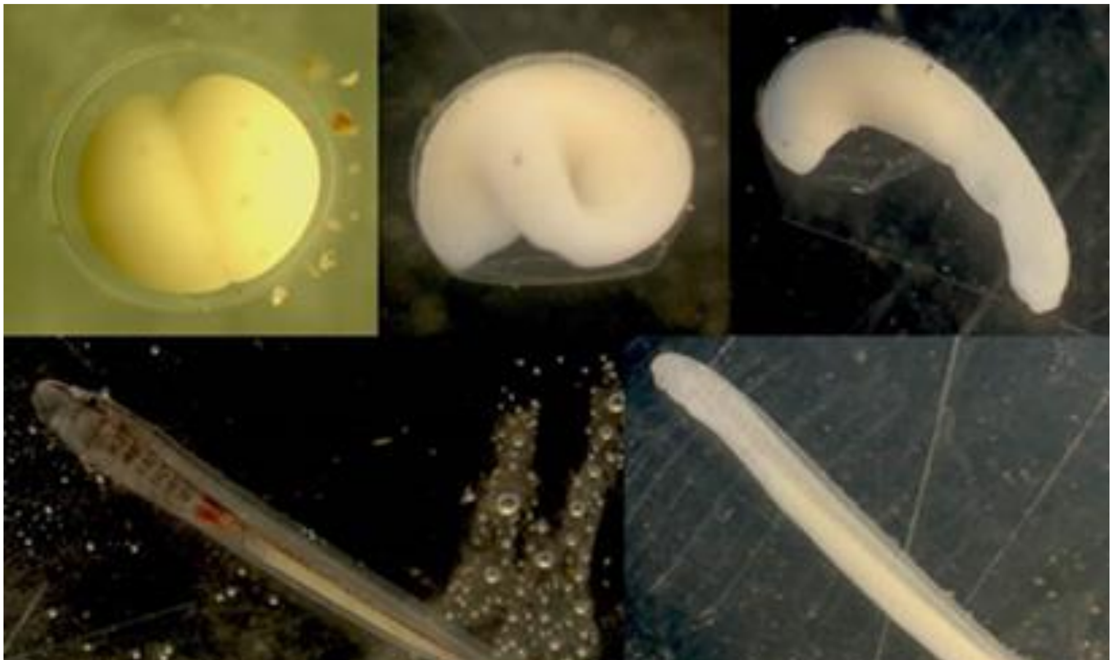

# Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research

## Conceptual phase to address Step 1 – Master Plan review elements


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# Preface

The Columbia River Tribal Fish Commission (CRITFC), the Confederated Tribes and Bands of the Yakama Nation (YN), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), and the Nez Perce Tribe (NPT) prepared this Master Plan to conceptually address Step 1 review elements of the Northwest Power and Conservation Council's review requirements for artificial propagation projects involving new construction and/or programs that will produce fish for reintroduction. This plan describes ongoing and proposed adult translocation and artificial propagation activities, as well as existing and proposed facilities needed to meet artificial propagation objectives. The plan focuses on activities of the YN and the CTUIR; however, to provide a comprehensive description of supplementation activities in the Columbia River Basin, the plan also describes ongoing adult translocation activities being conducted by the NPT. Actions described herein will work together and provide synergy with other actions such as improvements to passage, habitat, and water quality to help meet restoration goals for Pacific Lamprey in the Columbia River Basin.

# Acknowledgements

This plan was completed with funding from the Bonneville Power Administration (Project Nos. 2008-52-400 (CRITFC), 2008-47-000 (YN), and 1994-026-00 (CTUIR)) under the 2008 Columbia River Fish Accords. The Nez Perce Tribe (NPT) provided support from their non-accord Pacific Lamprey Translocation and Assessment Project.

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# Glossary

| | |
|---|---|
| Aquaculture | Characteristically defined as intensive (providing feed) or extensive (relying on natural feed), rearing of fish for a time period beyond artificial propagation. Used herein as a more general term encompassing both the fertilization and rearing stages; used somewhat interchangeably with artificial propagation. |
| Artificial Propagation | Characteristically defined as the creation of new life by means other than the natural ones available to an organism. Although sometimes strictly defined in fisheries as hand stripping gametes and fertilization (excluding rearing), It is used herein as a more general term encompassing both the fertilization and rearing stages; used somewhat interchangeably with aquaculture. |
| Artificial Propagation Research | Assessment that includes evaluation of hatchery techniques but may also include evaluation of releases of artificially propagated fish. |
| Juvenile | Used herein to describe the newly metamorphosed macrophthalmia life stage |
| Larva/larvae | Used herein to describe the ammocoete life stage |
| Outplanting | Releases of artificially propagated fish into the natural environment. |
| Panmictic | A population in which all individuals are potential partners. This assumes that there are no mating restrictions, neither genetic nor behavioral, upon the population, and that therefore all recombination is possible. |
| Polyandrous | Having more than one male mate at one time |
| Polygynous | Having more than one female mate at one time |
| Prolarvae | The life stage between embryo and larva (prior to first feeding stage with dependence on yolk sac absorption) |
| Supplementation | Putting fish in locations where existing or remnant population segments exist to increase numbers. Used herein as a general term that includes the release of both translocated adults and artificially propagated larvae and juveniles. |
| Translocation | Collection of adult Pacific Lamprey from one location and transported for release into a different location further upstream. |

# Acronyms

| | |
|---|---|
| BPA | Bonneville Power Administration |
| CRB | Columbia River Basin |
| CRITFC | Columbia River Inter-Tribal Fish Commission |
| CTUIR | Confederated Tribes of the Umatilla Indian Reservation |
| CTWSRO | Confederated Tribes of the Warm Springs Reservation of Oregon |
| EA | Environmental Assessment |
| ESA | Endangered Species Act |
| HGMP | Hatchery Genetic Management Plan |
| ISRP | Independent Science Review Panel |
| ITPLRP | Implement the Tribal Pacific Lamprey Restoration Plan |
| km | kilometers |
| NEPA | National Environmental Policy Act |
| NPCC | Northwest Power and Conservation Program |
| NPT | Nez Perce Tribe |
| PIT | Passive integrated transponder |
| PLRRP | Pacific Lamprey Research and Restoration Project |
| RKM | river kilometers |
| TPLRP | Tribal Pacific Lamprey Restoration Plan |
| USACE | U.S. Army Corps of Engineers |
| USBR | U.S. Bureau of Reclamation |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| WDFW | Washington Department of Fish and Wildlife |
| YN | Confederated Tribes and Bands of the Yakama Nation |
| YNPLP | Yakama Nation Pacific Lamprey Project |
| YOY | Young of Year |

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# 1 Summary

Pacific Lamprey (*Entosphenus tridentatus*) return to the Columbia River Basin (CRB) at a fraction of their historical numbers due to a variety of known and unknown threats. The CRB Tribes and other regional partners aim to have Pacific Lamprey widely distributed within the CRB in numbers that fully provide for ecological, tribal cultural and harvest values. Through various regional and tribal efforts, the goals are to reestablish Pacific Lamprey as a fundamental component of the ecosystem and restore Pacific Lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas. Though much work has been completed over the past 18 years, many critical uncertainties remain regarding Pacific Lamprey restoration. Regional entities have indicated that supplementation related activities may be an important component in active lamprey restoration as well as in the evaluation of existing and emerging limiting factors (CRITFC 2011; Luzier et al. 2011).

A Synthesis of Threats, Critical Uncertainties, and Limiting Factors in Relation to Past, Present, and Future Priority Restoration Actions for Pacific Lamprey in the Columbia River Basin (Synthesis; CRITFC 2017a) was recently prepared by the Columbia River Inter-Tribal Fish Commission (CRITFC) that includes, among other things, an overview of Pacific Lamprey in the CRB and a summary of existing Columbia River Basin guiding documents and efforts for Pacific Lamprey restoration.

The Synthesis and other regional assessment and planning documents support an evaluation of the feasibility of using supplementation to help restore Pacific Lamprey in the CRB. Pacific Lamprey supplementation is defined within this document as putting fish, either by adult translocation or the release of artificially propagated and reared larvae and juveniles, in locations where existing or remnant population segments exist to contribute to restoration efforts. The Columbia River Treaty Tribes developed the Tribal Pacific Lamprey Restoration Plan (TPLRP) for the restoration of Pacific Lamprey in the basin to numbers adequate for the basin's ecological health and tribal cultural use (CRITFC 2011). The TPLRP emphasizes actively and carefully developing a regional supplementation/augmentation approach including translocation and artificial propagation protocols, while concurrently developing pilot artificial propagation facilities. The Assessment and Template for Conservation Measures developed by the U.S. Fish and Wildlife Service (USFWS) (Assessment; Luzier et al. 2011) identifies critical uncertainties regarding Pacific Lamprey life history and improves the scientific understanding regarding the regional status of Pacific Lamprey. The Assessment acknowledges and values efforts to pursue critical knowledge gaps, such as critical uncertainties for Pacific Lamprey in the CRB (CRBLTWG 2005), which included a recommendation to develop, implement, and monitor reintroduction methods (e.g., transplantation, hatchery production). The USFWS developed the Conservation Agreement for Pacific Lamprey (USFWS 2012) to represent a cooperative effort among natural resource agencies and Tribes to reduce threats to Pacific Lamprey and improve habitats and population status. The Lamprey Conservation Agreement (LCA) recognizes the need to implement artificial propagation and translocation experiments to develop methods and strategies for reintroducing Pacific Lamprey to extirpated areas and advancing Pacific Lamprey conservation. The 2014 Columbia Basin Fish and Wildlife Program (Program) developed by the Northwest Power and Conservation Council (NPCC 2014) includes a section specific to lamprey, including guidelines for supplementation, including translocation and propagation.

Consistent with regional recommendations, this Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research (Master Plan) was prepared to describe a plan for Pacific

Lamprey artificial propagation, translocation, restoration, and research designed to make progress towards supplementation and aquaculture research goals and biological objectives. The overall goal of this document is to evaluate the feasibility of using artificial propagation and translocation techniques to better understand and ultimately restore Pacific Lamprey throughout its range, with particular emphasis on the CRB population segment.

Currently, three Bonneville Power Administration (BPA)-funded Columbia Basin Fish Accord (Accord) projects, and one non-Accord, non-BPA funded project deal directly or indirectly with Pacific Lamprey artificial propagation, translocation, restoration, and research activities. The three Accord projects are the Yakama Nation Ceded Lands Lamprey Evaluation and Restoration Project (2008-470-00; Confederated Tribes and Bands of the Yakama Nation), the Pacific Lamprey Research and Restoration Project (1994-026-00; Confederated Tribes of the Umatilla Indian Reservation), and the Implement Tribal Pacific Lamprey Restoration Plan project (2008-524-00; CRITFC) that are described in more detail below and in Section 4.9. The non-Accord project is the Nez Perce Tribe (NPT) Pacific Lamprey Translocation and Assessment Project, which is also described below and referenced in Section 4.9.

Although conservation and restoration of Pacific Lamprey is important to fisheries managers throughout the CRB, the focus of this Master Plan is Pacific Lamprey within subbasins co-managed by the Confederated Tribes and Bands of the Yakama Nation (YN) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Subbasins of focus for the YN are the Yakima and Methow. Subbasins of focus for the CTUIR are the Umatilla, Grande Ronde, Walla Walla, and Tucannon.

Supplementation efforts to date by the YN, the CTUIR, and the NPT have focused on the Yakima, Methow, Umatilla, Grande Ronde, Salmon, Clearwater, and Asotin subbasins, with management actions limited to adult translocation. Translocation has been successfully implemented (Ward et al. 2012), and well-designed post-reintroduction monitoring programs, which are imperative to documenting success, are a key focus for the tribes.

To date, artificial propagation and rearing efforts have been limited to preliminary research conducted in controlled environments. Work has focused on developing the best methods and techniques associated with gamete holding, gamete fertilization, egg incubation and prolarvae holding, transportation of gametes and larvae, disinfection (adult broodstock, eggs, and larvae), and larval culture (Lampman et al. 2016). As part of this Master Plan, experimental larval outplanting is proposed for the Yakima Subbasin by the YN, and for the Walla Walla and Tucannon subbasins by the CTUIR Reservation. Objectives for work identified in this Master Plan fall under four phases:

**Phase 1**

1. Develop and implement best management practices for adult handling and artificial propagation in the laboratory
2. Develop and implement best management practices for larvae and juvenile handling, feeding, and marking/tagging in the laboratory

**Phase 2**

3. Out-plant successfully held and reared adult and juvenile products as per supplementation experimental design
4. Provide successfully reared larvae and juveniles for migration and passage research studies

**Phase 3**

5. Cross compare and evaluate supplementation monitoring results to determine most successful strategies

6. Utilize results from supplementation research strategies to inform development of restoration actions

**Phase 4**

7. Implement restoration actions as per recommendations

This Master Plan includes an overview of existing and potential future facilities for Pacific Lamprey artificial propagation in the CRB. The YN and the CTUIR both have a small array of aquariums and relatively small numbers of circular and trough tanks to rear larval and juvenile lamprey, housing both propagated larvae and larvae and juveniles collected from the wild. All existing facilities and capacities are relatively small. Included in the plan are illustrations showing intended facility expansion over the next 2-5 years, to the best of current understanding.

This Master Plan also includes preliminary cost estimates based on the proposed programs and facilities presented. The foundational planning approach within the Master Plan is to develop lamprey artificial propagation, translocation, restoration, and research facilities within existing facilities, thereby significantly reducing all associated program costs.

# 2 Introduction

## 2.1 Northwest Power and Conservation Council Step Review Process

The NPCC is directed by the Northwest Power Act of 1980 to develop a program to protect, mitigate and enhance the fish and wildlife that have been affected by the development of hydropower dams in the CRB. The resulting Program (NPCC 2014) is the basis upon which the NPCC makes funding recommendations to the Bonneville Power Administration (BPA). The Program includes the Step-Review as part of the project review process.

The NPCC originally implemented a Three-Step Review process in 1997 for all "artificial production initiatives." An artificial production initiative qualifies for the review process if the project proposes to construct new production facilities, plant fish in waters where they have not been planted before, significantly increase the number of fish being introduced, change stocks or the number of stocks, or change the location of production facilities.

The Step Review includes a thorough review of review elements by the Independent Science Review Panel (ISRP) and the NPCC at three phases: master or conceptual planning, preliminary design and final design (Table 2-1). Projects do not move forward from one phase to another without a favorable review. The Program states, "The Council intends the Step-Review process to be flexible and cost-efficient. Depending on the nature and status of the proposed project, the Council may allow for a review that combines two or more steps in a single submission and review, or for a submission and review that addresses just part of a step of the review process."

During Step 1, project proponents identify all major development components, how they could be arranged on the selected site, and how facilities would be operated. Planning level facility sizing, configurations, and costs are estimated to a confidence level of +/- 35 to 50%. During Step 2, project proponents provide a preliminary design, including appropriate value engineering review of the proposed facility to a confidence level of +/- 25 to 35%. At this stage, design is advanced to a degree that allows completion of a full environmental review. Step 3 is the final design review prior to construction. Development plans are advanced to a confidence level of +/- 10 to 15% and are ready for bid. A 100% cost estimate accompanies this submittal along with details on all operational plans.

This document is a Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research, which is a conceptual phase to address Step 1 review elements (Table 2-1). Translocation of adult lamprey has been implemented in the CRB since 2000 (see **Section 4.3**). Experimental larval outplantings proposed for the Yakima, Walla Walla, and Tucannon subbasins require the development of this Master Plan.

It is possible that an Environmental Assessment (EA) would be needed to implement proposed releases of artificially propagated Pacific Lamprey. The EA would be initiated after review and approval of other components of this Master Plan. It is assumed that BPA would function as the lead federal agency for all efforts required by the National Environmental Policy Act (NEPA).

The intent of Hatchery Genetic Management Plans (HGMPs) is to outline how an artificial propagation strategy will protect a species and assist in recovery. Templates for these plans target anadromous salmonids and have considerable drawbacks and limitations when applying them to programs for fish such as Pacific Lamprey. This is especially true given the non-homing return migration strategy of Pacific Lamprey. Pacific Lamprey are not listed under the Endangered Species

Act (ESA) and therefore approval of the Master Plan should not be subject to the completion of an HGMP. At a future phase, dependent on the outcome and findings of the proposed work, development of an HGMP could potentially be initiated after review and approval of other components of this Master Plan.

Harvest of Pacific Lamprey is minimal, and limited to traditional and cultural needs of tribes. Almost all lamprey harvest occurs at Willamette Falls. No additional harvest is expected to occur as a result of actions described in this plan.

This Master Plan has not been developed for a large, capital construction project. No new facilities are planned for Pacific Lamprey, at least in the short term (2018-2026). A summary of the availability and utility of existing facilities, as well as proposed improvements to those facilities, is included in **Section 5.6**.

**Table 2-1. NPCC review elements addressed in this Master Plan.**

| Step Process Review Element | Master Plan Reference |
|---|---|
| **All Projects** | |
| Relationship and consistencies to the six scientific principles. | Section 6.1 - Consistency with Six Scientific Principles of the NPCC Fish and Wildlife Program |
| Link of the proposal to other projects and activities | Section 4.4 - Relationship to Other Lamprey Restoration Efforts or Processes;<br>Section 4.5 - Consistency with Other Regional Plans;<br>Section 4.9 – Relationships to Ongoing Projects |
| Principles, goals and biological objectives. | Section 5.4 - Phased Approach and Objectives for Artificial Propagation |
| Expected project benefits. | Section 5.9 – Expected Project Benefits |
| Cost-effective alternate measures | Section 3.5 – Alternatives Considered |
| Historical and current status of fish and wildlife. | Section 4 – Regional and Tribal Context |
| Current and planned management of fish and wildlife. | Section 4.5 - Consistency with Other Regional Plans;<br>Section 4.6 - Consistency with Other Supporting Documents;<br>Section 4.7 - Local and Regional Management Context |
| Consistency with recovery plans and other plans | Section 4.5 - Consistency with Other Regional Plans;<br>Section 4.6 - Consistency with Other Supporting Documents |
| Comprehensive environmental assessment. | Section 7 – Environmental Compliance |
| Monitoring and evaluation plan. | Section 5.5 - Experimental Designs for Phase 2 Projects |
| Specific items and cost estimates. | Section 5.8 - Summary of Cost Estimates |
| **Artificial Production Initiatives** | |
| Relationship to the fish propagation principles and measures | Section 6.2 - Consistency with NPCC Principles for Hatcheries |
| Hatchery and Genetic Management Plan | Not completed. See Section 2.1 – Northwest Power and Conservation Council Step Review Process |
| Harvest plan | Not applicable. See Section 2.1 – Northwest Power and Conservation Council Step Review Process |
| Conceptual design | Section 5.6 - Conceptual Design of Lamprey Facilities |
| Preliminary design | Not applicable. See Section 5.6 - Conceptual Design of Lamprey Facilities |
| Final design | Not applicable. See Section 5.6 - Conceptual Design of Lamprey Facilities |

## 2.2 Existing Columbia River Basin Fish and Wildlife Program Lamprey Projects

The YN and the CTUIR, with guidance from the TPLRP (CRITFC 2011) and with support from CRITFC, submit this Master Plan to advance the knowledge of Pacific Lamprey with the purpose of restoring lamprey throughout their range in numbers that support tribal cultural use. Currently, three BPA-funded Columbia Basin Fish Accord (Accord) projects and one non-Accord, non-BPA funded project deal directly or indirectly with Pacific Lamprey artificial propagation, translocation, restoration, and research activities. These projects deal with subbasins within the upper CRB that are most affected by poor passage and limited adult returns. The three Accord projects are the Yakama Nation Ceded Lands Lamprey Evaluation and Restoration Project (2008-470-00; YN), the Pacific Lamprey Research and Restoration Project (1994-026-00; CTUIR), and the Implement Tribal Pacific Lamprey Restoration Plan project (2008-524-00; CRITFC) that are described in more detail below and in **Section 4.9**. The non-Accord project is the NPT Pacific Lamprey Translocation and Assessment Project, which is also described below and referenced in **Section 4.9**.

The YN, through its Yakama Nation Pacific Lamprey Program (YNPLP), intends to assess status, abundance and distribution of Pacific Lamprey, develop a Yakama Nation Pacific Lamprey Supplementation Plan and a Yakama Nation Pacific Lamprey restoration plan, as well as implement and monitor these plans. For translocation, the YNPLP will focus on the Yakima and Methow subbasins, with the Klickitat and Entiat subbasins serving as controls (**see Section 4.3.3**). Previous restoration efforts in the Yakima Subbasin have proven that translocating adult lamprey can result in increased larval, juvenile, and more recently adult production (**see Section 4.1.1.2**). Specific to lamprey artificial propagation, translocation, restoration, and research activities, the YNPLP intends to improve all passage for adult lamprey and increase larval abundance in tributary streams, implement adult Pacific Lamprey translocation program from mainstem Columbia River hydro-electric projects into select subbasins, evaluate methodology and potential biological benefits and risks of expanding this program as appropriate (YNPLP Objective 7), and participate in the development and implementation of artificial propagation of and outplanting techniques of Pacific Lamprey (YNPLP Objective 8).

The CTUIR, through its Pacific Lamprey Research and Restoration Project (PLRRP), intends to provide the critical information to restore Pacific Lamprey in the Umatilla River that is called for in the Draft Umatilla/Willow Subbasin Plan (Phelps 2004). The CTUIR will also focus on the Grande Ronde, Walla Walla, and Tucannon subbasins. The John Day and Imnaha subbasins will serve as controls. Activities in the Grande Ronde subbasin are closely coordinated with the NPT. Restoration of Pacific Lamprey will eventually provide harvest opportunities and will recover the ecosystem functions that lamprey provide. Previous restoration efforts in the Umatilla Subbasin have proven that translocating adult lamprey can result in successful adult reproduction and increased larval production (**see Section 4.3.4**). The next step in this project is to ensure that translocated lamprey will become self-sustaining in the Umatilla Subbasin, in addition to increasing the abundance of larval lamprey in the subbasin. Specific to lamprey artificial propagation, translocation, restoration, and research activities, the CTUIR intends to monitor passage success to spawning areas (PLRRP Objective 3), increase larval abundance in the Umatilla River by continuing to translocate adult lamprey (PLRPP Objective 5), and monitor larval abundance trends in the Umatilla River by conducting electrofishing surveys (PLRPP Objective 6). The CTUIR will also monitor success of translocation efforts in the Grande Ronde Subbasin, and propose outplanting of larval lamprey in the Walla Walla and Tucannon subbasins.

The CRITFC, through its Implement the Tribal Pacific Lamprey Restoration Plan (ITPLRP) project, intends to improve adult and juvenile Pacific Lamprey passage at mainstem and tributary locations as well as provide information to reduce uncertainties with respect to lamprey distribution and abundance, habitat quality, habitat utilization, and genetic characteristics (**see Section 4.9.4**). The subbasins that the ITPLRP intends to focus on are the Willamette, Lower Snake, Upper Middle Columbia, Lower Middle Columbia, Lower Columbia, and Mid-Columbia. Specifically to lamprey artificial propagation, translocation, restoration, and research activities, the CRITFC intends to fulfill the TPLRP (CRITFC 2011) for the CRB (ITPLRP Objective 1) and develop, and implement, if appropriate, an experimental conservation artificial production facility, in collaboration with CRITFC member tribes and other regional entities (ITPLRP Objective 6). Within the completed TPLRP (CRITFC 2011), the CRITFC and its member tribes aim to continue translocation in accordance with tribal guidelines, develop and implement lamprey translocation as a component of a regional supplementation plan, and develop and implement lamprey artificial propagation as a component of a regional supplementation plan (TPLRP Objective 3; Supplementation/Augmentation).

Activities conducted by the NPT are not formally part of this Master Plan, but descriptions of NPT activities are included to provide a comprehensive context of Pacific Lamprey supplementation in the CRB (**see sections 4.3.5 and 4.9.6**). The NPT, through its NPT-funded Pacific Lamprey Translocation and Assessment Project, also supported by the ITPLRP project, U.S. Fish and Wildlife Service (USFWS) Cooperative Agreement No. F12AC01568, the CRITFC Hagerman Genetics Laboratory, various cooperators and other funding sources as available, intends to monitor results of its ongoing adult Pacific Lamprey translocation initiative. The subbasins that the NPT will continue to focus on are the Clearwater, Salmon, Grande Ronde, and Asotin. Activities in the Grande Ronde subbasin are closely coordinated with the CTUIR.

Two additional Accord lamprey projects implemented by the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) do not include artificial propagation or translocation (**see sections 4.9.2 and 4.9.5**). These projects are (1) the Willamette Falls Lamprey Study Project (2008-308-00) and (2) the Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek, and Hood River Project (2011-104-00). Activities conducted by the CTWSRO are not part of this Master Plan, and no further descriptions of activities are provided. It should be noted, however, that some adult lamprey collected at Bonneville and The Dalles dams for translocation to upstream subbasins may have otherwise entered subbasins co-managed by the CTWSRO. It is important that the CTWSRO continue to monitor the status of Pacific Lamprey in these subbasins.

## 2.3 Master Plan Overview and Organization

Today, Pacific Lamprey return to the CRB at a fraction of their historical numbers due to a variety of known and unknown threats. The Tribes and other regional partners aim to have Pacific Lamprey widely distributed within the CRB in numbers that fully provide for ecological, tribal cultural and harvest values. Through various regional and tribal efforts, the goals are to reestablish Pacific Lamprey as a fundamental component of the ecosystem and restore Pacific Lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas. However, much work has been completed over the past 18 years many critical uncertainties remain regarding lamprey restoration. Regional entities have indicated that supplementation related activities may be an important component in active lamprey restoration as well as in the evaluation of existing and emerging limiting factors (CRITFC 2011; Luzier et al. 2011).

This Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research includes an integrated phased approach for artificial production that emphasizes adaptive management, with the goal of making progress towards the artificial propagation research goals and biological objectives identified in TPLRP, LCA (USFWS 2012), the Framework for Pacific Lamprey Supplementation Research in the CRB (Framework; CRITFC 2014), subbasin plans, and the Accords in a feasible, cost effective, and biological conservative manner. The Master Plan intends to monitor and evaluate the continued use of adult translocation as well as the structured, strategic, and phased release of artificially reared Pacific Lamprey as potential strategies to reintroduce, augment, and/or supplement Pacific Lamprey within select CRB subbasins to achieve the stated, long-term goals identified in various lamprey planning documents and restoration efforts.

The Master Plan has been developed to address all applicable NPCC review elements for Steps 1 and 2 outlined in **Section 2.1** (Table 2-1). Pacific Lamprey are not a listed species and therefore approval of the Master Plan should not be subject to the completion of an HGMP. The Master Plan is specifically designed to develop and refine the methods, techniques, and understanding required to develop an HGMP for Pacific Lamprey, if needed, at a future date. Pacific Lamprey harvest within the CRB is minimal for traditional and cultural purposes; therefore, a harvest plan is not applicable at this time. Additionally, the implementation of proposed Master Plan objectives are expected to require a modest expansion of existing artificial propagation, translocation, restoration, and research efforts and infrastructure, therefore the development of a conceptual design and subsequent engineering review of any proposed facilities is not expected to be necessary. This Master Plan has not been developed for a large, capital construction project.

Following this introductory chapter, **Chapter 3** provides a general overview of regional and range-wide lamprey declines as well as completed and ongoing CRB lamprey restoration projects, specifically those that involve artificial propagation, translocation, restoration, and research activities. **Chapter 3** focuses attention on the vision and goals of existing plans and assessments within the CRB, specifically the TPLRP. **Chapter 3** also summarizes the reasons why a Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research should be developed to address needs and objectives contained within existing plans and assessments.

**Chapter 4** provides more detail describing the regional and tribal context for the proposed Master Plan. This chapter also includes background information about specific CRB subbasins expected to be influenced by the Master Plan, describes the relationship to other lamprey restoration efforts within the CRB, specifically Accord funded projects and processes, and describes supporting documents. Furthermore, this chapter presents the research efforts within a local and regional management context, and outlines the coordination with other entities and ongoing projects on a regional and subbasin scale.

**Chapter 5** describes in detail the proposed actions of the Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research for the CRB through the CTUIR (199402600), YN (200847000), and CRITFC (200852400) BPA-funded Accord projects under the general guidance of the TPLRP (CRITFC 2011). The NPT's Pacific Lamprey Translocation and Assessment Project is not funded by BPA; however, **Chapter 5** includes information on this project to provide a comprehensive description of supplementation activities in the CRB.

Four distinct alternatives for lamprey, artificial propagation, translocation, and research are presented, including the basis for selecting the preferred alternative. Within **Chapter 5**, the proponents describe four distinct, overlapping phases of progress for the selected, preferred alternative over the next 10 years. Phase 1 is characterized as the initial efforts towards successfully propagating and rearing lamprey through the first 6-12 months of their life history. Phase 2 is characterized by the initiation and monitoring of a variety of lamprey reintroduction strategies. Phase 3 is characterized by the evaluation and analysis of the results obtained in Phases 1 and 2 as well as the potential development of a restoration strategy utilizing artificial propagation and translocation. Phase 4 is characterized by the implementation of the restoration strategy developed in Phase 3. Lamprey monitoring, research and evaluation efforts are also described in the context of seven biological objectives.

**Chapter 6** describes how the preferred alternative of this Master Plan is consistent with principles of the NPCC Program. The Program includes six over-arching scientific principles, a number of principles for hatcheries, and a section specific to lamprey, including guidelines for supplementation.

**Chapter 7** details the environmental compliance needs for the Pacific Lamprey program.

# 3 Overview, Needs, and Goals for Master Plan

## 3.1 Background

Pacific Lamprey is an anadromous fish species that has occupied freshwater rivers of western North America for the last 350 million years. These ancient fish are distinct from other fishes within their range – lampreys are jawless, have no scales, and lack paired fins. Since pre-historic times, Native Americans have utilized lamprey for important subsistence, ceremonial, and medicinal purposes. Pacific Lamprey are also important ecologically because they provide marine-derived nutrients to the freshwater riverine environment and the aquatic and terrestrial food web (Beamish 1980; Brown et al. 2009) and provide a high-calorie prey source for various marine and freshwater species (Whyte et al. 1993).

Today, Pacific Lamprey return to the CRB at a fraction of their historical numbers due to a variety of known and unknown threats. Despite recent implementation of passage improvements at mainstem and tributary dams, habitat improvements, and adult lamprey translocation efforts (CRITFC 2011; Luzier et al. 2011; Ward et al. 2012; see **Chapter 4**), adult returns remain relatively low and spatial distribution is increasingly limited to the lower portions of the CRB (Figure 3-1). Returns of adult Pacific Lamprey have declined significantly across the CRB and lamprey are currently absent from the majority of historic tribal harvest locations due to poor adult returns (Peterson Lewis 2009) as well as the inundation of harvest sites (e.g., Celilo Falls). Pacific Lamprey have been extirpated from many subbasins in the interior CRB (Close et al. 1995; USFWS 2007; Luzier et al. 2011). In addition to declines in the CRB, observational trends suggest that abundances of Pacific Lamprey are declining from historical numbers in Pacific coast streams from Washington State to Southern California (Luzier et al. 2011).

In the CRB, daytime counts of adult Pacific Lamprey at Bonneville Dam have declined from an estimated 400,000 in the 1950's and 1960's to lows of under 10,000 in 2009 and 2010 (CRITFC 2011). Daytime counts rebounded somewhat from 2011 through 2014 (FPC 2017), but still remain far below historic levels (Figure 3-1). At Willamette Falls, a traditional harvest location on the Willamette River, estimates of harvest declined from about 400,000 in the 1940's to about 4,000 in 2001 (Ward 2001). Harvest has remained low in recent years (Table 3-1).

Numbers of Pacific Lamprey reaching the upper Columbia and Snake rivers has declined even more severely. Counts of adult Pacific Lamprey at mid-Columbia and lower Snake River dams are unavailable prior to 1996; however, available information indicates a substantial decline in numbers of Pacific Lamprey (Figure 3-1). Counts at Wells Dam on the Columbia River reached 1,408 in 2003, but have failed to exceed 35 since 2006 (FPC 2017). Adult counts at Lower Granite Dam on the Snake River were 490 in 1996 and 1,122 in 1997, but have only reached 100 once since 2004 (Ward et al. 2012; FPC 2017).

Recent studies on this trend of Pacific Lamprey decline in the CRB cite the construction of hydroelectric and flood control dams, irrigation and municipal water diversions, habitat degradation and loss, poor water quality, excessive predation, contaminants, ocean cycles, prey-species availability, and chemical eradication as major contributors (Close et al. 1995; CRITFC 2011; Luzier et al. 2011; Murauskas et al. 2012). More details regarding Pacific Lamprey status, threats and limiting factors, and restoration efforts, including ongoing supplementation activities, are provided in

**Chapter 4**. Passage at mainstem Columbia and Snake River dams is described in **Section 4.4.1.** The U.S. Army Corps of Engineers (USACE) Pacific Lamprey Passage Improvements Plan (USACE 2008), developed to address mainstem passage issues, is summarized in **Section 4.5.1**. Threats and limiting factors within specific subbasins, including passage, habitat, water quality and contaminants are described in **Sections 4.4.2 and 4.4.3**. Threats and limiting factors are more fully described and assessed in the TPLRP (CRITFC 2011) and the USFWS Assessment and Template for Conservation Measures (Luzier et al. 2011).

As more fully described in **Chapter 4** restoration efforts for Pacific Lamprey are ongoing, including improvements in mainstem and tributary passage, restoration of habitat and water quality, and supplementation actions. Until recently, supplementation was focused almost entirely on translocation of adults (see **Section 4.3**). Investigations into artificial propagation techniques have been recently undertaken by tribes and other entities (see **Section 4.3).** Intensive and extensive monitoring has indicated that translocation may be successful as a means to increase Pacific Lamprey abundance until passage and other restoration actions are undertaken (Ward et al. 2012). The continued decrease in abundance or complete extirpation in some subbasins, despite restoration actions, indicates that artificial propagation may be required in conjunction with other actions. This Master Plan provides the context and details of both artificial propagation and translocation activities expected to be undertaken that are consistent with the TPLRP and other regional documents.

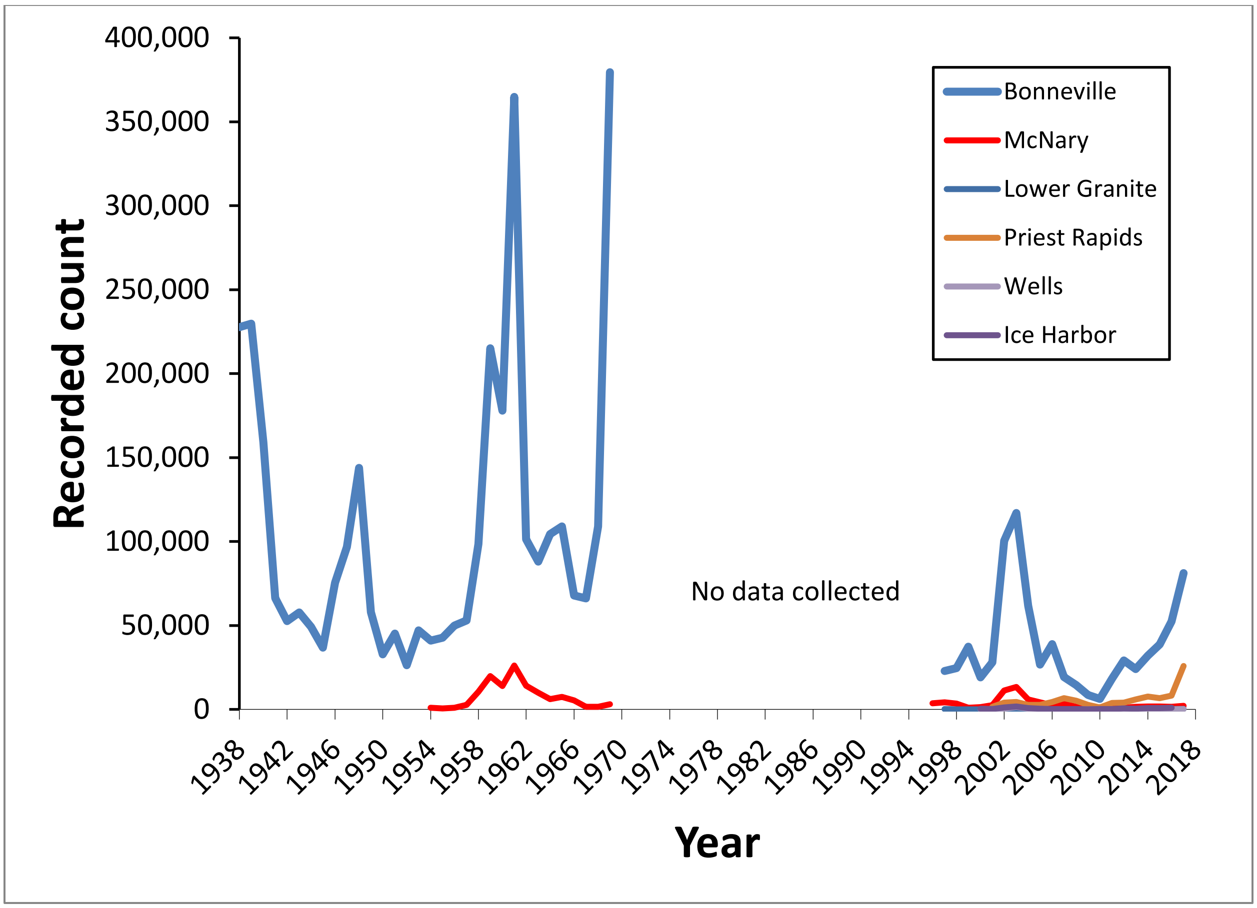


**Figure 3-1. Adult Pacific Lamprey annual daytime counts at Columbia and Snake River dams from 1938 to 2017.**

**Table 3-1. Adult Pacific Lamprey abundance, passage, and harvest at Willamette Falls, 2010-2017.**

| Year | Total Abundance | Upstream Escapement | Harvest | Percent Harvested |
|---|---|---|---|---|
| 2010 | 64,388 | 27,043 | 1,606 | 2.5% |
| 2011 | 107,383 | 46,819 | 4,318 | 4.0% |
| 2012 | 243,048 | 111,559 | 6,316 | 2.6% |
| 2013 | 173,821 | 49,365 | 7,552 | 4.3% |
| 2014 | 336,305 | 125,778 | 3,541 | 1.1% |
| 2015 | 168,398 | 66,763 | 2,143 | 1.3% |
| 2016 | 115,682 | -- | 2,692 | 2.3% |
| 2017 | 280,694 | -- | 6,376 | 2.3% |

Within this Master Plan, the term population refers to Pacific Lamprey of all life history phases that are migrating through, contained within, or emanating from the CRB. Though there is not strong evidence for delineating CRB Pacific Lamprey as distinct from other locations (Hess et al. 2012), treating CRB lamprey as distinct is a cautious approach to implementing the objectives contained within this Master Plan (See **Section 4.2** and **Section 4.10.1**). Regardless, the term population does not refer to an independent population with distinct demographic and genetic differences or local adaptability, as in the case of Pacific salmonids. Although more work is needed to better understand lamprey genetics, compared to salmonids, Pacific Lamprey appear to exhibit low genetic differentiation among regional stocks, and population structure reflects a single broadly distributed population across much of the Pacific Northwest (Goodman et al. 2008; Spice et al. 2012; see **Section 4.2**). Pacific Lamprey from specific geographic regions within the Columbia River Basin (e.g. Willamette River, Umatilla River, and Snake River) will be treated as segments of the CRB population and will be worded as such.

## 3.2 Vision

The long-term restoration goals guiding the development of this Master Plan are derived directly from the Vision and Goal of the TPLRP for the Columbia River Basin (CRITFC 2011). This Master Plan intends to support the TPLRP Vision and Goal by developing and monitoring potential supplementation actions aimed at restoring Pacific Lamprey in areas where they have been extirpated or substantially reduced.

The overarching goal of the TPLRP is to immediately halt the decline of Pacific Lamprey and ultimately restore lamprey throughout their historic range to levels that support their unique cultural, harvest, and ecological values (Figure 3-2). Though the TPLRP is a tribally focused document, it is generally understood that the restoration of Pacific Lamprey in the CRB will require a collaborative effort among Tribes, federal agencies, states, and local entities.

The TPLRP supports a collaborative path to address critical uncertainties, threats and limiting factors while implementing specific restoration actions, which include supplementation related actions. Specific to artificial propagation, translocation, restoration, and research, the tribes believe that it is important to:

1. Continue translocation in accordance with tribal guidelines,
2. Develop and implement lamprey translocation as a component of a regional supplementation plan,
3. Develop and implement lamprey artificial propagation as a component of a regional research and supplementation plan, and
4. Supplement/augment interior lamprey through reintroduction and translocation of adults and juveniles into areas with few or no lamprey.

The goals of the Master Plan are consistent with and supported by other regional plans focusing on Pacific Lamprey that have been developed and implemented in recent years. These include the Pacific Lamprey Passage Improvements Implementation Plan (USACE 2008), the Pacific Lamprey Assessment and Template for Conservation Measures (Luzier et al. 2011), and the Lamprey Conservation Agreement initiated by the USFWS (2012). The goals of the Master Plan are also consistent with the strategies, rationale, principles, and measures that address lamprey in the 2014 Program (NPCC 2014). These plans and programs are all further described in **Section 4.5**.

| | |
|---|---|
| **Plan Vision:** | Pacific Lamprey are widely distributed within the Columbia River Basin in numbers that fully provide for ecological, tribal cultural and harvest values. |
| **Plan Goal:** | Immediately halt population declines and prevent additional extirpation in tributaries. Reestablish Pacific Lamprey as a fundamental component of the ecosystem. Restore Pacific Lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas. |
| **Numeric Goals:** | 2012 - Halt decline<br>2020 - 200,000 adults (based on 2002–2003 Bonneville Dam counts)<br>2035 - 1,000,000 adults (from 1950s–1960s Bonneville Dam counts)<br>2050 - Restore lamprey to sustainable, harvestable levels throughout their historic range |

**Figure 3-2. Tribal Pacific Lamprey Restoration Plan vision and goal statements and numeric goals through 2050 (CRITFC 2011).**

## 3.3 Need

Considering the declining returns of Pacific Lamprey and their significance to the cultural and ecological health of the CRB, there is a strong and urgent need to address and recover lamprey stocks in the CRB. Potential cultural impacts on continued lamprey declines include loss of culture and traditional harvest opportunities. Similarly, ecological impacts include decreased connectivity of marine and freshwater ecosystems, declines in marine-derived nutrient deliverance into upper reaches of the CRB, changes to the primary/secondary productivity of rivers/streams in association with larval lamprey activity, and a decrease in the prey base available to native fish, avian, and mammalian predators.

As briefly described above, as well as outlined in more detail in **Chapter 4**, numerous projects have been implemented within the CRB that aim to address known limiting factors, obtain a better understanding of critical uncertainties, and address knowledge gaps for Pacific Lamprey. Collectively, these efforts are contributing to the ultimate vision and goal of the TPLRP as well as other regional and range-wide lamprey plans. However, there remain significant gaps in the collective understanding of Pacific Lamprey, many of which are hindered by a lack of study individuals and the presence of lamprey in any form. As described above in **Section 3.2,** and in summaries of related regional plans in **Section 4.5**, multiple plans and regional efforts have identified the development of artificial propagation as a need; to provide study fish, to develop and refine artificial propagation rearing techniques, and to provide a framework for developing conservation aquaculture within the region.

As described previously in this document and more fully in **Section 4.1**, as well as in related plans and documents summarized in **Sections 4.5 and 4.6**, Pacific Lamprey numbers have plummeted throughout their range and aggressive and significant actions are now required for restoration and recovery, especially within the interior portions of their range (e.g., upper CRB and Snake River Basin). Actions described in this Master Plan are needed because:

- Pacific Lamprey are in low abundance or extirpated in many subbasins within the CRB.
- Pacific Lamprey in some subbasins may need to be supplemented so that recovery can occur in a timeframe consistent with existing restoration plans.
- Artificial propagation, translocation, restoration, and research actions will provide valuable insights into lamprey biology and ecology.
- A collaborative artificial propagation, translocation, restoration, and research program will provide for a more comprehensive and systematic research and monitoring strategy and will contribute to greater consistency in data analysis and reporting.

Actions proposed as part of this Master Plan will serve to:

- Continue to evaluate the success of adult translocation to support Pacific lamprey restoration efforts in the CRB.
- Evaluate the feasibility of using artificial propagation techniques to support Pacific Lamprey restoration efforts in the CRB.
- Provide artificially propagated larval and juvenile lamprey for research projects to evaluate critical uncertainties and limiting factors.
- Obtain a better understanding of basic but important aspects of Pacific Lamprey biology and ecology through the scientific process.
- Develop techniques, protocols, and equipment needs for a future conservation aquaculture facility.

## 3.4 Goal

The goal of this plan is to evaluate the feasibility of using artificial propagation and translocation techniques to better understand and ultimately restore Pacific Lamprey throughout its range, with particular emphasis on the CRB population segment.

## 3.5 Alternatives Considered

A range of alternatives for implementing Pacific lamprey artificial propagation, translocation, and restoration research activities were considered and evaluated. These included (1) maintaining current research programs, facilities, and funding levels, (2) terminating current research programs for artificial propagation, translocation, and restoration, (3) modestly expanding artificial propagation, translocation, and restoration research efforts and (4) significantly expanding artificial propagation, translocation, and restoration research efforts. Alternatives 3 and 4 include reintroductions of artificially propagated fish into areas of low abundance or extirpation.

### 3.5.1 Alternative 1: Status Quo - Maintain Research Program and Facilities at Current Funding Level

Under this strategy, the current artificial propagation, translocation, and restoration research programs would continue without substantial changes to facilities, conditions, capacity, or scope. Artificial propagation research would continue to be limited to the laboratory environment with no effort to expand research into the natural environment. Existing adult collection, holding, and spawning procedures for translocation programs would be maintained. Standard maintenance would occur, but no structural or operational improvements would be implemented for existing artificial propagation and translocation research programs.

The outcome of this strategy would require minimal funding and planning beyond current levels. Progress towards stated supplementation research goals within the TPLRP and the LCA would continue at existing levels and not be expanded. Facilities for adult holding and spawning would remain marginally sufficient and operational but not necessarily to a standard of care that is ideal for longer-term expansion. Artificial propagation research would be limited by structural and operational space and resources. There would be no effort to utilize artificially propagated fish in the natural environment to evaluate critical uncertainties and limiting factors (e.g. mainstem juvenile dam passage and entrainment), which would hinder progress towards regional research and restoration objectives.

Costs would remain similar to current levels, ranging from $50,000 to $100,000 annually per project.

### 3.5.2 Alternative 2: Terminate Current Research Programs for Artificial Propagation

This strategy would terminate all research associated with lamprey artificial propagation. Existing adult collection, holding, and spawning procedures for tribal translocation programs would be maintained but no fish would be collected specifically for lamprey artificial propagation and artificial propagation research.

The general outcome of this strategy would be a reallocation of finite resources to other lamprey restoration activities. Supplementation research would focus entirely on the translocation of adults. Very little to no progress would be made towards the artificial propagation research goals and biological objectives identified in TPLRP, LCA, the Framework, subbasin plans, and the Columbia Basin Fish Accords. Negative aspects of adopting this alternative would be substantial, including the loss of momentum regarding artificial propagation and conservation hatchery techniques as well as minimal production of artificially propagated lamprey for use in evaluations of critical limiting factors and general life history information.

Costs would remain similar to current levels ($50,000 to $100,000 annually per project). Funds currently used for artificial propagation research would be diverted to other restoration actions.

### 3.5.3 Alternative 3: Implement Modest Expansion of Supplementation, Aquaculture, and Restoration Efforts

This strategy would implement modest structural improvements to existing artificial propagation research projects. Adult collection, holding, and spawning procedures for tribal translocation programs would be maintained, but translocation would be expanded into a small number of new areas. Structural improvements would include increased holding and rearing capacities for adult, larval, and juvenile lamprey. Monitoring to evaluate the success of outplanted larval lamprey would also be implemented. Artificial propagation research objectives would be expanded beyond the laboratory and include the structured and phased releases of artificially propagated larval and juvenile lamprey into areas of low abundance or extirpation within the CRB.

The general outcome of this strategy would be an expanded capacity to conduct artificial propagation research activities. This strategy would be expected to contribute greatly to field and laboratory research evaluating critical limiting factors, general biological questions, and potential supplementation and restoration strategies. Adopting this alternative would lead to a better understanding of the intricacies associated with rearing larval and juvenile lamprey at an expanded, albeit yet to be defined, scale. Significant progress would be made towards the artificial propagation research goals and biological objectives identified in the TPLRP, LCA, Framework, subbasin plans, and Columbia Basin Fish Accords. Intended capital improvements would increase efficiencies and capacity but not increase staffing needs significantly.

Costs would vary among years and phases, but over the next ten years would likely average from $100,000 to $200,000 annually per project (See **Section 5.8** for more detail).

### 3.5.4 Alternative 4: Implement Significant Expansion of Artificial Propagation and Restoration Efforts

This strategy would implement significant structural improvements to existing artificial propagation research projects. Adult collection and holding procedures for tribal translocation programs would be maintained, but translocation would be expanded into a small number of new areas. Structural improvements would include significant increases in holding and rearing capacities for adult, larval, and juvenile lamprey. Research objectives would be expanded beyond the laboratory and include the structured and phased releases of artificially propagated larval and juvenile lamprey into areas of low abundance or extirpation within the CRB. Research goals and biological objectives would progress at a greatly accelerated rate compared to Alternative 3.

The general outcome of this strategy would be a significantly expanded capacity to conduct artificial propagation research activities. This strategy would be expected to contribute significantly to field and laboratory research evaluating critical limiting factors, general biological questions, and potential supplementation and restoration strategies. Adopting this alternative would lead to a better understanding of the intricacies associated with rearing larval and juvenile lamprey at an expanded, albeit yet to be defined, scale. Significant progress would be made towards the artificial propagation research goals and biological objectives identified in the TPLRP, LCA, Framework, subbasin plans, and Columbia Basin Fish Accords. However, expansion of existing facilities would be relatively expensive and potentially cost-prohibitive. At this time, equipment and facility needs for a large-scale lamprey aquaculture facility are still unclear therefore design would be highly speculative until more is learned. Rearing larval and juvenile Pacific lamprey in the laboratory environment is still experimental, with much to be learned before substantial development of new facilities. Preliminary planning for this scenario has not commenced and it is expected that final plans could not be adopted within a 1-2 year time frame. Large-scale rearing and release protocols have not been developed at this time and it is premature to invest significant resources until a better scientific and economic foundation has been realized.

Cost would be highest in years of design and construction of expanded facilities, and then vary among years and phases. Design and construction costs could range from $3 million to $10 million per site. Subsequent costs would likely vary from $0.9 million to $1.8 million annually per tribe.

### 3.5.5 Basis for Selection of the Proposed Alternative (3)

The primary criterion for selecting an alternative is are to make progress towards the supplementation, artificial propagation, and aquaculture research goals and biological objectives identified in the TPLRP, LCA, Framework, subbasin plans, and Columbia Basin Fish Accords within a feasible, cost effective, and biologically conservative manner. As described above, Alternative 3, Implement Modest Expansion of Supplementation, Aquaculture, and Restoration Efforts, would best meet these criteria. Alternatives 1 and 2 would not make progress towards regional research goals and biological objectives. Although Alternative 4 would make significant progress towards regional research goals and biological objectives, this alternative is significantly more expensive than the other alternatives and would require research, development, and time to be implemented successfully.

Alternative 3, Implement Modest Expansion of Supplementation, Aquaculture, and Restoration Efforts, was selected as the Preferred Alternative. Specific reasons for implementing this alternative include:

1. Progress would be made towards the artificial propagation and aquaculture research goals and biological objectives identified in the TPLRP, LCA, Framework, subbasin plans, and Columbia Basin Fish Accords.
2. This strategy is expected to contribute greatly to field and laboratory research evaluating critical limiting factors, general biological questions, and potential supplementation and restoration strategies.
3. Modestly expanded facilities would allow for improved research efficiency and a better understanding of the tools, techniques, and equipment needed to spawn and rear larval and juvenile Pacific Lamprey.
4. By modestly expanding existing facilities, costs would remain relatively low and the logistics of setting up improved laboratory facilities would be greatly simplified.
5. Expanded artificial propagation research activities would provide increased opportunities for regional researchers to use artificially reared lamprey in a variety of critical uncertainty evaluations (e.g. passage, diet, growth, contaminant analysis, development of tagging technology, etc.).
6. Alternatives 1 and 2 do not address the needs of the TPLRP or the LCA. Alternative 4 addresses the needs of the TPLRP and the LCA but is logistically and cost prohibitive. Alternative 3 addresses the regional restoration goals and the needs identified in the TPLRP and the LCA in a financially and logistically feasible manner.

# 4 Regional and Tribal Context

## 4.1 Background

Declining numbers of Pacific Lamprey throughout the CRB have prompted the development of numerous plans and strategies to halt the decline and ultimately restore them throughout their historic range (see **Sections 4.4 and 4.5**). Actions to help restore Pacific Lamprey include those that will have basin-wide effects (e.g., passage improvements at mainstem dams), and others targeted for specific subbasins (e.g., passage improvements, habitat restoration, and adult translocation). Because recent evidence suggests that Pacific Lamprey do not home to natal streams to spawn (Hatch and Whiteaker 2009; Sorensen et al. 2005; Lin et al. 2008; Close et al. 2009; Spice et al. 2012), the effects of even these subbasin-specific actions will likely be far reaching.

Pacific Lamprey are of great importance to Native American tribes throughout the CRB for cultural, spiritual, ceremonial, medicinal, subsistence and ecological reasons. From a tribal perspective, the decline of Pacific Lamprey continues to have at least three negative effects: 1) loss of an important nutritional source and cultural heritage, 2) loss of fishing opportunities in traditional fishing areas, and 3) necessity to travel large distances to lower Columbia River tributaries, such as the Willamette River, for lamprey harvest opportunities. As a consequence of declining or eliminated harvest in interior CRB tributaries, many young tribal members have not learned how to harvest and prepare lamprey for drying. In addition, young tribal members are losing opportunities to learn historically important legends associated with lamprey and lamprey fishing. The TPLRP therefore includes development of an experimental artificial production facility to act as a regional safety-net for the conservation of Pacific Lamprey.

Although conservation and restoration of Pacific Lamprey is important to fisheries managers throughout the CRB (Luzier et al. 2011), the focus of this Master Plan is Pacific Lamprey within subbasins co-managed by the YN and the CTUIR (Figure 4-1). Subbasins of focus for the YN are the Yakima and Methow, with the Klickitat and Entiat subbasins serving as controls. Subbasins of focus for the CTUIR are the Umatilla, Grande Ronde, Walla Walla, and Tucannon, with the John Day and Imnaha subbasins serving as controls. Pacific Lamprey distribution and abundance will be monitored in control subbasins as well to help put any changes observed in focal subbasins into context. Controls were selected to allow comparisons of performance metrics between and among subbasins with and without supplementation strategies. Further details regarding comparisons may be found in **Section 5.4.2**, **Section 5.5**, and the Framework.

As described in **Section 4.9**, the YN (Project 2008-407-00), CTUIR (Project 1994-026-00), and CRITFC (Project 2008-524-00) have ongoing supplementation activities that utilize BPA funds. To date, ongoing actions and data collection have been focused in the Yakima, Methow, and Umatilla subbasins; therefore, little data are available for Pacific Lamprey in the Grande Ronde, Walla Walla, and Tucannon subbasins.

This Master Plan also provides information on adult translocation activities being implemented by the NPT. Subbasins of focus for the NPT are the Clearwater, Salmon, Grande Ronde, and Asotin. The NPT has no formal control subbasins because the tribe is not utilizing artificial propagation. Activities of the NPT do not directly utilize any BPA funds.

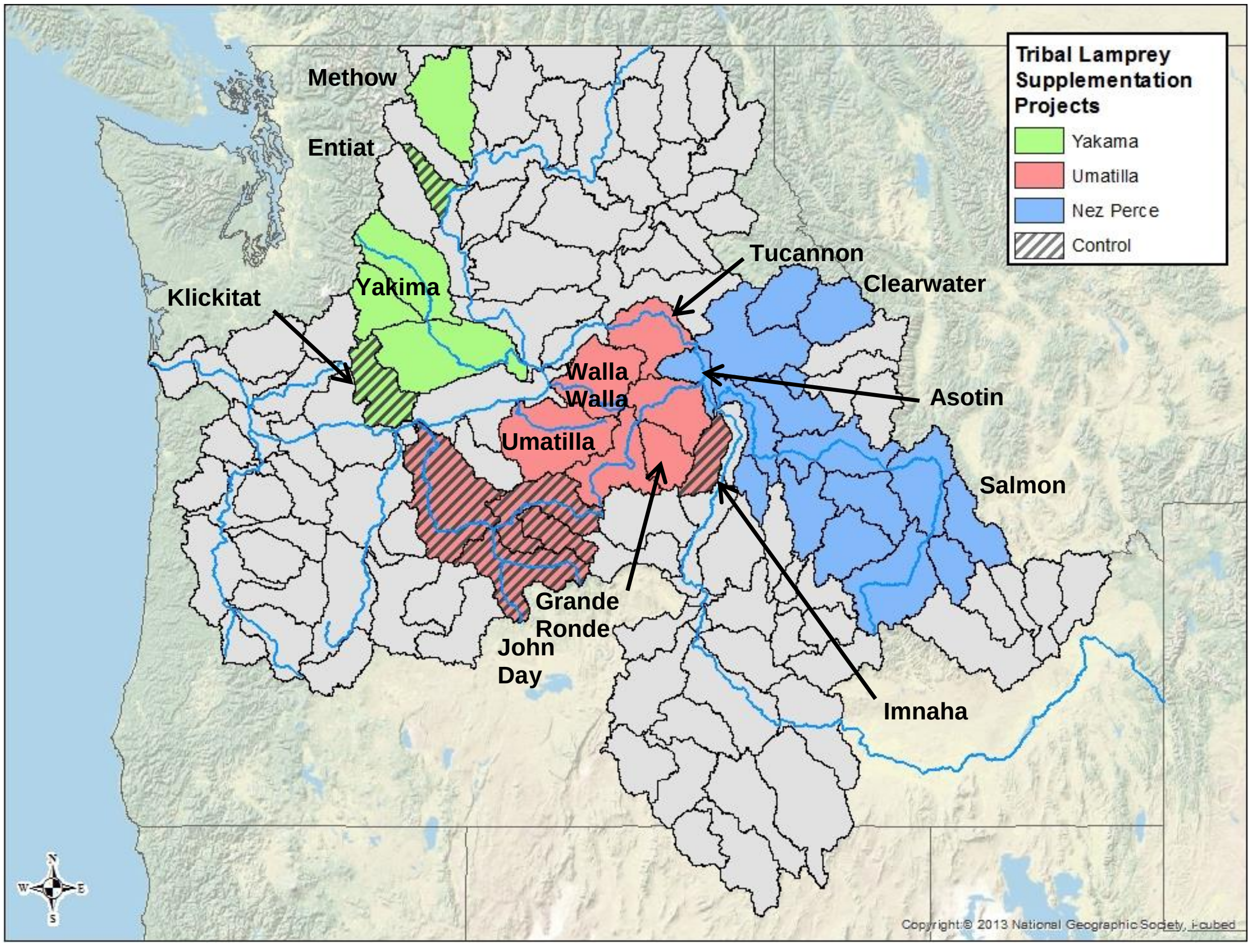


**Figure 4-1. Map of the Columbia River Basin showing subbasins in which supplementation actions (and those serving as controls) are described in this Master Plan.**

## 4.1.1 Yakima River Subbasin

### 4.1.1.1 Subbasin Description

The Yakima River Subbasin is located in south central Washington and contains a diverse landscape of rivers, ridges, and mountains totaling just over 6,100 square miles (Figure 4-2). Along the western portion of the subbasin, the glaciated peaks and deep valleys of the Cascade Mountains exceed 8,000 feet. East and south from the Cascade crest, the elevation decreases to the broad valleys and the lowlands of the Columbia Plateau. The lowest elevation in the subbasin is 340 feet at the confluence of the Yakima and Columbia Rivers at Richland. Precipitation is highly variable across the subbasin, ranging from approximately 7 inches per year in the eastern portion to over 140 inches per year near the crest of the Cascades. Total runoff from the subbasin averages approximately 3.4 million acre-feet per year, ranging from a low of 1.5 to a high of 5.6 million acre-feet.

Six major reservoirs are located in the Yakima Subbasin and form the storage component of the federal Yakima Project, managed by the U.S. Bureau of Reclamation (USBR). Total storage capacity of all reservoirs is approximately 1.07 million acre feet and total diversions average over 2.5 million acre-feet. The construction and operation of the irrigation reservoirs have significantly altered the natural seasonal hydrograph of all downstream reaches of the mainstem and some tributaries. Spring flows are decreased from historic highs, high and low flow events have been muted, and summer water temperatures have increased. Associated with these reservoirs are numerous irrigation dams and diversions throughout the subbasin. In addition, the Yakima Subbasin undergoes an annual "flip flop" operation during which flows from the Upper Yakima are gradually reduced in late summer while flows from the Naches watershed are increased.


**Figure 4-2. Yakima River Subbasin.**

### 4.1.1.2 Pacific Lamprey Status

The USFWS studied the distribution and abundance of fish in the Yakima River in 1957 and 1958 (Patten et al. 1970). The study covered the mainstem of the Yakima River from Richland upstream to Easton Dam (Figure 4-2), a total of approximately 281 kilometers (km). Patten et al. (1970) document catching 146 lamprey throughout 10 of 18 sample reaches. This included the collection of lamprey from the uppermost sample reach near Easton Dam, to the second to lowest sample reach. Although it is uncertain if these were Pacific Lamprey, western brook lamprey (*Lampetra richardsoni*), or both, this supports information from recent Washington Department of Fish and Wildlife (WDFW) and the YNPLP (Project 2008-470-00) surveys and oral histories indicating that lamprey utilized the entire mainstem Yakima River for migration and rearing.

Adult abundance was very low within the subbasin prior to 2016. Adult counts at Prosser Dam (river km (RKM) 75.7) from 2000 – 2016 (Figure 4-3) indicate that, on average approximately 20-40 adult lamprey have entered the subbasin per year and potentially moved into upper reaches suitable for spawning. In spring 2017, 555 adults were observed and counted passing Prosser Dam (Figure 4-3). This was a 38-fold increase compared to the previous 20-year average. This noticeable increase in adult returns in the Yakama River was observed four years after adult translocation efforts were expanded upstream of Prosser Dam (see **Section 4.3.3.1**). Although adult lamprey passage structures (vertical wetted walls) have been implemented at Prosser Dam since 2016, local and seasonal difficulties in passage at the various diversion dams in the subbasin (Grote et al. 2014) present numerous challenges to upstream migrations. Few adult lamprey have been observed at Roza Dam (RKM 210.5) since the new counting system was implemented in 1997; however, radio tagged lamprey that were transferred to the upper Yakima Subbasin approached the dam in 2012 and 2013 (Grote et al. 2014), and a group of translocated adults from the lower mainstem and tributaries have approached the dam more recently (with limited passage success).

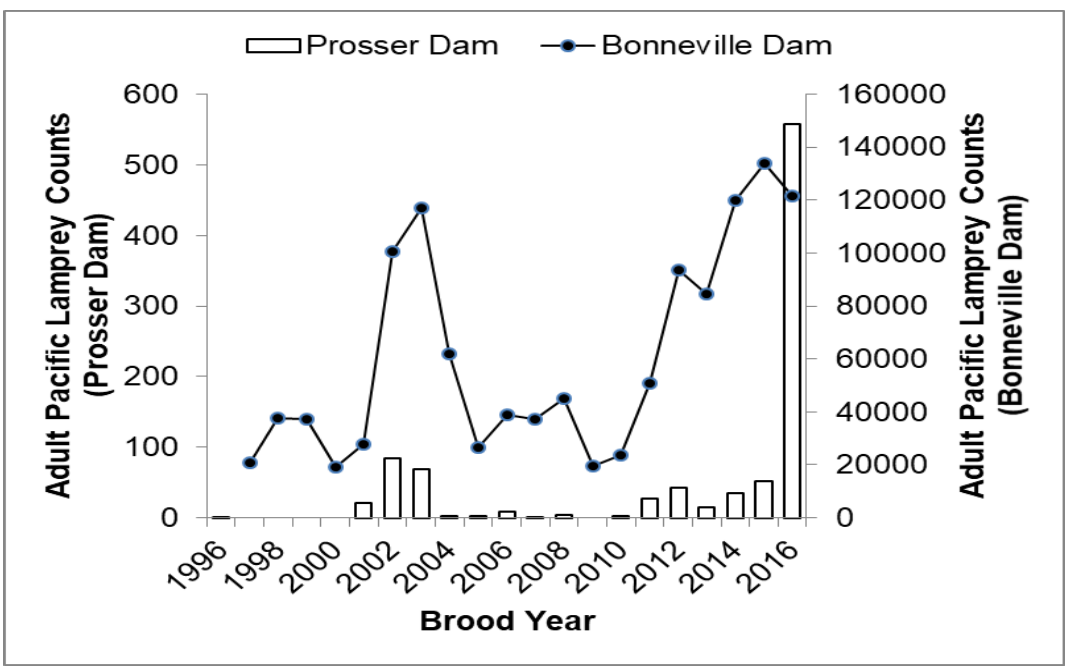


**Figure 4-3. Counts of adult Pacific Lamprey at Prosser Dam (Yakima River) compared to Bonneville Dam (Columbia River) by brood year.**

Because of the very low adult Pacific Lamprey returns over the past few decades, very little information exists that describes spawning activity, except in translocation streams. Tribal elders have shared some locations where adults were historically encountered during spawning, including Toppenish and Satus creeks, and middle reaches of the Yakima River. Given the combination of geomorphic characteristics (flow, gradient, and valley width), water temperature regime, and expert opinions, it is likely that Satus, Toppenish, Ahtanum, and Wenas creeks, and the Naches River and mainstem Yakima River (middle and upper reaches) would be productive spawning reaches. Tributaries in the upper Yakima, such as the Teanaway, Swaulk and Cle Elum rivers also appear to have suitable potential habitat and favorable conditions for Pacific Lamprey. More adult Pacific Lamprey translocated into the Upper Yakima in spring 2015 (**see Section 4.3.3**) entered the Teanaway River than the Swaulk and Taneum rivers (Lampman 2015).

Electrofishing surveys targeting larval lamprey were initiated in 2010 as part of YNPLP. Between 2010 and 2017 (including one site surveyed in 2009), a total of 452 electrofishing surveys occurred throughout the Yakima River Subbasin (Table 4-1; Table 4-2). These surveys have shown that Pacific Lamprey are in naturally low abundance throughout the subbasin, especially above Roza Dam (RKM 210.5), and in the upper Naches River (Lampman et al. 2014). Since adult translocation began in 2012, the abundance and distribution of Pacific Lamprey in the subbasin has increased. In the lower Yakima River (downstream of the Naches river confluence) between 2010 and 2012, Pacific Lamprey occupied only 10% of sites surveyed within the known Pacific Lamprey distribution (Table 4-1; Figure 4-4). However, between 2013 and 2017, Pacific Lamprey occupied 50% of surveyed sites, displaying substantially increased distribution and occupancy. Between 2010 and 2012, 7% of sites surveyed in lower Yakima River tributaries were occupied by Pacific Lamprey within the known Pacific Lamprey distribution; no Pacific Lamprey were found in Toppenish Creek (Table 4-1; Figure 4-5). However, between 2013 and 2017, occupancy in these streams increased extensively, with 72% of sites in Satus Creek, 100% of sites in Toppenish Creek, and 73% of sites in Ahtanum Creek occupied by Pacific Lamprey within the updated and extended Pacific Lamprey distribution.

No Pacific Lamprey were found in the Naches River prior to 2014 (Table 4-1; Figure 4-6). However, after a small release of radio tagged adults in 2013 and 2014, Pacific Lamprey were found at 44% of sites surveyed between 2014 and 2017 within the updated distribution of Pacific Lamprey. No Pacific Lamprey were found in the Upper Yakima River Subbasin (upstream of the Naches River confluence) between 2010 and 2015 (Table 4-2; Figure 4-7), prior to initiation of adult Pacific Lamprey translocation to sites upstream of Roza Dam in spring 2015. In 2016 and 2017, 44% of sites surveyed within the updated Pacific Lamprey distribution had Pacific Lamprey. In the Teanaway River, Pacific Lamprey were found at 57% of sites surveyed in 2016 and 2017 within the updated Pacific Lamprey distribution (Table 4-2; Figure 4-8).

Chandler Diversion at Prosser Dam (Figure 4-2) is a known migration corridor for outmigrating larval/juvenile Pacific Lamprey. Juvenile lamprey have been counted at Chandler Juvenile Fish Monitoring Facility since 2000 (Figure 4-9). The majority of collected lamprey (>75%) appear to be metamorphosed Pacific Lamprey. However, recent monitoring has shown that many of the lamprey captured in May and June were spawning and post-spawned Western Brook Lamprey. More monitoring is needed, but at least a portion of the early summer migrants in May and June may be adult Western Brook Lamprey instead of Pacific Lamprey juveniles. A small number of larvae (both Pacific Lamprey and Western Brook Lamprey) were also collected at the facility. Some of the juvenile lamprey migrating downstream may travel directly over Prosser Dam; however, because juvenile and larval lamprey are known to travel near the bottom, the portion that travel through the diversion may be relatively high (potentially >50%) because the head gate for the diversion opens from the river bottom. Although the extrapolated estimate of Pacific Lamprey from Chandler Diversion contains various assumptions, in general it provides a coarse relative abundance index value for juvenile Pacific Lamprey.

Analysis of run timing for outmigrating juveniles is limited in scope by the Prosser Dam sampling period, which typically runs between early January and mid-July. Recent data indicates two peak outmigration periods, one in winter and one in spring. The spring peak corresponds closely in timing with the adult counts at Prosser Dam. It appears that juveniles are keying into high flow events for outmigration and it is unlikely they are migrating in summer or fall when the flow is typically much lower and temperature is high. The Yakima Subbasin will continue to be monitored for Pacific Lamprey and ongoing effects from increased supplementation efforts throughout the subbasin (adult translocation primarily in the Lower Yakima Subbasin and larval outplanting primarily in the Upper Yakima and Naches subbasins).

**Table 4-1. Number of survey sites in the lower Yakima River Subbasin and the Naches River relative to known distribution of Pacific Lamprey, including the number of sites with larvae confirmed to be Pacific Lamprey.**

| Watershed, Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| **Lower Yakima** | | | | | | |
| Yakima River | 2010 | 73.5-191.8 | 21 | 0 | 29 | 3 |
| | 2011 | | 0 | 0 | 9 | 0 |
| | 2012 | | 0 | 0 | 22 | 3 |
| | 2013 | | 0 | 0 | 10 | 2 |
| | 2014 | | 1 | 0 | 3 | 1 |
| | 2015 | | 1 | 0 | 5 | 4 |
| | 2016 | | 0 | 0 | 4 | 3 |
| | 2017 | 13.0-191.8 | 0 | 0 | 4 | 3 |
| Satus Creek | 2010 | 12.9-41.2 | 1 | 1 | 2 | 0 |
| | 2011 | | 1 | 3 | 4 | 0 |
| | 2012 | | 4 | 0 | 6 | 1 |
| | 2013 | | 0 | 0 | 4 | 1 |
| | 2014 | | 2 | 0 | 4 | 2 |
| | 2015 | | 1 | 0 | 3 | 3 |
| | 2016 | | 0 | 0 | 4 | 4 |
| | 2017 | 12.9-43.8 | 0 | 1 | 3 | 3 |
| Toppenish Creek | 2010 | 44.6-44.7 | 6 | 3 | 1 | 0 |
| | 2011 | | 0 | 0 | 0 | -- |

| Watershed, Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| | 2012 | | 2 | 3 | 0 | -- |
| | 2013 | | 1 | 2 | 0 | -- |
| | 2014 | | 3 | 2 | 0 | -- |
| | 2015 | | 1 | 2 | 1 | 1 |
| | 2016 | | 4 | 3 | 0 | -- |
| | 2017 | 43.5-73.0 | 1 | 0 | 3 | 3 |
| Simcoe Creek | 2010 | -- | -- | 5 | -- | -- |
| | 2011 | | -- | 0 | -- | -- |
| | 2012 | | -- | 2 | -- | -- |
| | 2013 | | -- | 1 | -- | -- |
| | 2014 | | -- | 2 | -- | -- |
| | 2015 | | -- | 1 | -- | -- |
| | 2016 | 9.0-9.0 | 0 | 0 | 1 | 1 |
| | 2017 | | 0 | 0 | 1 | 1 |
| Ahtanum Creek | 2010 | 0.9-31.9 | 0 | 3 | 7 | 1 |
| | 2011 | | 0 | 0 | 1 | 0 |
| | 2012 | | 0 | 0 | 5 | 0 |
| | 2013 | | 0 | 1 | 2 | 1 |
| | 2014 | | 0 | 0 | 4 | 1 |
| | 2015 | | 0 | 0 | 4 | 3 |
| | 2016 | 0.9-34.9 | 0 | 0 | 5 | 5 |
| | 2017 | | 0 | 0 | 4 | 4 |
| **Naches River** | | | | | | |
| Naches River | 2010 | 1.7-29.0 | 0 | 3 | 7 | 0 |
| | 2011 | | 0 | 0 | 1 | 0 |
| | 2012 | | 0 | 6 | 1 | 0 |
| | 2013 | | 0 | 2 | 3 | 0 |
| | 2014 | | 0 | 3 | 4 | 1 |
| | 2015 | | 0 | 2 | 6 | 3 |
| | 2016 | 1.7-41.9 | 1 | 1 | 7 | 4 |
| | 2017 | | 1 | 0 | 3 | 2 |

RKM = river kilometer

**Table 4-2. Number of survey sites in the upper Yakima River Subbasin relative to known distribution of Pacific Lamprey, including the number of sites with larvae confirmed to be Pacific Lamprey.**

| Watershed, Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| Yakima River | 2010 | 191.8-195.3 | - | 4 | 1 | 1 |
| | 2011 | | 0 | 41 | 0 | -- |
| | 2012 | | 0 | 8 | 1 | 0 |
| | 2013 | | 0 | 13 | 0 | -- |
| | 2014 | | 0 | 14 | 0 | -- |
| | 2015 | | 0 | 12 | 0 | -- |
| | 2016 | 191.8-318.3 | 0 | 0 | 10 | 4 |
| | 2017 | | 0 | 0 | 8 | 4 |
| Wenas Creek | 2010 | -- | -- | 0 | -- | -- |
| | 2011 | | -- | 3 | -- | -- |
| | 2012 | | -- | 5 | -- | -- |
| | 2013 | | -- | 0 | -- | -- |
| | 2014 | | -- | 3 | -- | -- |
| | 2015 | | -- | 6 | -- | -- |
| | 2016 | | -- | 4 | -- | -- |
| | 2017 | | -- | 0 | -- | -- |
| SwaukCreek | 2010 | -- | -- | -- | -- | -- |
| | 2011 | | -- | 8 | -- | -- |
| | 2012 | | -- | 1 | -- | -- |
| | 2013 | | -- | 0 | -- | -- |
| | 2014 | | -- | 0 | -- | -- |
| | 2015 | | -- | 0 | -- | -- |
| | 2016 | | -- | 0 | -- | -- |
| | 2017 | | -- | 2 | -- | -- |
| Taneum Creek | 2010 | -- | -- | 0 | -- | -- |
| | 2011 | | -- | 4 | -- | -- |
| | 2012 | | -- | 1 | -- | -- |
| | 2013 | | -- | 0 | -- | -- |
| | 2014 | | -- | 0 | -- | -- |
| | 2015 | | -- | 0 | -- | -- |
| | 2016 | | -- | 0 | -- | -- |
| | 2017 | | -- | 0 | -- | -- |

| Watershed, Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| Teanaway River | 2010 | -- | -- | 0 | -- | -- |
| | 2011 | | -- | 3 | -- | -- |
| | 2012 | | -- | 0 | -- | -- |
| | 2013 | | -- | 0 | -- | -- |
| | 2014 | | -- | 0 | -- | -- |
| | 2015 | | -- | 0 | -- | -- |
| | 2016 | 0.3-7.1 | 1 | 0 | 5 | 2 |
| | 2017 | | 0 | 0 | 2 | 2 |

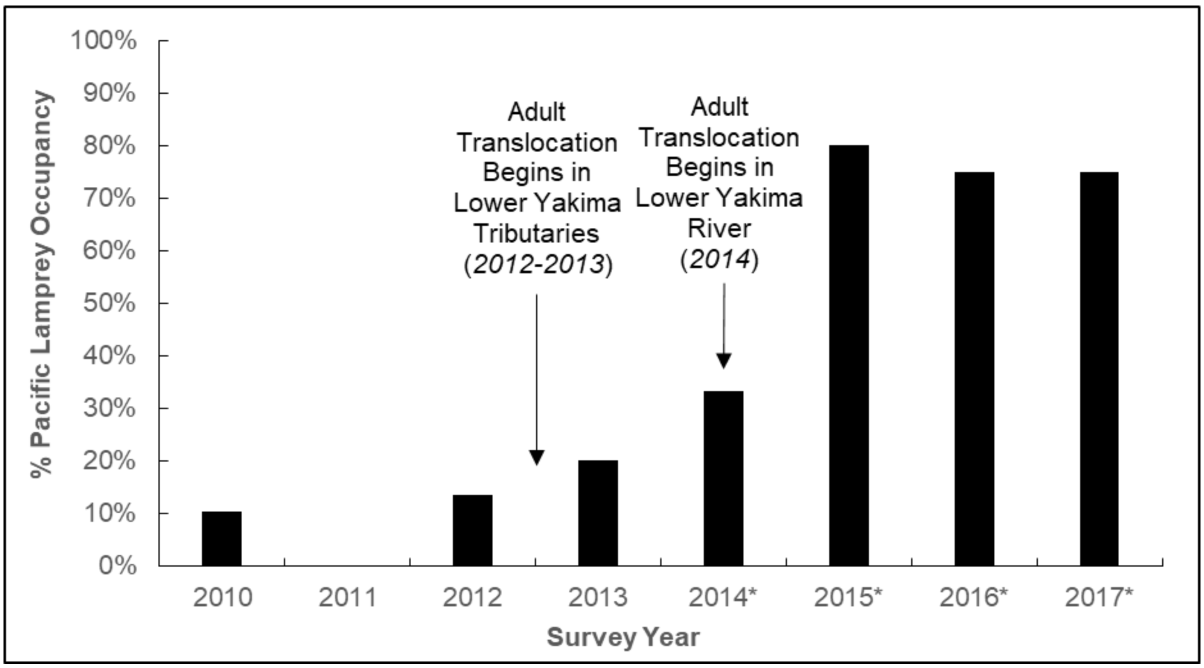


**Figure 4-4. Pacific Lamprey site occupancy in the Lower Yakima River (downstream of the Naches River confluence). Asterisks indicate years in which adult Pacific Lamprey were actively translocated.**

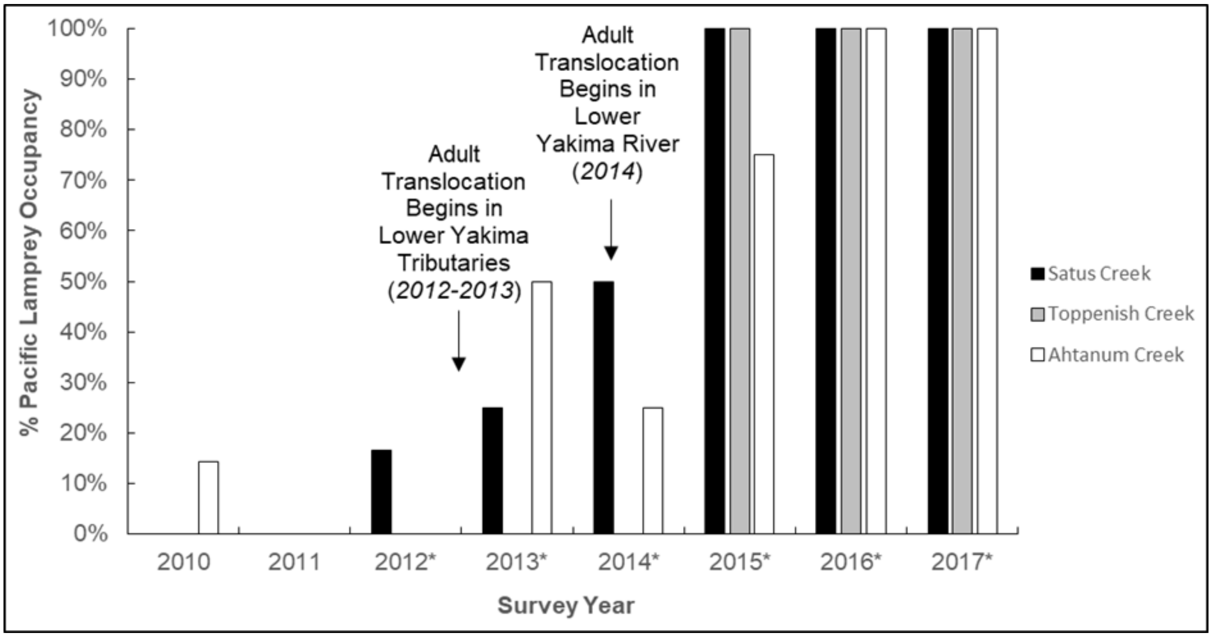


**Figure 4-5. Pacific Lamprey site occupancy in Lower Yakima River tributaries (Satus, Toppenish and Ahtanum creeks). Asterisks indicate years in which adult Pacific Lamprey were actively translocated (Satus Creek started in 2012 and Toppenish and Ahtanum creeks in 2013).**

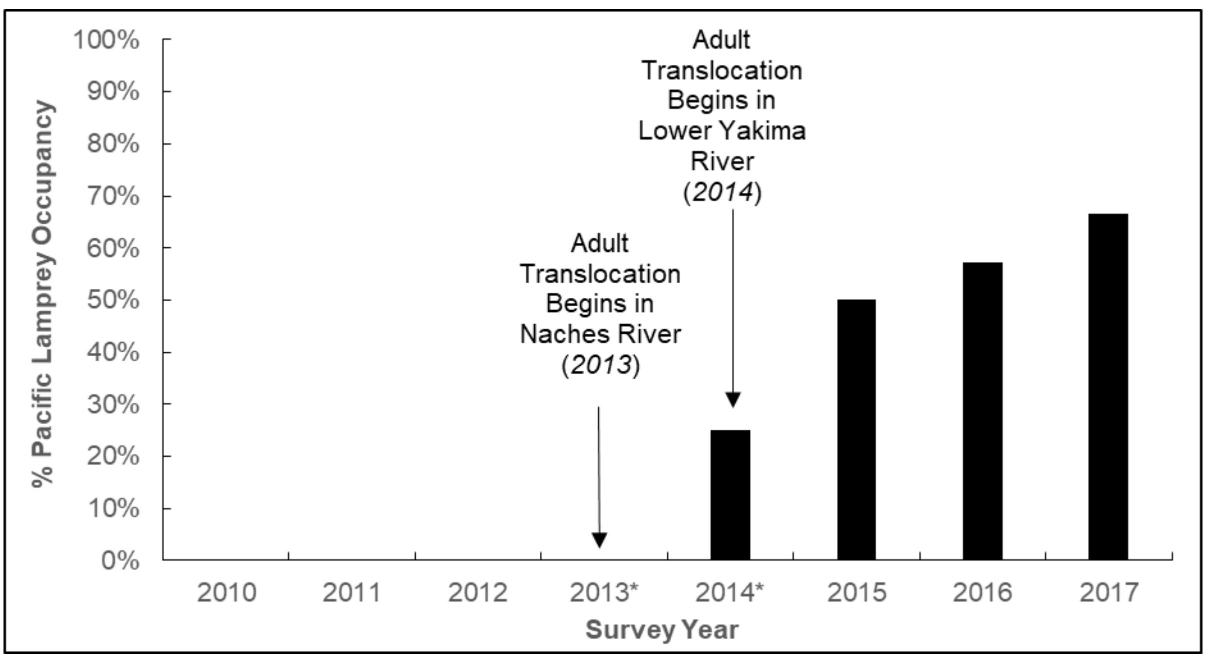


**Figure 4-6. Pacific Lamprey site occupancy in the Naches River. Asterisks indicate years in which adult Pacific Lamprey were actively translocated.**

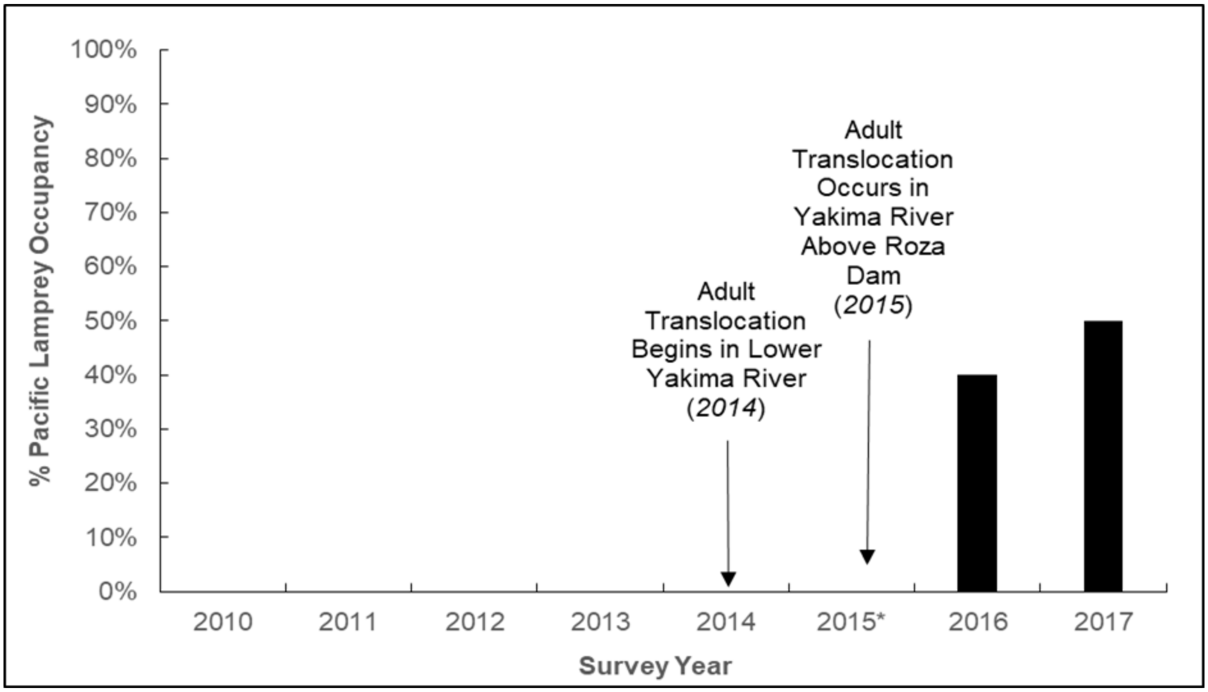


**Figure 4-7. Pacific Lamprey site occupancy in the upper Yakima River. Asterisks indicate years in which adult Pacific Lamprey were actively translocated.**

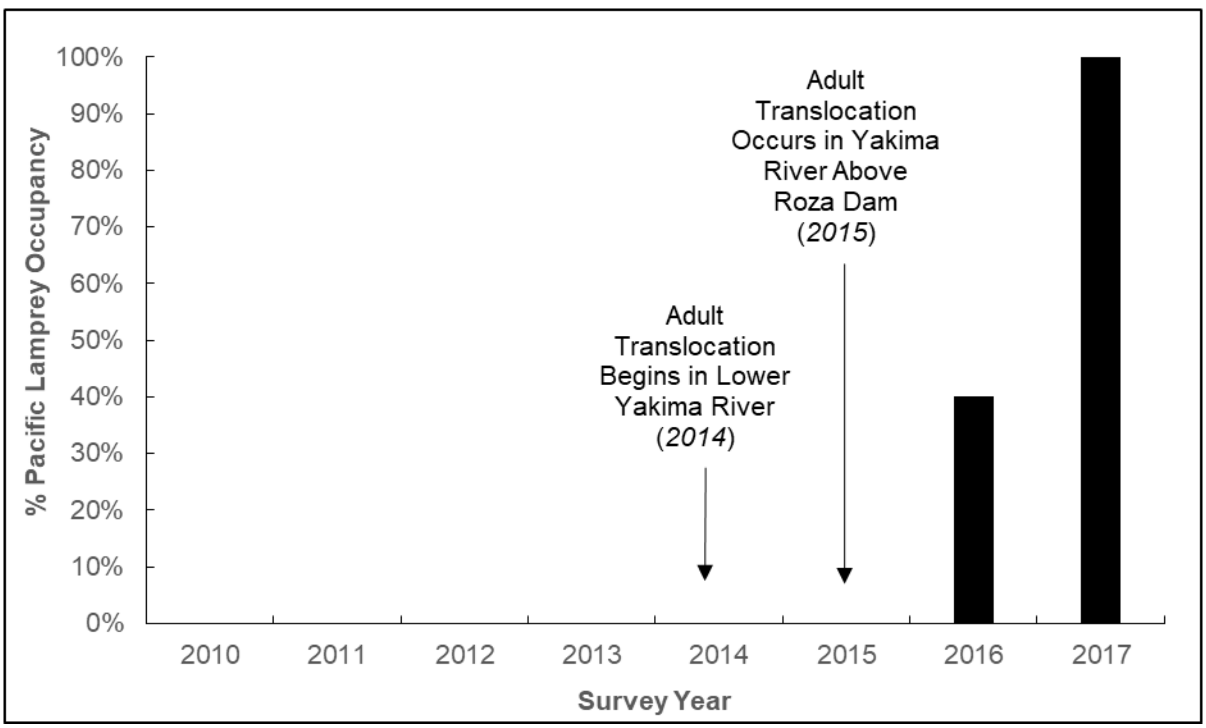


**Figure 4-8. Pacific Lamprey site occupancy in the Teanaway River in the upper Yakima River Subbasin.**

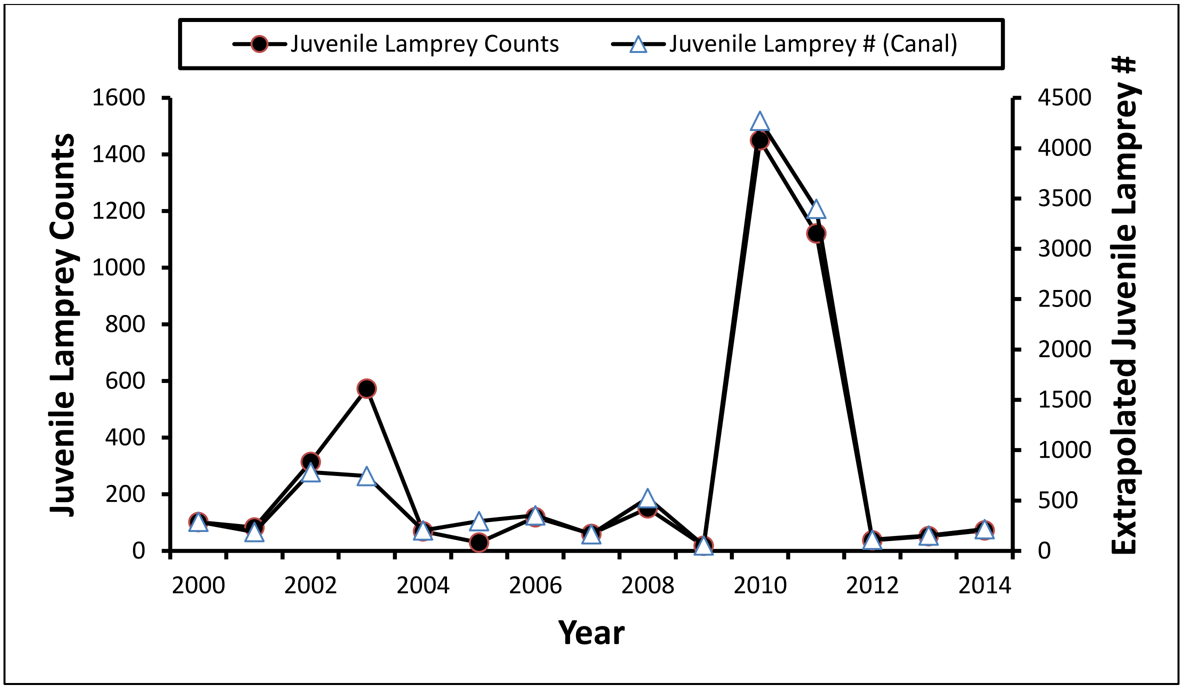


**Figure 4-9. Juvenile lamprey counts vs. extrapolated juvenile lamprey numbers from Chandler Juvenile Fish Monitoring Facility (Prosser Dam) between 2000 and 2014 based on subsampling rates.**

## 4.1.2 Methow River Subbasin

### 4.1.2.1 Subbasin Description

The Methow Subbasin encompasses an area of about 1,825 square miles in north-central Washington. It is characterized by large tracts of pristine habitat with over 80% of all lands in the watershed managed by the U.S. Forest Service. The Pasayten Wilderness borders the northern reaches, and the Lake Chelan-Sawtooth Wilderness borders the southwest rim. Major tributaries of the Methow River are the Lost, Chewuch, and Twisp Rivers. The Methow River flows into the Columbia River at river mile 524 near Pateros in central Washington just upstream from the Wells Dam.

Nearly two-thirds of the watershed's annual precipitation occurs between October and March, falling primarily as snow. Higher elevations (up to 8,600 feet) receive as much as 80 inches of precipitation a year while lower elevations (approximately 800 feet) receive only about 10 inches of precipitation annually. Average annual runoff from the Methow Subbasin is 12 inches.

Less than two percent of the land in the subbasin is irrigated, and no hydropower development has occurred. Activities related to timber harvest take place in the middle and upper reaches of the watershed. The height of logging occurred in the 1980s contributing to high road densities in some portions of the watershed, particularly concentrated around the Beaver Creek drainage (KWA Ecological Services et al. 2004).

### 4.1.2.2 Pacific Lamprey Status

It is likely that Pacific Lamprey occurred historically throughout the Methow Subbasin in conjunction with anadromous salmonids. Pacific Lamprey abundance estimates have primarily been limited to counts of adults and juveniles at Upper Columbia River dams or within subbasin juvenile salmon traps. No larval Pacific Lamprey were observed at any of the nine sample locations in the upper Methow and Twisp rivers during surveys conducted from 2013 through 2016 (Beals and Lampman 2017).

Counts of Pacific Lamprey over Wells Dam indicate that abundance was over one thousand in 2003, but counts have since declined precipitously (Figure 4-10). Less than 40 adults were counted annually starting in 2006, and less than 10 adults were annually counted starting in 2008. It is uncertain what caused the dramatic declines from 2006 through 2016. However, in 2017, 287 adults were counted (two years after adult translocation began in Methow Subbasin), making it the fifth largest count since counting began in 1998.

Pacific Lamprey larvae have been sampled during electrofishing surveys in the lower Methow River and in the Chewuch River each year since 2008, with involvement by the YN beginning in 2013 (Table 4-3; Figure 4-11). In the lower Methow Subbasin between 2013 and 2015, Pacific Lamprey were found at 70% sites surveyed within the known distribution of Pacific Lamprey in the lower reach of the mainstem Methow (RKM 2.9-81.4). Adult translocation began in 2015 in the lower Methow Subbasin in response to a declining abundance and lack of recruitment (i.e. virtually no younger age class larvae). In 2016 (first year post-translocation), Pacific Lamprey occupancy decreased, with larvae found at 33%) of surveyed sites. However, in 2017, Pacific Lamprey were found at 100% surveyed sites.

Pacific Lamprey were found at 79% of surveyed sites in the Chewuch River between 2013 and 2015 (Table 4-3; Figure 4-12). In 2016 and 2017 (after translocation began in 2015), Pacific Lamprey were found at 70%) sites surveyed. No Pacific Lamprey have been found in the Twisp River or the upper Methow River to date, but adult translocation began in 2017. In 2016, YN confirmed (through genetic analysis) the presence of *Lampetra* species in the Chewuch River at RKM 16.1, confirming the presence of both Pacific Lamprey and *Lampetra* in the Methow Subbasin.

The outmigration of larval and juvenile lamprey has been monitored from late winter or spring through summer or fall since 2004 using a rotary-screw trap located about 18 miles upriver from the mouth. The majority of the captures were larvae, and catch rate of larvae from 2012 through 2014 decreased substantially from previous years (Figure 4-13). The Methow Subbasin will continue to be monitored for Pacific Lamprey status and trends and ongoing effects from increased adult translocation throughout the subbasin.

**Table 4-3. Number of survey sites in the Methow River Subbasin relative to known distribution of Pacific Lamprey, including the number of sites with larvae confirmed to be Pacific Lamprey.**

| Watershed, Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| **Lower Methow** | | | | | | |
| Methow River | 2013 | 2.9-81.4 | 1 | 0 | 4 | 3 |
| | 2014 | | 0 | 0 | 3 | 2 |
| | 2015 | | 0 | 0 | 3 | 2 |
| | 2016 | | 0 | 0 | 6 | 2 |
| | 2017 | | 0 | 0 | 3 | 3 |
| Twisp River | 2013 | -- | 0 | 1 | 0 | -- |
| | 2014 | | -- | -- | -- | -- |
| | 2015 | | -- | -- | -- | -- |
| | 2016 | | 0 | 2 | 0 | -- |
| | 2017 | | -- | -- | -- | -- |
| **Upper Methow** | | | | | | |
| Methow River | 2013 | -- | 0 | 4 | 0 | -- |
| | 2014 | | -- | -- | -- | -- |
| | 2015 | | -- | -- | -- | -- |
| | 2016 | | 0 | 2 | 0 | -- |
| | 2017 | | -- | -- | -- | -- |
| Chewuch River | 2013 | 0.8-51.7 | 0 | 2 | 5 | 4 |
| | 2014 | | 0 | 0 | 4 | 4 |
| | 2015 | | 0 | 0 | 5 | 3 |
| | 2016 | | 0 | 0 | 5 | 4 |
| | 2017 | | 0 | 0 | 5 | 3 |

RKM = river kilometer

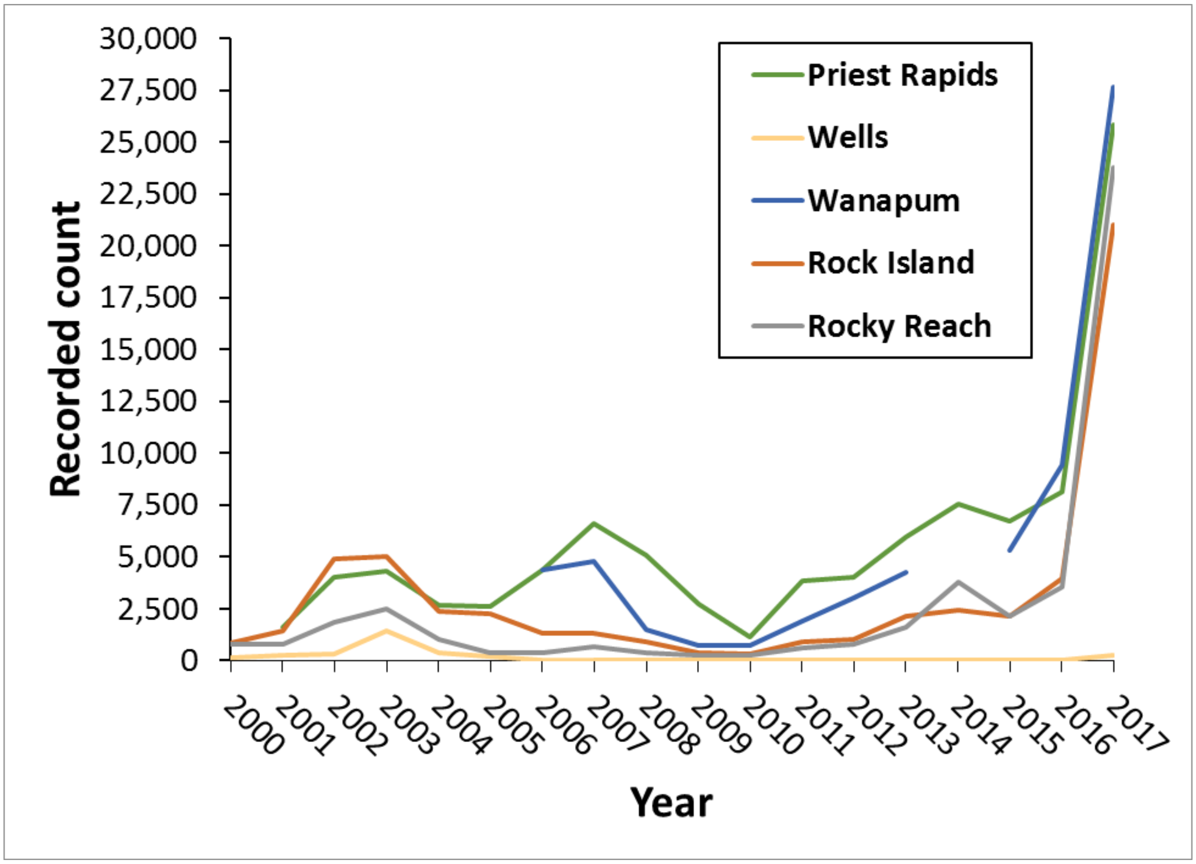


**Figure 4-10. Number of Pacific Lamprey ascending dams in the middle Columbia River, 2010 – 2017 (FPC 2018).**

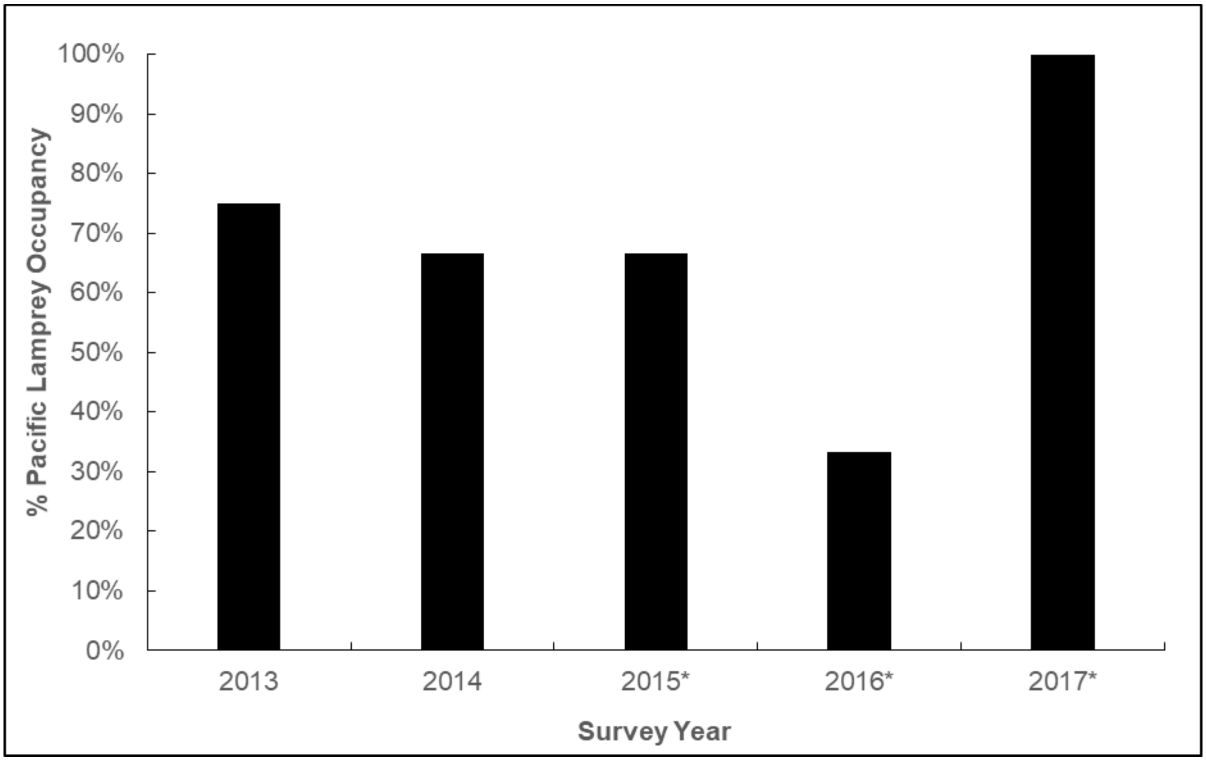


**Figure 4-11. Pacific Lamprey site occupancy in the Lower Methow River. Asterisks indicate years in which adult Pacific Lamprey were actively translocated.**

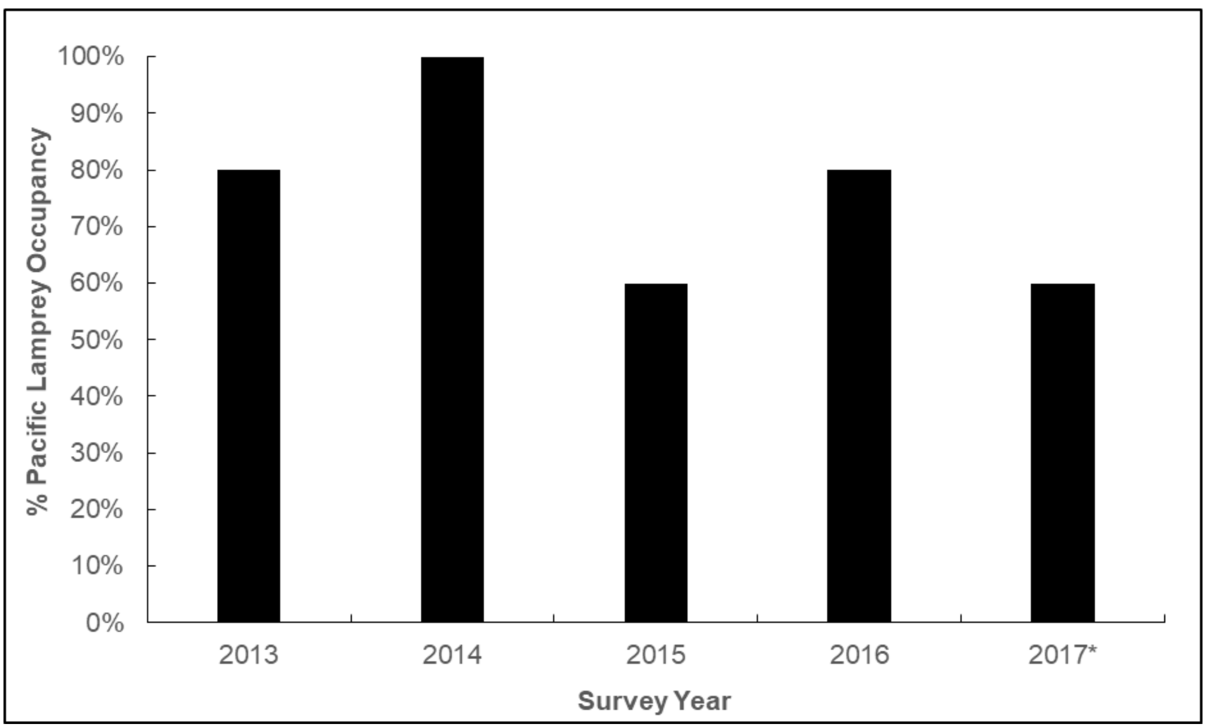


**Figure 4-12. Pacific Lamprey site occupancy in the Chewuch River. Asterisks indicate years in which adult Pacific Lamprey were actively translocated.**

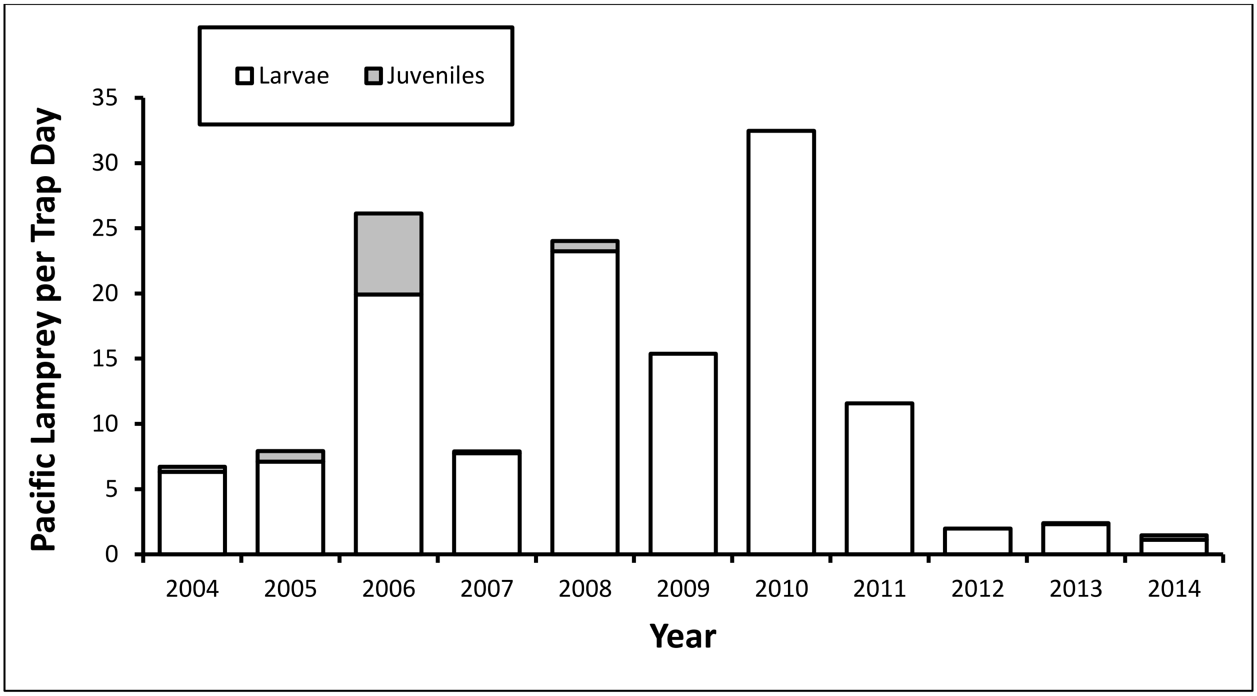


**Figure 4-13. Catch of Pacific Lamprey larvae and juveniles per day of trapping in the Methow River.**

### 4.1.3 Klickitat River Subbasin

#### 4.1.3.1 Subbasin Description

The Klickitat Subbasin encompasses an area of 1,350 square miles in south-central Washington. The Cascade Mountain range forms the eastern boundary; the basalt ridges and plateaus of the Yakama Indian Reservation make up the northern portion; and the Columbia River Gorge forms the southern boundary. The Klickitat River has its headwaters in the Goat Rocks Wilderness and flows just over 95 miles to the Columbia River at river mile 180, 34 miles upstream of the Bonneville Dam. It is one of the longest undammed rivers in the northwest.

Approximately 75% of the Klickitat Subbasin is forested whereas most of the remaining 25% is agricultural land concentrated in the Glenwood/Camas Prairie area. 8,600 acres within the subbasin are irrigated. Precipitation decreases dramatically from west to east across the subbasin, ranging from 140 inches on Mount Adams to nine inches on the southeastern plateau. Approximately 80% of all precipitation falls between November and May (Yakama Nation et al. 2004).

#### 4.1.3.2 Pacific Lamprey Status

Pacific Lamprey are known to occur in the Klickitat Subbasin; however, little is known about historic distribution and status. A rotary screw trap has been in operation since 1995 upstream of Lyle Falls in the lower river. A maximum of 3,772 and 200 larval/juvenile lamprey were captured per year and per day, respectively (outmigration appears to occur throughout the year with no apparent peak season).

Electrofishing surveys in the subbasin by YN between 2009 and 2017 revealed that Pacific Lamprey occupied 92% of sites surveyed within the known Pacific Lamprey distribution (Table 4-4). In 2017, larval Pacific Lamprey were found also immediately upstream of the Klickitat Fish Hatchery weir (RKM 69.5), showing that adult Pacific Lamprey can successfully navigate past the weir, but passage efficiency is still assumed to be low and seasonal. In the Little Klickitat River, Pacific Lamprey occupied 100% of sites surveyed between 2009 and 2017 within the known Pacific Lamprey distribution. The Klickitat River Subbasin will continue to be monitored for Pacific Lamprey status and trends throughout the subbasin primarily as a "control" subbasin with no, or minimal, supplementation.

**Table 4-4. Number of survey sites in the Klickitat River Subbasin relative to known distribution of Pacific Lamprey, including the number of sites with larvae confirmed to be Pacific Lamprey.**

| Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| Klickitat River | 2009 | 0.0-69.3 | -- | 3 | 27 | 25 |
| | 2010 | | -- | 0 | 0 | -- |
| | 2011 | | -- | 0 | 1 | 1 |
| | 2012 | | -- | 0 | 0 | -- |
| | 2013 | | -- | 4 | 8 | 8 |
| | 2014 | | -- | 0 | 5 | 4 |
| | 2015 | | -- | 3 | 6 | 5 |
| | 2016 | 0.0-69.4 | -- | 0 | 0 | -- |
| | 2017 | | 0 | 2 | 4 | 4 |
| Little Klickitat River | 2009 | 0.5-2.8 | 0 | 14 | 2 | 2 |
| | 2010 | | 0 | 0 | 0 | -- |
| | 2011 | | 0 | 0 | 0 | -- |
| | 2012 | | 0 | 0 | 0 | -- |
| | 2013 | | 0 | 2 | 0 | -- |
| | 2014 | | 0 | 0 | 0 | -- |
| | 2015 | | 0 | 0 | 0 | -- |
| | 2016 | | 0 | 0 | 0 | -- |
| | 2017 | | 0 | 0 | 1 | 1 |

RKM = river kilometer

## 4.1.4 Entiat River Subbasin

### 4.1.4.1 Subbasin Description

The Entiat Subbasin encompasses an area of 466 square miles located in north-central Washington. The Chelan Mountains bound the basin in the northeast portion, and the Entiat Mountains comprise the southwestern border. The headwaters lie in the Glacier Peak Wilderness flowing 57 miles before joining the Columbia River at river mile 484. The major tributary to the Entiat River is the Mad River. The Entiat watershed has no reservoirs, although the lowest 0.5 miles of the river is influenced by the backwatering effects of the Rocky Reach Dam on the Columbia River.

The climate of the Entiat Subbasin is characterized by extreme temperature variations with temperatures in the 90s and 100s lasting several weeks in the summer, and single digit/sub-zero temperatures for short periods in the winter. Water temperature and pH have exceeded state standards in the lower Entiat since 1992 (Peven et al. 2004). Approximately 75% of the mean annual precipitation falls from October through March primarily falling as snow in the winter.

### 4.1.4.2 Pacific Lamprey Status

Historical distribution of Pacific Lamprey was likely coincident wherever salmonids occurred in the Entiat Subbasin. Current adult abundance is mostly unknown, except for count differences between Rocky Reach and Wells dams. Detailed accounts of historical distribution, abundance, and productivity of adult Pacific Lamprey are difficult to determine because of the lack of specific information; however, it is reasonable to assume that current lamprey presence is lower than historic.

Incidental collections of Pacific Lamprey larvae and juveniles have been summarized by the USFWS (Nelson et al. 2014). Larvae were found throughout the Entiat River as far upstream as RKM 42 during 2008-2012 electrofishing surveys for salmonids. In addition, both YN and USFWS have found lampreys in the upper reaches in recent years (in 2013 at RKM 46.4 and in 2014 at RKM 46.2). No larvae have been detected in the Mad River. The YN initiated larval lamprey surveys in 2012, and these surveys are repeated every two years in index sites as well as exploratory sites (Table 4-5). Pacific Lamprey were collected at 92% of sites surveyed within the known Pacific Lamprey distribution between 2012 and 2016. In 2016, YN morphologically and genetically confirmed the presence of *Lampetra* larval lamprey at RKM 46.5, confirming the presence of Pacific Lamprey and *Lampetra* species in the Entiat Subbasin.

**Table 4-5. Number of survey sites in the Entiat River Subbasin, relative to known distribution of Pacific Lamprey including the number of sites with larvae confirmed to be Pacific Lamprey.**

| Stream | Year | Known Pacific Lamprey Distribution (RKM) | Number of Sites Surveyed Relative to Known Pacific Lamprey Distribution | | | Sites occupied within Pacific Lamprey Distribution |
|---|---|---|---|---|---|---|
| | | | Downstream | Upstream | Within | |
| Entiat River | 2012 | 1.2-46.4 | 2 | 0 | 3 | 3 |
| | 2013 | | 0 | 0 | 0 | -- |
| | 2014 | | 0 | 3 | 6 | 5 |
| | 2015 | | 0 | 0 | 0 | -- |
| | 2016 | | 0 | 2 | 4 | 4 |
| | 2017 | | 0 | 0 | 0 | -- |

RKM = river kilometer

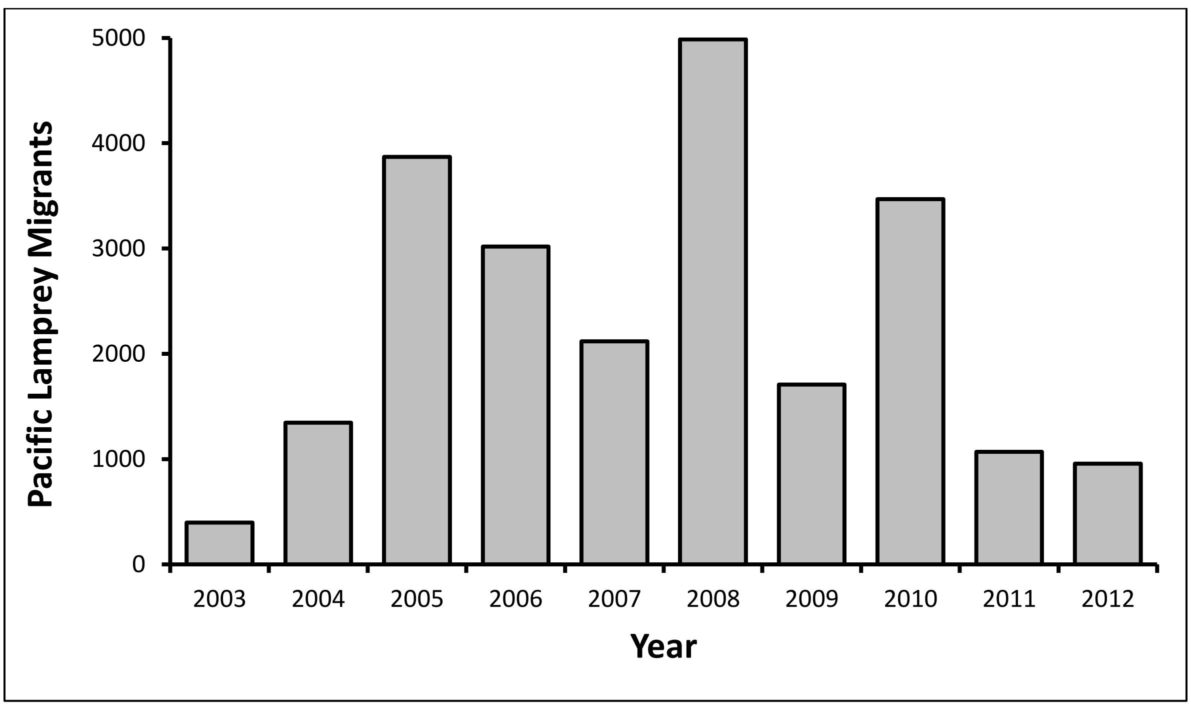


**Figure 4-14. Number of Pacific Lamprey downstream migrants (larvae and juveniles combined) collected at traps in the lower Entiat River, 2003-12.**

## 4.1.5 Umatilla River Subbasin

### 4.1.5.1 Subbasin Description

The Umatilla River originates in the Blue Mountains of northeastern Oregon and flows north and west to enter the Columbia River in Umatilla, Oregon (Figure 4-15). The mainstem Umatilla River is 89 miles long and drains an area of nearly 2,290 square miles (Phelps 2004). Elevations in the Umatilla River Subbasin range from about 5,800 feet near Pole Springs on Thimbleberry Mountain to 260 feet at the confluence with the Columbia River. Most precipitation in the subbasin falls during fall, winter and spring. Precipitation falls mainly as rain in the northwestern, low elevation portion of the subbasin and averages approximately nine inches annually. Up to 55 inches of precipitation falls in high-elevation areas of the Blue Mountains with much of this occurring as snowfall.

Water development for irrigation has had a large impact on both the hydrology and ecology of the Umatilla River Subbasin. Irrigated agriculture is served by six diversion dams found in the lower Umatilla River and two reservoirs. During summer, discharge in the lower Umatilla River decreases with water withdrawals and increases slightly with irrigation return water. Water is released from McKay Reservoir at RM 50.5 during peak irrigation periods. The impact of water storage in McKay Reservoir and releases during summer is to lower mean monthly instream flows during winter when water is stored and increase flows during the summer when stored water is released for irrigation.

### 4.1.5.2 Pacific Lamprey Status

In 1999, the CTUIR developed and began implementing a peer-reviewed restoration plan for Pacific Lamprey (Project 1994-026-00; Close 1999). The restoration plan called for 1) locating an appropriate donor stock for translocation of adult Pacific Lamprey, 2) identifying suitable and sustainable habitat within the subbasin for spawning and rearing, 3) translocating up to 500 adult lamprey annually, and 4) long-term monitoring of spawning success, changes in larval density and distribution, juvenile growth and outmigration, and adult returns. Translocations of adults began in 2000. The number of adults observed in the Umatilla River increased beginning four years after the first translocations, with a clear increase beginning after six years (Figure 4-16) although the total number of individuals entering the Umatilla River remained relatively low through 2010.

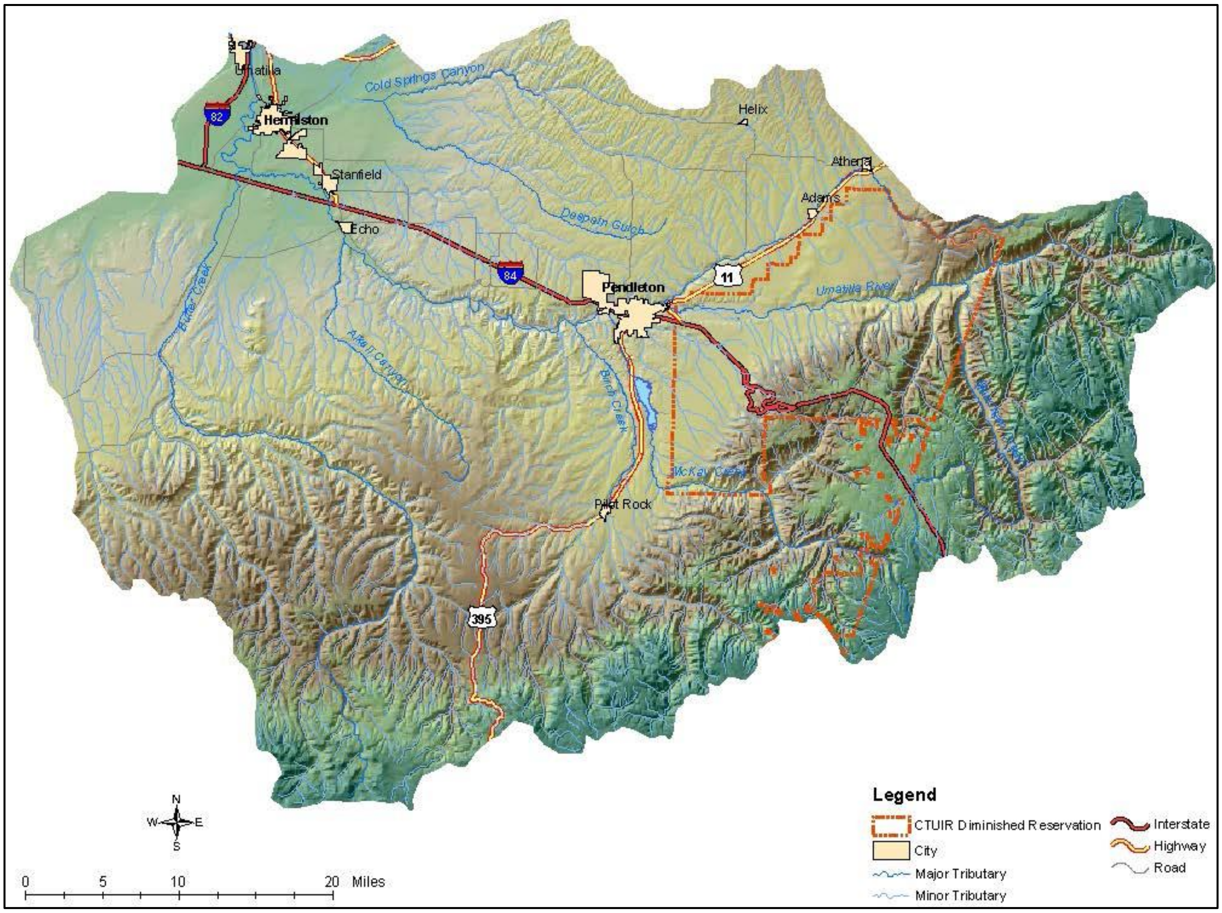


**Figure 4-15. Umatilla River Subbasin.**

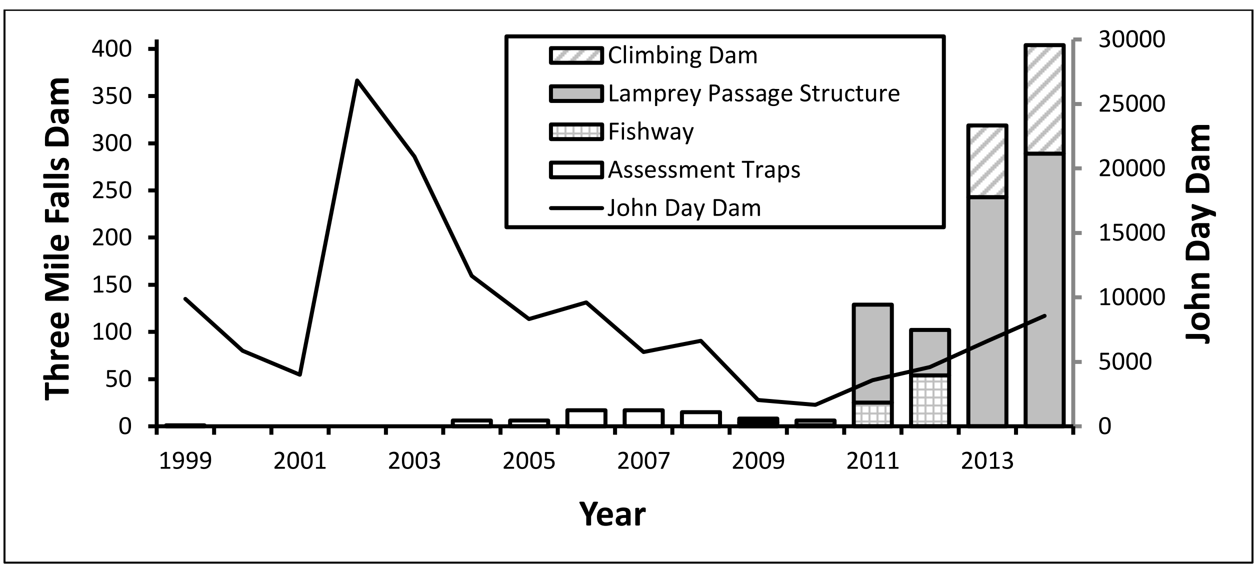


**Figure 4-16. Number of adult Pacific Lamprey counted at Three Mile Falls Dam on the Umatilla River (bars) and at John Day Dam on the Columbia River (line).**

Information on adult run timing into the Umatilla River Subbasin is limited to what can be concluded from counts at Three Mile Falls Dam since adults began entering the Umatilla River again in 2004. Information collected since adults began returning in greater numbers in 2011 indicates that numbers of returning adults appears to peak in May and then again in August/September (Figure 4-17). During these same years, adults were generally observed at John Day Dam from May through October, with counts peaking in early August. It is likely that the adult lamprey observed at Three Mile Falls Dam in May had passed John Day Dam the previous year and held in the Columbia River prior to ascending the Umatilla River to spawn. Fish observed at three Mile Falls Dam in August/September likely passed John Day Dam the same year, and some may over-winter in the Umatilla River before spawning.

Little is known about the current extent of Pacific Lamprey spawning in the Umatilla River Subbasin; however, in 2001, 2002, 2009, and 2010 surveys were conducted by foot on the Umatilla River and Meacham Creek to locate Pacific Lamprey redds. In 2001, 19 viable redds were found in the Umatilla River and 30 were found in Meacham Creek. In 2002, 21 viable redds were found in the Umatilla River and 46 were found in Meacham Creek. Mean egg viability per redd was 93.4% in the Umatilla River and 81.4% in Meacham Creek. No redds were found in the North Fork or the South Fork of the Umatilla River.

The outmigration of larval and metamorphosed lamprey has been monitored from approximately October through May using rotary-screw trap located about 1.2 miles upriver from the mouth (Figure 4-18). Abundance of outmigrating lamprey in the Umatilla River has increased in most years since restoration efforts began.

Thirty sites have been sampled in the Umatilla River in August and September annually since 1999 to document larval densities and distribution. Larval density in these index plots sharply increased one year after translocation of adult lamprey (Figure 4-19). Mean densities remained elevated through 2014. Larval distribution also increased through time. In the years prior to translocation of adults, no larvae were found in the upper Umatilla River. One year after translocation of adults, larval densities increased and the distribution of larvae moved downstream. By 2007, larval distribution extended downstream to the middle reaches of the Umatilla River, with little change in larval densities in the lower river. Distribution in 2011 was similar to that in 2007.

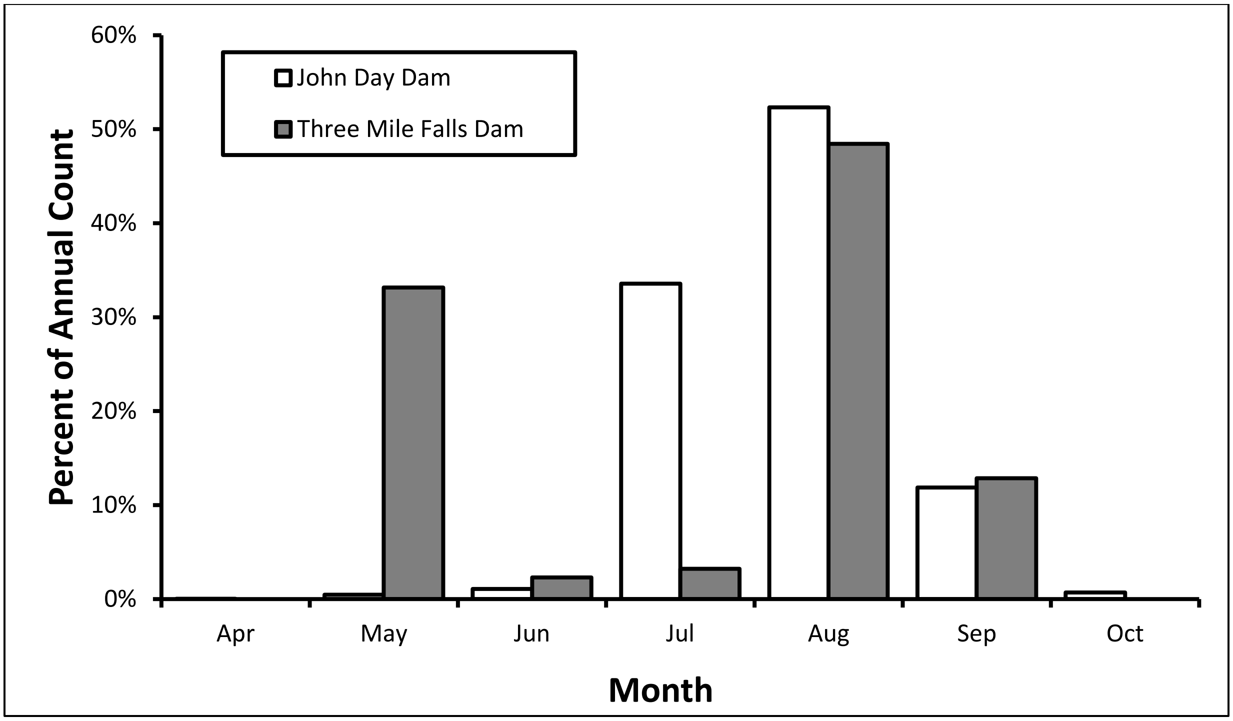


**Figure 4-17. Average 2011-2013 run timing of adult Pacific Lamprey at John Day and Three Mile Falls dams expressed as mean percent of annual counts.**

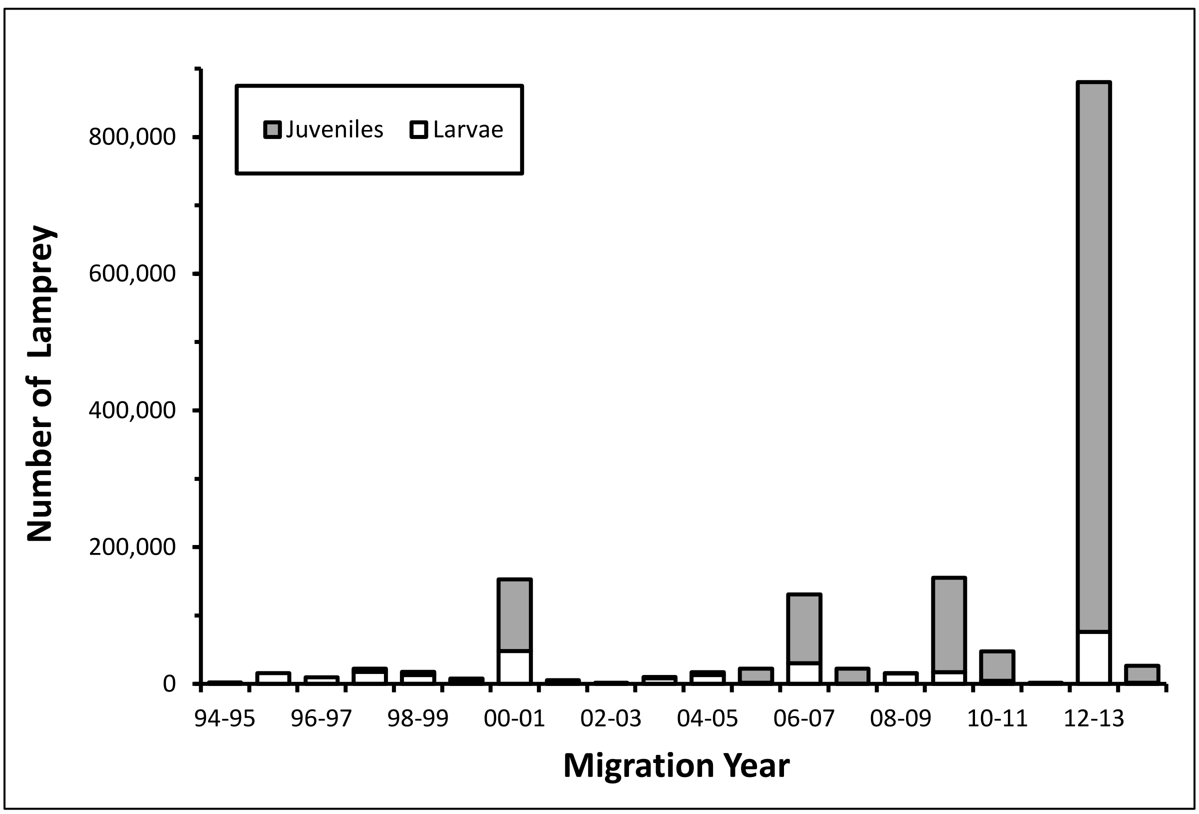


**Figure 4-18. Yearly estimates of the number of migrating Pacific Lamprey larvae and juveniles in the lower Umatilla River.**

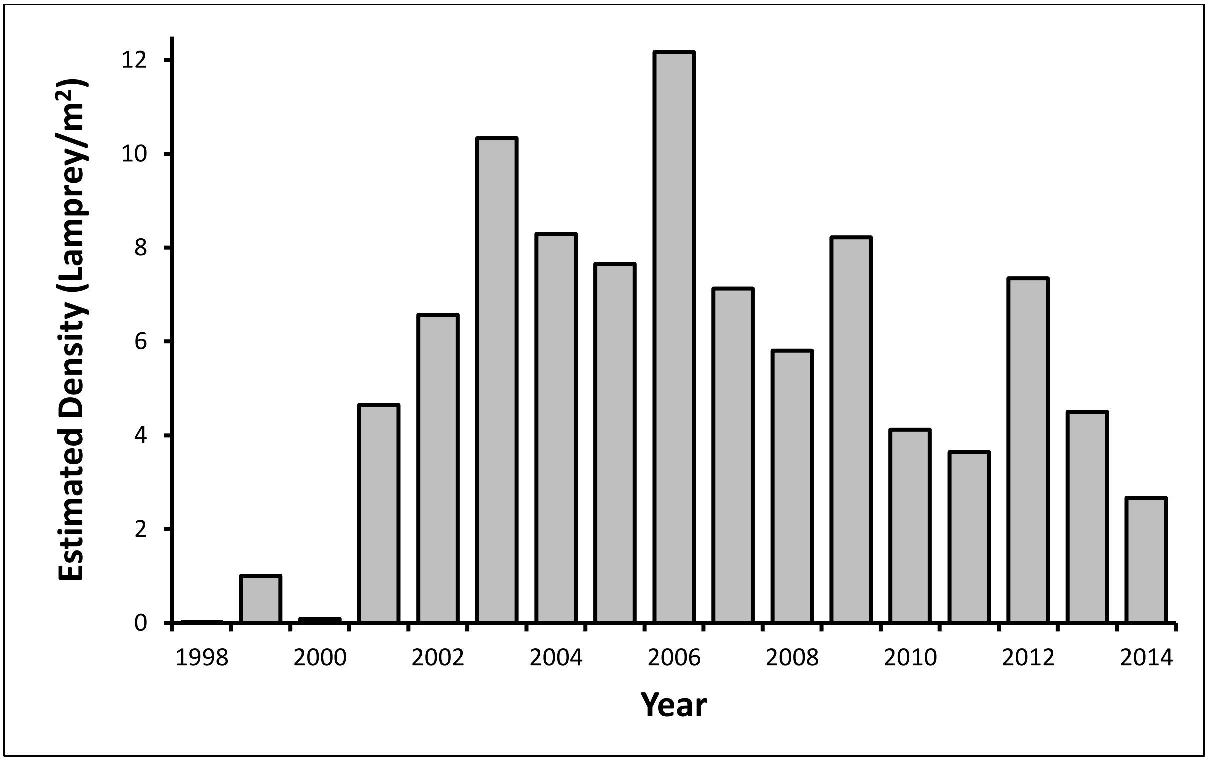


**Figure 4-19. Larval densities in the Umatilla River (mean of 30 index sites), 1999-2014.**

## 4.1.6 Grande Ronde River Subbasin

### 4.1.6.1 Subbasin Description

The Grande Ronde Subbasin encompasses an area of about 4,000 $mi^2$ in northeastern Oregon and southeastern Washington and is defined by the Blue Mountains to the west and northwest, and the Wallowa Mountains to the southeast. The Grande Ronde River flows generally northeast 212 miles from its origin to join the Snake River about 20 miles upstream of Asotin, Washington and 493 miles from the mouth of the Columbia River. Major streams flowing into the Grande Ronde are Catherine and Joseph creeks and the Wallowa and Wenaha rivers. Average annual precipitation increases from 14 inches on the valley floor to more than 60 inches in some mountain areas. Precipitation occurs in the mountains throughout the year but falls primarily as winter snow.

Wallowa Lake is the only major water impoundment in the Grande Ronde River Subbasin. Although it is a natural lake, a dam was constructed at the outlet in 1918 and enlarged between 1928 and 1929 to its present height. The subbasin also includes a number of minor impoundments as well as numerous small ponds that serve as water storage for irrigation and livestock.

### 4.1.6.2 Pacific Lamprey Status

Nowak (2004) noted that Pacific Lamprey occurred historically in the Grande Ronde River Subbasin, that they may persist in the subbasin, but their distribution and abundance are unknown. More recently, Luzier et al. (2011) reported that estimating adult Pacific Lamprey abundance and trends for the Lower Grande Ronde River is difficult due to the lack of targeted monitoring efforts and harvest records. Using best professional judgment based on available information, managers and researchers have estimated the current abundance of adult Pacific Lamprey to be less than 50 individuals on average with a short-term trend ranking of "severely declining." Only 1,165 adult lamprey have been counted at Lower Granite Dam from 1999 (when counting resumed) through 2016.

Moser and Close (2003) conducted surveys for Pacific Lamprey in a number of subbasins in the CRB and found larvae at only 2 of 11 sites sampled in the Grande Ronde River, both in the lower river. Average density was the lowest of any subbasin in which lamprey were found. All larvae were at least 70 mm in length, whereas individuals <30 mm were found in all other subbasins. Juvenile index site surveys are planned for 2016 and annually thereafter in the upper Grande Ronde River and in Lookingglass and Catherine creeks.

## 4.1.7 Walla Walla River Subbasin

### 4.1.7.1 Subbasin Description

The Walla Walla River drains an area of about 1,758 square miles from the Blue Mountains of southeastern Washington and northeastern Oregon to the Columbia River at Lake Wallula behind McNary Dam. Precipitation across the Walla Walla Subbasin falls mainly in the winter, with 64 percent occurring from October through March. Annual precipitation near the mouth of the Walla Walla River is less than 10 in. Precipitation increases progressively eastward with elevation, with the headwaters receiving over 40 inches annually.

Low flows have significant impacts in the Walla Walla Subbasin. Flows are annually depressed because of natural variability and human water use. Water diversions reduce flows in some reaches of the river and principle tributaries.

### 4.1.7.2 Pacific Lamprey Status

Pacific Lamprey and western brook lamprey were both abundant in the Walla Walla River Subbasin historically (Walla Walla Watershed Planning Unit and Walla Walla Basin Watershed Council 2004). Lamprey were present in eight of twelve subwatersheds inventoried in 1998, but were not keyed to species. A survey completed in 1999 found no Pacific Lamprey larvae in the Walla Walla River Subbasin. Moser and Close (2003) found no lamprey at any of seven sites sampled.

Luzier et al. (2011) reported that estimating adult Pacific Lamprey abundance and trends for the Walla Walla River is difficult due to the lack of targeted monitoring efforts and harvest records. Using best professional judgment based on available information, managers and researchers have estimated the current abundance of adult Pacific Lamprey to be less than 50 individuals on average with a short-term trend ranking of "severely declining."

## 4.1.8 Tucannon River Subbasin

### 4.1.8.1 Subbasin Description

The Tucannon River Subbasin encompasses 503 square miles and is located in southeastern Washington. The Tucannon River flows into the Snake River three miles upstream of Lyons Ferry State Park, near the mouth of the Palouse River. The largest tributary, Pataha Creek, drains 185 square miles. The subbasin receives a mean annual precipitation of 23 inches including a mean annual snowfall of 65 inches.

#### 4.1.8.2 Pacific Lamprey Status

Pacific Lamprey historically were common in the Tucannon Subbasin (Columbia Conservation District 2004), but have experienced severe declines. Moser and Close (2003) found larvae at only four of 11 sites sampled, all in the lower Tucannon River. Densities were higher than in the Umatilla and Grande Ronde rivers, but lower than the John Day River. Collections included fish <50 mm in length.

Luzier et al. (2011) reported that estimating adult Pacific Lamprey abundance and trends for the Tucannon River is difficult due to the lack of targeted monitoring efforts and harvest records. Using best professional judgment based on available information, managers and researchers have estimated the current abundance of adult Pacific Lamprey to be less than 50 individuals on average with a short-term trend ranking of “severely declining.”

Observations in a downstream migrant trap in the Tucannon River confirm the assessment of low abundance (Table 4-6). Although gaps exist in the information, the number of larvae and juveniles combined has exceeded 700 individuals only twice. Adults were observed in only three years. Larvae were detected year-round, with peak counts between December and April. Juveniles were observed primarily from December through February. All adults were observed in May or June.

**Table 4-6. Number of Pacific Lamprey larvae, juveniles, and adults observed in a downstream migrant trap operated by the Washington Department of Fish and Wildlife in the Tucannon River, 2007-16.**

| Year | Larvae | Juveniles | Adults |
|---|---|---|---|
| 2007 | 348 | 122 | 4 |
| 2008 | 456 | 214 | 0 |
| 2009 | 538 | 113 | 0 |
| 2010 | 759 | 522 | 0 |
| 2011 | 520 | 81 | 0 |
| 2012 | 448 | 89 | 0 |
| 2013 | 253 | 103 | 11 |
| 2014 | 475 | 242 | 0 |
| 2015 | 66 | 115 | 3 |
| 2016 | 359 | 187 | 0 |

### 4.1.9 John Day River Subbasin

#### 4.1.9.1 Subbasin Description

The 8,000 square mile John Day Subbasin in northeastern Oregon is bound by the Columbia River to the north, the Blue Mountains to the east, the Aldrich and Strawberry Mountains to the south, and the Ochoco Mountains to the west. The John Day River flows 284 miles from its origins in the Strawberry Mountains before joining the Columbia River at river mile 217. Major tributaries to the John Day are the North Fork, Middle Fork, and South Fork John Day rivers. The John Day system contains over 500 river miles and is the second largest undammed tributary in the western United States. Watershed conditions in the John Day Subbasin have changed significantly over the past 150 years due to mining, livestock grazing, timber harvest, intensive agricultural practices, road construction, flood events, stream channelization, and fire suppression. A combination of these alterations may have resulted in some portions of the John Day Subbasin reflecting marked stream channel instability (Columbia-Blue Mountain Resources Conservation & Development Area 2005).

### 4.1.9.2 Pacific Lamprey Status

Historically, the only measure of adult Pacific Lamprey abundance occurred through visual counts made at fish screening windows at hydropower dams. Estimating adult Pacific Lamprey abundance and trends for the John Day River has been difficult due to the inconsistencies of lamprey counting protocols at fish passage structures. Counting protocols at hydropower dams have typically been tailored toward salmonid migration, which has not necessarily been consistent with lamprey migration behavior (Moser and Close 2003).

Moser and Close (2003) conducted ammocoete abundance surveys in the John Day Subbasin and found that the average density of larvae was high in the John Day River and its major tributaries (Table 4-7). Although over 80 larvae $m^{-2}$ were collected at one sample location on the Middle Fork, the abundance of juvenile lamprey was highly variable among sample locations, emphasizing the need to couple detailed habitat mapping with higher resolution lamprey sampling. The relatively high abundance of larvae throughout the subbasin further stresses the importance of maintaining open access to spawning habitat.

**Table 4-7. Average Pacific Lamprey larval densities, total length, and average river temperature when lamprey were collected in the John Day River Subbasin. Ranges are in parentheses.**

| River | Number of Sites | Lamprey Larval Density (number $m^{-2}$) | Lamprey Length (mm) | Water Temperature (°C) |
|---|---|---|---|---|
| Mainstem John Day | 13 | 12.0 (3.8-36.6) | 56.2 (20-138) | 17.5 |
| North Fork John Day | 9 | 26.7 (0-43.3) | 69.6 (12-165) | 21.8 |
| Middle Fork John Day | 8 | 32.0 (0-87.1) | 63.1 (18-145) | 19.6 |
| South Fork John Day | 6 | 14.2 (0-42.4) | 90.5 (13-166) | 16.0 |

Source: Moser and Close 2003

## 4.1.10 Imnaha River Subbasin

### 4.1.10.1 Subbasin Description

The Imnaha Subbasin drains an area of 850 square miles in northeastern Oregon. It is bordered to the west by the Grande Ronde Subbasin, to the east by the Snake River Hells Canyon, and to the north by the Asotin Subbasin. The Imnaha River flows 73 miles from its headwaters in the Eagle Cap Wilderness before joining the Snake River, 192 miles from the Snake's confluence with the Columbia River.

Water availability within the Imnaha Subbasin is influenced by a major diversion on Big Sheep Creek and various smaller irrigation projects. Precipitation in the lower-elevation portions of the Imnaha Subbasin occurs primarily as rain during spring and early summer months. Peak streamflows in the subbasin occur from March through May, while lower flows occur August through September and December through February.

#### 4.1.10.2 Pacific Lamprey Status

Current abundance of Pacific Lamprey in the Imnaha Subbasin is unknown. Historical records of adult and juvenile Pacific Lamprey abundance and distribution are unavailable. (Ecovista 2004a) postulated that Pacific Lamprey may be extirpated from the Imnaha Subbasin; however, recent surveys found Pacific Lamprey in the lower Imnaha River (USFWS unpublished data).

### 4.1.11 Clearwater River Subbasin

#### 4.1.11.1 Subbasin Description

The Clearwater River Subbasin, located in north central Idaho, is characterized by mountains, plateaus, and deep canyons. The subbasin drains an area of approximately 9,645 square miles. It is bordered to the north by the St. Joe River Subbasin and to the south by the Salmon River Subbasin. Four major tributaries drain into the mainstem Clearwater River: the Lochsa, Selway, South Fork Clearwater, and North Fork Clearwater. The Dworshak Dam, located in the North Fork Clearwater River, is the only major water regulating facility within the subbasin. The Clearwater River enters the Snake River at the Washington –Idaho border, 139 river miles upstream of the Columbia River.

#### 4.1.11.2 Pacific Lamprey Status

Counts of adult Pacific Lamprey at Snake River dams did not begin until 1996; therefore, no long-term information at these sites is available. Nevertheless, available count information indicates a decline in numbers returning to the Snake River (see Figure 3-1). Approximately 3% of the Pacific Lamprey observed at Bonneville Dam are counted at Lower Granite Dam. Based on adult lamprey observations at Lower Granite Dam, the current status of Pacific Lamprey in the Clearwater Subbasin is thought to be extremely depressed (FPC 2017). Pacific Lamprey are thought to inhabit streams accessible to salmon and steelhead, suggesting they were once present in all major drainages of the Clearwater Subbasin.

The distribution of Pacific Lamprey in the Clearwater River and six selected tributaries declined by an estimated 66% between 1960 and 2006 (Cochnauer and Claire 2009). Counts at Lewiston Dam, near the mouth of the Clearwater River, decreased from over 5,000 in 1950 to zero by 1972, after which the dam was removed and lamprey once again had access to the upper subbasin. Pacific Lamprey larvae and juveniles were collected in Lolo Creek from 1994 through 2003; however, continued sampling failed to capture any lamprey from 2004 through 2006.

Recent surveys have confirmed the presence of Pacific Lamprey throughout most of the subbasin (USFWS unpublished data). In the South Fork Clearwater River watershed, presence has been confirmed up to and including the Red River, and in Newsome Creek. Surveys have detected Pacific Lamprey throughout the Lochsa and Selway rivers, at two sites in Lolo Creek, and in Orofino Creek. Although historically present, Pacific Lamprey have not been found in the Potlach River. Pacific Lamprey in the western portion of the Clearwater Subbasin may be limited to the mainstem of the Clearwater River and larger tributaries; however, this has not been recently confirmed. Potential limiting factors affecting the decline of lamprey include habitat disturbance due to low flows, poor riparian conditions, and high water temperatures.

Landlocked Pacific Lamprey may have persisted in the North Fork of the Clearwater River after construction of Dworshak Dam in 1973 (Wallace and Ball 1978); however, no Pacific Lamprey have been collected upstream of Dworshak Dam since 1989. Cochnauer and Claire (2009) reported that Pacific lamprey are no longer considered present upstream of Dworshak Dam.

Ward et al. (2012) noted that redds and larvae were observed in all streams in the Clearwater Subbasin receiving translocated adult Pacific Lamprey, including those in which lamprey were considered previously extirpated. McIlraith et al. (2015) found that when given the choice at the confluence of the Snake and Clearwater rivers, most Pacific Lamprey migrate up the Clearwater River. These findings confirm the potential to increase production in the Clearwater River Subbasin.

### 4.1.12 Salmon River Subbasin

#### 4.1.12.1 Subbasin Description

The Salmon River Subbasin is located in the central Idaho Rocky Mountains. Covering an area of approximately 13,984 square miles, the subbasin comprises 16.6% of the land area of Idaho and 6% of the land area of the CRB. Most of the subbasin is characterized by moderate to high elevation mountain ranges and deeply cut valleys, and encompasses some of the CRB's most pristine terrestrial and aquatic temperate montane ecosystems. The Salmon Subbasin has over 1,900 named streams with a combined length of 9,752 river miles. Over 90% of the land area is public lands. This large protected area serves as habitat strongholds for fish and wildlife. The Salmon River Subbasin provides more anadromous fish spawning area than any other subbasin in the CRB. The Salmon River joins the Snake River in lower Hells Canyon.

#### 4.1.12.2 Pacific Lamprey Status

The Salmon River Subbasin supports a remnant population segment of native Pacific Lamprey. Adults and larvae were historically documented in the Salmon River Subbasin upstream to Alturas Lake (Cochnauer and Claire 2009). In the late 1950s, thousands of larval lamprey were observed in the Lemhi River and irrigation canals off the Salmon River near Challis, Idaho. From 1970 through 2000, smaller numbers of lamprey were observed in the subbasin. Larvae were documented near the town of Salmon, Idaho in the late 1970's. Surveys from 2004 through 2006 detected Pacific Lamprey only in the Salmon River upstream to the North Fork Salmon River and in the Middle Fork Salmon River. Successful spawning was occurring downstream from the North Fork (Cochnauer and Claire 2009).

Recent surveys (USFWS unpublished data) have confirmed the presence of Pacific Lamprey in the mainstem Salmon River upstream to the North Fork Salmon River near Salmon, Idaho, in the Middle and South forks of the Salmon River, and in the Little Salmon River. Pacific Lamprey are likely not present upstream of Salmon, Idaho.

Larvae collected in the Salmon River Subbasin were larger than those found in the Clearwater Subbasin, and Hammond (1979) theorized that a factor other than size may trigger transformation and migration to the ocean. Factors that may be affecting the decline of Pacific Lamprey in the subbasin include problems with availability and accessibility of suitable spawning habitat, water withdrawals, irrigation canals, low flows, poor riparian conditions, high water temperature, and barriers within the migratory corridor.

### 4.1.13 Asotin Subbasin

#### 4.1.13.1 Subbasin Description

The Asotin Creek Subbasin covers an area of 325 square miles in southeastern Washington. Asotin Creek originates in the Blue Mountains and drains to the Snake River at the city of Asotin, Washington. The subbasin receives a mean annual precipitation of 23 inches. Vegetation in the subbasin is characterized by grasslands and agricultural lands at lower elevations and evergreen forests at higher elevations. Historically, Asotin Creek had a less severe gradient, a meandering flow pattern, well developed floodplain connections, deep pools, and a well-developed thalweg. Today, most of Asotin Creek has been straightened, diked, or relocated. The loss of well-developed thalwegs is responsible for much of the loss of fish habitat. Anthropomorphic activity in the watershed—including: farming, timber harvesting, and urbanization—has substantially altered the hydrologic cycle, reducing water infiltration and accelerating runoff.

#### 4.1.13.2 Pacific Lamprey Status

According to Native American oral recollections of fishing, Asotin Creek historically had a large run of Pacific Lamprey. Headgate Dam operators in the late 1950s recall numerous lamprey maneuvering over the dam. Operators also recall seeing lamprey being taken out of Asotin Creek for use as sturgeon bait by local fishermen. Prior to adult translocation efforts by the Nez Perce Tribe in 2007, Pacific Lamprey had been considered functionally extirpated from the subbasin as there had not been observations in Asotin Creek since at least 1980. Since 2008, larval lamprey have been observed throughout Asotin Creek though it is unclear if these observations are strictly the result of tribal translocation efforts, which began in 2007 (Ward et al. 2012), or from naturally returning adults. A thorough evaluation of the abundance and distribution of Pacific Lamprey in Asotin Creek has not occurred.

## 4.2 Pacific Lamprey Genetic Structure

Influence on neutral population genetic structure is an important consideration for all supplementation efforts, and the recent advances in the field of population genetic study of Pacific Lamprey has not only provided information on regional population structure, but has also provided information on genomic adaptation of this species (Hess 2016). These recent advances will help to inform conservation management of Pacific Lamprey with state-of-the-art genetic tools that rival even those available for salmonids that have had a longer history of genetic study; further, with these tools, Pacific Lamprey conservation monitoring can achieve a high standard of rigor for accuracy of parentage analysis and species identification, and can incorporate the ability to directly measure the impacts of natural selection on fitness (Hess 2016).

Based on studies of neutral population genetic structure, compared to salmonids, Pacific Lamprey appear to exhibit low genetic differentiation among geographic groups, and its population structure reflects a single broadly distributed population across much of its range in the Pacific Northwest (Goodman et al. 2008; Spice et al. 2012). The need for genetic diversity in artificial salmonid propagation and rearing programs has been well documented. With salmon, collecting broodstock across the entire run is advised to maintain the genetic diversity of supplemented populations (Cuenco et al. 1993; Bilby et al. 2003). In addition, it is generally advised to collect broodstock in close proximity to eventual release location so that "local" adaptation can be preserved (Galbreath et. al 2008). Genetic diversity among a population's individuals is a basic driving principle for sustainability to reduce the potential for deleterious population effects, including inbreeding depression. This genetic principle is applicable to all species, including Pacific Lamprey, and provides organisms the ability to exhibit a selective response to environmental variability.

Another well-established premise for artificial propagation in salmonids is the use of locally-adapted broodstock. Such local stock may be comprised of individuals that are adapted to specific conditions in a basin, and subsequently exhibit higher fitness. However, in comparison to salmonids, Pacific Lamprey do not appear to exhibit strict natal homing (Goodman et al. 2008; Hess et al. 2012; Spice et al. 2012). For this reason, unlike salmonids, the spatial scale that contains locally-adapted broodstock may be much broader for Pacific Lamprey, and thus the specific watershed- or subbasin-of-origin of this broodstock may not be critical to the success of artificial propagation programs for Pacific Lamprey.

Hess et al. (2012) concluded based on neutral genetic variation (i.e., gene variants detected have no direct effect on fitness) in Pacific Lamprey there is high gene flow among individuals collected from the Columbia River, Oregon and California. However, Hess et al. (2012) and Lin et al. (2008) documented significant genetic differences among fish from different large-scale geographic regions. In contrast, Goodman et al. (2008) found no obvious geographical pattern of gene flow or differentiation across large-scale geographic regions represented by samples from the Pacific Northwest (i.e., Washington, Oregon and California). The choice of genetic marker likely had some bearing on the results of the genetic studies that have been conducted on Pacific Lamprey. For example, the findings of Lin et al. (2008) and Hess et al. (2012) were obtained using relatively large numbers of amplified fragment length polymorphism and single nucleotide polymorphism markers (SNPs), respectively. These types of markers have high potential to represent adaptive variation (i.e. genomic regions under selection), which was one of the primary goals of the study by Hess et al. (2012). In contrast with patterns from neutral variation, adaptive variation was shown to drive relatively large genetic divergence between regions, even between the lower Columbia River and interior tributaries (Hess et al. 2012). In a subsequent study, Hess et al. (2014) demonstrated that adult Pacific Lamprey traits, primarily body size, were significantly correlated with the adaptive genetic divergence in the Columbia River. Specifically, adaptive genetic variants as measured by particular genetic markers were associated with large adult body size, and large adults tend to migrate furthest into the interior Columbia River.

Other genetic studies using putatively neutral markers (based on microsatellites and mitochondrial DNA) have provided evidence of high rates of gene flow across much of the range of Pacific Lamprey with low geographic association among samples (Goodman et al. 2008; Spice et al. 2012). Results from Spice et al. (2012) suggest that most Pacific Lamprey in the Pacific Northwest could be managed as a single unit. As stated by Hess et al. (2014): "It may initially seem paradoxical to observe adaptive divergence that is driven by body size and upstream distance traveled without also observing significant differentiation at neutral loci within the Columbia River Basin. The lack of neutral genetic differentiation among major rivers (e.g., Goodman et al. 2008; Hess et al. 2012) may be driven by non-specificity in choice of highly mobile hosts during its ectoparasitic feeding mode which results in wide dispersion in ocean waters (similar to Sea Lamprey, Waldman et al. 2008) and could subsequently be reinforced by selection against long return migrations to natal streams, a lack of sensory capacities to navigate and orient to natal streams, or other selective forces. Nonetheless, the apparent paradox may be explained by nonphilopatric migration, continuous distribution, historically high effective population size of this anadromous fish, and on-going selection for larger body size during long or difficult migration. While Pacific Lamprey appear to segregate according to body length and upstream distance, they have low probability of spawning in their natal stream, which would allow sufficient gene flow throughout the range to homogenize the neutral variation of the population." This explanation is helpful to reconcile the seemingly paradoxical contrast in patterns of neutral population structure (i.e. presence of a single population that includes the Pacific Northwest) and patterns of adaptive population structure (i.e. adaptive genetic divergence between Pacific Lamprey that migrate to the lower Columbia River versus interior Columbia River).

Recently, however, the USFWS (Luzier et al. 2011) divided Pacific Lamprey into ten Regional Management Units (RMUs). The division of lamprey stocks into regional units was not based on genetic information, but is intended to allow for a more refined level of life history and data collection from each RMU. At this time, the USFWS (2012) believes that "dividing management units into finer geographic scales would provide a risk-averse approach for conserving Pacific Lamprey." The weight of the evidence from the population genetic studies would suggest that it is not warranted to expect the smaller management units proposed by USFWS to behave as discrete populations. However, these smaller management units may provide some benefit for the purpose of abundance monitoring by establishing spatial units for characterizing how abundance of Pacific Lamprey is distributed through space and time.

Despite some conflicting results (e.g. Lin et al. 2008), genetic studies generally corroborate the pattern that rates of gene flow are high among Pacific Lamprey, particularly in the Pacific Northwest. The pool of potential donor-stock for artificial propagation or translocation programs may therefore be larger for lamprey than, for example, salmon. Relatively homogenous genetic composition could be viewed as an advantage because healthy donor-stocks could be obtained from any RMU and translocated, or seeded, into suitable watersheds throughout the Pacific Northwest. Still, tribal programs that utilize translocation have been conservative in selecting a source for donor stock by taking fish for translocation at Bonneville, The Dalles, and John Day Dams as opposed to further downstream (e.g. Willamette Falls), despite there being minimal evidence of neutral genetic structure in the entire Columbia River Basin. In addition, the lamprey that migrate farthest into the interior are also the ones that arrive relatively early in the run at Bonneville Dam (Hess et al. 2014). Tribal programs have generally been collecting most fish from Bonneville Dam at the beginning weeks of the run. Further, genetic results from all translocated adults genotyped to date (through release year 2015) have shown minimal differences in between the adaptive and neutral genetic composition of fish that volitionally migrate to the interior versus those that have been translocated (Hess et al. 2015b).

It would be prudent to try to balance the conservative and cautious desire to minimize the potential for human-mediated changes to adaptive genetic diversity with a desire to maintain a "healthy" level of adaptive genetic diversity, so that natural selection can work effectively on Pacific Lamprey and allow for future adaptation of the population. From the viewpoint of conservation management, Hess et al. (2012) emphasize that, although lamprey are capable of high levels of gene flow across most of their range, it is important to maintain "local" diversity (a suitable geographic area has not yet been described), primarily those adaptive genetic variants that have optimal fitness in localized conditions. This would indicate that broodstock management and collection protocols must be cognizant of the need to maintain the diversity of donor-stock when faced with the potential for artificial propagation (i.e., hatchery programs). Similarly, the "mining" of donor-stock associated with lamprey translocation programs should be conducted so it does not cause a substantial decrease in abundance in any currently occupied subbasin (Ward et al. 2012).

# 4.3 Recent Supplementation Efforts

Supplementation efforts to date by the YN, the CTUIR, and the NPT have focused on the Yakima, Methow, Umatilla, Grande Ronde, Salmon, Clearwater, and Asotin subbasins, with management actions limited to adult translocation (Table 4-8). Pacific Lamprey supplementation is defined as putting fish, either by adult translocation or the release of artificially propagated and reared larvae and juveniles, in locations where existing or remnant population segments exist to contribute to restoration efforts. Translocation has been successfully implemented, though well-designed post-reintroduction monitoring programs are imperative to documenting success (Close et al. 2009; Ward et al. 2012). Translocation is an interim strategy designed to support region-wide efforts to reduce threats to lamprey productivity and can occur while artificial propagation methods are researched and developed. Translocation and artificial propagation are not, however, mutually exclusive strategies, and could be implemented together.

**Table 4-8. Summary of Pacific Lamprey supplementation activities in the Columbia River Basin.**

| Year | Activity |
|---|---|
| **2000** | The CTUIR begins a translocation program with the release of 450 adults in the Umatilla River and 150 in Meacham Creek |
| **2007** | The NPT begins a translocation program with the release of 149 adults in the Clearwater Subbasin and 28 in the Asotin Subbasin |
| **2011** | The First International Forum on the Recovery and Propagation of Lamprey is held in Portland, OR |
| **2012** | The USFWS and USGS begin experiments to evaluate different rearing regimes for larvae<br>The YN and the CTUIR conduct pilot projects to hold, propagate, incubate, and rear larvae; lessons learned create a path forward for subsequent research<br>The NPT adult translocation program expands to include the Salmon River and Grande Ronde River subbasins<br>The YN begins a translocation program with the release of 15 adults in Satus Creek |
| **2014** | The CRITFC and member tribes develop the Supplementation Research Framework to initiate a regionally coordinated and long-term RM&E plan directed towards the implementation of supplementation and recovery actions<br>The majority of CTUIR propagation work is conducted at the Water Environment Center at Walla Walla Community College as the facility becomes fully established. |
| **2015** | The YN translocation program expands to release adults throughout the upper and lower Yakima River Subbasin and in the Methow River Subbasin.<br>The CTUIR translocation program expands to include the Grande Ronde River Subbasin |
| **2016** | The YN translocation program expands to release adults in the Wenatchee River. |
| **2017** | Translocation to Upper Columbia (mainstem Columbia upstream of Wells Dam and Okanagan River Subbasin) begins (lead by YN and Colville Tribe). Knowledge gained during the pilot projects and subsequent research creates a path forward for experimental releases of artificially propagated larvae. |

## 4.3.1 Translocation

By facilitating passage of adults past dams and releasing them in suitable streams, translocation efforts augment ammocoete abundance and maintain pheromone migration cues for migrating adults seeking suitable spawning areas. The approach for translocation efforts to date has been to collect adult Pacific Lamprey at Bonneville, The Dalles, and John Day dams. Adults are then transported past upstream dams and held at upstream facilities closer to spawning areas. Adults are treated for potential diseases (primarily using oxytetracycline to combat furunculosis) and a portion of them are tagged at the holding facilities and released the following spring. Virtually 100% of the translocated adults are genetically tagged (for parentage genetic analysis using sampled larvae/juveniles). Translocation is intended to be a stop-gap measure to maintain lamprey presence while known limiting factors and critical uncertainties are addressed. Although monitoring and evaluation of these efforts have yielded substantial information about effectiveness and have contributed to critical life history information on lamprey, further monitoring is needed to investigate whether translocation can help increase the number of adults migrating into the CRB. The overall goal of translocation is to help restore natural production across its broad geographic range to healthy, harvestable self-sustaining levels and to restore important ecological functions of the lamprey. Notably, absent substantial improvements to passage past mainstem dams, translocation alone would not be expected to achieve restoration goals.

### 4.3.2 Artificial Propagation

To date, artificial propagation efforts have been limited to preliminary research conducted in controlled environments. To prevent further decline and local extirpations of Pacific Lamprey, the Columbia Basin tribes and a consortium of partnering agencies began developing artificial propagation and early rearing techniques in 2012. Work to date has focused on developing the best methods and techniques associated with gamete holding, gamete fertilization, egg incubation and prolarvae holding, transportation of gametes and larvae, disinfection (adult broodstock, eggs, and larvae), and larval culture. This laboratory work has provided important insights into lamprey early life history. In early 2015, an article was submitted by scientists from the YN, CTUIR, NOAA Fisheries, and USFWS for a chapter in an AFS book titled “Jawless Fishes of the World” to describe the best management practices, techniques, and protocols developed over the years for the artificial propagation and early rearing of Pacific Lamprey (Lampman et al. 2016).

The authors described specific protocols for all life stages and discussed: 1) space requirement for larval and juvenile lamprey; and 2) survival bottleneck life stage. Because lamprey spend an extended time in freshwater as larvae, it is important to understand how much space is needed. Based on results to date, 125 $g/m^2$ was identified as the density above which survival and growth may be hampered. Adults and eggs can be held at a much higher density, so space is not an issue for these life stages (Table 4-9). Prolarvae and 3-month-old larvae can also be reared with minimum space. Large scale production would likely be less efficient for larvae older than 6 months and almost prohibitive for larvae older than one year (absent the availability of significantly increased rearing space). Rearing of multiple year classes would require even more space.

The bottleneck life stage has been identified as 1-3 months, during which prolarvae transition to burrowing first feeding larvae (Figure 4-20). Survival rate during this period has been 10-35% in the initial years of aquaculture research. However, recent research has demonstrated a considerable increase in the survival rate at this life stage (35% to 80%). Survival rates for fertilization, hatching, and first feeding larvae have been high (typically 85-95%). Cumulative survival rates up to age-4+ larvae is estimated to be 35%, whereas survival rates up to prolarvae stage is higher (~69%). Space requirement for rearing 100,000 larvae increases exponentially as they grow. Space required to rear 100,000 age 1+ larvae ranges from about 117 $m^2$ to about 336 $m^2$depending on growth rate (Table 4-9) but the need for space grows considerably beyond that point, rendering the rearing nearly impossible with the existing infrastructure available (especially when attempting to rear multiple age classes of larval lamprey). The potential level and scale of outplanting is therefore partially controlled by life stage specific growth and survival rates, but is also controlled by the amount of tank space available. Although larval lamprey survival will remain high even under high density conditions, the growth potential will be significantly hampered and very little growth will be achieved as a result.

**Table 4-9. Approximate size, growth, goal density levels, and area needed for 100,000 individuals (approximate equivalent of fecundity for one female) for each life stage of propagated Pacific Lamprey.**

| Life Stage | Length (mm) | Mean Monthly Growth (mm) | Weight (g) | Mean % Daily Weight Increase | Density Goal ($g/m^2$) | Density Goal ($no./m^2$) | Area Needed ($m^2$) for 100,000 Individuals |
|---|---|---|---|---|---|---|---|
| **Fast Growth Scenario** | | | | | | | |
| Adults | 600 | -- | 400 | -- | 20,000 | 50 | -- |
| Eggs | 1 | -- | 0.001 | -- | 800 | 800,000 | 0.1 |
| Prolarvae | 7 | 9.0 | 0.003 | 10.0% | 125 | 41,667 | 2.4 |
| Larvae (3 months) | 22 | 7.5 | 0.031 | 15.5% | 125 | 4,042 | 25 |
| Larvae (6 months) | 37 | 5.0 | 0.12 | 3.2% | 125 | 1,046 | 96 |
| Larvae (9 months) | 50 | 4.3 | 0.26 | 1.3% | 125 | 478 | 209 |
| Larvae (1 year) | 60 | 3.3 | 0.42 | 0.7% | 125 | 298 | 336 |
| Larvae (2 year) | 90 | 2.5 | 1.521 | 0.5% | 125 | 104 | 964 |
| Larvae (3 year) | 120 | 2.5 | 2.55 | 0.3% | 125 | 49 | 2,037 |
| Larvae (4 year) | 150 | 2.5 | 4.55 | 0.2% | 125 | 27 | 3,639 |
| **Slow Growth Scenario** | | | | | | | |
| Adults | 600 | -- | 400 | -- | 20,000 | 50 | -- |
| Eggs | 1 | -- | 0.001 | -- | 800 | 800,000 | 0.1 |
| Prolarvae | 7 | 9.0 | 0.003 | 10.0% | 125 | 41,667 | 2.4 |
| Larvae (3 months) | 18 | 5.5 | 0.018 | 8.5% | 125 | 6,811 | 15 |
| Larvae (6 months) | 28 | 3.3 | 0.058 | 2.4% | 125 | 2,159 | 46 |
| Larvae (9 months) | 35 | 2.3 | 0.103 | 0.9% | 125 | 1,209 | 83 |
| Larvae (1 year) | 40 | 1.7 | 0.146 | 0.5% | 125 | 854 | 117 |
| Larvae (2 year) | 60 | 1.7 | 0.420 | 0.5% | 125 | 298 | 336 |
| Larvae (3 year) | 80 | 1.7 | 0.887 | 0.3% | 125 | 141 | 710 |
| Larvae (4 year) | 100 | 1.7 | 1.585 | 0.2% | 125 | 79 | 1,268 |
| Larvae (5 year) | 120 | 1.7 | 2.546 | 0.2% | 125 | 49 | 2,037 |
| Larvae (6year) | 140 | 1.7 | 3.801 | 0.1% | 125 | 33 | 3,041 |
| Larvae (7 year) | 160 | 1.7 | 5.379 | 0.1% | 125 | 23 | 4,303 |

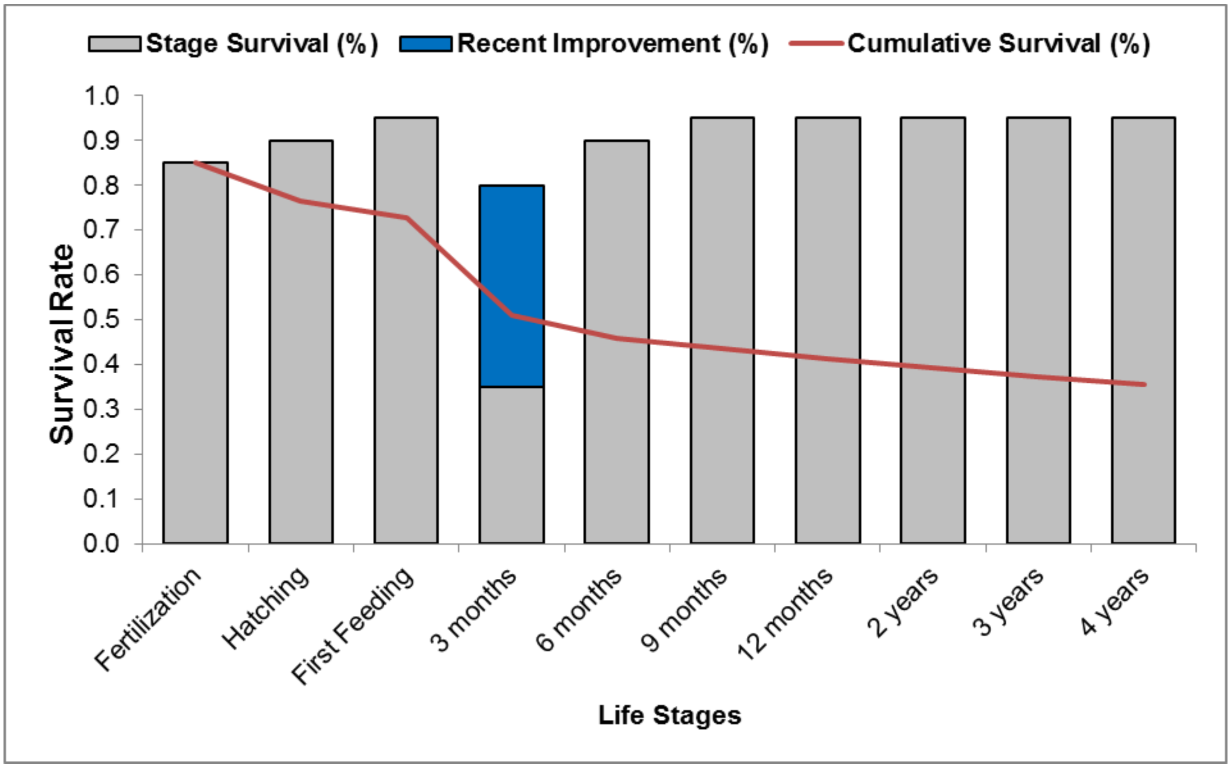


**Figure 4-20. Approximate life stage specific and cumulative survival rates observed for propagated young of the year Pacific Lamprey larvae at Prosser Fish Hatchery.**

## 4.3.3 Confederated Tribes and Bands of the Yakama Nation

### 4.3.3.1 Translocation

As part of YNPLP Project No. 2008-470-00, translocation of adult Pacific Lamprey into the Yakima River Subbasin is intended to reintroduce lamprey to locally extinct reaches and tributaries where historically they were present as well as to assist lamprey in rebounding from small numbers in areas with impaired passage (i.e. functionally extinct populations). Over 2,000 adult Pacific Lamprey have been translocated into the subbasin, beginning with just 15 in 2012 (Table 4-10). Releases were expanded from 2015 through 2017 to include the Methow River Subbasin. Adult lamprey are collected at John Day, The Dalles, and Bonneville dams, according to and within the limits set by the Tribal Collection Allocation Guidelines. Three primary release strategies are employed: 1) lamprey are released in the summer/fall season in reaches of interest soon after collection to monitor passage rates, migration behavior, and destination for spawning; 2) lamprey are held either until the beginning of the final migration season (typically early March) and released in reaches of interest; 3) lamprey are held until the beginning of spawning season (typically April-May) and released into the upper reaches within prime spawning habitat. PIT tags are inserted into most fish prior to release, especially for sites with PIT tag arrays available (upstream and/or downstream). The proportion of adults that move downstream from the release site has decreased steadily at all three translocation sites, indicating that adults are more motivated to migrate upstream potentially due to larval pheromones being established in these watersheds. Current research and monitoring efforts follow guidelines described in the Framework for Pacific Lamprey Supplementation Research in the CRB (CRITFC 2014; **see Section 4.3.8.4**).

Effectiveness of translocation efforts is being monitored as part of YNPLP Project No. 2008-470-00. Pacific Lamprey require extensive post-reintroduction management and a well-designed monitoring program, in part due to the long life cycle of Pacific Lamprey and the likelihood that they do not home to natal streams. As demonstrated by lamprey restoration efforts in the Umatilla River Subbasin (**see Section 4.1.5**) it may require several years before restoration efforts result in increased abundance of adult lamprey. In 2015, over 6,000 larvae (>90% were Pacific Lamprey) were salvaged from a small diversion in upper Ahtanum Creek, indicating that Pacific Lamprey are producing many offspring in the translocation streams.

**Table 4-10. Releases of adult Pacific Lamprey into the Yakima River Subbasin for each analysis unit, 2011-2016, as part of a translocation program.**

| Year | Number Released | Upper Yakima River | Lower Yakima River | | | | Methow River | |
|---|---|---|---|---|---|---|---|---|
| | | | Yakima River | Satus Creek | Toppenish Creek | Ahtanum Creek | Upper Methow River | Lower Methow River |
| 2011-2012 | 15 | -- | -- | 15 | -- | -- | -- | -- |
| 2012-2013 | 138 | -- | 1 | 46 | 45 | 46 | -- | -- |
| 2013-2014 | 264 | -- | 9 | 92 | 78 | 85 | -- | -- |
| 2014-2015 | 752 | 102 | 21 | 209 | 219 | 201 | -- | -- |
| 2015-2016 | 696 | -- | 72 | 117 | 128 | 130 | -- | 249 |
| 2016-2017 | 583 | -- | 324 | 30 | 30 | 29 | 30 | 140 |

### 4.3.3.2 Artificial Propagation

In 2012, the Yakama Nation succeeded in conducting a pilot project to successfully hold, propagate, incubate, and rear larval Pacific Lamprey. Important highlights from 2012 include:

- Propagation success (fertilization and hatching) appeared to depend on four main variables: 1) quality of gametes (sexual maturation level, being neither immature nor too ripe); 2) seasonality (eggs' adhesiveness seem to vary depending on whether it was early or late in the season); 3) water quality (water with high silt content made it difficult to keep high survival rates); and finally 4) incubation methods.
- The most successful methods to incubate viable eggs were 1) modified heath trays, 2) Eager upwelling jars, and 3) spawning mats within incubation troughs.
- Feed ready larvae cannot be reared and fed indefinitely in open water (without the fine sediment), although adding fine sediment contributes to difficulty in regularly monitoring survival and growth.

From this experience valuable lessons were learned, and this created a path forward for subsequent research. Over a 10-week period between April 12 and June 14, 2013, 41 adults were propagated successfully at Prosser Fish Hatchery. In 2013, the following was discovered:

- Sexual maturation improved greatly by switching the source of water from primarily well water (2011-2012) to primarily river water (2012-2013).
- Fertilization can be improved by 1) maintaining fertilization wait time at three minutes (compared to 6 and 12 minutes), 2) mixing eggs and milt before adding water, and 3) not rinsing eggs. However, when the YN examined hatching success from the same eggs, 1) mixing eggs and milt after adding water and 2) rinsing eggs contributed to higher success, showing that initial (fertilization) and final (hatching) success may not always be in harmony.
- Limited success in fertilization was observed with 1) dead adults (male and female), even if they died within a 24 hours and 2) milt that was preserved for longer than a day.
- Larval feeding trials from large outside tanks indicate that survival is improved in 1) trough tanks compared to circular tanks, 2) tanks containing fine sediment from diversion (with natural, rich organic material) compared to Prosser Fish Hatchery plain sand, and 3) a combination of salmon carcass and yeast feed compared to yeast only feed.
- Larval feeding trials from small 10 gallon aquarium tanks show that growth may be limited in tanks with yeast only feed compared to lamprey carcass feed, hatchfry encapsulon feed (Argent Chemical Laboratories), or a combination of yeast and lamprey carcass or hatchfry encapsulon feed.

In addition, the YN experimented and evaluated the use of visible implant elastomer (VIE) and passive integrated transponder (PIT) tags in tracking individual lamprey over time. Considering that only larger larvae can be tagged with pit tags (8 mm full duplex pico tags – not practical with larvae <60mm), VIE tagging is likely the best known way to tag smaller larval lamprey. Even 30 mm larvae can be successfully tagged and monitored over long periods. Changes in tail features have been documented over time, which is a key element for identifying Northwestern USA lamprey species. This has allowed observation of gradual changes in tail features as the larvae grow and understand the difference between Pacific Lamprey and Western brook lamprey at various size ranges.

In 2014, the following discoveries were made:

- Prolarvae held in a combination of spawning mat and fine sediment (<500 micron) underneath showed minimum mortality up to densities of 125 g/m2 (50,000 individuals /m2). Mortality increased when densities were 250 g/m2 (100,000 individuals /m2), yet addition of algae mats were shown to effectively reduce this mortality.
- At start densities of 100 g/m2 or higher, growth rates were limited to roughly half of the maximum growth rates observed under lower densities, showing that growth is also density dependent.
- Growth rates increased from summer to early spring whereas a decrease was observed in growth rates from early spring to summer.
- Bottleneck life stage in the hatchery environment appears to be the period between first feeding and 3 month old larvae based on results from YNPLP and partners research.
- Based on space requirement, survival, and growth calculations, a large scale production of larvae will likely be less efficient for larvae older than 6 months and almost prohibitive for larvae older than one year due to their space requirements.

## 4.3.4 Confederated Tribes of the Umatilla Indian Reservation

### 4.3.4.1 Translocation

As part of Project No. 1994-026-00 (**see Section 4.9.1**), and as described in the restoration plan for Pacific Lamprey (Close 1999), supplementation in the Umatilla River Subbasin is focused on translocation of adults and long term monitoring of success. Over 4,900 adult Pacific Lamprey were translocated into the subbasin from 2000 through 2017 (Table 4-11). Adult lamprey used for this program were initially collected during winter lamprey salvage operations at John Day Dam. In later years, collections were augmented with fish collected at Bonneville and The Dalles dams. Lamprey are held until they are considered sexually mature and then released into spawning habitat that has been determined to be suitable for adult spawning. This is typically the same type of spawning habitat that is utilized by summer steelhead and spring Chinook.

Monitoring the success of translocation efforts has been underway since 2000 (see **Section 4.1.5.2**). Pacific Lamprey require extensive post-reintroduction management and a well-designed monitoring program, in part due to the long life cycle of Pacific Lamprey and the likelihood that they do not home to natal streams. Current research and monitoring efforts therefore follow guidelines described by CRITFC (2014); **see Section 4.3.8.4**.

To be proactive and with expected increased returns of adult lamprey forthcoming, an adult radio telemetry study was initiated in 2005 to identify adult passage bottlenecks at low-elevation diversion dams within the subbasin. Results from the radio telemetry study identified where adults were having difficulties passing these structures and helped prioritize which diversion dams needed improvement first. After installation of a lamprey passage structure at Three Mile Falls Dam, the number of adults counted increased substantially in 2011 (Figure 4-16).

Translocation of adult Pacific Lamprey as part of Project No. 1994-026-00 expanded into the Grande Ronde River Subbasin in 2015. Of 2,100 adults released from 2015 through 2017, approximately 50% were placed in the Upper Grande Ronde River near Starkey, Oregon (Table 4-12). The remaining 50% were placed in Catherine Creek near Union, Oregon, and in the Lookingglass Creek watershed. Monitoring will be implemented as the translocation effort continues, and will follow guidelines described by CRITFC (2014); **see Section 4.3.8.4**.

**Table 4-11. Releases of adult Pacific Lamprey into the Umatilla River Subbasin by CTUIR, 2000-17, as part of a translocation program.**

| Year | Number Released | Umatilla River by River Kilometer (RKM) | | | | Iskúulktpe Creek | Meacham Creek | South Fork Umatilla River |
|---|---|---|---|---|---|---|---|---|
| | | RKM 98.8 | RKM 118.4 | RKM 128.7 | RKM 139.9 | | | |
| 2000 | 600 | -- | 150 | -- | 300 | -- | 150 | -- |
| 2001 | 244 | -- | 82 | -- | 81 | -- | 81 | -- |
| 2002 | 491 | 150 | 100 | -- | 141 | -- | 100 | -- |
| 2003 | 484 | -- | 90 | -- | 110 | 54 | 230 | -- |
| 2004 | 133 | -- | -- | -- | 63 | -- | 70 | -- |
| 2005 | 120 | -- | -- | -- | 50 | 15 | 55 | -- |
| 2006 | 198 | -- | -- | -- | 90 | 21 | 87 | -- |
| 2007 | 394 | -- | -- | -- | 200 | 25 | 169 | -- |
| 2008 | 68 | -- | -- | -- | 26 | -- | 42 | -- |
| 2009 | 337 | -- | -- | -- | 100 | 25 | 150 | 50 |
| 2010 | 291 | -- | -- | -- | 150 | 13 | 150 | -- |
| 2011 | 89 | -- | -- | -- | 40 | 10 | 39 | -- |
| 2012 | 232 | -- | -- | -- | 130 | 12 | 90 | -- |
| 2013 | 259 | -- | -- | -- | 126 | 10 | 123 | -- |
| 2014 | 384 | -- | -- | 64 | 199 | -- | 71 | 50 |
| 2015 | 156 | -- | -- | 156 | -- | -- | -- | -- |
| 2016 | 293 | -- | -- | 77 | 120 | -- | 96 | -- |
| 2017 | 142 | -- | -- | -- | -- | -- | 142 | -- |

**Table 4-12. Releases of adult Pacific Lamprey into the Grande Ronde River Subbasin by CTUIR, 2015-17, as part of a translocation program.**

| Year | Lookingglass Creek (RKM 8.0) | Little Lookingglass Creek (RKM 2.0) | Catherine Creek (RKM 76.4) | Grande Ronde River (RKM 241.6) |
|---|---|---|---|---|
| 2015 | -- | -- | 150 | 457 |
| 2016 | 175 | -- | 167 | 400 |
| 2017 | 150 | 150 | 250 | 201 |

### 4.3.4.2 Artificial Propagation

In 2012, the CTUIR embarked on a pilot lamprey propagation research at Minthorn Hatchery and the Mukilteo Research Station (see **Section 5.6.1.3**). By closely coordinating with the Yakama Nation, the CTUIR successfully fertilized gametes following protocols for Pacific Lamprey developed by

Japanese researchers (Hokkaido Fish Hatchery 2008). Direct comparisons of incubation rates at Prosser Hatchery (**see Section 4.3.3.2**) facilitated comparisons of incubation methods.

Key CTUIR lamprey propagation research objectives and results in 2012 were:

- Effects of flow-through vs recirculating water supply on incubation success. Gametes from the same spawning event were used in paired comparisons of incubation success (i.e., survival to hatching) under flow through (Eager upwelling jars at Prosser and Minthorn) and recirculating (Mukilteo tank rack) water supplies held at the same temperatures. Both Prosser Eager jars and Mukilteo recirculating systems delivered equally high incubation success. However, Eager upwelling jars at Minthorn hatchery were not successful due to high levels of silt in the source water supply.
- Effects of transport on fertilization success. In pilot trials, gametes from the same parents were fertilized within one hour of collection at Minthorn or Prosser hatcheries. A separate group of these same gametes was transported for 7 h on ice and then fertilized at Mukilteo Research Station. Fertilization rates for transported gametes were significantly lower than for un-transported samples.
- Exploration of egg disinfection methods. Fertilized eggs from the same spawning event were exposed to three disinfection treatments using 100 ppm iodophor (protocols developed for salmonids): 1) no disinfection, 2) disinfection on the day of fertilization only, and 3) disinfection every 3 d after fertilization. Assessment of egg survival during development indicated that disinfection within the first week after fertilization did not significantly reduce survival, but later disinfection resulted in high egg mortality, particularly late in egg development.
- Effects of substrate on larval growth. Growth and survival rates of larvae were determined in replicated treatments at the Mukilteo Research Station. Using a re-circulating water supply, larvae were fed identical types of food and held at the same temperature under four different substrate treatments. Each substrate (none, sand, mud, and filter floss) was replicated 5 times. After approximately one month, larval growth rates were lowest in treatments with no substrate. Growth rates did not differ among substrate types.

In 2013, propagation research was continued at the Mukilteo Research Station and pilot work was started at the newly established Water and Environment Center (WEC) at Walla Walla Community College. In collaboration with the YIN, the following research topics were explored:

- Water sources for incubation. Incubation success was compared between conditioned recirculating Walla Walla city water and ambient flow-through Titus Creek water. Both water sources were effective for egg incubation and early holding of larvae.
- Fertilization success. In concert with YN biologists, experiments were conducted to improve fertilization methodology. Replicated trials were conducted to compare effects of differential gamete contact time, effects of water hardening both before and after gamete exposure, and effects of rinsing to reduce egg adhesion. The resultant fertilization protocol was based on both assessment of survival to the morula stage (18 h) and to hatching: gamete exposure for 3 min coincident with water hardening, followed by rinsing to reduce egg adhesion.
- Larval transport. Experiments revealed that newly-hatched and pre-feeding larvae are particularly sensitive to transport that involves changes in water supply. However, larvae of the same stages of development did not suffer significant mortality when transferred and held in the

water supply at hatching. This has important implications for future translocation or out planting of larvae at various stages of development.

In 2014 the majority of CTUIR lamprey propagation work was conducted at the WEC, as that facility became more fully established. As in previous years, experiments were conducted in concert with the YIN and the advantages of sharing resources and findings from both tribal programs were again realized. A key limiting factor is the availability of mature broodstock and synchrony of maturing adults. The primary research interests in 2014 were:

- Gamete holding and transport. The ability to have both lamprey eggs and milt available at sufficient quality and quantity at the same time is a challenge that will be faced by future lamprey production facilities. To address this problem, we conducted controlled fertilization trials using eggs and milt held at various temperatures and time periods. In addition, pilot testing of cryopreservation of lamprey milt was conducted.
- Pre- and post- hatching shipment methods. Tests were conducted to assess survival of fertilized eggs at various stages of development under various transport methods (second-day air shipment, ground transport with temperature control and aeration, ground transport without aeration or temperature control, etc.). These pragmatic experiments are needed to achieve maximum survival and production, particularly in situations where broodstock at one location are limited.
- Fertilization and incubation methods. Collaboration with the YN was continued to assess safe methods for reducing egg adhesion, and to test survival to hatching under different flow conditions (no flow, low flow in recirculating and flow through settings, and high flow Heath trays with both recirculating and flow through water supplies).

### 4.3.5 Nez Perce Tribe

The NPT initiated its adult Pacific Lamprey translocation program in 2006. Purposes of this program are to:

- Thwart further local extirpations
- Prevent loss of pheromone migration cues from larval lamprey
- Maintain some level of production in the Snake Basin until mainstem passage improves
- Restore lamprey related ecosystem values to promote diversity, productivity and ecosystem health
- Preserve cultural values associated with lamprey

As a case study, the Tribe's translocation program methods and results are described in Ward et al. (2012).

Approximately 2,500 adult Pacific Lamprey have been translocated into Snake River Basin streams from 2007 through 2016 (Table 4-13). Adult lamprey used for this program were initially collected during winter lamprey salvage operations at The Dalles and John Day dams. Later and most recent adults for translocation were obtained from Bonneville, The Dalles and John Day dams during the active migration season. Lamprey are held over-winter at Nez Perce Tribal Hatchery, Nez Perce Reservation, Idaho, then released at sexual maturity into streams suitable for spawning and larval rearing.

Initial translocation releases were radio-tagged and monitored primarily to determine post-release movements and affinity to release streams (McIlraith et al. 2015). Observations associated with early radio-tracking also documented spawning behavior and spawn timing. Follow-up monitoring of progeny from translocated adults includes length, weight and outmigration timing data from fish collected in screw traps on Lolo Creek and Newsome Creek (Clearwater Subbasin).

**Table 4-13. Releases of adult Pacific Lamprey into the Clearwater, Salmon, Grande Ronde and Asotin subbasins, 2007-16, as part of the Nez Perce Tribe translocation program.**

| Year | Number Released | Clearwater | | | | Salmon[a] | | Grande Ronde[b] | | Asotin |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Little Canyon | Orofino | Lolo | Newsome | South Fork | Johnson | Wallowa | Minam | |
| 2007 | 177 | -- | 49 | 50 | 50 | -- | -- | -- | -- | 28 |
| 2008 | 106 | -- | 25 | 28 | 26 | -- | -- | -- | -- | 27 |
| 2009 | 140 | -- | 30 | 30 | 45 | -- | -- | -- | -- | 35 |
| 2010 | 91 | -- | 22 | 24 | 23 | -- | -- | -- | -- | 22 |
| 2011 | 29 | -- | -- | -- | 7 | -- | -- | -- | -- | 22 |
| 2012 | 257 | 17 | 40 | 40 | 40 | 40 | -- | 40 | -- | 40 |
| 2013 | 187 | 12 | 24 | 31 | 30 | 30 | -- | 30 | -- | 30 |
| 2014 | 51 | -- | -- | 10 | 10 | 11 | -- | 10 | -- | 10 |
| 2015 | 377 | 32 | 51 | 50 | 50 | 50 | 51 | 25 | 25 | 43 |
| 2016 | 586 | 41 | 56 | 57 | 56 | 56 | 48 | 55 | 55 | 56 |

[a] Approximately 50 additional adults were released into the Secesh River in 2016
[b] Approximately 50 additional adults were released into Joseph Creek in 2016

## 4.3.6 U.S. Fish and Wildlife Service

### 4.3.6.1 Eagle Creek National Fish Hatchery

The USFWS collected Pacific Lamprey larvae and reared them at Eagle Creek National Fish Hatchery in the Clackamas River Subbasin (Uh et al. 2014). Larvae were initially housed in four different rearing vessels that included three different plastic tub designs and circular fiberglass tanks. All vessels contained 5-7 cm of sand substrate and were placed in rectangular fiberglass troughs in a raceway and supplied with Eagle Creek water in a flow-through system.

A series of subsequent experiments using captive larvae were conducted to investigate the effect of different feeding regimes, including different food types and different food concentrations, on growth of larvae. In the first experiment, growth was evaluated among larvae fed four different food types (algae, leaves, yeast/larval fish food, salmon carcass analogs) and a control group that was not fed. Assimilation of food types was evaluated by tracking unique stable isotope signatures of $\delta$13C and $\delta$15N within larval tissues. Results from this experiment indicated that a diet of salmon carcass analog led to positive growth rate. Analyses of stable isotopes showed unique signatures specific to each food type. Isotopic analyses of larval tissues showed signatures that matched those of their specific food treatment. Based on the results of this experiment, a second experiment was conducted to evaluate growth of larvae fed four different quantities of salmon carcass analog. Results indicated that ammocoete growth rate increased with increasing dosages of food, but positive growth was observed in all feeding treatments. Health of Pacific Lamprey was investigated by screening a sample of wild-caught larvae from Eagle Creek for common viral and bacterial fish pathogens. Larvae were relatively pathogen free (Uh et al. 2014).

This work may provide information useful in the development of protocols for establishing wild-origin lamprey at captive facilities that likewise minimizes risk to co-housed species. Larvae were successfully reared in captivity with minimal mortality and positive growth.

### 4.3.6.2 Abernathy Fish Technology Center

The USFWS also conducted rearing experiments at the Abernathy Fish Technology Center in Longview, Washington. In one experiment, a 16-week feeding trial tested the effects of seven diet treatments on the survival, growth, fatty acid profile and whole body lipid content of larvae (Gannam 2015). Dietary treatments included active dry yeast, yeast with fish oil emulsion, micro-algae, micro-algae with fish oil emulsion, yeast with micro-algae, yeast with micro-algae and fish oil emulsion, and yeast with a commercial larval fish diet. Survival during the trial was not affected by diet; however, the greatest length and weight increases were in fish fed commercial larval fish diet. Lipid retention was significantly higher in fish fed this diet. Feed conversion ratio was lowest in fish fed diets containing yeast. Overall, commercial larval fish diet provided the best growth performance in larvae.

This experiment also investigated the effects ammocoete stocking density and ration size on length, weight and survival of larvae over a 63 day trial (Gannam 2015). Four levels of stocking density (152, 303, 1,515, and 3,030 larvae/$m^2$) were tested along with two levels of ration size (125 mg/L, and 250 mg/L). Survival was highest at the lowest stocking density paired with the highest ration size. Fish fed at the high ration at any stocking density were significantly longer than those fed low rations. Fish fed high ration were roughly double the weight of those fed the low ration, which equals the magnitude of the ration increase. Results indicate that careful consideration must be paid to ration size and stocking density as both factors affect growth and survival. Densities above 303 larvae/$m^2$ reduced weight, whereas density-induced reductions in length were minimized by feeding a high ration.

A study evaluating the addition of vitamins and minerals to the diet was also conducted. No relationship between the added nutrients and fish growth was detected (Gannam 2015).

An additional study was conducted to refine feeding ration size for larvae under intensive culture conditions. Food densities of 250, 500, 750 and 1000 mg/L were offered twice per week during a 12 week trial. The trial has concluded, and data analysis is underway. This project will provide needed insight on how ration affects culture conditions and the growth and survival of the larvae (Gannam 2015).

## 4.3.7 U.S. Geological Survey

Adult Pacific Lamprey collected at Willamette Falls, Oregon were spawned at the USGS Columbia River Research Laboratory in Cook, Washington, in June 2012 and May 2013, about a year after collection, with protocols adapted from Meeuwig et al. (2005). After fertilization, zygotes were incubated at 13–14°C in McDonald type hatching jars. Hatching occurred around 15–18 days. When burrowing behavior was observed, larvae were stocked into tanks (see description below) at 300 to 600 fish per tank. Mortality was high during this initial phase of culture, and remained high for approximately the first year.

Lamprey larvae were collected from Gibbons Creek, Washington and from Herman Creek, Oregon using electrofishing and sediment grab samples in 2010 and annually from 2012–2014. Laboratory-spawned Pacific Lamprey and larvae collected from the field were held in rectangular fiberglass tanks (51 × 43 × 27 cm, L × W × D). Each tank contained beach sand as the burrowing substrate at a depth of approximately 5 cm for wild larvae and 2.5 cm for laboratory-spawned larvae. The depth of the sand in the tanks was related to the size of the fish and the need to sort and clean sediments regularly. Tanks were provided a simulated natural photoperiod with overhead incandescent lights and supplied with sand-filtered water (1.5 L/min) from the Little White Salmon River, Washington.

Fish were fed a slurry of active yeast and commercial fry food (Gemma Wean 0.1; Skretting, Vancouver, British Columbia). Wild larvae were fed 13–15 g yeast and 1.5–4 g fry food twice each week. Laboratory-spawned larvae were fed 5.7 g yeast and 1.4 g fry food twice each week. Water flow was shut off during feeding for 6–7 h.

From August 2012 to March 2014 the feeding method was modified in an effort to slow the accumulation of food and food waste in the tanks. A modification was initiated because the very small larvae would get captured during the efforts to remove excess food and food waste following a feeding session. During this period fish were fed 10% of the weekly amount, twice each day, five days each week with the water flow on.

Although detailed data are not available on growth rates and survival for these culture efforts, lamprey showed growth over time, with generally low levels of background mortality. Larvae have been maintained successfully for several years, including those collected from the field in 2010 (Liedtke 2015).

## 4.3.8 Other Supporting Efforts

### 4.3.8.1 Rocky Reach Pacific Lamprey Management Plan

The Rocky Reach Pacific Lamprey Management Plan (GeoEngineers et al. 2011) is a component of the Rocky Reach Comprehensive Settlement Agreement (Chelan County PUD 2006). The ultimate goal of the PLMP is to achieve No Net Impact (NNI) to Pacific Lamprey from ongoing operations of the Rocky Reach Hydroelectric Project. Conducting artificial propagation of Pacific Lamprey was considered by the state and federal fishery agencies and Tribes that are parties to the Settlement Agreement as a potential Protection, Mitigation, and Enhancement measure for achieving NNI during the term of the current Rocky Reach license.

Based on experience and review of the literature, the potential for the artificial propagation of Pacific Lamprey seemed high (GeoEngineers et al. 2011), at least for spawning and initial rearing of larvae. Information gathered was compared with Pacific Lamprey biological needs and requirements (Luzier et al. 2011) to identify tentative recommendations for initiating propagation. Initial observations indicated that propagation would be most viable when using structural facilities close to riverine sites. Progress in the development of techniques and methods for artificial propagation were anticipated to come from the combined efforts of fisheries researchers, culturists, and nutritionists.

### 4.3.8.2 First International Forum on the Recovery and Propagation of Lamprey

The primary goal of the First International Forum on the Recovery and Propagation of Lamprey (April 19-21, 2011, Portland, Oregon) was to bring together people who had been working on various lamprey issues with many years of experience, for a discussion about recovery and artificial propagation. This conversation included international colleagues from Finland and Japan (Greig and Hall 2011).

The second goal of this workshop was to address three central questions about the artificial propagation of Pacific Lamprey:

- Is artificial propagation of Pacific Lamprey possible?
- Are any existing facilities and resources in the Columbia Basin appropriate for artificial propagation of lamprey?
- Where are the most appropriate or most beneficial locations for outplanting?

Based on the experience in Japan using Arctic Lamprey (*Lethenteron camtschaticum*), in Finland using European River Lamprey (*Lampetra fluviatilis*), and initial work in the Columbia Basin, the answer to the first question was a definitive yes. Over many years of experimentation and "learning by doing," Finnish biologists have developed the expertise to rear tens of millions of lamprey larvae per year, although only to a very small size prior to release. Research in Japan also demonstrated the possibility of producing large numbers of lamprey larvae if certain guidelines are followed. In the CRB, research by the USFWS and USGS (**see sections 4.3.6 and 4.3.7**) has improved the understanding of some of the key factors and steps of artificial propagation.

The workshop concluded that the answer to the second question was also yes. The experience in Finland demonstrated that it is possible to produce 10-30 million lamprey larvae per year in facilities that are less than ideal. Within the CRB, numerous facilities are much better equipped for lamprey propagation; preliminary reconnaissance of facilities in the mid-Columbia by the USGS (**Section 4.3.7**) revealed existing facilities with both space and interest.

Although information is available to help in evaluating the third question, answers are not yet clear and many key uncertainties and knowledge gaps remain. However, results from Finland and Japan with outplanting larvae into different types of habitat conditions, and laboratory experiments in Japan and the CRB on habitat preferences of larval and juvenile lamprey offer guidance, as do results of the Nez Perce and Umatilla translocation studies (Ward et al. 2012) and the Warm Springs ammocoete habitat association models (Graham and Brun 2004). Given the scale of the CRB and the diversity of potential habitats available for outplanting, there is an opportunity to design a helpful strategy. A carefully constructed program that included outplanting sites representing a strategic range of environmental and geographic conditions (e.g. upstream/downstream sites, substrate composition, hydraulic conditions, temperature characteristics, different subbasins, etc.) could provide useful information necessary to develop an effective long-term strategy.

#### 4.3.8.3 Pacific Lamprey Breeding and Rearing Methodologies - Recommendations for Chelan County P.U.D.

Results of rearing studies (Wade and Beamish 2012) and results described at the Juvenile Pacific Lamprey Seminar in Wenatchee, Washington, in August 2012 were similar. Wade and Beamish (2012) stripped eggs from ripe females and fertilized them with sperm from at least two males. Fine sand was mixed with the fertilized eggs to prevent adhesion to the walls of the container or other eggs. Small batches of eggs were reared, but in the studies described during the seminar, larger numbers of eggs were successfully reared. It appears therefore, that the fertilizing and rearing of eggs is not a significant obstacle.

From the seminar it was determined that acquiring mature broodstock is a problem. Only a small percentage of upstream migrating adults can be induced into the “running ripe” maturity state. Upstream migrants need to be held over winter in tanks where they are provided an environment similar to deep pools in which they can remain undisturbed and can hide (Wade and Beamish 2012).

Two approaches were recommended:

- Continue collaborative research to answer questions such as what factors drive the return of Pacific Lamprey to a river; what is the survival rate of Pacific Lamprey after passage through dams (up and downstream migration); what is the best artificial diet for Pacific Lamprey larvae; at what developmental stage should Pacific Lamprey be outplanted; can a tag be developed that is suitable for both upstream and downstream migrating Pacific Lamprey.
- In tandem with this collaborative research, if culture is pursued, it is important to begin culturing and outplanting animals with the best available information. These initial trials will move efforts forward providing information to improve culture and outplant methods, as well as developing techniques to measure success. The importance of the enhancement of the species cannot wait until all possible and probable issues and scenarios are taken into account. Continued communication and collaboration between research teams and culture teams cannot be undervalued.

### 4.3.8.4 Supplementation Research Framework

As suggested in the TPLRP (CRITFC 2011), the Supplementation Research Framework (Framework) was recently developed (CRITFC 2014) to initiate a regionally coordinated and long-term RM&E plan directed towards the implementation of supplementation and recovery actions for Pacific Lamprey within the CRB. Additionally, the Framework intends to "standardize" key elements of Pacific Lamprey supplementation RM&E so that findings associated with status and trends and other important objectives can be reported in a common and consistent format. Finally, the Framework provides specific guidance for the development of subbasin supplementation research plans (**see Section 4.6.1**).

The Framework is needed to coordinate Pacific Lamprey supplementation RM&E on both a regional and local level. The Framework will provide consistency and serve as a communication and management tool for stakeholders to remain focused on the overall goals of the TPLRP (CRITFC 2011) and the LCA (USFWS 2012). The Framework will be updated over time as new, pertinent information becomes available. Findings associated with local planning and activities informed by the Framework will provide sufficient information to update the Tribal Pacific Lamprey Restoration Plan. This will ensure consistency among stakeholders in providing a more cohesive foundation for lamprey recovery in the CRB over the next five years, leading to the development of a CRB Pacific Lamprey Management Plan.

## 4.4 Relationship to Other Lamprey Restoration Efforts or Processes

Restoration of Pacific Lamprey in the CRB requires not only a collaborative effort among Tribes, federal agencies, states, and local entities, but also an aggressive combination of various types of restoration activities. Full recovery of Pacific Lamprey will not be achieved by supplementation alone. Actions should be designed to work together and provide synergy, although not all actions will be appropriate for all areas. This section is organized similarly to the TPLRP (CRITFC 2011), with three primary areas of restoration efforts or processes:

- Mainstem passage and habitat
- Tributary passage and habitat
- Contaminants and water quality

Progress specific to the fourth primary activity discussed in the TPLRP, Supplementation/Augmentation, was described in **Section 4.3**.

### 4.4.1 Mainstem Passage and Habitat

Mainstem passage may be the most urgent problem-facing lamprey in the CRB (CRITFC 2011). Adult passage efficiencies average less than 50% at most mainstem hydroelectric dams. In addition, adults that do pass successfully often have increased passage times, which may affect long-term migration success. The USACE is working to improve lamprey passage at USACE dams along the lower Columbia and Snake Rivers through operational and structural modifications (USACE 2014). Modifications at dams include installation of adult lamprey passage structures and modifications to passageways to facilitate lamprey passage without hindering passage of salmonids.

Efforts to improve lamprey passage at mainstem dams have accelerated since development and implementation of the USACE 10-year passage Plan (USACE 2008; **Section 4.5.1**). Improvements have included installation of special lamprey passage structures with smooth metal plating and resting areas, rounding of corners to reduce impediments to lamprey passage, adjustments to gratings to provide potential attachment surfaces, and efforts to provide refuge from high water velocities. Effort to date has focused on Bonneville, The Dalles, and John Day dams, plus a new lamprey passage system at McNary Dam 30 feet below the Columbia River’s surface.

Pacific Lamprey research and restoration actions in the mid-Columbia River have been guided by Pacific Lamprey management plans developed by the public utility districts (Chelan County PUD 2005; Douglas County PUD 2009; Grant County PUD 2009). Radio telemetry and PIT-tags have been used to evaluate passage efficiencies at various dams. Grant County PUD implemented a comprehensive adult passage evaluation study plan (Nass et al. 2009), with final results expected in 2016. Chelan County PUD made modifications to the Rocky Reach Dam fishway during the 2010-2011 and 2011-2012 maintenance periods to improve adult lamprey passage. In 2015, Douglas County PUD surveyed Wells Reservoir for potential juvenile lamprey habitat and for presence of juveniles in areas with suitable habitat. Suitable juvenile lamprey habitat was limited and no juvenile lamprey were encountered over the course of the entire study.

Actions in the mainstem have focused primarily on adult passage; however, it is important to improve passage and survival of adults, larvae, and juveniles. Fish screens designed to assist with salmon passage at dams can create impingement hazards to all life stages of lamprey. Continuing to improve mainstem passage is critical to (1) increasing the survival of lamprey produced through supplementation (both translocation and artificial propagation), and (2) eventually decreasing the need for supplementation to maintain distribution on Pacific Lamprey throughout the CRB, including the upper reaches.

### 4.4.2 Tributary Passage and Habitat

Improving lamprey passage at dams and irrigation systems in tributary watersheds is imperative for lamprey numbers to increase. Artificial barriers impact distribution and abundance of Pacific Lamprey by impeding upstream migrations of adult lamprey and downstream movement of larvae and juveniles. Upstream adult migrations are blocked by dams without suitable passage alternatives or attraction to fish ladder entrances (Moser and Mesa 2009). Fish ladders and culverts designed to pass salmonids can block lamprey passage, especially if they have sharp angles and high velocities (Moser and Mesa 2009; Keefer et al. 2010). Culverts and other low-head structures are impassable by lamprey due to high velocities, insufficient resting areas, and lack of attachment substrate (CRBLTWG 2004). Fish screens designed to assist with salmon passage at many dams and irrigation diversions can create impingement hazards to larvae and juveniles, and studies are being conducted jointly by the USGS, USBR, YN and CTUIR to determine how these screens can be modified to benefit lamprey and juvenile salmon survival (Rose and Mesa 2012; Lampman et al. 2014).

Within the CRB, habitat quantity, quality, and diversity have been altered and this has negatively affected lamprey. Most restoration efforts are directed at restoring salmon habitat; however, restoration of salmon habitat may benefit lamprey by increasing habitat complexity in hydrologically degraded systems, particularly in low velocity, fine sediment laden areas for larvae. Water management is a large component of habitat improvement and restoring flow to otherwise dewatered habitat can increase lamprey survival and passage, lower water temperatures, and provide more in-channel habitat during critical life history phases. Because ammocoete habitat is primarily found in slow water channel margins, flow modification has the potential to heavily impact the availability of this channel margin habitat. Monitoring studies to determine temperature tolerances of adults, juveniles, and larvae within the mainstem are underway and may guide flow management practices in the future. Ongoing radio telemetry studies can shed light on current lamprey habitat use, and potentially provide information on how best to manage and restore habitat across the CRB. Restoring habitat is a critical step to ensure the success of supplementation efforts so that habitats have adequate flows, moderate temperatures, and sufficient passage options necessary for lamprey to thrive and reproduce.

#### 4.4.2.1 Yakima River Subbasin

Impaired passage has been identified as one of the main threats to lamprey survival in the Yakima Subbasin; followed by dewatering, flow management, and small population segment size (Luzier et al. 2011). Flow management and dewatering also affect lamprey passage, and ramping rates (the current practice of adjusting water flows in key parts of the subbasin to manage water availability using a group of reservoirs) are being evaluated in three reaches of the Yakima River Subbasin: Roza Dam through Wapato Dam, Tieton River to lower Naches River, and Wapato Dam to Zillah (Figure 4-2).

In 2011 the YN initiated a pilot radio telemetry study implemented by the USFWS to evaluate potential passage issues for returning adult Pacific Lamprey at irrigation diversions Horn Rapids, Prosser, Sunnyside, and Wapato dams (Figure 4-2) were equipped with multiple antenna telemetry stations (Phase I and Phase II studies). In 2012, passage success varied from a low of 39% at Sunnyside Dam to a high of 62% at Horn Rapids Dam. Only two lamprey passed all four dams. In 2013, passage success was 68% at Sunnyside Dam and 82% at Wapato Dam. Twelve tagged lamprey migrated to Roza Dam (Figure 4-2) and six ascended the ladder to the salmon trapping facility before descending the ladder, resulting in 0% passage efficiency.

Seasonal effects at Yakima River diversion dams have the potential to exacerbate cumulative passage throughout the system. Reduced passage rates in the fall at the lower river dams (Horn Rapids and Prosser) may decrease the number of lamprey available to pass upstream dams (Sunnyside and Wapato) in the fall when passage success at these facilities is highest.

During the Phase III adult passage study (Roza and Naches-Cowiche dams), six of ten lamprey (60%) passed Naches-Cowiche Dam (Figure 4-2) with the uppermost detection at RKM 53 of the Naches River, whereas no lamprey were able to pass the Roza Dam holding pool. Johnsen et al. (2013) and Grote et al. (2014 and 2016) noted that diversion dams impede the upstream migration of Pacific Lamprey and suggested several modifications to improve passage.

Lampman et al. (2014; 2015) noted that substantial numbers of larval lamprey are entrained behind screens on irrigation diversions in the Yakima River Subbasin. More lamprey overall reside downstream of the fish screens than immediately upstream. Levels of entrainment varied substantially among facilities, but in general, the effectiveness of fish screens in deterring lamprey entrainment is mixed. Small larvae (<50 mm) are more prevalent behind screens, whereas larger larvae (> 90 mm) are more prevalent immediately upstream of screens. From the 2014 through 2017 irrigation seasons, a total of 60,078 larval or juvenile lamprey were captured from Yakima Subbasin irrigation diversions and returned to their respective streams (Table 4-14). Pacific Lamprey were present in many of the surveyed diversions. At Sunnyside and Wapato diversions, two major irrigation diversions of the middle reach of the Yakima River, the percentage of lampreys identified as Pacific Lamprey (vs. Western Brook Lamprey) is increasing. In 2013, less than 3% of the captured lampreys were identified as Pacific Lamprey. The percentage of Pacific Lamprey at these two sites through 2017 (Table 4-14). The increase in Pacific Lamprey is likely due to increased production and recruitment from the extensive adult translocation efforts in the subbasin.

**Table 4-14. Information on lamprey returned from irrigation diversions to streams in the Yakima River Subbasin.**

| Year | Number of Lamprey Returned from Diversions to Streams | Percent at Sunnyside and Wapato Diversions Identified as Pacific Lamprey |
|---|---|---|
| 2014 | 1,783 | 7 |
| 2015 | 15,275 | 13 |
| 2016 | 36,920 | 36 |
| 2017 | 6,100 | 30 |

A considerable amount of larval lamprey habitat exists in irrigation diversions, with only 17.9% of the area observed (3,087 m2) being considered “unusable” by larval lamprey (based on a 2014 survey). With extremely limited observations, the total amount of Type I (preferred; Slade et al. 2003) and II (acceptable) habitat was estimated conservatively to be 7,024 $m^2$ upstream of fish screens (75% was Type I) and 7,159 $m^2$ downstream of fish screens (73% was Type I). More extensive surveys in 2013 yielded a total habitat estimate of 32,102 $m^2$. Areas upstream and downstream of irrigation diversion fish screens have been monitored consistently since 2012, and both the lamprey habitat available as well as the number of lampreys entrained in these systems have been consistently high.

Solutions and mitigations for larval entrainment in diversions are being implemented experimentally with the help of various partners and funding.

Through YNPLP Project 2008-407-00, lamprey habitat has been assessed for each assessment unit in the Yakima River Subbasin. Loss of side channel complexes has decreased productivity, carrying capacity, and life history diversity by reducing suitable habitat for all freshwater life stages in close physical proximity. Plentiful spawning and rearing habitat exists in the Upper Yakima although river flow management may be a potential limiting factor. Because of periodic flashy flows, rearing habitat in the Naches is somewhat limited, except in side channel and off channel habitat. The Middle Yakima has extensive spawning and rearing habitat and temperature remains mild (<70°F) most of the year. The Lower Yakima provides winter rearing habitat, but summer water temperatures likely exceed the tolerance of larvae (however, recent use of the lower Yakima River by larval lamprfey indicates the presence of some cold water refugia). Three tributary streams in the Lower Yakima (Satus, Toppenish, and Ahtanum) provide some of the best refuge habitat within the Yakima River Subbasin for steelhead and Coho Salmon, and likely for Pacific Lamprey as well. The YN is currently working with agencies such as the USFWS and the USACE to implement habitat improvement actions within the Yakima Subbasin to benefit lamprey and other aquatic resources.

Water temperature is also a concern within the Yakima Subbasin. Water temperatures in the lower Yakima River typically exceed or approach 80°F during the warmest periods in the summer months. These temperatures are known to be lethal for larvae and juveniles (Meeuwig et al. 2005). It is widely believed by resource managers that (1) river temperatures in the lower Yakima Subbasin during summer months were, in fact, relatively high in historic times but (2) river management (flow withdrawals) likely exacerbate these conditions, albeit to an un-quantified amount. These high temperatures occur when adults migrate past the Yakima River and discourage entrance and ascension up to headwater tributaries. Bateman Island Restoration Project, a restoration project orchestrated and proposed by various Yakima Subbasin partners, will likely improve the stagnant water conditions near the mouth of Yakima River considerably, benefiting many anadromous species, including and especially Pacific Lamprey. Low flows during the summer and fall can impede adult lamprey migration upstream, while also dewatering lamprey redds and isolating larvae in stream margins from flowing water.

#### 4.4.2.2 Methow River Subbasin

Water quality, stream and floodplain degradation, and dewatering have been identified as the primary threats to lamprey survival in the Methow Subbasin (Luzier et al. 2011). Irrigation diversions that reduce flows are common the in the Methow River and its tributaries. Diversions dewater the margins of the river, decreasing the amount of area usable by lamprey (Luzier et al. 2011).

#### 4.4.2.3 Klickitat River Subbasin

The upper reaches of the Klickitat Subbasin are heavily logged and roaded, and lower reaches are grazed and diverted, resulting in a lack of riparian cover, diminished base flows, increased temperature, habitat degradation, and loss of habitat complexity. Tributaries in the Klickitat River Subbasin have largely lost the ability to attenuate higher flows, resulting in more pronounced peak flows and reduced summer base flow. These extreme events are more likely to scour spawning gravel for Pacific Lamprey. The scope and severity of passage in the Klickitat Subbasin is considered low (Luzier et al. 2011).

#### 4.4.2.4 Entiat River Subbasin

Diversions are present in the Entiat Subbasin and contribute to reduced flow conditions; however, surface irrigation is being converted to wells and groundwater pumping, allowing more water to remain instream. Side channels have been lost, but are being restored (Luzier et al. 2011). Stream and floodplain degradation scope and severity are considered moderate, whereas water quality, predation, and passage issues are considered insignificant (Luzier et al. 2011). Chemicals, pollutants, dissolved oxygen, pH, sediment, and agricultural runoff have been identified as issues in the subbasin.

#### 4.4.2.5 Umatilla River Subbasin

Luzier et al. (2011) characterized the status of Pacific Lamprey as “imperiled to critically imperiled” for the Umatilla River Subbasin. Current distribution within the subbasin was estimated to be about 50% of historic distribution. Primary factors limiting Pacific Lamprey and habitat in the subbasin include passage, dewatering and flow management, stream and floodplain degradation, water quality, predation, and small population segment size.

Six major irrigation diversions are currently located in the lower Umatilla River. Results from a radio telemetry study conducted as part of Project 1994-026-00 in 2005 indicated that fewer than 50% of lamprey that approach Three Mile Falls Dam were able to pass successfully (Jackson and Moser 2012). Some lower elevation dams (< 2m) were found to impede passage, whereas others allowed higher rates of passage. Recommendations based on results from the telemetry studies included fitting some of the dams with lamprey passage structures. The removal of a small diversion dam in 2006 resulted in a substantial improvement in lamprey passage, particularly for spawning-phase fish.

Larvae are likely entering many irrigation diversion ditches within the Umatilla River Subbasin and being entrained behind various screens designed for salmonid criteria (Jackson 2015). To date, only preliminary work has commenced to understand how larvae are actually getting behind these screens. Investigations are currently underway to understand this issue and to develop and implement new screening criteria.

Water management has substantially changed flow conditions throughout much of the Umatilla River Subbasin (Phelps 2004). Multiple diversions still remove approximately half of the instream flows from June through September. Much of the flow in the Umatilla River was diverted at Three Mile Falls Dam, preventing continuous flow from reaching the Columbia River. The lack of flow during peak migration periods may explain why few adults were detected at Three Mile Falls Dam.

Beginning in 2006, an extension of the Umatilla Basin Project Act implemented pumping from the Columbia River during July and the first half of August to provide recommended passage flows for adult Pacific Lamprey during their peak migration period when flows have normally been near zero. The “year round” exchange period is now necessary because increased numbers of adult lamprey are expected as a result of the ongoing restoration program.

Land use practices have improved significantly over the past few decades. Land managers, local land owners, and others have improved habitat management to enhance watershed conditions to support anadromous salmonids. Actions to improve watershed conditions from the uplands to the floodplain are allowing, in some cases, natural ecosystem functions to recover. Although many steps have been taken, many more are needed. Habitat degradation from past and/or present land use remains a key concern. Pacific Lamprey have been adversely affected by degraded channel structure and complexity (including riffles, pools and large woody debris), loss of riparian vegetation, and reduced floodplain connectivity. Threats contributing to these factors include agricultural, forestry and grazing practices, roads, railroads and channel manipulations.

Water temperature is a concern throughout most of the Umatilla River Subbasin during periods of low flow from May through early November (Phelps 2004). The highest water temperatures have been recorded in late July and early August when ambient air temperatures are high. During this period, the Umatilla River warms rapidly from the headwaters to the mouth, reaching sub-lethal (64-74 ºF) and incipient lethal temperatures (70-77 ºF) for its entire length (Phelps 2004). Excessive stream temperatures in the Umatilla River Subbasin are influenced primarily by non-point sources including riparian vegetation disturbance (reduced stream surface shade), summertime diminution of flow (reduced assimilative capacities), and channel widening (increased surface area exposed to solar radiation).

#### 4.4.2.6 Grande Ronde River Subbasin

Water quality and predation have been identified as threats to lamprey survival in the lower Grande Ronde Subbasin, along with impaired passage and stream and floodplain degradation (Luzier et al. 2011). Problems are generally more severe in the upper subbasin, where primary threats include stream and floodplain degradation, water quality, and dewatering and flow management, followed by predation and impaired passage (Luzier et al. 2011). High water temperature is a concern, especially in the upper subbasin. Culverts throughout the subbasin could be full or partial passage barriers. The Wallowa Lake dam in the Wallowa watershed blocks passage, and several irrigation dams, while allowing salmonids passage, may be barriers to lamprey. Stream and floodplain degradation is often manifested in channelization caused by mining or road construction.

#### 4.4.2.7 Walla Walla River Subbasin

Dewatering and flow management, impaired passage, and water quality have been identified as the main threats to lamprey survival in the Walla Walla Subbasin, followed by stream and floodplain degradation and predation (Luzier et al. 2011). In addition to dewatering, numerous water diversions in the subbasin diversions contribute to high water temperatures. Many diversions have inadequate screening, especially for larvae. Channelization, loss of side channels, and scouring have been identified as primary concerns regarding stream degradation.

#### 4.4.2.8 Tucannon River Subbasin

Stream and floodplain degradation, water quality, and impaired passage have been identified as the main threats to lamprey survival in the Tucannon Subbasin (Luzier et al. 2011). Culverts and irrigation diversions throughout the subbasin could be full or partial passage barriers. Although analyses focused on anadromous salmonids, Columbia Conservation District (2004) reported that key habitat quantity, sediment load, and obstructions (fish passage barriers) were primary limiting factors.

#### 4.4.2.9 John Day River Subbasin

Passage in the John Day River Subbasin is moderately to highly impeded by low elevation diversion dams. General lack of screening criteria on irrigation pumps has been identified as a potential threat to Pacific Lamprey. The scopes and severities of water diversion, dewatering, and flow management for irrigation purposes is ranked high in the John Day Subbasin. Legacy effects from historic mining in the subbasin affect Pacific Lamprey through channelization, loss of side channels, and scouring (Luzier et al., 2011).

### 4.4.2.10 Imnaha River Subbasin

Pacific Lamprey within the Imnaha River Subbasin are faced with a low to moderate scope and severity of passage, dewatering, and flow management. However, due to passage issues at mainstem dams on the Snake and Columbia rivers, low abundance within the Imnaha has a high scope and severity, with the potential of being extirpated (Luzier et al., 2011; Ecovista 2004a). Culverts on the Imnaha River act as barriers to juveniles (USFS, 2003d as cited in Ecovista 2004a). Throughout the Imnaha River Subbasin, stream and floodplain degradation was rated low in scope and moderate in severity (Luzier et al. 2011).

### 4.4.2.11 Clearwater River Subbasin

The four main factors constraining Pacific Lamprey production in the Clearwater Subbasin are sedimentation, high water temperature, dewatering, and blocked or impeded passage. Approximately 451 stream miles are blocked or impeded within the subbasin; however, no data sources currently exist that accurately document location and description of all known barriers to fish passage. Culverts in tributaries and scattered irrigation diversions throughout the area could be full or partial passage barriers. Access to the North Fork Clearwater River has been blocked for decades by Dworshak Dam, blocking 26% of the anadromous fish spawning habitat. Lamprey have not been observed above Dworshak Dam since 1989. Additionally, Dworshak Dam has major impacts on hydrology, flow alteration, temperature alteration, stream alteration, and sudden fluctuations causing stranding and isolation downstream of the dam. The weir at Kooskia Hatchery on Clear Creek in the Middle Fork Clearwater watershed could be a barrier to Pacific Lamprey. Low flows and poor riparian conditions throughout the subbasin have resulted in high water temperatures, thus reducing the quality and quantity of adult spawning and juvenile rearing areas. Dewatering is considered to be low in scope and severity in the Clearwater Subbasin.

### 4.4.2.12 Salmon River Subbasin

Limiting factors to the success of Pacific Lamprey in the Salmon River subbasin include water withdrawals, irrigations canals, fish passage barriers, and habitat disturbance. Low flows and poor riparian conditions have resulted in high water temperatures, thus reducing the quality and quantity of adult spawning and larval/juvenile rearing areas. Passage in the subbasin was rated as low in scope and severity. Culverts in tributaries and scattered irrigation diversions throughout the area could be full or partial passage barriers. The weir at Rapid River Hatchery in the Little Salmon River watershed could be a barrier to migrating Pacific Lamprey. The water in the Challis area along the mainstem Salmon River is used for irrigation. The diversion of water for irrigation and its subsequent return is a major factor in decreased water quality and clarity and increased water temperatures. Mining and roads continue to deliver sediment to the upper Salmon River.

### 4.4.2.13 Asotin Subbasin

Key imminent threats to lamprey in the Asotin Creek Subbasin include unscreened diversions, passage barriers, and human-caused dry stream reaches. In the Asotin Creek Subbasin, five fish passage obstructions were identified: Headgate Dam, Trent Grade culvert, Asotin Road culvert, Mill

Creek Road culvert, and Pond Dam. These may be barriers to adult Pacific Lamprey passage (Schlosser and Peery 2010). Addressing habitat issues above these barriers may prove to be useless if these barriers are not removed or modified to allow for fish passage. Water withdrawals within the subbasin are minor; it is unknown if these are properly screened. Dry stream reaches have been identified within the subbasin, some of which may be due to anthropogenic causes. These dry stream reaches are not likely caused by withdrawals, but may be due to compromised upland conditions.

### 4.4.3 Contaminants and Water Quality

The Columbia River is water quality limited for multiple contaminants and physical attributes. Contaminants have been found in various fish species in rivers throughout the CRB. The states, tribes and federal government and non-governmental organizations (NGOs) are all engaged in efforts to restore and improve the water, land and air quality of the CRB and have committed to work together to restore critical ecosystems.

The effects of degraded water quality on lamprey may be similar to those observed in salmon with some exceptions. Lamprey have a higher lipid content than salmon in which toxics are known to accumulate. In addition, lamprey spend about five to seven years in the freshwater environment. Thus, their exposure period for toxins is considerably greater than for salmon. Like salmon, Pacific Lamprey must migrate through a complex hydroelectric corridor and estuary, rear in the ocean, and return again through the estuary and back through the corridor as adults. Movements through this variable environment expose lamprey to thermal and chemical pollution. Although the effects of decreasing water quality have not been thoroughly evaluated for lamprey, this information may be critical for their long-term restoration. Nilsen et al. (2015) screened Pacific Lamprey tissues from throughout the CRB and observed concentrations of contaminants (pesticides, flame retardants, mercury, and DDT) that were high enough to be detrimental to individual organisms suggesting that contaminants may negatively impact Pacific Lamprey. Contaminants may also impair the pheromone perception of adult Pacific Lamprey (Smith 2012). Very little information exists regarding the lethal and sublethal thresholds of various pollutants/contaminants for larvae, juveniles, and adult lamprey life stages as well as the degree of vertical transfer for these various chemicals from adult (female) to offspring. In addition, water temperature likely plays a role in determining the timing of adult lamprey migration, maturation and spawning (Clemens et al. 2009; Keefer et al. 2009). Laboratory analyses have generated water quality parameter tolerance limits for lamprey, including temperature, salinity, pH, turbidity and dissolved oxygen (GeoEngineers et al. 2011). It is vital to evaluate the synergistic relationships between water quality factors such as temperature and dissolved oxygen, metals, pesticides and other pollutants in relation to lamprey declines.

As with passage and habitat improvements, reductions in contaminants and improvements to water quality are important to the restoration of Pacific Lamprey in general, and to the success of supplementation actions specifically. In addition, lamprey produced through artificial propagation may provide individuals to evaluate effects of contaminants and water quality.

## 4.5 Consistency with Other Regional Plans

As noted in **Section 3.2**, the goals of this Master Plan are dependent in part on successful implementation of other regional plans, including existing CRB guiding documents and efforts for Pacific Lamprey. The various plans should be consistent to help facilitate successful implementation and outcomes. Regional plans include the USACE Passage Improvement Plan, the USFWS Assessment, the TPLRP, the LCA, and the Program.

### 4.5.1 USACE Passage Improvement Plan

The Passage Improvement Plan (USACE 2008) was developed by the USACE as part of the MOA with Tribes and CRITFC. The MOA requires collaboration with the tribes and USFWS to develop a 10-year plan, provides proposed funding, and identifies specific actions to be considered to improve lamprey passage and survival. The goal is to develop a 10-year lamprey plan that will improve adult and juvenile passage and survival through the Federal Columbia River Power System. Objectives of the plan will be achieved through adaptive management strategies, scientific research, adult and juvenile monitoring, and modifications at hydropower facilities to improve passage. Further, the plan aims to quickly and substantially contribute towards rebuilding depressed population segments to sustainable, harvestable levels throughout their historic range. Improved passage at mainstem dams will help increase the efficiency of Pacific Lamprey supplementation in the interior CRB.

The Passage Improvement Plan includes a preliminary prioritization approach based on two factors: (1) where passage efficiency is the poorest, and (2) where the affected numbers of Pacific Lamprey are the highest. Improvements at Bonneville, John Day, and McNary dams were considered the highest priorities. Although no specific performance targets or goals for lamprey passage currently exist, the USACE is working to improve passage at dams by at least 10% to 20% through operational and structural modifications. The timeframe for the plan is 2008-18.

An updated version of the Passage Improvement Plan was finalized in December 2014 (USACE 2014). It includes specific revisions given a better understanding of lamprey life history and the USACE's ability to implement passage improvements. Based on lessons learned and progress made since 2009, the USACE proposes to continue a prioritized strategy (e.g. where passage effectiveness is poorest and where the potential for adverse effects on lamprey are the highest), with a few notable deviations:

1. Increased focus on addressing adult lamprey passage bottlenecks in fishway sections that are upstream of entrances (i.e. transition pools, serpentine weirs). Post-hoc evaluation of historic telemetry data suggests this will enhance likelihood of improving overall dam passage efficiency and conversion to upriver dams (Keefer et al. 2013).
2. Based on success of Bonneville Dam Cascades Island Ladder entrance Lamprey Passage Structure and preliminary success at John Day North Ladder, and apparent benign effects on salmonids, install similar systems elsewhere at ladder bottlenecks (Corbett et al. 2013).
3. Accelerate implementation of small-scale modifications at Lower Columbia River dams (Bonneville, The Dalles, and John Day).
4. Consider alternative approaches to inform management decisions regarding juvenile lamprey passage improvements, other than the current strategy of developing a juvenile lamprey acoustic transmitter. Managers should consider technological feasibility, schedule, cost, and ESA obligations.

### 4.5.2 Pacific Lamprey Assessment and Template for Conservation Measures

The Assessment and Template for Conservation Measures developed by the USFWS (Luzier et al. 2011) identifies critical uncertainties regarding Pacific Lamprey life history and improves the scientific understanding regarding the importance of Pacific Lamprey. The Assessment tracks the current knowledge of Pacific Lamprey habitat requirements, abundance, and historic and current distribution; describes threats and factors for decline; and identifies conservation actions and RM&E needs. The approach is to be inclusive of other conservation measures with the objective of yielding coordinated efforts throughout the range of Pacific Lamprey. The Assessment notes that needed actions and RM&E identified in the TPLRP are applicable throughout the Columbia and Snake River regions.

The Assessment and Template recognizes and is inclusive of efforts such as the summary of critical uncertainties for Pacific Lamprey in the CRB (CRBLTWG 2005), which included a recommendation to develop, implement, and monitor reintroduction methods (e.g., transplantation, hatchery production). The Assessment and Template also cited objectives from the YN, including:

*Evaluate the potential for and participate in the development of supplementation/artificial propagation techniques for Pacific Lamprey.*

### 4.5.3 Assessment of U.S. Bureau of Reclamation Projects in the Columbia River Basin: Effects on Pacific Lamprey (Lampetra tridentata) and Reclamation Lamprey Plan

The USBR entered into a Memorandum of Agreement in 2008 with several CRB states and Tribes, the 2008 Columbia Basin Fish Accords. In the Accords, the USBR agreed to (1) conduct a study, in consultation with the Tribes, to identify all USBR projects in the CRB that may affect lamprey as well as (2) jointly develop a lamprey implementation plan for USBR projects as informed by commitment (1), the tribal draft restoration plan, and other available information.

The USBR assessment (USBR 2012) documents activities undertaken to satisfy commitment (1) described above. The USBR assessment was intended to inform the development of commitment (2), the Lamprey Implementation Plan for USBR projects (Reclamation Lamprey Plan). The USBR assessment of projects in the CRB that may affect Pacific Lamprey focuses on the Yakima and Umatilla subbasins, which is accomplished by tables summarizing all dams and diversions in these subbasins as well as recommendations for either further study or actions that may be taken to reduce effects on Pacific Lamprey.

The Reclamation Lamprey Plan (USBR 2012) outlines a collaborative strategy with the YN, CTUIR, and other partners to implement recommendations from the USBR assessment for further study or actions that may be taken to reduce effects to Pacific Lamprey. Further studies, as described in USBR (2012), are in progress to better understand the effects of USBR projects on lamprey. As these studies increase knowledge of Pacific Lamprey in and around low-head dams and diversions in the Yakima and Umatilla subbasins, an implementation plan is being developed in collaboration with partners to identify and prioritize actions needed to address effects on Pacific Lamprey.

### 4.5.4 Tribal Pacific Lamprey Restoration Plan

The Columbia River Treaty Tribes developed the TPLRP for the restoration of Pacific Lamprey in the CRB to numbers adequate for the basin's ecological health and tribal cultural use (CRITFC 2011). The tribes believe aggressive action must be taken, despite information gaps about the species' life history and population dynamics. The goals of the TPLRP are to immediately halt the decline of Pacific Lamprey and ultimately restore them throughout their historic range in numbers that provide for ecological integrity and sustainable tribal harvest. The objectives of the TPLRP include addressing key uncertainties and identified threats with focused and expedited actions.

The TPLRP emphasizes that with rapidly declining adult lamprey numbers, especially in the interior basin watersheds, and the existing passage problems and other threats that may take decades to resolve, natural recolonization and restoration will not be enough to halt the lamprey's decline. The likely relationship of adult lamprey attraction to ammocoete pheromones supports the recommended use of multiple management strategies including translocation, propagation, reintroduction and supplementation/augmentation for short and long-term preservation of Pacific Lamprey in the CRB. The TPLRP emphasizes actively and carefully developing a regional supplementation/augmentation approach including translocation and artificial propagation protocols, while concurrently developing pilot artificial propagation facilities. The TPLRP notes that artificially produced lamprey could offer an alternative source of research animals to naturally produced lamprey and also offer lamprey for supplementation or reseeding priority watersheds.

The TPLRP also emphasizes the importance of 1) developing a regional research and supplementation/augmentation plan, 2) establishing basic artificial propagation protocols that include both translocation and artificial propagation as critical components, and 3) concurrently developing artificial propagation facilities. Artificial propagation components for a regional supplementation plan would include:

- Immediate evaluation of potential regional lamprey artificial propagation facilities.
- Consolidation and synthesis of existing lamprey propagation information.
- Development and refinement of husbandry techniques for Pacific Lamprey.
- Continued research on lamprey genetics, population substructure, and source population segments.
- Assessment of appropriate release locations and strategies for propagated lamprey within the region.
- Monitoring and evaluation of supplementation using artificially propagated lamprey.

### 4.5.5 Lamprey Conservation Agreement

The LCA (USFWS 2012) is a voluntary commitment by interested parties to collaborate on efforts that reduce or eliminate threats to Pacific Lamprey to the greatest extent possible. The goal of the LCA is to achieve long-term persistence of Pacific Lamprey and support traditional tribal cultural use of Pacific Lamprey throughout their historical range in the United States. The intent of the parties is to achieve this goal by maintaining viable populations in areas where they exist currently, restoring populations where they are extirpated or at risk of extirpation, and doing so in a manner that addresses the importance of lamprey to tribal peoples. The LCA parties envision a future where threats to Pacific Lamprey are reduced, historic geographic range and ecological role are re-established and traditional tribal harvest and cultural practices are restored. The LCA provides a mechanism for interested parties to collaborate and pool available resources to expeditiously and effectively implement conservation actions. Cooperative efforts through the LCA intend to: a) develop regional implementation plans derived from existing information and plans; b) implement conservation actions; c) promote scientific research; and d) monitor and evaluate the effectiveness of those actions.

Objectives of the LCA include: 1) Evaluating Pacific Lamprey population substructure; 2) identifying global issues that are impacting Pacific Lamprey; 3) develop and implement public outreach; 4) continue to build and maintain data sharing; 5) identify, secure and enhance watershed conditions contained in the RMUs; 6) identify, secure and enhance watershed conditions contained in the RMUs; and 7) restore Pacific Lamprey of the RMUs.

Through the LCA, conservation aims to be advanced by the development of Regional Implementation Plans that will prioritize implementation of conservation actions and evaluate action effectiveness. The Regional Implementation Plans will build upon existing restoration plans that include conservation actions such as: modifying fish ladders and entranceways at dams, constructing lamprey passage structures at tributary barriers, restoring lamprey habitat, and considering lamprey during in-stream work. However, gaps in addressing threats to Pacific Lamprey remain. The RIPs will identify additional conservation actions needed at the watershed scale to address threats and issues identified by local experts.

Regional Management Unit Groups develop a Regional Implementation Plan that includes a list of prioritized actions and a strategy to implement them in the next 3-5 years. The Regional Implementation Plans consists of project spreadsheets for each 4th code hydrologic unit code (HUC) or watershed in the Regional Management Unit and a summary of how the actions and research needs in the spreadsheets will address overall Regional Management Unit threats. The Regional Management Unit project spreadsheets contain actions and research categorized by threat for each HUC. Efforts are made to include additional information including scope, benefit, feasibility, partner participation, cost, implementing entity, and potential funding source for each need.

### 4.5.6 Columbia Basin Fish and Wildlife Program

The NPCC, as directed by the Northwest Power Act, developed the Program (NPCC 2014) to "protect, mitigate, and enhance fish and wildlife, including related spawning grounds and habitat, on the Columbia River and its tributaries … affected by the development, operation, and management of [hydroelectric projects] while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply." The Program includes a set of strategies that provide specific guidance for topics that address particular policy needs. These consist of guidance for anadromous fish mitigation in blocked areas, wildlife mitigation, resident fish mitigation, sturgeon, and lamprey. The Program was revised in 2014 with added guidance on implementing actions that result in increased abundance and survival for Pacific Lamprey, including habitat actions, dam operations and passage, monitoring populations, and research to improve understanding of how the development and operation of the Federal Columbia River Power System affect migration success, survival and growth of lamprey.

Within the 2014 Program revision, the NPCC recognized and supported efforts to restore Pacific Lamprey consistent with The Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin and the LCA. Guiding principles of 2014 revision include (1) juvenile and adult lamprey should be able to safely pass dams in the basin, (2) the population size, distribution, and other limiting factors for lamprey related to the hydropower system need improved understanding, and (3) lamprey throughout their historic range should be self-sustaining and harvestable.

## 4.6 Consistency with Other Supporting Documents

Numerous other documents, or plans of smaller geographic scope, are relevant to or help guide restoration of Pacific Lamprey in the CRB. These include the Framework, subbasin specific lamprey plans attached to the Framework, and pertinent subbasin plans (amended to the Program).

### 4.6.1 Subbasin Specific Supplementation Research Plans

Subbasin supplementation research plans are integral components of the Framework for Pacific Lamprey Supplementation Research. The Framework guides the more specific subbasin supplementation research plans, and development of the plans is anticipated to guide future activities and funding. Plans provide information specific to a subbasin regarding lamprey status, limiting factors, ongoing and planed actions, and rationale for those actions. Plans describe supplementation actions and RM&E actions associated with supplementation, including metrics, parameters, etc. Although plans will vary in scope and content among subbasins, each plan will provide a minimum level of information to facilitate consistency and continuity of important methods, analysis, and reporting formats. As of 2015, subbasin supplemental research plans for Pacific Lamprey have been drafted for the Umatilla and Yakima subbasins.

### 4.6.2 Subbasin Plans

Subbasin plans for most subbasins within the CRB were completed in 2004 and have not been comprehensively updated since. However, subbasin plans still serve to help the NPCC, BPA, and other agencies recommend and prioritize actions in many of the subbasins.

#### 4.6.2.1 Yakima River Subbasin

The purpose of the Yakima Subbasin Plan (Yakima Subbasin Fish and Wildlife Planning Board 2004) is to provide the NPCC with a coherent and measurable plan for allocating BPA fish and wildlife mitigation and restoration funds within the Yakima Subbasin. This initial plan identifies the importance of Pacific Lamprey within the subbasin, and highlights distribution, abundance and life history characteristics. Key findings of the plan include the cultural importance of lamprey to Native American tribes within the subbasin, as well as uncertainties about the historic distribution and abundance. The Yakima Subbasin Management Plan also outlines specific conservation objectives for salmon and lamprey, including determining the feasibility of Pacific Lamprey reintroduction. The plan notes that scientists affiliated with the Yakima-Klickitat Fisheries Project (YKFP) are participating in regional studies to learn about lamprey restoration throughout the CRB, and that these efforts could lead to formal feasibility studies focused on restoring lamprey population segments within the Yakima Subbasin, while looking ahead to planning and implementing full-scale restoration and supplementation efforts in the long-term.

#### 4.6.2.2 Methow River Subbasin

The Methow Subbasin Plan is designated to provide strategic direction for supporting viable, self-sustaining, harvestable, and diverse populations of fish and wildlife and their habitats within the subbasin (KWA Ecological Services et al. 2004). Lamprey are listed as a focal species in the Methow Subbasin Plan; however, little information is provided about their extent in the subbasin. The Plan notes that Pacific Lamprey abundance declined significantly from the 1960s through the 1980s based on counts over Rocky Reach and Rock Island dams, but has appeared to be rebuilding since the early 2000s. The Plan also calls for a consistent, standardized system for monitoring lamprey abundance that is separate and distinct from salmonid monitoring. No estimates of redd, juvenile, or adult counts are available; all estimates come from dam counts.

#### 4.6.2.3 Klickitat River Subbasin

The Klickitat Subbasin Plan (Yakama Nation et al. 2004) defined the environmental and biological vision, objectives, and strategies specific to fish and wildlife in the subbasin. The plan identifies Pacific Lamprey as a “species of interest,” and involves the evaluation of Pacific Lamprey habitat needs and the implementation of restoration actions. The plan will help prioritize the spending of BPA funding for projects that protect, mitigate, and enhance fish and wildlife that have been adversely impacted by the development and operation of the Columbia River hydropower system.

#### 4.6.2.4 Entiat River Subbasin

The three primary parts of the Entiat River Subbasin Plan (Peven et al. 2004) are to analyze the biological potential of the subbasin and opportunities for restoration; inventory information on fish and wildlife protection, restoration, and artificial production activities; and supply a vision for the subbasin, biological objectives, and strategies addressing a 10-15 year planning horizon. The plan recognizes Pacific Lamprey as a species of concern and recommends a relatively high level of effort to monitor and enhance Pacific Lamprey population segments, evaluate habitat suitability, and address cultural significance to the Yakama Nation.

#### 4.6.2.5 Umatilla River Subbasin

The primary goal of the Umatilla Subbasin Plan (Phelps 2004) is to define the environmental and biological vision, objectives, and strategies specific to fish and wildlife in the subbasin. The biological objectives describe the physical and biological changes within the subbasin needed to achieve the vision and the strategies are the actions need to achieve the objectives. The objectives and strategies were driven by the vision for the subbasin, the current biological and ecological conditions, and the economic and social realities described in the assessment. The plan identifies Pacific Lamprey as “taxa of interest,” because of their cultural and ecological importance. The plan notes that Pacific Lamprey were historically used both as food and for medicinal purposes by Native Americans throughout the CRB, that lamprey numbers have declined dramatically in the subbasin over the past century and there is no longer a tribal harvest of these animals. The plan also notes that Pacific Lamprey are the focus of restoration efforts by the CTUIR.

#### 4.6.2.6 Grande Ronde River Subbasin

The Grande Ronde Subbasin Plan (Nowak 2004) defined the environmental and biological vision, objectives, and strategies specific to fish and wildlife in the subbasin. The plan identifies Pacific

Lamprey as a “species recognized as rare or significant to the local area,” and also as a species “recognized by Columbia Plateau tribes as having cultural or religious value.”

#### 4.6.2.7 Walla Walla River Subbasin

The Walla Walla Subbasin Plan (Walla Walla Watershed Planning Unit and Walla Walla Basin Watershed Council 2004) focuses on integration with federal obligations under the Northwest Power Act, Endangered Species Act, Clean Water Act, and tribal trust and treaty-based responsibilities. The plan also looks more broadly toward other federal, state, and local activities. The objectives and strategies outlined in the plan provide direction for implementing projects on tributary streams. The plan identifies Pacific Lamprey as a “species of interest,” and notes that abundance and range are currently unknown but Pacific Lamprey are believed to be at or very near extinction in the subbasin.

#### 4.6.2.8 Tucannon River Subbasin

The Tucannon Subbasin Plan (Columbia Conservation District 2004) focuses on integration with federal obligations under the Northwest Power Act, Endangered Species Act, Clean Water Act, and tribal trust and treaty-based responsibilities. Key components of the plan include aquatic species and habitat assessment, inventory of existing projects, and a management plan. The plan is based upon the best available science, and its various components explicitly identify the data, hypotheses, and assumptions used during its development. The plan identifies Pacific Lamprey as a “species of interest,” and notes that historically they were common in the subbasin. The plan also notes that Pacific Lamprey were well integrated into the native freshwater fish community, and as such had positive effects on the system. Finally, the plan notes that no current empirical data on abundance in the subbasin are available, and that additional research is required to establish current numbers, limiting factors, available habitat and rehabilitation potential.

#### 4.6.2.9 John Day River Subbasin

The John Day Subbasin Plan (Columbia-Blue Mountain Resource Conservation and Development Area 2005) will guide implementation of the NPCC Program to mitigate for fish and wildlife losses resulting from hydropower dams built on the Columbia River. The plan identifies Pacific Lamprey as a culturally important species for the CTUIR and the Confederated Tribes of Warm Springs Reservation. The plan recognizes the need to research Pacific Lamprey status, trends and habitat requirements as well as to understand lamprey population dynamics and habitat requirements within the subbasin. The plan states that the number of Pacific Lamprey in the John Day Subbasin is unknown.

#### 4.6.2.10 Imnaha River Subbasin

The Imnaha River Subbasin Plan (Ecovista 2004a) is intended to be a living document that increases analytical, predictive, and prescriptive ability to restore fish and wildlife. The plan states that little is known about lamprey in the Imnaha Subbasin; however, current data suggests Pacific Lamprey are declining with the possibility of being “extirpated from the Imnaha.” The plan recognizes the necessity to improve understanding of lamprey to facilitate sustainable population segments.

#### 4.6.2.11 Clearwater River Subbasin

The Clearwater River Subbasin Plan (Ecovista et al. 2003) discusses three main aspects: assessment of focal species and habitats, inventory of existing resources for protection and restoration in the subbasin, and a vision for the future of the Clearwater Subbasin. The plan proposes research to assess status, limiting factors, and rehabilitation potential for Pacific Lamprey in the Clearwater Subbasin. The plan states that Pacific Lamprey population segments are not yet determined, and that future research to establish a program to restore and monitor a recovered population segment is needed.

#### 4.6.2.12 Salmon River Subbasin

The Salmon River Subbasin Plan (Ecovista 2004b) includes three interrelated volumes that describe the characteristics, management, and vision for the future of the subbasin. Because of its large size, the Salmon Subbasin was split between working groups for the Upper Salmon and the Lower Salmon. The plan states that inventory work is needed to determine the present range and status of Pacific Lamprey within the subbasin.

#### 4.6.2.13 Asotin Subbasin

The Asotin Subbasin Plan (Asotin County Conservation District 2004) consists of three main components: assessment, implementation of a management plan, and development of hypotheses, objectives, and strategies. The plan states that Pacific Lamprey are a “species of interest”; but noted that no adult Pacific Lamprey had been documented in Asotin Creek since at least 1980.

## 4.7 Local and Regional Management Context

### 4.7.1 Habitat

Characterization of habitat for Pacific Lamprey usually focuses on needs for spawning and rearing, in addition to requirements for passage at potential barriers. Many actions to restore or enhance salmonid habitat will also likely benefit Pacific Lamprey. Because Pacific Lamprey spend the majority of their life cycle in freshwater as larvae, rearing habitat is extremely important. Some restoration actions targeting salmonids may not benefit rearing larvae because of differences in substrate requirements. Rearing habitat is commonly categorized as either Type I (preferred; in depositional zones with a mixture of sand and fine organic matter), Type II (acceptable; shifting sand that may contain gravel and other coarse substrate), or Type III (unacceptable; hard packed coarse substrate, hard-pan clay, and bedrock), based on suitability of substrate for rearing larvae (Slade et al. 2003).

Habitat has been altered throughout much of the range of Pacific Lamprey by dams, culverts, hydropower development, channelization, loss of side channels, and loss of riparian areas. These factors have all contributed to lamprey declines within the CRB. More detailed summaries of habitat status, investigations, and needs are provided for each subbasin in **Section 4.4.2**.

### 4.7.2 Hatcheries

Limited Pacific Lamprey propagation research is currently being conducted by the YN and the CTUIR (**see Section 4.3**); however, no facilities currently exist for the sole or primary purpose of propagating Pacific Lamprey. The four Columbia River treaty tribes recently completed a framework for Pacific Lamprey supplementation research (CRITFC 2014) and this Master Plan with general objectives that are experimental in nature and promote adaptive management.

The NPCC also outlined a series of recommended artificial production strategies for lamprey within the CRB (NPCC 2014). These strategies should be employed either: 1) in an integrated manner to compliment habitat improvements by supplementing native fish with fish that are as similar as possible, in genetics and behavior, to wild fish; or 2) in a segregated manner to maintain the genetic integrity of the local population segments to expand natural production while supporting harvest of artificially produced stocks.

Salmonid hatcheries are present at one or more locations in each of the subbasins currently utilized or targeted for Pacific Lamprey supplementation. Some hatchery facilities may be directly affected because lamprey programs use or will use available space at existing facilities. Although many hatchery practices for salmonids are not directly applicable to Pacific Lamprey, lamprey efforts will benefit from decades of experience, both positive and negative, gained from salmonid propagation.

Sharing facilities with other programs raises the potential risk of disease transmission (Jackson et al. *In Review*). Previous work has shown that the risk of transmission is low (Ward et al. 2012). The primary pathogen of concern has been a bacterium *Aeromonas salmonicida*, the causative agent of furunculosis. Only one of 114 live adult lamprey broodstock submitted for screening tested positive for *A. salmonidcida* (Jackson et. al. *In review*). Routine inoculations with oxytetracycline (0.1ml/400g body weight) appear to have been successful in preventing the outbreak of furunculosis. Because *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease, has been found in Sea Lamprey; (Faisal et al. 2006), tests for this bacterium are also conducted. No viral pathogens or parasites have been detected in any lamprey examined. Kurath et al. (2013) found that no lamprey contracted the disease during a viral challenge.

Influence on genetic integrity is a primary concern for all supplementation efforts, and much has been learned in this field regarding salmonids; however, the field of regional genetic study of Pacific Lamprey is still in its infancy (see **Section 4.2**). Although much more work is needed to better understand lamprey genetics, compared to salmonids, lamprey appear to exhibit low genetic differentiation among regional stocks, and its population structure reflects a single broadly distributed population across much of its range in the Pacific Northwest (Goodman et al. 2008; Spice et al. 2012). The need for genetic diversity in artificial salmonid propagation and rearing programs has been well documented. With salmon, collecting broodstock across the entire run is advised to maintain the genetic diversity of supplemented populations. Genetic heterogeneity among a population's individuals is a basic driving principle for sustainability to reduce the potential for deleterious population effects, including inbreeding depression. This genetic principle is applicable to all species, including Pacific Lamprey, and provides organisms the ability to exhibit a selective response to environmental variability.

Another well-established premise for artificial propagation in salmonids is the use of locally-adapted broodstock. Such local stock may include individuals that are adapted to specific conditions in a basin, and subsequently exhibit higher fitness. However, in comparison to salmonids, Pacific Lamprey do not appear to exhibit strict natal homing (Goodman et al. 2008; Spice et al. 2012; Hess et al. 2012). For this reason, unlike salmonids, the spatial scale that contains locally-adapted broodstock may be much broader for Pacific Lamprey, and thus the specific watershed- or subbasin-of-origin of this broodstock may not be critical to the success of artificial propagation programs for Pacific Lamprey.

### 4.7.3 Hydropower

Dams are known to impede Pacific Lamprey passage, whether they be large hydroelectric dams of the Columbia River or irrigation dams along smaller tributaries. Pacific Lamprey must negotiate either three (Umatilla), four (Yakima and Walla Walla), six (Tucannon), or eight (Grande Ronde) mainstem hydropower dams just to reach the subbasins of focus in this Master Plan. The Federal Columbia River Power System dams on the mainstem Snake and Columbia Rivers were identified as the highest threat to the persistence of Pacific Lamprey in the Snake River watersheds (Luzier et al. 2011). Additional obstacles await within each subbasin. Hydropower facilities are present in the Yakima River Subbasin, and Dworshak Dam totally blocks Pacific Lamprey access to the North Fork Clearwater River in the Clearwater Subbasin.

#### 4.7.3.1 Yakima River Subbasin

Pacific Lamprey face numerous passage challenges throughout the Yakima Subbasin associated with hydropower operations, storage reservoirs, and irrigation diversions (Figure 4-2). Power generation is associated with Prosser and Roza dams on the mainstem Yakima River, and the Wapato Irrigation Project and the Yakima-Tieton Irrigation District also have power-generating turbines installed in their irrigation distribution systems. Chandler Powerplant uses water diverted down the Chandler Power Canal at Prosser Dam to operate pumps to convey irrigation water across the Yakima River into the Kennewick Main Canal. The residual capacity remaining from irrigation needs, including when the pumps are not run for irrigation is diverted to power production. Roza Powerplant is located along Roza Canal northeast of the city of Yakima. Water is diverted into the canal at Roza Dam and returns to the river below the power plant in Yakima, WA. Some of the power from the Roza Powerplant is used to operate Roza Irrigation District’s pumping plants. Major storage reservoirs in the upper subbasin include Cle Elum, Kachess, Keechelus, Bumping Lake, and Tieton dams and reservoirs.

Based on radio telemetry studies between 2012 and 2014, Pacific Lamprey passage rates at Prosser Dam averaged 45-50% and Roza Dam was determined to be a complete impediment. Seasonal passage rates at other dams in the Lower Yakima River, such as Horn Rapids, Sunnyside, and Wapato dams ranged between 33% and 96%, but lower passage rates (33-53%) were detected at each dam at least seasonally.

In addition to hydropower related passage impediments on the mainstem Yakima River, flow management strategies at the storage reservoirs may negatively impact lamprey by rapid dewatering. Both adult and larval/juvenile lamprey are often stranded or subject to increased water temperature due to low flows and lack of thermal refugia during summer. Additionally, fishways are not adequately designed to facilitate upstream migration of lamprey and also lack sufficient attachment surfaces.

Storage reservoir operations have also altered the historic river hydrograph so that flows are lower in the fall, winter, and spring, and higher in the summer and early fall, Reservoir operations have reduced flood frequency, duration, magnitude, and spatial extent, reduced recharge from over bank flow, increased irrigation-induced recharge, and altered quantity, quality, and timing of groundwater discharge to the river and floodplain.

#### 4.7.3.2 Methow River Subbasin

Several irrigation diversion dams throughout the Methow Subbasin have significantly impacted passage and connectivity, but no hydropower projects currently operate within the subbasin.

#### 4.7.3.3 Klickitat River Subbasin

The Klickitat River Subbasin does not contain any hydropower dams. All flows in the subbasin occur within a natural flow regime, with the exception of portions of Outlet Creek, Hellroaring Creek, Swale Creek, and the Little Klickitat River, where diversion for water supply and irrigation occur.

#### 4.7.3.4 Entiat River Subbasin

No hydropower dams occur within the Entiat Subbasin; however, the lower 0.5 miles of the Entiat River and floodplain are influenced by the backwatering effects of Lake Entiat, which serves as the pool for the Rocky Reach Dam on the Columbia River.

The Entiat River did, however, have a varied history of impoundment between the late 1880s and the first half of the 1900s. A holding dam associated with the Harris-Cannon sawmill was constructed near the mouth of the river in 1898. In 1904 an electric power plant was built at the site of the dam; the plant experienced winter closure due to low water levels from 1905-1906. A log-holding dam was also built in 1904, in association with a saw mill constructed in Mills Canyon. In 1909, a dam and power plant were constructed near the present day Keystone Bridge. In some years little water remained in the channel below this dam. In 1932 the sawmill to the mouth of the Mad River at Ardenvoir (RM 10.5) and some remnants of the 13.5 foot high log storage dam constructed to serve the mill are still evident. U.S. Bureau of Fisheries surveys in 1934, 1935 and 1936 noted that three dams still remained on the Entiat River (Bryant and Parkhurst 1950). Of the three, the last to remain was the Ardenvoir Mill dam, which was washed out in the 1948 flood and never rebuilt.

#### 4.7.3.5 Umatilla River Subbasin

Although hydropower is one of the 15 designated beneficial uses of water in the Umatilla Subbasin (Phelps 2004), no hydropower projects currently operate within the subbasin. Three general types of water development projects that impact aquatic environments in the Umatilla Subbasin are impoundments, irrigation diversions, and water exchange projects (Figure 4-15). The largest impoundment projects are McKay Reservoir, with a design capacity of 73,800 acre-feet, and Cold Springs Reservoir, with a design capacity of 50,000 acre-feet. These reservoirs supply irrigation flows to three irrigation districts and to some individuals during high-demand summer months. A water exchange program has helped to restore stream flows that were reduced as a result of impoundments and diversions.

#### 4.7.3.6 Grande Ronde River Subbasin

Although hydropower is one of the 15 designated beneficial uses of water in the Grande Ronde Subbasin (Nowak 2004), no hydropower projects currently operate within the subbasin. Wallowa Lake is the only major water impoundment in the subbasin.

#### 4.7.3.7 Walla Walla River Subbasin

Numerous irrigation diversions throughout the subbasin and a USACE diversion dam within the City of Walla Walla have significantly impacted passage and connectivity, but no hydropower projects currently operate within the subbasin.

#### 4.7.3.8 Tucannon River Subbasin

No hydropower projects currently operate within the subbasin.

#### 4.7.3.9 John Day River Subbasin

No major hydropower dams are located in the John Day Subbasin.

#### 4.7.3.10 Imnaha River Subbasin

No hydropower dams are currently located within the Imnaha River Subbasin. Three hydropower facilities were decommissioned in 1997 in the Wallowa Valley Improvement Canal, thus decreasing the amount of water withdrawn from Big Sheep and Little Sheep creeks; however; water continues to be withdrawn for irrigation purposes.

#### 4.7.3.11 Clearwater River Subbasin

Dworshak Dam, completed in 1973, is the major hydropower facility in the subbasin, located two miles above the mouth of the North Fork Clearwater River. The dam has a height of 717 feet, has no fish ladder, and creates a 53.4 mile long reservoir behind the dam. Numerous other dams currently exist within the subbasin; however, none were constructed for hydropower.

#### 4.7.3.12 Salmon River Subbasin

No hydropower dams are located within the Salmon River Subbasin. Three hydropower dams were previously constructed in the subbasin, but have since been removed.

#### 4.7.3.13 Asotin Subbasin

No hydropower facilities currently exist in the Asotin Subbasin.

### 4.7.4 Harvest

Harvest throughout the CRB differs by state, each with its own management strategy. The State of Oregon recognizes that Pacific Lamprey are a conservation concern, and as a result, lamprey were listed as an Oregon State sensitive species in 1993. In 1996, lamprey were given legal protection (OAR 635-044-0130) whereby it became unlawful to harvest lamprey for commercial purposes. Harvest of adult lamprey for personal use at Willamette Falls is still permitted; however, harvesters must be authorized by either a federally-recognized Indian tribe or the Oregon Fish and Wildlife Commission. The State of Washington lists Pacific Lamprey as a Priority Species under the Priority Habitat Species program. Lamprey remain an important food and cultural resource for Native American tribes in Washington State, and therefore current sport fishing regulations prohibit the catch of lamprey. Idaho considers Pacific Lamprey an endangered species, and the Idaho Department of Fish and Game (IDFG) has documented the extirpation of lamprey in many watersheds and allows no harvest.

Anecdotal accounts indicate lamprey were historically plentiful in the YN Ceded Lands, specifically in the Yakima River where adult lamprey were harvested locally at least till the 1960s and early 70s (Yakama Nation and GeoEngineers, Inc. 2012). Because of the decline in lamprey numbers they are no longer harvested in the Yakima Subbasin and tribal members are forced to travel long distances to other locations, such as Willamette Falls and Fifteenmile Creek, to harvest lamprey for ceremonial purposes. Along with Willamette Falls, Sherars Falls on the Deschutes River is one of the few remaining harvest locations for lamprey in the CRB for the Warm Springs Tribe (Baker et al. 2015).

Lamprey numbers have also declined dramatically in the Umatilla River Subbasin over the past century and there is no longer a tribal harvest. Tribal members generally travel to Willamette Falls to harvest lamprey for ceremonial purposes.

Because of extremely low numbers, the Nez Perce currently have no directed harvest opportunities for Pacific Lamprey in local subbasins and must travel long distances to harvest lamprey.

## 4.8 Coordination with Other Entities

Supplementation actions for Pacific Lamprey require regional coordination efforts as well as coordination within specific subbasins of focus. Both local and regional coordination are important in part because potential transmission of disease is a significant consideration for fishery managers. Each of the tribes currently supplementing lamprey population segments engage with the USFWS, state and other appropriate fishery managers on a regular basis in consideration of these, and other relevant matters.

### 4.8.1 Regional Coordination

Adult Pacific Lamprey used for translocation are collected at mainstem Columbia River dams, predominantly Bonneville, The Dalles and John Day. The CRITFC member tribes have adopted specific criteria for collection of Pacific Lamprey at federal dams for translocation (CRITFC 2011). Each tribe is allowed to collect 1% of the run based upon counts at Bonneville Dam from the previous 2-years and must present a collection and translocation plan annually to the CRITFC Commission. Tribal collection is coordinated internally between each of the tribes and with Project and District USACE staff.

Coordination specific to the YN occurs within the ceded lands, including the Yakima, Methow, Klickitat, and Entiat subbasins. Adult translocation has been ongoing in the Yakima Subbasin since 2012 and in the Methow Subbasin since 2015, resulting in continual discussions with WDFW and USFWS representatives. Communication of these activities occurs primarily at the technical level with both WDFW and USFWS but information is also provided to the interested parties to the Mid-Columbia Public Utility District fisheries forums associated with the FERC Licenses (Priest Rapids Fish Forum, Rocky Reach Fish Forum, Wells Aquatic Settlement Work Group). A longer-term adult translocation program and potential research on supplementation with artificially propagated juveniles, proposed primarily by the Yakama Nation, WDFW and USFWS (in coordination with the Confederated Colville Tribes, Washington State Department of Ecology and each of the PUD's), is currently being discussed within each of these forums. Implementation of these activities is expected to occur by 2020.

Coordination specific to the CTUIR occurs within the ceded land that includes the Umatilla, Grande Ronde, Walla Walla, Tucannon and John Day subbasins. Adult translocation began in 2000 in the

Umatilla Subbasin and in 2015 in the Grande Ronde Subbasin. Coordination with ODFW, WDFW, USFWS, NOAA Fisheries and other CRITFC member tribes has continued since the inception of the CTUIR Pacific Lamprey Research and Restoration Project. Most coordination occurs at the technical level with counterparts of these agencies. As artificial propagation field activities ramp up, additional coordination will be needed to inform co-managers. Implementation of these actions is expected to occur within the next couple of years.

Coordination specific to the NPT occurs within the ceded land that includes the Clearwater, Salmon, Grande Ronde, and Asotin subbasins. Adult translocation began in 2007 in the Clearwater and Asotin subbasins and in 2012 in the Salmon and Grande Ronde subbasins. Coordination with ODFW, WDFW, IDFG, USFWS, NOAA Fisheries and other CRITFC member tribes has continued since the inception of the translocation program. Most coordination occurs at the technical level with counterparts of these agencies. The NPT also works cooperatively with the Ahsahka Fisheries Research Office of the USFWS to sample larvae in translocation and non-translocation streams. The USFWS Dworshak Fish Health Laboratory provides support for fish health and disease issues associated with translocation and holding of adult Pacific Lamprey.

The USFWS is acting as the coordinating agency to engage entities willing to participate, coordinate conservation efforts, facilitate increased knowledge about distribution, abundance, population structure, and threats, and work with partners in the development of regional implementation plans for restoring Pacific Lamprey (Luzier et al. 2011). Objectives of the Pacific Lamprey Conservation Initiative developed by the USFWS include:

- Developing an assessment range-wide and regionally.
- Constructing a conservation agreement.
- Developing regional implementation plans.

This Conservation Initiative has led to the development and implementation of the Pacific Lamprey Conservation Agreement, currently endorsed by 33 signatories including 11 tribes, 7 federal agencies, 5 states and many other partners. Objective 7 of this Agreement speaks directly towards supplementation: "*Where feasible implement artificial propagation and translocation experiments to develop methods and strategies for reintroducing Pacific Lamprey to extirpated areas and advancing Pacific Lamprey conservation through establishing self-sustaining populations within RMUs*" [Regional Management Units]. Discussion and coordination of future supplementation will also occur within this body, as appropriate.

The USFWS also chairs the regional Lamprey Technical Work Group (LTWG) that coordinates deliberations on technical aspects of Pacific Lamprey biology and conservation, and responds to specific requests regarding Pacific Lamprey technical issues. CRITFC member tribes are actively engaged in the proceedings of the LTWG.

### 4.8.2 Local Coordination

Discussion of local coordination includes that between the YN, CTUIR, or NPT and entities whose jurisdiction or influence is limited primarily to a single subbasin. Coordination with federal and state entities may also be subbasin specific in addition to the more general coordination described above. A general overview of somewhat localized coordination is provided here.

#### 4.8.2.1 National Marine Fisheries Service

The CTUIR has worked closely with the National Marine Fisheries Service (NMFS) while conducting Project 1994-026-00. The NMFS was listed as a project proponent during the most recent project review. The NMFS has played an especially prominent role in implementing radio telemetry studies and evaluating passage at diversion structures.

#### 4.8.2.2 U.S. Bureau of Reclamation

In the Accords, the USBR agreed to (1) conduct a study, in consultation with the Tribes, to identify all USBR projects in the CRB that may affect lamprey as well as (2) jointly develop a lamprey implementation plan for USBR projects as informed by their Accord commitments, the tribal draft restoration plan, and other available information. The USBR Lamprey Plan (USBR 2012) outlines a collaborative strategy with the YN, CTUIR, and other partners to implement recommendations from the USBR Assessment for further study or actions that may be taken to reduce effects to Pacific Lamprey. Further studies, as described in the Pacific Lamprey 2011 Annual Report and 2012 Plan (USBR 2012), are in progress to better understand the effects of Reclamation projects on lamprey. These coordination activities include but are not limited to 1) assessment and improvement of adult passage at dams, 2) assessment and improvement of larval/juvenile lamprey entrainment in irrigation diversions, 3) research on life stage bottleneck and implications of small effective population size on these objectives, and 4) water quality issues. As these studies increase knowledge of Pacific Lamprey in and around low-head dams and diversions in the Yakima and Umatilla subbasins, an implementation plan is being developed in collaboration with partners to identify and prioritize actions needed to address Pacific Lamprey effects.

#### 4.8.2.3 U.S. Forest Service

The Nez Perce Tribe works closely with the US Forest Service on implementation of the US Fish and Wildlife Service Best Management Practices to Minimize Adverse Effects to Pacific Lamprey. The Watershed Division of the Nez Perce Tribe’s Fisheries Department coordinates intensively with the Forest Service on habitat improvement actions.

#### 4.8.2.4 Yakima Basin Fish and Wildlife Recovery Board

The Yakima Basin Fish & Wildlife Recovery Board's mission is to restore sustainable and harvestable populations of salmon, steelhead, bull trout and other at-risk fish and wildlife species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Yakima River Basin. The Board:

1. Coordinates funding for fish and wildlife restoration projects in the Yakima Basin
2. Develops strategic plans to guide fish and wildlife recovery efforts in the Yakima Basin
3. Supports efforts to implement priorities identified in its strategic plans.
4. Fosters public awareness and engagement in fish and wildlife recovery

The YN Fisheries Department is an active partner with the Board in implementing fish and wildlife projects in the Yakima Subbasin.

#### 4.8.2.5 Irrigation Districts

The Tribes meet regularly with various irrigation districts in the subbasin to discuss and negotiate larval lamprey entrainment issues, impacts, and alternatives. Water quantity and quality are limiting factors for many aquatic species in the subbasin, including Pacific Lamprey.

#### 4.8.2.6 County Conservation Districts

The Tribes work closely with counties when and where it is appropriate. As an example, the NPT has engaged with the Asotin County Conservation District to communicate the scope (Asotin Creek) and purpose of the Pacific Lamprey translocation program and to increase awareness of the life history, status and value of Pacific Lamprey.

## 4.9 Relationships to Ongoing Projects

Only five projects specifically targeting Pacific Lamprey are currently funded by BPA through the NPCC's Program (Table 4-15). An additional project conducted by the NPT is not funded through the Program (**see sections 4.3.5 and 4.9.6**). Project proponents for each project are CRB Tribes. Development of this Master Plan is a joint effort of multiple projects, but is funded primarily through Project 2008-524-00, Implement Tribal Pacific Lamprey Restoration Plan (**Section 4.9.4**). Activities carried out under the guidance of this Master Plan will be conducted as part of projects 2008-470-00 (**Section 4.9.3**) and 1994-026-00 (**Section 4.9.1**).

Although most projects do not have an artificial propagation component, some projects may benefit from artificial propagation research and monitoring and vice versa. Project 1994-026-00 includes laboratory and field experiments to determine the effects of diversion screens on juvenile and larval lamprey. One objective of Project 2008-524-00 is to assess and address impacts of irrigation and other mainstem water withdrawal structures on lamprey. These efforts could be facilitated by the use of hatchery-reared fish in evaluations. Use of hatchery-reared lamprey would reduce the need to collect fish from the wild for use in the evaluations. Project 2008-470-00 includes an objective to evaluate the potential for and participate in the development of supplementation techniques of Pacific Lamprey.

**Table 4-15. Current Pacific Lamprey projects in the Columbia River Basin funded by the Bonneville Power Administration through the Program.**

| Project Number | Project Title | Project Proponent | Project Goals |
|---|---|---|---|
| 1994-026-00 | Pacific Lamprey Research and Restoration Project | Umatilla Confederated Tribes and National Oceanic and Atmospheric Administration | Provide essential information through implementation of a recovery plan for Pacific Lamprey in the Umatilla River. |
| 2008-308-00 | Willamette Falls Lamprey Escapement Estimate | Confederated Tribes of Warm Springs | Develop quantitative measures for indices of abundance and escapement estimates for adult Pacific Lamprey at Willamette Falls. |
| 2008-470-00 | Yakama Nation Ceded Lands Lamprey Evaluation and Restoration | Yakama Nation | Restore natural production of Pacific Lamprey in the Yakama Nation ceded lands of the Wind, White Salmon, Klickitat, Yakama, Methow, Entiat rivers and streams. |
| 2008-524-00 | Implement Tribal Pacific Lamprey Restoration Plan | Columbia River Inter-Tribal Fish Commission | Implement four objectives of the Tribal Pacific Lamprey Restoration Plan for the CRB. |
| 2011-014-00 | Evaluate Status & Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River subbasins | Confederated Tribes of Warm Springs | Evaluate the Status of Pacific Lamprey in the Lower Deschutes River; Determine Status and Limiting Factors of Pacific Lamprey in Fifteenmile Creek and Hood River subbasins |

### 4.9.1 Pacific Lamprey Research and Restoration – Project 1994-026-00

The CTUIR is currently implementing the project titled Pacific Lamprey Research and Restoration Project. The overall goal of this project is to provide essential information through implementation of a recovery plan for Pacific Lamprey in the Umatilla River. In addition, research conducted has provided valuable information on the biology and ecology of Pacific Lamprey within the subbasin. Results provide information that is useful for restoration efforts elsewhere in the CRB where lamprey may be declining or extirpated. Objectives of the project include:

- Increasing larval abundance in the Umatilla River by continuing to translocate adult lamprey.
- Estimating the numbers of adult lamprey entering the Umatilla River.
- Monitoring passage success to spawning areas.
- Developing structures to improve adult lamprey passage success.
- Monitoring larval trends in the Umatilla River by conducting electrofishing surveys.
- Estimating the numbers of juvenile lamprey migrating out of the Umatilla River.

- Investigating juvenile lamprey screening criteria for use in the Umatilla Subbasin.
- Publishing results of Pacific Lamprey studies.

Since initiation of lamprey restoration efforts in 1995, the CTUIR has gained a better understanding of program development as well as prioritizing restoration actions based upon the CTUIR lamprey restoration plan (Close 1999). In particular, the project has translocated over 4,700 adult lamprey into high-value spawning habitat in the Umatilla River Subbasin, monitored the increased distribution of larval lamprey and outmigration of juvenile lamprey in the Umatilla River, identified and monitored adult passage barriers and obstacles within the Umatilla River utilizing radio-telemetry, and developed artificial propagation and rearing techniques for Pacific Lamprey (**see Section 4.3.4**).

Translocation of adult Pacific Lamprey expanded into the Grande Ronde River Subbasin in 2015, with over 1,300 adults placed in the subbasin through 2016. Monitoring will be implemented as the translocation effort continues, and will follow guidelines described by CRITFC (2014; **see Section 4.3.8.4)**.

As described in **Section4.3.4.2**, in 2012 the CTUIR embarked on a pilot lamprey propagation research at Minthorn Hatchery and the Mukilteo Research Station (see **Section 5.6.1.3**). By 2014 the majority of CTUIR lamprey propagation work was conducted at the WEC in Walla Walla, as that facility became more fully established. Work has been closely coordinated with that of the YN as part of project 2008-470-00.

Continued implementation and monitoring of adult translocation, as well as expanded efforts regarding artificial propagation research and monitoring described in this Master Plan are next logical steps in the development and implication of mitigation activities under project 1994-026-00. Recent work has provided the foundation for objectives and strategies identified in this Master Plan.

### 4.9.2 Willamette Falls Lamprey Escapement – Project 2008-308-00

The CTWSRO Natural Resources Fisheries Program has been conducting research on Pacific lamprey since 2003 (BPA Projects 2002-016-00, 2007-007-00, 2008-308-00, and 2011-014-00). Project 2008-308-00 is aimed at establishing population status and trends in the Willamette River, relating patterns of migration to environmental variables, and estimating harvest at Willamette Falls River.

The project has provided abundance and escapement estimates at Willamette Falls. Based on regional and project specific results (Baker et al. 2015), the CTWSRO has included in its recommendations an objective to:

- Continue to estimate abundance of adult lamprey at existing harvest locations within the Columbia River Basin (e.g. Sherars, Willamette Falls, and Cushing Falls) as well as expand at other potential locations (e.g. Warm Springs River, John Day River, Hood River, Clear Creek – Clackamas Subbasin).

### 4.9.3 Yakima Nation Ceded Lands Lamprey Evaluation and Restoration – Project 2008-470-00

The YN is currently implementing the project titled YN Ceded Lands Lamprey Evaluation and Restoration. The goal of the lamprey restoration project is to restore natural production of Pacific

Lamprey in the in the YN ceded lands of the Wind, White Salmon, Klickitat, Yakama, Wenatchee, Entiat, and Methow subbasins. Objectives of the project include:

- Consolidate and summarize current and historical information related to Pacific lamprey distribution and abundance within the YN Ceded Lands.
- Monitor larval/juvenile production using a variety of monitoring tools (e.g. genetics, screw traps, VIE and PIT tags, length and weight data, etc.) and identify current habitat strongholds for larval/juvenile rearing. Quantify and index relative densities of larvae/juvenile.
- Describe known and/or potential factors, including habitat characteristics, which contribute to relatively strong or weak larval/juvenile growth and production in key (or index) watersheds, and identify the key limiting factors that prevent larvae/juvenile from successfully hatching, staging and achieving high levels of productivity in preferred habitats.
- Monitor adult production using a variety of monitoring tools (e.g. dam counts, adult traps, weirs, PIT and radio tags, length and weight data, etc.), and identify key areas where adults hold and/or spawn and identify environmental / physiological conditions that trigger spawning to occur.
- Describe known and/or potential factors, including habitat characteristics, which are key to adult holding and/or spawning, and identify actions that can be taken to restore or enhance adult holding and spawning.
- Identify adult and larval/juvenile lamprey migration characteristics.
- Identify known and suspected passage barriers (i.e. irrigation diversions and dams) and key limiting factors that prevent adult and larval/juvenile lamprey from successfully migrating (or spawning).
- Initiate small scale re-introductions of artificially propagated lamprey into selected areas within the Yakima Subbasin.
- Continue to translocate adults into watersheds where they have been extirpated, or nearly so, and to monitor productivity of these translocations.

The project is conducted in coordination with other fish and wildlife projects underway in the Yakima Subbasin. The Yakima/Klickitat Fisheries Project (YKFP) is a joint project of the YN (lead entity) and the WDFW, and is sponsored in large part by the BPA with oversight and guidance from the NPCC. The YKFP is one of the largest and most complex fisheries management projects in the CRB in terms of data collection and management, physical facilities, habitat enhancement and management, and experimental design and research on fisheries resources. The YKFP is a supplementation project designed to use artificial propagation in an attempt to maintain or increase natural production while maintaining long-term fitness of the target population and keeping ecological and genetic impacts to non-target species within specified limits. The Project is also designed to provide harvest opportunities. The framework developed by the Regional Assessment of Supplementation Project (Mobrand 1991) guides the planning, implementation, and evaluation of the Project. The purposes of the YKFP are to:

- Enhance existing stocks of anadromous fish in the Yakima and Klickitat river basins while maintaining genetic resources.
- Reintroduce stocks formerly present in the basins.

- Apply knowledge gained about supplementation throughout the CRB.

The YN Ceded Lands Lamprey Evaluation and Restoration Project also includes field work in the Methow, Wenatchee, and Entiat subbasins. Surveys for lamprey began in 2009 and are ongoing. Habitat restoration work is also ongoing.

Over 1,600 adult Pacific Lamprey have been translocated into the Yakima Subbasin as part of the project beginning with just 15 in 2012 (**see Section 4.3.3.1**). Releases were expanded in 2016 to include 249 in the Methow River Subbasin. Effectiveness of translocation efforts is being monitored as part of the project.

In 2012, the YN succeeded in conducting a pilot project to successfully hold, propagate, incubate, and rear larval Pacific Lamprey (**see Section 4.3.3.2**). Work is ongoing and has been closely coordinated with that of the CTUIR as part of project 1994-026-00.

Continued implementation and monitoring of adult translocation, as well as expanded efforts regarding artificial propagation research and monitoring described in this Master Plan are next logical steps in the development and implication of mitigation activities under project 2008-470-00. Recent work has provided the foundation for objectives and strategies identified in this Master Plan.

### 4.9.4 Implement Tribal Pacific Lamprey Restoration Plan – Project 2008-524-00

The CRITFC, through the Implement the Tribal Pacific Lamprey Restoration Plan project, is directed towards implementing objectives contained within the TPLRP (CRITFC 2011). This project is closely administered and coordinated with the Accord Lamprey Projects by the YN, CTUIR, and CTWSRO, and by the Nez Perce Tribal lamprey restoration project. Project objectives include:

- Improving lamprey mainstem passage, survival and habitat.
- Improving tributary passage and identify, protect, and restoring tributary habitat.
- Supplementing interior lamprey populations by reintroducing and translocating adults and juveniles into areas where they are severely depressed or extirpated.
- Evaluating and reducing contaminant accumulation and improving water quality for lamprey in all life stages.
- Establishing and implementing a coordinated regional lamprey outreach and education program within the region.
- Conducting research, monitoring and evaluation of lamprey at all life history stages.

Since initiation of the project, a better understanding has been gained regarding the prioritizing of restoration actions based upon the TPLRP. In particular, the CRITFC lamprey project has improved the understanding of migration characteristics, passage issues, and distribution/occupancy patterns of Pacific Lamprey in the Willamette River Subbasin, contributed to significant improvements in understanding lamprey genetics and population substructure of local, regional, and range-wide population segments, developed an improved baseline for water quality and contaminant accumulation in CRB lamprey, improved local and regional perceptions of Pacific Lamprey, and provided leadership in the development and implementation of alternative forms of restoration (e.g. translocation and artificial propagation).

As previously noted, development of this Master Plan is funded primarily through Project 2008-524-00. Continued coordination of activities described in this Master Plan is one logical next step for the project.

### 4.9.5 Evaluate Status and Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek and Hood River Subbasins – Project 2011-014-00

The CTWSRO Natural Resources Fisheries Program has been conducting research on Pacific lamprey since 2003 (BPA Projects 2002-016-00, 2007-007-00, 2008-308-00, and 2011-014-00). These studies were aimed at establishing population status and trends and documenting distribution in the Deschutes River, Fifteenmile Creek, and the Willamette River, monitoring recolonization of lamprey into Hood River after dam removal, investigating the potential for reestablishment upstream of Pelton-Round Butte Hydrological Complex, characterizing larval rearing habitats, identifying overwinter and spawning habitats, relating patterns of migration to environmental variables, and estimating harvest at Sherars Falls on the Deschutes River, Cushing Falls on Fifteenmile Creek, and Willamette Falls on the Willamette River.

Since initiation in 2003, the CTWSRO lamprey program has gained a better understanding of Pacific lamprey life history and limiting factors within CTWSRO Ceded Area streams. In particular, the CTWSRO lamprey program has provided abundance and escapement estimates at Willamette Falls (Willamette River) and Sherars Falls (Deschutes River), estimated adult abundance and spawning habitat in the lower Deschutes River, evaluated status and trends and distributions of lamprey in CTWSRO Ceded Area streams (e.g. Deschutes River, Fifteenmile Creek, Warm Springs River, and Shitike Creek), and refined larval sampling and habitat identification methods and techniques. Based on regional and project specific results (Baker et al. 2015), the CTWSRO has included in its recommendations objectives to:

- Continue to evaluate, and monitor status, trends, and distribution of lamprey at all life history stages across CTWSRO ceded lands (e.g. Deschutes River, Fifteenmile Creek, and Hood River).
- Continue to evaluate and monitor lamprey response to restoration activities at new sites.
- Continue to employ updated methods of genetic analysis, within existing lamprey projects, to help evaluate larval age at outmigration, to compare effective population size with estimated abundance, and to identify successful family groups employing parentage analysis) in addition to searching for genetic markers that indicate adaptive traits that may have geographic significance.
- Improve passage within the tributary environment, by identifying and modifying and/or removing (e.g. Powerdale dam) all potential passage barriers, which will continue to allow limiting factors to be identified.
- Develop and improve alternative passage routes and restoration strategies, such as adult translocation or artificial propagation, to maintain the presence of lamprey in upstream locations while mainstem limiting factors are being developed.
- Continue to understand primary and emerging (e.g. poor water quality, contaminants) limiting factors at the local level.

### 4.9.6 Nez Perce Tribe Pacific Lamprey Translocation and Assessment

Activities conducted by the NPT are not currently funded by BPA and therefore are not formally part of this Master Plan, however descriptions of NPT activities are included to provide a comprehensive context of Pacific Lamprey supplementation in the CRB. The NPT intends to monitor results of its ongoing adult Pacific Lamprey translocation initiative. The subbasins that the NPT will continue to focus on are the Clearwater, Salmon, Grande Ronde, and Asotin. Activities in the Grande Ronde Subbasin are closely coordinated with the CTUIR. A more detailed description of NPT translocation activities is provided in **Section 4.3.5**.

## 4.10 Coordinated Research, Monitoring, and Evaluation Activities

All Pacific Lamprey projects currently funded in the CRB by BPA (Table 4-15) and the NPT Translocation and Assessment Project have research, monitoring, and evaluation (RM&E) components. Projects 2008-407-00 and 1994-026-00 in particular include RM&E components focused on supplementation efforts by the YN and CTUIR. RM&E efforts and findings from these two projects are summarized in **sections 4.3.3** and **4.3.4.** A limited number of other projects focusing on lamprey are funded through other sources (Table 4-16) and have RM&E components. A summary of recent and current projects targeting lamprey was recently developed by CRITFC (Synthesis; CRITFC 2017a).

The Framework, recently completed by CRITFC (CRITFC 2014) is intended to guide and coordinate supplementation RM&E on regional and local levels. As described in **Section 4.3.8.4** the Framework is the first component of an envisioned regionally coordinated and long term RM&E and reporting plan. The Framework was developed with cooperation and review by CRITFC member tribes, ODFW, WDFW, IDFG, and the USFWS.

**Table 4-16. Non-BPA funded lamprey supplementation projects in the Columbia River Basin.**

| Project Title | Project Proponent | Project Goals |
|---|---|---|
| Translocation and Assessment Project | Nez Perce Tribe | Adult translocation |
| Pacific Lamprey Captive Rearing – Abernathy and Eagle Creek | USFWS | Captive rearing refinements |
| Pacific Lamprey Captive Rearing – Columbia River Research Laboratory | USGS | Captive rearing refinements |

Although incomplete and imprecise for a number of reasons, counts of Pacific Lamprey at mainstem and some tributary dams provide important indices of trends in abundance. Counts are now conducted at all Columbia and Snake River dams. State or federal agencies also count Pacific Lamprey at a number of tributary dams. In addition, work conducted at dams to improve lamprey passage provides valuable information.

Other projects collect information on lamprey only incidentally. Many projects include RM&E components that may add to the body of information on Pacific Lamprey.

Future RM&E needs include identifying future habitat restoration projects to develop recommendations on how best to restore and enhance lamprey habitat (Luzier et al. 2011). Studies to determine temperature tolerances for adult, juvenile, and larval lamprey will assist with water quality monitoring efforts to identify areas that are temperature limiting to lamprey.

### 4.10.1 Genetic Monitoring and Analysis

The potential risks of supplementation tools have been recognized, and measures to minimize risks are outlined in the lamprey translocation guidelines agreed to by the Columbia River Inter-Tribal Fish Commission (CRITFC 2011; Ward et al. 2012). Although consideration should be given to the potential risks of disruption of stock structure and genetic maladaptations that may be incurred by using donor stock from downstream sources (Weeks et al. 2011), the risk of adverse effects associated with the continued downward trend in abundance may outweigh these other potential risks (Ward et al. 2012). This is particularly true in areas where numbers are decreasing rapidly. In these areas, it is possible that so few adults find their way into the watersheds that they may have trouble finding mates and the potential for genetic founder effects is increased. Given general support among findings of genetic studies that a single population of Pacific Lamprey exists throughout the Columbia River and Pacific Northwest region, there is likely relatively minimal risk for temporary supplementation efforts to disrupt population structure. Further, any increase in adaptive genetic diversity that is influenced by these temporary supplementation efforts is likely to have benign consequences given that natural selection will continue to act on the Pacific Lamprey in the interior of the Columbia River (Hess et al. 2014).

Part of the planned monitoring that is described in this Master Plan includes a genetic analysis component that will provide a means for tracking genetic diversity and the fitness consequences (if any) that are associated with genetic variation of lamprey used for translocation/outplanting. Genetic analysis will allow direct measurement of reproductive success of translocated lamprey adults and/or outplanted larvae (e.g. via parental based tagging), as well as provide a way to assess the genetic background of each individual adult and test whether this background affects reproductive success in a particular environment. The other advantage of this genetic analysis is that the age of the larvae can be quantified accurately based on parentage assignment, allowing us to further our understanding of the age structure of Pacific Lamprey at various life stages. These methods can also be utilized to adaptively monitor the genetic diversity of existing, remnant, or naturally returning population segments which allow for comparisons with lamprey used in supplementation research activities.

The state of the technology for genetic monitoring of Pacific Lamprey has made recent advances (Hess 2016) that may facilitate addressing the following critical uncertainties:

1. Biological characteristics (e.g. timing, age, size-at-age, distribution in the hydrosystem, and mate-choice) of various life stages of Pacific Lamprey
2. Direct confirmation of reproductive success of translocated adults and viability of outplanted larvae that were artificially propagated; estimation of total number of successful spawners.
3. What is the relative contribution of translocated adults and outplanted larvae to the overall productivity of Pacific Lamprey in the interior Columbia River (i.e. upstream of John Day Dam)?
4. What factors (e.g. habitat variables, individual- and group-level lamprey characteristics) are predictive of the reproductive success of transplanted adults and viability of outplanted larvae?

Specifically, individual-level characteristics may include the individual's genetic background, and group-level characteristics may include the genetic diversity and sex bias in the group.

To date, approximately 300 SNP markers have been optimized that can be genotyped simultaneously using next generation sequencing equipment (Illumina HiSeq2000 sequencer; Illumina Inc., San Diego, CA, USA). With these next generation methods, single parentage assignments are now possible which will be useful in scenarios where not every potential parent is sampled as would be the case for translocated adults that spawn with volitional migrants (Hess 2016). Further, the greater number of SNP loci includes a larger number of adaptive markers (N~30) in addition to those that will be useful for parentage applications (N~270). Finally, the panel also includes multiple species diagnostic markers to facilitate species identification of small larvae, which will allow the essential task of accurately distinguishing Pacific Lamprey versus Western Brook Lamprey.

This current panel of 300 SNP loci will help to adaptively address the four critical uncertainties by improved accuracy for parent-pair assignments, single-parent assignments, and full- and half-sibship assignments. Estimation of these relationships will allow accurate pedigree reconstruction and the ability to track offspring of translocation efforts by proxy of the geographic information and collection/release date of their relatives (whether those are parents or full-/half-siblings). A parent baseline (artificial propagation spawners and translocated adults) will be utilized that represents nearly 100% of all adult Pacific Lamprey that were utilized for supplementation/reintroduction programs by the Yakama, Nez Perce and Umatilla tribal lamprey programs since 2013. In addition, collections of juvenile and larvae from electrofishing surveys and collections at weirs will be used to reconstruct full-/half-sibling familial relationships.

An appropriate study design will need to be adaptively tailored to address each uncertainty. This would include identifying an appropriate location to collect DNA samples from potential offspring and siblings that can be related back to these outplanting efforts. For example, John Day Dam may be one potential source of outmigrating juveniles where critical uncertainty #3 could be addressed for all three tribal outplanting programs. Generally, collections that are located within close proximity to the release sites of translocated adults and larvae would be appropriate for timely qualitative confirmation of reproductive success and viability of these efforts (i.e. critical uncertainty #2). Combined use of other tagging technologies (e.g. PIT-tags), will further increase the quality and depth of information that can be gained via genetic monitoring analyses. For example, genetic analyses can estimate the age and natal site of individuals identified as offspring of translocated adults (given the release site and date of these translocated adults is known), and PIT-tags could provide more detail on the movement of these individuals through the hydrosystem; thereby combined use of these tools provides potential for a complete picture of the early life stage demographics and distribution of Pacific Lamprey (critical uncertainty #1). Finally, the adaptive loci (N~30) will further understanding of the individual-level and group-level genetic diversity that may influence reproductive success in particular habitats (critical uncertainty #4). In short, relevant information that is revealed through genetic monitoring of existing and proposed supplementation research projects, can be used to adaptively manage existing and proposed programs.

# 5 Proposed Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research Program

## 5.1 Description of Proposed Pacific Lamprey Program

The proposed Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research is based on the selection of preferred Alternative 3 (**see Section 3.5**), Implement Modest Expansion of Artificial Propagation, Translocation, and Restoration Efforts, which would implement modest structural improvements to existing lamprey restoration projects as well as expand beyond laboratory rearing efforts and include releases of artificially propagated lamprey into areas of low abundance or extirpation within the CRB. The Master Plan implements a phased approach, emphasizing adaptive management, with the goal of making progress towards the artificial propagation research goals and biological objectives identified in the TPLRP, LCA, Framework, subbasin plans, the NPCC's Program, and the Columbia Basin Fish Accords within a feasible, cost effective, and biologically conservative manner.

The Master Plan intends to utilize adult translocation as well as the structured, strategic, and phased releases of artificially reared Pacific Lamprey as a way to potentially reintroduce, augment, and/or supplement Pacific Lamprey within select CRB subbasins to achieve the stated, long-term goals identified in various lamprey planning documents and restoration efforts. As described in **Section 4.3**, the YN and CTUIR, through the guidance of the TPLRP and in conjunction with parallel research by other entities within the CRB, have been working collaboratively on lamprey artificial propagation, translocation, and restoration research since 2011. The YN and the CTUIR envision the utility of a joint, collaborative effort and a phased approach (Figure 5-1; **Section 5.4**) in addressing regional lamprey restoration needs through emerging lamprey supplementation research efforts. Therefore, this Master Plan, specifically Phases 1 and 2 (described below), relies heavily on the YN and the CTUIR lamprey programs.

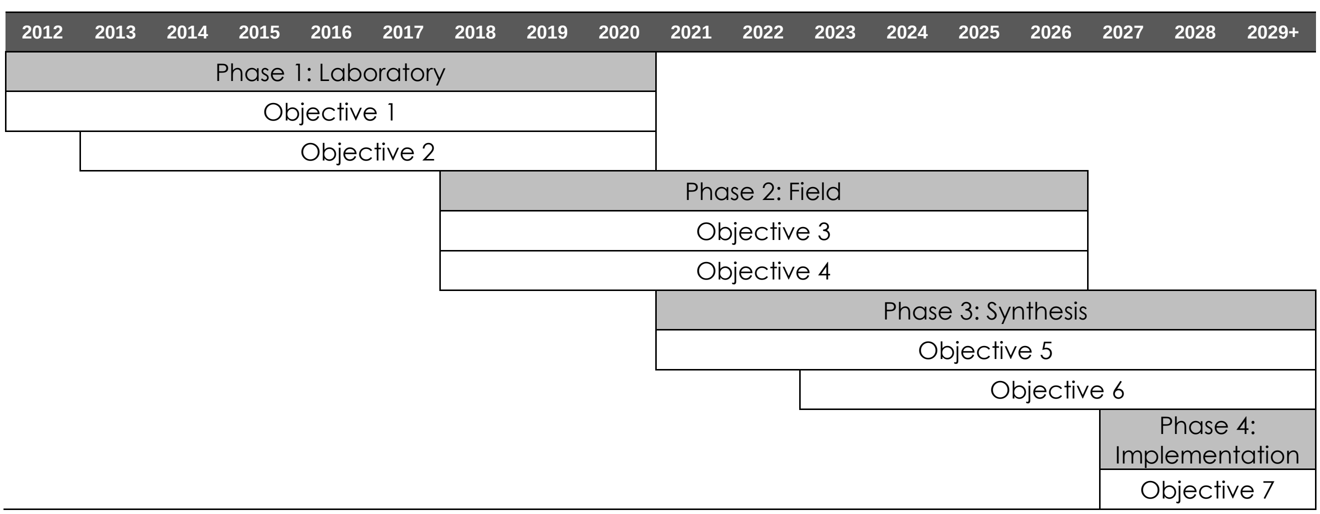


**Figure 5-1. Proposed timing of four phases and seven objectives of the Pacific Lamprey program.**

## 5.2 Scope

As described in **Section 3.4**, the goal of this Master Plan is to evaluate the feasibility of using artificial propagation and translocation to help restore Pacific Lamprey. Actions include continuing to evaluate the success of adult translocation and evaluating the feasibility of using artificial propagation to support restoration efforts. The temporal scope of this document is anticipated to be 9 years (2018-2026), but the program is anticipated to be implemented well beyond that. Actions beyond 2026 will rely in part on what is learned during the first 9 years, and the approach is phased to facilitate adaptive management. The geographic scope includes multiple subbasins within the middle to upper portions of the CRB, specifically in locations where Pacific Lamprey are in low abundance or extirpated. This includes, but is not limited to, the Yakima, Methow, Umatilla, Grande Ronde, Walla Walla, and Tucannon River subbasins. Supplementation actions will vary among subbasins (Table 5-1). Through Adaptive Management it is likely that additional subbasins will be identified and used to improve the comparable strength of the restoration and research program.

**Table 5-1. Pacific Lamprey supplementation strategies currently employed or planned by the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe.**

| Subbasin, Watershed | Strategy | Year Initiated or Proposed | Annual Release Target |
|---|---|---|---|
| **Confederated Tribes and Bands of the Yakama Nation** | | | |
| Yakima | | | |
| Lower Yakima River | Adult Translocation | 2012 | 40-400 |
| Upper Yakima River | Larval Outplanting | 2018 | 3,000-300,000 |
| Naches River | Larval Outplanting | 2018 | 20,000-150,000 |
| Methow | Adult Translocation | 2016 | 40-400 |
| Klickitat | Control | -- | -- |
| Entiat | Control | -- | -- |
| **Confederated Tribes of the Umatilla Indian Reservation** | | | |
| Umatilla | Adult Translocation | 2000 | 500 |
| Grande Ronde | | | |
| Upper Grande Ronde River | Adult Translocation | 2015 | 500 |
| Catherine Creek | Adult Translocation | 2015 | 250 |
| Lookingglass Creek | Adult Translocation | 2016 | 250 |
| Walla Walla | Larval Outplanting | 2018 | 500,000 |
| Tucannon | Larval Outplanting | 2018 | 1,000,000 |
| John Day | Control | -- | -- |
| Imnaha | Control | -- | -- |

| Subbasin, Watershed | | Strategy | Year Initiated or Proposed | Annual Release Target |
|---|---|---|---|---|
| **Nez Perce Tribe** | | | | |
| Clearwater | | | | |
| | Orofino Creek | Adult Translocation | 2007 | 50 |
| | Lolo Creek | Adult Translocation | 2007 | 50 |
| | Newsome Creek | Adult Translocation | 2007 | 50 |
| | Little Canyon Creek | Adult Translocation | 2012 | 50 |
| Salmon | | | | |
| | South Fork | Adult Translocation | 2012 | 50 |
| | Johnson Creek | Adult Translocation | 2015 | 50 |
| | Secesh River | Adult Translocation | 2016 | 50 |
| Grande Ronde | | | | |
| | Wallowa River | Adult Translocation | 2012 | 50 |
| | Minam River | Adult Translocation | 2015 | 50 |
| | Joseph Creek | Adult Translocation | 2016 | 50 |
| | Lostine River | Adult Translocation | -- | 50 |
| Asotin | | Adult Translocation | 2007 | 50 |

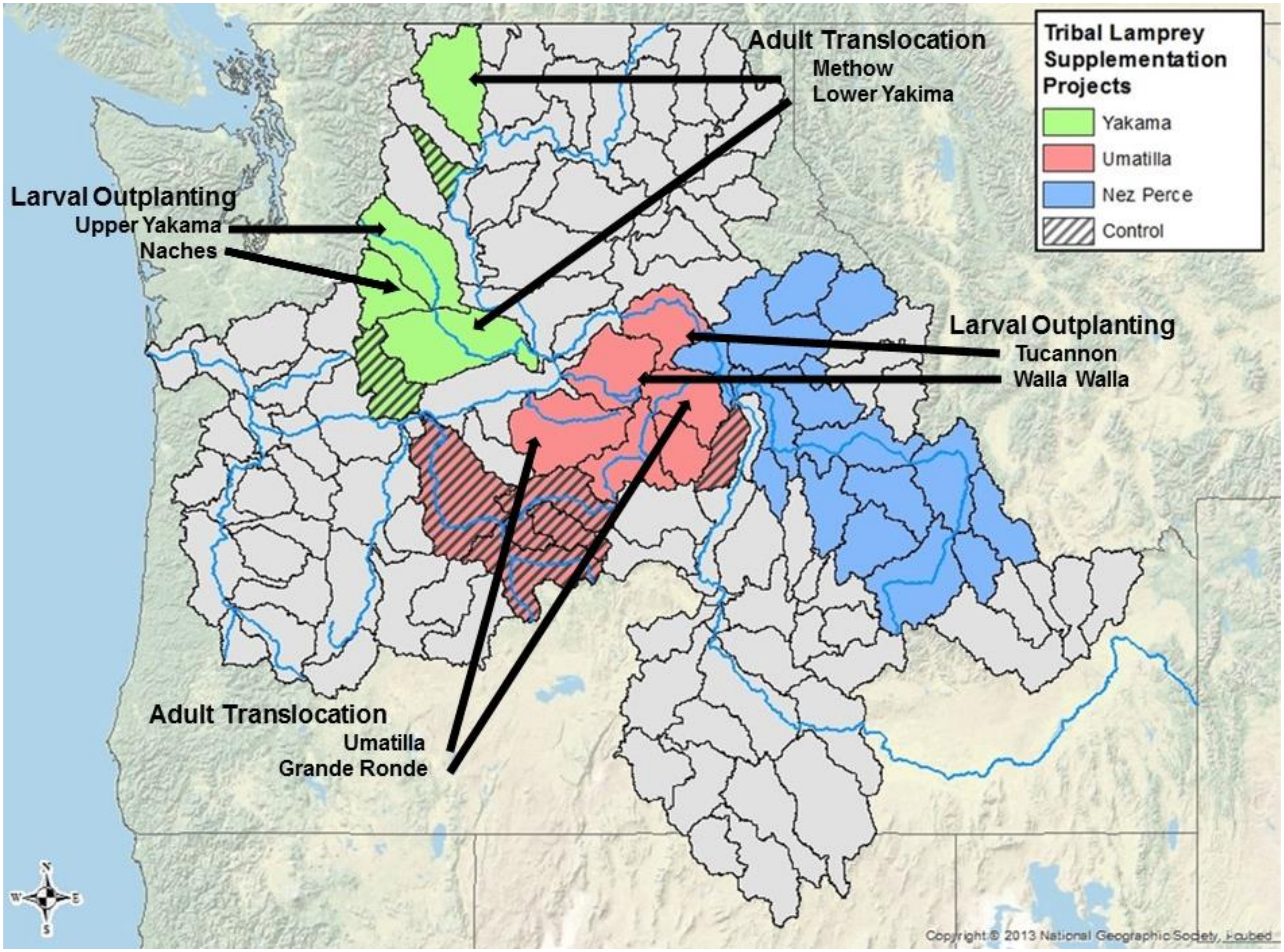


**Figure 5-2. Supplementation actions proposed by the YN and CTUIR in various subbasins or watersheds.**

## 5.3 Research Questions

The program is intended to address several research questions regarding Pacific Lamprey artificial propagation, translocation, and restoration. Each objective and associated hypotheses (see **Section 5.4.2**) relate directly to one of these questions. Each phase referred to below was initially described in **Chapter 1** and further details are provided in **Section 5.4.2**).

General research question related to Phase 1 (Laboratory Phase – Research basic artificial propagation techniques and equipment):

- Can lamprey artificial propagation techniques be advanced enough via laboratory research (e.g., demonstrated successful survival during spawning, incubation, and early rearing) in the near term to enable pilot supplementation strategies to be initiated in the Columbia River Basin tributaries? – see **Section 5.4.2**; Objectives 1 and 2.

General research question related to Phase 2 (Field Phase – supplementation and biological research):

- Can field monitoring of pilot lamprey artificial propagation strategies successfully demonstrate successful survival during the following stages: spawning, incubation, rearing, transport, outplant, growth and distribution, outmigration and adult returns? -see **Section 5.4.2**; Objectives 3 and 4.

General research question related to Phase 3 (Synthesis Phase - Evaluation and Planning Next Steps towards Recovery):

- Can successfully demonstrated pilot lamprey supplementation strategies be synthesized into long-term restoration plans as required for broader application into CRB tributaries? - see **Section 5.4.2**; Objectives 5 and 6.

Specific research questions related to adult translocation include:

1. Can adult translocation produce and sustain lamprey juvenile production and outmigration?
2. Can continuation/increase of this strategy, along with needed passage improvements, produce adult returns and eventual self-sustaining, harvestable numbers?
3. Does adult translocation avoid mortality associated with upstream migration without depressing abundance in downstream areas?
4. Can continuation of adult translocation provide naturally produced lamprey for applied field studies (habitat preferences, juvenile passage/entrainment and adult attraction, migration/passage)?

Specific research questions related to larva/juvenile outplanting include:

1. Can outplanted larvae/juveniles be detected and survive and grow near the release site or in downstream habitats?
2. Can the larva/juvenile release strategy produce and sustain lamprey juvenile production and outmigration?

3. Can genetic diversity be adequately preserved within artificially propagated larvae and juveniles? How will the release of artificially propagated lamprey impact existing lamprey population segments??
4. Can a continuation or increase in this strategy produce adult returns and an eventual self-sustaining and/or harvestable population? Would it be cost effective compared to adult translocation?
5. Can continuation of artificial propagation and larval/juvenile outplanting provide abundant naturally produced lamprey for applied field studies (habitat preferences, juvenile passage/entrainment and adult attraction, migration/passage)?

## 5.4 Phased Approach and Objectives for Artificial Propagation

As discussed earlier in this document (**see Section 4.1**), Pacific Lamprey are essentially extirpated from most watersheds of the upper Columbia and Snake rivers. The tribes recognize that restoration of Pacific Lamprey is long overdue and that supplementation, along with aggressive habitat and passage restoration, is a necessary component for re-establishing Pacific Lamprey within the foreseeable future.

Both the YN and CTUIR understand that a phased approach to artificial propagation and restoration research, emphasizing adaptive management, is an appropriate way forward, especially considering the unique and poorly understood life history of Pacific Lamprey. The tribes also recognize the value of learning by doing. The very nature of the 8-10+ year lamprey life cycle will necessitate time, patience, and innovation in conducting artificial propagation and restoration research and subsequent monitoring and evaluation. Now that the YN, CTUIR, and others have demonstrated successful propagation and rearing of larval and juvenile lamprey (**Section 4.3**), it is time to evaluate the structured, strategic, and phased releases of artificially propagated lamprey into the natural environment.

The tribes have identified four distinct phases of progress over the next 9 years (Figure 5-1; Table 5-2). Each Phase overlaps in various objectives and timing, recognizing that refinements will always be needed even after progression into new areas of emphasis. Learning and informing the implementation of various strategies through adaptive management will occur throughout all phases.

**Table 5-2. Description of four phases and seven objectives of the Pacific Lamprey artificial propagation program.**

| Phase No. | Phase Description | Objectives | Hypotheses | Timeframe |
|---|---|---|---|---|
| 1 | **Laboratory Phase:** Research Basic Artificial Propagation Techniques and Equipment | 1. Develop and implement best management practices for adult handling and artificial propagation in the laboratory<br>2. Develop and implement best management practices for larvae and juvenile handling, feeding, and marking/tagging in the laboratory | It is feasible to spawn and rear significant numbers of Pacific Lamprey in a hatchery | 2012-2020 |
| 2 | **Field Phase:** Supplementation and Biological Research | 3. Out-plant successfully held and reared adult and juvenile products from Phase 1 as per supplementation experimental design<br>4. Provide successfully reared larvae and juveniles from Phase 1 for migration and passage research studies | Hatchery-produced fish can adapt to natural conditions<br>Effective sampling methods can be tested and developed to sufficiently monitor lamprey in the short term, watershed scale and in the long term subbasin scale<br>It is feasible to produce larval/juvenile lamprey in sufficient numbers to evaluate critical limiting factors | 2018-2026 |
| 3 | **Synthesis Phase:** Evaluation and Planning Next Steps towards Recovery | 5. Cross compare and evaluate supplementation monitoring results to determine most successful strategies<br>6. Utilize results from supplementation research strategies to inform development of restoration actions | Hatchery fish survive, grow, and out-migrate, with needed passage improvements, in sufficient numbers to re-establish lamprey in targeted subbasins<br>Restoration benefits outweigh risks and costs involved in artificial propagation as a supplementation and research tool | 2022-2029 |
| 4 | **Implementation Phase:** Implement Restoration and Supplementation Actions | 7. Implement restoration actions as per Phase 3 recommendations | Naturally self-sustaining Pacific Lamprey can be restored through a combination of passage, habitat and hatchery actions | 2027-2029+ |

## 5.4.1 Artificial Propagation Phases

### 5.4.1.1 Phase 1 - Laboratory Phase (2012-2020): Research Basic Artificial Propagation Techniques and Equipment

Phase 1 is characterized as the initial efforts towards successfully propagating and rearing larval lamprey through the first 6-12 months of their life history. Ongoing translocation of adult Pacific Lamprey into the Yakima, Umatilla, and Grande Ronde subbasins would also continue. Phase 1 is well underway, and would continue with refinements in methods and equipment to be tested and evaluated.

Phase 1 was initiated with the "1st International Forum for the Recovery and Propagation of Pacific Lamprey" held in Portland, Oregon in April 2011. During this Forum much was shared and learned about lamprey propagation in both Japan and Finland. Tribes used this information to successfully spawn adults and rear larval lamprey in the spring and early summer of 2012, 2013 and 2014. Each year approximately 40-50 adults have been used to provide gametes producing approximately 0.1-1 million young-of-the-year larvae. Although survival rate from the initial year was low due to the bottleneck life stage 2-3 months post hatching, significant improvements were made over the years, allowing the tribes to hold over 10,000 larvae from 2013 (1+ age) and 50,000 larvae from 2014 (0+ age) well past the bottleneck life stage. During Phase 1, tribal staffs have procured basic equipment and sufficient space and water resources and developed propagation methods and sufficient understanding to routinely collect and care for adults, spawn and incubate eggs, feed and care for multiple age classes of larvae, collect appropriate data, and report on findings.

### 5.4.1.2 Phase 2 - Field Phase (2018-2026): Supplementation and Biological Research

Phase 2 is characterized as initiating a variety of lamprey re-introduction strategies as per experimental designs described in **Section 5.5**. These would include adult translocation and outplanting of larval / early juvenile lamprey from a laboratory environment into the natural environment. The tribes intend to initially determine post-release survival and then determine habitat use, densities, growth, health, movements, and ultimately understand extended larval survival for each strategy, providing juveniles for migration and passage research studies, a critical uncertainty in both the mainstem Columbia River and tributaries. The tribes intend to move towards production of Pacific Lamprey that can be used as surrogates for natural fish in other research efforts such as entrainment into irrigation facilities / diversions or in survival evaluations at hydroelectric dams.

During Phase 2 the tribes will establish and study population segments utilizing translocated adults and artificially propagated larval/juvenile Pacific Lamprey in the Yakima, Methow, Umatilla, Grande Ronde, Walla Walla, and Tucannon subbasins, with the Entiat, Klickitat, John Day, and Imnaha subbasins serving as unsupplemented controls. Outplanting strategies utilizing different lamprey life stages in different locations will be strategically selected to implement and monitor pilot supplementation experimental designs as per **Section 5.5**.

### 5.4.1.3 Phase 3 - Synthesis Phase (2022-2029): Evaluation and Planning Next Steps towards Recovery

Phase 3 is characterized as analysis of results obtained in Phase 2 and development of management alternatives identifying how best to proceed with the application of artificial propagation and translocation as continued research and supplementation tools. Comparisons of larval and juvenile lamprey originating from artificial propagation, translocation or natural production would be the basis of this analysis. Additional information addressing primary limiting factors and restoration progress within individual subbasins would be central to this analysis. Additionally, risk analysis on potential genetic impacts (Hatchery Genetic Management Plan) and disease transmission as well as potential expansion of propagation facilities (and associated cost estimates) are expected to be provided for regional review. The tribes anticipate that some aspects of this analysis could be sufficiently developed within the first two years of this phase.

#### 5.4.1.4 Phase 4 - Implementation Phase (2027-2029+): Implement Restoration and Supplementation Actions

Phase 4 is characterized as a comprehensive implementation of a restoration strategy for Pacific Lamprey within the Upper Columbia and Snake River systems developed under Phase 3. The tribes envision that significant progress would continue in mainstem adult passage efforts with increasing successes in tributary passage, primarily at irrigation diversion dams. These efforts along with continued involvement with the LCA and findings associated with Phase 3 analysis would allow the tribes and other fishery managers to gain a much clearer view in establishing regional management direction and funding priorities. Phase 4 actions would be dependent upon the many variables unknown at this time, including the status and trend of Pacific Lamprey population segments, the success of supplementation strategies and the success of habitat and passage improvement efforts. As with previous Phases, the tribes would continue to provide leadership in regional coordination.

### 5.4.2 Biological Objectives and Tasks

#### 5.4.2.1 Objective 1 (Phase 1): Develop and Implement Best Management Practices for Adult Handling and Artificial Propagation in the Laboratory

The tribes will establish and maintain cost-effective and high quality facilities to safely and efficiently collect, transport and hold adult Pacific Lamprey for artificial propagation, translocation, and other research and restoration purposes. This objective would be addressed in Phase 1.

- Collect and transport adult lamprey with minimal mortality. Seek >95% survival through collection and transport with no disease outbreaks or other health issues.
- Maintain health, condition, and reproductive condition of captive broodstock. Seek >95% survival in overwintering and maintaining captive broodstock.
- Provide adequate, synchronized breeding matrices for genetic diversity. Seek a 3x3 spawning matrix (or 4x4 whenever feasible) from over 3-5 spawning groups per year per site based on collection source and/or run timing to obtain 3-5 superfamilies each containing 9-16 subfamilies.
- Provide adequate mix of egg/milt/water for high fertilization rates. Fertilization success will be monitored to achieve a goal of >80%.
- Provide adequate incubation conditions and hatch rates. Hatching success will be monitored to achieve a goal of >80%.
- Provide adequate holding conditions for pre-feeding prolarvae. Survival, condition and health will be monitored, with target survival rates of >75%.

#### 5.4.2.2 Objective 2 (Phase 1): Develop and Implement Best Management Practices for Larvae and Juvenile Handling, Feeding, and Marking/Tagging in the Laboratory

The Tribes will establish consistent and well-founded lamprey culture methods that optimize fish health, productivity and facility costs for larvae through juvenile life history stages, focusing on pursuing optimal feeds, holding conditions and biosecurity, handling and monitoring methodology, and tank maintenance. The tribes will develop and employ methods to mark (tag / identify), release and recapture juvenile lamprey in a manner to be used to support multiple juvenile migration and passage research and monitoring objectives. This objective would be addressed in Phase 1.

- Provide adequate rearing conditions for early (2-3 months) larvae survival. The survival goal for 2-3 months old larvae is to exceed 75%.
- Provide adequate rearing conditions for young-of-year (YOY) larvae survival. The survival goal for 1 year old larvae (from 3 month old larvae) is to exceed 90%.
- Provide adequate rearing conditions for 1+ ~ larvae survival. The survival goal for older larvae (1+ ~) is to exceed an annual survival rate of 90%.
- Provide adequate rearing conditions for juvenile (juvenile) survival. The survival goal for juvenile lamprey is to exceed 90% (prior to the initiation of parasitic feeding).
- Provide adequate fish marking/tagging. Continue to develop and evaluate the use of VIE tags, PIT tags, coded-wire tags, acoustic tags, parentage-based tags, and fin/tail clips in monitoring juvenile lamprey.

#### 5.4.2.3 Objective 3 (Phase 2): Out-plant Successfully Held and Reared Adult and Juvenile Products from Phase 1 as per Supplementation Experimental Design

The tribes will out-plant lamprey of various life stages (fertilized eggs, 1 month, 3 month, 6 month, 9 month, and older larvae) into predetermined supplementation research sites and monitor these fish regularly to determine habitat use, growth, densities and movements over time and ultimately survival over the next 5-10 years. This objective would be addressed in Phase 2.

- Tag/Mark a portion of the outplanted larvae. Where feasible, tag/mark at least a portion of the larvae (VIE for smaller fish and PIT tags for larger fish) to increase our ability to distinguish the outplanted larvae (All larvae are genetically tagged through parentage analysis).
- Transfer lamprey from holding / laboratory facilities to field research sites as per supplementation experimental design. Release larvae at various life stages at pre-determined release sites to evaluate a suite of supplementation experimental designs.
- Monitor initial post-release survival. Monitor lamprey survival within the release sites, using enclosure traps, electrofishing, and/or sediment sifting surveys within 30 days after release.
- Monitor lamprey behavior and performance within stream reaches and watersheds over a short-term timeframe. Monitor lamprey behavior and performance, including habitat use, density, growth, movement, and continuing survival, using plankton nets, enclosure traps, electrofishing, and/or sediment sifting surveys 1 ~ 12 months post release.

- Monitor lamprey performance within subbasins over a long-term timeframe. Monitor performance, including habitat use, density, growth, movement, and continuing survival, using index site electrofishing surveys and other juvenile fish traps (rotary screw traps, etc.) 1~7 years post release.
- Identify and evaluate a sustainable juvenile population segment target.

#### 5.4.2.4 Objective 4 (Phase 2): Provide Successfully Reared Larvae and Juveniles from Phase 1 for Migration and Passage Research Studies.

The tribes will transfer lamprey of various life stages (fertilized eggs to juveniles) for survival, migration and passage research studies within the mainstem Columbia River and its tributaries. This includes dam passage, diversion entrainment, as well as predation, toxicology and other studies of interest related to their potential threats and limiting factors they face as larvae/juvenile. This objective would be addressed in Phase 2.

- Transfer propagated larval and juvenile lamprey to field migration/passage study sites. Identify and implement passage studies using the artificially propagated lamprey to close existing knowledge gaps on critical limiting factors for larval and juvenile lamprey.
- Collaborate with other passage research studies to ensure adequate post release survival. Collaborate and provide support as needed for various passage studies (to be determined under separate research efforts) in tagging or monitoring post release survival.

#### 5.4.2.5 Objective 5 (Phase 3): Cross Compare and Evaluate Supplementation Monitoring Results to Determine Most Successful Strategies

The tribes will evaluate and compare supplementation strategies implemented in Phase 2. Various comparisons between and among adult and larvae/juvenile supplementation strategies versus unsupplemented control sites will involve analysis of the performance metrics (productivity, growth and where possible, survival data) collected in Phase 2. This objective would be addressed in Phase 3.

- Compare lamprey life history stage performance in hatchery/laboratory versus watersheds/subbasins with outplanted larvae.
- Compare lamprey life history stage performance in watersheds/subbasins with outplanted larvae versus watersheds/subbasins without outplanted larvae (control).
- Compare lamprey life history stage performance in watersheds/subbasins with outplanted larvae versus watersheds/subbasins with adult translocation.
- Compare lamprey life history stage performance in watersheds/subbasins with outplanted larvae versus watersheds/subbasins with outplanted juveniles.
- Compare various lamprey outplanting strategies across watersheds/subbasins.

#### 5.4.2.6 Objective 6 (Phase 3): Utilize Results from Supplementation Research Strategies to Inform Development of Restoration Actions

Based on the results from Objective 5 in Phase 3, the tribes will develop recommendations for restoration actions that promote the best use of the various supplementation strategies experimented and tested. The roles and the effectiveness of larval outplanting from artificial propagation will be assessed separately as a supplementation tool and as a research tool for survival and migration studies. This objective would be addressed in Phase 3.

- Evaluate short-term and long-term monitoring results to determine the effectiveness and future potential of using artificially propagated larvae / juvenile as a supplementation tool.
- Assess the effectiveness of using artificially propagated larvae for passage and outmigration related research studies.
- Develop recommendations / reports based on results of supplementation experiments and passage and outmigration research studies.
- Identify necessary equipment and facilities needed for restoration actions, including supplementation (if warranted), and/or research studies.

#### 5.4.2.7 Objective 7 (Phase 4): Implement Restoration Actions as per Phase 3 Recommendations.

The tribes will implement the recommendations for restoration actions that promote the best use of the various supplementation strategies experimented and tested. Spawning, incubation, and larval lamprey rearing facilities will be developed and larval and juvenile lamprey will be produced based on the specific recommendations. Future supplementation and research activities will occur according to these recommendations and guidelines. This objective would be addressed in Phase 4.

- Develop the recommended artificial propagation capabilities.
- Produce lamprey needed to support restoration actions or research studies.
- Implement lamprey supplementation actions and/or research studies.

## 5.5 Experimental Designs for Phase 2 Objectives

The tribes have developed and embraced two different but coordinated approaches for research using artificial propagation to continue learning about Pacific Lamprey, to contribute to multiple research needs and to evaluate its efficacy as a potential supplementation tool. These strategies have been developed through close coordination among the YN, CTUIR and CRITFC, will incorporate similar phased and adaptive management approaches, and share common objectives that together will allow for a much stronger understanding and comparison of lamprey performance and future restoration / management direction through artificial propagation, translocation, and natural reproduction.

Over the next 9 years, the YN will focus artificial propagation research objectives in the upper Yakima and Naches watersheds where Pacific Lamprey are extirpated or functionally extinct. Initial emphasis will be to release larvae/juveniles of various age-classes into different habitats at predetermined sites and observe their performance over subsequent years. For each site, a specific age class will be released for one year and results will be compared to those from other releases within the watershed using different age classes (such as 3 month-old, 6 month-old, and/or 9 month-old larvae). Each watershed, as a result, will have multiple age classes that will be released and evaluated. In this way, an evaluation can occur to determine if differences in survival and growth are related to the specific age class of the release or specific conditions within the watershed. Monitoring will be conducted primarily near release sites and the surrounding area. Monitoring will also be conducted further downstream at a relatively small geographic scale, including index sites (approximately 50-100 m channel length), and at the stream reach scale (approximately up to 10 river-kilometers) using electrofishing surveys and monitoring of predation.

In a complimentary manner, the CTUIR will release larvae/juvenile of various age-classes in various watersheds within the Walla Walla and Tucannon subbasins over the next 10 years. The primary goals are 1) to release larvae of one specific age class over multiple years in predetermined sites and 2) to assess the short-term and long-term productivity based on those multiple years of releases. Although monitoring will occur at pre-determined index sites similar to the YN plans, the monitoring emphasis will be observations associated with larger scale movements (timing and age class) and productivity over a larger time interval.

## 5.5.1 Strategy Description

To monitor the effectiveness of various supplementation strategies, six watersheds within four subbasins within the YN Ceded Area and nine watersheds within six subbasins within the CTUIR Ceded Area were selected as key areas to evaluate 1) larval outplanting, 2) adult translocation, and 3) no supplementation (control) (Table 5-1; Figure 5-2). Within the YN Ceded Area, the Upper Yakima and Naches watersheds were selected for larval outplanting, the Lower Yakima Watershed and the Methow Subbasin were selected for adult translocation, and the Klickitat and Entiat subbasins were selected as controls. Within the CTUIR Ceded Area, the Walla Walla and Tucannon subbasins were selected for larval outplanting, the Umatilla and Grande Ronde subbasins were selected for adult translocation, and the John Day and Imnaha subbasins were selected as controls. Actions in the Grande Ronde subbasin are closely coordinated with the NPT, who also translocate fish to the subbasin (Table 5-1). The NPT also translocate lamprey into three other subbasins within the NPT Ceded Area.

Performance metrics of subbasins selected for the larval/juvenile outplanting strategy will be compared to those with adult translocation and control strategies. In some cases, control watersheds may be designated within the targeted subbasins selected for adult translocation and larval/juvenile outplanting to compare results within a more local area.

### 5.5.1.1 Determination of Adult Translocation Release Number

Release numbers were based primarily on three factors: 1) translocation guidelines that provide adult collection criteria (CRITFC 2011; 2017b), 2) number of adults available for translocation from mainstem dams in a given year, and 3) professional judgment within each watershed based on availability of spawning and larval rearing habitat. From 2011-2016, the potential annual adult collection for each CRITFC member tribe was determined as 1% of the average of the previous two-year run sizes from Bonneville Dam (CRITFC 2011). This percentage was increased to 2% in 2017 (CRITFC 2017b). From 2010 through 2018, potential per tribe annual adult collections have ranged from 216 to 4,120 adult Pacific Lamprey (Table 5-3). This range provides a rough approximation for how many adult lamprey each member tribe may attempt to collect in future years.

**Table 5-3. Adult Pacific Lamprey tribal allocation from 2010 through 2018 based on collection criteria.**

| Dam | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017[a] | 2018[a] |
|---|---|---|---|---|---|---|---|---|---|
| Bonneville | 0 | 22 | 80 | 238 | 263 | 289 | 215 | 1,444 | 2,235 |
| The Dalles | 94 | 101 | 168 | 281 | 372 | 450 | 601 | 599 | 1,056 |
| John Day | 138 | 93 | 131 | 204 | 275 | 329 | 424 | 453 | 829 |

[a] Tribal adult collection guidelines were updated in 2017

For reference on spawning density, Pacific Lamprey in Oregon coastal streams have not experienced as sharp of a decline compared to inland and southern range basins (Luzier et al. 2011). The 50th percentile of annual natural Pacific Lamprey spawning production per survey reaches was 5 fish/mile and the 80th percentile of that was 17 fish/mile (excluding zero redd counts using only positive numbers (Brumo 2006)). Annual peak levels of natural spawning production (99th percentile – max) ranged between 138 and 240 fish/mile. Given the current trends in Pacific Lamprey numbers and the existing allocation guideline in place for fish collection, translocation in higher density ranges (138-240 fish/mile) are likely too high to be sustainable and practical, yet provide a reference point for relatively high numbers of spawners at current levels. Even at lower density ranges (such as 5-17 fish/mile), translocation has been effective in reintroducing larval lamprey and maintaining species presence and production (Ward et al. 2012).

### 5.5.1.2 Determination of Larval/Juvenile Release Number

#### *Adult Spawning*

Based on evidence from parentage analysis of translocated adults, Pacific Lamprey appear to be both polygynous and polyandrous (Hess et al. 2014), similar to results shown for Sea Lamprey (Scribner and Jones 2002). Pacific Lamprey were confirmed to spawn with up to four partners. To maximize traits for genetic diversity, whenever possible a spawning cross matrix of 3 x 3 or higher will be used. For context, lamprey fecundity is approximately 20 times that of Chinook salmon; therefore, a lamprey release of 100,000 could be comparable to a juvenile salmon release of approximately 5,000. In addition, due to the outplanting at an early life history stage, significant natural mortality would be expected to occur over the 3-6 years between release and outmigration. To recover enough juveniles to produce significant results that can inform analysis of supplementation strategies (Phase 3), it is important to outplant a substantial number of larvae suited for the given habitat.

The broodstock target is 3-4 males and 3-4 females for each spawning event (3x3 or 4x4 crosses), with a minimum of 2-3 spawning events planned each year. To provide a scenario using eight females for artificial propagation, the total estimated egg number (based on fecundity range of 70-140k) from the eight adults would be approximately 800,000. A total estimated to survive to prolarvae would be about 560,000 (based on Phase 1 findings, our estimate from egg to prolarvae survival is approximately 70%). Survival to 3-month old larvae would likely be about 392,000 (survival estimate from prolarvae to 3-month larvae is approximately 70%). An additional 30% mortality would be expected due to larval collection, transport, and field release. This would result in a final release of about 274,400 3-month old larvae. This will result in approximately 18-48 unique crosses per year.

### *Larval Rearing*

The bottleneck life stage in the hatchery setting has been identified as the 1-3 month life stage during which prolarvae transition to burrowing first feeding larvae (see **Section 4.3**). Survival rates during this period are typically only about 70%. Life-stage specific survival rates from fertilization to hatched prolarvae as well as for 3-month-old and older larvae are high (85-95% and 90-99%, respectfully). As observed with prolarvae, larvae at the early life stage could also be sensitive to impacts from transport and changes in water sources, and more research is needed to understand how this sensitivity changes over time for future larval outplanting purposes.

It is also important to understand how much rearing space is needed to adequately rear a targeted number of larvae, considering that lamprey spend an extended time in freshwater as larvae. Based on past research, 100-125 $g/m^2$ was identified as the density above which survival and growth is hampered for both prolarvae and larvae life stages (Figure 5-3). Adults and eggs can be held at a much higher density (20,000 and 800 $g/m^2$, respectfully), so space is not an issue for these life stages. Due to their small weight, prolarvae and 3-month-old larvae can also be reared with minimum space (2.0 and 14.0 $m^2$ for 100,000 individuals, respectfully) (see **Section 4.3**). Mean percent daily increase in weight stays high (9.4-15.5%) for larvae up to 6 months old, but decreases sharply afterwards (<3.2%) and a similar trend is seen for length. As discussed in **Section 4.3**, large scale production may be less efficient for larvae older than 6 months and almost prohibitive for larvae older than one year given the growth rates and space currently available in existing facilities for lamprey. Smaller target numbers for older larvae/juveniles, however, are certainly attainable; for example, 1,000 larvae/juveniles can likely be reared in space smaller than 60 $m^2$. As described in **Section 4.3**, the level and scale of outplanting will be controlled not only by hatchery and natural survival rates but also by the amount of tank space available for larval lamprey.

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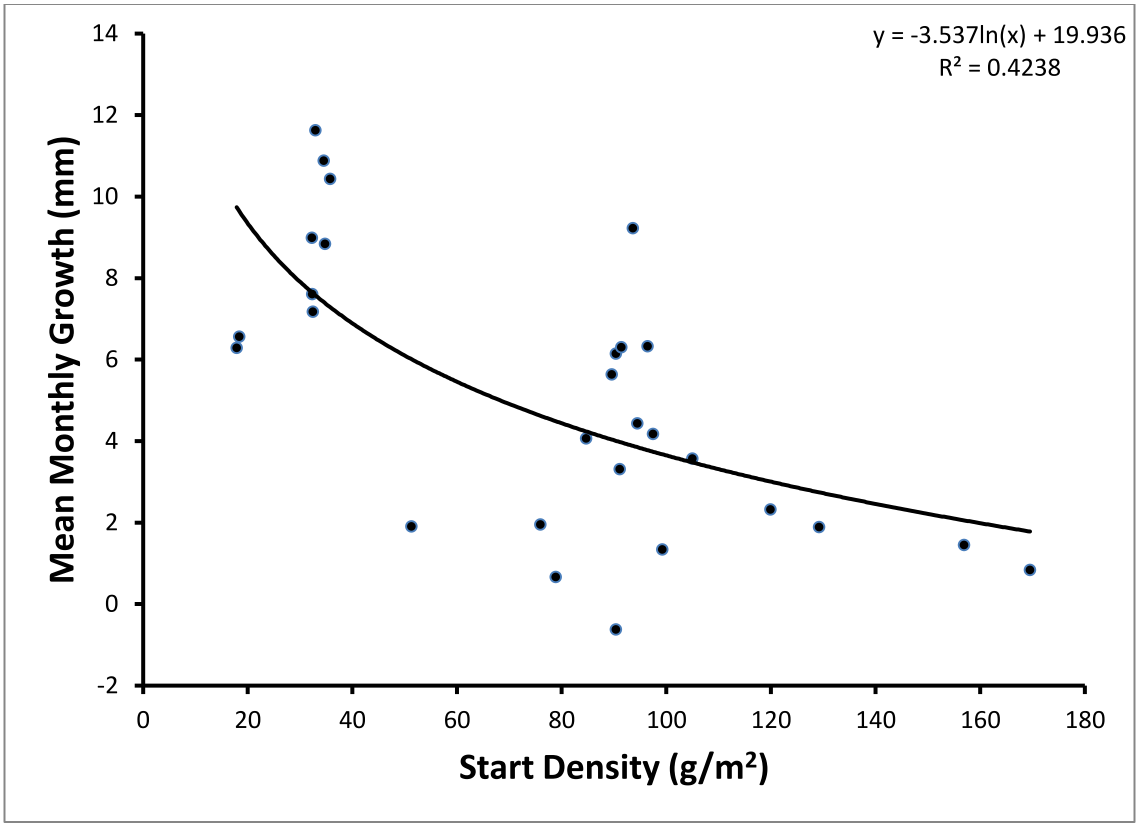


**Figure 5-3. Mean monthly growth (mm) observed for Pacific Lamprey larvae reared in various tanks (N=28) at Prosser Fish Hatchery in 2014 in association with the start density (g/m$^2$).**

### *Larval Outplanting*

Artificially propagated larvae will be released within the designated subbasins and watersheds (see Table 5-1) and according to the study designs outlined in **sections 5.5.2 and 5.5.3**. Prior to transportation, larvae will need to be gradually acclimated to the water temperature of the release site, and be sifted and separated from any fine sediment / other media. Lamprey will be either manually transferred (using syphon hoses and/or nets), moved in substrate, or transported to transport tanks and totes using fish pumps. Because larval lamprey are particularly small compared to salmon, commonly used commercially available fish pumps may potentially damage some of the larval lamprey in the transport process (especially YOY larvae); therefore, testing will need to be conducted prior to use. Because larval lamprey will be predominantly oriented toward the bottom of the tank, increasing the surface area of the fish transport tanks/totes will help reduce transport-related stress (e.g. multi-layered shallow totes stacked on top of each other can effectively reduce fish density while maximizing surface area available within a confined area). In addition, transporting larvae in tanks/totes supplied with fine sediment from the release site (in addition to water) will likely further help minimize transport-related stress. A transport tank designed specifically for larval lamprey may be designed and developed over time that suits the particular needs of the small lamprey. At the release site, lamprey will again be either manually transferred (using syphon hoses and/or nets) or transported using fish pumps to transport tanks and totes.

Because Pacific Lamprey are known to rear for up to 7-9 years as larvae, the number of potential outmigrants produced is determined by a combination of 1) release number and 2) annual survival rates (Table 5-4). Experience with other species suggests that survival rates of hatchery-reared fish will be lower during the first year at large as released fish adapt to natural conditions. For planning purposes, a first year survival rate of half the annual average is assumed. Although larval lamprey are known to be hardy and resilient in general, the early life stage appears to be sensitive and survival rates could certainly be lower. Assuming outmigrants are between 5 and 7 yrs. old, if the annual survival rates are 50% (lower end of our estimate), 10,000 larvae released will result in approximately 39-156 outmigrants (0.4-1.6% overall survival rates). A release of 100,000 larvae would be expected to produce approximately 391-1,563 outmigrants. If the annual survival rates are 90% (upper end of our estimate), 10,000 larvae released will result in approximately 2,391-2,952 outmigrants, and an increase in release to 100,000 larvae would be expected to produce approximately 23,915-29,525 outmigrants. The percentage of Pacific Lamprey that survive the ocean phase and return to freshwater is unknown, but is generally presumed to be 5-10% of these numbers based on limited existing literature (Lampman et al. 2014; Swink and Johnson 2014).

**Table 5-4. Sensitivity of Pacific Lamprey abundance to production numbers and survival rates.**

| Age | Estimated Numbers of Surviving Pacific Lamprey | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50% Annual Survival | | | | 70% Annual Survival | | | | 90% Annual Survival | | | |
| At Release | 10,000 | 25,000 | 50,000 | 100,000 | 10,000 | 25,000 | 50,000 | 100,000 | 10,000 | 25,000 | 50,000 | 100,000 |
| Age 1 | 2,500 | 6,250 | 12,500 | 25,000 | 3,500 | 8,750 | 17,500 | 35,000 | 4,500 | 11,250 | 22,500 | 45,000 |
| Age 2 | 1,250 | 3,125 | 6,250 | 12,500 | 2,450 | 6,125 | 12,250 | 24,500 | 4,050 | 10,125 | 20,250 | 40,500 |
| Age 3 | 625 | 1,563 | 3,125 | 6,250 | 1,715 | 4,288 | 8,575 | 17,150 | 3,645 | 9,113 | 18,225 | 36,450 |
| Age 4 | 313 | 781 | 1,563 | 3,125 | 1,201 | 3,001 | 6,003 | 12,005 | 3,281 | 8,201 | 16,403 | 32,805 |
| Age 5 | 156 | 391 | 781 | 1,563 | 840 | 2,101 | 4,202 | 8,404 | 2,952 | 7,381 | 14,762 | 29,525 |
| Age 6 | 78 | 195 | 391 | 781 | 588 | 1,471 | 2,941 | 5,882 | 2,657 | 6,643 | 13,286 | 26,572 |
| Age 7 | 39 | 98 | 195 | 391 | 412 | 1,029 | 2,059 | 4,118 | 2,391 | 5,979 | 11,957 | 23,915 |
| Potential Outmigrants | 39-156 | 98-391 | 195-781 | 391-1,563 | 412-840 | 1,029-2,101 | 2,059-4,202 | 4,118-8,404 | 2,391-2,952 | 5,979-7,381 | 11,957-14,762 | 23,915-29,525 |

### 5.5.1.3 Reporting Metrics by Life Stage

Monitoring and evaluation will be conducted in each subbasin or watershed identified to assess the effectiveness of adult translocation and larval/juvenile outplanting. Performance metrics have been identified (Table 5-5) and a more full description and narrative of these monitoring and associated metrics can be found in the Framework (CRITFC 2014).

**Table 5-5. Summary of performance metrics for each successive Pacific Lamprey life stage.**

| Life Stage and Activity | Performance Metrics |
|---|---|
| Adult collection and holding | Collection site and numbers<br>Holding conditions (temperature and flow rate)<br>Holding mortality and survival to outplanting<br>Genetic sampling and profile information<br>Pathogen detection<br>Sexual maturity (percent translocated vs. retained for additional holding) |
| Adult translocation and spawning | Transfer survival from holding facility to release locations<br>Number of redds near release locations<br>Lamprey distribution/location of redds<br>Number of adults engaged in reproduction<br>Number of eggs per redd<br>Redd viability (number and rates of fertilization and hatching) |
| Spawning, incubation, and larval rearing | Spawning conditions, gamete quality, observations<br>Spawning matrix (4x4, 3x3, etc.) and associated number of families<br>Fertilization and hatching rates<br>Survival rates – prolarvae<br>Survival and growth rates of feeding larvae<br>Genetic diversity and fitness |
| Larval outplanting | Pathogen detection prior to release<br>Survival from transport to outplanting sites<br>Size, age, and abundance of larval lamprey over time<br>Number and timing of immigrants and emigrants<br>Survival and growth rates within and outside enclosures |
| Larval monitoring | Larval/juvenile abundance, density, and size at index sites<br>Larval/juvenile distribution across index sites<br>Presence and proportion of various size classes<br>Physical data on index sites (temperature, habitat classification, conductivity)<br>Size, abundance, survival, and growth rates of various age classes identified as offspring from supplementation |
| Outmigrant monitoring | Outmigrant estimates by life stage (larvae, juveniles)<br>Timing, distance, and rate of movement of juvenile outmigration<br>Juvenile PIT tag detections/recovery(when and where)<br>Genetic diversity of larvae and juveniles |
| Returning adult monitoring | Number and timing of returning adults<br>Number of returning adults that were tagged or offspring of translocated lamprey<br>Adult life history phase (spawning or migratory) and location<br>Ratio of natural returns to translocated adults (run size and spawning numbers)<br>Genetic sampling and profile information |

## 5.5.2 Pacific Lamprey Research and Restoration Project, YN (BPA Project No. 2008-470-00)

### 5.5.2.1 Upper Yakima and Naches Watersheds

*Strategy Description*

The strategy proposed for the Upper Yakima and Naches watersheds is to release age 0+, 1+, and older larvae in four carefully selected release sites. Based lamprey life history, habitat preference, and migration patterns, the size, time, and location of the experimental larvae release will coincide with what would be expected to occur naturally. Several watersheds within the Upper Yakima and Naches watersheds will not receive any larval outplanting treatments and will serve as controls. In the Upper Yakima Watershed, these could potentially be the Taneum, Swaulk, Teanaway, and Cle Elum watersheds. In the Naches Watershed, these could potentially be the Cowiche, Tieton, Rattlesnake, Nile, Bumping, and Little Naches watersheds. Outplanted larvae are very unlikely to move any distance upstream and into control watersheds.

*Determination of the Release Location*

Perennial side channels, pool channel margins, acclimation ponds, and beaver pools are some of the best remaining available habitat for larval lamprey in the Yakima Subbasin. Three release sites were selected in the Upper Yakima Watershed and one site was selected in the Naches Watershed (Table 5-6): 1) Cle Elum Hatchery Site, 2) Holmes Acclimation Site, 3) Lower Wenas Site, and 4) Eschbach Park Site. The Cle Elum Hatchery Site is a perennial side channel; the Holmes Acclimation Site is a historic side channel that was converted to a perennial acclimation pond; the Lower Wenas Site is a reach near the mouth of Wenas Creek where beaver dam pools are naturally abundant; and the Eschbach Park Site is an irrigation diversion side channel located on the lower Naches River. The overall carrying capacity of these sites exceeds 680,000 larvae (based on a mean weight of 1.0 g per larvae, mean length of about 85 mm, and a carrying capacity of 10 g (larvae weight) /$m^2$ for Type I habitat and 1 g /$m^2$ for Type II habitat.

**Table 5-6. Description of larval release sites in the Upper Yakima and Naches watersheds.**

| Release site | Location | Description | Length (km) | Available Habitat (m²) | | Capacity (larvae) |
|---|---|---|---|---|---|---|
| | | | | Type I | Type II | |
| **Upper Yakima** | | | | | | |
| Cle Elum Hatchery | Yakima River km 301.2-303.2 | Perennial side channel | 2.6 | 27,295 | 18,581 | 286,305 |
| Holmes Acclimation | Yakima River km 260.7-261.5 | Perennial acclimation pond | 1.2 | 14,571 | 3,887 | 149,600 |
| Lower Wenas | Wenas Creek km 0.0-2.4 (Yakima River km 201.6) | Beaver pools | 3.0 | 4,090 | 3,359 | 49,475 |
| **Naches** | | | | | | |
| Eschbach Park | Naches River km 12.0-14.1 | Irrigation diversion side channel | 2.9 | 19,357 | 4,068 | 197,636 |

### *Determination of Release Number*

Perennial side channels, acclimation ponds for salmonids and irrigation diversions hold abundant rearing space for larval lamprey. For example, over 32,000 $m^2$ of larval lamprey habitat was identified in diversions alone within the Yakima River Subbasin (Lampman et al. 2014), which could theoretically rear 250,000 larvae/juveniles. These types of habitats can be monitored intensively to assess survival, growth, and migration over time. The most effective and productive life stages for release will need to be examined.

In Year 1 of outplanting (targeting year 2018), three age classes (0+ egg/prolarvae, 1+ larvae, and older larvae) are proposed to be released in three sites (Table 5-7). Cle Elum Hatchery site would receive fertilized eggs and/or newly hatched prolarvae in the lower reach of the site. Lower Wenas Site would receive age 2+ larvae. Eschbach Park Site would receive age 1+ larvae in the left channel (newly constructed).

In Year 2 of outplanting (targeting year 2019), releases would be limited to age 0+ larvae at three sites (Table 5-7). Cle Elum Hatchery site would receive 6-month-old larvae in the middle reach of the site. The Holmes Acclimation Site would receive fertilized eggs and/or newly hatched prolarvae in the middle reach of the site. The Eschbach Park Site would receive 3-month-old larvae in the middle reach of the site.

In Year 3 of outplanting (targeting year 2020), releases would again be limited primarily to age 0+ larvae at three sites (Table 5-7). Cle Elum Hatchery site would receive 3-month-old larvae in the upper reach of the site. Holmes Acclimation site would receive 6-month-old larvae in the upper reach of the site. Eschbach Park site would receive fertilized eggs and/or newly hatched prolarvae in the upper reach of the site.

**Table 5-7. Proposed releases of Pacific Lamprey larvae at each release site by year and age class.**

| Age Class | Release Year | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| **Cle Elum Hatchery** | | | |
| Eggs/Prolarvae | 300,000 | -- | -- |
| 3 month | -- | -- | 20,000 |
| 6 month | -- | 15,000 | -- |
| **Holmes Acclimation** | | | |
| Eggs/Prolarve | -- | 150,000 | -- |
| 6 month | -- | -- | 15,000 |
| **Lower Wenas** | | | |
| 2-5+ | 3,000 | -- | -- |
| **Eschbach Park** | | | |
| Eggs/Prolarve | -- | -- | 150,000 |
| 3 month | -- | 20,000 | -- |
| 1+ | 30,000 | -- | -- |

### *Rearing Methods*

Adult broodstock will be collected from lower Columbia River dams and held for 1-2 years until sexually mature at the YN adult holding facilities. The Prosser Hatchery has capabilities to hold adults in large 9 ft circular tanks separated by capture origin. The broodstock target will be 6-12 males and 6-12 females (2-4 groups of 3x3 crosses) for three sites per year. Egg fertilization and incubation will occur in Heath racks, incubation troughs, and/or Eager jars until hatching (approximately 15 days). Once hatched, prolarvae will be placed in incubation troughs with coconut fiber spawning mats layered on top of sifted fine sediment (<540 micron) for approximately 30 days, during which burrowing and first feeding begins (approximately 15-20 days).

Within a couple of weeks after feeding begins, larvae will be placed in larger tank space (aquaria and troughs) to accommodate continual growth. The same media (sifted fine sediment approximately 2/3 the depth of the larval fish length) will be pre-placed in these tanks in addition to other buried additive feeds (salmon carcass, wheat straw, alfalfa pellets, etc.). Water used will be primarily well water with limited use of river water (~20%) where possible to add natural food sources and daily thermal fluctuations. Feed will be primarily active dry yeast with other supplementary feeds (wheat flour, spirulina, larval starter feed, etc.). In general, larvae will be monitored for survival and growth approximately every three months and densities will be maintained below 100-125 g/m$^2$ (a threshold value above which growth is considerably reduced) as much as feasible using available tank space.

Larvae will be grown to various ages / life stages prior to outplanting; as described previously, some may be released as fertilized eggs (~1mm), prolarvae (~7 mm), 3-month-old (~20 mm), 6 month-old (~30 mm), 9 month-old (~40 mm), 2 years-old (~60 mm), 3 years-old (80 mm), etc. Those larger than 21 mm (generally >6 month-old) can be VIE tagged, and those larger than 70 mm (generally >3 year-old) can be PIT tagged. Outplanting will occur in pre-determined suitable Type I (fine sediment) habitat. Prior to outplanting, larvae will be separated from the fine sediment using siphoning hoses and mesh screens appropriate for the larval sizes for sifting. Larval disease clearance will occur prior to release by USFWS and/or WDFW. Genetic samples will be obtained and provided for analysis at Hagerman Genetics lab.

#### *Monitoring*

Ten pre-existing index sites have been established in the Upper Yakima and Naches watersheds (five and five sites respectively) for status and trend monitoring. Each site contains Type I habitat. These sites will be electrofished with an AbP-2 lamprey electrofisher at 125 volts, 3 bursts/second, 25% duty-cycle, and a 3:1 train pulse rate for 60-90 seconds per square meter of habitat. Sites are sampled annually in low flow conditions between summer and fall seasons. All index sites have been confirmed based on previous survey data dating back to 2010-2012 and knowledge acquired from local and regional experts. Specific index sites are relocated nearby if necessary, based on river processes/movement. Wild Pacific Lamprey are considered extirpated (or functionally extirpated) upstream of Roza Dam (RKM 210.5) based on a combination of radio telemetry and larval sampling data; however, some adults through translocation and radio telemetry moved upstream of Roza Dam and larval population is slowly growing. Larval habitat in the mainstem is abundant in most of the Upper Yakima reaches except for the Yakima River Canyon area, which is more confined geologically than other reaches.

In addition to regular index sites, local movement and status of larvae may be monitored at outplanting sites. Some larvae will be placed in enclosures to contain them and will be monitored over time for survival and growth. Plankton nets and custom made fine mesh nets will be deployed periodically to assess larval movement after release. To periodically sample the larvae, backpack electrofishing will be used in shallow water (<1m). In deep water habitat, where feasible, a deep water electrofisher (such as those used by USFWS and Pacific Northwest National Laboratory) may be used. Although no rotary screw traps are currently present in the Upper Yakima or Naches watersheds, some could be strategically placed in select areas near the larval outplanting sites to help document migration.

All downstream migrating lamprey will eventually pass through Prosser Dam (Yakima RKM 75.7), which has a juvenile fish monitoring facility through the diversion bypass and larval/juvenile lamprey could be monitored at this site generally from January through July. Biological data are collected, and some lamprey are PIT tagged/marked throughout the migration season for trap efficiency and juvenile migration studies. All lamprey are returned to the river (except for the smallest YOY larvae needed for genetic samples).

Returning adult lamprey will be enumerated at Prosser Dam. Counts are from the fish windows as well as the newly installed lamprey passage structures at the three fish ladders.

### 5.5.2.2 Lower Yakima and Methow Subbasins

#### *Strategy Description*

The strategy proposed for the Lower Yakima Watershed is to continue the adult translocation program that was initiated in 2012. Adults are collected from mainstem Columbia River dams, held for 0-2 years at the YN adult holding facilities until sexually mature, and then translocated to natural production locations in Satus, Toppenish, and Ahtanum creeks, and the mainstem Yakima River. Monitoring to date includes adult monitoring (PIT tagging and index spawning surveys), larval recruitment surveys (index as well as new exploratory sites), and genetic analysis. YOY larvae as well as older larvae and juveniles have been documented in all translocations streams.

Adult translocation is also proposed in the Methow Subbasin, focusing primarily on low, middle, and upper reaches of the Methow River. The absence of larvae smaller than 70 mm and an average size of 150 mm from 2013-2015 indicate that Pacific Lamprey recruitment is severely reduced, or has not occurred at all, in the past several years (Beals and Lampman 2014). Translocation is the best short-term option to prevent extinction in the Methow Subbasin. Adult translocation programs for other subbasins have shown long-term success, and continuation is proposed for comparison to other supplementation strategies and for continuing achievement towards self-sustaining, harvestable adult returns.

### *Determination of Release Location*

The YN has chosen this adult translocation strategy for the Lower Yakima because Satus, Toppenish, and Ahtanum creeks are the lower-most key tributaries in Yakima Subbasin where impacts of irrigation diversions are minimal and abundant intact habitats are present for both spawning adults and larval lamprey. These three streams are also strongholds for the threatened Middle Columbia River steelhead within the Yakima Subbasin (more than 50% of the population uses these three streams). Habitat for spawning adults and larvae are also available in the mainstem Yakima (primarily the middle reach), where temperature conditions are favorable as well.

Each of the three translocation streams have two release sites; one upper reach release and one lower reach release. Upper release locations were selected based on information about historic presence from tribal oral interviews, state fish and wildlife records, and knowledge of preferred spawning and larval lamprey habitat (particularly in relationship to gradient, flow, and substrate conditions). The upper release takes place around late April / early May when temperature approaches approximately 10-12°C (when adults actively move during spring migration). The lower release locations were selected below existing PIT tag antenna array stations near the mouth of these tributaries to allow spawning adults to migrate upstream to preferred habitat of their own choice while effectively monitoring the overall straying rates from each tributary. The lower release takes place around late March and early April. In future years, some adults will be released experimentally during the first migration period (summer) before overwintering to see if the straying rates change compared to those that are overwintered in tanks. Although lamprey use is limited currently, lower Toppenish Creek in particular provides ample braided, wetland habitat with an abundance of fine sediment for larval lamprey rearing. In this stream, a combination of adult translocation and larval outplanting strategies will potentially be implemented to evaluate the effectiveness of these two approaches through parentage genetic analysis as well as various marking technologies. Toppenish Creek has three channel-spanning PIT tag arrays (one in the lower reach and two in the upper reach) and two screw trap monitoring sites (lower and middle reach) for steelhead monitoring, enabling us to monitor larval and adult lamprey multiple times during their migration.

Trends from previous surveys through 2015 suggest that larval lamprey numbers in the Methow Subbasin are decreasing rapidly. Four release sites provide access to optimal spawning reaches and for the most part allow lamprey to choose their spawning destination: Methow River, Twisp River or Chewuch River. These release sites were selected throughout the mainstem Methow River and are located downstream from and within the Twisp and Chewuch rivers as well as in areas where Pacific Lamprey are assumed to be extirpated (Methow River upstream of the Chewuch River). By PIT tagging most or all of the released lamprey, detections by tag arrays in the subbasin could provide valuable insight to the proportion of lamprey that enter each tributary.

### *Determination of Release Numbers*

Beginning in 2013, the YN has annually released overwintered adult lamprey into Satus, Toppenish, and Ahtanum creeks to initiate lamprey reintroduction and restoration. The target will remain at least 100 fish per tributary (or 300 fish per subbasin). Each watershed has about 23-26 miles of suitable Pacific Lamprey spawning habitat, so this corresponds to approximately 5 fish/mile on average.

The exact number for translocation will vary from year to year based on translocation guidelines and fish availability. In years with low numbers of fish allocated for collection from Lower Columbia River dams (e.g. 216 per tribe in 2011), the YN would translocate approximately 40 fish per creek, which is roughly 1.7 fish/mile. In years with high numbers of fish allocated for collection (e.g. 2,175 per tribe in 2004), the YN would translocate approximately 400 fish per watershed per year, which is roughly 17.5 fish/mile. For the Methow Subbasin, a similar range in density of fish will be released based on fish allocation numbers and available spawning and larval lamprey habitat.

### *Translocation Methods and Monitoring*

Adult broodstock will be collected from lower Columbia River dams and held for 1-2 years until sexually mature at the YN adult holding facilities. The Prosser Hatchery has capabilities to hold adults in large 9 ft. circular tanks separated by capture origin. Following translocation, adults are monitored for migration movement (through the use of PIT and/or radio tags) and location of spawning. Based on observed distribution and spawning, spawning surveys are conducted in index reaches near the release sites between May and July. Redds are geo-referenced, and a subset may be documented to be a test for viability based on detection of viable eggs from probing a very small portion of the nest area. Observed redds may be from natural returns. Numbers of adults from both translocation and natural returns (Prosser Dam counts) will be used to estimate spawning contribution from each in addition to genetic parentage analysis examining larval production. The Methow Subbasin has no location established to count upstream migrating adults, but PIT tag arrays are plentiful and distributed widely allowing us to estimate abundance when combined with strategized releases.

Seventeen index sites have been established in the Lower Yakima Watershed for status and trend monitoring (3 sites in the mainstem lower Yakima River, 4 sites each in Satus, and Ahtanum watersheds, and 6 sites in Toppenish watershed). In the Methow Subbasin, twenty-four sites were initially identified, of which six with lamprey present have been sampled each year since 2008 (Lampman 2016). Each site contains Type I habitat preferred by larval/juvenile lamprey. Larval abundance, size classes, and species data will be collected along with genetic samples for parentage analysis. These sites (representative Type I and II habitat within a 50m reach) are electrofished for 60-90 seconds per square meter of habitat. Sites are sampled annually in low flow conditions between summer and fall seasons. All index sites have been confirmed based on previous survey data dating back to 2010 in the Lower Yakima Watershed and 2008 in the Methow Subbasin and knowledge acquired from local and regional experts. Specific index sites are relocated nearby if necessary, based on river processes/movement. Pacific Lamprey in the Methow River upstream of the Chewuch River were considered extinct based on a combination of radio telemetry and larval sampling data until translocation began recently. Larval habitat is plentiful in parts of the Upper Methow mainstem reaches, especially the area known as the "Big Valley."

In the Lower Yakima Watershed, at least one rotary screw trap is currently present in all three of the translocation streams, primarily for juvenile steelhead monitoring, but will be used also to monitor larval/juvenile lamprey out migration. In addition, all downstream migrating lamprey will eventually pass through Prosser Dam in the Lower Yakima, which has a juvenile fish monitoring facility through the diversion bypass and larval/juvenile lamprey could be monitored at this site. The facility is typically operated daily from January through July each year (with a 30% subsampling rate). Lamprey movement is greatest during large hydrologic events (winter floods and rain-on-snow events) so this covers the peak run timing for larval/juvenile migration. Biological data are collected, and some lamprey are PIT tagged/marked throughout the migration season for trap efficiency and juvenile migration studies. All lamprey are returned to the river (except for the smallest YOY larvae needed for genetic samples).

One screw trap in the mainstem lower reach of the Methow River (river km 29.1) offers lamprey data since 2004. This trap collects both larval and juvenile lamprey and can be used as an index for larvae/juvenile abundance (especially when combined with VIE and PIT tagging for trap efficiency tests). Juveniles on average make up roughly 10% of the overall lamprey capture in this trap.

Returning adult lamprey will be enumerated at Prosser Dam. Counts are from the fish windows as well as the newly installed lamprey passage structures at the three fish ladders.

### 5.5.2.3 Klickitat and Entiat Subbasins

#### *Strategy Description*

The YN will monitor the Klickitat and Entiat subbasins closely as "controls" for Pacific Lamprey status and trends in the region. Fish have to pass only Bonneville Dam to access the Klickitat Subbasin; it therefore represents areas with better access. Fish must pass eight dams to access the Entiat Subbasin, representing areas with inferior access. Despite inferior access, no dams are located within the Entiat Subbasin, allowing fish to freely access all watersheds within. Pacific Lamprey numbers appear to be relatively stable in both of these subbasins, albeit much reduced from historical numbers. In general, no supplementation is scheduled to be implemented in these two subbasins to allow monitoring of the natural, general shift in lamprey abundance over time. However, some limited translocation may occur in lower and mid reaches of the Klickitat River to evaluate passage at Lyle Falls and the Klickitat Hatchery weir. Monitoring to date includes rotary screw traps, larval electrofishing surveys in index sites, toxicological studies, and genetic analysis.

#### *Monitoring*

Four Index Sites were identified in the Klickitat River mainstem. All survey locations have been confirmed based on previous survey data dating back to 2011, and expert knowledge acquired from individuals on our crew who have surveyed these sites in earlier years. Very few larval Pacific Lamprey reside above the weir dam next to the Klickitat Hatchery at river km 69.6, which is likely hindering adult passage completely or at least seasonally. Only the Index Site at RKM 82.7 is located outside of the assumed distribution of Pacific Lamprey; however it is possible that lamprey could reach this upper site, if passage issues are resolved or improved. A rotary screw trap was operated between 1997 and 2007 immediately upstream of the weir dam and although they were not identified to species, a limited number of larval/juvenile lamprey (maximum of 88 per year; 1~60 per day) were captured primarily during spring. Overall, access to the mainstem Klickitat River is rather simple, and landowner permission is generally not required in most reaches. Larval habitat in the mainstem is abundant near the mouth and in patches further upstream. Returning adult Pacific Lamprey could potentially be monitored at Lyle Falls by the adult trap facility. As a result, all three life stages (larvae, juvenile, and adults) could be monitored in the Klickitat Subbasin.

Four Index Sites were identified in the mainstem Entiat River. Of the four sites, three survey locations have been confirmed based on previous survey data dating back to 2012. One site is still classified as a potential index site. Recently, Western Brook Lamprey were discovered in the upper reach of Entiat River, disproving the previous hypothesis that no Western Brook Lamprey exist in the Upper Columbia (upstream of the Yakima River confluence). The Entiat River is known to have one of the highest larval densities in the Upper Columbia. This river is an important control, as Pacific Lamprey seem to be thriving and stable, albeit in low numbers, while abundance in other streams is declining more rapidly. Access to the river is rather limited, and most sites require permission to access private property. Accessibility and larval habitat is patchy throughout the middle reach of the river. The lower river has large patches of larval lamprey habitat and the upstream reach has low gradient areas and a lot of fine sediment collects in the stream meanders. One to two rotary screw traps have been in operation since 2003 in the lower reach (river km 2.0 since 2007 and river km 11.0 between 2003 and 2009), showing interesting status and trends in lamprey numbers (**see Section 4.1.4**).

## 5.5.3 Pacific Lamprey Research and Restoration Project, CTUIR (BPA Project No. 1994-026-00)

### 5.5.3.1 Umatilla River Subbasin

*Strategy Description*

The strategy proposed for the Umatilla River is to continue the adult translocation program initiated in 2000. This program has shown initial success and continuation is proposed for comparison to other supplementation strategies and for continuing achievement towards self-sustaining, harvestable adult returns. The CTUIR has chosen this adult translocation strategy for the Umatilla River because of the success the program has had to date in terms of increased juvenile abundance and outmigration and increased adult returns (see **sections 4.1.5 and 4.3.4**). This strategy is ongoing and is working to re-establish Pacific Lamprey.

*Determination of Release Location*

Beginning in 2000, adult lamprey have been released annually into the upper Umatilla River, and Meacham and Iskuulktpe creeks to initiate lamprey reintroduction and restoration. These release locations were selected based on information about historic presence from tribal oral interviews, state fish and wildlife records, and knowledge of preferred spawning habitat. These locations will continue to be used.

*Determination of Release Number*

The CTUIR has annually released approximately 325 (translocation target of 500) adult lamprey into the upper Umatilla River, and Meacham and Iskuulktpe creeks since 2000 (Table 4-11). Release numbers are based primarily on three factors: 1) translocation guidelines that provide adult collection criteria (CRITFC 2011), 2) number of adults available for translocation from mainstem dams in a given year, and 3) professional judgment within each watershed based on availability of spawning and larval rearing habitat. Program continuation is proposed at the current translocation target of 500 per year.

### *Translocation Methods and Monitoring*

Adults are collected from mainstem Columbia River dams as per adult translocation guidelines, held for 1-2 years until sexually mature, and then translocated to natural production locations in the upper Umatilla River Subbasin. Lamprey are transported to the South Fork Walla Walla holding ponds for several months and then transported to Minthorn Springs Lamprey Holding Facility into 3' x 3' x 3' Bonar holding tanks in the late fall and held until release the following spring (approx. May 1). At Minthorn Springs, adults are supplied with spring water at ambient temperature with flow rate of 5 gallons/minute per holding tank. Adult holding survival has been 97% since initiation. Prior to release, disease checks are conducted by ODFW and tissue samples are collected for genetic analysis (parentage contribution). By examination of sexual maturity, equal male/female composition at each release location may be obtained. The 10-40% of adults that are not sexually mature are held for an additional year prior to translocation. These adults are maintained at the Minthorn Springs facility. Timing of release is targeted to be approximately 1-3 weeks from anticipated spawning. Adults are transported in a 300 gallon slip tank and hand-released directly into targeted release locations.

Following translocation, adults are monitored in the field for survival and location of spawning. Based on observed distribution and spawning (from radio telemetry observations in the Umatilla River and Catherine Creek), redd counts are conducted from late May to July. Redds are geo-referenced, and documented to be viable based on detection of viable eggs from probing a very small portion of the nest area. Because translocation has occurred since 2000 and number of adults returning to the Umatilla Subbasin is increasing, some observed redds may be from these natural returns. Numbers of adults from both translocation and natural returns (Threemile Falls Dam counts) will be utilized to estimate spawning contribution from each in addition to genetic parentage analysis.

Forty index sites have been established in the subbasin from the mouth to the headwaters. Each site contains Type I habitat. These sites are electrofished with an AbP-2 lamprey electrofisher at 125 volts, 25% duty-cycle and a 3:1 pulse rate for 90 seconds per square meter of habitat in late summer. Specific index sites are relocated nearby if necessary, based on river processes/movement.

An 8' rotary screw trap is utilized to document larval and juvenile outmigration in the lower Umatilla River (RKM 3.9). The trap is fished daily from fall through late spring each year. Lamprey movement is greatest during large hydrologic events (floods, rain-on-snow events) so traps are fished at all times except very extreme high flow events. The trap is checked every two hours during high flow conditions and once per day during average flow conditions. Biological data are collected, and some lamprey are PIT tagged/marked throughout the trapping season for trap efficiency and juvenile migration studies. Trapping efficiency is evaluated throughout the trapping season. All lamprey are returned to the river.

Returning adult lamprey are enumerated at Threemile Falls Dam. Three methods are used to count adult Pacific Lamprey: 1) video of the crest of the dam, 2) observations in the lamprey passage structure, and 3) video of the adult salmonid fish ladder.

### 5.5.3.2 Grande Ronde River Subbasin

#### *Strategy Description*

The strategy proposed for the Grande Ronde River Subbasin is to initiate an adult translocation program similar to that in the Umatilla River Subbasin. Adult translocation was chosen as the preferred strategy because adult translocation was initiated by the NPT in 2006 in the Wallowa River (tributary to the Grande Ronde River) and the CTUIR desires to keep a simple approach to experimental design for each subbasin. Because adult translocation has already been initiated within the subbasin by the NPT, the CTUIR will seek to continue this strategy to keep cross comparisons relevant and comparable between the supplementation strategies used.

#### *Determination of Release Location*

The NPT initiated translocation of adult lamprey to the Wallowa River at Minam State Park in 2006. The CTUIR initiated translocation to the upper Grande Ronde River near Starkey, Oregon and Catherine Creek near Union, Oregon in 2015, and plan to translocate lamprey to Lookingglass Creek near Lookingglass Hatchery in future years. Each release location is near anticipated natural spawning areas, and tribal oral history interviews have documented former presence and traditional use in these locations. In addition, state fish and wildlife records document historical presence within these tributaries.

#### *Determination of Release Number*

The number of adults translocated to the Umatilla River Subbasin has produced sufficient number of offspring for evaluation; therefore, a similar reintroduction effort is proposed for the Grande Ronde River Subbasin. The initial translocation effort by the CTUIR in 2015 included 451 adults in the Upper Grande Ronde River and 150 in Catherine Creek. Future allocation of releases would be approximately 500 in the Upper Grande Ronde River, and up to 250 each in Catherine and Lookingglass creeks. This would be in addition to the goal of 500 adults released in the Wallowa River by the NPT. Catherine and Lookingglass creeks each have approximately one-half the stream length of the upper Grande Ronde River, and both have available habitat that would support adequate spawning and rearing areas for these targeted numbers.

#### *Translocation Methods and Monitoring*

Adult Pacific Lamprey will be collected from mainstem Columbia River dams, held for 1-2 years until sexually mature, and then released to natural production locations in the upper Grande Ronde River, Catherine Creek, and Lookingglass Creek. Adult collection, holding, disease clearance, genetic sampling, time of release, release equipment and methodology will be similar to that described for the Umatilla River adult translocation program.

Following release, adults will be monitored for survival and location of spawning. Based on observed distribution and spawning (from radio telemetry observations in the Umatilla River and Catherine Creek), redd counts will be conducted in late May to July. Redds will be geo-referenced, and documented to be viable based on detection of viable eggs from probing a very small portion of the nest area.

Ten index sites in the Grande Ronde Subbasin were established in 1999 for presence/absence lamprey surveys from the mouth to the headwaters. This number will be expanded for increased monitoring to represent approximately 200 river miles in the upper Grande Ronde and Wallowa rivers and Catherine and Lookingglass creeks. These index sites will be used to monitor larval abundance and distribution resulting from adult translocation. Each site contains Type I habitat preferred by juvenile lamprey. As for all supplementation strategies, standardized lamprey electrofishing equipment and settings will be utilized. Sites will be sampled annually each summer. Specific index sites will be relocated nearby if necessary, based on river processes/movement.

Numerous screw traps in the Grande Ronde Subbasin operating under existing salmonid monitoring projects will be utilized to document larval and juvenile outmigration. For increased monitoring, the traps will be fished daily from fall through late spring each year. Lamprey movement is greatest during large hydrologic events (floods, rain-on-snow events) so traps are fished at all times except very extreme high flow events. Traps will be checked every two hours during high flow conditions and once per day during average flow conditions. Biological data will be collected, and some lamprey will be PIT tagged and/or marked throughout the trapping season for trap efficiency and juvenile migration studies. All lamprey will be returned to the river.

Numerous existing PIT tag arrays in the Grande Ronde Subbasin currently operating under existing salmonid projects will be utilized to document upstream migrating adults. Currently, the USACE funds Snake River adult lamprey passage studies via radio and PIT tagging efforts, and some of these fish will be expected to enter upper Snake River tributaries including the Grande Ronde River.

### 5.5.3.3 Walla Walla River Subbasin

*Strategy Description*

The strategy proposed for the Walla Walla River in both Oregon and Washington is to release age 1+ artificially propagated larvae in the mid to lower subbasin to initiate lamprey reintroduction where there is abundant documented Type I habitat. Based on knowledge of lamprey life history, habitat preference, and migration patterns (documented from Umatilla River studies) the CTUIR will target the size, time, and location of the experimental product release with what would be expected to occur naturally within the Walla Walla Subbasin.

*Determination of Release Location*

The CTUIR has selected locations for ammocoete releases based on an abundance of preferred Type I habitat. Previous physical habitat and lamprey presence/absence surveys in the Walla Walla Subbasin documented extensive Type I rearing habitat in the mid to lower subbasin. Habitat classification was based partially on documented location of juvenile lamprey rearing in the Umatilla River Subbasin, Furthermore, these are the same locations where presence/absence surveys documented Western Brook Lamprey in the Walla Walla Subbasin.

*Determination of Release Number*

Based on genetic studies (Hess et al. 2014), a 4 x 4 spawning cross matrix will be used to maintain genetic diversity. The CTUIR proposes to use 2-4 groups in a 4x4 spawning matrix, which would translate to 8-16 total adult brood needed. This would be genetically conservative in achieving a juvenile release target and would represent enough juveniles to produce significant results that can inform analysis of supplementation strategies (Phase 3). At this program experimental level, a total estimated egg number would be up to 840,000. A total estimated survival to age 1+ would be 344,000 larvae based on Phase 1 findings of egg to 1+ loss of 59% (**see Section 4.3**). An additional 30% mortality would be expected due to ammocoete collection, transport, and field release. This would result in a final survival to release of about 241,000. For context, lamprey fecundity (maximum of 238,400) is 30 times that of Chinook Salmon, but to be conservative lamprey fecundity is assumed to be 20 times that of Chinook Salmon. Therefore, a lamprey release of 241,000 could be compared to a juvenile salmon release of approximately 12,000 (Wydoski and Whitney 2003). This assumes a similar survival to hatch for the two species. In addition, due to outplanting at an early life history stage, significant natural mortality would be expected to occur over the subsequent 3-6 years of freshwater rearing prior to outmigration.

These estimates and initial program size will be subject to adaptive management as the CTUIR determines larval/juvenile recovery success and program size necessary to achieve significant findings. Based on documented Umatilla Subbasin larval/juvenile production/carrying capacity with similar or less amount of Type I habitat, the release target of 250,000 1+ age class larvae can be considered conservative for our Phase 2 pilot supplementation effort.

#### *Rearing Methods*

Adult broodstock will be collected from mainstem Columbia River dams, and held overwinter at the CTUIR adult holding facilities described above. Adults will be held for 1-2 years until sexually mature and ready for spawning. The WEC lab has capabilities to hold adults in 3-4’ circular tanks. Minthorn Springs has the ability to hold adults in 3’ x 3’ x 3’ bonar plastic tanks, and the SFWW lamprey building will have 3-4’ circular tanks for adult holding. Eggs will be fertilized at the adult holding locations and egg incubation will occur in Heath racks and/or Eager jars at either the WEC or SFWW facility. At hatching, prolarvae will be transferred to rearing troughs (2’x 2’ x 10’, 1.8 $m^2$) until first feeding at approximately 15-20 days after hatching.

Rearing troughs will be equipped with removable trays of 149–500 micron sand at a depth of approximately ⅔ fish body length. Substrate (sterilized sand) will be covered with coconut mat to reduce prolarval activity. Rearing densities will be maintained at approximately 100–125 $g/m^2$ (UV irradiated water) at flow rates of 15-20 gal/min. Larvae start feeding at approximately 20-30 days after hatching. At this time they will be fed a weekly ration of 1000 mg/L active dry yeast and 250 mg/L of larval fish food (Otohime (80% yeast / 20% Otohime)). As larvae develop, they will be transferred to additional tank space by lifting trays and/or siphoning and sifting larvae from sediment. As larvae grow they will require additional space (raceways) to support appropriate rearing densities for the product (approximately 500, 9-month old larvae per square meter). Our target is release of approximately 250,000 age 1+ at 60 mm in size. Larvae for release will be transported in rearing sediments at ambient receiving water temperatures. The CTUIR envisions a volitional release system in which larvae are introduced to release sites in rearing sediments and allowed to disperse naturally (to reduce predation effects). Larval mortalities will be removed. Larval/juvenile disease clearance will occur prior to release by ODFW NE Oregon Pathology lab. Genetic samples will be obtained and provided to the Hagerman Genetics laboratory for analysis.

### *Monitoring*

Larval/juvenile monitoring index sites were established in the Walla Walla River Subbasin in 1999 for presence/absence lamprey surveys from the mouth to the headwaters. These index sites will be used to monitor juvenile abundance and distribution following ammocoete outplanting. Each site contains Type I habitat preferred by larval/juvenile lamprey. As for all supplementation strategies, standardized lamprey electrofishing equipment and settings will be utilized. Sites will be sampled each summer. Specific index sites will be relocated nearby if necessary, based on river processes/movement.

A rotary screw trap will be utilized to document larval and juvenile outmigration in the lower Walla Walla Subbasin. The trap will be fished daily from fall through late spring each year. Lamprey movement is greatest during large hydrologic events (floods, rain-on-snow events) so traps are fished at all times except very extreme high flow events. The trap will be checked every two hours during high flow conditions and once per day during average flow conditions. Biological data will be collected and some lamprey will be PIT tagged and/or marked throughout the trapping season for trap efficiency and juvenile migration studies. All lamprey will be returned to the river.

Adult lamprey returns will be monitored via mark-recapture using adult lamprey fyke nets. A portion of adults will be externally marked and released downstream from the capture sites. Recaptured adults will be enumerated and released upstream from fyke net sites. Non-marked adults will also be counted and released upstream of the fyke nets. Trapping efficiencies and estimates of adult abundance will be determined. In addition, nest surveys will be conducted to document successful nest building and adult activity. The same methods were used in the mouth of the Umatilla River and in the John Day River with low salmonid incidents (Close et al. 2002).

A Section 10 Endangered Species Permit was approved for this activity and the same gear will be used and necessary permits obtained.

## 5.5.3.4 Tucannon River Subbasin

### *Strategy Description*

The strategy proposed for the Tucannon River is to release age 0+ pro-larvae in the mid to upper subbasin to initiate lamprey reintroduction. Based on knowledge of lamprey life history, habitat preference, and migration patterns (documented from Umatilla River studies) the CTUIR will match the size, time, and location of the experimental product release with what would be expected to occur naturally within the upper Tucannon Subbasin. The CTUIR has selected a larval release based on the physical characteristics of the subbasin. The Tucannon River Subbasin has national forest property that allows access and habitat that would support an early life history larval release in the upper subbasin.

### *Determination of Release Location*

The CTUIR has selected locations for a larval stage release based on an abundance of preferred Type I habitat. A mid- to upper- Tucannon release location for 0+ larval juveniles would be very near areas where naturally-spawned lamprey of this age class would be expected (based on spawning habitat and larval drift). These sites would be in public forest property just below the confluence of Panjab Creek and also in the mid mainstem near the Tucannon Hatchery. In addition, previous physical habitat and lamprey presence/absence surveys in the Tucannon Subbasin documented extensive Type I rearing habitat in the mid to upper subbasin. Previous presence/absence surveys for juvenile lamprey only found lamprey in the mid to lower Tucannon River Subbasin. Annual screw trapping records in the lower Tucannon River have shown very few lamprey outmigrating from the subbasin.

### *Determination of Release Number*

Based on genetic studies (Hess et al. 2014), a 4 x 4 spawning cross matrix will be used to maintain genetic diversity. The CTUIR proposes to use 2-4 groups in a 4x4 spawning matrix, which would translate to 8-16 total adult brood needed. This would be genetically conservative and recognize higher mortalities associated with outplanting a younger and smaller life history stage. An adequate number of larvae must be outplanted and survive to produce significant results that can inform analysis of supplementation strategies (Phase 3). At this program experimental level, a total estimated egg number would be up to 840,000. A total estimated survival to age 1+ would be 344,000 larvae based on Phase 1 findings of egg to 1+ loss of 59% (**see Section 4.3**). An additional 30% mortality would be expected due to ammocoete collection, transport, and field release. This would result in a final survival to release of about 241,000. These estimates and initial program size will be subject to adaptive management as juvenile recovery success and program size necessary to achieve significant findings is assessed.

In the Umatilla River an average of 325 adult lamprey are translocated annually which is thought to be far below carrying capacity. An estimated one-half of those are females with fecundity ranging from 34,000-238,400. This would equate to approximately 5.525,000 to 38,740,000 eggs deposited into the river. Based on redd capping sampling in the Umatilla River, an average of 86.2% (Close et al. 2001, 2002) survive to the 0+ age class which would equate to approximately4.7 million to 33.4 million larvae. Therefore, the CTUIR's proposed translocation target of approximately 250,000 0+ age class larvae in the Tucannon River can be considered a very conservative target for the Phase 2 pilot supplementation effort.

### *Rearing Methods*

Adult broodstock will be collected from mainstem Columbia River dams, and held overwinter at the CTUIR adult holding facilities described above. Adults will be held for 1-2 years until sexually mature and ready for spawning. Adults will be transferred to the Walla Walla WEC lab for final maturation and spawning. The WEC aquatic research lab has capabilities to hold adults in 3-4' circular tanks. Our broodstock target will be 16 males and16 females (4 groups of 4x4 cross). Fertilized eggs will be incubated in Heath racks and/or Eager jars until hatching. Upon hatching, larvae will be transferred to early rearing troughs until release.

Rearing troughs (1.8 $m^2$) will be equipped with removable trays of 149–500 micron sand at a depth of approximately ⅔ fish body length. Substrate (sterilized sand) will be covered with coconut mat to reduce larval activity. Rearing densities will be maintained at approximately 100–125 $g/m^2$ (UV irradiated water) at flow rates of 15-20 gal/min. Larvae start feeding at approximately 20-30 days after hatching. At this time they will be fed a weekly ration of 1000 mg/L active dry yeast and 250 mg/L of larval fish food (Otohime; (80% yeast / 20% Otohime)). Our target is release of approximately 1,000,000 age 0+ at 10-25 mm in size.

Larvae for release will be transported in rearing sediments at ambient receiving water temperatures. The CTUIR envisions a volitional release system in which larvae are introduced to release sites in rearing sediments and allowed to disperse naturally (to reduce predation effects). Larval mortalities will be removed Juvenile disease clearance will occur prior to release by the ODFW NE Oregon Pathology lab. Genetic samples will be obtained and provided to the Hagerman Genetics laboratory for analysis.

#### *Monitoring*

Larval/juvenile monitoring index sites were established in the Tucannon in 1999 for presence/absence lamprey surveys from the mouth to the headwaters. These index sites will continue to be used to monitor juvenile abundance and distribution following outplanting of larvae. Each site contains Type I habitat (silt/fines) that are preferred by juvenile lamprey. As for all supplementation strategies, standardized lamprey electrofishing equipment and settings will be utilized. Sites will be sampled annually each summer. Specific index sites will be relocated nearby if necessary, based on river processes/movement.

A rotary screw trap will be utilized to document larval and juvenile outmigration in the lower Tucannon River Subbasin. The trap will be fished daily from fall through late spring each year. Lamprey movement is greatest during large hydrologic events (floods, rain-on-snow events) so traps are fished at all times except very extreme high flow events. The trap will be checked every two hours during high flow conditions and once per day during average flow conditions. Biological data will be collected, and some lamprey will be PIT tagged/marked throughout the trapping season for trap efficiency and juvenile migration studies. Trapping efficiency will be evaluated throughout the trapping season. All lamprey will be returned to the river.

Adult lamprey returns will be monitored via mark-recapture using adult lamprey fyke nets. A portion of adults will be externally marked and released downstream from the capture sites. Recaptured adults will be enumerated and released upstream from fyke net sites. Non-marked adults will also be counted and released upstream of the fyke nets. Trapping efficiencies and estimates of adult abundance will be determined. Nest surveys will be conducted to document successful nest building and adult activity. The same methods were used in the mouth of the Umatilla River and in the John Day River with low salmonid incidents (Close et al. 2002). A Section 10 Endangered Species Permit was approved for this activity and the same gear will be used and necessary permits obtained. In addition, adult counts from Lower Monumental and Little Goose dams will be monitored to help determine escapement into the Tucannon Subbasin.

## 5.6 Conceptual Design of Lamprey Facilities

Both YN and CTUIR have facilities to maintain propagated larval lamprey that are operational at various capacities. Both tribes also have sufficient means to collect and hold large numbers of adult lamprey due to ongoing adult translocation efforts. The YN has established the capacity to spawn, fertilize, incubate, and rear lamprey at the YN Marion Drain Fish Hatchery (MDFH) in Toppenish, WA, and the YN Prosser Fish Hatchery (PFH) in Prosser, WA, with assistance from YKFP salmonid and YN White Sturgeon propagation programs (through surplus equipment and technical assistance). Additional capacity is currently available and continues to be developed by the CTUIR at the Water and Environmental Center (WEC) at Walla Walla Community College (Walla Walla, WA) and at the Mukilteo Research Station (MRS) in Mukilteo, WA operated by the NOAA Fisheries. Both tribes have a small array of aquariums and relatively small numbers of circular and trough tanks to rear larval and juvenile lamprey, housing both propagated larvae and larvae and juveniles collected from the wild (through irrigation diversions or hydroelectric facilities). All existing facilities and capacities are relatively small.

## 5.6.1 Overview of Existing and Future Lamprey Facilities

The YN and CTUIR anticipate having separate facilities, but integrated and well-coordinated research programs designed to accelerate progress in understanding artificial propagation and its intrinsic values towards future lamprey restoration. Images and narratives are provided below illustrating current facilities for both YN and CTUIR, and to the best of our current understanding, illustrations are provided outlining intended facility expansion over the next 2-5 years.

### 5.6.1.1 Yakama Nation – Existing Facilities

The YN began lamprey propagation at MDFH in 2012 using available equipment and space prior to the White Sturgeon propagation season. However, all propagation activities have taken place at PFH since the latter half of the season in 2012. The PFH has substantial space, power and water (river and well) for all research objectives. Over the next 10 years, the primary facility used by the YN for lamprey research will continue to be the PFH although small projects may potentially occur in the other Yakima Subbasin hatcheries, including MDFH and Cle Elum hatchery.

Facilities occur in two locations within the general PFH site (Figure 5-4; Table 5-8). The East Facility includes a variety of small- to medium-sized outdoor circular and trough tanks for adult and larval lamprey (Figure 5-5). The majority of adults collected from the Lower Columbia River as well as propagated larvae are held in these tanks, which hold between 50 and 1,165 gallons each. Some of these tanks are built on foundations and are off the ground, which allows siphoning of fine sediment and larval lamprey for monitoring. The facility uses about 400 gallons of water per minute when all tanks are in use, with both river and well water available (all water is recycled and returned to the Yakima River). With minor re-construction, approximately 200 gallons per minute of additional water could be made available. Additional power is readily available if needed.

The West Facility serves as the primary area for spawning, incubation, prolarvae / early larvae rearing, and feeding experiments (Figure 5-6). This facility is simply a pole barn storage shed in which one-half of the building has been re-furbished to accommodate lamprey research. Primary features contained in this facility include six columns of Heath tray racks each with 16-tray space, two deep incubation troughs, sufficient shelf space to hold twenty 10-gallon aquariums, and modest desk and table space for artificial propagation and monitoring work. Each of the deep incubation troughs is 14 feet long and 16.5 inches wide, and can be divided into 10 smaller sub-sections. All tanks are built on foundations allowing easy siphoning of fine sediment and larval lamprey for monitoring. Only well water is currently available to this facility, which uses approximately 40 gallons per minute when all tanks, troughs, and trays are running. The current plan is to move all the West Facility tank spaces (and associated hatchery activities) to the East Facility to merge and combine the two facilities and operations to occur in one area (see **Section 5.6.1.2** for more information).

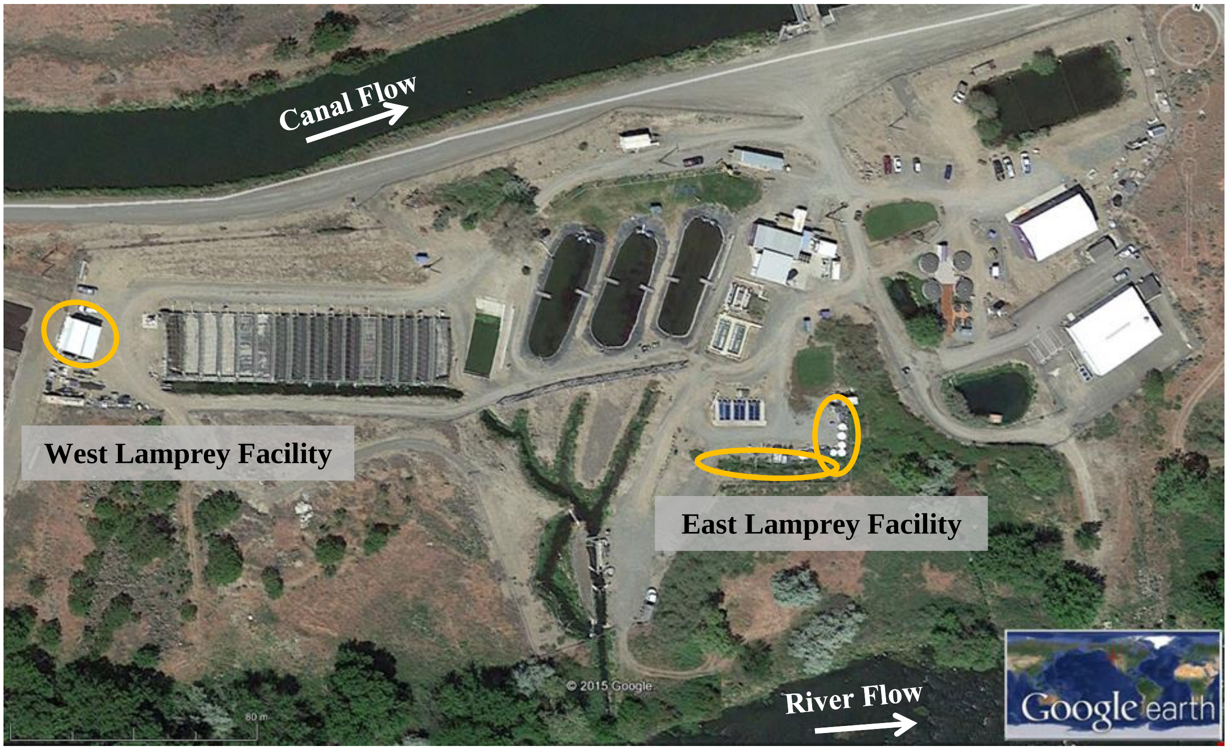


**Figure 5-4. Existing Prosser Fish Hatchery aerial overview. Orange circles highlight the West and East Lamprey Facilities.**

**Table 5-8. Existing space, flow rate, and total carrying capacity of tanks at Prosser Fish Hatchery for Pacific Lamprey. All tanks are fiberglass unless otherwise noted.**

| Tank Type | Primary Life Stage | Water Depth (cm) | Area (m²) | Volume (gallon) | Flow Rate (gallons/min) | Water Turnover Time (min) | # of Tanks | Total Area (m²) | Total Volume (gallon) | Total Flow (gallon/min) | Goal Density (g/m²) | Total Capacity (Adult #) | Total Capacity (Egg #) | Total Capacity (Prolarva #) | Total Capacity (9-Mo. Larva #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | **East** | | | | | | | |
| Circular | Adult | 66 | 4.68 | 816 | 33.0 | 24.7 | 4 | 18.7 | 3,263 | 132 | 20,000 | 935 | - | - | - |
| Trough | Adult | 52 | 8.48 | 1165 | 60.0 | 19.4 | 1 | 8.5 | 1,165 | 60 | 20,000 | 424 | - | - | - |
| Circular[a] | Larva | 42 | 4.68 | 519 | 21.0 | 24.7 | 6 | 28.1 | 3,113 | 126 | 125 | - | - | - | 8,781 |
| Trough | Larva | 17 | 1.16 | 50 | 2.0 | 25.2 | 10 | 11.6 | 505 | 20 | 125 | - | - | - | 3,625 |
| Trough | Larva | 29 | 4.00 | 309 | 12.5 | 24.7 | 4 | 16.0 | 1,236 | 50 | 125 | - | - | - | 5,007 |
| Circular | Larva | 55 | 2.41 | 349 | 14.0 | 25.0 | 1 | 2.4 | 349 | 14 | 125 | - | - | - | 753 |
| | | | | | | | | **West** | | | | | | | |
| Circular | Adult | 42 | 1.17 | 130 | 5.2 | 24.9 | 1 | 1.2 | 130 | 5 | 20000 | 58 | - | - | |
| Heath | Egg | 10 | 0.126 | 3.3 | 3.0 | 11.1 | 60 | 7.5 | 199 | 18 | 1000 | - | 7,543,800 | - | - |
| Trough | Prolarva | 16 | 1.87 | 79 | 4.5 | 17.6 | 1 | 1.9 | 79 | 5 | 125 | - | - | 78,001 | 586 |
| Trough | Prolarva | 15 | 1.79 | 71 | 4.0 | 17.7 | 1 | 1.8 | 71 | 4 | 125 | - | - | 74,534 | 560 |
| Aquarium[b] | Larva | 20 | 0.125 | 6.6 | 0.3 | 24.5 | 20 | 2.5 | 132 | 5 | 125 | - | - | - | 783 |
| | | | | | | | | **Total** | | | | | | | |
| - | Adult | - | - | - | - | - | 6 | 28.4 | 4,558 | 197 | - | 1,418 | - | - | - |
| - | Egg | - | - | - | - | - | 60 | 7.5 | 199 | 18 | - | - | 7,543,800 | - | - |
| - | Prolarva | - | - | - | - | - | 2 | 3.7 | 150 | 9 | - | - | - | 152,535 | - |
| - | Larva[c] | - | - | - | - | - | 43 | 64.3 | 5,485 | 224 | - | - | - | - | 20,095 |

[a] Metal

[b] Glass

[c] Tanks designated for prolarvae can also be used for larvae; therefore, they are counted towards the total capacity for both life stages


**Figure 5-5. East Lamprey Facility at Prosser Fish Hatchery.**


**Figure 5-6. West Lamprey Facility (incubation room) at Prosser Fish Facility.**

### 5.6.1.2 Yakama Nation – Future Facility Conceptual Designs

Over the next 2-5 years the YN intends to modestly enhance the existing facilities to provide for additional research capacity, efficiency, staff safety and convenience. The primary developments will include a pole building on the East Facility to house eight additional 14-ft-long trough tanks, eight additional 7-ft-deep shallow trough tanks, and four additional 6 foot circular tanks (Figure 5-7; Table 5-9). This will require some improved ground surface (cement, asphalt, roadwork, and rockwork such as retaining wall), water intake and piping, installation of tanks, and anchored structures and their attached infrastructure (e.g. piping, re-roofing, re-siding, and cabinets). As a result, the use of the West Facility will be discontinued over time.

Ideas for new tank designs:

- Tank raised from bottom on foundation to allow siphoning
- Use more recycled water from lamprey and salmon tanks (with byproducts and feed leftover)
- Built-in non-corrosive metal screens (500 micron) in tanks for sifting and lifting larvae out from tank
- Tank lids with sliding cover (for shade adjustment depending on season)
- Construction of a side channel along ditch to increase rearing space (if a side channel is created, any plugging of screens will not affect flow in main ditch)

Needs:

- Automated adult / egg / larva treatment system (formalin / hydrogen peroxide)
- More tank space where available (potentially at Marion Drain Hatchery)
- Transport tote / system / pump for large #s of larvae outplanting
- Metal divider that does not corrode
- River water in incubation room
- Automated sifter (for sifting sediment to <500 micron and for separating larvae from fine sediment)
- Sensor system for overflowing

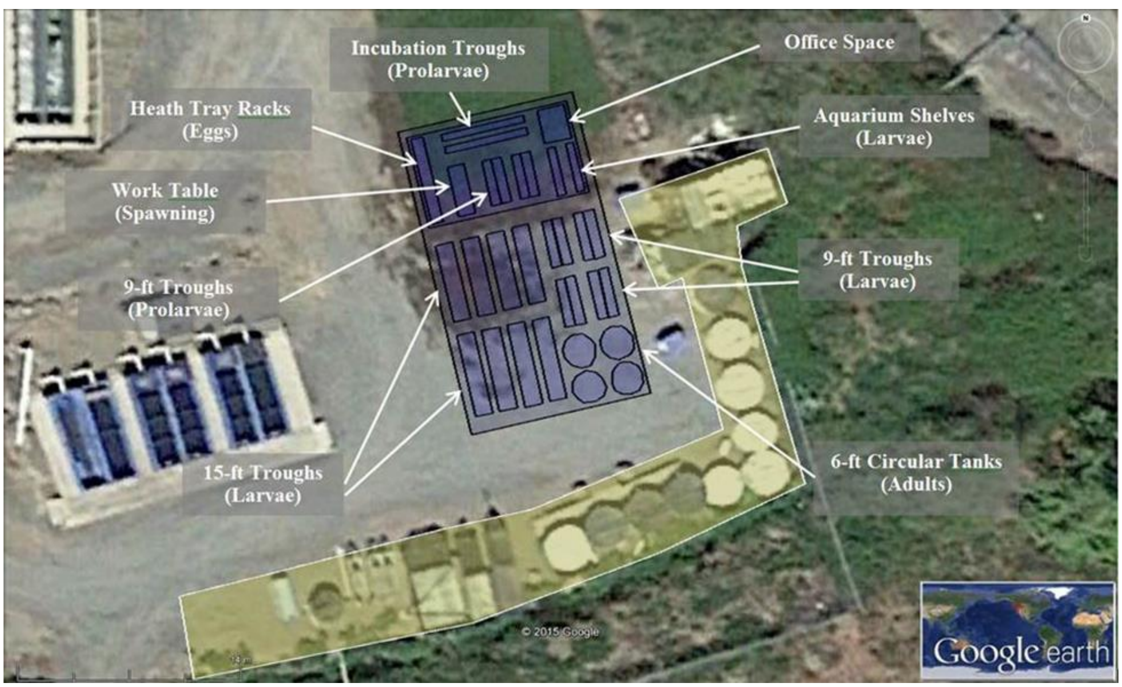


**Figure 5-7. Aerial overview of the new pole building and tanks proposed at the East Lamprey Facility at Prosser Fish Facility.**

**Table 5-9. Estimated additional space, flow rate, and total carrying capacity of tanks from proposed new pole building construction at Prosser Fish Hatchery for Pacific Lamprey. All tanks are fiberglass unless otherwise noted.**

| Tank Type | Primary Life Stage | Water Depth (cm) | Area ($m^2$) | Volume (gallon) | Flow Rate (gallons/min) | Water Turnover Time (min) | # of Tanks | Total Area ($m^2$) | Total Volume (gallon) | Total Flow (gallon/ | Goal Density ($g/m^2$) | Total Capacity | Total Capacity (Egg #) | Total Capacity (Prolarva #) | Total Capacity (9-Mo. Larva #) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Circular | Adult | 55 | 2.63 | 382 | 14.0 | 27.3 | 1 | 2.6 | 382 | 14 | 20000 | 132 | - | - | - |
| Trough | Prolarva | 17 | 1.16 | 50 | 2.0 | 25.2 | 12 | 13.9 | 606 | 24 | 125 | - | - | 579,155 | 4,351 |
| Heath | Prolarva | 10 | 0.126 | 3.3 | 3.0 | 11.1 | 10 | 1.3 | 33 | 3 | 125 | - | - | 52,388 | 394 |
| Aquarium[a] | Larva | 20 | 0.125 | 6.6 | 0.3 | 24.5 | 10 | 1.3 | 66 | 3 | 125 | - | - | - | 391 |
| Trough | Larva | 29 | 4.00 | 309 | 12.5 | 24.7 | 8 | 32.0 | 2,472 | 100 | 125 | - | - | - | 10,013 |
| **Total** | | | | | | | | | | | | | | | |
| - | Adult | - | - | - | - | - | 1 | 2.6 | 382 | 14 | - | 132 | - | - | - |
| - | Prolarva | - | - | - | - | - | 22 | 15.2 | 639 | 27 | - | - | - | 631,543 | - |
| - | Larva[b] | - | - | - | - | - | 18 | 48.5 | 3,177 | 130 | - | - | - | - | 15,149 |

Note: The additional water use from this new facility will be offset by the reduction in the water use from the termination of the West Facility.
[a] Glass
[b] Tanks designated for prolarvae can also be used for larvae; therefore, they are counted towards the total capacity for both life stages

### 5.6.1.3 Confederated Tribes of the Umatilla Indian Reservation - Existing Facilities

The CTUIR began holding brood stock in 2000. Two existing facilities are used for adult lamprey brood stock holding, the South Fork Walla Walla (SFWW) facility located near Milton-Freewater, Oregon and the Minthorn Springs Acclimation facility located near Mission, Oregon. Both of these facilities were constructed for salmonid holding with salmonid project funds. Over the next several years, the CTUIR intends to use the SFWW and Minthorn Springs facilities for adult holding, and to use the Walla Walla Community College Water Environmental Center (WEC) and the NOAA Mukilteo Research stations for propagation research. In addition, we are pursuing repurposing the SFWW ozone building for additional lamprey artificial propagation needs.

#### *South Fork Walla Walla*

Upon collection (see **Section 4.3.4**), adult lamprey are transferred to the SFWW adult holding facility (Figure 5-8) until late fall. This facility has ideal water quality conditions and readily available space. Adults are held in aggregate in 3 m x 3 m x 30 m concrete ponds supplied with ambient river water (100 g/min) and artificial tarp shading from May through October.

**Figure 5-8. Existing South Fork Walla Walla Adult Holding Facility. The center-most pond is used for adult lamprey holding. Planned repurposed ozone building is in the black circle.**

#### *Minthorn Springs*

In October, adults are transferred to the Minthorn Springs Adult Lamprey holding facility (Figure 5-9) until release in the spring. Adults are placed in 1 m x 1 m x 1 m Bonar high density polyethylene tanks with lids. Each tank is supplied with ambient spring water and pumped atmospheric air.

**Figure 5-9. Existing Minthorn Springs Adult Lamprey Holding facility. Adults are held in tanks located in the black circle.**

### *Water Environmental Center*

The CTUIR began artificial propagation activities at the WEC in 2013. The WEC is currently supplied with City of Walla Walla water, but addition of well water is planned for the near future. The city water supply is passed through a carbon filter, chilled and UV irradiated. The lab has 5 independent re-circulating systems with a variety of tanks that can support adult holding, spawning and incubation, and limited rearing (Table 5-10). Physical space is the major limiting factor at this facility. Some outdoor space is available for future addition of tanks in a secure bullpen behind the WEC lab.

Adult holding facilities at the WEC include four, 4' circular fiberglass tanks that are supplied with temperature-controlled, UV-irradiated recirculating water (Figure 5-10). These tanks can be covered or left open to natural lighting.

The WEC also features well-appointed wet and dry labs with sinks, disinfection areas, dissecting microscopes, precision balances, freezers, refrigerators, glassware, and equipment storage. During lamprey spawning, gametes are held on ice and combined in disinfected containers and eggs are incubated in either Heath racks (one bank of five trays modified for lamprey culture; Figure 5-11), flow through Eager jars (n = 3; Figure 5-11), or polycarbonate Cambro food-grade trays (n=30) in troughs or a tank rack with re-circulating water (Table 5-10; Figure 5-12). The troughs and tank rack are also used for early rearing of hatched larvae. Grow-out facilities are extremely limited, but could be expanded to include four, 5' circular indoor tanks or additional outdoor tanks or troughs in the secure bullpen area.

**Table 5-10. Existing space, flow rate, size and tank type at the Water Environmental Center.**

| Tank Type | Material | Primary Life Stage | Depth (cm) | Volume (gallon) | Flow Rate (gallons/min) | # of tanks | Total Volume (gallon) |
|---|---|---|---|---|---|---|---|
| Circular | Fiberglass | Adult | 122 | ~300 | Recirculating | 4 | ~1,200 |
| Circular | Fiberglass | Larva | 91 | ~400 | Recirculating | 4 | ~1,600 |
| Trough (Sys 2) | Fiberglass | Larva | 30 | ~150 | Recirculating | 2 | ~300 |
| Cambro Pans (on LLRR and on Sys 2 troughs) | Food grade plastic | Larva | 15 | ~2 | Recirculating | 30+ | 60+ |
| Heath | Plastic | Egg | | up to 5 trays | 3-4 | 1 | -- |
| Eager Jar | Plastic | Egg | 60 | -- | 12-14 | 4 | -- |

**Figure 5-10. Adult lamprey holding tanks at the Water Environmental Center.**

**Figure 5-11. Heath rack (left) and Eager upwelling jars (right) modified for lamprey egg incubation.**

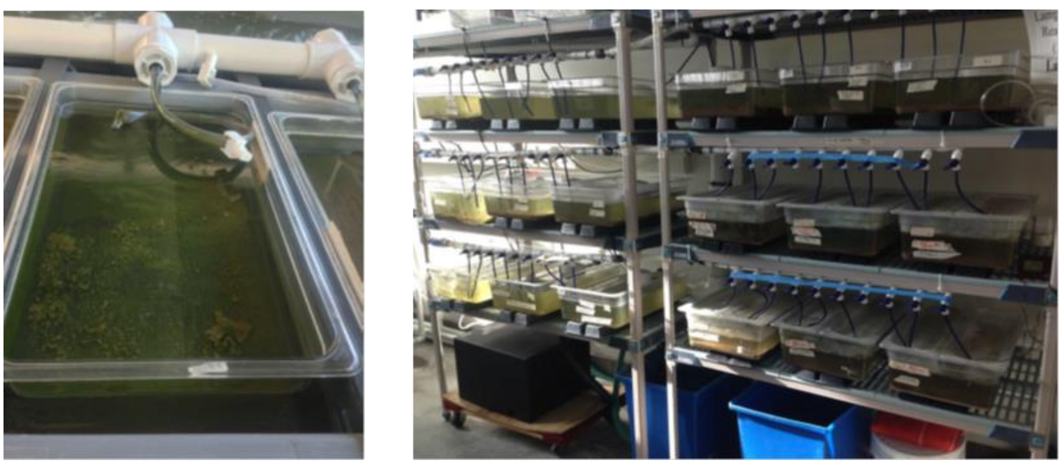

**Figure 5-12. Recirculating water trough (left) and tank rack (right) with interchangeable Cambro polycarbonate tanks or trays.**

### *Mukilteo Research Station*

Lamprey propagation research at NOAA's Mukilteo Research Station was initiated in 2012. This facility is located approximately 20 miles north of Seattle and is used primary for mariculture and larval rearing of both marine and freshwater species. The lamprey facilities include a 30-tank rack system with temperature-controlled, UV-irradiated freshwater (conditioned Everett City Water; Figure 5-13) to conduct egg incubation and early larval rearing research. This system is housed in a dedicated room with temperature and light control. Other facilities regularly used for lamprey propagation at this facility include: 8' living stream, office space for one researcher (summer), -20°C freezer, ice machine, refrigerator, hazardous materials storage and hood, dissecting microscope, materials shop, wet lab with sinks, and dry equipment storage.

**Figure 5-13. De-watered lamprey rack system at MUK with 30 replicate polycarbonate tanks.**

### 5.6.1.4 Confederated Tribes of the Umatilla Indian Reservation – Future Facility Conceptual Design

#### *South Fork Walla Walla Ozone Building*

The former Ozone building at the SFWW hatchery (Figure 5-8) will be re-purposed to permit expansion of the CTUIR lamprey propagation program. This 32’ × 36’ building can be supplied with either South Fork Walla Walla River water or high-quality well water at flows sufficient to maintain three, 4’ circular tanks for adult holding and 36, 8’ troughs for larval rearing (Table 5-11). The concept is to take advantage of the vertical space in this building and construct banks of shallow troughs that are plumbed individually for future research and grow-out of larvae.

**Table 5-11. Space, flow rate, size and tank type at the planned South Fork Walla Walla Facility.**

| Tank Type | Material | Primary Life Stage | Depth (cm) | Volume (gallon) | Flow Rate (gallons/minute) | # of tanks | Total Volume (gallon) |
|---|---|---|---|---|---|---|---|
| Trough | Fiberglass | Larva | 60 | ~150 | 2 | 36 | ~5,400 |
| Circular | Fiberglass | Adult | 91 | ~200 | 15 | 3 | ~600 |

#### *Mukilteo Research Station*

Seawater rearing tanks for marine life stage research will be needed in the near future. Three or four, 8’ circular fiberglass tanks will be used when lamprey rearing expands to include metamorphosis and marine-phase of life history. These tanks will be housed outdoors in a secure compound with high quality flowing seawater pumped directly from Puget Sound (10 g/ min).

## 5.7 Adaptive Management of the Lamprey Program

As described previously (see **Section 5.4.1**), the phased approach to the program emphasizes adaptive management. The state of the science for lamprey artificial propagation both in laboratory and applied in the field is limited therefore it will be critical that new findings are utilized to inform successive stages of lamprey restoration. This plan has specifically identified four phases that are designed to inform adaptive decisions for each successive stage. Through the use of standardized protocols and metrics, the Tribes and other entities will evaluate the risks and benefits/success of the proposed and ongoing lamprey program and will systematically address critical scientific uncertainties (Figure 5-14). It is anticipated that documentation of successful lamprey survival during Phase 1 laboratory research will inform implementation of pilot restoration strategies in the field (Phase 2). Furthermore, it is anticipated that Phase 3 documentation of successful lamprey survival during Phase 2 field monitoring will inform development of broader restoration strategies (Phase 4) for Columbia Basin tributaries. An adaptive management workgroup will guide development, implementation, evaluation, and refinement of the plans. Guidance will be sought from research, management, and policy entities to craft efficient implementation, monitoring, and evaluation programs that address and meet success criteria of these programs.

### 5.7.1 Adaptive Management Objectives

The primary purpose of the adaptive management component of the Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research is to meet the goals defined for the lamprey program by: 1) minimizing risks of short- and long-term adverse effects through monitoring and iteratively refined management; 2) maximizing the chances of meeting numerical success criteria targets; and 3) periodically reevaluating project success criteria by integrating research, monitoring, and evaluation results.

Previously identified critical uncertainties (**see Section 5.3**) and hypotheses (**see Section 5.4**) will be addressed through appropriately designed experimentation where needed. Monitoring components will be refined to ensure that relevant data are being properly collected to evaluate program progress, successes, and failures. Key decision points for the lamprey program will be triggered by the success of research-scale rearing, significant survival of propagated larvae/juveniles upon release, and subsequent adult return and spawning success in the wild. The decision framework for interpreting monitoring data relevant to artificial propagation operations will be led by the YN, CTUIR, and CRITFC, along with ODFW, WDFW, USFWS, and the many collaborating academic and private sector scientists. This consortium of agencies with strong leadership from the YN, CTUIR, and CRITFC will interpret monitoring results and determine if objectives are being achieved or if operational or facility changes are needed in the programs. Interaction will occur regularly with this team to ensure that artificial propagation production is appropriately scaled to habitat and abundance conditions.

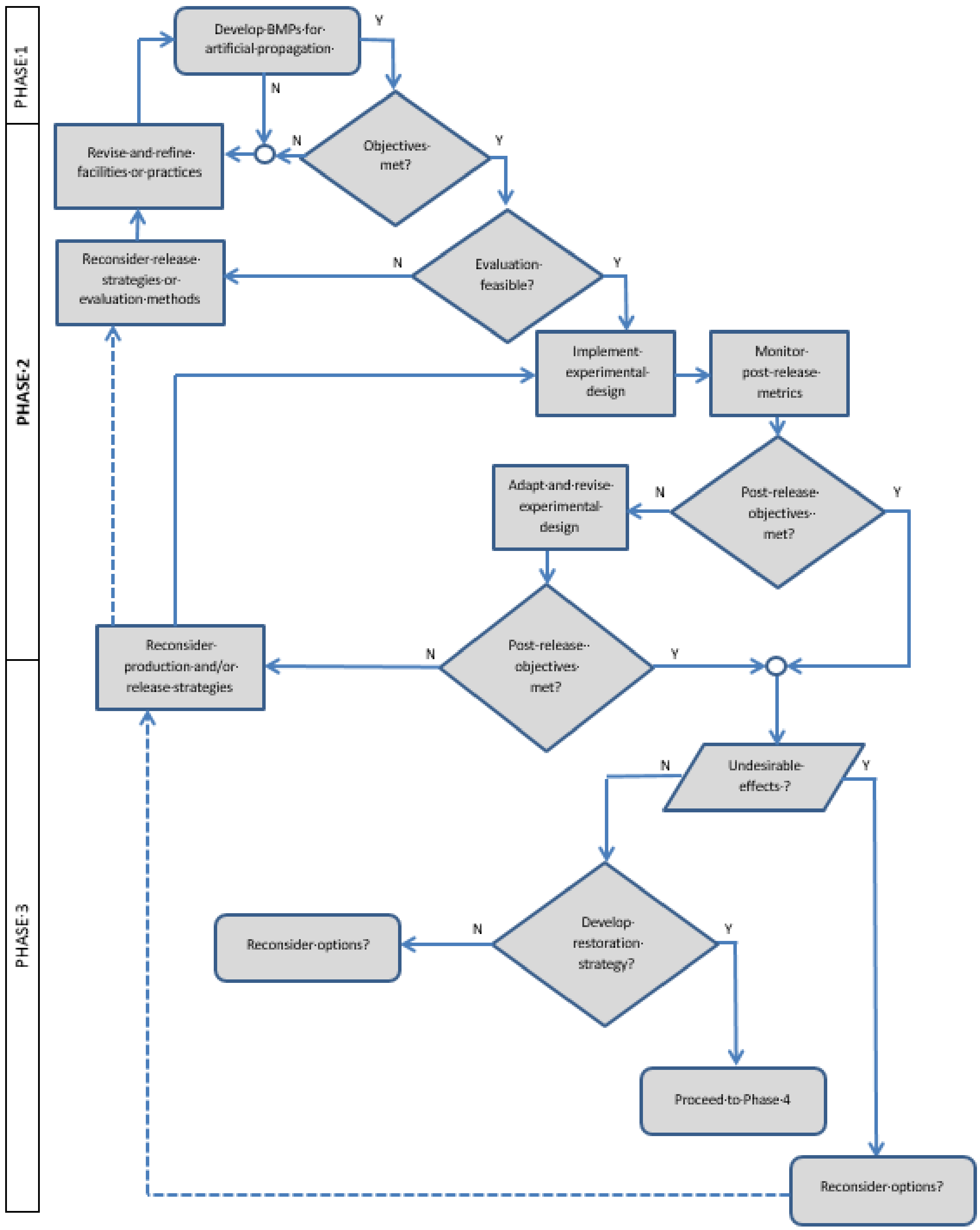


**Figure 5-14. Adaptive management framework for Pacific Lamprey artificial propagation.**

### 5.7.2 Conditions for Ending the Programs

The proposed Master Plan for Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research aims to implement an overlapping, phased approach to supplementation research to develop a restoration strategy for Pacific Lamprey utilizing artificial propagation and adult translocation as potential supplementation strategies. Although products of the proposed Master Plan (i.e. a restoration strategy) intend to be stop-gap measures in lamprey restoration, the operational duration is uncertain due to the regional and rangewide status of Pacific Lamprey and the time required for lamprey to be restored in numbers that fully provide for ecological and cultural values. Restoration of Pacific Lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas would need to be assured before ceasing any restoration strategy. Within the Tribal Pacific Lamprey Restoration Plan, the presence of ~1,000,000 adult lamprey counted at Bonneville Dam (by 2035), is a preceding step prior to sustainable and harvestable levels throughout the historical range and in all usual and accustomed areas (by 2050) (CRITFC 2011).

Conditions signaling termination may be biological (e.g. genetically diverse population segments, reproduction of adults, adequate recruitment to support population segment persistence and viability) as well as cultural (sustainable tribal harvest). However, due to the limited but improving understanding of Pacific Lamprey biology and ecology (**see Section 4.1**), it is difficult to define traditional, biological conditions for terminating lamprey programs within the Master Plan.

The first three phases of the proposed Master Plan span from 2012 through 2028. Specifically, Phase 3 is characterized by the analysis of Phase 1 and Phase 2 results in association with the development of a restoration strategy (Phase 4) in which better-defined biological conditions for terminating lamprey programs are expected to be developed. Phase 4 actions (Implement Restoration and Supplementation Actions) will depend heavily on the results obtained in Phases 1-3. Achieving biological conditions outlined in Phase 4 may require multiple subsequent generations (potentially +/- 50 years for lamprey).

Despite unresolved biological uncertainties regarding lamprey life history as well as the potential role of supplementation in Pacific Lamprey restoration and recovery, conditions signaling termination of Master Plan objectives during Phases 1-3 (2012-2028) may include but are not limited to:

- Adverse conflicts with disease transmission that cannot be overcome.
- Potential adverse effects from limited genetic diversity within supplementation research programs.
- Conclusion that artificial propagation of older (e.g. 3+ years) larvae and juveniles is too time consuming and expensive for producing study fish compared to other methods (e.g. extraction of naturally reared larvae and juveniles from regional streams).
- Conclusion that artificial propagation is not effective and/or has limited cost effectiveness when compared to adult translocation in long-term restoration.
- Conclusion that artificial propagation is not productive and/or has limited productivity when compared to adult translocation in long-term restoration.
- Conclusion that adult translocation is not productive and/or has limited productivity when compared to artificial propagation in long-term restoration.

The ultimate goal of this program will be achieved when CRB Pacific Lamprey are restored to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas.

# 5.8 Summary of Cost Estimates

## 5.8.1 Direct Cost Estimates

Estimates provide a planning baseline from which to refine costs, evaluate alternatives, and protect against budget expansion as the program progresses from Phase 2 (field phase) to Phase 3 (synthesis phase) and eventually Phase 4 (implementation phase). Estimated costs (Table 5-12 and Table 5-13) are based on the proposed programs and conceptual designs presented in **Section 5.5**. Research, monitoring, and evaluation, as well as operations and maintenance, are included in these estimates; however, Phase 4 implementation costs are not. Phase 3 analyses will inform the range of costs for Phase 4 implementation.

The foundational planning approach taken by the two tribes is to develop lamprey artificial propagation, translocation, restoration, and research facilities within existing facilities to achieve design, construction and operational efficiencies, thereby significantly reducing all associated program costs, and to fulfill ecosystem restoration objectives. All design effort to date has been based on this precept. Costs to implement Pacific Lamprey artificial propagation, translocation, restoration, and research objectives at a completely separate new facility would be significantly more expensive, would not include the combined operational and implantation efficiencies of sharing the existing infrastructure currently available.

**Table 5-12. Estimated conceptual costs for a 10-year YN lamprey artificial propagation project from FY 2018 through FY 2027.**

| Expense Type | Phase 1 | | | | | | | | | | 10-Year Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Phase 2 | | | | | | | | | | |
| | | | | Phase 3 | | | | | | | |
| | | | | | | | | | | Phase 4[a] | |
| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | |
| Payroll/fringe | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $60,000 | $600,000 |
| Building | $60,000 | -- | -- | -- | -- | -- | -- | -- | -- | -- | $60,000 |
| Equipment | $40,000 | $35,000 | -- | -- | -- | $10,000 | -- | -- | -- | $10,000 | $95,000 |
| Supplies | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $9,000 | $90,000 |
| Utilities | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $3,000 | $30,000 |
| Vehicles | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $8,000 | $80,000 |
| Travel | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $5,000 | $50,000 |
| Indirect | $23,213 | $22,284 | $15,785 | $15,785 | $15,785 | $17,642 | $15,785 | $15,785 | $15,785 | $17,642 | $175,487 |
| Total | $208,213 | $142,284 | $100,785 | $100,785 | $100,785 | $112,642 | $100,785 | $100,785 | $100,785 | $112,642 | $1,180,487 |

[a] Cost estimates do not include Phase 4 implementation.

**Table 5-13. Estimated conceptual costs for a 10-year CTUIR lamprey artificial propagation project from FY 2018 through FY 2027.**

| Expense Type | Phase 1 | | | | | | | | | | 10-Year Cost |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Phase 2 | | | | | | | | | | |
| | | | | Phase 3 | | | | | | | |
| | | | | | | | | | | Phase 4[a] | |
| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | |
| Payroll/fringe | $100,000 | $100,000 | $100,000 | $200,000 | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 | $250,000 | $2,000,000 |
| Travel, training, vehicles | $10,000 | $10,000 | $10,000 | $15,000 | $15,000 | $15,000 | $15,000 | $15,000 | $15,000 | $15,000 | $135,000 |
| Materials, supplies, services | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $25,000 | $250,000 |
| Facilities upgrades | $50,000 | $10,000 | $10,000 | -- | -- | -- | -- | -- | -- | -- | $70,000 |
| Indirect | $79,550 | $62,350 | $62,350 | $103,200 | $124,700 | $124,700 | $124,700 | $124,700 | $124,700 | $124,700 | $1,055,650 |
| Total | $264,550 | $207,350 | $207,350 | $343,200 | $414,700 | $414,700 | $414,700 | $414,700 | $414,700 | $414,700 | $3,510,650 |

[a] Cost estimates do not include Phase 4 implementation.

### 5.8.2 Cost Sharing with Other Organizations and Entities

Cost sharing will be an important aspect of funding the proposed programs. Conceptual costs take into consideration the extensive amount of cost sharing that is occurring in current programs and that is expected to continue in future programs. Most cost sharing identified for the two Tribe's supplementation programs relate to artificial propagation and adult translocation research, monitoring, and evaluation. Cost sharing includes both direct funding and in-kind support (Table 5-14 and (Table 5-15). As a result of these matching funds, over one million dollars in cash value are expected to be contributed towards this project, and a similar amount of contribution (~$1 million) is estimated for contribution through in-kind match from various partnering and collaborating agencies. Although these cash and in-kind contributions are not shown as direct deductions from the line item budgets presented in this document, they were considered when developing annual operations and M&E cost estimates.

**Table 5-14. Summary of YN and CTUIR cost sharing (cash contribution) with other organizations and entities.**

| Agency | Match Duration (End Year) | Average Annual Match (2016-2025) | Comments |
|---|---|---|---|
| Bonneville Power Administration | ~2018 or longer | ? | Fish Accords Funding - CTUIR |
| | | 300k | Fish Accords Funding - YN |
| | | ? | Fish Accords Funding - CRITFC |
| United States Bureau of Reclamation | ~2018 or longer | 100k | Fish Accords Funding - YN / operation of PIT tag arrays |
| | | ? | Fish Accords Funding - CTUIR / operation of PIT tag arrays |
| | | 100k | Science and Technology Program Funding |
| Chelan County Public Utility District | ~2018 or longer | 234k | Funding to develop artificial propagation methods for juvenile production |

**Table 5-15. Summary of YN and CTUIR cost sharing (in-kind match) with other organizations and entities.**

| Agency | Match Duration (End Year) | Comments |
|---|---|---|
| National Marine Fisheries Science | Long-Term | Operation of PIT tag arrays in YN & CTUIR Ceded Lands |
| US Fish and Wildlife Service | Long-Term | Assistance in larval/juvenile distribution surveys, rotary screw trap monitoring, incidental redd surveys, operation of PIT tag arrays in YN & CTUIR Ceded Lands |
| Oregon Department of Fish and Wildlife | Long-Term | Rotary screw trap monitoring, incidental redd surveys, operation of PIT tag arrays in YN & CTUIR Ceded Lands |
| Washington Department of Fish and Wildlife | Long-Term | Rotary screw trap monitoring, incidental redd surveys, operation of PIT tag arrays in YN & CTUIR Ceded Lands |
| YN - Yakima-Klickitat Fisheries Project | ~2018 or longer | Shared resources and assistance from Prosser Hatchery (Yakima R.), monitoring at Chandler and Roza juvenile fish monitoring facilities (Yakima R.), rotary screw trap monitoring (Klickitat R.), incidental redd surveys (Yakima and Klickitat R.) and radio telemetry, and operation of PIT tag arrays |
| YN - Yakama Reservation Watersheds Project | ~2018 or longer | Rotary screw trap monitoring, incidental & coordinated redd surveys and radio telemetry, operation of PIT tag arrays in YN Ceded Lands. |
| CTUIR - Grande Ronde Natural Production Monitoring and Evaluation Project | ~2018 or longer | Rotary screw trap monitoring (Lookingglass Cr.), operation of PIT arrays |
| CTUIR - Grande Ronde Artificial Propagation Project | ~2018 or longer | Weir monitoring (Upper Grande Ronde R.) |
| CTUIR - Walla Walla Basin Natural Production Monitoring and Evaluation Project | ~2018 or longer | Rotary screw trap monitoring and incidental & coordinated redd surveys in Walla Walla Subbasin |

An important aspect of expected costs for the proposed programs involves shared facilities and functions with existing salmon hatcheries. Some proposed facilities, as well as staffing and equipment, will be shared between the Pacific Lamprey and salmon programs. Pacific Lamprey program costs are based on an assumption that salmon hatchery programs will continue to be implemented; therefore, inseparable components remain. Planning estimates suggest that the operational cost of these programs will be at least 60-90% lower with shared facilities, functions and operational staffing than if two separate, parallel programs were developed and operated. Independent construction costs would include separate water supply and treatment facilities, separate effluent treatment and distinct operational infrastructure. Expanding existing facilities or constructing facilities outside of the basin (even if possible and recommended) also would require greater expenditures over the long term.

Efficiencies are also realized in monitoring and evaluation activities. These facilities will incorporate best management practices, which call for isolating the different fish species to avoid disease problems and ensure efficient operations and activities for each life stage of the cultured species. Because of the experimental nature of some aspects of the proposed programs, it should be noted that conceptual designs for facilities and infrastructure were approached in a manner that accommodates cost effective operational flexibility in each functional area (i.e., egg take, incubation, rearing, release) to accommodate and adapt for future changes based on new information obtained through experimental work and/or monitoring and evaluation.

## 5.9 Expected Project Benefits

The goal of this Master Plan is to evaluate the feasibility of using artificial propagation and translocation techniques to better understand and ultimately restore Pacific Lamprey throughout its range, with particular emphasis on the CRB population segment. Expected benefits of phases 1-3 of the proposed Pacific Lamprey program include: 1) making progress towards artificial propagation and aquaculture research goals identified in numerous regional plans (CRITFC 2011; Luzier et al. 2011), 2) contributing to research evaluating critical limiting factors for Pacific Lamprey, 3) improving research efficiency and expanding research capabilities through improved facilities, 4) providing increased opportunities for regional researchers to use artificially reared lamprey in a variety of critical uncertainty evaluations, and 5) meeting Tribal trust responsibilities. If Phase 4 is fully developed, the program would eventually be expected to provide increased numbers of Pacific Lamprey in the CRB until passage and habitat improvements can successfully support numbers that meet goals identified in numerous regional plans.

As noted in Section 5.4.1.4, Phase 4 is characterized as a comprehensive implementation of a restoration strategy for Pacific Lamprey within the Upper Columbia and Snake River systems developed under Phase 3. The tribes envision that significant progress would continue in mainstem adult passage efforts with increasing successes in tributary passage, primarily at irrigation diversion dams. These efforts along with continued involvement with the LCA and findings associated with Phase 3 analysis would allow the tribes and other fishery managers a much clearer view in establishing regional management direction and funding priorities. Phase 4 actions would be dependent upon the many variables unknown at this time, including the status and trend of Pacific Lamprey population segments, the success of supplementation strategies and the success of habitat and passage improvement efforts.

# 6 Consistency with the Fish and Wildlife Program

In addition to justifying the need for and describing in detail the actions proposed to help restore Pacific Lamprey in the CRB, the Master Plan must summarize how the proposed actions are consistent with the Program. In addition, proposed actions will need to be compliant with federal, state, and other environmental regulations.

## 6.1 Consistency with Six Scientific Principles of the NPCC Fish and Wildlife Program

### 6.1.1 Principle 1: Healthy Ecosystems Sustain Abundant, Productive, and Diverse Plants and Animals Distributed over a Wide Area

Tribal efforts to maintain and restore Pacific Lamprey through multiple actions including passage improvements, habitat and water quality restoration, and multiple supplementation/augmentation strategies support Principle 1. The commitment to conduct priority research and to monitor and evaluate restoration actions further exemplifies recognition of this principle. In this ecological context, Pacific Lamprey supplementation research is needed because Pacific Lamprey return to the CRB at a fraction of their historical numbers. Despite recent implementation of passage improvements at mainstem and tributary dams, habitat improvements, and adult lamprey translocation efforts (CRITFC 2011; Luzier et al. 2011; Ward et al. 2012), adult returns remain low, spatial distribution is increasingly limited to the lower portions of the CRB, and Pacific Lamprey have been extirpated from many subbasins in the interior CRB (Close et al. 1995; USFWS 2007; Luzier et al. 2011). Uncertainty about the environmental and ecological conditions required to restore Pacific Lamprey remains, but implementation of a suite of integrated management and restoration strategies is prudent. Pacific Lamprey should continue to be an important component of a functional ecosystem.

### 6.1.2 Principle 2: Biological Diversity Allows Ecosystems to Adapt to Environmental Changes

Pacific Lamprey have played a key role in the ecosystem of the CRB. Potential ecological impacts of decreased lamprey abundance include decreased connectivity of marine with freshwater ecosystems and decline in delivery of marine-derived nutrients into upper reaches of the CRB. Low lamprey abundance may also decrease the potential prey base available to native fish, avian, and mammalian predators. Pacific Lamprey may also be an important indicator of ecosystem health.

Because of their complex and extended life history, Pacific Lamprey occupy numerous trophic levels and habitats. Pacific Lamprey larvae remain in fresh water for 4-7 years before metamorphosing. They are filter feeders, with a diet consisting of detritus, diatoms, and algae. During metamorphosis, Pacific Lamprey move from fine substrate in low velocity areas to silt covered gravel in moderate current. When fully transformed they are found in gravel or boulder habitats in moderate to strong currents (Beamish 1980). Adult Pacific Lamprey re-enter freshwater after spending 2-3 years in the ocean, and generally spawn in the spring after overwintering in freshwater habitat. Historically, Pacific Lamprey likely played an important role in shaping or regulating of freshwater community attributes as well as affecting food web dynamics.

Fish community interactions and responses to restoration actions can be very complicated and interdependent. This may be particularly true for a species such as Pacific Lamprey. Supplementation research will increase knowledge regarding how Pacific Lamprey will respond to and affect the altered ecosystem. In addition, supplementation research may provide valuable insights into lamprey biology and ecology as well as provide the opportunity to research known and potential limiting factors and critical uncertainties.

### 6.1.3 Principle 3: Ecosystem Conditions Affect the Well-Being of All Species Including Humans

Principle 3 emphasizes the importance of individual species, including humans, as integral and necessary parts of functioning ecosystems. This is a primary justification to restore Pacific Lamprey throughout the CRB. As described previously, Pacific Lamprey occupy numerous trophic levels and habitats, and have played a key role in the ecosystem of the CRB. Pacific Lamprey provide connectivity of marine with freshwater ecosystems including the delivery of marine-derived nutrients into the CRB. They also provide a prey base available to native fish, avian, and mammalian predators.

Indigenous peoples historically harvested Pacific Lamprey throughout the CRB (Close et al. 1995), but now harvest is restricted to the lower basin. Declines have been precipitous in the upper CRB. It is in this context that supplementation research is proposed. The Tribes understand that supplementation programs will not resolve physical habitat problems or limitations; however, it is unlikely that restoration and passage improvement activities, though necessary for long-term sustainability, will result in increased abundance or distribution at a rate sufficient to offset continuing declines and preclude further extirpations. The development of Pacific Lamprey supplementation tools has therefore been identified as a recovery action that should occur concurrently with improvements in fish passage, water quality, and habitat (CRITFC 2011; Luzier et al. 2011; USFWS 2012; Ward et al. 2012; YN and GeoEngineers 2012).

### 6.1.4 Principle 4: Cultural and Biological Diversity is the Key to Surviving Changes

Physical, biological, and spatial diversity are primary foundations of ecological processes and functions and of population viability and persistence. Recent and planned efforts by Tribes and others to pioneer and refine conservation aquaculture for Pacific Lamprey operate within this larger ecological context of Principle 4. Efforts to improve passage, restore habitat, and initiate supplementation research combine to address the physical, biological, and spatial diversity that are needed for Pacific Lamprey to persist despite environmental variation.

Tribes have an innate understanding of ecological hierarchies, and these fundamental beliefs have guided proposed restoration plans for Pacific Lamprey. Tribes have consistently shown a commitment to multi-scale (e.g., spatial and temporal) ecosystem treatments by developing, implementing, and refining multi-faceted plans to restore Pacific Lamprey throughout the CRB. Pacific Lamprey supplementation research is one component of a restoration program that also includes passage improvements and habitat restoration.

Columbia River mainstem and tributary dams represent the source of major ongoing ecological perturbations that affect both cultural and biological diversity. Other cumulatively significant perturbations affecting Pacific Lamprey include land use changes (agricultural, urban, etc.) and associated infrastructure. In response to problems caused by these continuing impacts, this supplementation research plan focuses on Pacific Lamprey artificial propagation at the experimental level, to help obtain information needed to supplement and rebuild numbers for future generations.

### 6.1.5 Principle 5: Ecosystem Management Should be Adaptive and Experimental

This plan for Pacific Lamprey supplementation research is based, in part, on the recently developed Framework (CRITFC 2014). The Framework recognizes the importance of adaptive management. Through adaptive management the Framework will expand with the intention of maintaining its relative simplicity. As more information becomes available through supplementation research efforts, the management actions guided by the Framework will be refined and individual subbasin strategies may be developed. Many critical uncertainties about Pacific Lamprey remain and fishery managers expect that continued research activities will likely modify the overall objectives and methods.

The very nature of this Master Plan is adaptive and experimental in approach (**see Section 5.7**). Supplementation continues to be a tool necessary for learning, both in laboratory and the natural environment. The four Columbia River treaty tribes proposed creating the Framework and this Master Plan with general objectives that are experimental in nature and promote adaptive management (CRITFC 2011):

- Immediate evaluation of potential regional lamprey artificial propagation facilities
- Consolidation and synthesis of existing lamprey propagation information
- Development and refinement of husbandry techniques for Pacific Lamprey
- Continued research on lamprey genetics, potential population substructure, and source locations
- Assessment of appropriate release locations and strategies for hatchery reared lamprey within the region
- Monitoring and evaluation of supplementation using hatchery reared lamprey

Information obtained through supplementation research is anticipated to guide future activities associated with periodic updates for the (1) TPLRP, (2) LCA, and (3) NPCC Program (NPCC 2014). Each of these activities will be important contributions towards the eventual development of a CRB Pacific Lamprey Management Plan.

### 6.1.6 Principle 6: Ecosystem Management Can Only Succeed by Considering People

As described previously, one focus of the Master Plan is to address unnatural, anthropogenic changes in the CRB ecosystem. A larger-scale supplementation program, in conjunction with passage improvements and habitat restoration actions, would be designed to mitigate for these changes. Collaboration among various partners will be used to the extent possible to achieve these goals. All restoration actions, including supplementation, are designed to produce minimal negative ecological or environmental impacts and to have minimal anthropogenic effects. Restoration actions are also intended to provide sustainable harvest opportunities for tribal members. Learning from and adapting in response to supplementation research is an important step towards this end.

## 6.2 Consistency with NPCC Principles for Hatcheries

The NPCC supports using hatcheries as a mitigation tool because habitat restoration actions alone do not meet mitigation requirements of the Northwest Power Act. Although focused primarily on artificial production of anadromous salmonids, the 2014 Program includes artificial propagation principles and measures appropriate for Pacific Lamprey as well. Over-arching principles from the Program are stated in terms of how hatcheries should operate.

### 6.2.1 Follow an Adaptive Management Approach

The phased approach to the program emphasizes and facilitates adaptive management. Through adaptive management planning, the Tribes and other entities will evaluate the risks and benefits of the proposed and ongoing lamprey program and will systematically address critical scientific uncertainties (**see Section 5.3**). An adaptive management workgroup will guide development, implementation, evaluation, and refinement of the plans. Guidance will be sought from research, management, and policy entities to craft efficient implementation, monitoring, and evaluation programs that address and meet success criteria of these programs (see **Section 5.7**).

The tribes have developed coordinated approaches for research using artificial propagation to continue learning about Pacific Lamprey, to contribute to multiple research needs and to evaluate its efficacy as a potential supplementation tool. These strategies will incorporate similar phased and adaptive management approaches, and share common objectives that together will allow for a much stronger understanding and comparison of lamprey performance and future restoration / management direction through artificial propagation, translocation, and natural reproduction.

### 6.2.2 Operate According to Sound Scientific Principles

In consideration of low numbers of adult Pacific Lamprey, multiple management strategies must be employed as stop-gap measures to slow extirpation within local areas throughout the CRB. Supplementation areas will be identified, prioritized, and defined by local area managers and tribal groups to ensure research is conducted to maximize effectiveness. Important attributes, such as local genetic diversity will be monitored through ongoing CRITFC genetic analyses so that if/when supplementation is determined to move forward at a larger scale, the working knowledge will have increased to better plan and implement future management actions. As supplementation research is implemented in specific areas, monitoring and evaluation to determine action effectiveness will provide valuable insights into lamprey biology and ecology as well as provide the opportunity to research known and potential limiting factors and critical uncertainties.

All federal and other legal mandates for fish protection, mitigation, and enhancement relevant to this project will be met. Implementing the proposed programs would assist the federal government in fulfilling its Tribal Trust responsibilities and would aid in restoring Tribal ability to exercise Treaty-reserved fishing rights.

### 6.2.3 Use an Adaptive Management Process

An adaptive management framework will be critical to implementation of the Master Plan. As described in **Sections 5.7 and 6.2.1**, and emphasized in the TPLRP, the program must successfully apply adaptive management to address uncertainties in conservation aquaculture for Pacific Lamprey. Adaptive management is stressed in the Framework (CRITFC 2014).

### 6.2.4 Operate Within the Broader Basin, Regional, and Global Systems

Decisions to explore supplementation research for Pacific Lamprey were made in the context of fish and wildlife goals, objectives, and strategies at multiple levels. The Master Plan has been developed within the large context of the Pacific Lamprey Assessment and Template for Conservation Measures developed by the USFWS (Luzier et al. 2011) and the TPLRP. The Framework, which has been vetted with federal and state co-managers, focuses on coordination and continuity in research and reporting of information associated with emerging and active lamprey restoration strategies such as propagation, translocation, reintroduction, and augmentation. As such, it provides basin and province level guidance. Subbasin specific supplementation research plans are guided by the Framework and are currently in place for the Yakima and Umatilla subbasins.

### 6.2.5 Restore, Maintain, or Minimize Impacts upon Species Diversity

Given the precipitous decline in Pacific Lamprey abundance, particularly in the upper reaches of the CRB, it is unlikely that restoration and passage improvement activities, though necessary for long-term sustainability, will result in increased abundance or distribution at a rate sufficient to offset continuing declines and preclude further extirpations. The development of Pacific Lamprey supplementation tools has therefore been identified as a recovery action that should occur concurrently with improvements in fish passage, water quality, and habitat (CRITFC 2011; Luzier et al. 2011; USFWS 2012; Ward et al. 2012; YN and GeoEngineers 2012). Supplementation would increase larval or juvenile abundance in seeded watersheds or stream reaches. Not only would these actions re-establish juveniles back into the local ecology, they may improve pheromone attraction of returning adults. Emerging evidence strongly suggests an association between juvenile lamprey pheromones and adult returns (Sorensen et al. 2005; Lin et al. 2008; Close et al. 2009; Spice et al. 2012). Adult Pacific Lamprey, like Sea Lamprey, may be attracted to spawning sites by pheromones released by larvae (Lin et al. 2008).

### 6.2.6 Use Locally Adapted Fish as the Model for Successful Rebuilding and Restoration

A well-established premise for artificial propagation in salmonids is the use of locally-adapted broodstock. Such local stock may comprise individuals that are adapted to specific conditions in a basin, and subsequently exhibit higher fitness. Although much more work is needed to better understand Pacific Lamprey genetics, they appear to exhibit low genetic differentiation among regional stocks, and population structure reflects a single broadly distributed population across much of the Pacific Northwest (Goodman et al. 2008; Spice et al. 2012). The spatial scale that contains locally-adapted broodstock may therefore be much broader for Pacific Lamprey than for salmonids, and thus specific watershed- or subbasin-of-origin of broodstock may not be critical to the success of artificial propagation programs (see **Section 4.2**).

### 6.2.7 Set Clear Goals and Identify Specific Criteria

This Master Plan supports the TPLRP Vision and Goals by implementing supplementation actions aimed at restoring Pacific Lamprey in areas where they have been extirpated or substantially reduced. Biological objectives are clearly stated in **Section 5.4.2**. Each of the seven objectives includes specific tasks with numeric criteria where appropriate for evaluating performance. Descriptions of the planned activities in **Section 5.5** include clear targets for production and release numbers during Phase 2.

### 6.2.8 Mitigate for Losses in Fish Survival and in Fish Production

Abundance of Pacific Lamprey has declined throughout the CRB, and counts decline rapidly from downstream to upstream areas. Given this decline, the development of Pacific Lamprey supplementation tools has been identified as a recovery action. Research needs related to supplementation identified by the USFWS (Luzier et al. 2011) include evaluating if artificial propagation can be used to “jump start” larval production in appropriate watersheds. Supplementation is intended to be a short term action to boost Pacific Lamprey numbers and make other restoration actions more meaningful. Supplementation will not be implemented in areas of relatively high abundance, or when natural production has good potential.

### 6.2.9 Operate in Consideration of Other Factors

Restoration of Pacific Lamprey in the CRB requires not only a collaborative effort among Tribes, federal agencies, states, and local entities, but also an aggressive combination of various types of restoration activities. Actions should be designed to work together and provide synergy, although not all actions will be appropriate for all areas. Three additional areas of restoration efforts or processes are:

- Mainstem passage and habitat
- Tributary passage and habitat
- Contaminants and water quality

The need for and relationship among various restoration efforts are described in **Sections 4.4 through 4.7.**

All federal and other legal mandates for fish protection, mitigation, and enhancement relevant to this project will be met. Implementing the proposed programs would assist the federal government in fulfilling its Tribal Trust responsibilities and would aid in restoring Tribal ability to exercise Treaty-reserved fishing rights.

### 6.2.10 Operate Based on Conditions that are Unique to Every Location

The preferred alternative does not include new facilities or significant structural improvements to existing supplementation research projects. It instead calls for modest structural improvements to existing supplementation research projects. In addition, the tribes have developed separate, but coordinated approaches for use of artificial propagation to continue learning about Pacific Lamprey, to contribute to multiple research needs and to evaluate its efficacy as a potential supplementation tool. This course of action necessitates differences in operations based on differences among locations. These different facilities and operations are described in **Section 5.6**.

## 6.3 Consistency with NPCC Principles for Lamprey

The 2014 Program also includes a section specific to lamprey, including guidelines for supplementation, including translocation and propagation. The NPCC recognizes and supports efforts to restore Pacific Lamprey consistent with:

- The Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin.
- The Conservation Agreement for Pacific Lamprey.

The Program recognizes that lamprey translocation efforts have been successful at increasing adult spawning activity, larval recruitment, and larval distribution and have provided important lamprey life history information. The Program also recognizes progress in the development of a framework for Pacific Lamprey supplementation research in the CRB. The 2014 Program includes one specific guideline regarding lamprey propagation:

- Evaluate the potential role of lamprey propagation and translocation as a way to mitigate for lost lamprey production when passage and habitat improvements alone are insufficient to restore lamprey.

# 7 Environmental Compliance

Use of federal funding and undertaking of activities that have a potential for impacting fish and fish habitat require various permits. Preparation of a detailed environmental assessment that meets the criteria of the NEPA is normally initiated as part of Step 2 in the NPCC's three-step process. The assessment also provides a foundation for compliance with a number of other environmental and regulatory requirements.

## 7.1 National Environmental Policy Act

The NEPA of 1969, as amended (42 USC 4321 et seq.), requires federal agencies to assess and disclose the effects of a proposed action on the environment prior to funding, approving, or implementing an action.

Adult translocation and laboratory-based propagation research have been covered under BPA's programmatic Environmental Impact Statement; however, this Fish and Wildlife Implementation Plan EIS does not cover proposed release of artificially propagated lamprey into the wild. The proposed program warrants an Environmental Assessment primarily because of the numbers of releases proposed in some of the subbasins (see Table 5-1), and because of the geographical scale anticipated. Hatchery-reared Pacific Lamprey larvae would be released into three subbasins. The NEPA process would include public outreach to assist in identifying key issues that should be addressed in the environmental analysis. At this time, BPA is assumed to function as the lead federal agency for the NEPA effort.

## 7.2 Endangered Species Act

The Endangered Species Act of 1973, as amended (16 U.S.C. § 1531 et seq.) requires that federal agencies ensure that actions they authorize, fund or conduct are not likely to jeopardize the continued existence of any ESA proposed or listed species or their designated critical habitat. Pacific Lamprey are considered a "species of concern" by USFWS but are not formally listed as threatened or endangered under the ESA. However, lamprey distribution coincides with many Pacific salmon species (*Oncorhynchus* spp.) that are formally listed under the ESA. Therefore, possible impacts to ESA listed salmon that could be incidental to lamprey supplementation actions must be considered.

Propagating lamprey in an existing fish hatchery and releasing them to streams that contain ESA listed salmon should be evaluated and permitted though the NMFS to ensure consistency with the ESA. Like other hatchery programs, the lamprey supplementation program could be permitted under section 4(d) or Section 10(1)(A) of the ESA through development of HGMPs. Templates for HGMPs target anadromous salmonids and have considerable drawbacks and limitations when applying them to programs for fish such as Pacific Lamprey. This is especially true given the non-homing return migration strategy of Pacific Lamprey. At a future phase, dependent on the outcome and findings of the proposed work, development of an HGMP could potentially be initiated after review and approval of other components of this Master Plan. Likewise, the USFWS would follow a similar process if Pacific Lamprey are released into streams containing bull trout (*Salvelinus confluentus*).

## 7.3 Clean Water Act

Consistency of project construction and operation will be demonstrated with Section 401 of the Federal Water Pollution Control Act (Clean Water Act). The authority to review the programs for consistency with Section 401 has been delegated to the states of Washington, Oregon, and Idaho.

## 7.4 National Historic Preservation Act

Funding this project is considered an undertaking within Section 106 of the National Historic Preservation Act of 1966, as amended (P.L.89-665, 16 U.S.C. 470). Section 106 requires that every federal agency take into account how each of its undertakings could affect historic properties. Historic properties are districts, sites, structures and traditional cultural places that are eligible for inclusion on the National Register of Historic Places. It is unlikely that historical properties will be encountered during Pacific Lamprey supplementation research activities.

## 7.5 State Approvals

Developing any new artificial propagation facilities will require various regulatory approvals from state agencies. Possible approvals include new water rights if supplement water is needed at hatchery facilities, scientific take or handling permits for the collection lamprey brood stock and sampling, or a National Pollution Discharge Elimination System permit for hatchery operation if production reaches a regulated level.

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