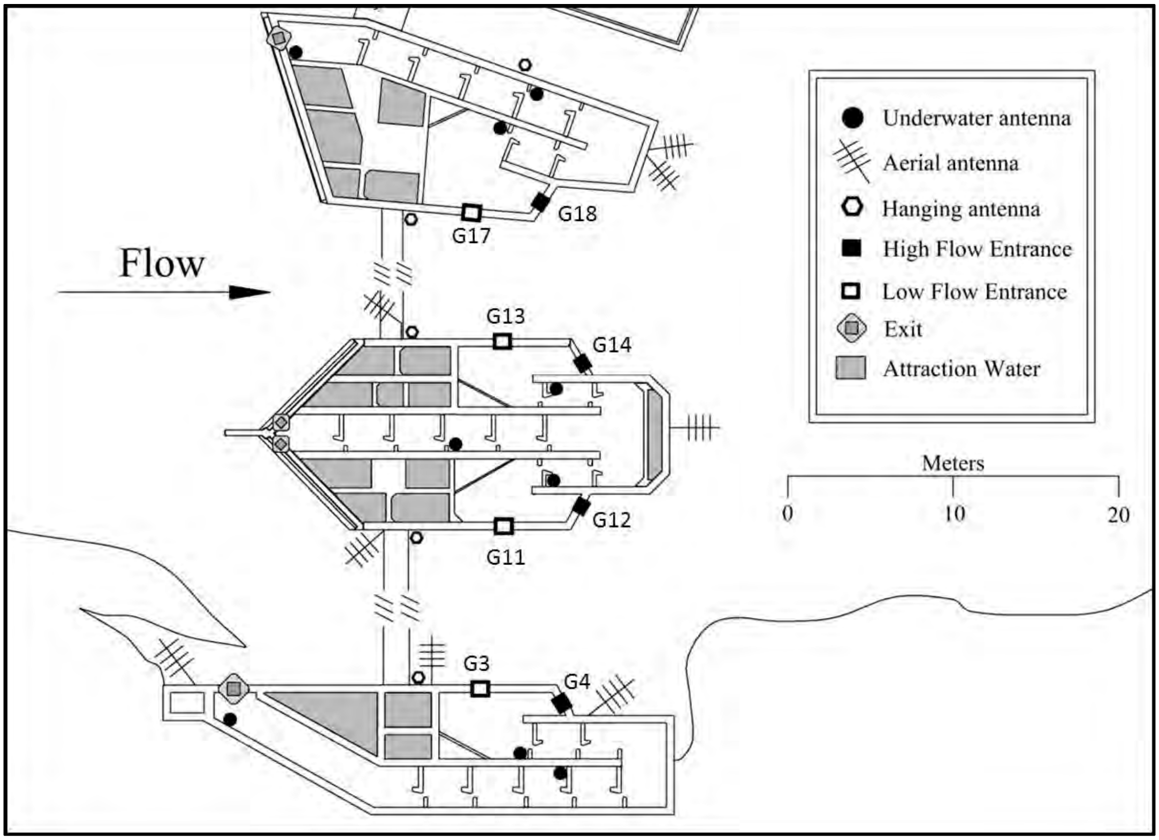

Figure B-3. Sunnyside Dam fishway entrance gate labels.

Table B-4. Water velocities (ft/s) measured at the entrances to fish ladders at Wapato Dam during 2012.

	East Branch Center Island		East Branch Right Bank	West Branch Center Island			
Date	G8	G10	G4	G7	G8	G9	G10
4/5/2012	4.21	4.21	4.1				
4/6/2012					7.4		4.8
4/19/2012	2.13	2.3	2.8		2.45		2.26
4/25/2012	2.2	2.1	3.6		3.9		3.2
4/30/2012	2.19	2	4.6				
5/1/2012					3.29		2.18
5/11/2012	1.83	1.59					
5/16/2012	2.3	2	1.6		6.2		5.6
5/24/2012	2.41	2.18	2.88		2.66		1.99
5/31/2012	1.81	1.65	4.1		6.76		5.04
6/7/2012	2.34	1.32	3.95				
6/8/2012					2.12		2.53
6/13/2012	2.36	2.15	5.5				
6/14/2012					2.91		3.37
6/20/2012	1.37	0.84	5.32				
6/21/2012					3.33		3.35
6/28/2012	1.96	1.8			4.76		3.62
7/3/2012	1.6	1.71	5.56	0.71		0.87	
7/13/2012	1.96	1.98	4.85		0.94		0.95
7/19/2012	1.9	1.7	6.69	3.28		3.41	
7/26/2012	1.54	1.98	1.28		4.69		4.55
8/7/2012	1.92	1.98	5.89				
8/8/2012					4.4		6.35
9/5/2012	1.98	2.03	5.7		5.71		5.39
9/13/2012	3.07	3.36	4.76		3.75		3.83

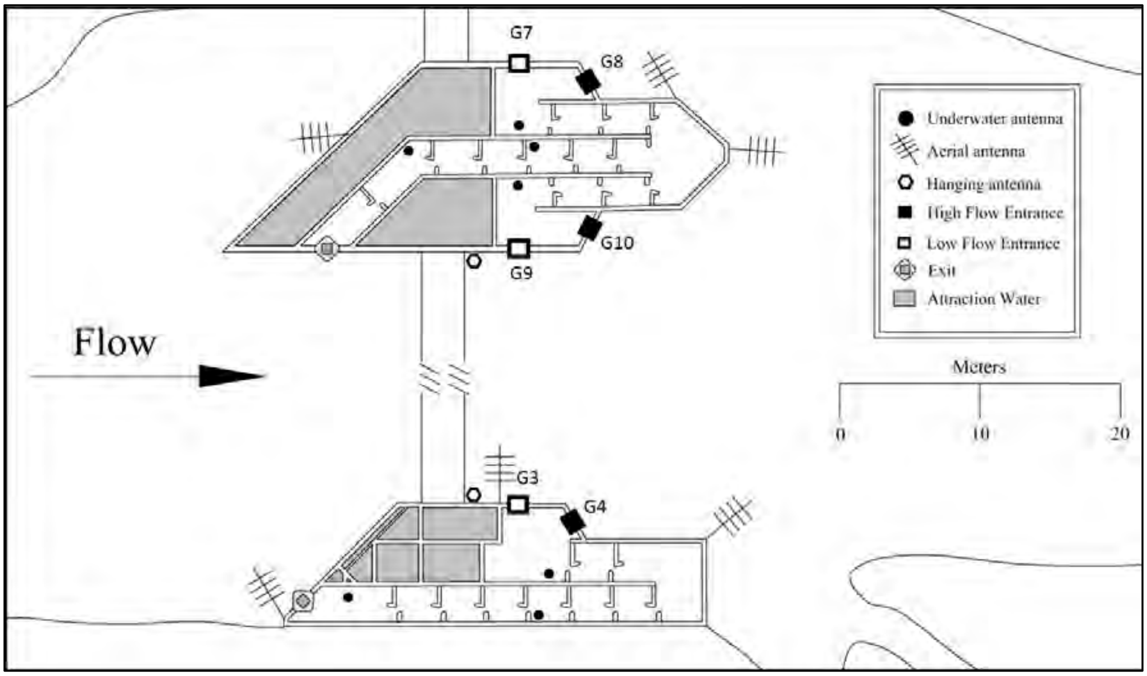

Figure B-4. Wapato Dam east branch fishway entrance gate labels.

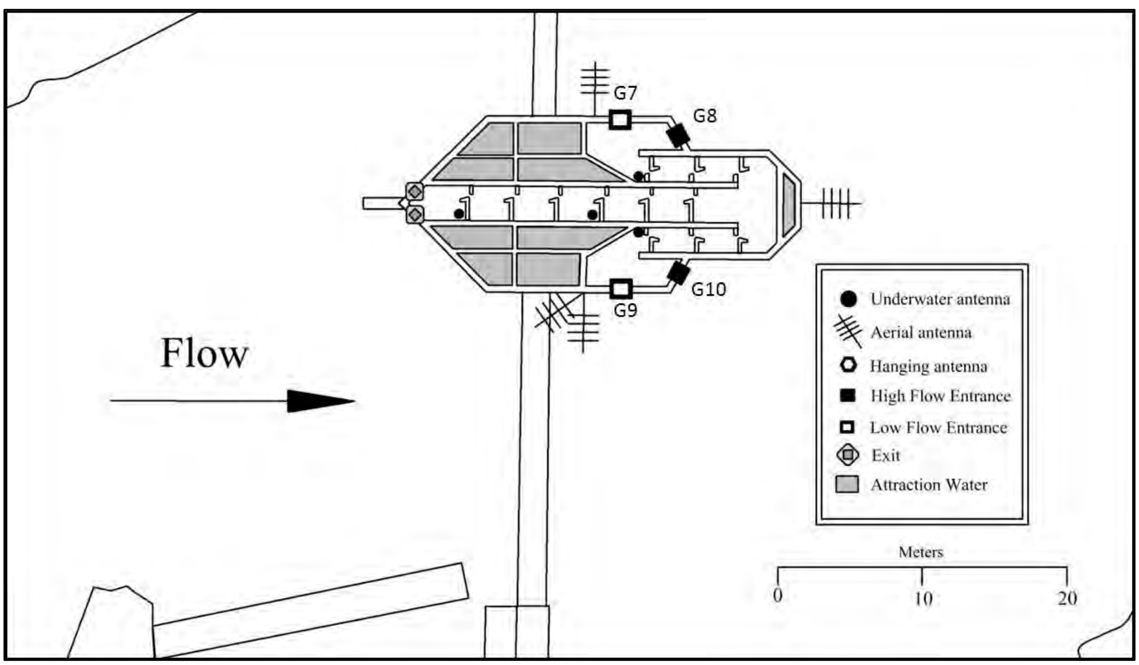

Figure B-5. Wapato Dam west branch fishway entrance gate labels.

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Confederated Tribes and Bands of the Yakama Nation
Department of Natural Resources, Fisheries Resources Management Program

Yakama Nation Pacific Lamprey Project

Juvenile Lamprey Surveys in the Yakama Nation Ceded Lands

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
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2012 Annual Preliminary Report

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Acknowledgement

Many individuals and various agencies have contributed to the success of this project and we would like to thank each and every one. Without the expertise and knowledge base of these resourceful people, these extensive surveys for juvenile lamprey covering the entire Ceded Area of the Yakama Nation (YN) would not have been possible. For the Yakima Subbasin sampling, we would especially like to acknowledge Joe Gutierrez from the Bureau of Reclamation and Mike Porter and his Aviation Predation Study Crew from the YN Yakima/Klickitat Fisheries Project (YKFP). For the Wenatchee Subbasin sampling, we would like to thank the following: Michael Kane from the Chelan County Natural Resource Department, Susan Dretke from the Natural Resources Conservation Service (NRCS) - Cascadia Conservation District (CCD), R.D. Nelle and Dan Sulak from the U.S. Fish and Wildlife Service (USFWS), and Matt Collins and Greg Robison from the YN YKFP Coho Project. For the Entiat Subbasin sampling, we would like to again show our gratitude to Susan Dretke from the NRCS-CCD. For the White Salmon Subbasin sampling, we would like to thank the following: Jeff Jolley from the USFWS, Brady Allen from the U.S. Geological Surveys (USGS), Greg Morris from the YN Fisheries, and Joe Zendt from the YN YKFP. We are also indebted to all the willing private landowners, who have graciously allowed us to access the streams and rivers through their property for these surveys to take place. Last but not least, we want to thank all of our hard working Lamprey Team members, Dave'y Lumley (now in a permanent position), Tammy Swan, Markeyta Pinkham, Frank Spillar, and Tyler Beals.

Executive Summary

Since 2009, the Yakama Nation Pacific Lamprey Project (YN PLP) has begun conducting juvenile lamprey surveys to document their distribution and relative abundance within the Ceded Area of the Yakama Nation. Our primary objectives for the juvenile lamprey surveys in project year 2012 were: 1) to assess the presence/absence, distribution, and relative abundance of juvenile Pacific lamprey (primary focus) and Western brook lamprey (secondary focus) and 2) to evaluate the relative abundance of juvenile lamprey habitat and 3) to establish “Index Sites” for long-term status and trend monitoring within the Ceded Area of the Yakama Nation. Yakima and Klickitat subbasins has been the primary focus of this project since we started in 2009, and in project year 2012, we have expanded this area to include the Wenatchee, Entiat, and White Salmon subbasins.

In 2012, we surveyed a total of 98 sites using a backback electrofisher designed for larval lamprey. In addition, there were over 70 other sites that were surveyed quickly (quick assessments) using an electrofisher or a fine-mesh hand net to simply evaluate prescence/absence of juvenile lamprey. Juvenile Pacific lamprey were only found in the Lower Yakima, Naches, Wenatchee, and Entiat Subbasins and the mean ratio of Pacific lamprey (vs. Western brook lamprey) were 13.3%, 5.3%, 100%, and 100%, respectfully. Within the Yakima Subbasin, we only found Pacific lamprey ammocoetes in the Yakima River, Satus Creek, Ahtanum Creek, and Naches River. The ratio of Pacific lamprey vs. Western brook lamprey in these rivers/streams were 22.0%, 8.3%, 28.6%, 7.7%, respectfully. We did not detect any juvenile lampreys in the lower reaches of the Yakima River until river km 137.6. No juvenile Pacific lamprey have been detected upstream of river km 195.2 in the Yakima River since these surveys began in 2009. On the other hand, Western brook lamprey were detected most frequently in the Upper Yakima Subbasin (73.7% of all sites surveyed) compared to all other subbasins surveyed in 2012.

We also detected an inverse relationship between habitat availability and fish density at the subbasin scale. For instance, Naches Subbasin had the lowest amount of habitat available per site, but the mean fish density was the highest of all the subbasins. This potentially indicates that lack of habitat within the stream/river may force the lamprey to use the habitat at a higher fish density level compared to sites with more larval habitat available, and suggests that density may

not be the best indicator for fish abundance and status (i.e. it could be an indication that habitat was limiting).

All previous surveys starting in 2009 paint the general same picture for the Yakima Subbasin. That is, Pacific lamprey is rare and primarily limited to the Lower Yakima Subbasin (below Roza Dam) and the majority that we have detected were found in side channels of the Yakima River (primarily in the Wapato reach area) and the lower reaches of major tributaries, including Satus and Ahtanum Creek. Ammocoete habitat and Western brook lamprey, on the other hand, is fairly abundant in the Lower Yakima as well as in the Upper Yakima subbasins.

Introduction

Pacific lamprey, *Lampetra tridentatus*, which is among the earliest fish species in fossil records from 450 million years ago, has inhabited the rivers, streams and coastal waters of the western U.S. relatively unchanged in its primordial form (Schwab and Collin 2005; Bond 1996). Historically, Pacific lamprey were abundant throughout much of the Columbia River Basin (Hamilton et al. 2005; Hammond 1979; Kan 1975), yet populations have drastically decreased over the last 30-50 years due to a variety of factors. Adult counts at Roza Dam (river km 210) continue to indicate no Pacific lamprey entering the upper Yakima basin. Adult counts at Prosser Dam fish counting station continue to indicate very few adult lamprey passing this location each year. Only in the years 2002, 2003, and 2004, larger numbers were counted (22, 87, 65, respectfully) whereas in all following years, very few if any were counted. Since 2009, the Yakama Nation Pacific Lamprey Project (YN PLP) has begun conducting juvenile lamprey surveys to document their distribution and relative abundance within the Ceded Area of the Yakama Nation (Figure 1). We have focused primarily on larval lamprey (or ammocoetes) life stage, but transformed lamprey (or macrophthalmia) are also documented and monitored in these surveys as well.

Our primary objectives for the juvenile lamprey surveys in project year 2012 were: 1) to assess the presence/absence, relative abundance, and distribution of juvenile Pacific lamprey (primary focus) and Western brook lamprey (secondary focus) and 2) to evaluate the relative abundance of juvenile lamprey habitat and 3) to establish "Index Sites" for long-term status and trend monitoring within the Ceded Area of the Yakama Nation. Yakima and Klickitat subbasins has been the primary focus of this project since we started in 2009, and in project year 2012, we have expanded this area to include Wenatchee, Entiat, and White Salmon subbasins. At each of the subbasins, we targeted habitat that had the highest potential of Pacific lamprey being present (based on existing knowledge) starting from lower reaches to higher reaches. We also tried to conduct more surveys in areas that were not covered or only lightly covered during the 2010-2011 sampling effort. The information from this project will fill important data gaps on the current status of both Pacific lamprey and Western brook lamprey region wide and will be vital to any future conservation / restoration activities. In this report, we will outline the key findings discovered up to date related to these objectives.

Figure 1. Ceded Lands (grey) and Reservation Boundary (blue) of the Confederated Tribes and Bands of the Yakama Nation within the state of Washington. Yakima Subbasin rivers and streams of interest for the Pacific Lamprey Project are highlighted in yellow lines. Other rivers and streams of interest (outside the Yakima Subbasin) are highlighted in red lines. Although not highlighted here, mainstem Columbia River is also of significant importance for the conservation of Pacific lamprey.

Study Area

The Yakama subbasin is one of the major tributaries of the Columbia River basin, with its confluence 335 miles from the ocean (Figure 1). The Yakima River flows 214 miles and is located in central Washington. The watershed contains an area of approximately 6,155 square miles with nearly 2,000 miles of perennial rivers and streams from the crest of the Cascade Mountain to the Columbia River. Its large size contributes not only to sheer volume of available lamprey habitat but the wide variety of geologic, topographic, and ecological conditions producing a wide range of habitat types. These habitats are suitable for a variety of species and provide habitat diversity that supports multiple life stages of lamprey species. Specifically, Pacific Lamprey ammocoetes, macrophthalmia, and adults have different optimal habitat types necessary to carry out essential life functions, including feeding, rearing, migration, and spawning. The rivers and streams of interest for the Pacific Lamprey Project include Satus, Toppenish, and Ahtanum creeks in the lower reach, Naches (including Cowiche and Tieton) and Wenas rivers/streams in the mid reach, and Wilson, Manastash, Taneum, Swauk, Teanaway, Cle Elum rivers/streams in the upper reach. There are five major reservoirs located in this subbasin, and form the storage components of the federal Yakima Projects managed by the Bureau of Reclamation, including: Keechelus Lake, Kachess Lake, Cle Elum Lake, Rimrock Reservoir and Bumping Lake. The north fork of the Tieton River connects Clear Lake with Rimrock Lake (Figure 2).

Wenatchee, Entiat, and White Salmon subbasins are also important streams for Pacific lamprey within the Ceded Area of the Yakama Nation (Figure 1). Wenatchee Subbasin contains an area of 1,333 square miles with 53 miles on the mainstem river. Major tributaries of interest include Icicle, Nason, and Chiwawa creeks. Entiat Subbasin contains an area of 466 square miles with 57 miles on the mainsteam river. Major tributaries of interest include Mad River. White Salmon Subbasin contains an area of 400 square miles with 44 miles on the mainstem river. Major tributaries of interest include Rattlesnake and Trout Lake creeks. Pacific lamprey have been detected in all three of these subbasins (only below Conduit Dam on White Salmon River), but information on distribution and relative abundance has been limited to date.

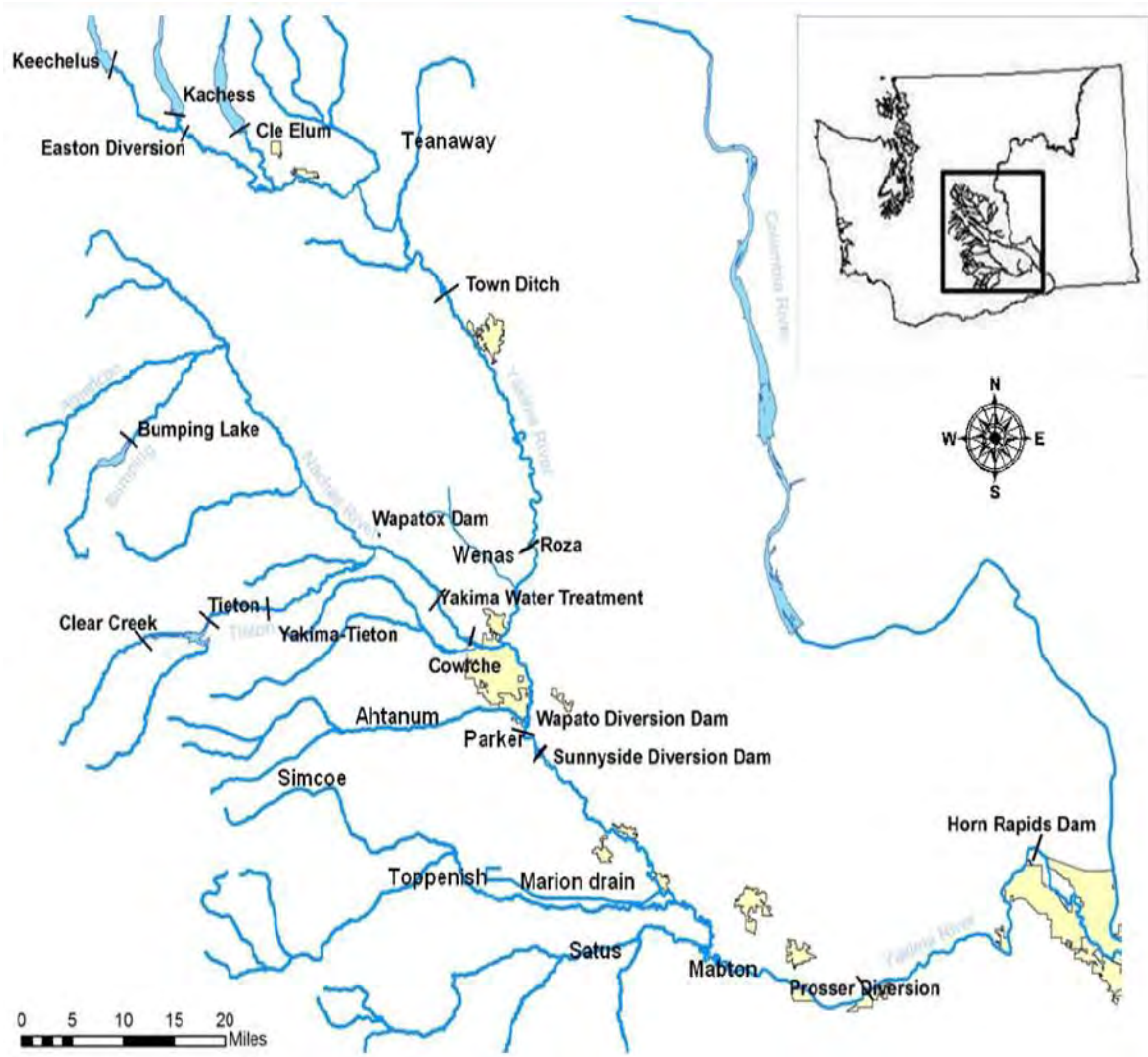

Figure 2. Schematic diagram of the Yakima River and major tributaries and irrigation facilities.

Methods

Juvenile lamprey (focusing on ammocoetes) were surveyed in each of the targeted subbasins (Yakima, Wenatchee, White Salmon, and Entiat) during summer low flow season between mid-June and mid-October in 2012. As in previous years, we targeted preferred (Type I) and acceptable (Type II) ammocoete habitat as defined by Slade et al. (2003) within a sampling site. Their definition of the three strata (Type I, II, and III – see below) is qualitatively defined based on substrate components and compactness, as suggested originally by Applegate (1950).

> "Type I habitat is located primarily in depositional zones preferred by the filter-feeding larvae, and consists primarily of a mixture of sand and fine organic matter. Type II habitat often consists of shifting sand that may contain some gravel, is utilized by some larvae for burrowing, but it is inhabited at much lower densities. Type III habitat is unacceptable because larvae are unable to burrow into it. Hard packed gravel, hardpan clay, and bedrock are examples of Type III habitat."

Although these habitat types are determined subjectively, agreement in habitat type determination is good among observers (Mullett and Bergstedt 2003) and definitions used to separate habitat types are supported by more than 30 years of data that demonstrate habitat preference by sea lamprey ammocoetes. According to studies from the Great Lakes tributaries, as many as 93% of the sea lamprey ammocoetes were found in Type I habitat (Mullet 1997) and the densities in Type I habitat can be 4-30 times higher than Type II habitat (Slade et al. 2003; Fodale et al. 2003). Therefore, we focused our sampling on Type I (preferred) habitat and subsequently Type II (acceptable) habitat. Type III (unsuitable) habitat was skipped and not surveyed. Type I and II habitat is generally found in backwater areas or along the margins of larger pools.

In 2009, Klickitat Subbasin was the single target area. In 2010, the general focus for surveys was in the lower portion of the Yakima Subbasin. In 2011, the general focus for surveys was in the upper portion of the Yakima Subbasin. A systematic survey was attempted where sample sites were generally randomly selected and equally spaced. Site locations were pre-determined using National Agriculture Imagery Photos at 1:24,000-scale aerial maps and GIS software. Sampling sites were spaced every four river kilometer (RK), and at each site a search by foot was conducted to find the first preferred (Type I or II) habitat for ammocoetes (Hansen et al. 2003). Some exceptions were made to these criteria when access was unavailable or unsafe.

In 2012, the overall sampling scheme was modified slightly based on habitat potential and accessibility. Based on aerial images from Google Earth and GIS software, we primarily selected sites that had higher chances of being a Type I habitat (such as slow water, shallow channel margin with dark tints [usually indicating fine sediment], backwater eddies, confluence of side channels, behind island bars, and tail end of deposition bars, etc.) within the targeted reaches, rather than taking a more systematic and random approach. Furthermore, due to the extensive sampling area (four major subbasins) and difficulties commonly associated with private landownership, we decided to take advantage of sites that had better accessibility. We focused on road crossings and other areas that both appeared optimal for ammocoete rearing and also made site access quicker, simpler, and easier in order to cover more ground efficiently. To evaluate lamprey distribution effectively within the 12-million-acre Yakama Nation Ceded Area, ease of access was a critical issue. Moreover, we determined that targeting the preferred habitat more effectually will provide us with a better framework for evaluating presence/absence, distribution, and relative abundance.

We also modified the in-the-field sampling protocols moderately. In the past years, a 7.5m^2 plot was surveyed at each site using a depletion pass protocol. In many of the sites, there was not enough Type I or II habitat to make up a 7.5m^2 plot and made comparisons among sites problematic. In 2012, we reduced the plot size down to 2m segments, and up to 16 plots (32m of the channel) were surveyed at each site (we initially experimented with 1m plots, but it was too difficult to accurately account for the lamprey from each plot). A rope labeled with 2m increments were laid out on the bank to assist with the plot boundary delineation. We also modified the survey to be single pass electrofishing. Based on studies conducted by others, such as the Confederated Tribes of Warm Springs (2012), single pass electrofishing conducted at a standardized rate of effort showed highly similar trends in relative abundance compared to multiple pass electrofishing. We determined that conducting a thorough single pass electrofishing at a slow deliberate pace will yield just as meaningful results as a multiple pass electrofishing that was conducted at a faster pace. We paid close attention to the rate of electrofishing and aimed at a rate of 90 seconds / 1 meter of electrofishing (and ensured that it was no faster than 60 seconds / 1 meter of electrofishing). We only conducted multiple pass electrofishing when no lamprey were sampled at a site to evaluate further whether ammocoetes were truly absent at the site in an effort to substantiate presence/absence.

The methods of electrofishing remained the same. Using AbP-2 backpack electrofisher (Engineering Technical Services, University of Wisconsin, Madison, Wisconsin), 3 pulses per second (125 V direct current) at 25% duty cycle with a 3:1 burst pulse train (three pulses on, one pulse off) was delivered to elicit ammocoetes to emerge from the substrate (Moser et al. 2007; Pajos and Weisse 1994). After emerging, ammocoetes were stunned with a current of 30 pulses per second for collection (Slade et al. 2003).

Besides the total number of lamprey observed (captured/missed), the following elements were generally recorded at each of the survey site: date, time, stream type (mainstem/tributary), channel type (main/side), flow conditions (high/medium/low), visibility (above and under water), gps location (latitude/longitude/ elevation), sample location (left/right/center), substrate composition (% detritus/clay/silt/fine sand/coarse sand/others), maximum sediment depth, habitat ratio (Type I/Type II), mean water depth, % cover (detritus/plant/algae/canopy), and water temperature. Furthermore, we measured the channel length of habitat we surveyed (electrofished) along the channel margins and the channel length of habitat that was available at each site within a 100m reach (50 m upstream and downstream from the center point of the survey). Surveying in 2m segments also allowed us to evaluate juvenile lamprey density at various spatial scales (2m/8m/overall). When any juvenile lamprey was present, we also recorded the species, life stage (ammocoete/transformer), length, and weight (not all sites). Finally, using the "Construct Points" function in ArcGIS 10 software and the stream shapefile available from StreamNet, Portland, OR (Hydrort_MSHv3), we created river kilometer points (0.1 km segments) in all of the survey streams from mouth to headwaters to standardize our way of identifying and labeling the survey sites.

Results

Presence/Absence, Distribution, and Relative Abundance

In 2012, 98 sites were officially surveyed using the electrofishing methods described above (Table 1, Figure 3). In addition, there were over 70 other sites that were surveyed quickly using an electrofisher or a fine-mesh hand net to simply evaluate prescence/absence of juvenile lamprey. Only quick assessment surveys were conducted in the White Salmon Subbasin due to lack of available ammocoete habitat that was accessible during the survey period between September 24, 2012 and September 26, 2012; no juvenile lamprey was captured or observed from these quick assessment surveys. More surveys were scheduled to be conducted in the mid reaches of the Wenatchee and Entiat subbasins, but due to a combination of factors (issues with rafting equipment, land access, etc.), we were not able to sample most of those sites during the short window of opportunity we had available (Figure 4).

Table 1. Summary of 2012 juvenile lamprey surveys by HUC4 watersheds. "Total juvenile lamprey observed" is the sum of "total juvenile lamprey captured" and "total juvenile lamprey missed" combined together. "Ratio of pacific lamprey" refers to the percent of Pacific lamprey among those that were captured and large enough to identify (>60mm). "Ratio of unknown (<60mm) lamprey" refers to the percent of captured unknown lamprey among those that were captured.

HUC4 Watersheds	# of Survey Sites	# of Quick Assessment Sites	Ratio of Survey Sites with Lamprey	Mean Juvenile Lamprey / Site (with Lamprey)	Total Juvenile Lamprey Captured	Total Juvenile Lamprey Missed	Total Juvenile Lamprey Observed	Total Pacific Lamprey Captured	Total Western Brook Lamprey Captured	Ratio of Pacific Lamprey	Total Unknown Lamprey Captured	Ratio of Unknown (<60mm) Lamprey
Lower Yakima	45	20+	53.3%	18.7	334	115	449	16	104	13.3%	214	64.1%
Upper Yakima	19	10+	73.7%	12.4	109	65	174	0	73	0.0%	36	33.0%
Naches	11	5+	45.5%	23.2	107	9	116	1	18	5.3%	88	82.2%
Wenatchee	18	10+	22.2%	25.3	80	21	101	36	0	100%	44	55.0%
Entiat	5	10+	60.0%	29.0	37	50	87	34	0	100%	3	8.1%
White Salmon	0	15+	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall	**98**	**70+**	**51.0%**	**18.5**	**667**	**260**	**927**	**87**	**195**	**30.9%**	**385**	**57.7%**

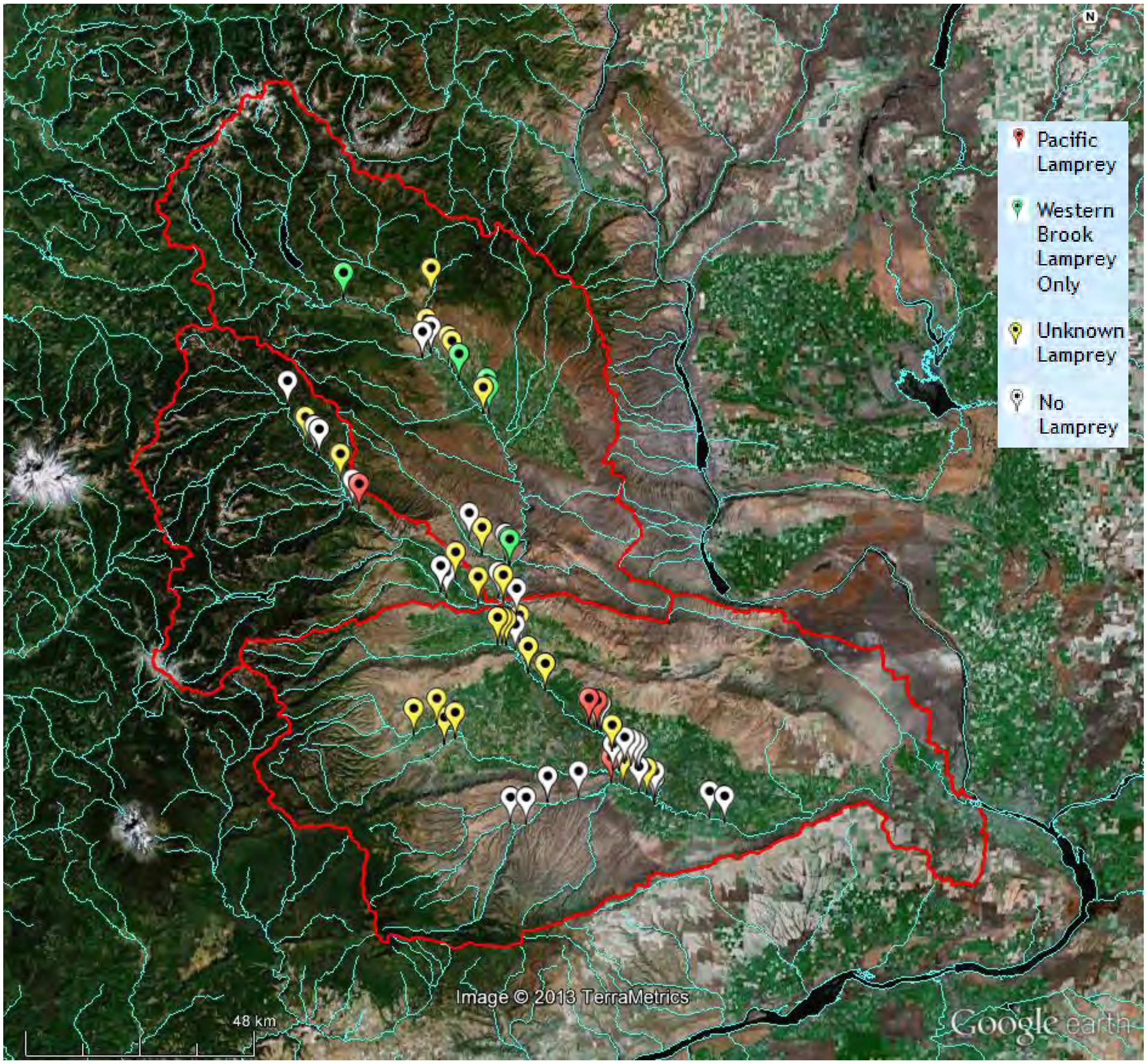

Figure 3. Juvenile lamprey survey sites within the Yakima Subbasin in 2012. As shown in the legend, red balloons indicate sites that had Pacific lamprey, green balloons indicate sites that had only Western brook lamprey, yellow balloons indicate sites that had no Pacific lamprey but included some lamprey that were unidentifiable (due to small size), and white balloons indicate sites that had no lamprey.

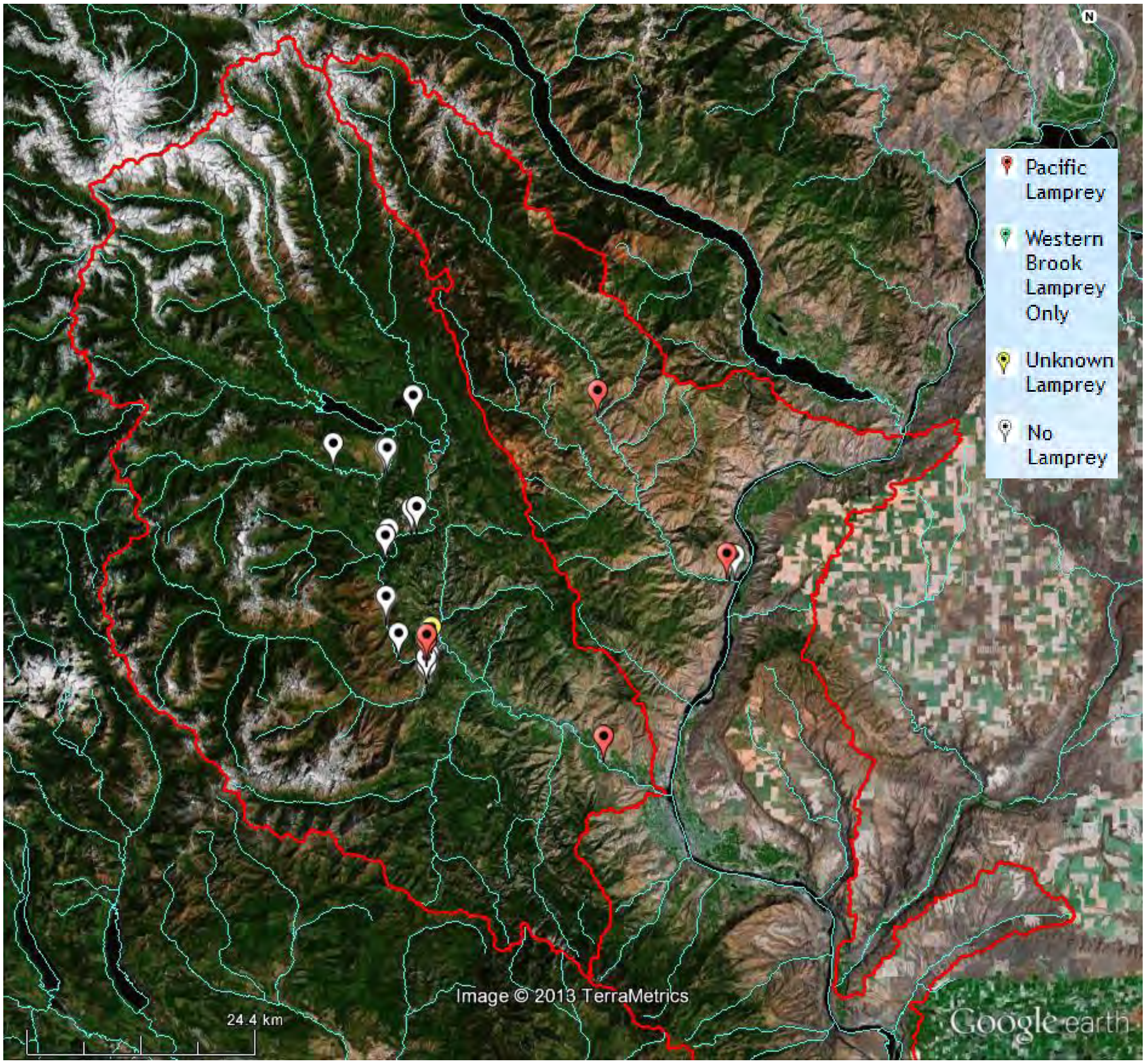

Figure 4. Juvenile lamprey survey sites within the Wenatchee and Entiat subbasins in 2012.

In 2012, juvenile Pacific lamprey were only found in the Lower Yakima, Naches, Wenatchee, and Entiat subbasins and the ratio of Pacific lamprey (vs. Western brook lamprey) were 13.3%, 5.3%, 100%, and 100%, respectfully. Although no juvenile Pacific lamprey were found in the Upper Yakima subbasin, Western brook lamprey was well distributed there (73.6% of sites had lamprey present). No juvenile Western brook lamprey was found in the Wenatchee and Entiat subbasins. The size of ammocoetes were noticeably smaller in the Lower Yakima and Naches subbasins; 64.1% and 82.2% of those captured, respectfully, were smaller than 60mm, which is the general size class for 0+, 1+, and some smaller 2+ aged ammocoetes. The ratio of smaller lamprey (<60mm) was much lower for the Lower Yakima and Entiat subbasins (33.0% and 8.1%, respectfully).

We found Pacific lamprey ammocoetes in the following rivers and streams: Yakima (Lower), Satus, Ahtanum, Naches, Wenatchee, and Entiat (Table 2). The ratio of Pacific lamprey vs. Western brook lamprey in these rivers/streams were 22.0%, 8.3%, 28.6%, 7.7%, 100%, and 100%, respectfully. We did not detect any juvenile lampreys in the lower reaches of the Yakima River until river km 137.6 (Figure 5). Western brook lamprey were extensively distributed in survey sites upstream from this point on, though there was some fluctuations in numbers from site to site. As for the distribution within the tributary streams, some streams had higher numbers of ammocoetes in the upper reaches, such as Toppenish Creek, whereas some streams only had higher numbers in the lower reaches, such as Satus, Ahtanum, and Wenas creeks (Figure 6).

Table 2. Summary of 2012 juvenile lamprey surveys by rivers/streams. "Ratio of Pacific Lamprey" refers to the percent of Pacific lamprey among those that were captured and large enough to identify (>60mm). "Ratio of Unknown (<60mm) Lamprey" refers to the percent of captured unknown lamprey among those that were captured.

HUC4 Watersheds	Stream Name	# of Survey Sites	River km of Lowermost Site with Lamprey	River km of Uppermost Site with Lamprey	Ratio of Survey Sites with Lamprey	Mean Juvenile Lamprey / Site (with Lamprey)	Total Pacific Lamprey Captured	Total Western Brook Lamprey Captured	Ratio of Pacific Lamprey	Total Unknown Lamprey Captured	Ratio of Unknown (<60mm) Lamprey
Lower Yakima	Yakima	22	137.6	191.8	54.5%	34.5	13	46	22.0%	104	63.8%
	Ahtanum	5	5.1	7.7	80.0%	24.0	2	5	28.6%	37	84.1%
	Logy	1	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
	Satus	10	2.9	12.9	30.0%	27.0	1	11	8.3%	26	68.4%
	Simcoe	2	9.0	15.3	100%	61.5	0	26	0%	34	56.7%
	Toppenish	5	56.9	59.9	60.0%	23.0	0	16	0%	13	44.8%
Naches	Naches	7	13.2	63.3	57.1%	33.0	1	12	7.7%	53	80.3%
	Cowiche	2	1.1	1.1	50.0%	91.0	0	6	0%	35	85.4%
	Little Naches	1	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
	NF Cowiche	1	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
Upper Yakima	Yakima	9	261.3	300.9	77.8%	29.9	0	49	0%	31	38.8%
	Recer	1	0.1	0.1	100%	7.0	0	2	0%	0	0%
	Swauk	1	11.7	11.7	100%	6.0	0	0	N/A	3	100%
	Taneum	1	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
	Wenas	5	0.5	13.9	60.0%	15.3	0	15	0%	2	11.8%
	Wilson	2	11.4	13.6	100%	6.5	0	7	0%	0	0%
Wenatchee	Wenatchee	12	8.9	41.0	33.3%	45.3	36	0	100%	44	55.0%
	Icicle	3	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
	Nason	3	N/A	N/A	0%	N/A	0	0	N/A	0	N/A
Entiat	Entiat	5	1.2	31.0	60.0%	41.3	34	0	100%	3	8.1%
Overall		**98**	**N/A**	**N/A**	**51.0%**	**10.5**	**87**	**195**	**30.9%**	**385**	**57.7%**

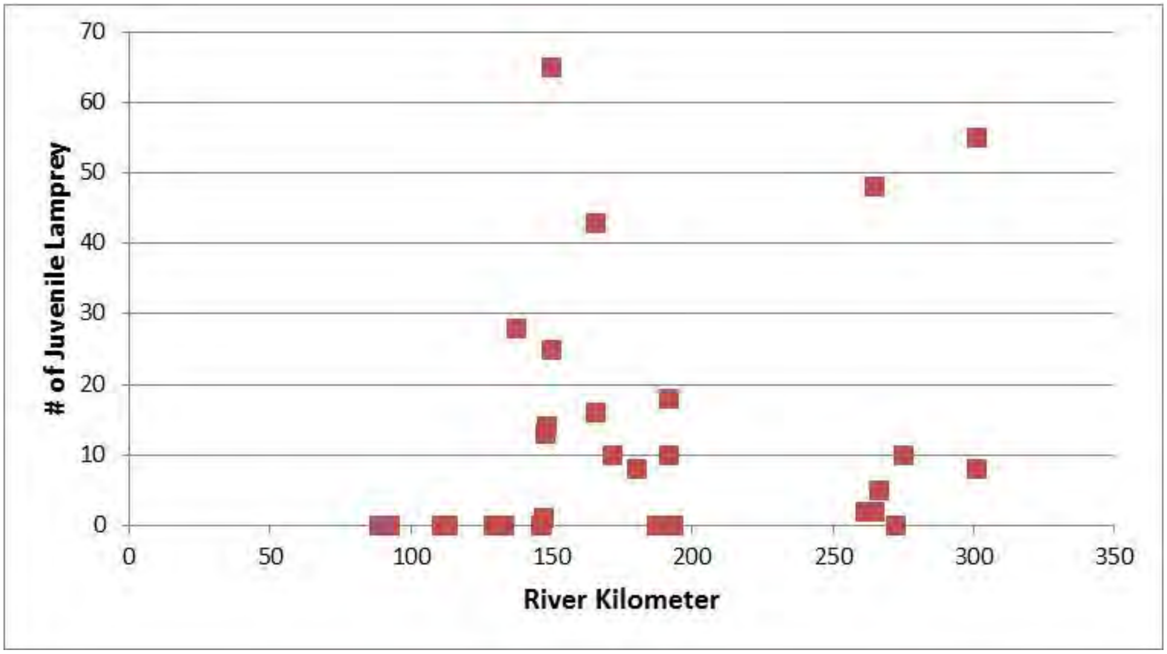

Figure 5. Number of lamprey ammocoetes observed by the river kilometer of the site for Yakima River.

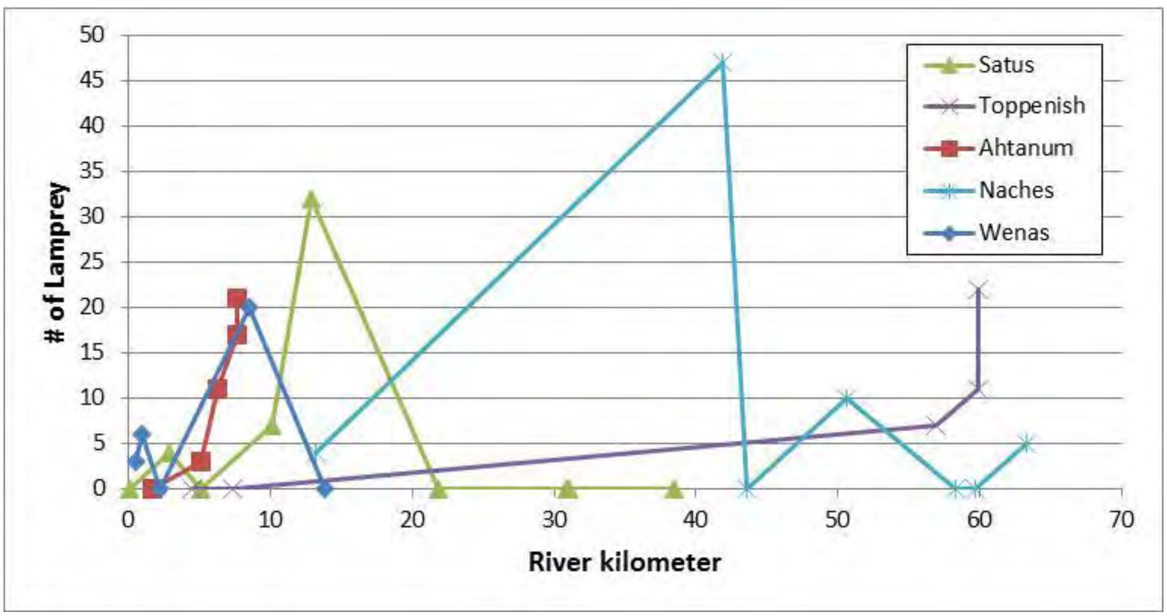

Figure 6. Number of lamprey observed by the river kilometer of the site for Satus, Toppenish, Ahtanum, Naches, and Wenas creeks. These streams contained a minimum of five survey sites.

Ammocoete Habitat Availability

Assessing habitat availability is a key component of any standard fish monitoring studies. For ammocoetes, the best known physical habitat feature we can easily monitor is the availability of fine substrate and organic matter, as defined by Type I, II, and III habitat (see methods section). In 2012, we monitored the availability of Type I (optimal) and II (acceptable) habitat at each of the survey sites (within a 100m reach) and also measured the channel length we electrofished to assess fish density at three spatial scales (Table 3). Mean length of Type I and II habitat was highest in Entiat and Wenatchee subbasins (60.2 m and 34.8m, respectfully) and was the lowest in Naches Subbasin (13.2m). The mean ratio of Type I habitat was roughly around 60 – 70% for most subbasins, except it was comparatively high in Wenatchee and Upper Yakima (90.9% and 73.2%, respectfully). On the other hand, mean ammocoete density within the site was highest in the Naches Subbasin (1.48 fish/m) and was comparatively lower in Upper Yakima, Entiat and Wenatchee subbasins (0.51 fish/m, 0.60 fish/m, and 0.64 fish/m, respectfully), displaying an inverse relationship with Type I habitat availability (Figure 7). Mean ammocoete density at the site and 8m scales were fairly similar to each other (except for the Entiat Subbasin), and mean ammocoete density at the 2m scale was generally twice as high as the density at the 8m scale.

Table 3. Summary of habitat availability and ammocoete density by HUC4 watersheds. Mean length of habitat was calculated within a 100 meter reach at each survey site. "Ratio of Type I Habitat" refers to the percent of Type I habitat within the overall Type I and II habitat. Mean density refers to ammocoete density per meter detected using electrofishing at various spatial scales.

HUC4 Watersheds	# of Survey Sites	Mean Length of Type I & II Habitat (m)	Mean Length of Type I Habitat (m)	Ratio of Type I Habitat	Site Mean Density (#/m)	8m Mean Density (#/m)	2m Mean Density (#/m)
Lower Yakima	45	25.5	17.8	69.6%	0.93	1.01	1.91
Upper Yakima	19	21.3	15.6	73.2%	0.51	0.49	1.08
Naches	11	13.2	8.2	61.6%	1.48	0.99	2.55
Wenatchee	18	34.8	31.7	90.9%	0.64	0.69	1.14
Entiat	5	60.2	36.6	60.8%	0.60	1.00	2.20
White Salmon	0	N/A	N/A	N/A	N/A	N/A	N/A
Overall	**98**	**26.8**	**19.8**	**73.8%**	**4.2**	**4.2**	**8.9**

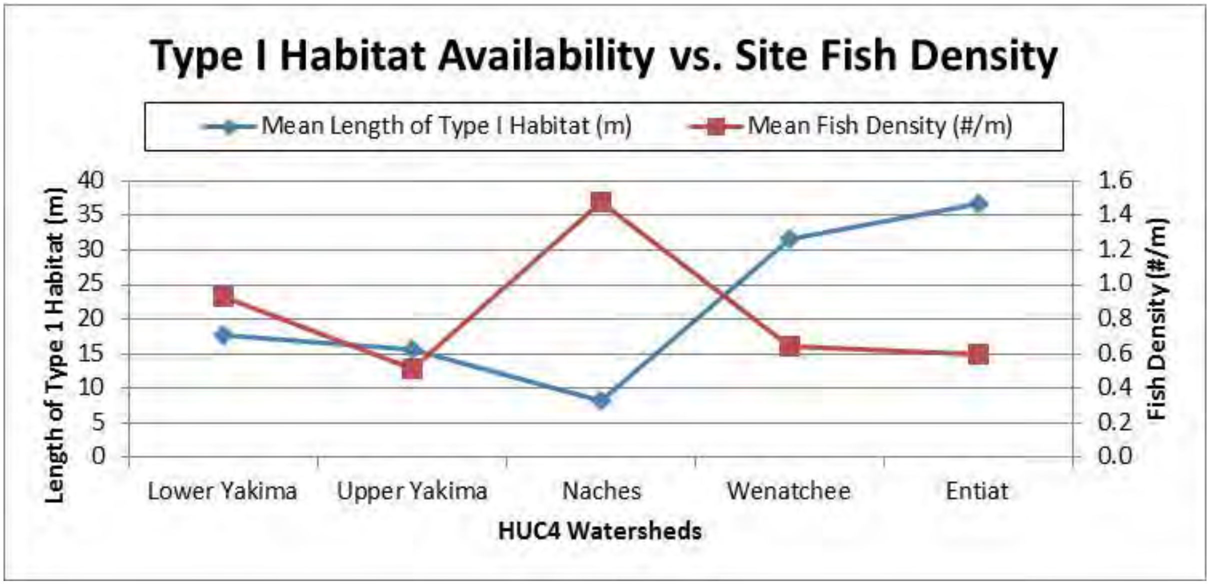

Figure 7. Relationship between Type I habitat availability and ammocoete density for the five subbasins that were surveyed in 2012.

Other habitat features worth noting include side channel availability and thalweg habitat. Many of the potential ammocoete habitat we surveyed was located in side channel habitat, and sites with lamprey also had an higher ratio of side channel habitat (Table 4). Approximately half of the sites with lamprey were located on side channel habitat. Although the proportion of thalweg habitat naturally available in the subbasins was not measured and remains unknown, we assume that riffle, glide, and pool habitat are more or less evenly available. However, the thalweg habitat of the ammocoete preferred (Type I and Type II) habitat was composed of mostly slow water habitat, including glide (39%), pool (37%), and glide/pool (18%) (Figure 8). Analysis of other habitat features (such as substrate composition, substrate depth, types of cover, and water temperature) are still ongoing at this stage, and data from all three survey years will be combined to improve the dataset and potential analysis.

Table 4. Ratio of side channel habitat compared to main channel habitat among the sites by HUC4 watersheds.

HUC4 Watersheds	Ratio of Side Channels (Overall)	Ratio of Side Channels (with Lamprey)
Lower Yakima	42.2%	50.0%
Upper Yakima	31.6%	42.9%
Naches	36.4%	60.0%
Wenatchee	55.6%	75.0%
Entiat	40.0%	33.3%
White Salmon	N/A	N/A
Overall	**41.8%**	**50.0%**

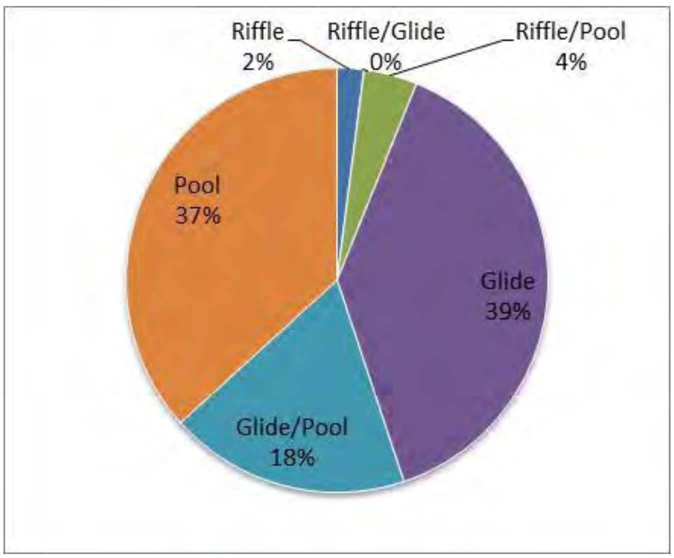

Figure 8. The proportion of thalweg habitat types among the sites with lamprey present in 2012. When ammocoete habitat extended beyond one type of thalweg habitat, we recorded the two types of habitat.

Establishment of Index Sites

Eighteen sites were recommended as potential index sites for long-term status and trend monitoring within the Yakima Subbasin (Table 5). Ten out of these eighteen sites were successfully surveyed in 2012. Index sites in other subbasins will be determined in 2014 based on past surveys and future planning. For more details on the index site monitoring, please see Appendix E2.

Table 5. Potential index sites for long-term status and trend monitoring

HUC4 Watersheds	River/Stream	River Kilometer	Location Description	Surveyed in 2012?
Lower Yakima	Yakima	86.0	Byron Ponds Bridge	No
Lower Yakima	Yakima	149.8	Zillah Bridge	Yes
Lower Yakima	Yakima	165.5	Wapto Bridge	Yes
Lower Yakima	Yakima	191.8	below Naches	Yes
Lower Yakima	Satus	12.8	Plank Rd.	Yes
Lower Yakima	Satus	21.8	Tule spur Rd.	Yes
Lower Yakima	Toppenish	44.6	Harrah Rd.	No
Lower Yakima	Toppenish	59.9	Shaker Church Rd.	Yes
Lower Yakima	Simcoe	10.0	Stephenson Rd.	No
Lower Yakima	Ahtanum	7.7	16th Ave.	Yes
Lower Yakima	Ahtanum	16.8	79th Ave.	No
Lower Yakima	Ahtanum	27.6	Carson Rd.	No
Naches	Naches	14.6	Eschbach Park	No
Naches	Naches	41.6	below Rattlesnake	Yes
Naches	Cowiche	5.6	W. Powerhouse Rd.	No
Upper Yakima	Yakima	242.4	above Cherry	No
Upper Yakima	Yakima	264.8	above Town Canal	Yes
Upper Yakima	Yakima	300.9	Cle Elum Bridge	Yes

Discussion

Presence/Absence, Distribution, and Relative Abundance

Summary of juvenile lamprey surveys from 2010 and 2011 are listed and shown below for comparison with the 2012 surveys (Table 6 and 7; Figure 9 and 10). In general, surveys conducted in 2010 and 2011 show the general same trend that the 2012 surveys demonstrated. One exception is that a few juvenile Pacific lamprey was found in the Upper Yakima Subbasin in 2010 at river km 195.2, which is located east of Union Gap, WA. This is the furthest upstream site where we have confirmed juvenile Pacific lamprey to date. No lamprey, adult nor juvenile, has been confirmed above Roza Dam in recent years. Another significant difference between the three years of surveys is that the percent of sites with lamprey present have increased steadily from 2010 to 2012 (21.4%, 39.8%, and 51.0%, respectfully). The mean counts of juveniles captured at sites with lamprey present have also increased steadily during this period (7.3, 10.6, 31.8, respectfully). This most likely reflects a couple things: 1) our lamprey team is gaining more experience in locating suitable lamprey habitat throughout the basin; and 2) the slight change in survey protocol (from a systematic design to a more focused design specifically targeting ammocoete habitat) have allowed us to search for suitable lamprey habitat more effectively.

Table 6. Summary of 2011 juvenile lamprey surveys by HUC4 Subbasins. "Total juvenile lamprey observed" is the sum of "total juvenile lamprey captured" and "total juvenile lamprey missed" combined together. "Ratio of pacific lamprey" refers to the percent of Pacific lamprey among those that were captured and large enough to identify (>60mm). "Ratio of unknown (<60mm) lamprey" refers to the percent of captured unknown lamprey among those that were captured.

HUC4 Watersheds	# of Survey Sites	# of Quick Assessment Sites	Ratio of Survey Sites with Lamprey	Mean Juvenile Lamprey / Site (with Lamprey)	Total Juvenile Lamprey Captured	Total Juvenile Lamprey Missed	Total Juvenile Lamprey Observed	Total Pacific Lamprey Captured	Total Western Brook Lamprey Captured	Ratio of Pacific Lamprey	Total Unknown Lamprey Captured	Ratio of Unknown (<60mm) Lamprey
Lower Yakima	27	5+	18.5%	3.2	14	2	16	0	9	0.0%	5	35.7%
Upper Yakima	66	10+	48.5%	10.1	291	31	322	0	251	0.0%	40	13.7%
Naches	4	5+	25.0%	5.0	5	0	5	0	0	N/A	5	100.0%
Klickitat	1	5+	100.0%	69.0	69	0	69	40	29	58%	0	0.0%
Overall	**98**	**25+**	**39.8%**	**10.6**	**379**	**33**	**412**	**40**	**289**	**12.2%**	**50**	**13.2%**

Table 7. Summary of 2010 juvenile lamprey surveys by HUC4 Subbasins. "Total juvenile lamprey observed" is the sum of "total juvenile lamprey captured" and "total juvenile lamprey

missed" combined together. "Ratio of pacific lamprey" refers to the percent of Pacific lamprey among those that were captured and large enough to identify (>60mm). "Ratio of unknown (<60mm) lamprey" refers to the percent of captured unknown lamprey among those that were captured.

HUC4 Watersheds	# of Survey Sites	# of Quick Assessment Sites	Ratio of Survey Sites with Lamprey	Mean Juvenile Lamprey / Site (with lamprey)	Total Juvenile Lamprey Captured	Total Juvenile Lamprey Missed	Total Juvenile Lamprey Observed	Total Pacific Lamprey Captured	Total Western Brook Lamprey Captured	Ratio of Pacific Lamprey	Total Unknown Lamprey Captured	Ratio of Unknown (<60mm) Lamprey
Lower Yakima	94	10+	22.3%	7.5	129	30	158	12	86	12.2%	31	24.0%
Upper Yakima	6	5+	33.3%	8.0	16	0	16	3	1	75.0%	12	75.0%
Naches	12	5+	8.3%	1.0	1	0	1	0	1	0.0%	0	0.0%
Overall	**112**	**20+**	**21.4%**	**7.3**	**146**	**30**	**175**	**15**	**88**	**14.6%**	**43**	**29.5%**

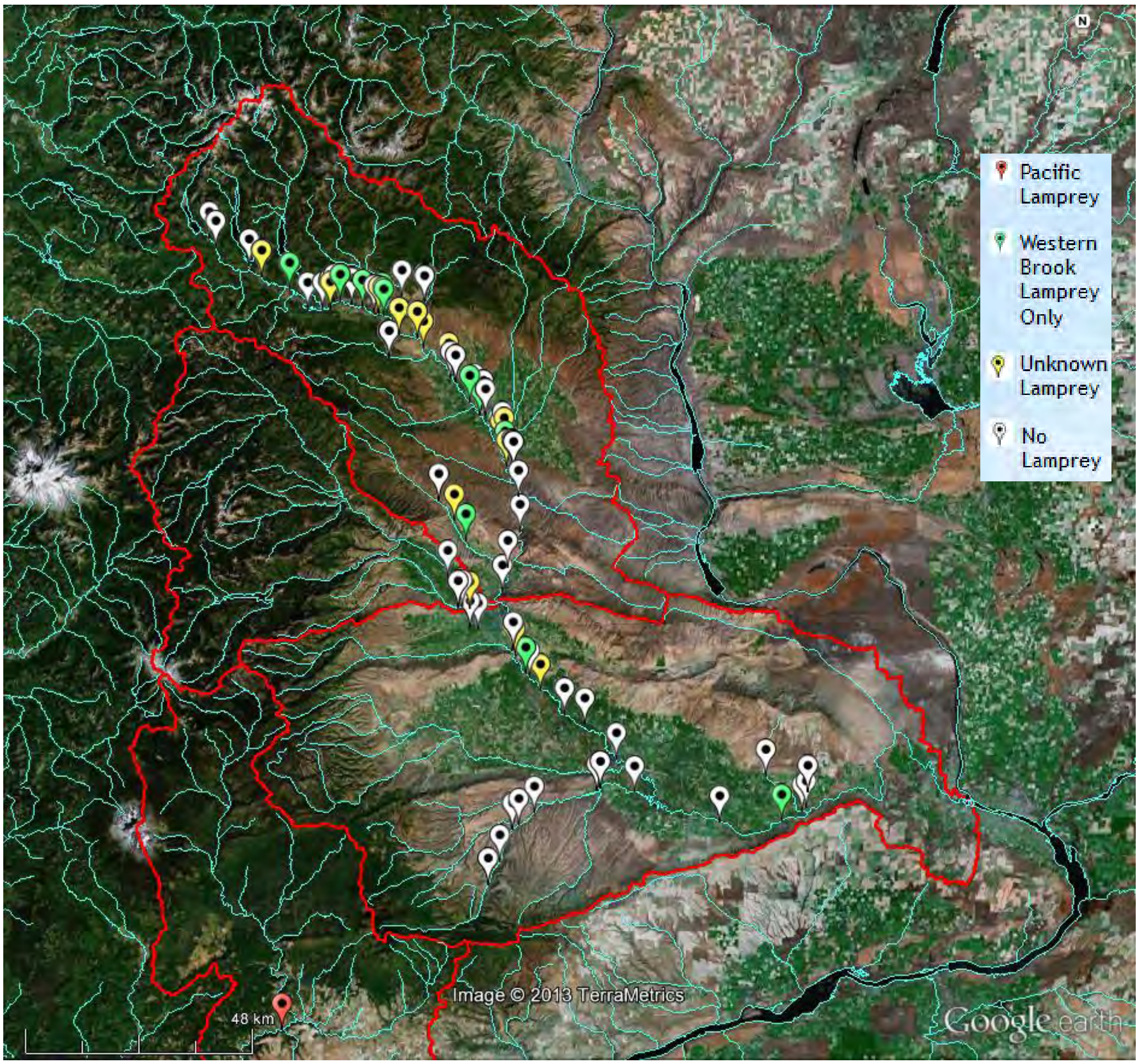

Figure 9. Juvenile lamprey survey sites within the Yakima and Klickitat subbasins in 2011.

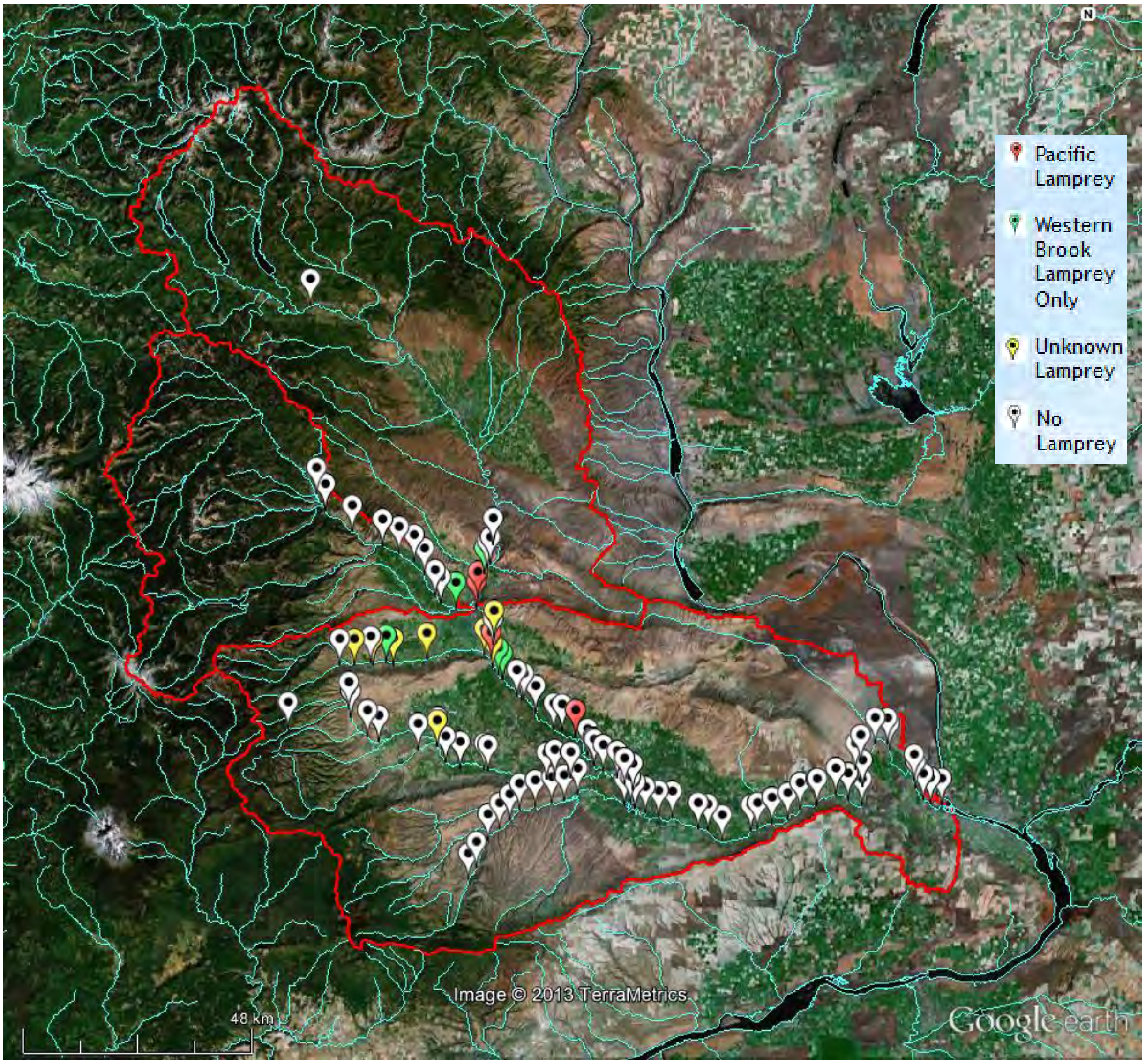

Figure 10. Juvenile lamprey survey sites within the Yakima Subbasin in 2010.

Ammocoete Habitat Availability

Two conference calls focusing on the juvenile lamprey monitoring protocols were set up on July 23, 2012 and January 29, 2013 to exchange ideas on how to best sample for ammocoetes in a standardized way across the region. The first conference call was organized by the Yakama Nation and included a wide range of participants (11+) from various entities, including USFWS, ODFW, Columbia River Intertribal Fisheries Commission (CRITFC), Confederated Tribes of the Warm Springs, and Confederated Tribes of the Umatilla Indian Reservation, the Cow Creek

Tribe, as well as private fisheries consulting companies. Listed below is the take home message from the first conference call:

1. Objectives
This really is the critical part and determines how we sample down the road. Most folks were interested in "presence/absence", and many also had "relative abundance" as the secondary goal. Some groups were past those stages and were interested in absolute abundance / population #s (Warm Springs Tribe, for instance). Some expressed hesitation for calculating absolute abundance because there are so many variables (habitat accessibility, habitat quality even within type I&2 habitat [preferred larval habitat with fines & organics], surveyor experience, flow conditions, etc.). In general, we agreed that "presence/absence" is something we can all do, and "relative abundance" is something within our reach that could be shared across basins especially if we coordinate well. Long-term status and trend is another important objective (although we didn't discuss this in detail).

2. Sampling Area
To the question on whether we should sample all areas or just the type 1&2 habitat, most expressed that it would be a waste of time to sample all areas (best to focus on just type 1&2 habitat), but we didn't hear as much input from those that think otherwise. Lanse (from OSU) wasn't able to call in, but he mentioned to me how they were able to collect many macrophthalmia in areas beside type 1&2 habitat, so if macrophthalmia sampling was part of the objective,sampling all areas may have some merit. For random sampling purposes, there may be some merit in sampling everything (but if we set a protocol that only type I&2 habitat will be sampled within the study reach, it shouldn't affect the validity of random sampling). Moreover, if the population level is low, chances are higher that they will be found in their preferred habitat. Because their distribution is highly patchy, it may be more relevant to look at their density at a finer scale (in their preferred habitat). For instance, for juvenile coho sampling, we normally only look in pools and glides, because we know that they hang out primarily in these specific habitats, and I think the disproportional nature is even more apparent for larval lamprey. (sorry this may sound more subjective, but I would like to hear all your points).

As far as how large the sampling area should be, most expressed that the type 1&2 habitat will vary widely depending on availability, size of stream, etc., and is probably not a good idea to set in concrete the size of sampling (1x1m, 1x7m, etc.). Finding the size that works best for each project may be the best way to go.

3. # of Passes
Abel shared data on their findings related to capture efficiency and # of passes - on average, 86% were captured on the 1st pass (rate of 60 sec / 1 m2). With more passes, capture efficiency improved, but the rate of improvement steadily decreased. Again, if absolute population was the objective, there may be a reason to conduct multiple passes, but otherwise time may be better spent checking other sites if you can get the majority of the fish in the 1st pass. I also feel that a 1st pass at a real slow pace will most likely have a higher capture efficiency compared to a 2-pass sampling that was conducted rather fast. Stewart mentioned how those that popped up but burrowed back again are extremely hard to recapture (because they are determined to hide), so the recapture efficiency for those will most likely stay low no matter what. Abel also

mentioned Christina's study that showed that there were distinct problems in depletion sampling for larval lamprey.

4. Basic Settings and Settings Modifications

Most everyone uses the AbP-2 backpack electrofisher, 3 pulses/sec [125 volts], 25% duty cycle [3:1 pulse train], 30 pulses/sec after lamprey emergence. Some said they increase the voltage in some areas (up to 250~300 volt) to ensure that the electrofisher is working adequately and the lamprey are really absent. In cold water conditions (<5 C), many said they change the settings: for example, 5 pulses/sec [150 volts], 10% duty cycle [2:1 pulse train], 30 pulses/sec after lamprey emergence (25% duty cycle). Stewart thought that this cold water setting may be effective not because of the setting itself but because of the change in electric signals. Chris mentioned that in Idaho winters, it was really hard to get the lampreys out of the sediment (maybe due to deeper burrowing?). Patrick mentioned that lots of larvae show up even during the winter months in dewatered canals, etc. Conductivity was another variable that may change capture efficiency. But if the capture efficiency is pretty high even in low conductivity streams (such as in the Deschutes), do we really need to be concerned about this (I'm just throwing this out there). I'm not saying that conductivity doesn't affect capture efficiency, but I'm just wondering does it need to be a core variable that everyone should measure. Burke O'Neal (ETS Electrofishing) 608-833-2088 is a great person to contact and discuss regarding the setting modifications.

5. Useful Variables to Measure

# of lamprey (& species if larger than >50mm), area sampled (although we need to clarify habitat quality here), and sampling time (CPUE) are good variables to measure regardless of objectives. Size of lamprey could also provide some clues as to the makeup of the year classes (recruitment success, etc.), with the understanding that size specific capture efficiencies may be at work as well. In general, the larger ones may escape better and smaller ones are harder to see & capture. Cyndi (from a conversation later) also mentioned that visibility (wind/shade or in water), and sediment depth appear to be significant variables and are worth recording.

Follow-Up Questions:

A. Should we set a rate of electro-fishing (1 m2 / 60 sec, for example)? I'm hesitant to set a e-fishing rate because I feel that you need to adjust your speed according to the given conditions (for example, if visibility was low, you will want to go slower to let turbidity go away), but would like to hear everyone's opinion. What's your take?

B. I would caution m2 (2-dimensional) density as a measure of population health because when there is limited habitat and lamprey are packed in there, it shows that the level is high (hence, give a false impression that population is healthy). How about using meter (1-dimensional) density, showing number per stream bank length? This way it shows the population level per given stream length and it should be comparable across basins (with the understanding that protocols may be slightly different among projects). We do need to clarify whether the stream bank was all type 1, 2, and/or 3 habitat to make this number more meaningful. Or is the CPUE a better index for relative abundance? Appreciate hearing your opinion.

C. Definition of type 1, 2, 3 habitat. If we are going to use these terms, we probably need to make the definition of these terms crystal clear for everyone (so it's not an abstract idea, but more practical to identify).

D. Could we use a one-pass capture number divided by the bank length (of type 1&2 habitat) as an index of fine-scale relative abundance that could be shared across basins? Why yes, or why not?

E. What's an effective way to conduct a long-term status and trend study for larval lamprey? (with a focus on minor details)

F. For presense/absence studies, how much area do we need to survey to say with higher confidence that they are absent (at least from the study reach)?

F. How do we answer the question of habitat availability for lavallamprey (especially at a larger scale)?

The second conference call was organized by Kelly Coates (The Cow Creek Tribe) and besides the tribal participation from CRITFC and YN, OSU and ODFW researchers from Corvallis, OR, were the primary participants in this meeting. Results from recent studies were shared and various ideas on sampling were exchanged. The main conclusion from this conference call again was that the methods we choose will have to be carefully orchestrated based on the goals and objectives of the study. However, there are many assumptions that are directly associated with the sampling protocol we choose, but these assumptions are rarely described. Listed below are some assumptions that I shared with the group:

Assumption 1: larval lamprey distribution is (very) patchy. As we all know, any species has its niche in habitat and they tend to congregate where this habitat is more readily available. For lamprey, we call this Type-I and Type-II habitat (Slade et al. 2003). Definition of Type-III is that they are not suitable for lamprey. For example, with juvenile coho we primarily survey in pools because that is where you find the vast majority of the population. With coho, you wouldn't want to compare the density in riffle with the density in pool. For the same reason, I don't think we can compare the density in a 100m reach UNLESS we qualify what the available habitat is (in terms of Type-I and Type-II). The density level at Type-II habitat is considered to be about 10% of Type-I habitat density from the Great Lakes research (and that's about right in my eyes for what I see in the field). Of course, a larger number of larvae can be in Type-II habitat, if this habitat is simply a lot more abundant and available.

Assumption 2: Larval lamprey habitat (both Type-I and Type-II habitat, but especially Type-I habitat) can be absent sometimes for several 100 meters and more. Of course, each stream is different, and some streams could have suitable habitat throughout the majority of the stream length. But there are many, many streams that won't have suitable habitat for extended length (see attachment 1). If we limit ourselves to intensive surveys in 100m reaches, I think there is a big chance that we will miss the high density areas. There may be one lamprey in a Type-III habitat, but is it worth our time to try to find that one lamprey, when there are infinitely more in the Type-I habitat (or at least higher chances of them being there, if minimally seeded).

Assumption 3: If we target the suitable habitat, we can get a better idea of whether they are fully seeded, partially seeded or absent with higher confidence. If they are not in the cream of the crop habitat, it's much less probable that any would be in the less suitable habitat. Of course, this all depends on the specific conditions - if there is only one tiny Type-I habitat available, they may not find it, but in general they seem pretty efficient in finding good habitat (as long as the stream is seeded).

Assumption 4: Electrofishing efficiency for larval lamprey is highly variable. Many studies have looked at efficiency and the results range anywhere from 10% to 99%. Lamprey behave differently from most fish, and it is virtually impossible to capture every single fish in an area (at least consistently). There are so many variables, from conductivity, temperature, abundance, wind speed, sediment depth, sampler variability, the list goes on. As suggested by the Warm Springs Tribe data, the efficiency seems to go up with each increase in passes, but the overall trend of "relative" abundance really doesn't seem to change whether it was a 45 sec or 360 sec (multiple passes) sampling (see attachment 2). If the difference between efficiency is 10% (85% vs. 95%), but the time it takes to do the electroshocking is 8 times more between 45 sec and 360 sec sampling, does it really make sense to require multiple passes (if relative abundance is our goal).

Assumption 5: Electrofishing efficiency varies depending on the rate of shocking. For lamprey, some may pop up immediately, and others don't pop up right away. We want to make sure we capture as much as we can in each pass, so we go very slow (90 sec / square meter is what we shoot for, but no less than 60 sec / square meter). We see a big difference depending on this rate. I believe a nice and slow rate of shocking would yield just as many larvae as a quickly operated sampling (say 20 sec/ square meter) of 3 passes. If you are going quicker, I think you'll see a lot more variability in what you capture as well as a higher detection of larger larvae.

Based on all these assumptions, if our goal is to understand the distribution and how much of its habitat is seeded in a large scale region, I would argue that it is better to focus on the suitable habitat (Type-I &Type-II) for shocking, and do a nice and slow one pass sampling to get relative abundance. Assessing the availability of Type-I & Type-II habitat within the sample site is critical in order to assess the level of seeding. When we skip Type-III habitat, we can still measure the amount of this habitat to get a sense of Type-I & Type-II availability. When we have over 1000km of streams/rivers that we are trying to assess the distribution and abundance, it is just not feasible to do any kind of intense monitoring in a limited area (especially when what we see in the limited area may not mean much in the large picture). If we don't find any larvae in the 1st pass, we could certainly bump up the voltage and do another pass to increase our confidence in the absent determination.

There are many interesting things we can learn from the 100m intense sampling and modeling, but if we really wanted to understand presence/absence, I think we need to shock the Type-I & Type-II habitat (and more of it) - that will give us a better answer (with highest confidence) rather than a random approach. This point is perfectly illustrated in Jason's paper (change in probability depending on larval #).

For our purpose (understanding large scale distribution and relative abundance), I would suggest these 3 measurements as a core data for larval sampling: total number of lamprey (by species and life stages with length measurement), sampled habitat area of Type-I and Type-II, and relative availability of suitable habitat (vs. non-suitable habitat) for the stream. Rate of electrofishing should be identified as well (I don't think we need to measure it each time, but need to describe the pace that we are aiming for). Of course, anyone can and should add additional measurements as desired, but everyone agreeing to contribute to these basic 3 measurements, I believe, could go a long way in understanding the lamprey status at a regional scale.

In summary, coordination among the tribal entities and other agencies has only began recently and there is no so-to-speak "silver bullet" for a standard juvenile lamprey sampling protocol, at least today. The Yakama Nation will continue to make a strong effort in trying to coordinate and gain cooperation among the various agencies and entities in finding a standardized sampling protocol that we can all share, so that all of our lamprey sampling efforts across the region can be integrated together.

Establishment of Index Sites

As we move forward with the strategies and actions outlined in the "Pacific Lamprey Yakima Subbasin Action Plan" to protect, conserve, and enhance Pacific lamprey populations within the Upper Columbia, it becomes all the more important to monitor the long-term status and trend of the existing populations. This type of monitoring in the long run will be able to showcase how well our restoration projects are contributing to the recovery of the species. In 2013, the potential list of sites will be narrowed down further to establish semi-permanent long-term monitoring sites. Other life stages will also be monitored as well. Outmigrating juveniles (ammocoetes and macrophthalmia) from screw traps located in Satus, Toppenish, and Ahtanum creeks will be monitored closely focusing on species and life stage identification and relative abundance in individual streams. Outmigrating juveniles (primarily macrophthalmia) from the Chandler Juvenile Fish Counting Facility in lower Yakima River will continue to be monitored closely, assessing basin-wide juvenile outmigration abundance. Adult counts at Prosser Dam and Roza Dam will continue into the future and adult trapping sites is scheduled to be set up at

Horn Rapids Dam in 2012 for the collection of local stock Pacific lamprey, which could also be used as an index site for adult abundance in the near future.

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Taneum Diversion

Date: October 15th and 16th 2012

Location: The Taneum Creek Diversion is located outside of Thorp off of Thorp Cemetery Rd.

Screens: Drum

Temp: 13.5°C

Above Screen Survey Dates (Total Days): 10/15, 10/16 (2)

Lamprey Total Above Screens (Total Observed): 47 (53)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	20	30	20	5	5	10

Total Survey Area (m²): 75

Mean Density (#/m²): .49

Below Screen Survey Dates (Total Days): 10/15, 10/16 (2)

Lamprey Total Below Screens (Total Observed): 10 (12)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	35	40	20	4	1	0

Total Survey Area (m²): 52

Mean Density (#/m²): .15

Observations:

The first area that was surveyed on the Taneum Diversion of was above the screens while the water was still high on October 15th. Here the only section that was surveyed was along the bank where the Eschocker could reach both above and below the screens with a total area of 4m. There were 4 lampreys found on this day and they were released into the Yakima River.

The next survey session was on October 16th and it began above the screens after the canal was dewatered. The sediment in this area was fine and coarse sand mixed with lots of woody debris and detritus along the screens and the further upstream you traveled cobble and gravel became spaced around about 6m up. In this area we captured 44 lampreys, 17 of which were stranded on top of the dry sand after the dewatering. All were still alive and was a mixture of ammocoetes and macropthalmia. There were also crawfish, water skippers, worms, sculpin and trout observed. One 4in trout and one 7in trout were captured and released into Taneum Creek.

The next area surveyed was below the screens after surveying above the screens. The area we surveyed was piles of sediment spaced around on top of the cement bottom and 9 lampreys were captured. The sediment here was a combination of fine and coarse sand mixed with detritus. The lamprey captured on October 16th was released into the Yakima River off of Old Hwy 10 outside of Thorp.

Figure 1: Overview of Taneum Diversion

Figure 2: Close up of Taneum Screens

Yakima-Tieton Diversion

Date: October 17th 2012
Location: Yakima-Tieton Diversion is located off of Highway 12 outside of Naches on the Tieton River
Screens: Drum with a wall screen with automated cleaning brush
Temp: 11.4°C

Above Screen Survey Dates (Total Days): 10/17 (1)
Lamprey Total Above Screens (Total Observed): 0 (0)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Total Survey Area (m²): 71
Mean Density (#/m²): .00

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens: N/A

Lamprey Total Above Screens: No Lamprey Found
Observations:

Only above the screens was sampled because there were no collections of sediments below the screens on the cement floor. The area that was sampled was along the bank in the more shallow water and was composed of thick clay, and fine and coarse sand with some large woody debris mixed in. The survey started at the screens and we worked our way upstream and more gravel and cobble became present to where there was no more sediment to sample. There were no lampreys found here as well as no other life seen.

Figure 3: Overview of Yakima-Tieton Diversion

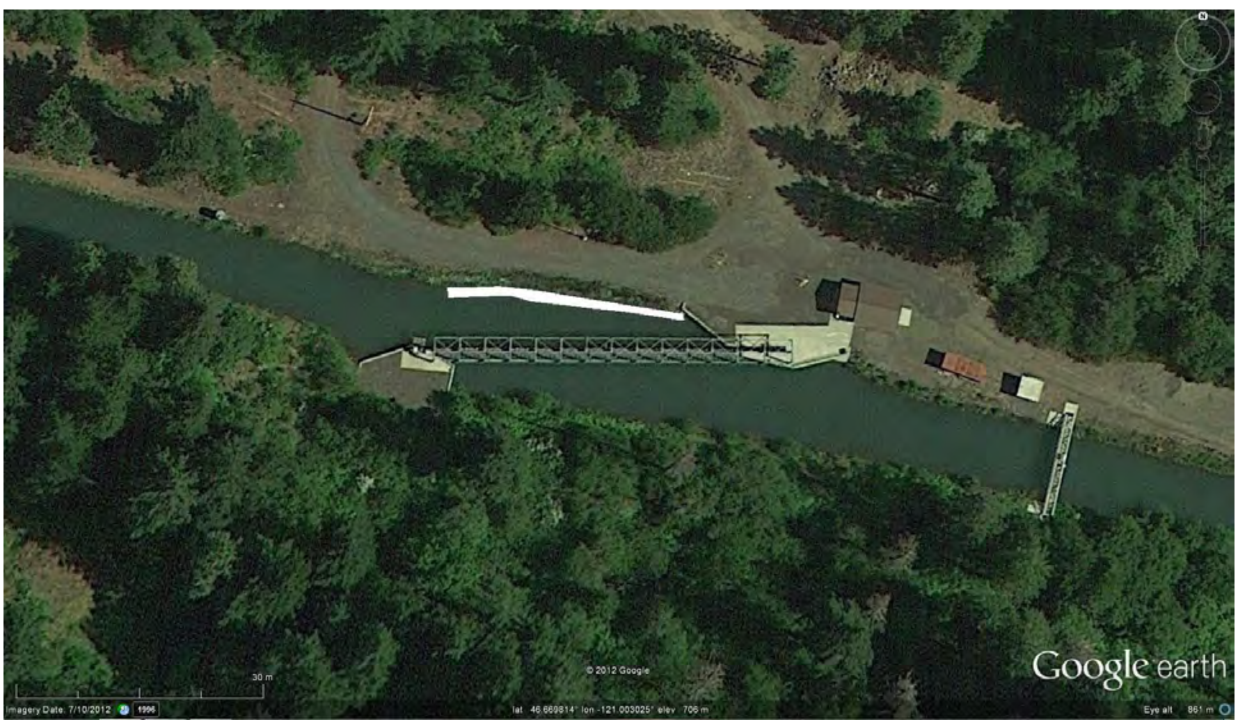


Figure 4: Close up of Yakima-Tieton Screens

Westside Diversion

Date: October 17th 2012
Location: Westside Diversion is located off of N. Thorp Rd. on the Yakima River
Screens: Drum
Temp: 10.8°C

Above Screen Survey Dates (Total Days): 10/17 (1)
Lamprey Total Above Screens (Total Observed): 3 (3)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	0	33	33	33	0	0

Total Survey Area (m²): 28
Mean Density (#/m²): .11

Below Screen Survey Dates (Total Days): 10/17 (1)
Lamprey Total Below Screens (Total Observed): 1 (4)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	0	0	100	0	0	0

Total Survey Area (m²): 89
Mean Density (#/m²): .01

Observations:

At this diversion, the first survey was conducted above the screens in the shallow areas nearest to the diversion because the further upstream you traveled the deeper the water got and we were unable to sample with the backpack Eshocker. In this area the sediment was composed mostly of fine sand with mixed with coarse sand along the banks and also had many long aquatic grasses growing out of it decreasing visibility. We found three lampreys before moving to the next sampling section

The next area that was sampled was below the screens starting where the cement ended. There was very little sediment that collected on the cement while the entire channel bottom past that point for 20yds was composed of fine and coarse sand mixed with silt, clay, long aquatic grasses, small and medium woody debris and small amounts of detritus. In this area there was only one lamprey found while small sculpin, crawdads, and stickleback fish were observed. The lampreys that were caught were released in the Yakima River below the diversion.

Figure 5: Overview of Westside Diversion

Figure 6: Close up of Westside Screens

Cowichee Diversion

Date: October 17th 2012
Location: Cowichee Diversion is located west of Yakima off of Highway 12
Screens: Drum
Temp: 11.2°C

Above Screen Survey Dates (Total Days): N/A
Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): 10/17 (1)
Lamprey Total Below Screens (Total Observed): 10 (15)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	20	50	30	0	0	0

Total Survey Area (m²): 11
Mean Density (#/m²): .94

Observations:

The only area that was sampled on the Cowiche Diversion was directly below the screens due to the lack of water and available habitat. In this area there was a small pool touching the screens and then about 2m away was a small puddle. The sediment was composed of clay and silt mixed with small amounts of cobble and gravel. There were at one time long aquatic grasses that were no dried up along the bottom of the thick mud. There were 10 lamprey found here and were released into the Naches River at the 16th St. Ext. outside of Yakima.

Figure 7: Overview of Cowiche Diversion

Figure 8: Close up of Cowiche Screens

Union Gap Diversion

Date: October 18th 2012
Location: The Union Gap Diversion is located behind Bureau of Reclamation office on Terrace Heights outside of Yakima
Screens: Drum
Temp: 11.6°C

Above Screen Survey Dates (Total Days): 10/18 (1)
Lamprey Total Above Screens (Total Observed): 217 (267)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	35	30	20	5	5	5

Total Survey Area (m²): 413
Mean Density (#/m²): .53

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observations:

The Area that was surveyed in this diversion was the channel above the screens. We started behind private property and walked .60miles down to the screens surveying the entire section. At the start area there was a deep pool with thick clay and silt mixture along the banks with cobble spaced around. This was where the only macropthamia were found through the survey while only a few ammocoetes were observed.

Walking further down the canal was more sediment made of thick clay and silt with long aquatic grasses that grew in and out of the water. Throughout the midsection of the canal there was no more cobble, and the grasses made visibility very poor to the point where we were unable to capture the entire lamprey that emerged from the sediment. This midsection was where most of the lamprey was found and a majority of them were below 40mm in length. Other fish that were observed included whitefish and other salmonids, sclupin, crawfish, and caddis flies. The area below the screens was composed of bare sediment so it was not surveyed due to lack of habitat. There were 217 lamprey captured and taken to Prosser for further study

Figure 9: Overview of Union Gap Diversion

Figure 10: Close up of Union Gap Screens

Kittitas-Easton

Date: October 23rd 2012
Location: Kittitas-Easton Diversion is located just outside the Easton along the Iron Horse Trail
Screens: Drum

Above Screen Survey Dates (Total Days): N/A
Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observations:

The diversion was accessible but there was no habitat to sample. The bottom of the cement floor was exposed with very little sediment spaced around in a thin layer. There was some large woody debris but no detritus below the screens. Above the screens there was gravel and cobble with a very small amount of coarse sand mixed in but no good depositional areas.

Figure 11: Overview of Kittitas-Easton Diversion

Figure 12: Close up of Kittitas-Easton Screens

New Cascade Diversion

Date: October 23rd 2012

Location: The New Cascade Diversion is located off of Old Hwy 10 outside of Ellensburg behind private property

Screens: Drum

Temp: 12.2°C

Above Screen Survey Dates (Total Days): 10/23 (1)

Lamprey Total Above Screens (Total Observed): 1 (3)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**100**	**0**	**0**	**0**	**0**	**0**

Total Survey Area (m^2): 29

Mean Density (#/m^2): .03

Below Screen Survey Dates (Total Days): 10/23 (1)

Lamprey Total Below Screens (Total Observed): 3 (4)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**0**	**0**	**100**	**0**	**0**	**0**

Total Survey Area (m^2): 39

Mean Density (#/m^2): .08

Observations:

The first area surveyed was below the screens where there was still water collected. In this area it was over the cement floor but there was some sediment that collected along the edge of the water. It was thick clay and silt mixture with long aquatic grasses growing out of it and only one lamprey was found here. There were many small trout and one salamander observed.

The next area that was surveyed was above the screens and the sediment here was composed of fine sand with a small amount of clay mixed in along with long aquatic grasses. The sediment here was raised above water level in the midsection of the cemented area before the screens and there were a variety of bird and small animal tracks in the mud. There were 3 lampreys found in this area and all lampreys were released at the Ringer Loop public fishing area outside of Ellensburg near the Yakima Canyon.

Figure 13: Overview of New Cascade Diversion

Figure 14: Close up of New Cascade Screens

Ellensburg Mill

Date: October 24th 2012

Location: The Ellensburg Mill diversion is located in Ellensburg and must travel though the granite company's property

Screens: Drum

Above Screen Survey Dates (Total Days): N/A
Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observations:

The gates were locked and there was no access to this diversion so no survey was conducted. While there we observed that the water was still high and long grasses were growing in and out of the water decreasing visibility.

Figure 15: Overview of Ellensburg Mill Diversion

Figure 16: Close up of Ellensburg Mill Screens

Lower WIP Diversion

Date: October 24th 2012
Location: Lower WIP Diversion is located off of 79th Ave. in Union Gap on Ahtanum Creek
Screens: Drum
Temp: 7.4°C

Above Screen Survey Dates (Total Days): 10/24 (1)
Lamprey Total Above Screens (Total Observed): 17 (21)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**30**	**40**	**10**	**10**	**10**	**0**

Total Survey Area (m²): 3
Mean Density (#/m²): 5.01

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observations:

The first area that was surveyed was above the screens. At this diversion there are two small drum screens so the sample area was only a 3mx2m section above them. The sediment was composed of thick silt and fine sand mixed with large, medium, and small woody debris and detritus. There were also long grasses and cattails growing out of the water that decreased visibility with their stalks. There were 17 ammocoetes found in this area and sculpin, crawfish, stickleback, and small trout were also observed. The lamprey was found in all areas above the screens but none were found below the screens. Below the screens the water was deeper and murky so visibility was very low. The sky had a cloudy overcast that created a glare on the water, the breeze created ripples, and there was no current to the mud took a while to settle and that all decreased visibility. All lampreys were taken to Prosser for further study.

Figure 17: Overview of Lower WIP Diversion

Figure 18: Close up of Lower WIP Screens

Upper WIP Diversion

Date: October 30th 2012
Location: The Upper WIP Diversion is located 1 mile up of the Museum off of Ahtanum Rd. oh Ahtanum Creek
Screens: Drum
Temp: 10.0°C
Above Screen Survey Dates (Total Days): 10/30 (1)
Lamprey Total Above Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): N/A
Mean Density (#/m²): N/A

Below Screen Survey Dates (Total Days): 10/30 (1)
Lamprey Total Below Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 30
Mean Density (#/m²): .00

Observations:

The Area that was sampled was located below the screens on the Upper WIP Diversion. While Eshocking, 2 dead lampreys were found on top of the silt, fine sand, woody debris, and detritus mixed sediment. There were also 50 sculpin and 30 crawfish observed during this survey. The screens were lifted up after the dewatering and the sediment depths were 36cm, 10cm, and 18cm.

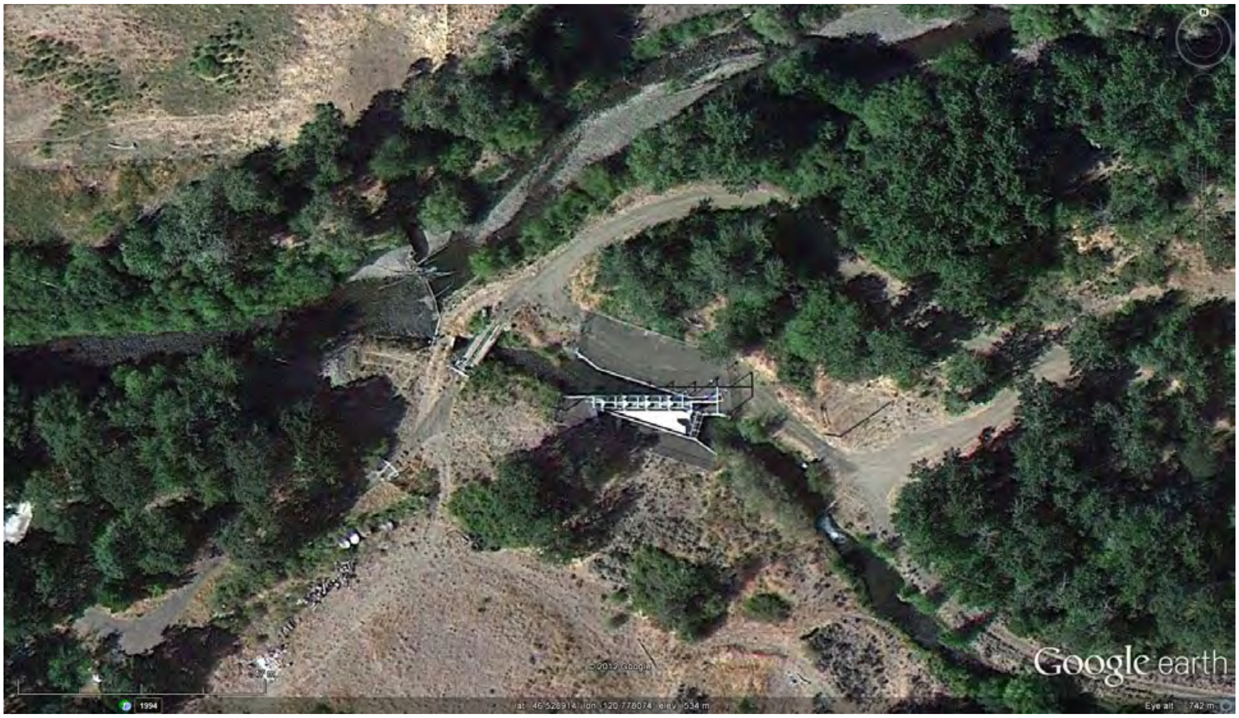


Figure 19: Overview of Upper WIP Diversion

Figure 20: Close up of Upper WIP Screens

Selah-Moxee Diversion

Date: October 24th 2012
Location: The Selah-Moxee Diversion is located outside of Selah in Pamona on the back side of Private Property at the end of Pamona Rd.
Screens: Drum
Temp: 11.3°C

Above Screen Survey Dates (Total Days): 10/24 (1)
Lamprey Total Above Screens (Total Observed): 29 (39)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**80**	**13**	**6**	**1**	**0**	**0**

Total Survey Area (m²): 261
Mean Density (#/m²): .11

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observations:

The only area that was surveyed was the section above the screens to the head gate. The area below the screens had no available habitat to survey and was composed of an armored channel. The sediment that was located above the screens was a mixture of fine sand and silt with long aquatic grasses growing out of it which decreased visibility. The entire section was also cement and the sediment thinned and eventually was no long along the bottom near the head gate. In the section where the sediment was raised above the water level there was a mixture of smells being emitted, such as plant decomposition, manure and other animal fecal matter. There were also some oil residues on top of the mud which could have been natural plant oils or pollution. There was also a variety of bird and small animal tracks imprinted into the mud.

There were 29 ammocoetes found above the screens along the midsection of the canal and all measured below 100mm. There were water skippers, small aquatic beetles, worms, and leeches observed in this area. The entire lampreys captured were taken to Prosser for further study.

Figure 21: Overview of Selah-Moxee Diversion

Figure 22: Close up of Selah-Moxee Screens

Chandler Diversion

Date: October 25th 2012
Location: The Chandler Diversion is located along side of the Prosser Salmon Hatchery in Prosser
Screens: Drum
Temp: 11.1°C

Above Screen Survey Dates (Total Days): 10/25 (1)
Lamprey Total Above Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 427
Mean Density (#/m²): .00

Below Screen Survey Dates (Total Days): 10/25 (1)
Lamprey Total Below Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 390
Mean Density (#/m²): .00

Observations:

The first day of surveying the diversion was the day of the fish salvage for Chinook and Coho Salmon. Our crew got clearance for the survey during the salvage before the canal was watered up again. The first area that was surveyed was above the screens between the screens and the trash racks. This diversion has not been dredge for a few years so the sediment build up was around 4ft at its deepest. The sediment was composed of coarse and fine sand mixed with small amounts of woody debris and detritus located against the screens and trash racks. The sediment top formed mounds and water had collected in the valleys creating small areas to survey along the midsection. The only places to survey other than that were directly in front of the trash racks and screens with an average width of 1m due to the lack of water flow. No lamprey were found above the screens but over 100 whitefish were seen stranded on top of the sand barely in the water and small juvenile salmon, stickleback, chisel mouth, channel and bullhead catfish, worms, and crawfish were also observed.

The next area of the diversion that we surveyed was below the screens. There wasn't nearly as much sediment behind the screens as there was above. The cement shelf that was built under the drums screens was exposed with no sediment on top. The water depth average 40cm in its deepest parts and was shallower along the sediment banks. The survey area was composed of coarse sand and fine sand mixed with small woody debris and detritus with cobble and gravel spaced around. There were many aquatic insects and large numbers of catfish observed but no lamprey were found.

Figure 23: Overview of Chandler Diversion

Figure 24: Close up of Chandler Screens

C-Town Diversion

Date: October 29th 2012

Location: C-Town Diversion is located off of Old Hwy 10 outside of Thorp

Screens: Drum

Above Screen Survey Dates (Total Days): N/A

Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): N/A

Lamprey Total Below Screens (Total Observed): N/A

Observations:

All gates were locked and we did not have a key so no survey was conducted at this diversion.

Figure 25: Overview of C-Town Diversion

Figure 26: Close up of C-Town Screens

Sunnyside Diversion

Date: October 29th, 30th, and 31st 2012
Location: Sunnyside Diversion is located off of Yakima Valley Hwy outside of Union Gap on the Yakima River
Screens: Drum
Temp: 14.0°C

Above Screen Survey Dates (Total Days): 10/30, 10/31 (2)
Lamprey Total Above Screens (Total Observed): 199 (235)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	40	30	20	10	0	0

Total Survey Area (m²): 393
Mean Density (#/m²): .50

Below Screen Survey Dates (Total Days): 10/29 (1)
Lamprey Total Below Screens (Total Observed): 357 (416)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	30	30	10	10	10	10

Total Survey Area (m²): 408
Mean Density (#/m²): .87

Observations:

The first area that was surveyed at the Sunnyside Diversion was located below the screens. The diversion had not been dredge before we started our survey so there were large mounds of coarse and fine sand that had collected throughout the year. Because of this, we were only able to survey along the screens where the water ran alongside the sediment banks. There was a total of 357 lamprey captured throughout the entire survey area and small juvenile fish were observed as well. There was a large area of exposed sediment that was raised above the water level and there were many bird and small animal tracks imprinted into it. There were also approximately 20 dried up dead lamprey found on top of the dry sediment that must have gotten stranded during the dewatering process.

The next area that was surveyed was above the screens. During this survey, we joined Joel Hubble's fish salvage crew assisting in capturing salmonids along with lamprey. The area that was surveyed above the screens was located along the screens, the trash racks, and part of the bank due to the available habitat. These areas were composed of fine and coarse sand mixed with high densities of woody debris and detritus. The majority of lamprey found here were macropthalmia and large ammocoetes. The midsections of the survey area were composed of large cobble mixed with small amounts of sand and gravel.

Most of the lampreys were taken to Prosser for further study while the lampreys captured on October 29th were released into the Yakima River in Zillah.


Figure 27: Overview of Sunnyside Diversion

Figure 28: Close up of Sunnyside Screens

Toppenish-Satus Diversion

Date: October 31st 2012
Location: The Toppenish-Satus Screens are located off of Hwy 22 just outside of Toppenish
Screens: Drum
Temp: 13.2°C

Above Screen Survey Dates (Total Days): N/A
Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): 10/31 (1)
Lamprey Total Below Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 119
Mean Density (#/m²): .00

Observations:

Only below the screens were sampled, above the screens was completely locked so there was no access and above the trash racks was stagnant water with very little sediment mixed with cobble along its armored bottom. Below the screens held the most habitat with many good depositional areas along the bank consisting of thick clay, silt, and fine sand. In most areas there were long aquatic grasses growing out of the sediment decreasing visibility. While there, a water pump was on and was lowering the water level decreasing the available habitat for the survey. No lampreys were found at this site but other life was observed including worms, leeches, beetles, skippers, stickleback, and spotted dace. Sediment samples were also taken and frozen at the Toppenish Fisheries office for further study.

Figure 29: Overview of Toppenish-Satus Diversion

Figure 30: Close up of Toppenish-Satus Screens

Unit 2 Feeder Diversion

Date: October 31st 2012
Location: The Unit 2 Feeder Diversion is located at the end of Harrah Rd. off of Fort Rd. outside of Toppenish
Screens: Drum
Temp: 14.1°C

Above Screen Survey Dates (Total Days): 10/31 (1)
Lamprey Total Above Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 16
Mean Density (#/m²): .00

Below Screen Survey Dates (Total Days): 10/31 (1)
Lamprey Total Below Screens (Total Observed): 0 (0)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	N/A	N/A	N/A	N/A	N/A	N/A

Total Survey Area (m²): 20
Mean Density (#/m²): .00

Observations:

Both above and below the screens was sampled but no lamprey were found. There seemed to be good depositional areas with thick clay, silt, and sand mixed with woody debris and detritus although the only fish observed were stickleback and small dead trout. There were also water skippers, crawfish, leeches, and small aquatic beetles seen. In the sample area there was a variety of garbage and also an oily substance in parts of the stagnant water.

Figure 31: Overview of Unit 2 Feeder Diversion

Figure 32: Close up of Unit 2 Feeder Screens

Roza Diversion

Date: October 30th and 31st 2012

Location: The Roza Dam is located in the Yakima Canyon outside of Selah on the Yakima River. We gained access with the help of Joel Hubble.

Screens: Drum

Average Temp: 10.4°C

Above Screen Survey Dates (Total Days): 10/30 (1)

Lamprey Total Above Screens (Total Observed): 98 (123)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	15	15	20	20	20	10

Total Survey Area (m²): 54

Mean Density (#/m²): 1.82

Below Screen Survey Dates (Total Days): 10/31 (1)

Lamprey Total Below Screens (Total Observed): 125 (155)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	10	10	25	50	3	2

Total Survey Area (m²): 400

Mean Density (#/m²): .31

Observations:

The first area that was sampled was above the screens on the upper most part of the diversion. This area had a very thin layer of sediment in all areas except directly in front of the screens. In that area there was sediment mounds with lots of woody debris and detritus and is where the entire lamprey was captured from. There were 98 lampreys captured in this area. There were also small trout, stickleback, and spotted dace observed as well.

The next area that was sampled was located below the screens and was composed of hard clay along the banks with soft clay and sand mixed with gravel and cobble along the midsection. The best depositional areas collected below the screens where the cement had ended leaving a drop off for sediment to settle. Here there was woody debris and detritus. Along the banks there were many animal tracks from birds and small animals and even a few dried up dead lamprey. There were small trout, stickleback, spotted dace, crawfish, skippers, and other small aquatic insects observed.

There was no sampling further downstream because the canal was made up of cement for 11 miles down. After that point the canal widens and is composed of an armored bottom of gravel, cobble, and boulders with very little sediment.

Joel Hubble, who works for the Bureau of Reclamation, runs two live boxes that are attached to Roza canal and collect fish during dewatering and are later released into the Yakima River. This year we checked both and found lamprey, one held 18 which were all either large ammocoetes or macropthalmia and were separated into a bucket for easy pickup. The second live box has not been cleaned out for the past couple years so there was sediment that collected along the bottom. We climbed into the box and sifted through the mud and found small, medium, and large sized ammocoetes along with macropthalmia with a total of 32 Lamprey.

ALL lampreys that were captured were taken to Prosser to the Hatchery for further study.

Figure 33: Overview of Roza Diversion

Figure 34: Close up of Roza Screens

Kelly-Lowery Diversion

Date: November 1st 2012
Location: Kelly-Lowery Diversion is located in Naches off of N. Naches Rd.
Screens: Drum

Above Screen Survey Dates (Total Days): N/A
Lamprey Total Above Screens (Total Observed): N/A

Below Screen Survey Dates (Total Days): N/A
Lamprey Total Below Screens (Total Observed): N/A

Observation:

We were unable to access this diversion at an earlier date due to the gate being locked and no key but when we finally did there was no water in the diversion. Because of the lack of water no survey was taken although there would have been a good depositional area. The thick mud consisted of clay, silt, and fine sand mixed with small amounts of detritus.

Figure 35: Overview of Kelly-Lower Diversion

Figure 36: Close up of Kelly-Lowery Screens

Wapatox Diversion

Date: November 1st and 5th 2012
Location: The Wapatox Diversion is located in Naches off of Hwy 12 and is supplied by the Naches River
Screens: Panel
Average Temp: 10.3°C

Above Screen Survey Dates (Total Days): 11/1 (1)
Lamprey Total Above Screens (Total Observed): 87 (107)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	40	20	30	5	5	0

Total Survey Area (m²): 77
Mean Density (#/m²): 1.13

Below Screen Survey Dates (Total Days): 11/5 (1)
Lamprey Total Below Screens (Total Observed): 52 (61)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	14	85	0	0	0	1

Total Survey Area (m²): 39
Mean Density (#/m²): 1.32

Observations:

This Diversion was only surveyed above and below the screens and not down the canal due to lack of sediment along its cement bottom. The first place that was sampled was above the screens and required a ladder for access. The sediment here was thick and composed of clay, silt, and fine sand with long aquatic grasses growing along the bottom. 87 lampreys were captured above screens and were taken to Prosser to the hatchery for further study. The next area that was sampled was below the screens. This area was composed of clay and fine sand and 52 lampreys were captured. After captured, data was collected, they the lamprey were released back into the diversion were they were found for further study. The lamprey that was found varied in sizes from 5mm-150mm, indicating different age groups.

Figure 37: Overview of Wapatox Diversion

Figure 38: Close up of Wapatox Screens

New Rez Diversion

Date: November 7th, 8th, 9th, 14th, 15th, 16th, 20th, and 28th 2012

Location: The New Rez Diversion, also known as Parker Diversion or Wapato diversion, is located Highway 97 just outside of Union Gap and is supplied by the Yakima River

Screens: Drum

Average Temp: 9.1°C

Above Screen Survey Dates (Total Days): 11/7, 11/8, 11/15, 11/16, 11/28 (5)

Lamprey Total Above Screens (Total Observed): +1118 (1514)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	50	10	15	10	10	5

Total Survey Area (m²): 3842

Mean Density (#/m²): .29

Below Screen Survey Dates (Total Days): 11/7, 11/14, 11/20, 11/28 (4)

Lamprey Total Below Screens (Total Observed): 66 (132)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	50	40	5	5	0	0

Total Survey Area (m²): 1616

Mean Density (#/m²): .04

Observations:

The diversion consisted of a mixture of gravel, cobble, fine and coarse sand, silt, and clay with small amounts of detritus and woody debris located near the screens (above and below) and above the trash racks toward the head gates. In some areas the sediment was thick and up to 3ft deep below water level while some areas the mounds were raised above creating islands. On the sediment mounds there were a variety of tracks from small animals and birds. There was also many small dried up dead lamprey in all areas with exposed sediments. Sediment samples were also taken and frozen at the fisheries office for further studies. In the canal there was also an oily residue located along the banks in the mud and on the water along with garbage consisting of tires, plastics, glass, cans, large metal bars and other house hold containers. Traveling down the canal there was significantly less sediment and gravel, cobble, boulders, and long aquatic grasses. There was other life observed including squawfish, carp, stickleback, spotted dace, whitefish, steelhead, sculpin, trout, crawfish, and many aquatic insects.

Many lamprey were found in this diversion ranging from above the screens past the trash racks to below the screens down the canal approximately 8 miles downstream including Westernbrook's and Pacific's ranging in sizes from 5mm-170mm indicating different age groups. There were many new born fish of this year seen and were unable to catch due to their small size because they would slip right through the net of there would be too many to catch at once. Out of the lamprey captured, some were taken and preserved while others were taken to Prosser to the hatchery for study, or were released into the Yakima River at the Zillah public fishing area in the Wapato Reach.

Figure 39: Overview of New Rez Diversion

Figure 40: Close up of New Rez Screens

Repeat Sampling of Juvenile Lamprey in New Rez Diversion (rkm 175.5) within Yakima Basin

Above Screens (Above Trash Racks) – Survey #1
Date: 11/8/12
Total # of Lamprey Captured (Total Observed): 182 (202)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	20	40	20	0	7	13

Total Area (m²): 228
Observation:

This survey area is located above the screens in the section between the trash racks and the cement weir. The start of the survey began at the trash racks and the crew worked their way upstream surveying along the bank in the available habitat. The sediment that was present was a combination of fine sand, coarse sand and detritus mixed with small and medium sized detritus. There was also a fair amount of garbage deposited inside the canal including used tires, plastics, metal, and empty liquid containers. The majority of the surveyed area was located along the east bank with some surveyable habitat located along the mid-section while the rest of the canal bottom was composed of gravel, cobble, and boulders creating armored sections. In the morning there was a strong wind that decreased visibility considerably (affecting detection) until it calmed in the afternoon. Lampreys were found throughout the entire section and all varied in size, indicating the presence of various age groups, including macropthalmia. There was other organisms present as well including sculpin, small aquatic beetles, caddisflies, crayfish, whitefish, suckers, and other small unknown larvae. There were also many small animal and bird tracks imprinted on the exposed sediment along the banks.

Figure 1: Overview of 11/8/12 Survey Above Screen

11/8/12: View of the canal bottom composed of gravel and cobble with sediment located along the bank. The Trash racks are pictured downstream.

11/8/12: Close up of the survey area, being sampled by Tyler Beals, located along the bank of the canal. The sandy bottom is mixed with detritus with small amounts of gravel spaced around.

11/8/12: Close up of the lampreys that were captured. The diversity in lengths indicate different ages of the lamprey.

__Above Screens (Above Trash Racks) – Survey #2__

Date: 11/16/12

Total # of Lamprey Captured (Total Observed): 118 (144)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	55	10	20	4	10	1

Total Area (m²): 75

Observation:

- Similar sediment content and water did not decrease to a noticeable level.
- The weather was more clear and visibility was higher than the previous survey
- Spent more time surveying around the cement weir then than the previous survey, then sampled along the bank near the trash racks, making sure to survey the areas that had high densities
- Found 4 macrothalmia lamprey
- Observed some large fish (possibly carp)

11/16/12: Overview of the cement weir and the collected sediment and woody debris in between the head gates and the trash racks above the screens.

11/16/12: Close up of the sediment near the cement weir which is a combination of fine sand, coarse sand, small woody debris and detritus. Glare on the water from the sun.

11/16/12: Close up of a Macropthalmia captured in the sediment below the weir.

Above Screens (Below Trash Racks) – Survey #1
Date: 11/7/12
Total # of Lamprey Captured(Total Observed): 254 (454)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	50	25	5	5	5	10

Total Area (m²): 1736
Observation:

This survey area was located above the screens behind the trash racks. Majority of this area was composed of thick sediment that was a combination of silt, fine sand, coarse sand and detritus. There was some small woody debris that collected along the bank and some gravel and cobble had collected along the mid-section in the deeper water of the canal. In the sediment located in the downstream end of the surveyed area there was also an oily substance that collected in small amounts around the bank. Located along the corners of the screens were small piles of silt and fine sand mixed with high amounts of detritus, leaves, and small/medium woody debris creating a small pile. The majority of the large fish that were captured with a length over 100mm were found in these sections along the screens. Lampreys with a length below 100mm were mostly found along the thick sediment banks. Located further onto the bank was a small secluded pool that was only a few inches in depth. When sampled, there were many lampreys that emerged from the mud and were in such high numbers that it was impossible to capture all of them. It was estimated that there may have been over 200 lampreys below the length of 40mm that were observed but missed. There were many small fish observed and also bird and small animal tracks imprinted in the muddy banks.

11/7/12: Close up of the area located above the screen while behind the trash racks. Sediment collects on top of the cement bottom.

11/7/12: View of the drum screens near the trash racks.

<u>Above Screens (Below Trash Racks) – Survey #2</u>
Date: 11/15/12
Total # of Lamprey Captured (Total Observed): +520 (+770)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**60**	**28**	**10**	**1**	**.5**	**.5**

Total Area (m²): 341
Observation:

- Similar sediment including silt, sand, cobble, and woody debris. Still had small piles of sediment that collected along the screens
- Did a walk-through survey but spent more time in the small areas that held the highest densities in the previous survey
- Visibility good, no wind but did have a small glare on the water from the sun at times
- Still lots of small fish present, although seen much larger suckers (over 1ft in length)
- Surveyed in the small secluded puddle again; it was smaller in length, width, and depth, being almost a meter by meter circle with a water depth of 1-2 inches. A significant increase of lamprey observed in this puddle (several 100s)
- 30 lamprey (17 ammocoetes picked at random) identified and released: 6.7% (2) identified as Pacific lamprey, 40% (12) identified as Western brook lamprey, and 53.3% (16) was too small to identify to species. 4 transformers (3 Western brook, 1 Pacific), 9 large ammocoetes (all Western brook), and 17 smaller ammocoetes (1 Pacific, 16 unknown)

11/15/12: View of the muddy bank at the water's edge with the drum screens in the background.

11/15/12: Close up view of the sediment located in the small secluded puddle where many lamprey were found.

11/15/12: This was what was found after sifting the mud depicted in the above photo. There are various sizes of lamprey, insects and small fish.

Above Screens (Below Trash Racks) – Survey #3

Date: 11/28/12

Total # of Lamprey Captured (Total Observed): 148 (168)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	30	10	30	20	5	5

Total Area (m²): 1462

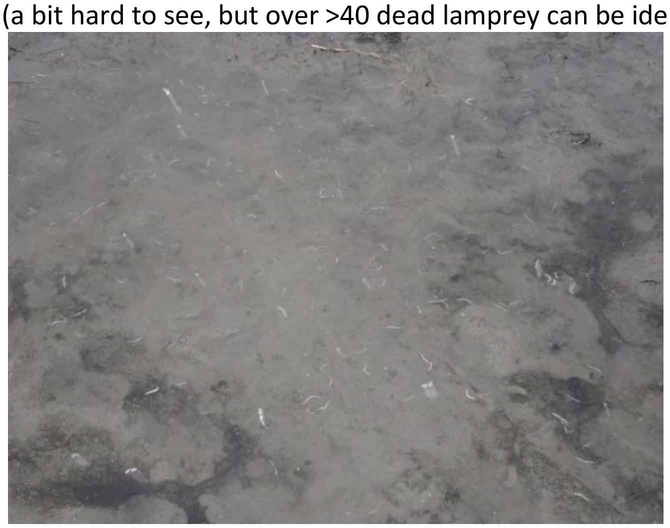
Observation:

- Similar sediment contents
- Surveyed areas that contained high densities of lamprey
- Spent time sampling the small secluded puddle that has shrunk more in size ranging from .5x.5m maybe with a depth of less than half an inch.
- Many dead lampreys (>50) were on the waters bottom in the puddle – mostly likely due to oxygen depletion. Photos were taken.
- Started to snow during the survey

11/28/12: View of the screens, trash racks, and muddy bank during the survey in snow.

11/28/12: View of the small secluded puddle.

11/28/12: Close up of the small secluded puddle showing the dead lamprey on the bottom of the water (a bit hard to see, but over >40 dead lamprey can be identified just in this photo).



<u>Below Screens – Survey #1</u>
Date: 11/7/12
Total # of Lamprey Captured (Total Observed): 37 (53)

Size Class (mm)	**0-40**	**41-70**	**71-95**	**96-110**	**111-135**	**>135**
%	**0**	**50**	**40**	**6**	**0**	**4**

Total Area (m²): 736
Observation:

- First survey below the screens, sediment similar to that above the screens but more gravel and cobble.
- Significantly less lamprey found below the screens compared to what is found above the screens.
- No photos found

<u>Below Screens – Survey #2</u>

Date: 11/20/12

Total # of Lamprey Captured (Total Observed): 28 (35)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	20	10	50	20	0	0

Total Area (m²): 422

Observation:

- Similar sediment as the previous survey, cold day
- Slightly less lamprey were found during this repeat survey
- A fike net was put below the diversion so the survey was from the net to the screens – no lamprey were found near the downstream net
- No photos found

<u>Below Screens (In Canal) – No Repeat Surveys</u>
Date: 11/14/12
Total # of Lamprey (Total Observed): 1 (1)

Size Class (mm)	0-40	41-70	71-95	96-110	111-135	>135
%	0	0	100	0	0	0

Total Area (m^2): 458
Observation:

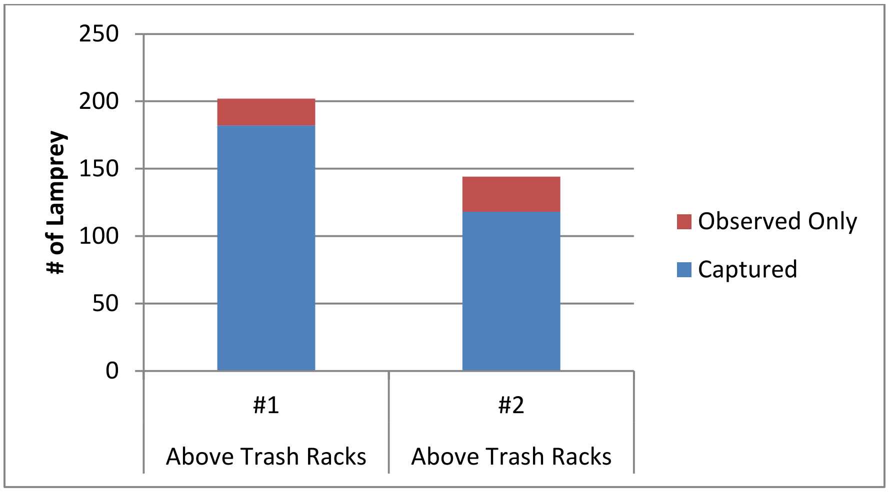
- Surveyed 4 places below the screens in the canal
- Mostly armored bottom, some sediment found, mostly contained fine and coarse sand with no woody debris
- Only one lamprey found approx. 8 miles downstream from the screens

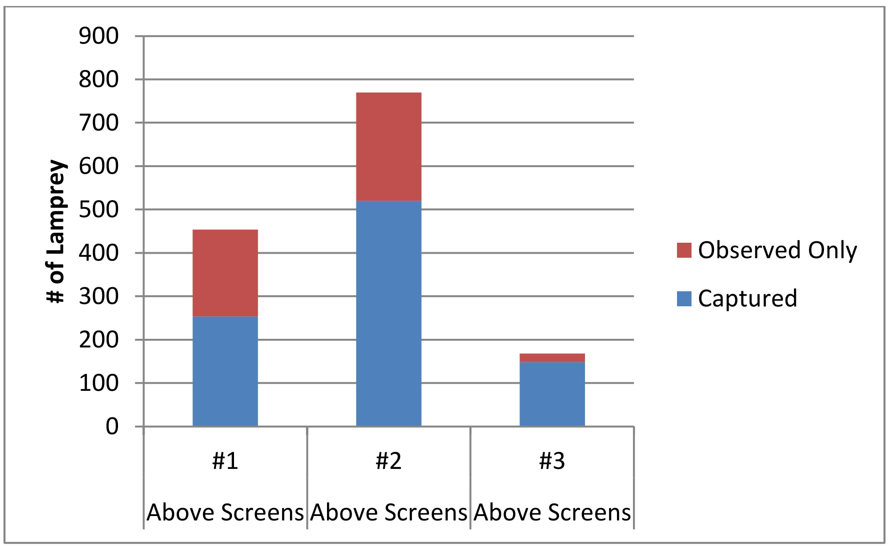
11/14/12: The dried up canal bottom is exclusively fine sediment in some places.

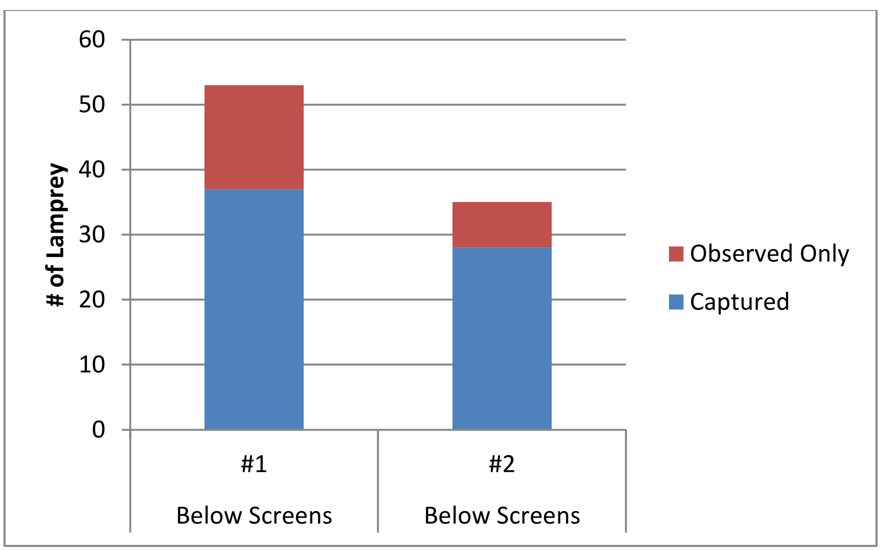
11/14/12: Some areas hold more water, providing a potential habitat for overwintering lamprey larvae

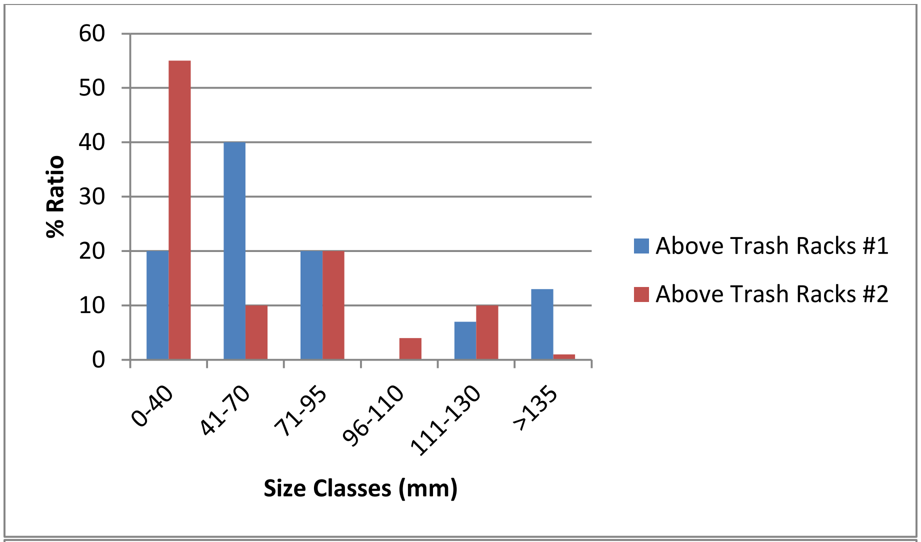
11/14/12: Photo of the one and only captured lamprey larvae in the canal further past the screens.

Summary Graphs:

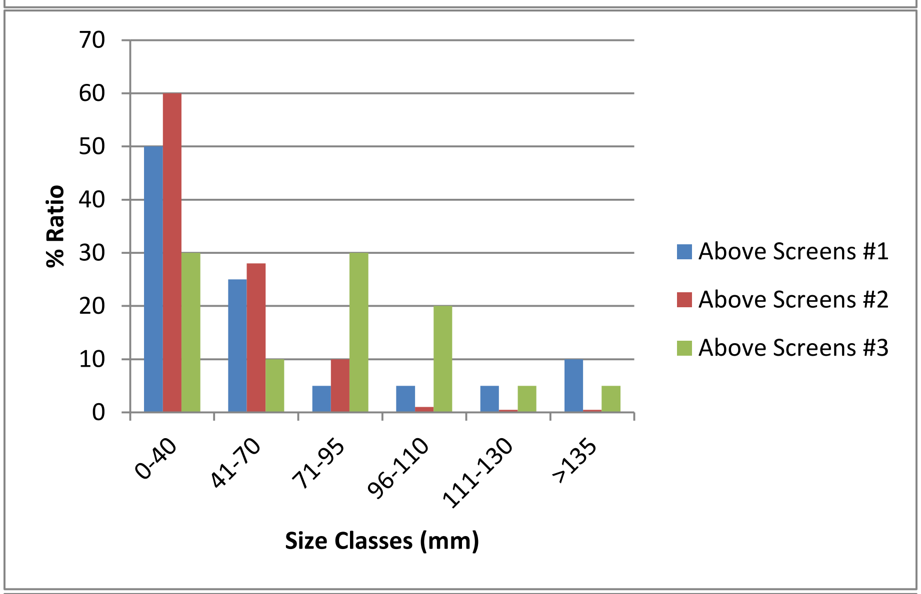




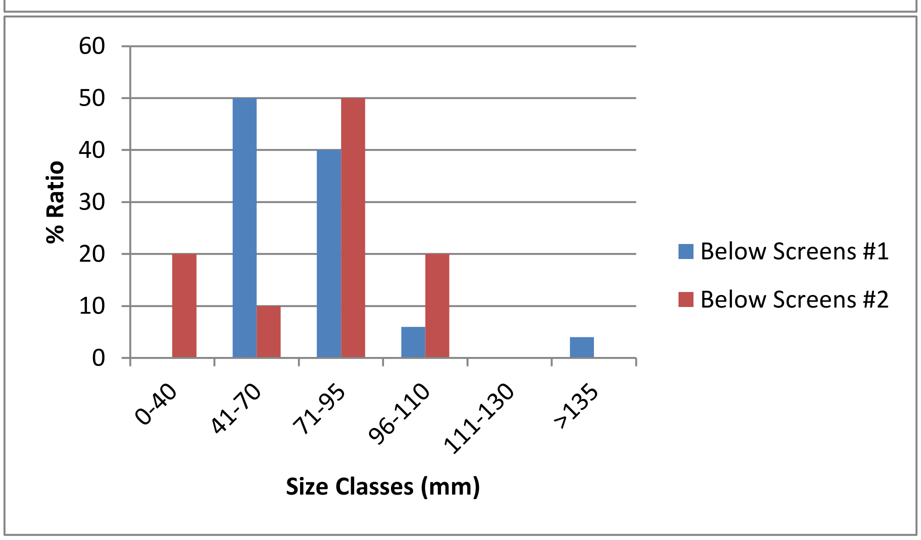




60
50
40
30
20
10
0
% Ratio
0-40
41-70
71-95
96-110
111-130
>135
Size Classes (mm)
Above Trash Racks #1
Above Trash Racks #2



70
60
50
40
30
20
10
0
% Ratio
0-40
41-70
71-95
96-110
111-130
>135
Size Classes (mm)
Above Screens #1
Above Screens #2
Above Screens #3



60
50
40
30
20
10
0
% Ratio
0-40
41-70
71-95
96-110
111-130
>135
Size Classes (mm)
Below Screens #1
Below Screens #2