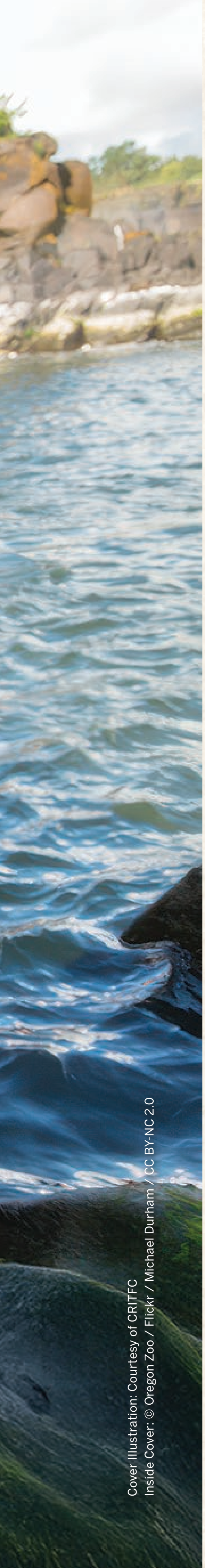
2025 Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin

TECHNICAL DOCUMENT

Columbia River Inter-Tribal Fish Commission

Nez Perce ▪ Umatilla ▪ Yakama ▪ Warm Springs


Willamette Falls fishery.



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Confederated Tribes of the Warm Springs Indian Reservation of Oregon

Nez Perce Tribe

Confederated Tribes of the Umatilla Indian Reservation

Confederated Tribes and Bands of the Yakama Nation

Confederated Tribes of the Warm Springs Reservation of Oregon

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COMMONLY USED ACRONYMS

BMG	Best Management Guidelines
BPA	Bonneville Power Administration
CCPUD	Chelan County Public Utility District
CRB	Columbia River basin, including the mainstem Columbia, Snake, and Willamette rivers and their tributaries
CRBLTWG	Columbia River Basin Lamprey Technical Working Group
CRFW	Columbia River Fish and Wildlife
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
DCPUD	Douglas County Public Utility District
DNR	Department of Natural Resources
EIS	Environmental Impact Statement
ELAT	Eel-Lamprey Acoustic Tag
ESA	Endangered Species Act
F degrees	Fahrenheit degrees
FERC	Federal Energy Regulatory Commission
GCPUD	Grant County Public Utility District
GLFC	Great Lakes Fish Commission
IDFG	Idaho Department Fish and Game
ISAB	Independent Science Advisory Board
ISRP	Independent Science Review Panel
JLATS	Juvenile Lamprey Acoustic Telemetry System
km	kilometers
LPS	Lamprey Passage Structure
MEA	Millennium Ecosystem Assessment
NEPA	National Environmental Policy Act
NFHP	National Fish Habitat Project
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPT	Nez Perce Tribe
NSF	National Science Foundation
ODFW	Oregon Department Fish and Wildlife
OHA	Oregon Health Authority
OSU	Oregon State University
PIT	Passive Integrated Transponder
PL	Pacific Lamprey
PLCA	Pacific Lamprey Conservation Agreement
PLCI	Pacific Lamprey Conservation Initiative
PLTW	Pacific Lamprey Technical Workgroup
PNNL	Pacific Northwest National Laboratory

RME	Research, Monitoring and Evaluation
RMU	Regional Management Unit
SMP	Smolt Monitoring Program
SNP	Single Nucleotide Polymorphism
SRWG	System Review Work Group
TEK	Traditional Ecological Knowledge
TPLRP	Tribal Pacific Lamprey Restoration Plan (2011 or 2025)
U of ID	University of Idaho
U of OR	University of Oregon
U of WA	University of Washington
USACE	U.S. Army Corps of Engineers
USBIA	U.S. Bureau of Indian Affairs
USBOR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VIE	Visible Implant Elastomer
WDFW	Washington Department of Fish and Wildlife
YKFP	Yakima-Klickitat Fisheries Project
YN	Confederated Tribes and Bands of the Yakama Nation
YNPLP	Yakama Nation Pacific Lamprey Project

Acronyms Related to Columbia/Snake River Dams

BON	Bonneville Dam (USACE)
IHR	Ice Harbor Dam (USACE)
JDA	John Day Dam (USACE)
LGR	Lower Granite Dam (USACE)
LGS	Little Goose Dam (USACE)
LMN	Lower Monument Dam (USACE)
MCN	McNary Dam (USACE)
PRD	Priest Rapids Dam (Grant County PUD)
RIS	Rock Island Dam (Chelan County PUD)
RRH	Rocky Reach Dam (Chelan County PUD)
TDA	The Dalles Dam (USACE)
WAN	Wanapum Dam (Grant County PUD)
WEL	Wells Dam (Douglas County PUD)

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The lack of lamprey in our river systems is an environmental degradation and the lack of tribal harvest of toxin-free Pacific lamprey in usual and accustomed places is an ongoing degradation of treaty trust, treaty-reserved rights and our unique cultures. Our tribal members, and especially the children are losing important parts of our culture and our connections. This loss cannot continue.

How Lamprey Lost His Bones

The story of how Lamprey, also known as Eel, lost his bones is a creation story.

Lamprey is a gambler. Coyote is the creator.

One day Coyote was walking along the river going about his business, Coyote sees Beaver walking and looking sad. Coyote asks Beaver "What's wrong? Why are you sad?"

Beaver answers "I lost everything, all my belongings to Eel playing stick game. Eel is beating all the animals and taking all their possessions. Eel is bragging he can't be beat playing stick game."

Now Muskrat comes walking up to them and tells them that he has lost everything to Eel. So, Coyote tells them to take him to Eel and he will play Eel stick game and try to win their possessions back.

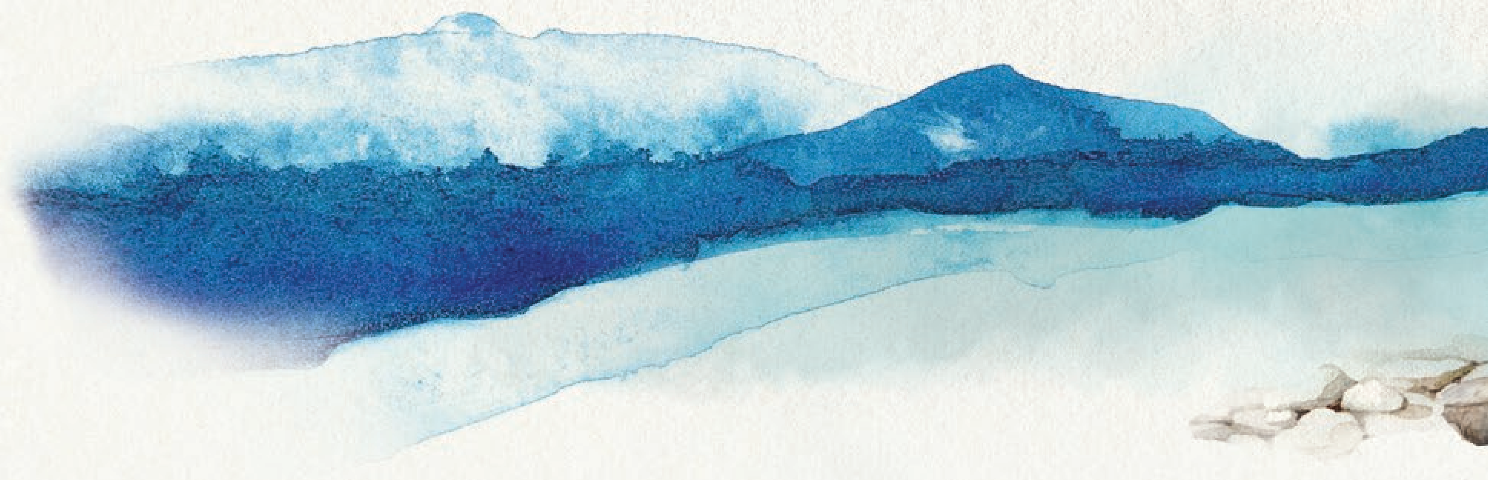
Beaver and Muskrat bring Coyote to the riverbank where Eel was laughing and bragging to all the animals how easy it was to beat them and take their possessions. Coyote sees all the animals' possessions piled up along the riverbank. All the animals are sad they don't know how they will survive without their possessions. Coyote tells the animals he will play Eel for their belongings and he will give their belongings back to them.

So Coyote walks down to the river bank and says to Eel, "What's going on, can I play? Let me play you, Eel."

Eel laughs and brags "I can't be beat Coyote, I have beaten all the animals and own all their possessions, I am very rich now. I can't lose, Coyote, and will beat you next and own everything."

Coyote tells Eel "You shouldn't act this way and you should give the animals back their possessions." Eel refuses to give back anything. "You have to beat me Coyote," Eel says.

So Coyote plays Eel for Beaver's belongings and wins. Coyote gives Beaver back his possessions. Beaver is very grateful to Coyote for giving him back his possessions. Coyote plays Eel for Muskrat's belongings and beats Eel again and gives Muskrat back



his possessions. Muskrat is grateful to get his belongings back. Soon Coyote wins all the animals' belongings back from Eel and returns all the animals' possessions back to them. So now, Eel sittin' there — he has no more possessions. He has nothing — no more to gamble with.

The animals are very happy to get their possessions back and thank Coyote for returning them. Eel is upset for losing all that he had won. Eel wants to keep playing Coyote but has nothing to bet with.

Eel asks Coyote to play again. Coyote says, "Eel you don't have anything left, what are you going to bet with?"

Eel says "All I have left is my bones to bet, so I'm going to bet you my left arm, and I'm going to beat you finally."

Coyote plays him again and beats him again. So Eel bets his right arm next and loses again.

Coyote warns Eel that his mouth and ego is getting him into trouble and to stop.

Eel doesn't care and says to Coyote, "I'm going to beat you this time Coyote. I'll bet you my right leg." Eel loses again and bets his other leg and loses again. Eel gambles all his bones away to Coyote.

Now, Lamprey is sitting there with no arms and no legs or bones left in his body.

So Coyote looks at him. "You have nothing to gamble with now, all you have is your mouth."

Coyote kicks Eel into the river and tells Eel "Since your mouth got you into trouble, now your mouth is all you will have to suck onto the rocks with."

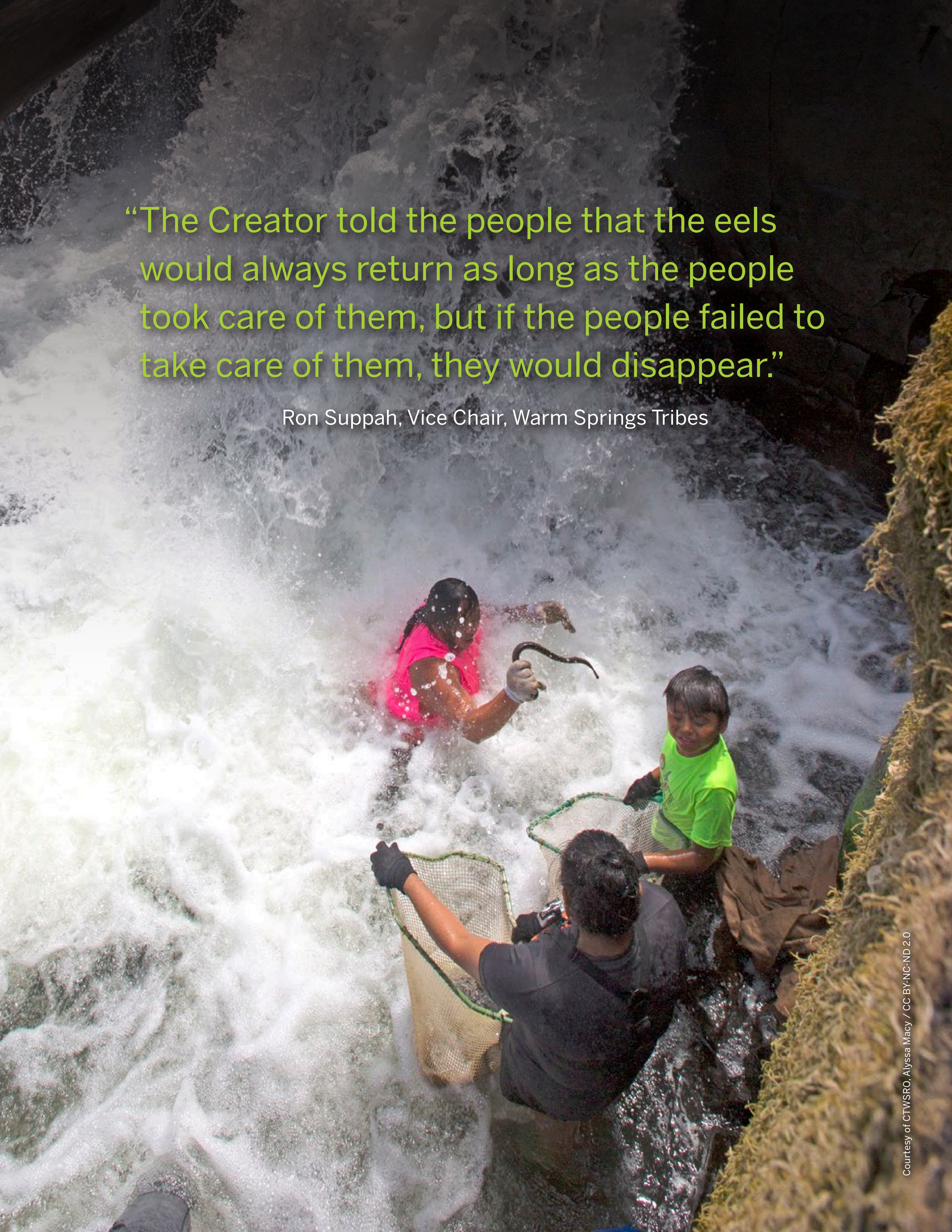
That's how lamprey was created. That's why he's in the river sucking onto rocks with his mouth.

— As told by Jerrid Weaskus

NEZ PERCE TRIBAL MEMBER
AND CTUIR LAMPREY TECHNICIAN

"The Creator told the people that the eels would always return as long as the people took care of them, but if the people failed to take care of them, they would disappear."

Ron Suppah, Vice Chair, Warm Springs Tribes



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EXECUTIVE SUMMARY

Pacific lamprey populations in the Columbia River basin (CRB) were once abundant, self-sustaining, and harvestable. Settlement, anthropogenic alterations, and dam construction disrupted Pacific lamprey populations. In 2010, daytime counts at Bonneville Dam dropped to an all-time low of 6,234. Pacific lamprey (sometimes referred to as “eels”) were in trouble. The tribal voices were the loudest — and often the only voices shouting that something must be done.

Our frustration and our determination to recover lamprey was focused and the 2011 Tribal Pacific Lamprey Restoration Plan (CRITFC 2011) was presented to the region. Really, this was more than a lamprey plan. Lamprey represents the rivers, the environment, ecologies, and the other fish. The Tribes understand that the land and the animals focus more on the bigger picture; we understand the connectedness of the Tribes to our environment. This knowledge was also a part of our frustration.

The 2011 TPLRP was comprehensive, and it was effective. The region began to mobilize. Although the lamprey population seems to have averted the most critical crisis, it is far from being secure. Since the implementation of conservation and restoration actions, the highest 24-hour count at Bonneville Dam (BON) was approximately 292,000 in 2017. This was followed by a low count of approximately 44,000 a few years later in 2020, which is less than 5% of the numbers that were estimated before the dams (1,000,000s). Urgency and significant actions are required to ensure the populations do not slip downward again.

In this 2025 Tribal Pacific Lamprey Restoration Plan (2025 TPLRP) we highlight progress and we provide a clear assessment of regional shortcomings. Yes, progress has been accomplished and there is much to talk about. Before 2011, regional collaboration to aid Pacific lamprey was barely an idea — now it is established and growing. Interesting, useful, and fun public outreach is available, there are

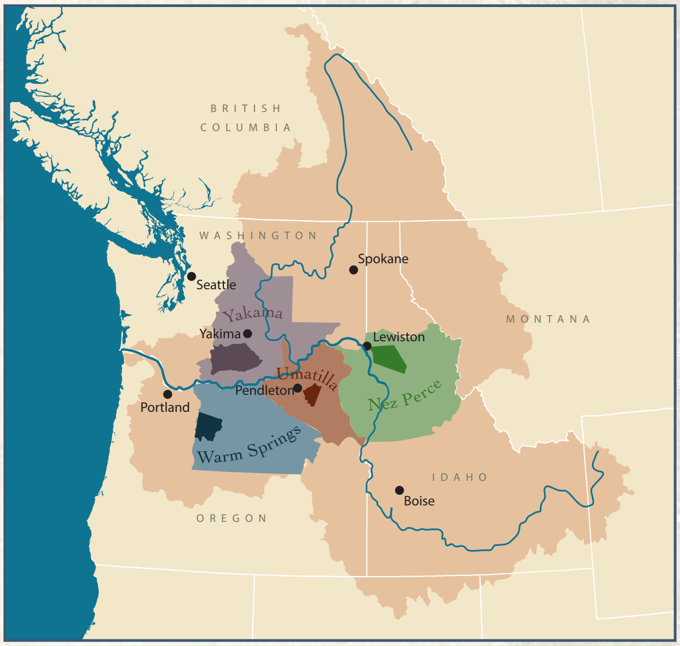

FIGURE 1. The Columbia River basin with reservations (dark shade) and ceded lands (lighter shade) of the four CRITFC member tribes.

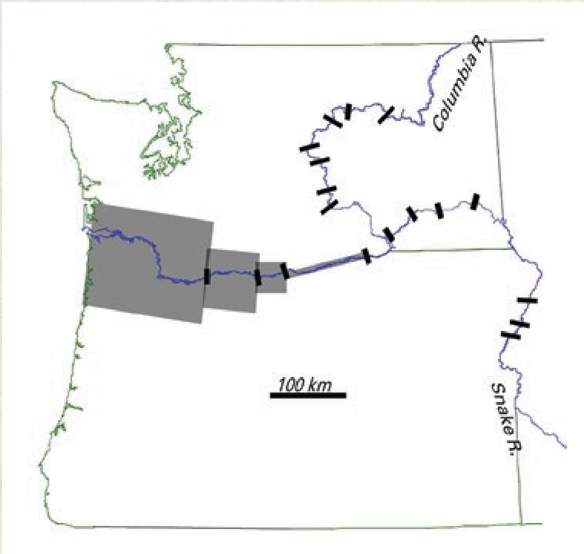

FIGURE 2. Only a fraction of adult lamprey that approach each dam (shown in gray bars) are able to make it over, resulting in a much-reduced population upstream from the dams.

news stories, and we are happy to see annual gatherings where our traditional ecological knowledge and contemporary sciences come together as equals. The region has learned much about the lamprey life history, their genetics, population status, and their needs. The future seems a little brighter than before, and the Tribes are hopeful the region will take better care of our lamprey so they can once again provide a reciprocal relationship with our people.

Yet, the tribes remain frustrated that sufficient and sustained resources are not immediately being made available for lamprey recovery. Passage through the Columbia, Snake, and Willamette river dams is inadequate. The scale of the problem is depicted for the lower Columbia River dams in FIGURE 2, which shows that only a fraction of adult lamprey that approach each dam (shown in gray bars) are able to make it over, resulting in a much-reduced population upstream from the dams (based on radiotelemetry data, Keefer et al. 2020). Regional partners refuse to provide a passage standard and progress toward passage over the dams is often, at best, too slow and incremental. In fact, there continues to be a need to discuss many of the same topics that were specifically identified nearly 15 years ago in the 2011 TPLRP. And, not only have tribal members lost essentially all harvest, the small number of lamprey that are harvested are now known to be contaminated with toxins. There are advisories to limit consumption of Pacific lamprey collected in the Columbia River and its tributaries (Oregon Health Advisory, 2022, Washington Health Advisory, 2023). The water is no longer clean. The Tribes are working to address water quality issues and increase water quality standards so that fish are not contaminated in the first place (*https://critfc.org/2022/10/05/lamprey-advisory/*).

> **“When the world was created, [the First Foods] said, I will give my body for the people that are going to be placed here after us. They gave themselves up so that we could live on this world.”**
>
> **— Wilson Wewa (CTWSRO)**

With this 2025 TPLRP the Tribes want accountability. Steady progress, measured within a well-defined adaptive management framework is needed for all aspects of lamprey recovery. This includes greater efficiency in planning and design, timely implementation of actions and a robust, effective research, monitoring and adaptive management process. Accountability will require annual reporting of progress, both

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technical and policy focused, that speaks toward our developments and future priorities. Accountability will also require the resources we need to achieve measurable progress. Funding levels for mainstem and tributary actions must immediately be significantly increased and be reliable over longer time periods. A long-term dependable funding source and appropriate staffing will be needed to accomplish this adaptive management process.

In the Columbia River basin (CRB), the lamprey suffers from multiple, complex factors limiting their populations, yet it is abundantly clear that the Columbia, Snake, and Willamette river dams are the greatest limiting factor. The abrupt and rapid decline of Pacific lamprey is evident not only from recent dam counts, but from the many stories our elders have shared. From these stories we know lamprey were very abundant throughout much of the CRB rivers and there were countless places from which tribal members could fish for lamprey. But now most of our harvest locations have been significantly modified or destroyed, and there are either no, or insufficient numbers of lamprey to catch in many traditional harvest locations.

> **"Spiritually, [the lamprey is] one of us."**
>
> **— Elmer Crow Jr. (NPT)**

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All the limiting factors discussed in this document are important and they all contribute to the lampreys' decline, but the Tribes believe that the development of the Federal Columbia River Power System (FCRPS), and the installation of myriad other dams is primarily responsible.

These, and the many developments sanctioned by the federal, state, and local governments have harmed the Tribes' most fundamental treaty reserved right — ***to take fish in all of our usual and accustomed places*** (Bernholz and Weiner 2008). Now when tribal members fish for eels, they travel a long distance — primarily to one last location: Willamette Falls. Even here, abundance varies considerably from year to year. Furthermore, despite the high dependence on Willamette Falls for harvest needs, the Willamette subbasin has its own set of impassible dam barriers, few of which have been addressed to remedy the extirpation of Pacific lamprey.

There are many technical nuances as to why the lamprey disappeared and who caused what. The main fact is that adult passage upstream is poor and juveniles passing downstream can die for trying. For example, based on conversion rates (upstream passage success from one dam to the next) from the late 1990s to present, for every 20,000 adults that approach BON (**FIGURE 2**), about half will be blocked and unable to move upstream. Approximately only 1,200 (6%) of the run will make it to the confluence with the Snake River. Of the few moving up the Snake River (< 500), less than 100 get past Lower Granite Dam (LGR) and reach the productive lamprey habitats in the upper tributary streams. And even fewer adults (< 50) move past Wells Dam (WEL) in the upper Columbia River and reach the productive lamprey habitats in the Methow and Okanogan subbasins.

In other words, the average daytime passage over BON continues to be a small fraction of historic daytime passage runs. Only about 15% of the lamprey that approach BON make it to the Warm Springs Reservation. Only about 10% and 3% of the run reaches much of the Umatilla and Yakama reservations, respectively. Passage to the Nez Perce and Umatilla territories of the Snake River and north end of the Yakama treaty territories is typically less than 1% of the run; the average percentage passing lower Yakima River at Prosser Dam (an important historical harvest site) has averaged around 0.3%. Adult day time counts at LGR (Snake River) are sometimes less than 100 fish, and total counts at WEL (Upper Columbia River) were < 10 fish for eight of the nine years between 2008–2016 (and zero fish in 2015).

We understand that some of these lamprey move into the tributaries away from the mainstem, but not in large quantities (and certainly not enough to harvest). **Yes, we can quibble with the numbers, but the overall story remains the same.**

Adult historical counts at BON only go back to 1938 (less than a 100-year time span) when we should be evaluating the population at a much longer time scale. Our scope is severely limited. It begs the questions, "What were the numbers like in the 1800s before anthropogenic channel spanning dams existed? In the early 1500s (only several years after Christopher Columbus arrived in the Americas)? What about several thousand years ago?" Unfortunately, we do not have those answers. But our traditional knowledge, imbedded and reflected within this 2025 TPLRP will always guide us toward these needed actions:

- **Fix passage at all dams.** Adult passage throughout the CRB must significantly increase. In the short-term, the highest priority is in the lower Columbia River and Willamette Falls. Actions must be implemented to provide passage for the ~50% of the migrating adults that are "lost" (unaccounted for) and do not pass the BON and ~20% of the migrating adults that are "lost" in its reservoir. Passage through this location must be corrected before the Columbia Basin will begin seeing significant improvements in lamprey populations. Passage standards are needed for both adults and juvenile lamprey that are commensurate with salmonid passage (i.e., > 95% passage rates). Protective measures for downstream-migrating larvae and juveniles are needed, to prevent entrainment, impingement and death.
- **Unimpeded access to high quality water and habitats** must be available throughout the CRB so that lamprey can be sustained and thrive in our tributary streams. Specifically, passage issues within the tributaries must be corrected (including irrigation diversions and culverts). Acceleration of lamprey habitat restoration and protection is needed (in-channel margins, side channels, and floodplains). This will benefit everyone and all things.
- **Our oceans** are growing sick with persistent over-harvest of fishes that are host species for Pacific lamprey. Many uncertainties regarding the ocean ecology of Pacific lamprey remain, but lamprey as well as the disappearing large-bodied hosts are important to the ocean ecosystem, and we must protect them.
- **Predation** from birds, mammals (e.g., sea lions), northern pikeminnow, and non-native species in environments that are heavily manipulated (e.g., dam tailraces and forebays) must be rigorously controlled. All restoration is greatly diminished if unnatural levels of predation persist.
- **Water quality must be significantly improved and toxins eliminated.** The Tribes want to drink the clean water from our rivers and eat Pacific lamprey again without restrictions, as provided by our Creator.
- **Water quantity and flows within the tributary streams** must be better managed to protect and restore not only lamprey but the entire ecosystem. Everything depends upon the water. Ecosystems and fishes within them need to be considered important stakeholders for water allocation and distribution.
- **Translocation of adults and propagation of early life stages** must be expanded to re-establish populations that are severely impacted or extirpated. The Tribes will continue this practice until it is no longer needed, and we look forward to that day.
- **Climate change** threatens to overshadow much of what we need to accomplish. All our planning and future work must account for this. We must build long-term resilience in all that we do.

- **Our work can only be successful if we have greater public support.** Outreach and education programs must be expanded and occur for a variety of audiences and communities. Every agency and organization must participate and carry out a common, hopeful and urgent message of the importance of Pacific lamprey to the Tribes and our ecosystems.
- The region must **adopt and use an adaptive management process** to better track progress and accountability for all of our partners. This includes improved research and monitoring to support development of both a life-cycle model and a status and trend annual report. Both of these tools will greatly improve annual decision making.
- **Improvements in all of these areas, and others will require additional resources;** we need greater levels of funding and more staff working in these directions. This need is long overdue and cannot be overstated.
- **Healthy lamprey populations** belong in every watershed they once existed before the dams. **Make it like it was.**

Accountability, annual reporting and the rigorous use of adaptive management is central to our continued learning and our progress toward the goals and objectives found within this 2025 Tribal Pacific Lamprey Restoration Plan. We must all be clear about the urgency to act and be determined to obtain the funding needed to be successful.

Tribal wisdom teaches that we, the living, are only borrowing the earth from our future children. It is our obligation to the Creator and to our future children that we protect all creatures on Earth and leave our rivers and homelands better than we found them. This is our challenge. This is our promise, through thousands of generations, to our children and to their children.

Today, we have many challenges in front of us and there are many uncertainties regarding how best to proceed. However, we continue to learn that together we can accomplish common goals.

Tribes have a history since time immemorial that links lamprey to the people. Lamprey are our food and our medicine. They need to live in clean water. We need to live in a clean environment. We will continue to value and use lamprey. They are important, especially to our children.

"The right to resort to…fishing places…was a part of larger rights possessed by the Indians upon exercise of which there was not a shadow of impediment and which were not much less necessary to the existence of the Indians than the atmosphere that they breathed…"

United States v. Winans 198 U.S. 371,381 (1905).

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FIGURE 3. James Williams (Nez Perce) dipnetting Pacific lamprey in the Clearwater River near Spalding, Idaho, circa 1920.

"The lamprey is our elder; without him the circle of life is broken."

— The late Elmer Crow Jr., Vice Chair, Nez Perce Fish and Wildlife Committee

A member of the Yakama tribe harvests lamprey at the Willamette Falls.

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1 2011 TPLRP

SUMMARY Section 1 introduces the **2011 Tribal Pacific Lamprey Restoration Plan (2011 TPLRP)** and its authors: which include the **Nez Perce (NPT)**, the **Umatilla (CTUIR)**, the **Yakama (YN)**, the **Warm Springs (CTWSRO)** and the **Columbia River Inter-Tribal Fish Commission (CRITFC)**. It provides a brief history of the abrupt decline of Pacific lamprey and the tribal response in developing the 2011 TPLRP. The 2011 Vision, Goal, Numeric Goal, and Objectives are provided. The document is a **Call for Action!**

In 2011, the Columbia River treaty tribes (Tribes) completed the Tribal Pacific Lamprey Restoration Plan (2011 TPLRP) for the CRB. The 2011 TPLRP was the first comprehensive restoration guide for Pacific lamprey *(Entosphenus tridentatus)* and contained a vision, goals and objectives, cultural context, lamprey life history, abundance/status, critical uncertainties/limiting factors, and prioritized actions needed for recovery. The Tribes, which include the Nez Perce Tribe (NPT), the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), the Confederated Tribes and Bands of the Yakama Nation (YN) and the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO) believed that aggressive actions were needed immediately, despite information gaps regarding Pacific lamprey life history and population dynamics.

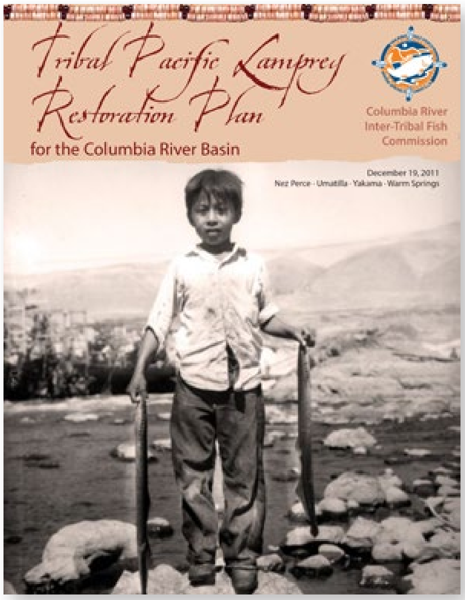

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FIGURE 4. Cover of the 2011 Tribal Pacific Lamprey Restoration Plan.


Courtesy of CRITFC

CRITFC Pacific lamprey outreach event at the Bonneville Hatchery Captive Brood Building.

The goals of the 2011 TPLRP were to immediately halt the decline of Pacific lamprey and ultimately restore this culturally important species throughout its historic range in numbers that provide for ecological integrity and sustainable tribal harvest.

The completion of the 2011 TPLRP coincided with a culmination of a series of events and efforts occurring within the previous decade (1999–2010). Pacific lamprey abundance and distribution in the Columbia River and throughout the Pacific Northwest was declining precipitously. To the Tribes, the decline of Pacific lamprey, one of Columbia River's most ancient and foundational species, was jeopardizing the cultural and ecological balance in the basin (Lampman and Luke 2016). Importantly, the Tribes were also concerned about declining adult returns to their traditional harvest locations (Close et al. 2004, Goudy and Lampman 2018). Historically, Pacific lamprey were plentiful in many tribal lands including the Umatilla River, Walla Walla River, Asotin Creek, Clearwater River tributaries, the South Fork of the Salmon River, Swan Falls, the Methow, Wenatchee and Yakima rivers, the Klickitat, Deschutes and Willamette rivers and most of the tributary streams throughout the Columbia River.

Pacific lamprey (referred to as "eels" by many tribal members) are just as important to tribal peoples as salmon. For over 10,000 years the Nez Perce, Umatilla, Yakama, and Warm Springs people depended on plant and animal species, including lamprey, salmon, elk, deer, roots, and berries. The tribal people used lamprey for food and medicine, and many stories and legends surrounding them were passed down from generation to generation. Tribal elders still remember that before the construction of The Dalles Dam (TDA) in 1957, the Columbia River at Celilo Falls was often "black with eels."

In the late 1990s, due to the dramatic decline in adult returns, the Tribes began sounding the alarm, which resulted in the U.S. Army Corps of Engineers (USACE) reinstating annual adult lamprey counts at BON and other mainstem Columbia River dams. The updated lamprey

In our tribal languages, Pacific lamprey are called ***ksúyas, hésu*** or ***asúm***. Elders sometimes still refer to them as "eels."

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counts at BON indicated that returns had declined from an estimated 1,000,000+ in the 1960s and 1970s to less than 20,000 in the early 2000s. At this point, the plight of the Pacific lamprey had garnered some regional attention but limited effective action. The tribal community was justifiably concerned and, in many cases, deeply frustrated.

In 1999, the CTUIR developed a lamprey restoration plan and began implementation of Pacific lamprey monitoring and restoration efforts (e.g., adult translocation). In 2004 and 2008 the treaty tribes organized two Lamprey Summits to sound the alarm and establish a call to action to facilitate the restoration and conservation of Pacific lamprey within the CRB. Action was needed to maintain the cultural and ecological integrity of the basin. At Lamprey Summit II (2008), the Tribes presented their initial vision of Pacific lamprey restoration within the Columbia River which provided the framework for 2011 TPLRP.

The 2011 Tribal Pacific Lamprey Restoration Plan is a call to action.

The rapid declines in lamprey populations challenge resource managers to accelerate coordination and collaboration, both in terms of establishing priorities and in acquiring necessary funding. While regional initiatives (e.g., U.S. Fish and Wildlife Service Pacific Lamprey Conservation Initiative) were being developed and adopted, substantive actions (based on current knowledge) required immediate implementation to prevent the impending loss of Pacific lamprey across its remaining range within the basin.

The 2011 TPLRP was a collaborative effort between the Columbia River Inter-Tribal Fish Commission (CRITFC) and its four member tribes. It addressed lamprey issues at the basin-scale, but generally focused on the mainstem Columbia, Snake, and Willamette rivers and the issues affecting lamprey within these locations. Included in the 2011 TPLRP were Tribal Ceded Area Action Plans, designed to (1) summarize immediately needed lamprey actions proposed by the Tribes and (2) link these tribal lamprey projects in the tributaries with needed mainstem actions.

In 2011, the TPLRP vision and goals were stated in Section 2, and the objectives (Section 4) were identified and associated with various types of actions. These are stated below:

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2011 Vision

Pacific lamprey are widely distributed within the CRB in numbers that fully provide for ecological, tribal cultural, and harvest values.

2011 Goal

Immediately halt population declines and prevent additional extirpation in tributaries. Re-establish 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 places.

Numeric Goals for CRB

- **2012** — Halt decline.
- **2020** — 200,000 adults (based on 2002–2003 Bonneville Dam counts).
- **2035** — 1,000,000 adults (from 1950s–1960s Bonneville Dam counts).
- **2050** — Restore lamprey to sustainable, harvestable levels throughout their historic range.

The Goals of 2011 TPLRP led to specific 2011 Objectives. These objectives provided an explicit and timely path to address critical uncertainties, threats and limiting factors while implementing specific restoration actions that could be completed immediately and in the foreseeable future for the mainstem Columbia, Snake, and Willamette rivers and tributaries.

2011 Objectives

- Improve lamprey mainstem passage, survival, and habitat.
- Improve tributary passage and identify, protect, and restore tributary habitat.
- Supplementing/augmenting interior lamprey populations by reintroduction and translocation of adults and juveniles into areas where they are severely depressed or extirpated.
- Evaluate and reduce contaminant accumulation and improve water quality for lamprey in all life stages.
- Establish and implement a coordinated regional lamprey outreach and education program within the region.

As concluded in the 2011 TPLRP and remains true today:

> **"While the Plan's timeline focuses on the next seven years, actions must be taken immediately. As one tribal fisheries manager put it, *'For some of us, our seven years was up ten years ago'.* The tribes strongly encourage the region to collaboratively engage in further development and implementation of the Tribal Pacific Lamprey Restoration Plan for the CRB."**

Now is the time to take action!

Lamprey harvest at Willamette Falls.

Courtesy of CTWSRO, Alyssa Macy / CC BY-NC-ND 2.0

2025 TPLRP: Vision, Goals, Objectives and Principles

2

SUMMARY Section 2 introduces the 2025 Vision, Goals, Numeric Goals, Objectives and Principles based on the significant learning that has occurred since 2011. Eight Principles that guide the tribal development of the 2025 TPLRP are described, each originally discussed in ***Wy-Kan-Ush-Mi Wa-Kish-Wit***. Section 2 concludes with the integration of many elements of this 2025 TPLRP into a narrative about why this plan is needed and why all the Actions described herein are necessary for the restoration of our rivers and Pacific lamprey.

Lamprey populations remain very low or are extirpated in many upper watersheds. Due to passage barriers, many healthy habitats are not populated — or near what we consider lamprey "carrying capacity." Additionally, our people have become aware of another great issue: the contamination of our lamprey by PCBs, mercury and other toxins which they are exposed to throughout their life history (freshwater and ocean phases). The water is no longer clean. Once mercury and PCBs get into the water, they get consumed by bacteria, insects, and other small organisms that fish eat. When fish eat these organisms, the contaminants are absorbed into the fish's flesh and fat rather than passing out of the fish as waste. Over time, the

> **"We must all work together to make limiting consumption a temporary solution because the tribes believe that the long-term solution to this problem isn't keeping people from eating contaminated fish — it's keeping fish from being contaminated in the first place."**
>
> **— Aja DeCoteau**
> Executive Director, CRITFC

amount builds up to toxic levels. The bigger and older a fish is, the more likely it is to have eaten lots of smaller, contaminated organisms. Since lamprey feed off those larger and older fish, they are exposed to a much higher concentration of contaminants.

Yes, we may have a few more lamprey to harvest now than were present in 2011, but due to contaminants, and consumption advisories in the CRB, they should not be consumed in traditional quantities by all members of the community (CRITFC Lamprey Consumption Advisory, 2022; https://critfc.org/2022/10/05/lamprey-advisory/; Oregon Health Advisory, 2022; Washington Health Advisory 2023).

Because of the changes we have seen, we have updated our 2025 Tribal Pacific Lamprey Restoration Plan (TPLRP) vision, goals, and objectives. We invite you to look closely at the entirety of this 2025 TPLRP and ***act with the urgency*** that this situation requires. These pages will reflect our continued interest and our obligation to the Creator to protect and restore lamprey populations and their habitats. We all share this obligation to our Creator and to our future children.

Courtesy of CRITFC / Jeremy FiveCrows

2.1
2025 TPLRP Vision

Pacific lamprey are widely distributed in the Columbia River basin and throughout their entire range in healthy, self-sustaining, harvestable numbers that fully provide for tribal traditional, cultural, ceremonial, and spiritual uses. Lamprey are safe for consumption in large quantities by all members of the community and provide important ecological services to habitats where they reside for the entirety of their lifecycle.

2.2
2025 TPLRP Goals

- **Regional efforts to restore Pacific lamprey populations** throughout the CRB will increase immediately and adult returns throughout the region will expand quickly allowing for greater ecological contributions and substantially greater tribal harvest in treaty territories as well as usual and accustomed places.
- **Pacific lamprey are provided with at least the same level of recognition, appreciation, and respect** experienced by Endangered Species Act (ESA)-listed species.
- **Strategies that rely on long-term natural production** and healthy, diverse, and clean river systems are emphasized so that harvest is widely available and consumption is safe for all tribal members.
- **Protect tribal sovereignty and treaty rights** related to Pacific lamprey harvest and traditional, cultural, ceremonial, and spiritual use.
- **Understanding by all people** of the cultural, spiritual, ecological, and economic value that lamprey provide is strongly supported.

2.2.1 Numeric Goals

- **2035** — 1 million adults passing Bonneville Dam (from 1950s–1960s counts) and 1 million adults passing Willamette Falls.
- **2050** — Restore adult lamprey populations so that they can be harvested sustainably in as many historical locations locally and consumed safely in quantities historically available.

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2.3 2025 TPLRP Objectives

- **Mainstem Passage and Habitat:** Fix passage, survival, and habitat for Pacific lamprey in the mainstem Columbia, Snake, and Willamette rivers.
- **Tributary Passage and Habitat:** Fix passage problems and protect/restore important habitats in tributaries including the Willamette Valley System.
- **Oceans:** Ensure that Pacific lamprey and their hosts are protected in the estuary and ocean and improve water quality and reduce (eliminate) contaminants.
- **Predation:** Monitor, evaluate, and control excessive bird, fish, and mammal predation.
- **Water Quantity, Quality and Contaminants:** Evaluate and significantly reduce (eliminate) contaminant accumulation and improve water quality and quantity for all lamprey life stages.
- **Supplementation:** Supplement Pacific lamprey populations by using adult translocation and reintroduction of all life stages into areas where they have severely declined or are extirpated.
- **Climate Change:** Implement appropriate mitigation, resilience, and adaptation actions to protect lamprey populations and their environments during climate change.
- **Outreach and Education:** Conduct Pacific lamprey outreach and education by coordinating with public and private institutions and using a variety of forms to reach all age groups of tribal and non-tribal people.
- **Effective Population Size and Structure:** Ensure that the distribution, total abundance, and effective numbers of spawners of Pacific lamprey in the CRB population continues to grow to levels that are self-sustaining and can support tribal harvest and ecological contributions.
- **Research, Monitoring, and Adaptive Management:** Develop and implement regional Research, Monitoring, and Adaptive Management to (1) inform tribal and regional policy about priority actions and (2) accelerate our ability to implement important actions that will return lamprey populations to historic abundance and distribution.

2.4 Principles

The following principles from ***Wy-Kan-Ush-Mi Wa-Kish-Wit*** (CRITFC, 2014) expand on the 2011 descriptions of our vision, goals, and objectives, reflecting a deeper understanding of our traditions and how they can be adapted to address changing circumstances.

HONOR TRIBAL CULTURE AND VALUES

Since time immemorial, the Pacific lamprey have faithfully returned to the river to provide for human and other needs. In turn, we honor and protect them. For Native cultures in the CRB, the continuation of human life depends on the return of Pacific lamprey. The interdependence of Pacific lamprey and the people is a foremost example of what traditional Native thinkers call the connectedness, or connection of all life. This connectedness, such as with the lamprey, is also the ***reciprocity*** between the people and our resources which is central to our relationship with our Creator.

In the basin's Native cultures, water and food were never taken for granted. Tribal society recognized that the earth's water and food are always matters of survival and spiritual nourishment. This knowledge is at the foundation of the Tribes' recommendations for the 2025 TPLRP; the human dimensions of Pacific lamprey, in addition to abundance and distribution, must be restored.

FULFILL TRIBAL SOVEREIGNTY, TREATY RIGHTS AND TRUST RESPONSIBILITY

The Tribes co-manage fish resources pursuant to their inherent sovereignty and their 1855 treaty rights as interpreted by federal court decisions, including *U.S. v. Oregon* and *U.S. v. Washington*. The Plan establishes a foundation for the United States government and its citizens to honor their treaty and trust responsibilities to the four Tribes. Returning fish to the Tribes' treaty territories and usual and accustomed fishing places as guaranteed in the 1855 treaties would begin to meet the ceremonial, subsistence, and commercial needs of tribal

Dancers performing the Eel Dance at the grand opening of the Pacific lamprey exhibit at the Oregon Zoo in 2019.

members. In addition, meeting these obligations benefits the non-Indian public via the unique ecological services that lamprey provides and the attainment of healthier, more natural river systems.

INTEGRATE THE BEST SCIENCE WITH TRADITIONAL ECOLOGICAL KNOWLEDGE

An integrated approach provides a range of tools to understand and evaluate efforts to protect and restore the CRB's natural resources, particularly its riverine resources. The Umatilla River Vision (Jones et al. 2011) is an excellent example of blending Western science and traditional ecological knowledge. It supports the natural production and use of salmon and other fishes by tribal members while describing the attributes of an ecologically functional river system in terms of hydrology, geomorphology, habitat connectivity, riparian vegetation, and aquatic biota.

RESTORE ECOSYSTEMS THAT ARE HOLISTIC, SUSTAINABLE, AND RESILIENT

Tribal cultures have coexisted with both anadromous fishes (e.g., Pacific lamprey, sturgeon, salmon, and steelhead) and resident species for millennia. In the last 200 years, population growth, economic development, species introductions, and climate change have disrupted the formerly balanced systems. Climate change will exacerbate and accelerate change in unexpected ways. Maintaining and restoring lamprey, salmonid, and sturgeon populations under these conditions require management practices and tools that: (1) are broadly multidisciplinary, (2) account for social and ecological influences at multiple temporal and spatial scales, (3) protect biodiversity, functional processes, and interrelationships that sustain ecosystems, (4) incorporate continuous change, (5) allow for uncertainty, and (6) avoid thresholds that will tip ecosystems into a state unfavorable to anadromous fishes.

PUT FISH BACK IN THE RIVERS

The Tribes' long-standing commitment to re-establishing wild fish runs is based on traditional values. To achieve this central goal, the 2025 TPLRP includes a propagation strategy the Tribes call supplementation. Rather than perpetuating the dominant hatchery rearing and release paradigm (which focuses on hatchery returns for harvest), supplementation uses hatchery technology to rebuild naturally spawning fish stocks while also providing harvest. Supplementation is essential because, in so many situations, remedial actions needed are not being implemented. The remedial actions that are occurring, unfortunately, cannot be implemented quickly enough, or on a scale that is large enough to halt long-term population losses.

PROTECT WATERSHEDS WHERE FISH LIVE NOW AND HISTORICALLY

To support anadromous fishes, CRB riverine and aquatic habitats must be returned to natural conditions closer to those that existed prior to dam construction, irrigation withdrawals, forest clearcuts, cattle grazing, metal mining, urbanization, and other consumptive uses. Salmon and lamprey need connected migratory habitat that supports biological function throughout their life cycle, not just fragments of good habitat here and there. The Plan describes how the basin's watersheds can be protected and how degraded areas can be rehabilitated, including the use of lamprey translocation and supplementation. To return the basin to health and productivity, the Tribes seek to engage their watershed neighbors in local as well as regional collaborative efforts.

Photo by Raymond Matheny / Courtesy of CRITFC

Celilo Falls before the dams, ca. 1952.

Before The Dalles Dam, harvest at Celilo Falls was abundant and sustainable. Now it is not.

MANAGE GRAVEL-TO-GRAVEL

Technical recommendations are aimed at increasing survival at each stage of the anadromous life cycle from spawning gravel to spawning gravel—from eggs hatching in the streambed gravel to juveniles/larvae migrating downstream through dams and reservoirs to saltwater homes where they feed and grow to adult fish that return to spawn in freshwater gravel, renewing the cycle.

USE ADAPTIVE MANAGEMENT

Adaptive management principles allow resource managers to take immediate on-the-ground actions to reverse anadromous fish decline even in the face of scientific uncertainty. The Tribes' technical recommendations are designed as testable hypotheses: they define problems, propose remedial actions, set objectives, and describe means to evaluate the actions. Using the adaptive management framework described in this document, restoration actions will be measured for success and can be modified as indicated by scientific evaluation.

2.5 The Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin

The 2025 TPLRP has very similar vision and goals that were presented in the 2011 TPLRP. As more has been learned, Objectives have been added or modified. Our Principles remain the same and are now clearly stated. The Tribes note the widening gap between current Pacific lamprey status and our 2011 Goals: ***our lack of progress***. The region must answer: ***For how many years will we continue this environmental degradation and for how many generations will we prevent the tribal members from harvesting their traditional foods?*** The Tribes are determined to restore lamprey populations and their habitats back to the abundance and health that our Creator provided for us. With this document, we describe how our vision and goals for Pacific lamprey will be realized.

Currently, restoration is not proceeding at the necessary rate; this can, and must change. What is needed foremost is an immediate commitment by the regional "players" to fully engage and participate. Restoration of our natural resources is not a spectator sport; it is not another meeting one must occasionally go to. ***Restoration requires immediate and long-term support for research, actions, monitoring, and funding***.

It will also require (1) immediate implementation of a regional adaptive management process to support accountability, and (2) use of our expanding knowledge and guidance for future decisions.

Pacific lamprey restoration will benefit environmental quality in multiple habitat types for multiple species and will help build resilience during climate change. These are benefits for all people. It is also important for us to realize that significant participation and greatly increased and sustained resources are required before progress toward Tribal goals will be realized.

The 2025 TPLRP provides information on both Pacific lamprey and their role in tribal cultures:

- **Background information** (**SECTION 3**) and context about the Tribes and our values so that the reader can better understand and more fully appreciate the necessity, complexity, and difficulty in restoring Pacific lamprey.
- **Regional Progress** made since the 2011 TPLRP (**SECTION 4**) toward Pacific lamprey restoration. Many actions discussed within this document can now be taken with confidence because we know more about their contribution toward restoration.
- **Actions** are identified (**SECTION 5**) that are required to address key limiting factors and restore Pacific lamprey populations. Critical uncertainties are addressed with specific research and monitoring needs, in addition to a framework for Adaptive Management to better understand the effects of our actions and to track progress. Additional and more detailed information about actions, and many other interesting aspects about Pacific lamprey are also found in **SECTION 6** (Appendix).

Appropriately addressing each of the limiting factors is critical for Pacific lamprey restoration. However, the Tribes view the dams on the lower Columbia River, Snake River, and Willamette subbasin as the greatest near-term impediment toward achieving our goals (see **FIGURE 2**). As such, the Tribes advocate for substantially greater resources, including capacity and staffing within multiple agencies to accelerate work to improve lamprey passage at dams.

Because such a large number of adult Pacific lamprey are unable to pass the lower river (BON and reservoir, particularly, and excessive predation below all mainstem dams) we strongly advocate for the USACE to mitigate these losses by working with the Tribes to develop and implement the tribal "Lamprey Emergency Assisted Passage Program" (LEAPP) in areas where needed. The impetus behind LEAPP is based on the realization that the current level of adult translocation as well as improvement in passage (even when combined together) is

The lack of lamprey in our river systems is an environmental degradation and the lack of tribal harvest of toxin-free Pacific lamprey in all of our usual and accustomed places is an ongoing degradation of treaty trust, treaty reserved rights, and our unique cultures. Tribal members, and especially the children are losing important parts of our culture and our connections. This loss cannot continue.

still nowhere near approaching the passage rates achieved by anadromous salmonids (i.e. > 95%) and drastic changes are required to achieve these levels of connectivity. Instead of translocating 3–5% of the adult lamprey population that approach BON, we need to find ways to provide passage for ten times this number (30–50% of the adults that are currently turning around at BON each year). LEAPP should also be evaluated at Willamette Falls and implemented, as appropriate, to increase productivity in the upper Willamette subbasin. While most LEAPP lamprey will be released above the dams in the mainstem environment, others may be translocated into different productive tributary environments throughout the Columbia, Willamette, and Snake river areas, particularly in Tribal treaty territories, as a temporary measure to help re-populate these streams with larval lamprey.

Additionally, the Tribes recognize and promote a very important notion that must be regionally acknowledged: as habitat restoration continues for the Regional Management Units (RMUs) throughout the CRB, it is essential to maintain Pacific lamprey larval populations at high densities (if not at carrying capacity). These larvae emit pheromones that attract migrating adults into healthy watersheds for spawning and production. At this time, the Tribes do not believe that the pheromone signal is at the level it should be, and that there are not enough migrating adults able to reach key watersheds upriver due to poor passage at the mainstem Columbia,

Example: Contribution of Supplementation to Natural Production of Pacific Lamprey over Time

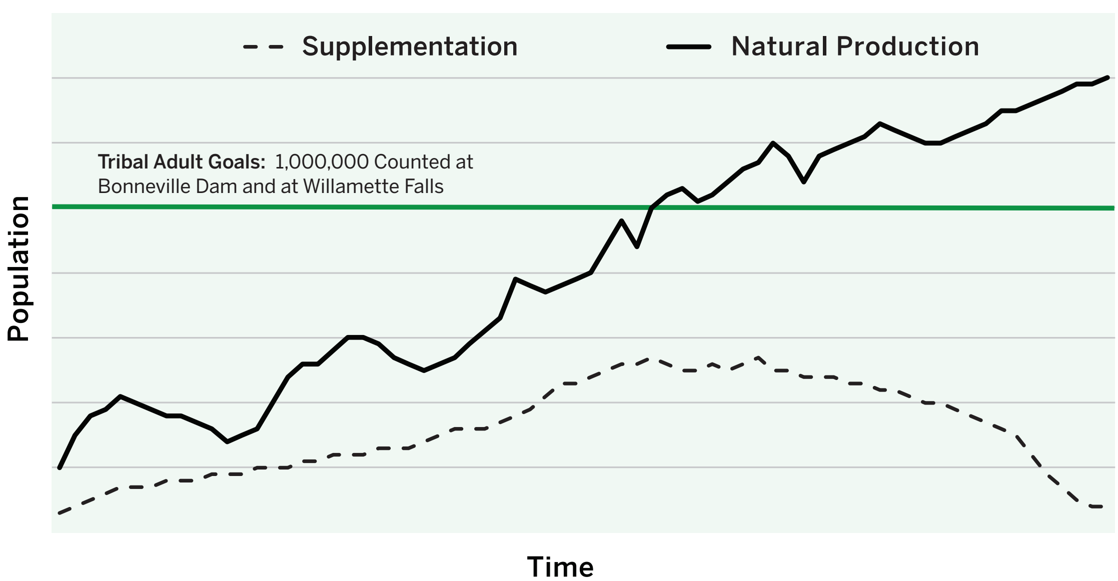


FIGURE 5. Hypothetical illustration of near- and long-term use of adult and larval supplementation practices to repopulate watersheds within the Columbia River basin.

Snake, and Willamette river dams. This is why the adult translocation and larval production programs (and their future expansion) are fundamental to Pacific lamprey restoration.

As clearly stated here and reiterated in other places within this document, the Tribes view this supplementation program as an interim stop-gap measure. Yes, we intend to expand the current program, in both lamprey numbers supplemented and in geographic distribution (see Tribal Supplementation Master Plan). However, once our goals are met and sustained through natural production of lamprey along with significant improvement in volitional passage, these interim supplementation programs will be eased and eventually terminated. **FIGURE 5** illustrates this concept by showing the planned increase in supplementation in the next 20+ years until natural production becomes established, remains stable and eventually reaches our goal for abundance and genetic health.

Furthermore, the Tribes recognize that certain projects require more time to mature and become useful to lamprey. Some projects, such as passage structures over dams, may require only a few years to become fully functional. However, it is common for certain aspects of habitat restoration (e.g., revegetation, stream connectiveness to its floodplain, pool-riffle ratios) to mature after several decades. To accomplish reasonable progress and achieve our goals within "the foreseeable future" implementing actions must be accelerated today.

Finally, we conclude with **SECTION 5.10**, the development and use of Research, Monitoring and Adaptive Management, to (1) guide our future priorities and actions and (2) track accountability. This will also guide us in the development of regionally acknowledged abundance based goals and the implementation of passage standards at mainstem and tributary dams. Going forward, this is an important interest for the Tribes. Rigorous application of adaptive management will be the impetus for greater regional contributions to Pacific lamprey restoration.

Courtesy of USFWS, John Heil / Public Domain

We support the principles of adaptive management outlined by the NPCC and recognize their attention in the development of this process through their NPCC Program Goals, Objective and Strategies (NPCC 2014, Theme Two, Goal 1; Objective j; Strategy k) and the involvement of the Independent Scientific Review Panel (e.g., Memorandum 2017-13, ISRP 2017). The principles outlined in the NPCC Program will be important to incorporate as we develop and employ this regional process.


Warm Springs tribal members harvest lamprey at Willamette Falls.

Courtesy of CTWSRO, Alyssa Macy / CC BY-NC-ND 2.0

3 Background

SUMMARY Section 3 provides brief, but important background information associated with the cultural significance of lamprey to the Tribes, the legal backdrop of treaty rights and harvest, and the value of using traditional ecological knowledge in our work. It also provides an institutional and regulatory context and concludes by defining "threats" which include the primary limiting factors and critical uncertainties.

CRITFC and its member tribes — Nez Perce, Umatilla, Warm Springs, and Yakama — understand and emphasize that Pacific lamprey are an important part of the ecosystem. Lamprey provides ecosystem services and contributes to food web dynamics; they act as a predator buffer for salmon, contribute important marine-derived nutrients to watersheds, recycle nutrients, and alter fine sediment habitat as burrowing larvae. The Tribes believe that lamprey are intrinsically important and linked to the ecological health of the CRB, as are sturgeon, salmon, steelhead, and all native aquatic species. The Tribes revere Pacific lamprey for their cultural, spiritual, ceremonial, medicinal, subsistence, and ecological values (Close et al. 1995, CRITFC 2011, CRITFC 2018). A limited understanding of the ecological and cultural importance of Pacific lamprey in the CRB has been made worse by unfortunate association with sea lamprey (*Petromyzon marinus*) which have invaded the Great Lakes to the detriment of that ecosystem. As a result, our lamprey have unfairly suffered from a negative image among non-tribal peoples. However, due to ongoing collaborative education and outreach efforts in the CRB (e.g., CRITFC and tribal outreach and education, Pacific Lamprey Conservation Initiative (PLCI), Lamprey Communication Committee, the Oregon Zoo, and the USACE visitor center exhibits, etc.) there is increasing public exposure to Pacific lamprey and recognition of their significance.

More specifically, the importance of a comprehensive understanding of the relationship between balanced environmental function and healthy lamprey populations cannot be overstated. Like the beaver or the salmon, lamprey are essential — a keystone species as well as an ecological engineer (Shirakawa et al. 2012, Boeker and Geist 2016), and perhaps the first species to have ever provided all four ecological service categories outlined by the Millennium Ecosystem Assessment (MEA, 2005) study (Provisioning, Supporting, Regulating and Cultural services; *https://www.millenniumassessment.org/en/index.htm*). In Japan, lamprey species are considered important "index species" as they require a diverse array of habitat to successfully complete their life cycle, such as fine sediment slow water habitat for larvae, overwintering habitat with abundant interstitial spaces, and refuge for juveniles and adults, and shallow fast water upwelling spawning habitat (Hokkaido Fish Hatchery, 2007).

The tribes call on the entire region to better understand and document these ecological services over the coming years. There are likely many other 450-million-year-old secrets that lamprey may be hiding under their sleeves (fins).

3.1 Cultural Significance

Harvesting lamprey for ceremonial and subsistence use has been and is critically important to each of the CRITFC member tribes. In 1855, they relinquished millions of acres of CRB lands in treaties to the United States (**FIGURE 1**) but retained their rights to fish at "all of our *usual and accustomed places"* on both their reservations and ceded lands (CRITFC 2014).

Fishing rights are not limited to salmon and steelhead, but include lamprey, sturgeon, and many other species. The Tribes are resolute in their desire to restore healthy and abundant lamprey fisheries to all their usual and accustomed fishing places recognized by treaties with the United States. Since time immemorial, lamprey have been of great importance to most tribes throughout the Pacific Northwest (Close et al. 1995; Close et al. 2002, Close et al. 2004). The CRITFC member tribes traditionally harvested lamprey in many locations

Courtesy of CTWSRO, Alyssa Macy / CC BY-NC-ND 2.0

FIGURE 6. Tribal elders, youth and resource specialist participating in lamprey harvest below Willamette Falls.

throughout the mainstem Columbia, Snake, and Willamette rivers and their tributaries, but now are forced to travel extensively and harvest primarily at Willamette Falls (E. Crow, NPT. pers. comm. 2008).

From a tribal perspective, the recent drastic decline of lamprey has at least three important negative effects (Close et al. 2002; Close et al. 2009; E. Crow 2011 pers. comm.). These include:

- **Loss of lamprey from the ecological circle and the tribal way of life.**

  The Tribes consider the lamprey as their sacred elder and without them the circle of life is unbalanced.

- **Loss of cultural heritage, especially for young tribal members—many have never even seen a lamprey.**

  Many tribal youths have not learned how to harvest and prepare lamprey and are losing historically important legends associated with these fish.

- **Loss of fishing opportunities in traditional fishing areas.**

  Tribal members are forced to travel long distances to lower CRB tributaries, such as the Willamette Falls, due to severely limited lamprey harvest opportunities elsewhere.

To the Tribes, restoration of Pacific lamprey is as necessary to the restoration of the ecological health of the CRB and its tributaries as is salmon and other native fish populations. In the original Columbia River Tribes' Anadromous Fish Restoration Plan, ***Wy-Kan-Ush-Mi Wa-Kish-Wit*** (CRITFC 1995), the Tribes' objective is: *"to halt the declining trends in salmon, sturgeon and lamprey populations originating upstream of BON in seven years and to increase Pacific lamprey populations to naturally sustainable levels within 25 years to support tribal harvest opportunities."*

Courtesy of CTUIR

CTUIR tribal member Inez Spino-Reves, Twa'Wy, holding a lamprey prepared for drying, in 1998.

It has been 30 years since that original document was completed, and we are not there yet.

To better understand the cultural significance of Pacific lamprey we must also understand that lamprey are not just a fish to be harvested. They are considered an elder to the tribal members and are a part of our Creation Story. There is a reciprocal relationship between the lamprey and the people to take care of each other. Fishing for lamprey includes the travel to harvest sites and the retelling of various stories shared between the families. It includes the preparation of the food, for that time and later, for winter use. There are roles each of the family members perform and much is learned by our children. Lamprey are consumed sometimes at harvest locations or brought back to the longhouses and residential homes. Dried lamprey tails are used as pacifiers for teething babies and seven lamprey are typically served in traditional funerals, so they are used essentially "from cradle to the grave!" Lamprey harvest is all these things, and many more.

As illustrated in **FIGURE 7**, the butterflied filet for drying is an act of biocultural sovereignty at *Toptut* (Prosser, WA) and along *Nchi-Wana* (the Columbia River). This artwork and cultural practice is a symbol of cultural revitalization. It demonstrates that without harvest and ceremony, the life cycle of a lamprey is never complete. (Buck, 2024, co-creation was an iterative process among M. Buck (UW), R. Lampman (YN), M. Shibuya (Ocean Nexus), and M. Blanchard (WDFW/USFWS).

The loss of lamprey is a loss of culture. The extirpation of lamprey from an area greatly diminishes our culture and opportunities for cultural practices. The restoration of Pacific lamprey will contribute to the restoration of our culture. But, because of the long absence of lamprey from some areas, it is likely that part of our culture has been irreversibly impacted. Yes, this document calls upon the region to restore Pacific lamprey to their historic populations, but it also calls upon the region to help us protect and restore our traditional culture for youths, elders, and everyone in between.

3.2 Sovereignty, Treaties and Reserved Rights

Tribal sovereignty and formal government-to-government consultation are among the basic principles that guide this plan. Pacific lamprey are also foundational to the relationship between federally recognized Tribal Nations and the United States. They define certain aspects of the legal relationship between tribes, the US federal government, and the states.

Tribal people lived on this land, with these waters, for millennia — long before there was a United States of America. In signing treaties with the federal government, the tribes and bands that now compose the CTUIR, CTWSRO, YN and NPT retained their inherent authority to govern themselves. The Tribes' independent governments are sovereigns, autonomous and self-governing. Inherent in this sovereign authority is the power to make and enforce laws, administer justice, manage and control Indian reserved lands, exercise tribal rights, and protect tribal trust resources.

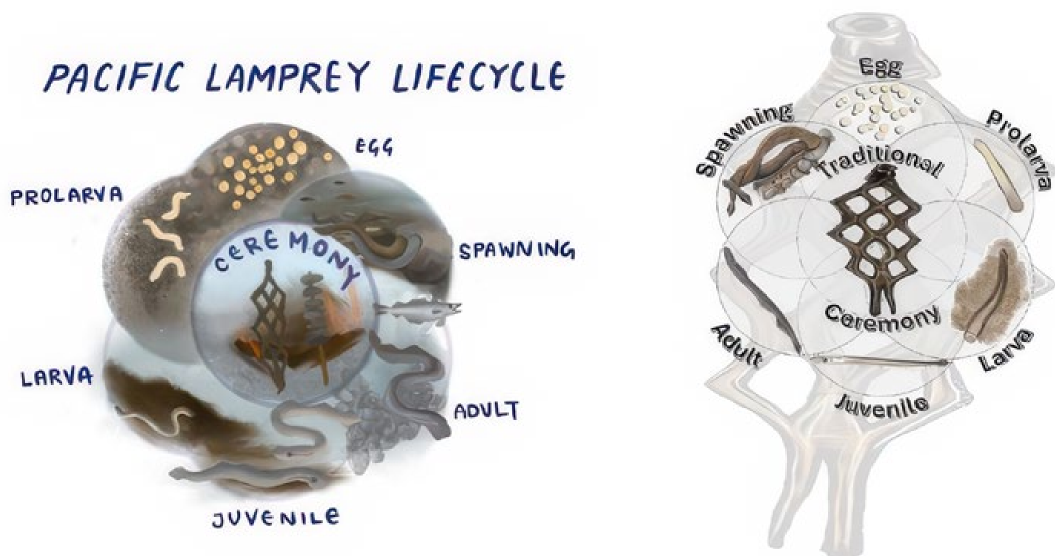


Illustration co-created by M. Buck (UW), R. Lampman (YN), M. Shibuya (Ocean Nexus), and M. Blanchard (WDFW/USFWS)

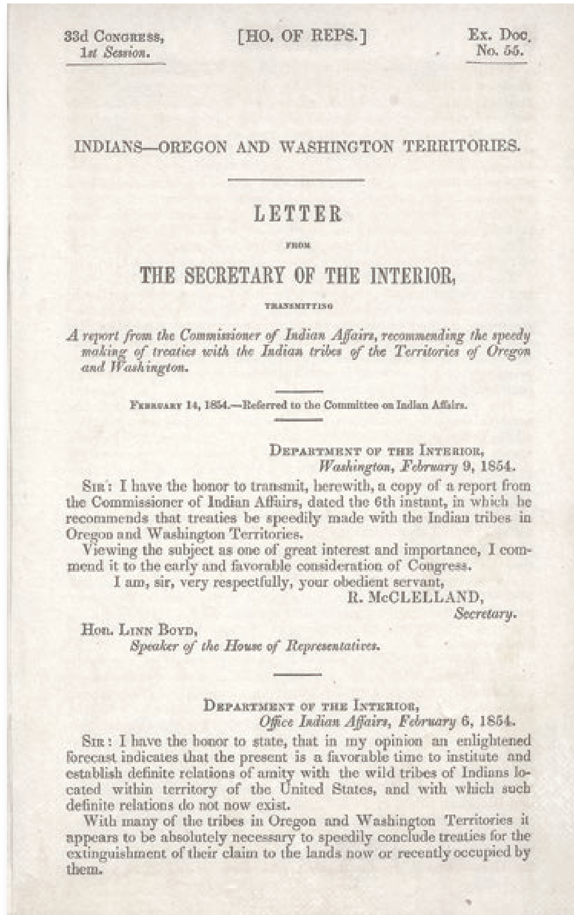
FIGURE 7. Artwork illustrating the lamprey lifecycle and their sacred tribal ceremonial use in the center, honoring their special role in sustaining tribal people both spiritually and physically.

The unique and distinctive political relationship between the United States and Native American tribes is defined by treaties, statutes, executive orders, judicial decisions, and the ethical foundations embedded in the unique relationship between the United States and Indigenous people. This relationship has given rise to a special federal trust responsibility, involving the legal responsibilities and obligations of the United States toward Native American tribes and the application of fiduciary standards of due care with respect to tribal lands, tribal trust resources and the exercising of tribal rights.

Consultation, a formal process for U.S. government communication with the tribes, should occur whenever it appears that tribes may have an interest in the outcome of an agency's action, whether the tribal interest is direct or indirect (CRITFC, 2014).

While these principles are not new, the federal government's understanding of and prescriptions for sovereignty and consultation have changed to some extent since the 2011 TPLRP was completed. These developments and some of the legal and historical background are presented in this section.

The trust responsibility is a legal doctrine that has grown out of treaties, statutes, court decisions, and other dealings between the United States and Native American tribes. The



33d Congress, 1st Session. [HO. OF REPS.] Ex. Doc. No. 55.

INDIANS—OREGON AND WASHINGTON TERRITORIES.

LETTER

FROM

THE SECRETARY OF THE INTERIOR,

TRANSMITTING

A report from the Commissioner of Indian Affairs, recommending the speedy making of treaties with the Indian tribes of the Territories of Oregon and Washington.

February 14, 1854.—Referred to the Committee on Indian Affairs.

Department of the Interior,
Washington, February 9, 1854.

Sir: I have the honor to transmit, herewith, a copy of a report from the Commissioner of Indian Affairs, dated the 6th instant, in which he recommends that treaties be speedily made with the Indian tribes in Oregon and Washington Territories.

Viewing the subject as one of great interest and importance, I commend it to the early and favorable consideration of Congress.

I am, sir, very respectfully, your obedient servant,
R. McCLELLAND,
Secretary.

Hon. Linn Boyd,
Speaker of the House of Representatives.

Department of the Interior,
Office Indian Affairs, February 6, 1854.

Sir: I have the honor to state, that in my opinion an enlightened forecast indicates that the present is a favorable time to institute and establish definite relations of amity with the wild tribes of Indians located within territory of the United States, and with which such definite relations do not now exist.

With many of the tribes in Oregon and Washington Territories it appears to be absolutely necessary to speedily conclude treaties for the extinguishment of their claim to the lands now or recently occupied by them.

Source: Library of Congress / Public Domain / https://lccn.loc.gov/2022690809

A letter from the Secretary of the Interior, transmitting a report from the Commissioner of Indian Affairs, recommending the speedy making of treaties with the Indian tribes of the Territories of Oregon and Washington. February 14, 1854.

Treaties did not, as is frequently assumed, grant rights to Indians from the United States; rather, the tribes ceded certain rights to the United States government and reserved the rights they never gave away. Tribal governments use these treaties today to affirm and retain rights such as the sovereign right of self-government, fishing and hunting rights and jurisdictional rights over their lands.

United States is obligated to represent the best interest of the tribes, protect the safety and wellbeing of tribal members, and fulfill treaty obligations. This is why the federal government, and its implementing agencies owe a duty to recognize the impacts of their activities on the tribes, as well as a duty to safeguard natural resources, including Pacific lamprey, which are fundamental to tribal self-government and prosperity.

Government-to-government consultation is a key means to preserve sovereignty, tribal self-determination, self-governance, and treaty rights. "Consultation" means the meaningful and timely process of seeking, discussing, and carefully considering the views of another sovereign in a manner that is cognizant of all parties' cultural values and, when feasible, seeking agreement. It means that there is direct dialogue between tribes and the U.S. government on issues of relevance and importance to tribes. Consultation provides mechanisms by which tribes can have a voice in federal management of their interests.

It is also important to note that the 1974 "Boldt Decision" (*US v. Washington*) reaffirmed tribes as co-managers of fisheries resources. This means that the tribes and the states are jointly responsible for managing fisheries and hatchery programs and that they collaborate in regional efforts to recover depleted fisheries resources (Northwest Indian Fisheries Commission: *https://nwifc.org/about-us/fisheries-management/*).

However, in many cases the tribes witness undue restrictions on lamprey recovery actions. These restrictions extend the time for recovery of these fish and impose upon the tribal treaty rights. In addition, the tribes view the conservation standards often brought up as a hinderance toward progress and as an undue burden on co-management responsibilities. We outline below conservation standards ***that limit*** federal and state restrictions of tribal activities exercising the treaty fishing right (CRITFC 2014).

The restriction is reasonable and necessary for conservation of the species at issue if:

- The conservation purpose of the restriction cannot be achieved by reasonable regulation of non-Indian activities.
- The measure is the least restrictive alternative available to achieve the required conservation purpose.
- The restriction does not discriminate against Indian activities, either as stated or applied.
- Voluntary tribal measures are not adequate to achieve the necessary conservation purpose.

Courtesy of USFWS / Public Domain

3.3 Tribal Harvest and Willamette Falls

While most tribes in the Columbia Basin have deep cultural ties to anadromous fish returning to their homelands, the four Columbia River treaty tribes are the only ones with reserved rights to fish for salmon and Pacific lamprey (i.e., anadromous fishes) in their treaties with the United States. The Nez Perce, Umatilla, Warm Springs and Yakama Tribes negotiated treaties in 1855, reserving the right to maintain use of the natural resources on which their culture depends, including rights to water, land, fish, wildlife, and medicines.

B. C. Towne, photographer / Courtesy of Willamette Falls & Landings Heritage Area Coalition and Old Oregon Photos

FIGURE 8. Tribal members fishing at Celilo Falls. Note lamprey in foreground.

Retaining the right to continue their fishing practices was a primary objective of treaty negotiations. Each treaty contained a nearly identical provision securing the Tribes the right to take "fish at all of our usual and accustomed fishing places in common with citizens of the United States" which includes areas outside the tribal reservations and ceded areas (Bernholz and Weiner 2008).

The Tribes' right to govern their members and manage their territories and resources comes from tribal sovereignty as recognized by treaties. The fact that treaties were made with the Tribes reflects the United States' recognition of tribal sovereignty. The U.S. Supreme Court has described tribal governmental powers as "inherent powers of limited sovereignty which has never been extinguished." For this reason, and because of the vast geographical differences they live within and manage, none of the four CRITFC member tribes are currently inclined to establish Columbia Basin-wide lamprey harvest regulations, but rather, will continue to manage lamprey harvest within their own separate governments.

Discussion of tribal harvest guidelines for Pacific lamprey is outside of the scope of the TPLRP 2025. Harvest guidelines will be developed, coordinated, and presented within a different process by the CRITFC member tribes as appropriate.

Because of the Tribes' unique history and political status, the federal government and its agencies have a trust responsibility to use their expertise and authority, in meaningful consultation with the Tribes, to safeguard treaty-reserved natural resources, such as Pacific lamprey.

The Nez Perce, Umatilla, Warm Springs, and Yakama tribes have harvested lamprey throughout the CRB since time immemorial. Fishing sites were spread widely throughout the basin — at the waterfalls and rocky shores of the mainstem Columbia, Snake, and Willamette rivers. Larger fishing sites such as Celilo Falls on the Columbia, Willamette Falls on the Willamette, and Sherars Falls on the Deschutes are among the well-known tribal harvest sites. But there were countless sites within all major

National Park Service / Public Domain

Public Domain / Courtesy of Doug Hatch

FIGURE 9. Pacific lamprey found at Kettle Falls (left) and the Bruneau River (right). Dates unknown.

tributaries including the Clearwater, Grande Ronde, Wenatchee, Yakima, and Umatilla; as well as smaller streams, such as Fifteenmile, Trout, Satus, Mill, Asotin, and many others.

Although the fishery is much diminished, some of the usual and accustomed lamprey fishing places are visited each year by many fishers and families. Other sites are visited intermittently. Over recent years with the rapid and drastic decline of Pacific lamprey, most of these local sites no longer have sufficient numbers of lamprey to harvest. Additionally, many of these areas have been dramatically degraded, destroyed, and/or lost due to development. Examples include Celilo Falls, which was inundated behind TDA in 1957 and Kettle Falls, which was inundated behind Grand Coulee Dam in 1942. Based on historical photographs (FIGURE 9), it is clear that historically a large abundance of Pacific lamprey migrated to these upper river reaches in the CRB, including Kettle Falls (picture on the left) in the upper Columbia River (total river km 1,126) and Bruneau River (picture on the right) in the upper Snake River (total river km 1,369 and an elevation of 1,133 ft). In the Columbia River, Pacific lamprey migrated at least to Kinbasket Lake (total river km 1,615) (Scott and Crossman 1973; Lee et al. 1980) and is suspected to have migrated to Windermere and Columbia lakes (total river km 1,909 and 1,943, respectively) (Scholz in press). In the Snake River, it is suspected that they traveled up to Shoshone Falls (total river km 1,502) (Scholz in press).

In addition to the lamprey population decline itself, the Tribes are also confronting the repercussions from the severe loss of culture and opportunities to teach traditional ways of harvesting, preparing, and consuming Pacific lamprey. Even though lamprey genes may be considerably resilient and reintroduction efforts can help local populations bounce back, the consequence for “lost culture” is considerably more severe and may never be fully recoverable. Although tribal culture is still strong and resilient, considerable local traditional ecological knowledge and wisdom has been lost over time largely due to the sharp declines in lamprey populations and harvest opportunities in many locations throughout the CRB.

WILLAMETTE FALLS

Due to the near extirpation of this species upstream of barriers (both partial and complete barriers) throughout the Columbia Basin, Willamette Falls is one of the few remaining traditional harvest locations for the Tribes and is an important location for continuing treaty-reserved tribal practices and sharing traditional ecological knowledge. Tribes often bring youth groups to the falls to harvest, with elders and youth sharing knowledge of the harvest and preparation of lamprey, cultural significance, and ecological benefits. Undoubtedly, high commercial takes of Pacific lamprey at the falls in the early 1900s contributed to declines of this species and reduced harvest operations for tribal members. Well into the 1940s, hundreds of thousands of adult lamprey were harvested at the falls by commercial interests, illustrating both the highly abundant resource that was available and the damage that these excessive takes inflicted (Almeida et al. 2021). Commercially harvested lamprey were transported to a reduction plant at Warrenton, OR, where the vitamin oil was extracted; the residual material was manufactured into protein food for livestock and poultry as well as fertilizer and hatchery fish feed (Mattson 1949; Close et al. 2002).

Between 1943 and 1952, approximately 97,000–530,000 lamprey were harvested each year at Willamette Falls primarily through non-tribal commercial harvest (**FIGURE 11**; Ward 2001; Kostow 2002; Clemens et al. 2023). However, between 1997 and 2001 harvest rates at the falls had dropped to as few as 16,000–46,000 lamprey per year, and current harvest levels (2020s) are less than 8,000 adults per year (primarily collected by tribal members). Based on a prominent commercial harvester (L. T. Critchlow) who reckoned that his crew was able to harvest 10–20% of the overall lamprey population that appeared at Willamette Falls

oregondigital.org / Public Domain Mark 1.0 Universal

FIGURE 10. Pacific lamprey at Willamette Falls, July 1913.

Number of Pacific Lamprey passing Bonneville Dam and Willamette Falls (Historic vs. Current) and the Percent of Harvest at Willamette Falls for Both Time Periods

FIGURE 11. Comparison of Pacific lamprey Willamette Falls harvest and Bonneville Dam counts (estimated with nighttime count extrapolation) between 1943 and 1952 (top figure) and 1997 and 2001 (bottom figure).

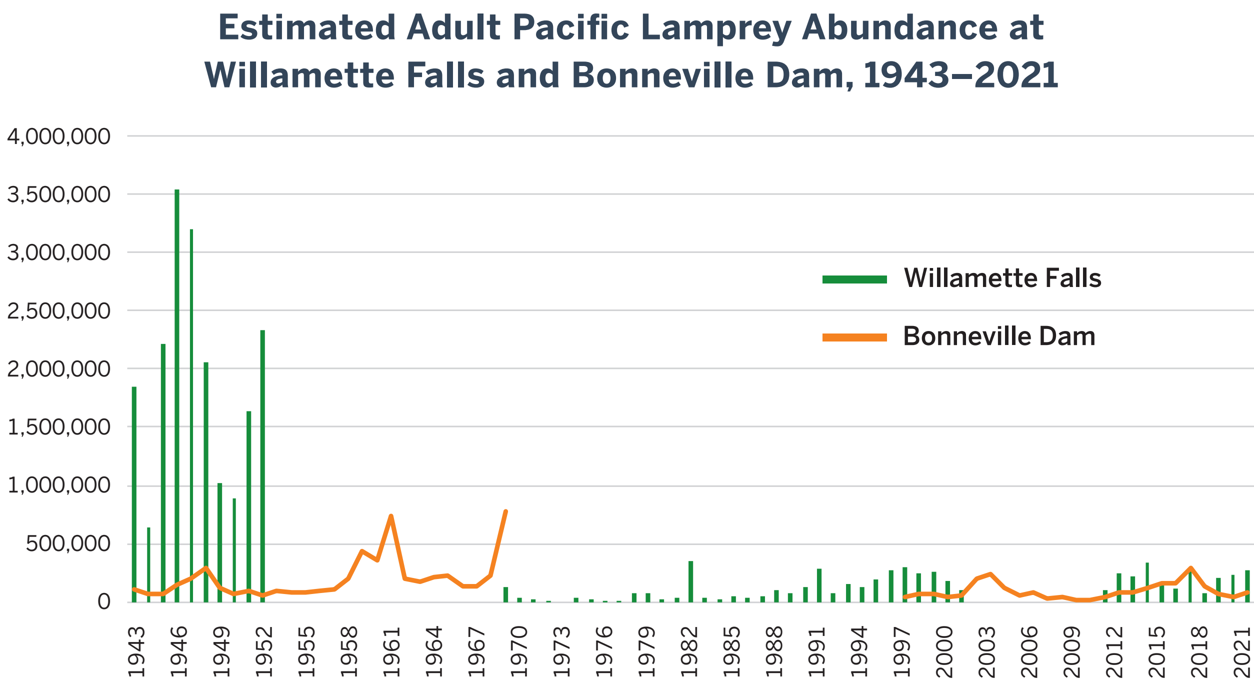


FIGURE 12. Estimated adult Pacific lamprey abundance at Willamette Falls (based on estimates from Mattson 1949 and Ward 2001) and Bonneville Dam estimated counts between 1943 and 2021 (Hess et al. 2023).

(Mattson 1949), we can then estimate that Willamette Falls held approximately 3.5 million lamprey during these early years, which is a magnitude larger than the maximum numbers ever estimated at BON (**FIGURE 11**).

The USACE owns and operates numerous dams in the Willamette Basin known as the Willamette Valley System. Historically, adult Pacific lamprey were very abundant and occupied over 3,000 river km across five Willamette subbasins alone (North Fork Santiam, South Fork Santiam, McKenzie, Middle Fork Willamette, and Upper Willamette). This abundant and productive habitat most likely allowed the high number harvested at Willamette Falls to occur until the dams were constructed and commercial harvest became unsustainable. These dams have blocked passage of Pacific lamprey to prime spawning and rearing habitat, thereby contributing significantly to the decreased abundance of the species at Willamette Falls. The combination of blocked passage and extreme harvest undoubtedly contributed to the sharp population decline, not only within the Willamette River Basin, but also within the CRB in general (due to the unique role of the Willamette River serving as a key "source" population).

Today Pacific lamprey occupy less than a third of historically available habitats within the Willamette Basin due to passage being blocked by dams and abundances no longer support the high harvest rates historically observed at Willamette Falls. Immediate restoration efforts within the Willamette Valley System are needed to increase the abundance of Pacific lamprey locally, and to mitigate habitat losses by the Willamette Valley System.

ADDITIONAL ORAL HISTORIES RELATED TO WILLAMETTE FALLS (Engum, 2020)

In interviews, elders talk about the impact of the dams that were put in along the rivers.

INTERVIEWER: **So the dams stopped the people from fishing, going down to fish?**

ELDER: **Yeah, the people fished when it was free country. Then they fished every day. Find fishing places along the river. They used to fish all over the place.** Whenever they knew where the fish is coming, they try to make raft to try and catch fish. Eels too.

INTERVIEWER: **They were just right in the river? The eels?**

ELDER: **Yeah, I know they used to go 70-some places for eels.** They use to know where to catch eels."

"...not as many people gather *asím* or *kˀsúyas* or *héesu* because of the polluted river [Willamette]... We have always been able to regulate ourselves naturally and that **we've always been protectors of the land."**

"Getting the eels would be probably late summer, mid-summer. They would run, really a short time. I mean, 'cause they'll come and go. Like, what was it this year, it was July; July time's when they ran this year. **Fishing for eels is, like many of the Indian people know from the five tribes, it's gonna be an ongoing battle** and so many things are happening today. **We're conflicting now with each other, with our own Indian people** and that needs to be documented too. **Whereas it used to be all of us together [would] go down and fish, you know, not just certain families. It was everyone.** Same way with Celilo. When it came to Celilo, the stories that we were told from our dad, it wasn't just the Yakamas fishing, or just the Warm Springs, or Wanapum, or Umatillas. You know, it was everyone."

FIGURE 13. Tribal statements from interviews about fishing in the old days.

"...the days before they put that Bonneville Dam in. **The whole river was, had a lot of whitewater, a lot of rapids. All of these fish here were in the river then; like your spring chinook, fall chinook, sockeye, steelhead, eels, sturgeon, suckers, whitefish, a lot of whitefish...there was a lot of fishing sites along the Columbia;** I mean, it wasn't just like now you either fish around The Dalles or go to Cascade Locks or somewhere where they got scaffolds going up, **in those days there was so many fish you didn't have to, heck you could catch 'em right from the bank if you had a good place to stand."**

"And so then, and times are changing where today when they go get eels, Oh, **Warm Springs is allowed this much, Umatillas are allowed this much, Yakamas are allowed this much...so, it's changing again constantly and it shouldn't be like that.** And it shouldn't be, you're Yakama, you're this, you're that, or you're Umatilla, you don't know about this, or you don't know about...it shouldn't be like that at all. **But, it is very important to know the things that we've all done together, you know, we're all in the same boat. We're all the same people, we're all related one way or another. And it shouldn't be us, them..."**

"...**there were enough fish before Bonneville started taking its toll that you could just, if you had a place to anchor a gill net or a set net or anything, you should catch fish almost anywhere. They were that plentiful.** If you had, were strong enough and you wanted to wade out in that swift water and just swing a big long dip down in that current, you could catch fish...grab hooks, set nets, hoop nets, dip nets. They built some fish weirs, the older guys did, but there wasn't very many places along the river when it was running wild, with just the Bonneville Dam down there; practically at the end of the river, well not practically, but gettin' close to it, there wasn't many places to build a weir to catch 'em. I'm sure they had 'em up here, Kettle Falls and through there probably. **Some pretty good places to build traps, fish traps. We was kids, we used to build traps in them little spring branches to catch fish.** We never did build 'em right but tried (laughs)...I've seen a lot of them [fish wheels] along the Columbia...."

"...**Before the dams were built, heck there, the Indian people fished all along the Columbia; down around Hood River, the Wasco people fished around there and the Yakamas.** Our people from here would even go down there that far. They more or less went down there just to visit."

> "The eel was part of the July feast…because along with the salmon…this is what our older people tell us…that when the time began the foods were created. The foods were here before us…and they said that the foods made a promise on how they would take care of us as Indians, and the eels was one of those who made a promise to take care of us."

—Umatilla Tribal elder

From Lee Moorhouse (1850–1926) photographs / oregondigital.org / Public Domain

FIGURE 14. Camp of Billy Barnhart, Umatilla Indian on the Umatilla River, 1903.

3.4 Traditional Ecological Knowledge and Science

Integrating traditional ecological knowledge with contemporary science is one of the basic foundations of the 2025 TPLRP. Traditional Ecological Knowledge (TEK) is the knowledge, practice and belief about the relationships that exist between humans and the natural environment, rooted in a familial relationship with plants, animals and the environment. It is passed down from many generations through oral traditions, such as storytelling, songs, and ceremonies. For tribes in the Columbia Plateau, traditional ecological knowledge imparts cultural values and worldviews as well as specific practical knowledge, such as techniques and stewardship principles for fishing and hunting, gathering plants, roots and berries, and cultivating the land.

One of the most precious traditional teachings is the concept that "everything is connected." For thousands of years, the tribes lived in an appropriate and sustainable way on the earth. To properly address this threat, the world must be willing to listen and incorporate the traditional wisdom of the tribes into their activities and actions.

The Tribes have a deep history of being connected to the earth, as reflected in their culture, spirituality, and everyday lives. Their spiritual and cultural values and practices are grounded in *Tamánwit,* the natural law or philosophy of the traditional Plateau peoples. *Tamánwit* describes the responsibilities whereby humans must give back to the earth that provides for them. *Tamánwit* requires an intimate familiarity with seasonal patterns in nature, including the flowering of plants, migrations of fish and birds, and changing weather. These and other seasonal patterns are closely linked to cultural practices, such as gathering, processing and storing food or other materials for shelters and toolmaking, and even prescribing the time for storytelling.

For example, the Umatilla River Vision (Jones et al. 2011) provides an outline for managing rivers from an ecosystem perspective that focuses on the minimum ecological products required to sustain CTUIR culture. Managing from a First Foods perspective calls for a change from management practices employed in recent decades, which were often single-species approaches narrow in scope and with limited spatial and temporal extents. In contrast, a First Foods perspective for river management means integrating the entire ecosystem, a broader range of biodiversity, and broad spatial scales—from ridgetop to ridgetop. The River Vision highlights several processes in need of restoration and protection that extend beyond the immediate focus of anadromous fish: water quantity and quality (both groundwater and surface water), geomorphic diversity of the river channel (side channels, off-channel habitats, tributary junctions, etc.), connectivity across habitats and across the river network, and the community structure and health of the entire riverine biota, and riparian communities. While River Vision outlines a farsighted approach for a particular river, a First Foods perspective can be applied across the Tribes' treaty territories and beyond, along with the principles from other tribal sources of traditional ecological knowledge.

> **"...English is very tricky and you can't say anything correctly if you say it in English, but if you use the Native language, you can understand nature... I can explain this a lot better in the Native language because I would be reciting the Creator's words...In English, on paper, it doesn't come through."**
>
> **— Johnson Meninick, "Meninokt"**
> YN Cultural Resources Program Manager

3.4.1 Principles of Traditional Ecological Knowledge

The principles that inform the 2025 TPLRP are grouped into four broad categories (CRITFC 2013):

- Documentation of natural conditions prior to Euro-American settlement (not post CRB dams), including knowledge about indicators of ecosystem change.
- A framework for holistic management of anadromous fishes based on relationships between tribal members and natural resources encompassing the past, current, and future timeframes.
- An adaptive management framework, due to the Tribes' unique ability to accommodate environmental change in their social systems.
- Recognition of the importance of "place" and the relationship between that place (that area where the Tribes live, fish, hunt, gather, and maintain their cultural practices) and the community it supports.

3.5
Ecological Significance of Pacific Lamprey

Ecosystems are complex and dynamic areas that contain plants, animals, microbes and non-living components that function and interact together. Ecosystem services include the benefits people obtain from their ecosystems (MEA 2005). Pacific lamprey are known to provide many ecological services and clearly play provisioning and supporting roles in ecosystem diversity and complexity. Abundant Pacific lamprey are critical to a healthy, balanced ecosystem (Beamish 1980, Close et al. 1995, and Shirakawa et al. 2013). "Evidence suggests that the Pacific lamprey was well integrated into the native freshwater fish community and as such had positive effects on the system" (Close et al. 1995).

The following are some examples of the important ecological services identified by TEK and contemporary science:

- Adult lamprey provide food to people and many terrestrial and aquatic animals (Close et al. 2004; Cochran 2009; Miller 2012; Wicks-Arshack et al. 2018).
- Adult lamprey, during spawning (via eggs) and after spawning and dying, provide key marine-derived nutrients to interior and upland watersheds (Close et al. 1995; Nislow and Kynard 2009; Weaver et al. 2015 and 2016; Dunkle 2020).
- Larval lamprey — also known as "the worms of the river bottom" can increase fine particulate organic material in substrate (after food digestion), increase oxygen redox potential within the streambed, which helps create macroinvertebrate hotspots, and are

Courtesy of Yakama Nation Museum

FIGURE 15. Yakama member, Harry Tomalawash, holding lamprey ready for roasting by open fire.

important in "soil formation, photosynthesis, primary production and nutrient cycling" (MEA 2005; Shirakawa et al. 2013).

- Lamprey act as an ecosystem engineer burrowing in sediment as larvae and moving rocks when constructing their nests as adults (Limm and Power 2011; Shirakawa et al. 2013; Hogg et al. 2014; Boeker and Geist 2016).
- Lamprey are an important part of the food web and are preyed upon by a diversity of species including white sturgeon (*Acipenser transmontanus*), northern pikeminnow (*Ptychocheilus orogenesis*), walleye (*Sander vitreus*), smallmouth bass (*Micropterus dolomieu*), sculpins (*Cottoidea*), rainbow trout (*Oncorhynchus mykiss*), salmonid fry, river otters (*Lontra canadensis*), whales, pinnipeds, and various birds (Cochran 2009; Arakawa and Lampman 2020; Arakawa et al. 2021; Bingham et al. 2025).
- Lamprey can act as a buffer to salmonid populations, as they are often preferentially eaten by these predators, reducing the pressure on salmonids, which share similar migration timings and predators (Close et al. 1995; Merrell 1959; Pfeiffer and Pletcher 1964; Dunkle 2020).
- Adult lamprey often travel collectively, making them easier for marine mammals to catch. Pound for pound, they offer more caloric value than adult salmonids (Whyte et al. 1993; Close et al. 1995).
- Ecosystem role as a non-selective top predator in the ocean food web, keeping "checks and balances" on other predators that may be out of equilibrium.

Indigenous peoples of the Pacific Northwest have utilized lamprey since time immemorial in cultural practices and there are legends and myths surrounding lamprey and tribal use. Recent harvest and use of lamprey in the Pacific Northwest has been primarily by tribal peoples, but all the region's residents derive benefits from ecosystem services that lamprey provide at multiple scales. Moreover, lamprey harvest is a tradition for both indigenous and non-indigenous peoples around the world (including Asia and Europe) and in many areas they are considered a delicacy (Almeida et al. 2021; Hanel et al. 2022).

Biodiversity must be sustained simply because humans have a moral obligation to ensure the natural, evolutionary existence of species and ecosystems whose values do not depend on their human usefulness.

— Winter and Hughes 1996

NUTRIENT CYCLING AND BIOTURBATION

At all life stages, lamprey play a critical role in the sequestration and release of nutrients to stream ecosystems. Larval lamprey capture particulates as they filter feed and provide a constant source of nutrients to sediments they occupy for extended periods (reviewed in Wang et al. 2021). The presence of larval lamprey can provide higher oxygen availability, alter sediment quality and microbial fauna, and increase deposition of organic matter, all of which are processes that are key to healthy stream ecosystems (Shirakawa et al. 2013; Boeker and Geist 2016; Nika et al. 2021). Adult lamprey disturb stream beds as they build nests and participate in spawning. This activity significantly reduces substrate embeddedness for months after nests are built (Hogg et al. 2014). The resulting habitat heterogeneity produces higher abundance of pollution-sensitive benthic invertebrates and release of fine sediment particles that can smother fish eggs.

MARINE-DERIVED NUTRIENT SUBSIDY

Like salmonids, adult lamprey can travel hundreds (even thousands) of kilometers from marine environments to their freshwater spawning areas, sometimes accessing small interior streams that are inaccessible to other anadromous species (Moser et al. 2015a; Clemens et al. 2023). After spawning, they die and carcasses decompose, releasing nutrients to oligotrophic streams (Weaver et al. 2015 and 2016). Marine derived nutrients from carcasses may also be deposited in the riparian zones when transported by predators or scavengers (Dunkle 2020). On a per weight basis, nutrient subsidies from lamprey equal those of salmonids and occur during times of the year when other marine-derived sources are scarce and nutrients are most needed by salmonid species (Guyette et al. 2013; Dunkle 2017; Wensloff 2021).

PREDATOR-PREY DYNAMICS

Pacific lamprey has co-evolved with its hosts and predators for millennia. While the role of Pacific lamprey in the ocean ecosystem is poorly understood (Clemens et al. 2019), this species clearly plays an important role as a calorie-rich food source for fish, birds, and marine mammals in the estuary, near-shore ocean, and in freshwater (Cochran 2009; Qunitella et al. 2021) and may also play a crucial role for the food web as a top predator in the ocean. Lamprey muscle is rich in monounsaturated fatty acids, which are ready sources of energy for predators, including those participating in long-distance migrations, like salmon and seabirds (Quintella et al. 2021).

EVOLUTIONARY DEVELOPMENT AND MEDICINAL RESEARCH

Lamprey are important for studies of the early evolutionary development of vertebrates and there is rising interest in their use in biomedical research (Docker et al. 2015). Such research may result in treatments for human ailments resulting from blood coagulation disorders, biliary atresia, hemochromatosis, spinal cord injury, and even diabetes. The value of traditional medicinal properties of Pacific lamprey oil were summarized by Miller (2012) and include use as a skin ointment, earache remedy, and tonic. In 1693, Arctic lamprey was documented in Japan to be a great cure for nyctalopia (also known as night-blindness), which is often caused by deficiency in vitamin A (Saito et al. 2007). In addition, oil extracted from Arctic lamprey (Yatsume Pharmaceutical Co., Ltd., Tokyo, Japan) is sold as medicine to help treat dry eyes, night blindness, and fatigue, and is also recommended as a supplement during pregnancy and lactation periods. The potential for modern use of lamprey to treat human ailments is now being recognized and may increase the value of these fish to the broader human population (Docker et al. 2015).

3.6
Climate Change

> **Climate change is real and, unfortunately, the effects appear to be in motion. We are witnessing changes in the seasons. Our roots and berries must be gathered sooner, and salmon returns are less predictable. Our people notice less snow in the mountains now, and there is less cool water during the summer when it was once abundant. The changes we see may not bode well for our future. Over the years to come, we may lose natural resources that are important to our culture and our heritage. Some of these losses may be irreversible.**
>
> — Yakama Nation Climate Action Plan, 2021

While climate change affects all the First Foods, the Tribes are especially concerned about how it will affect fish and the watersheds in which they live. And to be frank, the picture is not encouraging. It will take a concerted effort to mitigate and prevent the most extreme effects. Due to their longevity, geographic range, and complex life history, lamprey may be especially vulnerable to these environmental changes (Wang et al. 2021).

Pacific lamprey are dependent upon cold water. The changes that climate change brings may be catastrophic. More winter snow will instead fall as rain. Snow that does accumulate will melt earlier. This results in more water traveling during the winter, leaving less for the hot summer months. The increased winter flows scour the riverbeds, disturb spawning and rearing areas, and could cause physical damage to both larvae/juvenile lamprey. Lower summer flows increase water temperatures and reduce habitat available to lamprey and all native aquatic species. In the spring and summer, lamprey eggs may hatch too early. Both adults and juveniles may migrate too late to safely navigate warming mainstem/tributary rivers or find food in the ocean.

The warmer summers will increase demand for hydropower (used by humans for air conditioning), resulting in decreased release of water to dam spillways. Less spillway releases mean more mortality for larval and juvenile migrants and higher costs for returning adults. In the ocean, lamprey will face changing host availability, acidification, low oxygen zones and reduced productivity. The years of collaboration, hard work, and millions of dollars spent on restoring lamprey could be undone by an ecosystem rendered inhospitable by climate change.

> **"That which can be connected cannot be separated."**
>
> **— Atway Louie Dick,**
> Tribal Knowledge Keeper, CTUIR

Global climate change is a direct threat not only to ecosystems, but the human cultures built on them. Climate change will affect everyone, but the Tribes will feel a particular sting, as the very foundation of our cultures is based on respect for and wise use of the natural resources the Creator has given us. While we seek ways to influence national and international responses to reverse climate change, as individuals and communities, our task will be to try to understand what to expect in an altered environment and how to prepare for it in a way that perpetuates our culture.

For example, two telling graphics demonstrate changes in temperature (**FIGURE 16**, below) and discharge (**FIGURE 21, SECTION 4.7**) within the Columbia and Snake rivers and their effects on the timing of lamprey migrations (O'Connor 2021; Columbia River DART).

Recent water temperatures often exceed the decadal average temperature and have been near or have set record high temperatures for that day of the year during summer to winter season. In 2023, for example, lower Columbia water temperatures exceeded average temperatures in mid-May through late August by a few degrees (approximately 2–3° F [1.1–1.7° C]) and exceeded 70° F (21°C) from mid-July through August (https://waterdata.usgs.gov/). In the lower Columbia River, the increase is most prominent between July — December time-frame and the rate of increase is estimated to be 2.0°C ± 0.2°C/century during this time-frame (Scott et al. 2022). Higher temperatures also occur earlier at BON now than historically and this results in earlier migration of adult Pacific lamprey (**FIGURE 16**; Keefer et al. 2009; O'Connor 2021; Columbia River DART). Average daily temperatures approach safe handling thresholds (22°C, yellow shading in **FIGURE 16** and maximum daily temperatures are now approaching known mortality thresholds for lamprey (24° C; red shading in **FIGURE 16**). Whereas the number of days with water temperatures below 2°C decreased from ~10 to 0 days per year since the

Advanced Run Timing of Pacific Lamprey at Bonneville Dam as a Result of Changed Water Temperatures (Historic vs. Current) from May through September

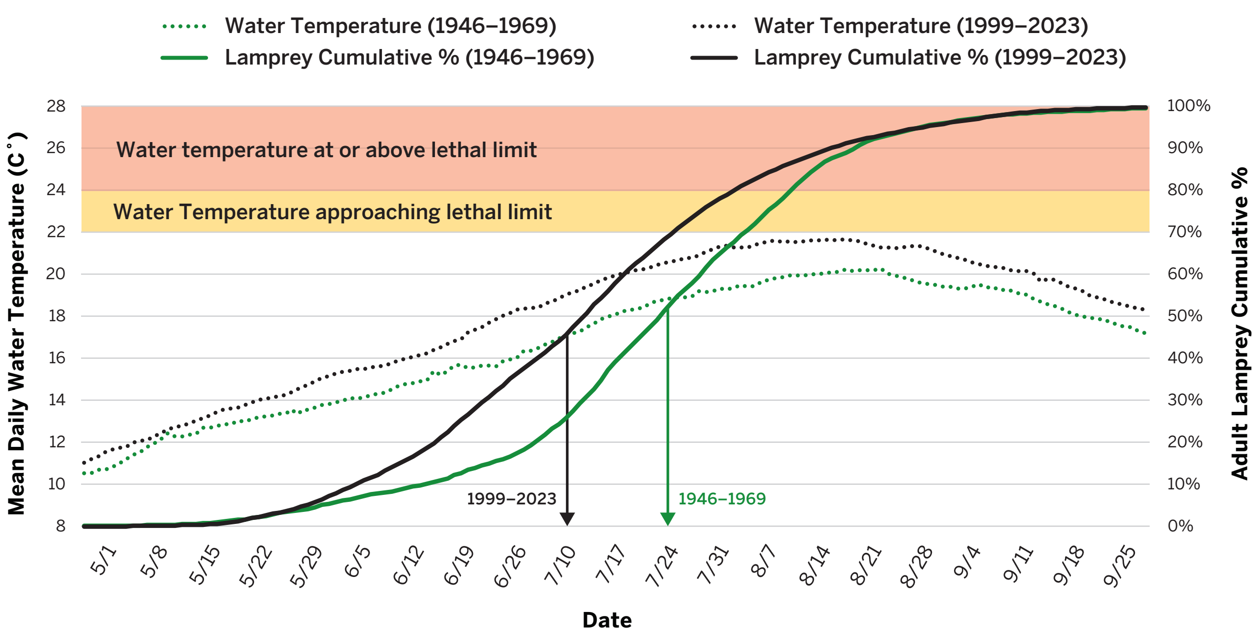


FIGURE 16. Water Temperature Changes and Pacific Lamprey Run Timing at Bonneville Dam.

1850s, the number above 20°C increased from ~5 to 60 per year, which inevitably impacts the probability of exceeding ecologically important thresholds for many species (Scott et al. 2022).

Although Pacific lamprey are known to be capable of effectively adjusting their run timing based on mainstem Columbia River water temperature and discharge conditions (Keefer et al. 2011), further changes in water temperature and/or flow may seriously hinder their ability to pass mainstem and tributary dams effectively to reach good spawning habitat in the upper watersheds due to impacts from physiological thermal limitations and changes in ocean migration timing.

Greater attention and a growing body of information is now being developed to better understand current and future impacts of climate change on Pacific lamprey (Wang et al. 2020; Clemens 2022). Much of this recent and important work is discussed in SECTION 4 (Regional Progress). Specific actions to address these impacts are presented in SECTION 5 (Actions).

Tribal Resilience Action Database

The new Tribal Resilience Action Database project brings together a group of project partners and advisors representing more than two dozen tribes across North America. This effort aimed to create a culturally sensitive, easily accessible, and useful database of climate adaptation strategies and community examples already published by tribes.

www.tribalresilienceactions.org

3.7 Genetics: Effective Population Size and Structure

Potential influence on population genetic structure is an important consideration for all supplementation efforts. Recent advances in genetic study of Pacific lamprey have not only provided information on regional population structure but also on genomic adaptation (Spice et al. 2012, Hess et al. 2013, Hess 2016, Parker et al. 2019, Hess et al. 2020). These advances inform conservation management and restoration of Pacific lamprey.

MAINTAIN GENETIC DIVERSITY

Compared to salmonids, Pacific lamprey appear to exhibit low genetic differentiation among geographic groups. 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). Moreover, salmonid broodstock should be collected close to the eventual release location so that "local" adaptation can be preserved (Galbreath et al. 2008). These supplementation practices are also important for Pacific lamprey, although the definition of "local" is not necessarily synonymous for salmon and lamprey (see below). Maintaining genetic diversity among a population's individuals is a basic driving principle for sustainability. It reduces potential deleterious effects, including inbreeding depression. It also provides organisms with 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 composed 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. Hence, the specific watershed (or subbasin of origin) contributing broodstock may not be critical to the success of artificial propagation programs for Pacific lamprey.

GENETIC CONSIDERATIONS

Although Pacific lamprey populations appear to contain locally-adapted broodstock at relatively large scales, care in selection of individuals such that their adaptive diversity is representative of the region of interest is warranted. Hess et al. (2012) concluded that based on neutral genetic variation (i.e., gene variants detected to 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 these differences. 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, respectively (as opposed to mitochondrial DNA in Goodman et al. 2008). These types of markers have high potential to represent adaptive variation (i.e., genomic regions under selection), a primary goal of the Hess et al. (2012) study. 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). 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 measured by particular genetic markers were associated with large adult body size, and large adults tend to migrate furthest into the interior Columbia River (Keefer et al. 2009).

In addition to body size, Pacific lamprey exhibit two maturation ecotypes (ocean- and river-maturing), which were first discovered in a population of the Klamath River (Parker et al. 2019) and then confirmed to co-occur in the Willamette subbasin (Hess et al. 2020). Similar to anadromous steelhead (*Oncorhynchus mykiss*, Hess et al. 2016), the maturation ecotypes manifest in Pacific lamprey as an ocean-mature form that enters freshwater in relatively advanced state of maturation and a river-mature form that enters freshwater in a less advanced state of maturation (Parker et al. 2019). The genetic basis of these adaptive traits has been identified to particular regions of the genome, including a region on chromosome 1 associated with maturation and a region on chromosome 2 associated with body size (Hess et al. 2020).

Further, Hess et al. (2020) surveyed range-wide for maturation ecotypes and body size and found evidence that small, ocean-mature Pacific

Courtesy of USFWS / Public Domain

lamprey are concentrated along the coastal range compared to large, river-mature Pacific lamprey, which were found in more interior streams. Aside from evidence of geographic association with these adaptive traits, there is some evidence that adaptive traits can also be temporally structured. For example, Hess et al. (2020) also showed that the ocean-mature ecotype arrives earlier at Willamette Falls than the river-maturing form. Moreover, Hess et al. (2014) showed that large-bodied forms arrive relatively early in the run at BON compared to other body sizes. For these reasons, the geographic location and the seasonal timing of broodstock collection affect the composition of their adaptive traits.

Ocean-maturing and river-maturing forms, however, may be best described as “early-maturing” and “late-maturing” forms instead because ocean-maturing individuals are not necessarily completely ready to spawn when they move in from the ocean and the temporal timing of when they display sexual maturity appears to be heavily dependent on the specific environment. In coastal rivers/streams, this may mean that a larger portion of the ocean-maturing forms will spawn soon (i.e., a few months) after they enter freshwater, whereas a larger portion of river-maturing forms may require overwintering prior to their spawn the next spring/summer. In interior rivers/streams, on the other hand, this may mean that more ocean-maturing forms tend to overwinter only once whereas a larger portion of river-maturing forms will overwinter twice prior to their spawning (J. Nagler. University of Idaho, unpublished data). Although there appears to be a difference in their maturation stages (not necessarily a black-and-white difference, but rather a relative difference on the spectrum), how that difference manifests itself in terms of temporal timing of spawning may vary widely depending on the specific environment they reside in.

Other genetic studies using putatively neutral markers (based on microsatellites and mitochondrial DNA) have provided evidence of high range-wide gene flow and low geographic association among samples (Goodman et al.

2008; Spice et al. 2012). This suggests 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 CRB. 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 parasitic 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*** *(species does not necessarily return to its area of birth), 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."*

Courtesy of Lea Medeiros, University of Idaho

A scientist ultrasound scans and takes blood samples of Pacific lamprey to assess sex and reproductive maturation status.

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).

It is also important to understand that Pacific lamprey exhibit some detectable levels of coarse scale homing ability while still maintaining genetic cohesiveness across a large geographic area of the Pacific Northwest. For example, subtle preferences for migration routes of adult Pacific lamprey have been observed in the Columbia River, such that thousands of Snake River-origin adults can appear to return to BON after spending an average of over five years in the ocean and bypass other destinations along the way, including Willamette Falls (Hess et al. 2023). This example underscores the importance in drawing distinction between the evolutionary time scale of gene flow as indicated by genetic distance metrics (e.g., F_{ST}) versus the more recent time scale of dispersal that has been measured by Hess et al. (2023).

To illustrate this point, Hess et al. (2023) measured the rate of dispersal of Snake River-origin Pacific lamprey to the Willamette River at the falls in Oregon City and reported that 6.4% occurred there. However, most Snake River origin adults favored a route toward their natal streams, up the mainstem at BON (93.6%, Hess et al. 2023). Previously an F_{ST} of 0.002 was reported for the entire CRB supporting a single population (Hess et al. 2013). Therefore, at evolutionary time scales the Pacific lamprey population that encompasses the CRB and surrounding portions of the Pacific Northwest behaves as a single cohesive population. However, at more recent time scales, subtle differences arise such that Snake River Pacific lamprey rarely go to the Willamette River, opting instead to remain in the mainstem. These subtle differences in dispersal rates of Snake River Pacific lamprey within the Columbia River appear to have achieved sufficient gene flow to maintain a single population in the Columbia River but the near lack of dispersal outside the Columbia River has given rise to population level differences between the Columbia and a northern population in Canada (Hess et al. 2023a).

RMUs and Genetic Interpretation: Recently the USFWS (Luzier et al. 2011) divided Pacific lamprey into 17 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 data collection. Furthermore, the USFWS believes that "dividing management units into finer geographic scales would provide a more risk-averse approach for conserving Pacific lamprey." The weight of the evidence from the population genetic studies suggests 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 population abundance monitoring by establishing spatial units for characterizing how larvae/juvenile and adult abundance of Pacific lamprey is distributed through space and time and how lamprey respond to changes in habitat quality and/or quantity.

TRANSLOCATION PRACTICES

Despite some conflicting results (e.g., Lin et al. 2008), genetic studies generally indicate 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 (the collection of adult Pacific lamprey from one location and transport for release into a different location) 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 donor-stock from mainstem Columbia River dams (BON, TDA, and JDA) throughout most of the total run as opposed to relying on other tributaries (e.g., Willamette Falls). For areas of the upper Columbia River, adult Pacific lamprey have been sourced from mainstem dams at Priest Rapids and further upstream, an even more conservative approach. Pacific lamprey that migrate farthest into the interior on their own volition are also the ones that arrive relatively early in the run at BON (Hess et al. 2014).

Therefore, it is important to preserve these large-bodied adaptive variants by representing the entirety of the run in the translocation collections, including this early run. The translocation programs have been successful in maintaining the diversity found in the volitional Pacific lamprey of the interior Columbia River based on genetic results from all translocated adults genotyped to date (through release year 2022, Hess et al. 2023b). Translocated lamprey have shown minimal differences in adaptive and neutral genetic composition relative to fish that volitionally migrate to interior streams (Hess et al. 2014).

It is prudent to try to balance the conservative and cautious desire to minimize the potential for *human-mediated* changes to adaptive genetic diversity (via translocation) with a desire to maintain a "healthy" level of *natural* adaptive genetic diversity (via natural distribution). In other words, the Tribes intend to support the increase of lamprey populations while allowing natural selection to work effectively for future adaptation of the population. From the viewpoint of conservation management, Hess et al. (2012) emphasizes that, although lamprey are capable of high levels of gene flow across most of their range, it is important to maintain "local" diversity (although a suitable geographic area or scale has not yet been described).

Thus, broodstock management and collection protocols will continue to be cognizant of the need to maintain the diversity of donor-stock for translocation and artificial propagation. Similarly, the collection of donor-stock associated with lamprey translocation programs should be conducted so that it does not cause any substantial decreases in abundance in any currently occupied subbasins (Ward et al. 2012). Ultimately, even the short-term "mining" of donor-stock is expected to return dividends through a boost in abundance to all life stages of Pacific lamprey especially given the larval and juvenile production documented at areas near translocation release sites (Hess et al. 2022), as well as the thousands of returning adult offspring from translocations that have been observed at BON and upstream areas where they can be harvested (e.g., Sherars Falls, Deschutes River; Hess et al. 2023a).

CRB Pacific Lamprey Status

In 2009 the TPLRP 2011 was initiated due to continued low adult lamprey counts throughout the CRB. This fact was especially evident in 2008 when less than 9,000 adults (day-time counts) were counted at BON and just a handful in the upper basin tributaries.

5-Year Average Day-Time Counts at Bonneville, Ice Harbor and Priest Rapids Dams

5-Year Avg.	BON	IHR	PRD
2009–2013	17,273	383	4,512
2014–2019	44,681	873	11,187
2020–2024	36,466	1,460	7,001

(Fish Passage Center, www.fpc.org)

Since that time counts have improved, but not appreciatively. In fact, the 2024 counts somewhat resemble the 2009–2013 average. Some improvements since that time are noted in the upper watersheds. Much of this may well be due to the translocation programs implemented by the Nez Perce, Umatilla, and Yakama tribes.

3.8
Institutional and Regulatory Context

The current management of Pacific lamprey provides a patchwork of measures that mirrors the many jurisdictions that lamprey cross in their lifetime. This cobbled-together regulatory scheme fails to provide substantive protections to this culturally and ecologically important species (Wicks-Arshack et al. 2018, Clemens et al. 2021). As lamprey travel from their freshwater rearing areas, into marine waters and across oceans, they pass through dozens of local, state, tribal, federal, and international jurisdictions. These entities are not equally committed to protection of Pacific lamprey (Clemens et al. 2021) and disconnects between Western and Native value systems make for disjunct management (Wicks-Arshack et al. 2018).

Nevertheless, the generally consistent classification of Pacific lamprey as imperiled implies that fisheries and natural resource managers generally agree that protections for this species are needed. The following provide current listing from the Columbia Basin states and federal government:

- **U.S. Fish and Wildlife Service:** Species of Concern and Tribal-Trust Species
- **U.S. Forest Service:** Sensitive Species
- **Bureau of Reclamation:** Sensitive Species (Type 2).
- **Idaho:** Species of Greatest Conservation Need (Tier 1) and Endangered (Idaho Wildlife Classification).
- **Oregon:** Sensitive Species (wildlife species, subspecies, or populations that are facing one or more threats to their populations, habitat quantity or habitat quality or that are subject to a decline in number of sufficient magnitude such that they may become eligible for listing on the state Threatened and Endangered Species List).
- **Washington:** Species of Greatest Conservation Need and a Priority Species (require protective measures for their survival due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance).
- **PLCI:** (Depending on geographic area) Presumed Extirpated, Possibly Extirpated, Critically Imperiled, Imperiled, Vulnerable and Unrankable.

Based on treaties with the United States, the Tribes are not only entitled to harvest Pacific lamprey but are also co-managers of this species. Because Pacific lamprey are a treaty-reserved resource and a tribal trust resource, the United States is obligated to not only ensure that harvest is shared, but also that the burden of restoring Pacific lamprey is shared equally. To date, this burden has largely been via voluntary acts, with the exception of support received from the Columbia Basin Fish Accords (via Bonneville Power Administration), Pacific Lamprey Conservation Initiative, and state- and federal-led requirements for Pacific lamprey protections that are required for federal re-licensing of dams (Wicks-Arshack et al. 2018).

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3.9 Threats: Key Limiting Factors and Critical Uncertainties

The 2011 TPLRP summarized several important regional efforts that identified critical uncertainties, threats, and key limiting factors to Pacific lamprey restoration. Since that time additional efforts have identified these threats at local scales, most notably:

- Critical Uncertainties for Lamprey in the CRB: Update and Revision (Pacific Lamprey Technical Workgroup. April 28, 2011)
- Synthesis of Threats, Critical Uncertainties, and Limiting Factors in Relation to Past, Present, and Future Priority Restoration Actions for Pacific Lamprey in the CRB, (ISAB 2012–3)
- Pacific Lamprey *Entosphenus tridentatus* Assessment and Template for Conservation Measures (USFWS, 2018 and 2022 unpublished)
- Pacific Lamprey RMU Implementation Plans (18 different Plans from the 18 different regions; updated annually, or as needed)
- Clemens et al. (2017) published on conservation challenges and research needs.

We incorporate by reference the documents listed above.

For the purposes of this document, the Tribes see a "threat" as being either (1) a Key Limiting Factor or (2) a Critical Uncertainty. We draw a general distinction between these two in that a limiting factor is known to negatively impact individuals and population(s) and critical uncertainties are not well understood but could have significant impacts to individuals and population(s). In the case of limiting factors, actions are implemented to fix the issue and monitoring of the result is desired to ensure the action was effective and to support adaptive management. However, because critical uncertainties are less understood, research is needed to understand what actions to implement, while prioritizing effectiveness and efficiency.

KEY LIMITING FACTORS

As is true throughout most of the CRB, the Tribes see the hydroelectric and irrigation dams as being the greatest threat to Pacific lamprey within the region. Dams have not only led to very small (and extirpated) populations in many areas but also diminished to very little public awareness of these important fish where they once existed in great numbers.

It is well past time for the federal government and the utility districts to fix the passage issues (not just improve them) so that lamprey passage is on an even keel with the successes we see for salmon passage at all mainstem dams.

The Tribes believe that best management practices in the face of climate change are to protect and restore spawning and rearing habitats, naturally repopulate the basin, and to allow the greatest number of migrating adults to successfully reach their preferred spawning grounds. Although we appreciate the recent efforts and successes in passage that we have achieved, we have long grown weary, frustrated, and disheartened with the lack of a sufficient and urgent response by the federal government, the various utility districts and some irrigation districts that own and operate these dams.

To be clear, the Tribes consider translocation of adults and supplementation of larval lamprey as mitigation to the impacts of these dams and the other limiting factors. The Tribes do not want to continue this into perpetuity. But these are desperate times, and we consider these to be desperate and necessary actions. There is broad regional consensus that other threats to Pacific lamprey recovery include predation by invasive and non-native species, lack of awareness and understanding of the species, exposure to contaminants and bottom-disturbing activities, water withdrawals, and increasing temperature, unfavorable ocean conditions, and climate change (see threats identified for individual Regional Management Units by the Pacific Lamprey Conservation Initiative, **SECTION 6.6**).

CRITICAL UNCERTAINTIES

Regional and local threats to Pacific lamprey extend beyond the key limiting factors discussed above. Lack of knowledge (Critical Uncertainties) is also considered a threat. In most cases Critical Uncertainties are linked directly to the various limiting factors; however, without a certain level of research and/or monitoring, it is difficult to decide which restoration actions will be most effective and efficient

Over the past two decades, our understanding of Pacific lamprey biology has expanded exponentially (see next section). Where lamprey management was previously ignored, it is now the topic of entire sessions at scientific meetings. Pacific lamprey technical working groups are devoted solely to developing a better understanding of threats to lamprey and methods to recover them. These accomplishments are highlighted in **SECTION 4**, but there is still much to learn.

In **SECTION 5**, we identify important Critical Uncertainties (Research Needs) associated with each of the Limiting Factors. Long-term research, status and trend monitoring, and annual reporting to address Critical Uncertainties are the foundation of adaptive management.

Courtesy of USACE

Releasing Pacific lamprey into the water.

Courtesy of USFWS, Sarah Ortiz / CC BY-SA 2.0

Courtesy of USFWS, Sarah Ortiz / CC BY-SA 2.0

4 Regional Progress

SUMMARY Section 4 assesses progress from a policy, collaborative, and technical perspective. The following assessments focus on threats and uncertainties identified in the 2011 TPLRP but also include additional threats identified more recently by the Tribes and regional biologists.

The Tribes acknowledge substantial progress toward Pacific lamprey restoration goals since the 2011 TPLRP. We also note many deficiencies. **SECTION 4** reviews both regional progress and deficiencies since 2011. Throughout this assessment, and for simplicity, the Tribes rate progress as:

- **Good** — NO COLOR — We need to ***Maintain*** the effort.
- **Fair** — YELLOW — Improvement is needed, and we need to ***Add to the effort***.
- **Poor** — RED — If little or insignificant progress was made, and we need to ***Focus the effort*** to get it done.

Below is a summary of progress in the realm of Policy (**TABLE 1**) and regional Collaboration (**TABLE 2**). Progress to date on specific actions prescribed in the 2011 TPLRP is summarized in **SECTIONS 4.1–4.10** (below).

Courtesy of USFWS / Public Domain

Policy Progress

Progress on inclusion of Pacific lamprey in policy decisions is rated as **Fair – Good**. There are still important deficits in budgeting and staffing needed to meet the urgent needs of Pacific lamprey recovery.

TABLE 1. Examples of key Policy Progress since the 2011 TPLRP.

Policy Progress	Examples
Expansion of existing policy working groups	▪ CRITFC Lamprey Committee ▪ PLCI Policy Committee
Development of range-wide, collaborative restoration and conservation initiatives	▪ USFWS PL Assessment (2011, 2018) ▪ PLCI PL Assessment (2024) ▪ USFWS Lamprey Conservation Agreement (2011) ▪ PLCI Lamprey Conservation Agreement (2022) ▪ PLCI RMU Implementation Plans (updated annually)
Extension of existing Pacific lamprey funding to maintain and improve ongoing restoration and conservation activities	▪ USACE CRFM Lamprey Funds ▪ BPA/Tribal Accords
Identification of additional collaborative efforts and funding	▪ Hiring new PLCI Coordinator ▪ Funding: BPA (CRB), USFWS and National Fish Habitat Partnership ▪ National prestige (Washington DC influence)
Pacific lamprey supplementation, artificial propagation, aquaculture, restoration, and research plans	▪ Development (2018) and implementation of Master Plan for Pacific Lamprey Supplementation, Aquaculture, Restoration, and Research (Phase 1 – 2012, Phase 2 – 2021, Phase 3 ˆ in development) ▪ Collaboration among CRITFC member tribes, USFWS, and Great Lakes Fish Commission — funding from BPA, BOR and CCPUD
Development and implementation of Pacific lamprey focused positions and plans within local, state, federal, and tribal agencies	▪ State of Oregon: Lamprey Conservation Plan ▪ WDFW and ODFW lamprey coordinator positions ▪ Implementation of 2011 TPLRP and development of this 2025 TPLRP
Inclusion within regional and range-wide planning and environmental impact	▪ CRSO, Willamette Valley System Programmatic EIS, Hells Canyon (NPT, Idaho Power, CTUIR), NPCC F&W Program, FERC
Updates in state and federal listing of Pacific lamprey	▪ WDFW: updated to "Species of Greatest Conservation Need," USFS: updated to "Species of Conservation Concern"

Collaboration Progress

Good progress has been made on Collaboration within the region (**TABLE 2**) but funding is still limited and staffing is inadequate to meet the urgent needs of Pacific lamprey recovery in a timely manner.

TABLE 2. Examples of key Collaboration Progress since the 2011 TPLRP.

Collaboration Progress	Examples
Focused positions and plans within various agencies	▪ Coastal, Columbia, and Snake Conservation Plan for Lampreys in Oregon (Clemens et al. 2019) ▪ USFWS Lamprey Assessment (Luzier et al. 2011) ▪ USACE Pacific Lamprey passage improvements implementation plan 2008–2018; 2014 revision (USACE 2014); 2018 Columbia Basin Fish Accords Extension (USACE 2021) ▪ Designated staffs: ODFW, USFWS, USACE, CRITFC member Tribes
Outreach and education activities and products	▪ 2011 International Forum for the Propagation and Restoration of Pacific Lamprey (CRITFC member tribes) ▪ Publication of 2011 TPLRP (CRITFC member tribes) ▪ Videos: The Lost Fish; Guardians of our Future ▪ Social Media: USFWS Luna the Lamprey ▪ ArcGIS HUB StoryMap (Oregon State University) ▪ Exhibits: Oregon Zoo, High Desert Museum, Vancouver Water Resources Education Center; USACE exhibits at visitor centers ▪ MK Nature Center with adult lamprey (IDFG, NPT) ▪ Lamprey in Classroom/OSU 4-H (CTUIR, YN)
Tribal specific cultural, traditional, and ecological knowledge outreach and education	▪ Willamette Falls Lamprey Celebration (CRITFC member Tribes) ▪ Elder interviews, research (CRITFC and member tribes, Heritage University, University of WA, University of ID, Central WA University) ▪ iNature (Indigenous iNtegration of Aquatic Sciences and Traditional Ecological-Knowledge for Undergraduate Culturally Responsive Education) (NSF [funding], Heritage University [lead], various tribes and universities)
Expansion of local, regional, and range-wide development and distribution of technical Pacific lamprey information	▪ Annual Lamprey Information Exchange (PLCI) ▪ Webinars for lamprey info exchange with international participation (PLCI) ▪ Lamprey Technical Work Group— subgroups and white papers (PLCI) ▪ 2018 and 2024 Pacific Lamprey Assessment document (PLCI) ▪ Partnership for the Aquaculture of Lampreys (Pacific Northwest, Great Lakes, and international researchers) ▪ Collaboration with Ishikawa Prefecture University (Hiroaki Arakawa, intern with the YN) ▪ Lamprey Communication Committee formed to help unite the messaging from Pacific Northwest and Great Lakes Fish Commission ▪ Pacific Lamprey Habitat Restoration Guide (McNary Fisheries Compensation Fund) ▪ Native Lampreys of Oregon (ODFW, 2021) ▪ "Lamprey as Bait" flyer (SOLAR Subgroup, 2022)

(Continues next page)

TABLE 2. Examples of key Collaboration Progress since the 2011 TPLRP. *(Continued)*

Collaboration Progress	Examples
Translocation programs and other regional restoration activities	▪ Translocation: CRITFC member tribes (BPA funding) ▪ Translocation above Wells Dam: Priest Rapids Fish Forum and Aquatic Settlement Work Group, Grant County PUD, Douglas County PUD, Confederated Tribes of the Colville Reservation, Yakama Nation ▪ Translocation in the Willamette Basin: Confederated Tribes of the Grand Ronde
Supplementation, artificial propagation, aquaculture, restoration, and research plans	▪ CRITFC member tribes, USFWS, and GLFC (funding from BPA, BOR, CCPUD, and GLFC) ▪ Pacific Lamprey Master Plan (Phase 1 implemented in 2012, Phase 2 implemented in 2021, Phase 3 in development) ▪ Adult lamprey holding at Bonneville Hatchery (ODFW, BPA, USACE, CRITFC)
Media awareness of the cultural and ecological importance of Pacific lamprey (traditional and social)	▪ Various media articles addressing Pacific lamprey and importance to tribal culture and ecological importance ▪ Social media (Luna the Lamprey, YN Fisheries, NPT Lamprey Heesu, CRITFC Facebook pages, etc.)
Existing partnerships: range-wide restoration, conservation, and management	▪ Larvae/Juvenile Protection, Rescue and Research (CRITFC member tribes, USBOR, USFWS, WDFW, ODFW, Irrigation Districts, USGS, CCPUD, PNNL, WA Conservation Corps, North Yakima Conservation District, BPA, McNary Mitigation Fund, PLCI) ▪ Distribution/occupancy research (via e-fishing & eDNA) CRITFC member tribes, Confederated Tribes of the Colville Reservation, USFS, USGS, USFWS, many other entities)

Progress Towards Addressing Limiting Factors

In the 2011 TPLRP, the region's co-managers were called upon to implement actions, including monitoring and research, toward restoration of lamprey populations and their habitats. Since that time, several limiting factors have been more specifically identified (Oceans, Predation, Climate Change, and Effective Population Size and Structure) and brought forward in the 2025 TPLRP. Progress toward implementation of actions identified in 2011 has been assessed by the Tribes and is presented below.

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4.1
Progress: Mainstem Passage and Habitat

For Mainstem Passage and Habitat (TPLRP 2011, Section 4.1) the assessed progress toward **Objective 1:** ***Improve lamprey mainstem passage, survival and habitat*** (TABLE 3) is considered **Fair**. No progress has been made toward obtaining adult regional passage standards, and progress toward predation directly associated with lower river passage is insufficient.

TABLE 3. 2025 Tribal Assessment of regional progress toward actions Identified in the 2011 TPLRP: Section 4.1 Mainstem Passage and Habitat.

2025 Tribal Assessment of Progress since the 2011 TPLRP Mainstem Passage and Habitat			
2011 Action Type		**2011 Specific Action**	**2025 Assessment**
Adult Mainstem Passage	a.	Obtain accurate counts of adult lamprey passing mainstem dams	Fair
	b.	Continue to apply near-term structural improvements to known problem areas to facilitate adult passage at mainstem dams	Fair to Good
	c.	Continue to identify and implement long-term structural and operational improvements to mainstem dams to improve adult passage	Fair to Good
	d.	Continue to develop regional passage standards and metrics for adult lamprey at mainstem hydroelectric facilities	Poor
Juvenile Mainstem Passage	a.	Continue to apply near-term structural and operational improvements to known problem areas in order to facilitate mainstem passage	Fair
	b.	Increase (larval and) juvenile lamprey monitoring at dams	Poor
	c.	Utilize (larval and) juvenile tag technology and other methods to obtain route-specific passage and survival at mainstem dams	Fair
	d.	Identify and implement longer term structural and operational improvements to mainstem dams to improve juvenile passage and survival through dams and reservoirs	Poor
Mainstem and Estuary Habitat	a.	Identify lamprey life histories and impacts through temporal and spatial assessments of mainstem and estuary habitats	Fair
	b.	Evaluate and reduce avian, piscivorous, and mammalian predation	Poor
	c.	Apply PLCI Best Management Guidelines relative to mainstem dredging activities	Fair

2011 Adult Mainstem Passage *(Section 4.1.1)*

a. Obtain accurate passage estimates for adult lamprey at mainstem dams

Accurately counting adults provides a much-needed index of Pacific lamprey abundance over time (TPLRP 2011, Section 4.1.1a). The last decade has seen Fair progress in this area (TABLE 3). Improvements in adult abundance estimates included the requirement for 24-hour abundance counts at some of the mainstem dams (started in 2015 by the USACE). In addition, counts at Lamprey Passage Systems (LPS) associated with conventional fishways have been instituted and refined. Within the upper Columbia River, regional PUDs and others have modified fish ladders to eliminate dead ends and reduced unmonitored areas near counting stations to improve count accuracy. Though there have been monitoring improvements, accurate counts remain elusive. At many USACE dams, provision of final validated counts are also deferred considerably, eliminating the ability to understand or improve passage within a migration season. Recent optical counting methods show promise (Gibbons et al. 2022) for LPS lamprey counting and should be implemented at all dams to allow real-time monitoring of adult lamprey passage timing.

b. Continue to apply near-term structural improvements to known problem areas to facilitate adult passage at mainstem dams

In 2011, the Tribes specified that the most urgent threat facing Pacific lamprey was poor upstream and downstream passage survival within the CRB hydrosystem. Considering the declining returns of adult Pacific lamprey and the poor mainstem passage environment for lamprey at all life history stages, the Tribes believed that an aggressive mix of actions would be required to improve mainstem passage, survival, and habitat (2011 TPLRP, Section 4.1.1b). Keefer et al. (2013) modeled passage results from 3,250 radio-tagged adult lamprey over 10 years at BON. They found that 33% of tagged fish released downstream of BON failed to re-enter any of the fishways and that only 21% of fishway entries resulted in dam passage. The unsuccessful fish often made multiple attempts. No progress was made on recovering these "lost fish" for restoration or tribal use.

Fair (to Good) progress was made on near-term passage improvements during the past decade. A variety of minor structural alterations to fishways were identified based on studies of Pacific lamprey's limited ability to navigate high velocity locations and their tendency to congregate in blind corners and pockets within fishways (Stansell 2002; Moser et al. 2002a; Moser et al. 2006). Fixes included ramping concrete lips, rounding sharp corners, plating over diffuser grating, modifying head differentials over weirs, installing lamprey orifices and passage structures through existing serpentine weirs, restricting access to "dead ends", adding refuge areas (Moser et al. 2021), and raising picketed leads within count stations where they can be counted via alternative means (USACE 2020).

c. Continue to identify and implement long-term structural and operational improvements to mainstem dams to improve adult passage

Fair (to Good) progress was also made on larger-scale projects to improve adult lamprey passage at mainstem dams (2011

Courtesy of CRITFC

FIGURE 17. Lamprey passage ramp at Bonneville Dam.

TPLRP, Section 4.1.1c). Several LPSs were installed to provide routes past problematic areas such as serpentine weir sections of fishways (Moser et al. 2011; Moser et al. 2019a). These structures consist of a series of ramps and long metal boxes, connected to a consistent flow of water, which allow adult lamprey to efficiently ascend barriers. Currently, LPSs exist at all three BON fishways (Bradford Island, Washington Shore, and Cascades Island), one JDA fishway (North Ladder Entrance; Le et al. 2020) and one at TDA.

Other large projects included entrance modifications at JDA north entrance and Cascades and Bradford Island fishway at BON (Moser et al. 2019a). Like the structures installed by GCPUD at Priest Rapids and Wanapum Dams, these entrance modifications included a keyhole weir arrangement, velocity disrupters and an integrated lamprey-specific route (e.g., Cascades Island LPS, Figure 13).

Although additional long-term structural and operational fixes needed at mainstem dams have been identified (e.g., Johnson et al. 2012; Keefer et al. 2013a; 2013b; 2013c; USACE 2020), implementation has been hindered by maintenance schedules and overall lack of funding.

d. Continue to develop regional passage standards and metrics for adult lamprey at mainstem hydroelectric facilities

Poor progress has been made in association with this action. The CRB still lacks consistent quantitative performance standards for adult Pacific lamprey at mainstem dams (TPLRP 2011, Section 4.1.1d). In the 2011 TPLRP the Tribes recommended that adult Pacific lamprey should have fishway passage efficiencies of 80% or higher as an interim standard, like rates regularly recorded for lamprey at TDA (Keefer et al. 2009). However, 80% passage is not sufficient in the longer term. The Tribes expect passage to equal or exceed that of salmonids at all mainstem dams and other passage barriers (95–98%, Keefer et al. 2021). A subgroup of the CRB Lamprey Technical Working Group (CRBLTWG) was tasked with developing basin-wide adult lamprey passage standards and measurable/biologically-relevant metrics (2011 TPLRP). Unfortunately, this effort has not advanced past identifying guidelines for incorporating adult Pacific lamprey passage at mainstem fishways. Although adult passage efficiencies are greater than 80% at some mainstem dams (e.g., long-term adult fishway passage efficiencies of 87.4% and 89.4% at Priest Rapids and Wanapum dams; Le et al. 2020), lamprey passage standards throughout the basin are not commensurate with those of salmon, which are typically 95% or higher. Moreover, only about half of the adults that approach BON make it over (Keefer et al. 2013a; 2020). This is a huge problem, as an enormous amount of potential reproduction in the upper Columbia Basin is lost due to a lack of passage. Every adult lamprey that is denied passage contributes to extirpation of this species in the upper reaches of the mainstem Columbia, Snake, and Willamette rivers as well as interior tributaries. Pacific lamprey are known to follow large flows and large rivers/streams (Clemens and Wagner 2024) and a simple model for passage standards and dam-to-dam conversion rate metrics could be constructed using the flow attrition rates within the CRB. Furthermore, once region-wide intrinsic habitat potential models are developed across the CRB (see eBLIMP from Carim et al. 2017), the passage standards and dam-to-dam conversion rate metrics could be refined even further.

Courtesy of USACE

FIGURE 18. Larvae/juvenile lamprey entrapped in turbine water cooling screen from mainstem dam.

2011 Juvenile Mainstem Passage *(Section 4.1.2)*

a. Continue to apply near-term structural and operational improvements to known problem areas in order to facilitate larval and juvenile mainstem passage

Fair progress has been made in association with this action. Application of structural and operational improvements to facilitate mainstem passage of larval and juvenile Pacific lamprey (TPLRP 2011, Section 4.1.2a) has been minimal. The USACE now delays the installation of extended bar screens at McNary Dam (MCN) to minimize larvae/juvenile impingement; however, turbine intake screens, vertical barrier screens, and turbine cooling strainers continue to cause mortalities each year.

Unlike provisions for salmonids, spill patterns have not been modified to facilitate downstream passage of larval and juvenile lamprey. Identification of fixes for larval and juvenile lamprey requires more knowledge of route-specific mortality as well as the source of its mortality (e.g., physical contact, physiological stress, predation, dead ends, etc.). The recent miniaturization of an acoustic transmitter should advance this knowledge and studies are underway (Beals et al. 2019, Liedtke et al. 2022, Deng et al. 2021; 2023, 2025). Even where bottlenecks to larval and juvenile passage are known, lack of funding has restricted the ability to implement fixes.

b. Increasing (larval and) juvenile lamprey monitoring at dams

Larval and juvenile lamprey monitoring at mainstem dams (2011 TPLRP Section 4.2.1b) has improved in some aspects since 2011, but progress on this action is still considered Poor. For many years, larval and juvenile lamprey were found in mainstem dam bypass systems and transportation facilities used for juvenile salmon; but these lamprey were not counted or identified to life stage or species until more recently (2011 TPLRP). Opportunistic sampling of Pacific lamprey within the CRB Smolt Monitoring Program (SMP), primarily at the JDA SMP, improved the ability to monitor larvae/juvenile screen impingement/entrainment, swimming performance, and tagging feasibility. The JDA SMP collections also provided information on run timing (both seasonal and within-day), abundance indices/relative abundance, life history/life stage related migration behavior, and condition monitoring. These samples have also been used for genetic analysis and other research.

However, 24-hour SMP operations at JDA, LMN, and RIS ended in 2019–2022 and have not resumed, despite the significance of this information. Moreover, smolt bypass operations are not conducted during winter and early spring months (October — early March) when many lamprey are known to emigrate from freshwater rearing areas. Hence, studies that rely on PIT-tag detection during lamprey outmigration are hindered by the lack of winter and early spring detection (Moser et al. 2015a).

Some efforts are underway to assess what the SMP collections represent in terms of the overall population of downstream migrants passing each dam. Use of tagging with either passive integrated transponders (PITs) or acoustic transmitters will help to provide insights. However, the progress is slow given logistical challenges (limited funding to operate detectors, winter freezing temperatures, etc.) as well as priority given to salmonids (e.g., minimization of ESA-listed species "take").

c. Utilize (larval and) juvenile tag technology and other methods to obtain route-specific passage and survival estimates at mainstem dams

There has been Fair progress on identification of route-specific dam passage rates and survival for larval and juvenile lamprey (TPLRP 2011, Section 4.1.2c). Studies of PIT and visual implant elastomer tagging have helped expand use of these methods. Most recently, the USACE and Pacific Northwest National Lab (PNNL) led an effort to successfully develop an Eel-Lamprey Acoustic Tag (ELAT) which can be used to study the behavior and survival of large-bodied larvae/

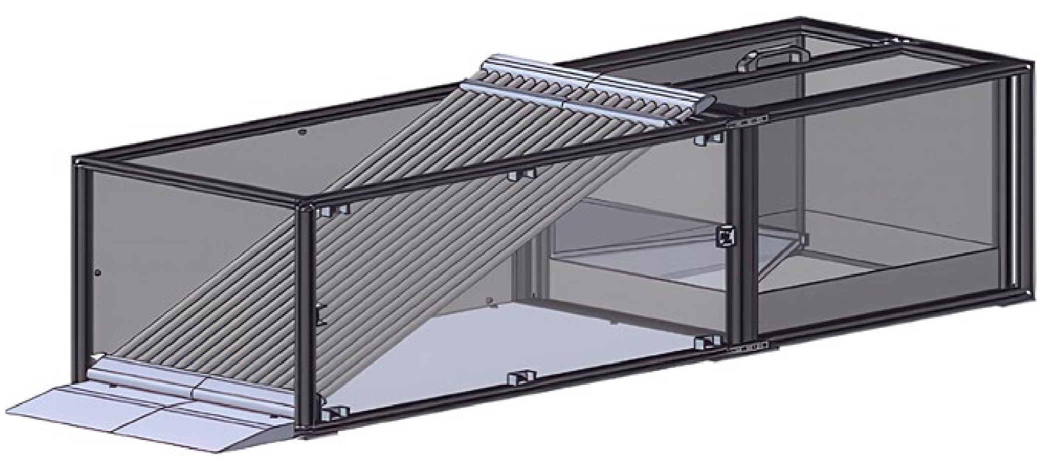


FIGURE 19. Prototype outmigration lamprey-specific collector (PNNL, unpublished data).

juvenile lamprey. This prototype ELAT was used in CRB mainstem and tributary field trials to determine its feasibility in juvenile lamprey behavior and survival studies (Beals et al. 2019, Liedtke et al. 2022, Deng et al. 2021). A regional research, monitoring, and evaluation plan for future juvenile lamprey passage investigations was also developed (Deng et al. 2021).

Although improvements have been made in juvenile tag technology and other methods to obtain route-specific passage and survival at mainstem dams, more comprehensive studies have been limited by funding constraints and difficulty in obtaining sufficient outmigrants for passage studies. Consequently, the ability to identify and fix areas that impede or kill larval and juvenile lamprey has lagged behind similar efforts for adults.

One potential impediment to work on outmigrant larvae and juveniles is the challenges in effectively and safely capturing study animals for use in these studies. The Tribes have worked in collaboration with the PNNL to obtain funding from the Department of Energy (Water Power Technologies Office) to design a novel lamprey-specific collector (**FIGURE 19**), which will help boost opportunities for juvenile lamprey collection at the hydro dam bypass facilities. In addition, designs could potentially be modified to suit collection in rivers/streams in future iterations.

d. Identifying and implementing longer term structural and operational improvements to mainstem dams to improve juvenile passage and survival through dams and reservoirs

Progress on protecting larval and juvenile outmigrants with long-term improvements at mainstem dams (TPLRP 2011, Section 4.1.2d) has lagged behind other initiatives to protect this species. Progress on this action is considered Poor. The need to reduce bar screen dimensions to protect larvae and juveniles from impingement has been known since 2001 (Moursund et al. 2001). The need to protect larvae and juveniles from impingement at bypass raceway tailscreens has been known since 2006 (Moser et al. 2015b). Mortalities at turbine cooling water strainers have been known for even longer. Remedies for these sources of mortality are costly and funding constraints have prevented much movement toward long-term protections since 2011. The USACE has developed a new prototype Turbine Unit Cooling Water Lamprey Exclusion Structure that is being installed at Ice Harbor Dam (IHR) in 2025. A cooling water strainer replacement timeline is also being developed to ultimately replace all cooling water strainers at each dam with lamprey-friendly designs.

2011 Mainstem and Estuary Habitat *(Section 4.1.3)*

a. Identify lamprey life histories and impacts through temporal and spatial assessments of mainstem and estuary habitats

There has been Fair progress toward identification of lamprey life histories and their distribution in the estuarine and mainstem habitats (TPLRP 2011, Section 4.1.3a). In 2011, temporal and spatial assessments of Pacific lamprey life history primarily came from the mainstem dam via adult passage studies. Information obtained outside of the mainstem dam environment has increased since this time. U.S. Fish and

Wildlife Service (USFWS), PNNL, and U.S. Geological Survey (USGS) monitored and evaluated larval and juvenile presence/absence and potential impacts from water-level adjustments in mainstem habitats upstream and downstream of BON and within the Willamette River, downstream from Willamette Falls. Moreover, deepwater electrofishing methods have been developed and utilized and studies of dewatering effects have recently been summarized (Beals and Lampman 2019; Liedtke et al. 2023).

Modeling efforts revealed that climate change impacts to Pacific lamprey will be highest in altered hydrographs (Wang et al. 2020). Acoustically tagged juvenile lamprey were monitored to evaluate downstream movements (Liedtke et al. 2022; Beals et al. 2019, Deng et al. 2021; 2023, 2024) and Mesa et al. (2014) completed a synthesis of larval and juvenile passage. This and the timing of lamprey entry into the estuary and ocean (Weitkamp et al. 2015) sheds light on the timing of larval and juvenile outmigration within the CRB. Although these efforts incrementally increased information related to lamprey life histories within mainstem and estuary habitats, the impacts of altered thermal regimes and reduced mainstem discharge and habitat remains unknown for all stages of life.

b. Evaluate and reduce avian, piscivorous, and mammalian predation

While there have been apparent increases in predation on lamprey of all life stages due to anthropogenic effects (TPLRP 2011, Section 4.1.3b), there has been Poor progress on this topic since 2011. Adult lamprey takes by seals and sea lions below BON have been documented during regular surveys by the Fisheries Field Unit (Keefer et al. 2012). Avian predation has been less well-documented, and PIT tags from juvenile lamprey have been recovered from bird colonies (A. Evans, Realtime Research, personal communication, 2024; Beals and Lampman 2023) and from gull stomachs collected at TDA tailrace. However, the degree to which these predators and non-native fish species (e.g., smallmouth bass, walleye, etc.) have altered natural mortality rates and the effect of this mortality at each life stage have not been evaluated for the mainstem. Recently, a predation study using molecular methods (metabarcoding and environmental DNA qPCR) was conducted in the Lower Yakima and mainstem Columbia River, shedding light for the first time on predation rates of Pacific lamprey (as well as anadromous salmonids) by key predator fish species (smallmouth bass, northern pikeminnow, largemouth bass, walleye, and channel catfish) in relation to their location and timing/seasonality (Bingham et al. 2024). In 2024, this study was successfully expanded to include samples from avian (e.g., sea gulls, cormorants) and sea lion (California and Stellar) species. Excreta samples from species that cannot be lethally removed, such as American white pelicans, were also collected experimentally to explore the utility of these samples. More studies, such as these, are needed to gain a comprehensive understanding of predation impacts as well as the means to reduce this negative impact.

c. Apply USFWS best management practices relative to mainstem dredging activities

There has been Fair progress toward applying Best Management Practices (Guidelines) to protect Pacific lamprey during mainstem dredging and dewatering

(TPLRP 2011, Section 4.1.2c). A subgroup of the Lamprey Technical Workgroup developed a document which outlines recommendations for minimizing effects of mainstem dredging (LTWG 2020a). Recommendations include placing dredge material in fast currents to dissipate sediments and allow lamprey to drift downstream or remove the top 30 cm of sediment (and lamprey) and transport it (and lamprey) downstream to areas with low to no known concentrations of predatory fishes (LTWG 2020a). If these options are not possible, larvae should be salvaged prior to or during dredging (Lampman and Beals 2019; LTWG 2020a; Liedtke et al. 2023). Very little is currently known about the impacts dredging may have on larval and juvenile lamprey, including their survival when suctioned or when sediment is deposited on top of larval lamprey habitat (T. Liedtke, USGS, personal communication, 2024). In addition, very little is being done to minimize or even assess the impacts from dredging activities in the mainstem environment.

Some progress has been made regarding the protection of larval and juvenile lamprey during dewatering operations. A summary of research conducted on this topic (Lampman and Beals 2019; Liedtke et al. 2023) provides specific recommendations for reducing the rate of dewatering, reducing larval and juvenile mortality during salvage, and basic information on larval behavior in response to dewatering events (primarily in tributary streams). Armed with this new information, it is imperative that agencies adopt these new recommendations for all mainstem and tributary dewatering projects.

4.2
Progress: Tributary Passage and Habitat

For Tributary Passage and Habitat (TPLRP 2011, Section 4.2) the assessed progress toward **Objective 2:** ***Improve tributary passage and identify, protect, and restore tributary habitat*** (**TABLE 4**) is considered **Fair**. Although good progress was made in protecting and restoring habitat, progress for larvae/juvenile and adult passage must be accelerated.

TABLE 4. The 2025 Tribal Assessment of regional progress toward actions identified in the 2011 TPLRP: Section 4.2 Tributary Passage and Habitat.

2025 Assessment of Progress since the 2011 TPLRP Tributary Passage and Habitat			
2011 Action Type	**2011 Specific Action**		**2025 Assessment**
Tributary Passage	a.	Implement structural and operational changes within tributaries to improve dult passage	Fair
	b.	Implement structural and operational changes within tributaries to improve juvenile passage	Poor
Tributary Habitat	a.	Restore and protect migratory, spawning, and rearing habitat	Fair

2011 Tributary Passage *(Section 4.2.1)*

a. Implement structural and operational changes within tributaries to improve adult passage

Progress toward this action is rated Fair, however significant progress has been made in some tributaries with regard to improving access of adult lamprey to upstream habitats in tributaries (TPLRP 2011, Section 4.2.1a). For example, fixes at River Mill Dam in the Willamette River drainage (Clackamas River) have made this structure much more permeable to adult Pacific lamprey with passage rates as high as 98% (Ackerman et al. 2019).

Quantitative indices of lamprey abundance and escapement were estimated at Willamette Falls (Clemens et al. 2023). In 2005 and 2006, radiotelemetry revealed that only 23–34% of the adult Pacific lamprey approaching the dam were able to pass over (Mesa et al. 2010). Hence, while annual abundance estimates of lamprey passing over Willamette Falls range from 27,043–127,981, nearly three to four times that number are unable to pass upstream (Clemens et al. 2023). These studies addressed the lack of population information within the Willamette subbasin, but passage problems persist across this drainage (Clemens et al. 2023).

In the Yakima and Umatilla rivers, tribal biologists have pushed for fixes at the most egregious dams and irrigation diversion structures. In the Umatilla River, this has included the removal of several particularly problematic dams (Brownell, Boyd's and Dillon dams; Jackson and Moser 2012); installation of LPS at existing dams; and restoration of minimum flows needed to achieve passage at other irrigation diversion dams. Innovative technologies such as wetted walls (Frick et al. 2017), transport tubes (Goodman et al. 2017), and 4- and 6-inch PVC volitional passage routes have been employed at several Yakima River sites (Prosser, Sunnyside, and Wapato dams) and at Lyle Falls in the Klickitat. Yet thousands of impediments to adult passage remain across the landscape within CRB.

As is the case in the Columbia River mainstem and estuary, restoration of habitat and access to it are recognized as being critical to Pacific lamprey recovery. Progress toward restoration goals in tributaries has varied by tributary, or even within tributary sub-watersheds. This has largely been a function of the piecemeal approach to habitat restoration, which is typically driven by salmon-centric goals. While restoration of habitat can benefit both lamprey and salmonids (e.g., restoration of habitat complexity and woody debris, Roni 2002; 2003), salmonid-based solutions to passage

Courtesy of CTUIR

FIGURE 20. Experimental lamprey passage structure on the Umatilla River.

problems are rarely successful for lamprey (e.g., Jackson and Moser 2012) unless lamprey passage is considered in both the planning and implementation phases (Ackerman et al. 2019, PLCI 2022).

b. Implement structural and operational changes within tributaries to improve juvenile passage

Impediments to larval and juvenile lamprey passage in tributaries (TPLRP 2011, Section 4.2.1b) have largely been ignored during the past decade; as a result, progress is considered Poor. PIT tagging has confirmed that significant numbers of outmigrant lamprey are entrained in irrigation diversions, with unknown consequences (Lampman and Beals 2019). Impingement on screens at larger dams in the Willamette subbasin is also a concern (Clemens et al. 2023).

Further study is needed to develop Best Management Practices (BMPs) for lamprey outmigrants at irrigation diversions and other water abstraction points. These may include more effective pump intake screening (D. Dedrickson, WDFW, Information Exchange 2023, pers. comm.), altering water movement to reduce entrainment (Beals and Lampman 2023), or reducing sediment accumulations that are attractive to larvae (Beals and Lampman 2019). In addition, salvage operations are often needed to rescue a large number of larvae that are entrained in irrigation canals or restoration sites that will subsequently be dewatered (Liedtke et al. 2023; J. Skalicky, Information Exchange, personal communication, 2023).

2011 Tributary Habitat

(Section 4.2.2)

a. Restore and protect migratory, spawning, and rearing habitat

Fair progress has been made in restoration of lamprey habitats in tributaries of the CRB (TPLRP 2011, Section 4.2.2a). Stream habitat restoration projects in tribal ceded areas have generally resulted in collaboration with lamprey biologists. Some positive outcomes for lamprey rearing and spawning have resulted. However, summer flows in many streams are still too low to allow adequate access to rearing habitats for larvae and passage for juveniles or adults (Moser et al. 2019a). Moreover, water management in some rivers can result in channel dewatering and larval lamprey mortality (Mueller et al. 2015; Liedtke et al. 2023). An example is the Yakima River, where reservoir sources for irrigation are switched in late summer (“flip-flopped”), resulting in extensive dewatering of backwaters and side channels occupied by larval lamprey at a much higher rate than what is observed naturally (Lampman and Beals 2019).

Although the focus is on anadromous salmonids, the majority of habitat restoration projects place importance on restoring ecosystem processes and functions (L. Bodford, USFS, Information Exchange, personal communication, 2023). These measures will help anadromous as well as resident native lamprey. Pacific lamprey and anadromous salmonids spawn in similar habitats (Gunckel et al. 2009; ODFW 2020); however, lamprey larvae require fine sediments and outmigrating larval and juvenile Pacific lamprey migrate deeper in the water column than more surface-oriented juvenile salmonids (ODFW 2020; Deng et al. 2023; LTWG 2023). Adult Pacific lamprey rely heavily on large substrate such as boulders and bedrock crevices for overwintering (Robinson and Bayer 2005; Lampman 2011; Starcevich et al. 2014). These differences in habitat requirements require different types of habitat restoration.

Although many restoration actions may benefit both lamprey and Pacific salmonids, some actions considered beneficial to salmonids may be harmful to lamprey. For example, a common restoration practice includes the creation of seasonally wetted side channels to increase larvae/juvenile salmon rearing habitats. Although these side channels may also provide habitat for larval lamprey temporarily, lamprey, along with any redds or eggs, could become stranded and desiccated when seasonal low flows result in dewatering (LTWG 2020a).

The short-term impacts during the implementation of restoration projects have not been quantified but have the potential to adversely impact lamprey. Tributary in-water work windows for instream construction are generally set during summer to minimize impacts to salmonids. These windows often do not specifically consider lamprey impacts. Lamprey larvae are present in freshwater year-round. In some watersheds lamprey spawn as late as August, so spawning and egg incubation may be occurring at construction sites. Adult lamprey may also be migrating upstream or holding during these summer construction months.

4.3 Progress: Oceans

The 2011 TPLRP did not identify oceans as a specific limiting factor. The following discussion lists several important contributions toward our understanding of the marine phase of Pacific lamprey life history. There is increasing evidence that lack of prey/feeding opportunities, bycatch mortality, and ocean conditions may be important limiting factors (Murauskas et al. 2013; Clemens et al. 2019).

With emerging tagging technology, genetic methods (parental genetics and DNA/metabarcoding), and increased attention, the trophic phase of Pacific lamprey life history is slowly becoming more understood. For example, an adult tagged with a PIT in the western Bering Sea made a transoceanic crossing, entered the Columbia River, and was detected at BON and in the Deschutes River (a migration distance of over 5,000 km, Murauskas et al. 2019). The intriguing marine phase of this and other anadromous lamprey species was recently reviewed in Clemens et al. (2019) and Quintella et al. (2021). Genetic analyses of lamprey captured in West Coast marine waters indicate that Columbia River-origin Pacific lamprey rapidly disperse from the area in spring, while lamprey from rivers south of the Columbia River largely remain along the West Coast throughout the summer and fall (J. Hess, CRITFC, unpublished data). The use of modern tools, such as DNA metabarcoding and trophic biomarkers (e.g., stable isotopes, fatty acids) are also shedding new light on Pacific lamprey feeding behavior and nearly doubled the number of known hosts (e.g., fin and humpback whales and many small-bodied fishes) (K. Frick, NOAA NWFSC, unpublished data; C. Goodfellow, Oregon State University, unpublished data).

Trawl captures indicate that Pacific lamprey are typically caught in both mid-water and bottom trawls at 30–500 m, depending on host occurrence (Clemens et al. 2019). Pacific lamprey annual counts in the CRB are correlated with peaks of annual prey abundance in the ocean, suggesting that lack of prey resources in the marine environment and/or unfavorable ocean conditions could limit lamprey abundance (Murauskas et al. 2013; Clemens et al. 2019). In addition, bycatch of Pacific lamprey in walleye pollock (*Gadus chalcogrammus*) and Pacific hake (*Merluccius productus*) fisheries, among others, could be an unmonitored threat to the species. New research to understand sources and sinks of lamprey production, critical host resources, sources of contaminants, effects of new invasions (e.g., Asian copepods; Cordell et al. 2008), and the role of climate change will supplement our understanding of threats lamprey face in the ocean and estuary.

4.4 Progress: Predation

The 2011 TPLRP did not identify predation as a specific limiting factor; rather it was included as a part of the Mainstem Passage and Habitat. The following discussion lists important contributions toward increasing our knowledge regarding predation and its role in lamprey recovery.

Efforts to reduce predation on Pacific lamprey have been minimal since 2011. Evidence of avian and mammalian predation on lamprey has been observed (e.g., Close et al. 2002, Cochran 2009, Quintella et al. 2021) but very little research has specifically focused on lamprey predation within the CRB (Clemens et al. 2017). Studies to date include bioenergetics modeling to estimate larval lamprey consumption by smallmouth bass (Schultz et al. 2017). Laboratory studies that assessed the predation potential of native and non-native species within the CRB (Arakawa and Lampman 2020), and the testing and confirmation of molecular methods to identify lamprey species within predator gut contents (Arakawa et al. 2021). A field study was initiated in 2023 in the Yakima subbasin and mainstem Columbia River to sample predator fishes using molecular methods (eDNA and DNA metabarcoding). Efforts are underway to continue this study in the mainstem Columbia River in coordination with an acoustic telemetry study between MCN and TDA in 2024 and between TDA and BON in 2025. Regional measures to reduce predation on salmonids likely benefit Pacific lamprey but this has not been quantified; it is possible that there may also be some key differences in predation patterns spatially as well as temporally and species-wide between salmonids and lamprey. In addition, active efforts to remove one type of invasive species (e.g., northern pikeminnow via the dam angling program) may potentially result in an expansion and increase in another type of non-native invasive species inadvertently (e.g., smallmouth bass) that occupy similar habitat and ecological niches. In fact, Bingham et al. (2023) concluded that northern pikeminnow preyed equally on non-native predatory fish species (e.g., sunfishes, American shad, smallmouth bass) and native fish species, whereas other non-native predator fish species (e.g., walleye) preyed predominantly on native species (such as anadromous salmonids, Pacific lamprey, and sculpin species).

4.5
Progress: Contaminants and Water Quality

The assessed progress toward **Objective 4:** ***Evaluate and reduce contaminant accumulation and improve water quality for lamprey in all life stages*** (TABLE 5) is considered Fair. Although some progress has been made in partnerships, no progress has been made in the reduction of contaminants or improvements in water quality.

TABLE 5. The 2025 Tribal Assessment of regional progress toward actions identified in the 2011 TPLRP: Section 4.4 Contaminants and Water Quality.

2025 Assessment of Progress since the 2011 TPLRP Contaminants and Water Quality			
2011 Action Type		**2011 Specific Action**	**2025 Assessment**
Contaminant Accumulation	a.	Conduct literature review on the effects of toxics on lamprey	Fair
	b.	Conduct toxicology studies and assessments in partnership with other entities	Fair
	c.	Partner with appropriate entities and forums to reduce pollutants and chemical contaminants throughout the basin	Poor
Water Quality	a.	Conduct a literature review on the effects of mainstem, estuarine and ocean water quality on lamprey	Fair
	b.	Increase water quality monitoring in the mainstem and estuary in partnership with other entities	Good
	c.	Partner with appropriate entities and forums to improve water quality throughout the basin	Poor

Evaluating and reducing contaminant accumulation and improving water quality for Pacific lamprey was identified as an important 2011 TPLRP objective. The 2011 TPLRP highlighted that the Columbia River is water quality-limited for DDT, DDE, PCBs, arsenic, mercury, and PAHs and that the prevalence of toxic pollutants in traditional and culturally important foods (e.g., Pacific lamprey) is concerning to the CRB Tribes. The 2011 TPLRP indicated that it is critical to evaluate the synergistic relationships between water quality factors such as temperature and dissolved oxygen, metals, pesticides, and other pollutants and their effects on Pacific lamprey.

2011 Contaminant Accumulation *(Section 4.4.1)*

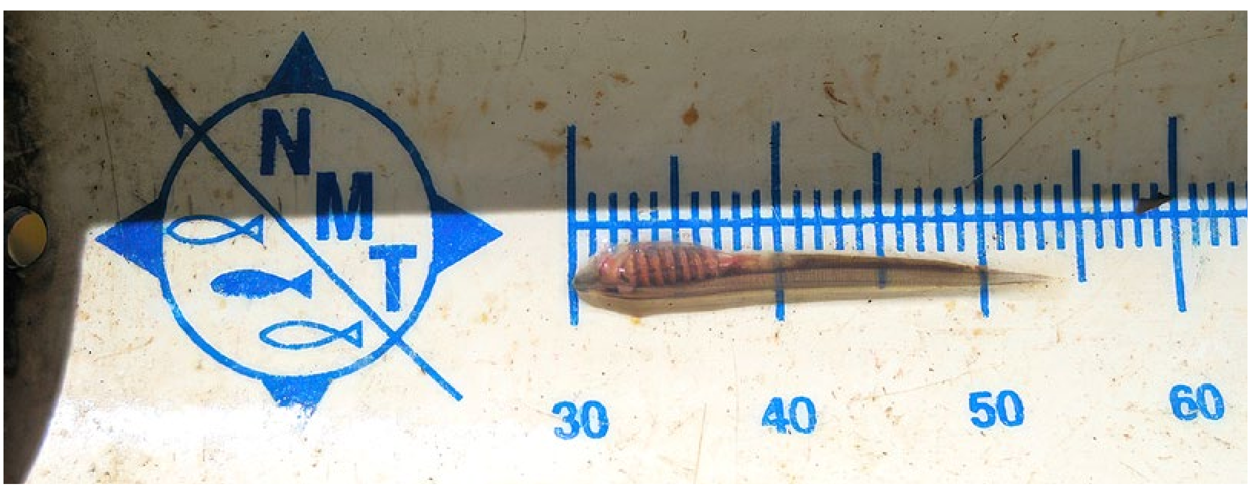
a. Conduct literature review on the effects of toxics on lamprey

Fair progress has been made for this action. Nilsen et al. (2015) developed the largest dataset of contaminants in habitats and tissues of Pacific lamprey and was the first to compare contaminant bioburden during the larval life stage to that of adults. This full literature review on contaminant loading effects on lamprey was critically needed; however, Nilsen et al. (2015) specified that there is limited data on the effects of contaminants on lamprey species, which has not changed since their review. They found that pesticides, flame retardants, mercury, and DDT in lamprey tissue were high enough to be detrimental to individual organisms. Larval contaminant levels appeared to be particularly high in the Yakima, Umatilla, and Pudding (Willamette) subbasins. Madenjian et al. (2021) conducted a worldwide synthesis study on contaminants in lamprey and concluded that they are having sublethal effects. Moreover, toxins such as mercury are higher in lamprey than other fish species. More studies on other contaminants of emerging concern need to be conducted (Madenjian et al. 2021).

b. Conduct toxicology studies and assessments in partnership with other entities

Progress toward this action is considered Fair. Nilsen et al. (2015) was a collaborative effort between USGS, CRITFC, and the CRITFC member tribes. With the existing partnerships, additional sampling occurred across Pacific lamprey life stages, but these data have not been analyzed yet.

Exposure to contemporary and legacy contaminants has profound effects on all lamprey life stages. For example, larvae had poor growth and burrowing ability in sediments collected from the Portland Harbor Superfund (Unrein et al. 2016). Jolley et al. (2012) conducted deep water electrofishing surveys within the Portland Harbor Superfund site and observed lower occupancy rates of larval lamprey there, relative to other benthic sites in the Willamette River. Linley et al. (2016a) analyzed mercury (Hg) concentrations within the fine sediment and larval lamprey tissues and concluded that these fish may have experienced and/or continue to experience lethal and sub-lethal adverse effects from Hg that constrain population recruitment. According to Linley et al. (2016b), overwintered adults at Prosser Hatchery (Yakima River) had a mercury concentration that was on average approximately six times higher than that of fresh migrants from the ocean, and vertical transmission rates of



Courtesy of USFWS / Public Domain

mercury from ripe females to eggs ranged from 4.7% to 12.8%. Smith (2012) tested the effects of environmentally relevant concentrations of Atrazine on the behavior of adult Pacific lamprey and found that these chemicals may alter perception of larval pheromones and disrupt migration behavior.

In 2022, the Oregon Health Authority (OHA) issued for the first time a health advisory that warned the public about toxic contaminants found in Pacific lamprey (OHA 2009). Lamprey tissues collected by CRITFC in 2009 were reanalyzed by the OHA utilizing a cumulative health risk approach from multiple contaminants, which subsequently resulted in the health advisory primarily due to the high concentration of mercury and polychlorinated biphenyls (PCBs). The Washington State Department of Health followed the OHA and released a consumption advisory recommendation for limiting consumption of lamprey collected in the Columbia River due to elevated PCBs and mercury that was above Washington's health-based screening value (Fish consumption update, advisory issued for Columbia River, Washington State Department of Health).

c. Partner with appropriate entities and forums to reduce pollutants and chemical contaminants throughout the basin

Progress toward this action is considered Poor. Nilsen et al. (2015) and OHA (2022) are good examples of toxicology study partnerships and water quality monitoring efforts. However, this is not enough. Little effort was expended to reduce pollutants and chemical contaminants and improve water quality throughout the CRB.

2011 Water Quality *(Section 4.4.2)*

a. Conduct a literature review on the effects of mainstem, estuarine and ocean water quality on lamprey

There has not been a comprehensive review of water quality effects on Pacific lamprey, although several recent publications have highlighted the need for such an assessment (e.g., Wang et al. 2020 and 2021; Main 2020; Moser et al. 2021, Clemens et al. 2023). Consequently, only Fair progress was made on this action.

b. Increase water quality monitoring in the mainstem and estuary in partnership with other entities

The Tribes have made Good progress toward increasing the monitoring of water quality with support from partners throughout the CRB. These efforts need to be continued and expanded to include such metrics as turbidity, nitrate concentration, and dissolved oxygen in habitats important to lamprey.

c. Partner with appropriate entities and forums to improve water quality throughout the basin

With few exceptions, efforts to improve water quality have met with Poor support from partners in the CRB. More emphasis is needed in this area to effect positive change for all life history stages.

4.6
Progress: Supplementation/Augmentation

The assessed progress toward **Objective 3: *Supplement/augment interior lamprey populations by reintroduction and translocation of adults and larvae/juvenile into areas where they are severely depressed or extirpated*** (TABLE 6) is considered **Good**. Significant progress has been made for each of the actions identified.

TABLE 6. The 2025 Tribal Assessment of regional progress toward actions identified in the 2011 TPLRP: Section 4.3 Supplementation/Augmentation.

2025 Assessment of Progress since the 2011 TPLRP Supplementation and Augmentation			
2011 Action Type	**2011 Specific Action**		**2025 Assessment**
Supplementation/ Augmentation	a.	Continue translocation in accordance with tribal guidelines	Good
	b.	Develop and implement lamprey translocation as a component of a regional supplementation plan	Good
	c.	Develop and implement lamprey artificial propagation as a component of a regional supplementation plan	Good

In 2011, the Tribes specified that the most urgent threat facing adult Pacific lamprey was surviving upstream and downstream passage through the CRB hydro system as well as tributary passage barriers. Considering the 2009–2010 adult lamprey return (19,429–23,608), especially to the interior basin watersheds (e.g., WEL Dam < 10 lamprey, LGR Dam < 110), the existing passage environment and other long-term threats, the Tribes did not believe that natural recolonization and restoration alone would be enough to halt lamprey declines.

Alternative management strategies, including translocation, propagation, reintroduction, and augmentation were proposed. As a result, the Tribes focused on augmenting interior lamprey populations by translocation of adults and outplanting of early life stages. Adult Pacific lamprey are collected at lower river dams (BON, TDA, JDA) and transferred to tribal holding facilities in summer. Adults are released into their historical range in upper tributaries, particularly where they have been extirpated or are in very low abundance. Lamprey release strategies include holding over winter until maturation or release during the first summer (no extended holding). Both strategies are monitored using parentage analysis from genetic samples of offspring. Expansion of trap and haul methods and efforts is currently being considered to employ and improve on the current methodology in the mainstem Columbia and Willamette rivers.

2011 Supplementation/ Augmentation *(Section 4.3.1)*

a. Continue translocation in accordance with tribal guidelines

Progress toward this action is considered Good. Since 2000, over 53,000 adult Pacific lamprey have been translocated by the YN, CTUIR, and NPT into interior subbasins, in close collaboration with CRITFC and in accordance with the Tribal Guidelines for Translocation (L. Porter, CRITFC, personal communication, 2025). Genetic samples obtained from larvae and outmigrant Pacific lamprey from the Snake River drainage indicated that translocations increased production by ~3% in 2017 and 2018 and that per capita juvenile production from Snake River adult translocations was higher than that of volitional migrants. Moreover, these data suggest that the translocations will eventually yield enough adult offspring to replace the annual take of adults for translocations (Hess et al. 2023b).

b. Develop and implement lamprey translocation as a component of a regional supplementation plan

Progress toward this action is considered Good. The Tribal Guidelines for Translocation were adopted in 2011 (2011 TPLRP) and revised in 2017 and 2022 to maximize tribal conservation and restoration goals. The Tribes also developed and implemented translocation as a component of the peer-reviewed Supplementation Framework and Master Plan: "Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research." These documents specify the role that translocation plays in the overall recovery of this species.

Courtesy of CRITFC

c. Develop and implement lamprey artificial propagation as a component of a regional supplementation plan

Progress toward this action is considered Good. In 2018, CRITFC, YN, CTUIR, and NPT completed the Master Plan: "Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research," which evaluates the feasibility of using artificial propagation and translocation techniques to better understand and restore Pacific lamprey throughout its range, with particular emphasis on the CRB population segment. The first release of artificially propagated lamprey occurred in spring 2021. Monitoring efforts are underway (eDNA sampling, electrofishing surveys, rotary screw trap operations, and parentage analysis of larvae) to evaluate the success of outplanted larvae produced in the hatchery and their potential contribution to natural production.

4.7
Progress: Climate Change

The 2011 TPLRP did not identify climate change as a specific limiting factor, rather included it in various other parts of the document. The following discussion lists several important contributions toward our understanding likely effects of climate change on lamprey and their ability to recover (Phase 3).

We must begin preparations to maintain our community and our natural resources. We must carry forward our culture and traditions for our tribes' future and for your own families' well-being.

For many generations, you will be challenged with a changing climate. But always remember, since time immemorial, we have looked to our elders for their wisdom and guidance, and within our children, we will always see hope.

— Shxmyah (Arlen Washines)
Yakama Nation Higher Education Programs Manager

A substantial body of knowledge has developed regarding likely impacts of climate change facing the CRB (Wang et al. 2020 and 2021). Discussions about projected effects on freshwater ecosystems are also detailed in tribal documents: Clearwater River Subbasin Climate Change Adaptation Plan, the Yakama Nation Climate Action Plan 2021, the CTUIR Climate Adaptation Plan 2022, and the CRITFC Climate Change web-based planning documents. However, the effects from climate change on Pacific lamprey remain unclear.

In the Willamette subbasin, altered hydrologic regimes are projected, including lower streamflows in September and higher incidence of spring flooding (Jung and Chang 2012). In the Yakima River, existing thermal barriers during peak lamprey migrations may be exacerbated by high spring and summer temperatures (Lampman and Beals 2015; R. Lampman, Yakama Nation, personal communication, 2025). The presence of Bateman Island at the river mouth hinders flow and further aggravates these impacts (Mueller 2017). Climate effects are observed by tribal lamprey biologists throughout the CRB, including the Snake River (L. Porter, CRITFC, personal communication, 2025; T. Sween, NPT, personal communication, 2025), the Umatilla River (A. Jackson, CTUIR, personal communication, 2025) and the Deschutes River (L. Jim, CTWSRO, personal communication, 2025).

Over just the past few decades of Pacific lamprey counts at mainstem dams, there has been a shift to earlier migration timing with increased mainstem temperature (**FIGURE 16**) and altered flow regimes (Keefer et al. 2009; O'Connor 2021; Columbia River DART). Compared to historic flow patterns, impoundment of the Columbia River has resulted in drastic reduction in flows at BON from May through early August (**FIGURE 21**; O'Connor 2021; Columbia River DART). The maximum discharge of mainstem Columbia River in recent years (1999–2023; average of 314 kcfs) has decreased on average by ~40% compared to maximum discharge 53 years ago (1946–1969; average of 519 kcfs). The average flow between June 1 and August 31 has also decreased by ~35%.

These discharge impacts will exacerbate increases in water temperatures. Based on their study, Scott et al. (2022) concluded that the increased water temperature documented

Advanced Run Timing of Pacific Lamprey at Bonneville Dam as a Result of Changed Discharge (Historic vs. Current) from May through September.

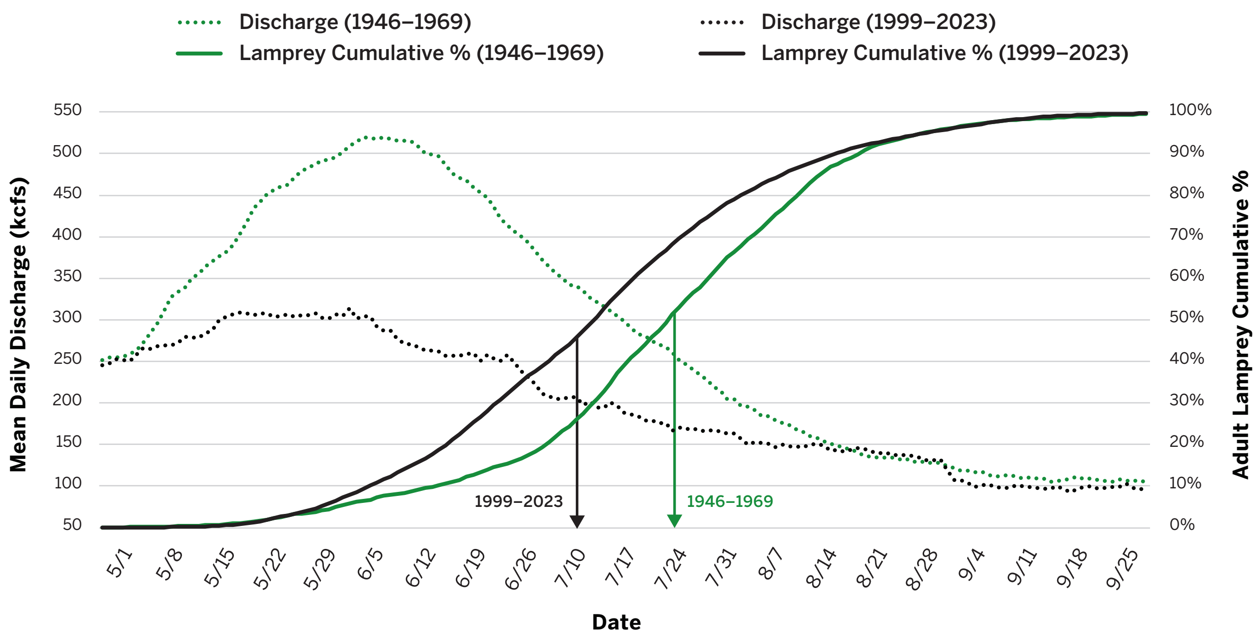


FIGURE 21. Changes in discharge and Pacific lamprey run timing at Bonneville Dam.

in the CRB appears to be driven primarily by water resource management (~57%), followed by warming air temperatures (~29%), and altered river flow (~14%). Indeed, water from winter and spring runoff is nowadays stored in the many reservoirs upstream from the dam and reduced snowpack will continue to exacerbate this effect. Lamprey is an ancient fish that has demonstrated strong resiliency to climate change (surviving five mass extinction events on earth) and studies show that larval Pacific lamprey are resilient to extremely high water temperatures (>29.0° C; Whitesel and Uh 2022; Whitesel and Sankovich 2025) that salmonids cannot withstand. Although the direct consequences of climate change for lamprey production and distribution are still unclear, the intersection of increased temperature and passage barriers is likely where the negative impacts are going to be most severe. High water temperature (generally 21–22° C and higher) are known to result in decreased adult passage (Lampman 2011; Clemens 2022; Keefer et al. 2022). Adult lamprey approach mainstem passage barriers during June-September when water temperatures approach and surpass these thresholds. Creative solutions are desperately needed to minimize the anticipated climate change impacts on adult lamprey distribution and production in the CRB.

TABLE 7, below, is a summary of the recent work accomplished by the Tribes and CRITFC in relation to climate change. All of this work is incorporated by reference including all recommendations and actions contained within these documents.

TABLE 7. Key tribal resources recently developed to address climate change.

Year	Recent CRITFC and Member Tribe Climate Change Plans and References
2011	First International Forum on the Recovery and Propagation of Lamprey (Grieig et al. 2011)
2011	Clearwater River Subbasin (Idaho). Climate Change Adaptation Plan. (Nez Perce Water Resources Division, Model Forestry Policy Program, Cumberland River Compact. December 30, 2011)
2013	Climate Change and Indigenous Peoples in the United States: Impacts, Experiences and Actions. (Maldonado et al. 2014, 2016)
2014	Framework for Pacific Lamprey Supplementation Research in the CRB
2018	Nez Perce Tribe Climate Change and Community Well Being Survey: Results and Discussion (see CRITFC website)
2018	Master Plan: Pacific Lamprey Artificial Propagation, Translocation, Restoration, and Research, CRITFC 2018
2021	Yakama Nation Climate Action Plan for the Territories of the Yakama Nation (see CRITFC website)
2022	CTUIR Climate Adaptation Plan (see CRITFC website)

Pacific lamprey and the tribal members that fish for them will undoubtedly be impacted by distribution changes, altered phenology, and a contraction in the species' range (Wang et al. 2020; 2021). The Tribes recognize the extensive ongoing work in the region, especially that of other local tribes, the University of Oregon Climate Change Research Group, University of Washington Climate Impacts Group, the PLCI, other federal agencies and the local representatives to the RMUs, to name a few. The continued research to predict climate change effects on Pacific lamprey is needed to help direct recovery efforts.

4.8
Progress: Public Outreach and Education

Progress toward **Objective 5:** ***Establish and implement a coordinated regional lamprey outreach and education program within the region*** (TABLE 8) is considered **Fair – Good**. Although good progress has been made in partnerships and networks, and progress has been made on institutional commitments, more work is needed within the non-agency and non-tribal cultures.

TABLE 8. The 2025 Tribal Assessment of regional progress toward actions identified in the 2011 TPLRP: Section 4.3 Public Outreach and Education.

2025 Assessment of Progress since the 2011 TPLRP Public Outreach and Education			
2011 Action Type		**2011 Specific Action**	**2025 Assessment**
Public Outreach and Education	a.	Establish learning networks	Good
	b.	Secure institutional and investment commitments	Fair
	c.	Communicate the importance of lamprey and the consequences of failure to act	Fair

In 2011, primary challenges to advancing lamprey restoration were (1) the lack of appreciation for Pacific lamprey and their vital role in freshwater ecosystems, (2) lack of general public awareness of their cultural importance, (3) the need to invest in lamprey restoration, and (4) the consequences of failing to act (2011 TPLRP). The 2011 TPLRP identified an objective of establishing and implementing a coordinated regional lamprey outreach and education program.

2011 Public Outreach and Education *(Section 4.5.1)*

a. Establish learning networks

Good progress has been made in this area. In recent years, CRITFC, its member tribes, USFWS, PLCI and others have presented to various schools, colleges, regional workshops, interest groups (e.g., watershed councils), federal, state, and local agencies, and the general public. These presentations have improved knowledge of lamprey status, cultural and ecological significance, and opportunities to support lamprey restoration. These learning networks have expanded to include other tribes, federal agencies, states, non-governmental organizations (NGOs), universities, and public utility districts throughout the range of Pacific lamprey (USFWS 2022).

Through the Pacific Lamprey Conservation Initiative (PLCI) and the CRB Lamprey Technical Working Group, multiple lamprey information exchanges have occurred, providing a venue for hundreds of interested participants (where until recently, there were very few). Even during the recent COVID pandemic, face-to-face information exchanges were temporarily replaced by “webinar virtual meetings” and presentations (all accessible and available online). The subjects covered have expanded to include supplementation, disease, eDNA sampling, passage, dewatering/dredging, other native lamprey species, and outreach. These meetings have garnered regional and international participation from the Great Lakes, New Zealand, Japan, Portugal, and Finland.

b. Secure institutional and investment commitments

Fair progress has been made in this area. The Pacific Lamprey Conservation Initiative (PLCI) represents a large step forward in federal government and associated partnerships commitment to Pacific lamprey recovery. The PLCI was initially funded by the USFWS and more recently by the National Fish Habitat Partnership, and has worked to secure written commitments from state, federal, tribal, and local organizations on behalf of lamprey recovery. The PLCI has also successfully developed a funding stream for Pacific lamprey-specific research and restoration actions (via BPA and National Fish Habitat Partnership). Other major funding for Pacific lamprey restoration has come from federal agencies (USACE, BPA, USBOR) and public utility districts (e.g., McNary Mitigation Fund, Chelan County Public Utility District).

Some state and federal agencies have followed tribal leadership and have secured funding for lamprey-specific positions (i.e., focused personnel) and made Pacific lamprey outreach and education a component of their respective fish and wildlife programs. However, there are still insufficient staff (both tribal and non-tribal) and insufficient funding and commitments from many entities to accomplish the work that needs to be done. Although much progress has been achieved related to outreach efforts, examples where actions directly resulted in institutional and investment commitments are still few and far between.

Many state and federal agencies have made Pacific lamprey outreach and education a component of their fish and wildlife programs. Meager yet steady regional and national funding has been added to support these outreach and education efforts. However, sufficient long-term commitments for investment in outreach and education are lacking, particularly when compared to the negative messaging stemming from sea lamprey eradication efforts in the Great Lakes. As a result, misconstrued messages can sometimes create confusion for the public about the importance of Pacific lamprey and native lampreys in general (Clemens and Wang 2021). Stemming from these concerns, a Lamprey Communication Committee, consisting of biologists, managers, and outreach specialists from

Courtesy of NPT

FIGURE 22. Outreach with the NPT.

the Great Lakes and West Coast regions was formed in 2021. This has become a formal vehicle for committee members to collaborate, discuss, and improve the respective agencies' "messaging" with a focus on the mutual goals of protecting native species and ecosystems.

c. Communicate the importance of lamprey and consequences of failure to act

Fair progress has been made in communication of the importance of lamprey and consequences of failure to act. Restoration projects highlight lamprey declines and have re-established cultural and ecological connections (e.g., school classroom and public outreach via adult translocation). This has helped to elevate regional awareness (Crandall and Wittenbach 2015). Continuing to conduct outreach and education is critical to restoration of Pacific lamprey (ODFW 2020; CRITFC 2011; Lumley and Lampman 2023). The Pacific Lamprey Conservation Initiative and the 2025 TPLRP aim to foster coordination and implementation of lamprey research and restoration projects (CRITFC 2011; Luzier et al. 2011; USFWS 2022).

Though the Pacific lamprey restoration paradigm has shifted in a positive direction in many ways, significant work throughout the CRB remains. The PLCI was initiated as a means to proactively act for lamprey conservation and restoration without a listing; however, listed ESA species continue to be prioritized over lamprey in both planning and implementation. The Tribes argue that Pacific lamprey should be granted the same level of recognition, appreciation, and respect experienced by ESA-listed species. Despite the many positive tangible impacts that the

Courtesy of CRITFC

Pacific Lamprey Conservation Agreement has provided (PLCA 2012, 2017, 2022), the Tribes maintain that the agreement lacks both urgency and accountability.

The Tribes approach lamprey conservation and restoration through a 'fisheye' lens. However, we feel that others may still be wearing their "salmon glasses." The Tribes' culture is rooted and founded on a reciprocal relationship between humans and the fishes. Without this reciprocity, the agreement is severed. Tribal connections to lamprey have suffered greatly due to extirpation or near extirpation in their historic ranges as well as in tribal homelands. For some tribes, this generation must travel long distances to exercise their treaty rights to harvest lamprey. There are still no abundance-based goals available that track lamprey recovery and abundance from past, present, to future. Without important benchmarks and clear timelines agreed upon, the Tribes feel that a lack of accountability will continue.

4.9
Progress: Effective Population Size and Structure

The 2011 TPLRP did not identify effective population size and structure as a specific limiting factor, rather identified it as a research need within Research, Monitoring and Evaluation (2011; Section 4.6.1a). Although Good progress has been made in understanding this topic, no tribal assessment is provided for this specific limiting factor. The following discussion highlights progress toward lamprey recovery and research implemented to increase knowledge of population size and structure since 2011.

Genetics

The optimization of single nucleotide polymorphism (SNP) markers in Pacific lamprey and other lamprey species has provided unique insights into lamprey population structure and basic biology (Hess et al. 2015). Additional applications have arisen with the recent panel of genotyping-in-thousands by sequencing (GT-seq) 295 SNP assays (Hess et al. 2020). This line of research is currently in progress for *Lampetra* applications as well. Whole genome sequencing of both male (gametic and somatic) and female (somatic only) genomes of Pacific lamprey was conducted to identify candidate SNP markers for sex, life-history diversity, and range-wide geographic diversity (Hess et al. 2020). Similar work is underway for *L. richardsoni* (G. Silver, CRITFC, unpublished data).

Our understanding of lamprey biology has exploded with the creation and expansion of genetic baselines for parentage and sibship identification. Insights into the success of Pacific lamprey translocation work has resulted, along with information about life history timing and residency associated with translocations. Similarly, sibship and parentage baselines for Pacific lamprey have resulted in range-wide information on sources of production, colonization rates, estimation of time at sea, and other heretofore unknowns of Pacific lamprey life history (Hess et al. 2021: 2022; 2023a).

"These biological data suggest that larger watersheds produce faster-growing larvae and that most juveniles may leave freshwater at about age 5–7. However, some larvae may linger for a decade of freshwater rearing, and after metamorphosis they could reside in the ocean for half a decade before returning to freshwater as adults, even then spending up to 2 years before spawning. Importantly, this species exhibits enough philopatry to ensure that the thousands of adults taken for the translocation program will be replaced by their returning offspring. Further, a majority of those Pacific lamprey that return to this basin will likely bypass lower-river tributaries and occur at the first main-stem dam on their way to streams in the interior Columbia River basin." — Hess et al. (2022)

FIGURE 23. Important Life History information learned from ongoing genetic research.

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Effective Population Size and Structure

The development of genetic baselines for parentage and sibship identification also permits the calculation of effective population size. Effective population size is the size of an idealized lamprey population that has the same level of genetic drift and inbreeding as the actual lamprey population (Waples 1989). It is possible to determine how effective population size changes over time using genetic markers of lamprey demographics. For example, Hess et al. (2021) used genetic stock identification, parentage, and sibship assignments to quantify the increase in successful spawners after dams in the Elwha River were removed. They found a 12-fold increase in spawner numbers that matched effective spawner populations in neighboring Olympic Peninsula subbasins. Application of these methods is now underway throughout the CRB (Hess et al. 2022).

Census of Pacific lamprey populations has also increased with improved monitoring of adults at mainstem dams, at Willamette Falls and at other structures/barriers in tributaries (e.g., Deschutes, Umatilla and Yakima rivers). Ongoing efforts to sample index sites for larval lamprey abundance have been used to assess status and map trends in Pacific lamprey occupancy (Luzier et al. 2011; Lumley et al. 2023). Innovation, improvement, and implementation of environmental DNA (eDNA) techniques and protocols have rapidly advanced regional and range-wide distribution data (e.g., Carim et al. 2017; Ostberg et al. 2019). New evidence shows that even life stages and sexes of lamprey can be detected from water samples using environmental RNA techniques (Bingham et al. 2023). These multitudes of monitoring methods, both old and new, are enhancing ways to assess lamprey status at various life stages and geographic scopes (Clemens et al. 2022); however, more work is needed to ensure they can be standardized for regional use within the CRB and across the species distribution.

4.10
Progress: Research, Monitoring and Evaluation

The assessed progress toward **Objective 6: *Conduct research, monitoring and evaluation of lamprey at all life history stages*** (TABLE 9) is considered **Fair – Good**. Although good progress has been made in partnerships and networks, as well as within the Tribes, and some progress has been made toward institutional commitments, more work is needed within non-tribal cultures.

TABLE 9. The 2025 Tribal Assessment of regional progress toward actions identified in the 2011 TPLRP: Section 4.6 Research, Monitoring and Evaluation.

2025 Assessment of Progress since the 2011 TPLRP Research, Monitoring and Evaluation			
2011 Action Type		**2011 Specific Action**	**2025 Assessment**
Research, Monitoring and Evaluation	a.	Genetics and population substructure	Good
	b.	Migratory cues	Fair
	c.	Marine life history	Fair
	d.	Natal origin	Good
	e.	Climate change	Good
	f.	Monitoring and evaluation of progress	Fair
	g.	Effective population size	Fair
Data Management	a.	Identify agency representatives and processes to develop lamprey regional data structure and data sets	Poor
	b.	Define key management and research questions to be addressed and develop consistent protocols and formats for data collection, evaluation and reporting	Fair
	c.	Define data storage approach and data dissemination protocols	Fair
	d.	Identify key entities expected to collect specific information relative to key questions and describe deficiencies, or “gaps” in long-term data needs	Poor

A primary challenge to advancing Pacific lamprey restoration was the lack of information about their basic biology, ecology, and life history (2011 TPLRP). The 2011 TPLRP identified an objective of conducting research, monitoring and evaluation of lamprey at all life history stages. The region’s co-managers did moderately well in advancing this objective. The Tribes have played a strong leadership role in research on Pacific lamprey biology and management, which is reflected in the prevalence of peer-reviewed publications that originate from tribal research efforts (see SECTION 6, Literature Cited).

The Good

Significant progress was made during the past decade in understanding the genetics and population substructure of Pacific lamprey (see SECTION 4.1). Progress is specifically noted in genetic and population substructure, natal origin and a better understanding of potential impacts associated with climate change.

Genetic baselines for parentage and sibship assignments provide information on the length of time larvae are in freshwater and juveniles are in the ocean, while microchemistry of hard body parts (eye lens and statolith) can potentially be used to identify natal origin of juveniles captured in the mainstem Columbia River and at sea. The use of these methods may lead to identification of sources and sinks of production, which are crucial information in assessing population dynamics and demographics.

Hess et al. (2023a) used parentage and sibship analysis to determine natal origin and estimate proportions of Snake River Pacific lamprey in adult collections distributed within and outside the Columbia River. Datasets that utilize sibship and parentage to determine natal origin require many, many years of genetic sampling for either juveniles (sibship) or adult candidate parents (parentage). These collections must be large enough (100s per stream) to adequately represent high proportions of families originating from each stream site. Only with substantial investment in this type of genetic sampling (i.e., routine collections of outmigrating juveniles and returning adults at multiple index sites across the species range) will this type of analysis be able to determine precise and accurate natal origins from many sources of broadly distributed Pacific lamprey.

Aside from these examples of genetic applications that deliver precise and accurate natal origin determinations with sibship/parentage analysis, there is another genetic method "(genetic stock identification": Hess et al. 2021) that can provide at least a coarse spatial scale level of natal origin information. Hess et al. 2021 divided the Pacific lamprey species range in the Pacific Northwest into five regional genetic stocks: Northern B.C. (NORTBC), Vancouver Island/Puget Sound/Lower Columbia (VIPSLC), Willamette River/Bonneville Pool (WILBON), interior Columbia River (INTCOL), and Southern U.S. (SOUTUS). Individual assignments to these five stocks can be made with moderate accuracy to provide general information at coarse spatial scales for the origin of Pacific lamprey which is useful for some applications when multiple sources of Pacific lamprey may be found as mixed stocks (e.g., in the ocean; Weitkamp et al. 2023).

The monitoring and evaluation of ongoing Pacific lamprey actions and research has improved since 2011. The PLCI coordinates an annual review of each RMU, its status and threats assessment. The CRITFC developed a framework for regional Pacific lamprey RME and a Master Plan for artificial propagation (CRITFC 2018) and a framework for regional Pacific lamprey RME.

In addition, genetic monitoring was integrated into all tribal lamprey projects and coordinated by CRITFC, which has strengthened the ability to quantify the success of various restoration and conservation actions.

Furthermore, the USFS has coordinated regional eDNA surveys for Pacific lamprey and other species as part of the "eDNAtlas" project since 2018. Several thousand eDNA samples have been taken and processed for Pacific lamprey throughout their historical range and these data have been used to help identify lamprey presence/absence and spatial and temporal habitat use (Carim et al. 2017). These data are being used to develop a regional species distribution model to predict intrinsic habitat potential for Pacific lamprey. Using a large regionally balanced and representative dataset and developed using innovative GIS software, the model will help map Pacific lamprey probability of occurrence across its entire historical range. This is expected to be available sometime in 2025 (D. Isaak, U.S. Forest Service, pers. comm., 2025).

Several multi-year projects have monitored and evaluated larval and juvenile abundance within mainstem environments, larval and juvenile downstream outmigration, and upstream spawning migration of adult Pacific lamprey (**APPENDIX 6.2**). More and more data collection for Pacific lamprey has been integrated into many existing fish and wildlife projects and programs within the CRB. The PLCI conducts regular assessments of status in individual RMUs and maintains a map of Pacific lamprey occurrence/distribution and level of risk (USFWS 2024).

Although the effects of climate change on Pacific lamprey largely remains in the realm of speculation, reasonable progress is noted. A review of climate change impacts on this and other native lamprey species predicts range contractions and changes to phenology (Wang et al. 2021). For the CRB, Sharma et al. (2017) predicted that Pacific lamprey will be adversely affected by poor ocean condition, scouring and premature emigration due to high winter flows, reduced spawning and rearing habitats in tributaries, and increased impediment to upstream migration for adults.

The interaction of tribal fishers with Pacific lamprey show that they are already being impacted severely by warming conditions and increased fire risk in the Pacific Northwest (Buck 2024). In addition, operations to collect adults at hydropower dams are halted when water temperatures are too high for fish (i.e., salmonids) handling safety and/or when air quality is unsafe (due to smoke) for tribal biologists, affecting the overall scope and capacity of the translocation restoration activities.

The Fair

Less progress has been made in understanding migratory cues, lamprey within the marine environment, development of regional monitoring and evaluation processes, elements of data storage and dissemination protocols, and estimating effective population size.

Few advances were made regarding the cues that drive Pacific lamprey migration behavior. Understanding the mechanisms of navigation and orientation are needed for all life stages to help protect downstream migrants and to aid upstream passage of pre-spawning adults. Much of this information is also very relevant to lamprey biology in the marine environment, although very little has been done in this area and it is very difficult to obtain the necessary funds to initiate this work.

However, new developments are currently underway for assessing juvenile lamprey diet and ecology in the ocean (see **SECTION 4.3**). Although data are still limited, several articles have described the migration patterns of juvenile Pacific lamprey and the key drivers appear to be flow, turbidity, as well as water temperature (Goodman et al. 2015; Mesa et al. 2015; Moser et al. 2015; Clemens and Wagner 2024) and detailed migration behavior, such as diel activity and lateral/vertical movement, by other juvenile lamprey species have also been evaluated in recent years (https://www.sciencedirect.com/science/article/abs/pii/S038013301830039X; https://animalbiotelemetry.biomedcentral.com/articles/10.1186/s40317-023-00318-1).

Adult Pacific lamprey migration is also influenced heavily by flow, turbidity, and temperature (Keefer et al. 2009; Keefer et al. 2012; Clemens and Wagner 2024) as well as other factors including lunar cycles (Lampman 2011). In addition, pheromone signals from larval lamprey appear to play a large role in adult lamprey navigation. For example, very few adult lamprey approached Wells Dam (the uppermost dam with fish passage in mainstem Columbia) between 2006 and 2016; total counts ranged between 0 and 35 and averaged only 10. When an adult lamprey acoustic telemetry study was conducted in 2016–2017, only ~25% of adult lamprey released at the forebay of Rocky Reach Dam approached Wells Dam. Results from eDNA water sampling at Wells Dam (from four locations) indicated that there was no positive detection of Pacific lamprey in 2018. Starting in 2017 adult lamprey from Priest Rapids were stocked above Wells Dam for five years (average of 390 [150–671] adults annually).

In a new acoustic telemetry study in 2022–2023, the overall approach rate to Wells Dam increased considerably to 82%. Results from eDNA sampling also showed that there were positive detections of Pacific lamprey at some of the Wells Dam sites in 2022. Interestingly, 2,449 adult lamprey passed Wells Dam in 2022, which is the highest number on record at this dam since 1999. These results, and other translocation studies, indicate that lamprey occupancy and associated larval pheromones stimulate adults to move either upstream or into a particular tributary. The role of larval Pacific lamprey pheromone may be especially important when there is no other native lamprey species present in the river/stream.

While some entities and individuals in a few areas are improving monitoring and evaluation of lamprey, a regional approach is needed and remains elusive. The same holds true for a regional approach to data storage and dissemination of information. Additionally, data on the effective population size (N_e) are still lacking for Pacific lamprey though it is recognized as a critical need for the conservation and enhancement of populations (USFWS 2018). A genetic-relatedness-based metric of effective population size was recently employed to determine how quickly Pacific lamprey may be able to recolonize a stream naturally and achieve healthy levels of abundance once passage barriers have been removed (Hess et al. 2021). Currently, many regional and range-wide assessments use this adult abundance (N) as a surrogate for N_e, because there are still no studies that estimate the ratio of N_e:N for Pacific lamprey.

The Poor

Two related elements stand out within Data Management: (1) the identification of agency representatives and processes to develop a lamprey regional data structure and data sets, and (2) the identification of key entities expected to collect specific information relative to key questions and describe deficiencies, or "gaps" in long-term data needs. In general, the region's co-managers have not done this, and it is needed. This is why the Tribes recognize the need for and call for the initiation of an adaptive management approach, as discussed in **SECTIONS 5.10** and **6.3**.

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5 Actions

SUMMARY Section 5 provides a list of actions that are urgent and necessary for Pacific lamprey recovery. **TABLE 10**, below, summarizes immediate actions that must be implemented within the next 10 years. All actions are grouped under nine major threats (**SECTIONS 5.1–5.9**). **SECTION 5.10** also discusses the need for accelerated research and monitoring and development of a regionally implemented Adaptive Management Program. This will require maintenance of a status and trend annual report and application/continued development of a life cycle model.

The Tribes understand that most of the actions discussed in **SECTION 5** will require considerable time to complete and will remain important to this document for the foreseeable future. However, many of the *specific tasks* and research and monitoring needs will change as they are completed and re-prioritized. We refer the reader to **SECTION 6.1** which consolidates all actions identified in **SECTION 5** and includes a prioritized list of *specific tasks* and research needs. These *tasks* are not intended to be a complete description but do provide significant guidance toward the implementation of each action. **SECTION 6** is considered the "living" portion of the document and is expected to change over time as new information is gained and new paths forward emerge.

As noted throughout this document, action is urgently required to restore Pacific lamprey to sustainable and harvestable population levels throughout the region. All actions identified within this document are considered by the Tribes as priority actions. However, the Tribes obviously recognize that not all actions will occur simultaneously. The Tribes consider the following actions to be of highest priority (**TABLE 10**, below). We identify these actions because (1) they are most needed, (2) we have or can obtain the technology and methods of completing them successfully and (3) they engage the entire regional community to accelerate Pacific lamprey recovery.

The Tribes recognize that many of these actions will require a great deal of effort and funding. Our intent is to become more fully integrated with local, state, and federal budgeting processes to ensure adequate resources are made available to achieve "reasonable progress" towards our vision and goals. It is important to remember, these efforts and resources will benefit many species and ecologies and will also benefit our people and their children.

TABLE 10. Priority near-term actions that must be initiated and/or implemented within 1–10 years to obtain "reasonable progress" and accelerate Pacific lamprey restoration to an acceptable level.

Near-Term Actions Supporting the 2025 TPLRP Vision and Goals

VISION: Pacific lamprey are widely distributed in the CRB and throughout their entire range in healthy, self-sustaining, harvestable numbers that fully provide for tribal traditional, cultural, ceremonial, and spiritual uses. Lamprey are safe for consumption in large quantities by all members of the community and provide important ecological services to habitats where they reside for the entirety of their lifecycle.

NUMERIC GOAL: 1 million adults passing BON and 1 million adults passing Willamette Falls by 2035. By 2050 — restore adult lamprey populations so that they can be harvested sustainably in as many historical locations locally and consumed safely in quantities historically available.

Priority Near-Term Actions	Responsible Parties	Section
1. **Secure additional and immediate research and monitoring funds** necessary to accelerate the implementation of restoration actions with greater confidence of their success.	All Parties	All Sections
2. **Increase capacity (staffing and funding)** to accelerate the implementation of restoration actions, with a focus on mainstem and tributary passage, excessive predation, and identification and cleaning of toxics in the water and sediments.	All Parties	All Sections
3. **Increase regional passage standards** for adult lamprey at mainstem dams to be **95% or higher**.	USACE, PUDs	5.1
4. **Implement LEAPP** (Lamprey Emergency Assisted Passage Program) at Columbia, Snake, and Willamette river dams.	USACE, Tribes	5.1
5. **Fix key areas that are known to impede or kill larval and juvenile lamprey at mainstem dams** (e.g., cooling water strainer screens) based on basin-wide acoustic telemetry (and other studies). Initial focus at IHR, LGR, MCN, and JDA. Options for barging must be considered if these fixes are not made immediately.	USACE, PUDs	5.1
6. **Obtain accurate annual passage estimates** for adult lamprey at all mainstem dams, including the Willamette River, and obtain highly precise passage counts for key mainstem dams to allow accurate and precise assessment of reach-to-reach conversion rates in the mainstem Columbia, Snake and Willamette rivers.	USACE, PUDs	5.1

Priority Near-Term Actions	Responsible Parties	Section
7. **Obtain annual larvae/juvenile abundance estimates** at all dams, beginning at PUD structures, LGR, LGS, MCN, BON and Willamette Falls. Provide assessment of winter run sizes at suitable facilities (e.g., JDA, BON, and/or MCN).	USACE, PUDs	5.1
8. **Install a system of passage structures** (including wetted wall, LPS, and surface collectors) at key bottleneck locations to significantly address the incidence of "lost fish" in the CRB. Focus near-term work at PUD structures and BON, TDA, JDA, MCN, and IHR.	USACE, PUDs	5.1, 5.2
9. **Apply rigorous high standards for lamprey restoration and protection to tributary environments** to ensure safe passage and connectivity across their life history.	All Parties	5.2
10. Develop models that **evaluate the effects of key host fish abundance and ocean regime changes** on lamprey.	NOAA Fisheries	5.3
11. Implement lamprey specific measures to **reduce the negative impacts of unnaturally high predation on lamprey**. Near-term focus on sea lion predation on adults concentrated below BON, juveniles and larvae predation by terns and gulls in the lower CRB, by smallmouth bass in the John Day, Umatilla, Yakima and Grande Ronde rivers, and by walleye in the mid-Columbia River. Develop/implement a basin-wide predation reduction plan.	WDFW, ODFW, IDFG, BPA	5.4
12. Partner with action agencies to **clean up contaminants** in lamprey-bearing streams.	EPA, USACE, State Agencies	5.5
13. **Continue using both adult and larval supplementation techniques** with improvements in facilities and capabilities.	Tribes, USACE, USFWS	5.6
14. **Predict or assess likely changes in regional and local lamprey habitat and distribution due to climate change** and manage adaptively. Initial focus should address effects of temperature and flow changes on mainstem adult and larvae/juvenile passage and effects of these changes on larvae in Key Index Survey Sites for each RMU.	USFWS, USFS, USBOR, USBLM	5.7
15. **Preserve Traditional Ecological Knowledge** related to lamprey and restore intergenerational lamprey culture. Through partnerships, develop a comprehensive outreach program that helps educate a variety of audiences, including students, the general public, agency staff, managers, as well as state and federal legislators.	Tribes, USFWS, PLCI, All Parties	5.8
16. Initiate, identify, maintain, and expand **baseline population monitoring at key index sites** in each RMU using genetic and population monitoring (quantification of key life stages).	PLCI RMUs	5.9, 5.2
17. **Develop and adopt a life-cycle model** (for prediction of population dynamics) **and a regional species distribution model** (for intrinsic habitat potential) that can be used to evaluate passage requirements at various dams and assess restoration progress from other (completed or proposed) actions at various temporal or geographic scales.	USGS, All Parties	5.9
18. **Initiate and develop an Adaptive Management process**, including a Status and Trend Annual Report, for the CRB according to the framework identified in SECTION 6.3.	PLCI, All Parties	5.10

5.1
Actions: Mainstem Passage and Habitat

TRIBAL OBJECTIVE

Fix passage, survival, and habitat for Pacific lamprey in the mainstem Columbia, Snake, and Willamette rivers.

PURPOSE AND NEED

The purpose of these actions is to achieve the same rate of adult and larvae/juvenile passage, distribution, and survival through the CRB as if the system were not dammed, making passage safe and high-quality habitat available to all life stages.

Impediments to passage and the mortality associated with mainstem dams are the greatest factors limiting recovery of Pacific lamprey within the CRB. Fixing adult and larvae/juvenile passage problems at all dams is urgently needed, as are abundance-based passage standards. Consistent, accurate and timely reporting of Pacific lamprey passage (24 hour) and distribution is critical to assessing population status. This includes using existing and emerging technologies to obtain and understand route-specific passage and timing for larval, juvenile, and adult lamprey. Moreover, requirements for use of Best Management Guidelines during mainstem dredging and dewatering are needed to protect larvae in mainstem rearing habitats.

BACKGROUND

The Tribes believe that poor mainstem passage/survival and lack of habitat (or access to habitat) for all life stages, are the most urgent issues facing Pacific lamprey in the CRB. These effects will be exacerbated by alterations to river mainstem hydrology and water quality caused by climate change. Addressing mainstem passage, survival, and habitat for Pacific lamprey remains the highest priority throughout the CRB (CRITFC 2018; ODFW 2022; USFWS 2022). Indeed, inadequate passage and degraded habitat limit lamprey populations worldwide (Clemens et al. 2017; Clemens et al. 2021; Moser et al. 2021).

Over the past 10–15 years much work has been done to address adult lamprey passage, however, these improvements have not markedly increased adult passage or population size in many parts of the CRB. At lower Columbia River dams, only 50–75% of the migrating adult Pacific lamprey that approach an individual dam are able to pass over (Keefer et al. 2013a; 2020). More recent PIT-tagging has produced similar results (Keefer et al. 2020). While lamprey passage efficiency at mid- and upper Columbia and Snake river dams is generally greater than 60%, it is poor relative to salmonid passage efficiency. Average salmonid passage efficiency across the eight mainstem dams in the Columbia and Snake rivers was 97% (Keefer et al. 2021). Many of the Willamette River dams represent an extreme in passage deficiency for the CRB with many providing 0% passage for adult Pacific lamprey. Due to the low abundance of Pacific lamprey in locations within the CRB upstream of BON, Willamette Falls is one of the few remaining traditional harvest locations for the Tribes. The dams of the Willamette subbasin have blocked passage of Pacific lamprey to prime habitat and have diminished the abundance of the species at Willamette Falls. Abundance at the Falls was historically estimated to be well over 1 million (with some estimates as high as 3.5 million) and commercial harvest peaked at ~200 tons or >500,000 lamprey in 1946 (Alemida et al. 2021). These dams have had other notable negative impacts including loss of spawning and rearing habitat, loss of stream sinuosity through channelization, loss of floodplain function, and introduction and retention of contaminants.

Of 100 PIT-tagged lamprey adults approaching BON, approximately 58 will make it over the dam (see **FIGURE 2**). Of those remaining, approximately 30 will make it over TDA, 22 will make it over JDA and approximately 5 will make it over MCN (Keefer et al. 2020).

Over the past decade, the Tribes and USACE have met quarterly to identify and prioritize actions needed to aid lamprey passage at mainstem dams (specific actions are summarized and included in **APPENDIX 6.1** Actions Table). Tribal biologists emphasize that novel passage solutions should be developed, tested, and implemented, including the development of structures that mimic the natural world or take advantage of behaviors and performance unique to lamprey. Unfounded concerns about effects on listed salmonids should not limit the ability to employ new solutions for lamprey.

Interim trapping and haul options below BON to reclaim the "lost fish" are viable options that support restoration of connectivity. Similar trap-and-haul efforts to source fish from Willamette Falls to move them above Willamette Valley System dams are crucial to jumpstart the Willamette subbasin productivity. The region's co-managers must develop a "culture of YES" for lamprey-related research and fixes. The lack of flexibility on the part of agencies continues to be a source of frustration for the Tribes and limits effective recovery of the species.

Passage of out-migrating larval and juvenile Pacific lamprey is poorly understood. These life stages are susceptible to impingement in water diversions or turbine screens, entrainment in diversion canals, and predation (Moser et al. 2015b). A two-year acoustic telemetry study (2022/2023) indicated that juvenile lamprey passage survival at LGR dam in 2022 was approximately 91% and in 2023 was approximately 80%. The study also found that approximately half use the spillway (vs. the turbine route) at LGR Dam (Deng et al. 2023). Given that larvae/juvenile lamprey have to pass up to nine hydroelectric dams in the mainstem Columbia/Snake river system, these losses will result in approximately 13.4%–16.8% cumulative survival to the estuary/ocean. The losses that larvae/juvenile lamprey would incur if they were to pass Willamette Valley System dams is currently unknown because data cannot be collected given their current extirpated status above many of these dams. This pilot work needs to be supported and continued at more dams in the CRB. Solutions will need to be developed, and funding dedicated to fix problem areas and ensure safe and efficient passage.

5.1.1 Important Actions for Adult Lamprey — Mainstem

5.1.1.1 Obtain accurate 24-hour passage estimates for adult lamprey at mainstem dams

Adult lamprey abundance is estimated by the USACE at Columbia and Snake river mainstem dams (BON, TDA, MCN, ICH, LGR). These counts are typically taken at salmonid count windows but are also reported for Lamprey Passage Structures, which can pass 30%–47% of the total adult lamprey escapement at BON (Gibbons et al. 2022). From mid-April to mid-November, public utility districts (PUDs) maintain 24/7 adult lamprey counts using similar methods at Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams.

There is currently no daily summary of lamprey passage available for each dam that includes night counts and LPS passage. The USACE and PUDs should implement real-time counts through the Fish Passage Center website for adult Pacific lamprey (as is the case for other species). This would allow in-season status evaluation with sufficient time for determination of annual tribal collection estimates.

In 2022, optical sensors at LPS exits were used in addition to traditional physical (paddle) count systems and this new technology demonstrated much higher accuracy (Gibbons et al 2022). Emerging count technology, including the appropriate development of artificial intelligence for lamprey counting, should be implemented at all dams.

5.1.1.2 Fix areas that are known to obstruct or delay adult lamprey at mainstem dams

The Tribes and USACE have a prioritized list of actions required to promote adult lamprey passage at known problem areas for each mainstem dam (summarized in APPENDIX 6.1). The costs of these actions are sometimes high. Funding levels must account for costs of design, review, permitting, materials, construction and inflation. As projects are delayed, costs can escalate. The USACE needs to (1) increase its staffing capacity to implement more actions, (2) secure additional funding for, and (3) move rapidly to address passage problems. Funding must be secured for ongoing operation and maintenance of structures in addition to implementing passage fixes.

A host of structural and operational changes have been implemented over the last decade to improve adult lamprey passage at mainstem dams. These changes have resulted in incremental improvements to overall passage efficiency; but, no "silver bullet" has been identified. The USACE and PUDs need to explore new strategies to promote adult lamprey passage. The Tribes urge these agencies to investigate, develop, and implement innovative and novel passage devices instead of being obstructive and overly-conservative at every turn (Tribes expect a culture of "Yes"). In addition, NOAA Passage Policy should focus on multi-species conservation and a more holistic approach to passage management, rather than the current "salmon first" mantra.

5.1.1.3 Use adult counts at dams to estimate escapement to upstream sites and losses between dams (conversion rates)

Adult Pacific lamprey counted at mainstem Columbia and Snake river dams provide an important index of abundance, escapement, and conversion rates (the percentage of adults at a mainstem dam that are counted at the next dam upstream). These counts and conversion rates provide critical information about potential passage bottlenecks, run timing relative to environmental conditions, effects of management activities, and other insights into run size and structure. Having in-season information about conversion rates will allow rapid identification of problem areas and results of management actions. The Willamette River dams do not have similar count data and staff need to be instructed to spend the time to provide these data for Pacific lamprey.

5.1.1.4 Update regional passage standards for adult lamprey at mainstem dams

In spite of fluctuating run sizes over time, adult lamprey passage efficiency at mainstem Columbia and Snake river dams has varied less than 20% during nearly a decade of consistent monitoring at these structures (Keefer et al. 2020). The development of attainable and interim (until a longer-term basin-wide standard is adopted) passage standards tailored to each dam is needed. For example, TDA historically has higher escapement than either BON or JDA. Most mid-Columbia dams report higher passage efficiency than any of these lower river dams. Fixing problem areas at lower dams is of the highest priority, as these dams control escapement to the entire middle and upper CRB (Keefer et el. 2013).

Lamprey escapement is far lower than that reported for salmonids and needs to be viewed with the same level of urgency. In addition, the metrics of successful passage have not been standardized, nor applied uniformly across the CRB. For example, passage efficiency should be defined as the number of adult lamprey that pass over a dam of those that approach the dam. Use of life cycle models to estimate escapement needed at each dam is now within our reach (D. Gomes, USGS, 2023 Lamprey Information Exchange, personal communication). Funding for such modeling efforts is urgently needed.

Courtesy of NOAA

FIGURE 24. Lamprey passage structure on mainstem dam.

5.1.1.5 Protect mainstem habitats used for migration, holding, and possible spawning

Adult lamprey can reside in mainstem migration corridors for months and even years (Moser et al. 2015a). During this time, they seek sheltering areas to hide from predators and require thermal refugia during extreme temperatures to hold station with minimal energy expenditure. Over time, they develop from the migratory phase to spawn-ready adults. Ensuring that mainstem habitat complexity is maintained will provide safe sheltering areas for adults. There may even be some marginal spawning gravels available to adults in the mainstem and these should be assessed for spawning use and protected if productive.

5.1.1 Important Actions for Larval and Juvenile Lamprey — Mainstem

5.1.1.6 Monitor dam passage and reservoir survival for larvae and juveniles using best available science

To date, very little is known about losses of larval and juvenile lamprey in the Columbia and Snake mainstems. Monitoring of mortalities at dams and of survival through reservoirs is needed. In particular, sampling of lamprey at “key” (important) salmonid bypass systems (e.g., JDA) should be extended to capture the entire lamprey outmigration period, which often peaks in winter. New information on outmigration timing could be used to focus sampling efforts on discharge events that are most likely to trigger larval and juvenile outmigration (Goodman et al. 2015). Continued monitoring with PIT and acoustic techniques should be coupled with past PIT and acoustic tagging studies to estimate losses through reservoirs and in the estuary (ala Haas et al. 2023).

5.1.1.7 Obtain annual larvae/juvenile abundance estimates

Assessment of juvenile and larval lamprey outmigration has lagged work on adult passage. Counts, measures of demographics, and disease/injury assessment are needed for larvae and juveniles at all dams, beginning at RRH, LWG, MCN, BON, and Willamette Falls. These data will provide an assessment of winter run sizes at suitable facilities (e.g., JDA) and allow for a better understanding of the relationship between adult passage success and larvae/juvenile recruitment.

5.1.1.8 Identify areas above impassable dams that would benefit from lamprey re-introduction

Dams that are impermeable to adult Pacific lamprey still exist (e.g., Willamette River dams) and reduce access to important spawning and rearing habitat. The benefits of reintroducing lamprey above these dams must be evaluated. Considerations should include the amount of functional lamprey habitat, the potential for safe downstream passage, and the amount of production that can be achieved for the least effort (greatest bang-for-the-supplementation-buck). Establishment of Pacific lamprey above these dams could also provide information needed to assess downstream passage success in these currently extirpated reaches.

5.1.1.9 Fix mainstem water diversions and screens to protect larvae and juveniles

Recent research has indicated that salmon criteria for water abstraction points (pump intake screens) will help protect large larvae and juveniles. In addition to diversion and pump screens, reengineering water diversion entrances may be critical to the reduction of entrainment and impingement at diversion sites for all size classes of lamprey (e.g., dam and hatchery water intakes).

5.1.1.10 Fix areas that are known to impede or kill larval and juvenile lamprey at mainstem dams

Protecting larval and juvenile lamprey at mainstem dams has lagged changes to protect adults. The small size of these fish has prevented route-specific tracking until recently. New information on the routes of passage and route-specific survival should be used to fix structural problems (e.g., removal of screens that impinge lamprey, installation of excluders at turbine cooling water strainers) and/or alter operations (e.g., spillway release methods) at each dam.

Tribal and USACE biologists learned that cooling water strainers kill larval and juvenile lamprey over 15 years ago. Engineered plans for excluders were developed; however, these devices have yet to be installed at any dam. This glacial pace is one of the key issues that needs to be improved. Such work must be implemented at a faster rate to protect lamprey during dam passage. The initial focus should include IHR, LGR, MCN, and JDA projects.

Courtesy of USGS

FIGURE 25. Larval lamprey on the Green River during a dewatering experiment with USGS.

If measures to protect downstream migrant lamprey are not put into place immediately, it will become necessary to start directed interim barging of these fish until sources of mortality at dams are fixed. Barging of salmonid smolts to facilitate downstream passage at dams has been an ongoing program at FCRPS. Methods to ensure the safe passage of larval and juvenile lamprey should be considered in the same way.

5.1.1.11 Document larval and juvenile lamprey in the reservoir and estuarine habitats

To date, lamprey presence in the Columbia River estuary has been observed through extremely inefficient capture methods in surveys for salmonids and by the presence of lamprey wounds on host species collected in these surveys (Weitkamp et al. 2015). To help document lamprey losses to dredging and dewatering operations, agencies conducting these activities should be required to maintain records of lamprey occurrence, injury, and mortality rates and provide these records to the Tribes and the CRB Lamprey Technical Work Group annually.

5.1.1.12 Apply Best Management Guidelines for mainstem/ estuarine dredging, dewatering, and other disturbances

The updated PLCI Best Management Guidelines (BMGs) minimize adverse effects on lamprey (LTWG 2020a) and should be incorporated into any project that involves aquatic disturbance (e.g., dredging, dewatering, habitat restoration, prescribed fire, recreational development, grazing, gravel extraction/mining, water abstraction, etc.) within the range of Pacific lamprey.

5.1.2 Critical Uncertainties and Research Needs

Along with research to improve counting methods and identify passage impediments at dams, elaboration of a Pacific lamprey life cycle model could allow testing of different passage scenarios and prediction of escapement needed at each dam to achieve abundance-based goals (D. Gomes, USGS, 2023 Lamprey Information Exchange, personal communication).

A thorough investigation into the structural and operational changes that have resulted in the greatest improvements in lamprey passage is warranted. Focus on the types of changes that result in the greatest “bang for the buck” will ensure that costly improvements result in higher adult escapement. Investigation of hydraulic conditions in fishways that function well for adult lamprey (e.g., TDA north fishway) could also provide insights. New tools, such as the use of artificial intelligence to prioritize complex systems should be employed where possible.

In addition to using new technologies to assess route-specific passage of larvae and juveniles at dams, mortality rates stemming from reservoir drawdowns, predation, dredging, impingement and/or entrainment must be documented (Lampman 2018, Liedtke et al. 2023). Studies to estimate losses from these sources of mortality (e.g., dredge spoil monitoring, acoustic tagging) are needed to determine how much of a problem these operations represent.

Understanding the relative mortality rates of all lamprey life stages in the Columbia River estuary has been thwarted by a lack of information on the temporal and spatial patterns of lamprey occupation, let alone their abundance and primary sources of mortality. A first step will be to use recently developed acoustic tagging technology to estimate the length of time that outmigrants reside in estuaries and their escapement of the estuary (as in Haas et al. 2023) and its gauntlet of predators (see **5.3 PREDATION**).

Courtesy of USACE

- **RN 5.1.2A** Continue research to obtain accurate real-time reporting of adult passage at all mainstem dams
- **RN 5.1.2B** Identify areas that obstruct or delay adult Pacific lamprey at mainstem dams
- **RN 5.1.2C** Identify and implement fixes that have the most "bang for the buck" at mainstem dams
- **RN 5.1.2D** Identify hydraulic conditions that favor adult lamprey passage (e.g., TDA north fishway)
- **RN 5.1.2E** Investigate effects of "shad mode" operation on adult Pacific lamprey (BON, TDA, JDA)
- **RN 5.1.2F** Conduct adult Pacific lamprey trap and haul feasibility study for mainstem and tributary dams of the Columbia, Snake, and Willamette rivers
- **RN 5.1.2G** Identify critical habitats used by adults for migration, holding and spawning in reservoirs and the estuary
- **RN 5.1.2H** Develop and refine larval and juvenile counting methodologies in 2–3 reservoirs and expand to entire river
- **RN 5.1.2I** Investigate new technologies to improve estimates of larval and juvenile lamprey abundance at mainstem dams (e.g., PNNL prototype collector)
- **RN 5.1.2J** Identify larval and juvenile mortality rates associated with mainstem dam passage (as in Juvenile Lamprey Study, PNNL at LGR)

Courtesy of USFWS / Public Domain

RN 5.1.2K Research the use of existing juvenile transport (e.g., barge, truck) to facilitate downstream transport of larvae and juveniles

RN 5.1.2L Evaluate efficacy of larval and juvenile transport programs

RN 5.1.2M Continue to investigate appropriate ways to dewater side channels to minimize lamprey losses

RN 5.1.2N Explore using water depth at canal intakes to keep lamprey out of irrigation facilities.

RN 5.1.2O Identify larval and juvenile mortality rates associated with mainstem dam passage (reference the Juvenile Lamprey Study, PNNL at LGR)

RN 5.1.2P Identify sources of larval and juvenile lamprey mortality in estuarine habitats

RN 5.1.2Q Investigate optimal timing of juvenile entry to the estuary

RN 5.1.2R Identify larval and juvenile mortality rates associated with mainstem dredging, water abstraction and dewatering

5.2 Actions: Tributary Passage and Habitat

TRIBAL OBJECTIVE

Fix passage problems and protect/ restore important habitats in tributaries including the Willamette Valley System dams.

PURPOSE AND NEED

The purpose of these actions is to maximize lamprey productivity in CRB tributaries by fixing impediments to adult passage, protecting larvae and juveniles from entrainment/impingement, and restoring habitat in all tributary areas important to lamprey. In all cases, restoration actions and best management practices should seek to provide natural features and hydraulic conditions.

Pacific lamprey spawn and rear in tributary streams. Recovery of lamprey, along with the recovery of many salmonid populations cannot occur without abundant, healthy, and diverse stream habitats (biologically and structurally).

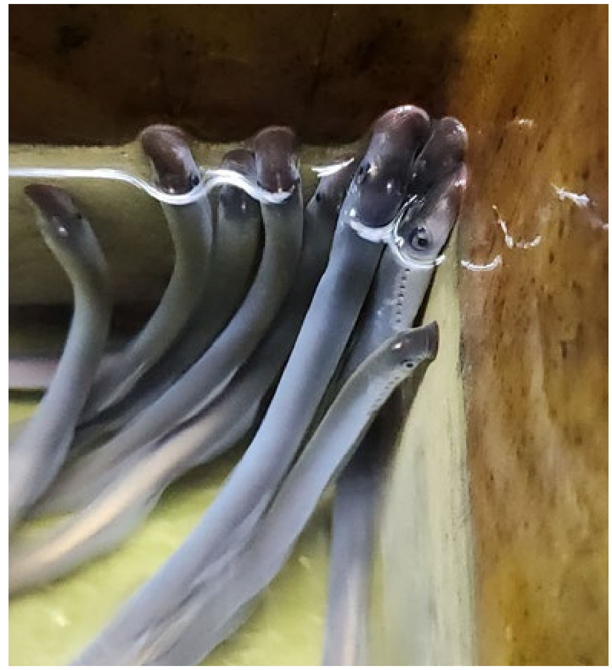
Lamprey cannot survive or thrive in these habitats if they are inaccessible due to passage impediments. For recovery to be realized, there is an urgent need for the following complementary types of actions:

- fixing barriers to adult passage to ensure access to high quality spawning habitats in tributaries,
- enhance instream flows to protect adult spawning migration and ensure adequate larvae/juvenile rearing habitat and outmigration success,
- protecting and restoring adult spawning and larval rearing habitats in tributaries,
- fixing screens at diversions to minimize or eliminate losses of downstream migrants, and
- addressing passage and maximizing survival of larvae and juveniles as they migrate downstream past dams and other facilities.

BACKGROUND

Pacific lamprey face numerous passage challenges throughout Columbia, Snake, and Willamette river tributaries including hydropower operations, storage reservoirs, and irrigation diversions. Improving lamprey passage at tributary dams and irrigation systems is imperative for lamprey numbers to increase. Impaired tributary passage has been identified as one of the main threats to lamprey survival (Luzier et al. 2011).

Upstream adult migrations are blocked by dams without suitable passage alternatives or attraction flows at 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 due to high velocities,



Courtesy of USFWS, Amanda Sheehy / Public Domain

insufficient resting areas, and lack of attachment substrate (CRBLTWG 2004; LTWG 2020b). Every effort should be made to employ nature-like features when restoring passage at such structures. The resulting hydraulic conditions will not only benefit passage of lamprey, but will restore connectivity for all species, regardless of swim performance or body size.

Fish screens designed to protect salmon can impinge or entrain larvae and juveniles (Rose and Mesa 2012; Lampman et al. 2014). In addition, thousands of unscreened, or inadequately screened pump intakes suck up larvae and juveniles resulting in unmeasured, but potentially massive, levels of mortality in tributaries (D. Didrickson, WDFW, 2023 Information Exchange, personal communication).

Flow management and dewatering also affect lamprey. 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 subbasin: Roza Dam through Wapato Dam, Tieton River to lower Naches River, and Wapato Dam to Zillah.

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. Most restoration efforts focus on restoring salmonid habitat. Larvae prefer depositional zones with a mixture of sand and fine organic matter (Type I habitats). Shifting sand that may contain gravel and other coarse substrate is acceptable (Type II), but hard packed coarse substrate, hard-pan clay and bedrock are unacceptable rearing areas. Addition of woody debris and restoration of channel heterogeneity will result in increased larval lamprey habitat (Roni 2002; 2003). While restoration of salmonid habitat may benefit lamprey by increasing habitat complexity, project managers need to be cognizant of lamprey habitat requirements and should work to incorporate these features (e.g., depositional areas, backwaters, alcoves) into habitat restoration projects.

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 larval habitat is primarily found in slow water channel margins, flow modification has the potential to heavily impact this habitat.

Determination of temperature tolerances of adults, juveniles, and larvae within the mainstem are underway and may guide flow management practices in the future. Ongoing 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.

5.2.1 Important Actions for Adults — Tributaries

5.2.1.1 Obtain accurate passage estimates of adult lamprey at tributary dams, facilities and road crossings

Dams and other barriers to lamprey passage in CRB tributaries are operated by a variety of federal (e.g., USBOR), state, and private interests (e.g., irrigation districts, small hydro operators). These barriers also present a diversity of hydraulic height, structural design, and fish passage routes (or lack thereof). Moreover, these barriers are ubiquitous across the landscape and can present significant barriers to adult lamprey passage (Jackson and Moser 2012).

Obtaining counts of adults at key points along major tributaries is needed to assess adult escapement to spawning habitats. This will require continued refinement of count methods tailored to each site. For example, there is a strong correlation between adult counts at Three Mile Falls Dam (Umatilla River) in spring and the number of adults counted at JDA during the previous summer (A. Jackson, CTUIR, personal communication, 2025). Establishing these relationships using consistent monitoring will help provide early warnings for passage failures.

5.2.1.2 Identify and implement structural and/or operational fixes at tributary dams irrigation facilities and other obstructions to adult lamprey passage

To date, structural and operational improvements to aid adult lamprey performance at low elevation structures in tributaries have been made at a handful of sites (Jackson and Moser 2012, Ackerman et al. 2019, R. Lampman, YN, personal communication, 2025). With

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the identification of particularly problematic dams, funds should be made available to either remove the barrier (e.g., Boyds Dam, Umatilla River, Jackson and Moser 2012), or provide retrofits that will fix adult lamprey passage problems (e.g., River Mill Dam, Clackamas River, Ackerman et al. 2019). In addition, maintaining minimum flows in some rivers may be required to allow passage (e.g., Clemens et al. 2023).

5.2.1.3 Implement Best Management Guidelines as described by the Pacific Lamprey TWG, particularly those that mimic features in naturally occurring bypass systems

Every effort should be made to employ nature-like features when restoring passage or rehabilitating habitat for Pacific lamprey adults. The resulting hydraulic conditions will not only benefit adult lamprey, but will restore connectivity and functionality for all species, regardless of swim performance or body size.

5.2.1.4 Monitor and implement measures that protect holding and spawning habitat in tributaries

Adult Pacific lamprey need adequate holding and overwintering habitat. For example, adults have been shown to over-winter in tributary streams, using overhanging banks and large substrate to shelter (Robinson and Bayer 2005).

Adult Pacific lamprey require shallow, clean, gravel and cobble substrate for spawning (Johnson et al. 2015). Lamprey nest surveys at index sites can help to identify high-quality spawning habitat. This habitat is sometimes found at river margins or in side channels and is therefore vulnerable to peaking operations and other artificial flow control measures. Operations that dewater side channels in spring and early summer can limit spawning habitat or destroy nests.

In-water work windows to protect salmonids can ignore lamprey spawning requirements. Hence, salmon restoration projects need to be cognizant of adult lamprey occupation, nest presence, and habitat required for spawning. As is the case for salmonids, instream activities that increase stream embeddedness and siltation (e.g., livestock access, instream construction, forestry) will limit spawning habitat for lamprey. Increased monitoring of adult lamprey habitat use can help to identify important spawning habitats that need to be protected.

5.2.1 Important Actions for Larvae and Juveniles — Tributaries

5.2.1.5 Monitor mortality of larval and juvenile lamprey at tributary dams, irrigation diversions, pump intakes, and other sources of mortality

Numbers of larval and juvenile lamprey passing downstream at tributary dams and the potential mortality at these structures is completely unknown. Tribal studies have shown that larval and juvenile lamprey are also entrained at the many irrigation dams in tributary streams (Lampman and Beals 2019). Moreover, entrainment at unscreened or inadequately screened pump intakes should be monitored to identify where lamprey mortality from these sources is highest (D. Dedrickson, WDFW, 2023 Information Exchange, personal communication).

There are currently no methods in place to estimate larval and juvenile abundance at these sources of loss. Almost 102,000 lamprey were collected from dewatered irrigation canals in the Yakima subbasin between 2011 and 2018 and nearly 47,000 were collected in 2016 alone (Lampman and Beals 2019). However, these collections were from sites immediately upstream or downstream of fish screens; numbers passing further downstream in these irrigation channels is unknown. Outmigrant lamprey typically move during high discharge events in winter (Goodman et al. 2015; Moser et al. 2015), presenting difficult and dangerous sampling challenges. Nevertheless, developing indices of outmigrant abundance could be assessed relative to mainstem juvenile bypass sampling to estimate system escapement. And methods to determine loss into irrigation canals can be conducted using electrofishing surveys behind intake screens, acoustic telemetry, PIT tagging, or experimental pump intake sampling.

5.2.1.6 Implement structural and operational fixes at areas where larval and juvenile lamprey are entrained and/or killed

For larvae and juveniles, implementing actions that reduce losses due to impingement and entrainment are needed (Rose and Mesa 2012; Beals et al. 2019). Structural fixes to reduce larval and juvenile mortality include: modification of irrigation canal intakes, use of bypass or turbine strainer screening that precludes lamprey impingement or entrainment, and replacing inadequate pump intake screens with fish safe screening (PumpRite ml-130 or Zimvent were both safe for larvae, D. Dedrickson, WDFW, 2023 Information Exchange, personal communication). Operational fixes could include altering flows or deposition areas near entrances to irrigation diversions (e.g., Flow Velocity Enhancement System, Beals and Lampman 2023) or using light or other deterrents (e.g., Haro et al. 2020).

In addition, raising screens at turbine intakes or salmon bypasses during periods of high lamprey outmigration could reduce impingement. This action might be useful at some sites. These sites should be identified, and studies should be conducted to determine the effectiveness of such actions. In addition, using information on the environmental conditions that correlate with lamprey outmigration events (e.g., high turbidity and discharge, Goodman et al. 2015) could help to ensure protections are in place during critical migration periods. Simply keeping water in irrigation canals all year, or salvaging lamprey after entrainment using BMGs may be necessary at some sites (Liedtke et al. 2023).

5.2.1.7 Protect larvae during dewatering and dredging

Maintaining minimum flows and using BMGs during dewatering events are key to protecting larval lamprey. Slowly ramping flows may allow larvae sufficient time to relocate to thalweg habitats (Liedtke et al. 2023). Planning for intensive salvage between headracks and screens during irrigation canal dewatering may also mitigate losses and help to evaluate the scale of mortality during individual dewatering events (Lampman et al. 2014). Allowing deposition of sediment that contains lamprey back into rivers and streams (i.e., relaxing Clean Water Act Section 401 constraints on dredge disposal) would save the lives of thousands of lamprey that are traditionally left to die following dewatering or dredge operations.

5.2.1.8 Increase monitoring of temporal and spatial use of tributaries by larvae and juveniles to identify actions that limit rearing habitat

Monitoring of larval lamprey needs to be extended to habitats where they are most vulnerable (e.g., side channels that are periodically dewatered, areas slated for channel rehabilitation, realignment, or log jam removal, etc.). Larval lamprey habitat and its occupants are very vulnerable to peaking operations and other artificial flow control measures. For example, in the Yakima River, flows are switched between reservoirs in late summer to accommodate irrigators ("flip-flop"). This results in rapid dewatering of side channel habitats and marginal areas where lamprey can rear (Lampman and Beals 2013).

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5.2.1.9 Develop improved restoration designs for salmonid recovery that also maximize larval and juvenile lamprey habitats and benefits

Ironically, larval lamprey losses can be high during habitat restoration efforts for salmonids (Boyce et al. 2022, Moser et al. 2022, J. Skalicky, USFWS, 2023 Information Exchange, personal communication). Attention to the distribution of Type I habitat and use of BMGs during these actions could help to reduce losses. Restoration activities that restore woody debris and river habitat heterogeneity will ultimately result in improved larval rearing habitat (Roni 2003).

Restoration activities that provide perennial off-channel habitat (e.g., side channel, backwater eddy, alcove) are especially important for larval lamprey and recently-metamorphosed juveniles (Schultz et al. 2014). These actions should be implemented to achieve higher production for both lamprey and their salmonid co-occupiers.

5.2.1.10 Accelerate the rate of actions to restore and protect riverine habitat complexity and diversity

Larval lamprey require depositional areas for rearing. Much of this optimal (Type I) habitat is found in side channels and along river margins. Actions to increase the diversity of channel morphology and restore depositional sites (e.g., wood placement, increasing channel sinuosity, restoring hyporheic flow, creating backwaters, etc.) will provide more optimal habitat for larval and juvenile rearing. Habitats needed for larval lamprey in the upper Willamette system are unknown because dams there completely block adult passage. The amount of lost productivity cannot be assessed until adults are reintroduced and habitat use/recruitment are studied sufficiently.

5.2.2 Critical Uncertainties and Research Needs

Identification of passage impediments requires expensive and time-consuming tagging (radio/acoustic telemetry or PIT) studies. Increased funding is needed to support tribal efforts to evaluate tributary dam passage and provide estimates of escapement. This would allow tribal biologists to prioritize structures for removal or retrofit (Jackson and Moser 2012, Ackerman et al. 2019). As is the case with adults, one group of tagged larvae and juveniles can potentially support passage evaluations at multiple downstream dams or water abstraction points.

Novel methods to improve upon labor-intensive salvage operations are desperately needed (Lampman and Beals 2019; J. Skalicky, USFWS, 2023 Lamprey Information Exchange) as are studies to evaluate long-term survival of salvaged Pacific lamprey larvae. Novel methods might include use of larval behavior to guide lamprey to safe areas, redesign of irrigation canal intakes to reduce entrainment, new techniques for sediment management/disposal, (e.g., relaxing Clean Water Act 401 restrictions in some cases) or use of staging areas that serve as larval refugia during dewatering.

RN 5.2.2A Research novel methods to monitor adult lamprey passage at barriers in tributaries

RN 5.2.2B Identify areas that obstruct or delay adult lamprey at tributary dams

RN 5.2.2C Identify sources of mortality for larval and juvenile lamprey at tributary dams, irrigation diversions, and pump intakes

RN 5.2.2D Research methods to improve salvage of larvae during diversion canal drawdowns and other dewatering

RN 5.2.2E Identify irrigation canals where redesign of intakes to reduce entrainment would benefit juvenile and larval lamprey

5.3
Actions: Oceans

TRIBAL OBJECTIVE

Ensure that Pacific lamprey and their hosts are protected in the estuary and ocean and improve water quality and reduce (eliminate) contaminants.

PURPOSE AND NEED

This is a new action not included in the 2011 TPLRP. Research in the last decade has revealed that threats to Pacific lamprey in their marine phase may significantly limit lamprey populations or their availability for tribal consumption (due to contaminant body burdens). More information about this poorly understood phase of lamprey life history is critically needed including: identification of the prey species that lamprey rely on most, the contaminant levels in those prey, long distance migratory movements, genetic structure, and how climate change will alter ocean trophic structure and affect Pacific lamprey survival and growth at sea.

BACKGROUND

Until recently, very little was known about the threats facing Pacific lamprey in the estuary and at sea. Lamprey abundance is apparently tied to that of their primary hosts (Murauskas et al. 2013) or to unfavorable ocean conditions (Clemens et al. 2019). Hence, it is critical to understand this major part of lamprey life history that heretofore has been a mystery. Pacific lamprey may be regularly captured as bycatch in industrial fisheries at sea and their burden of contaminants may be elevated by feeding on certain contaminated prey. Clemens et al. (2019) specified seven marine-related limiting factors or threats to Pacific lamprey during their trophic phase. Here we have winnowed these research needs to those that will most inform recovery of lamprey abundance and threats that restrict harvest (e.g., contaminant levels).

Weitkamp et al. (2023) found that most Pacific lamprey bycatch occurs in the midwater trawls fishing for Pacific hake. The lamprey captured are typically < 300 mm and occur along the continental shelf break from northern California to northern Washington. The observers on at-sea trawlers targeting Pacific hake measure and weigh all lamprey that are caught. They are trained in identification of both Pacific and western river lamprey, but 99% of the lamprey caught are Pacific lamprey. There is typically insufficient time or staffing to record the type of scarring, but observers are able to take pictures (L. Weitkamp, NMFS, personal communication 2025). Similarly, observers are able to take data on the condition of lamprey that occur in the fishery (dead, barely alive, lively) and their fate (thrown overboard or into fishmeal bins) as time and interest allows. Given that CRB Pacific lamprey spend approximately half of their life (4–7 years) in the ocean (Hess et al. 2022), NOAA should take more responsibility for managing this tribal trust species, adopting the much-needed accountability for its protection in the ocean, as well as freshwater.

5.3.1 Important Actions

5.3.1.1 Document and estimate bycatch mortality or other fishery effects on Pacific lamprey

Pacific lamprey are not fished commercially in the ocean or estuary, but they are captured as bycatch when attached to targeted host species (e.g., Pacific hake and walleye pollock). This is a largely unmonitored source of potential mortality (and ocean movement) for this species. Fishery observers should record condition of Pacific lamprey captured and the freshness of scars that they observe on hosts to estimate the magnitude of bycatch as well as direct and indirect mortality (e.g., loss of host, exposure to predation).

5.3.1.2 Monitor availability of hosts

Pacific lamprey feed on a diverse array of fish and marine mammals (Quintella et al. 2021). This suggests that lamprey are opportunistic and rely on local availability of suitably large-bodied species. Understanding the relative importance of various hosts is now within reach thanks to the emergence of DNA metabarcoding methods that could allow identification of host species, in addition to stable isotopic analyses to place hosts in the ocean's trophic hierarchy.

5.3.1.3 Monitor contaminant body burdens of important Pacific lamprey hosts and whether this is a significant route of exposure for Pacific lamprey

Host quality can also be affected by high levels of contaminants in the blood and body fluids of hosts. Lamprey feed at the top of the food chain and are very susceptible to bioaccumulation of contaminants. Improved understanding of the sources of contaminants, either in hosts or in the marine environment, is needed.

5.3.1.4 Monitor pathogens of important Pacific lamprey hosts and their effects on Pacific lamprey

Host quality is also potentially affected by pathogens that hosts harbor. While adult Pacific lamprey captured in freshwater appear to be relatively free of many common fish pathogens (Jackson et al. 2019), it is possible that large losses of lamprey occur in the ocean when they are exposed to marine pathogens and die prior to freshwater return. A better understanding of potential marine pathogens and their effects on Pacific lamprey is needed.

5.3.1.5 Continue to employ existing technology (PIT tagging) or emerging tools (acoustic or pop-off tags) to determine migration routes and behavior of Pacific lamprey in the ocean

The distance, timing, and specific routes of Pacific lamprey in the ocean are unknown. This information is needed to inform management, understand lamprey exposure to threats, and allow for prediction of effects stemming from climate changes. In the case of one individual, use of PIT tagging has successfully demonstrated the extent of Pacific lamprey movement at sea (Murauskas et al. 2019). More PIT tagging studies could help to illuminate these patterns, as well as close kin mark recapture analyses using genetic baselines of siblings and parents (Hess et al. 2023a). In addition, miniaturization of acoustic and pop-off satellite tags may eventually allow for more detailed migration tracking.

5.3.2 Critical Uncertainties and Research Needs

The distribution of Pacific lamprey at sea and their ability to transition between hosts successfully is poorly understood. Consequently, it is difficult to predict the effects of changing ocean conditions and the level of threat that these changes pose to lamprey and their hosts. Will lamprey be able to adapt and switch to new host resources in the face of changing host availability? Will lamprey be directly affected by ocean conditions that create hypoxic zones, temperature anomalies, inundated estuaries, or areas of decreased food web productivity? What important hosts will become unavailable? How will these changes affect Pacific lamprey growth and survival at sea? Will shifts in copepod community structure (Cordell et al. 2008) affect lamprey? Are there stock specific differences in distribution, prey use, or behavior at sea?

RN 5.3.2A Estimate both direct and indirect mortality of Pacific lamprey that results from fishery bycatch

RN 5.3.2B Continue to research the distribution and population genetics of Pacific lamprey at sea

RN 5.3.2C Characterize the stock-specific marine distribution, prey preferences, and migration patterns in the ocean

RN 5.3.2D Identify important feeding areas and how lamprey get to and from them (long distance migration movements)

RN 5.3.2E Study the effects of marine pathogens on Pacific lamprey in the laboratory

RN 5.3.2F Increase understanding of how oceanographic regimes and climate change affect distribution, host use, and survival of lamprey at sea

RN 5.3.2G Model effects of major ocean regime changes on important host species for Pacific lamprey

RN 5.3.2H Develop and implement a research plan to determine effects of alternative energy developments (e.g., wave energy facilities) on Pacific lamprey

5.4 Actions: Predation

TRIBAL OBJECTIVE

Monitor, evaluate, and control excessive bird, fish, and mammal predation.

PURPOSE AND NEED

The purpose of these actions is to address, control, and where necessary, eliminate excessive predation on Pacific lamprey, especially in areas where they are most vulnerable. Although lamprey are adapted to natural levels of predation and normally occurring groups of predators at all life stages, widespread modifications of our waterways have substantially increased "human induced" predation.

The value of many recovery actions is greatly diminished if excessive predation continues. Adults returning from the ocean are very vulnerable to predation by marine mammals in front of BON. Larval and juvenile lamprey are very vulnerable to birds, especially in the lower river and below the dam powerhouse and spillways. Introduced fish species that support sport fishing are known to feed on larvae/juvenile lamprey, often at excessive levels (Schultz et al. 2017; Arakawa and Lampman 2020). To support lamprey recovery, the need to understand and manage predation is great, as this threat is widespread and urgent.

BACKGROUND

Sources of natural mortality for Pacific lamprey of all life stages include predation by birds (avian), fish, and mammals. While lamprey are adapted to natural levels of predation and normal arrays of predators, human-induced changes can result in unnaturally high predation. Introduced fish predators, such as smallmouth bass, are poised to become even more significant sources of lamprey mortality. Known to occupy larval, juvenile and adult Pacific lamprey habitats, smallmouth bass are voracious predators and, with predicted climate change effects, may increase their range by two-thirds, thereby occupying up to 30,000 river kilometers in the Columbia Basin by 2080 (Rubenson and Olden 2020).

Avian, fish, and mammalian predators are attracted to concentrations of both juvenile and adult Pacific lamprey at dams on both the Columbia River mainstem and its tributaries. At mainstem dams, adult lamprey congregating below the dams are exposed to abnormally high mammalian (e.g., California sea lions [*Zalophus californianus*] and Steller sea lions [*Eumetopias jubatus*] and fish (e.g., white sturgeon [*Acipenser transmontanus*]) predation. Juveniles and larvae are exposed to avian and fish predators as they pass over spillways and become entrained in boils at the surface.

In tributaries, smaller dams function in the same way by exposing adult lamprey to congregations of wading birds and mammals (e.g., river otters, minks, and bears). In the Willamette River downstream from Willamette Falls, an average of 493–1,254 adult lamprey are consumed annually by California sea lions, which is estimated to be 0.1–1.1% of the total adult Pacific lamprey abundance in that tributary (Clemens et al. 2023). There is a clear need to understand the impacts of human-induced predation on Pacific lamprey, its timing and the locations and life stages most at risk. This information will allow actions to correct increased predation on Pacific lamprey that stem from anthropogenic actions.

5.4.1 Important Actions

5.4.1.1 Develop and implement long-term programs necessary to reduce excessive predation on lamprey adults and juveniles/larvae

Predation on lamprey life stages during migration (pre-spawning adults and emigrating juveniles) is the most immediate and obvious need. Regional partners need to be engaged to elevate this priority and establish long-term and lasting solutions to curb excessive predation. This may include provision of refuge areas, predator blocking, relaxation of fishing restrictions on non-native predators, and/or their removal.

5.4.1.2 Monitor for timing, location, life stage and natal origin most affected by unnaturally high predation

The first step in reducing significant predation effects on Pacific lamprey is to understand where and when each life stage is most vulnerable to unnaturally high predation. Evaluation of the location and timing of lamprey mortality can be achieved via gut content analysis of potential predators for lamprey parts (e.g., McHugh et al. 2012, Schultz et al. 2017) or DNA (e.g., Shink et al. 2019, Arakawa et al. 2021; Bingham et al. 2024), by conducting experimental exposures to various predators (e.g., Porter et al. 2017, Arakawa and Lampman 2020; Bingham 2024) and/or by observing predation events (e.g., visual observations of sea lion predation at BON). PIT detection on bird colonies can also help to identify avian predators.

Unnaturally high predation on larvae occurs in small streams where they may be exposed to non-native species or flushed from suitable habitat and exposed to predators during altered hydraulic conditions, dewatering, entrainment, or dam passage. Larvae/juvenile and adult lamprey are exposed to unnatural predator aggregations during anadromous migrations. And changes in marine fisheries management can increase abundance or density of lamprey predators in the ocean and could have profound effects on survival of these life stages.

5.4.1.3 Control or eliminate unnaturally high predator impacts on Pacific lamprey

Actions to reduce sources of anthropogenic predation could include predator blockage (e.g., overhead wires over spillway boils to limit bird access to lamprey) or removal (e.g., sea lion removals at BON) in locations and at times when they are most destructive. Other alternatives include providing artificial shelter (e.g., lamprey refuges in fishways, Moser et al. 2021) or habitat complexity to allow lamprey to successfully evade predators (Jones et al. 2020).

Proliferation of non-native predators is a difficult and often a contentious topic. Information on predation risks to lamprey and salmonids could be used to support the loosening of regulations on sport fisheries (e.g., smallmouth bass, walleye) and/or efforts to provide refugia from or eliminate smallmouth bass (and other fish predators) from specific areas where species overlap and associated risks are high.

5.4.2 Critical Uncertainties and Research Needs

A major challenge in justifying actions to control predation is the ability to separate natural mortality (e.g., consumption of lamprey eggs by co-occurring native stream species) from those caused by human intervention (e.g., consumption of larvae by non-native smallmouth bass). Moreover, it is important to understand the overall potential for predators to limit lamprey populations. For example, is the loss of adult Pacific lamprey to sea lions significant enough to warrant actions to reduce it?

This type of evaluation will require modeling efforts to examine lamprey mortality under different scenarios of predator abundance/density and the timing of exposure. For example, Schultz et al. (2017) modeled the potential impacts of smallmouth bass on lamprey by using bioenergetic models, coupled with gut content analysis in a single stream. Similarly, Jones et al. (2020) measured larval lamprey habitat overlap with smallmouth bass and were able to predict the effects of climate change on the degree of overlap (and therefore lamprey mortality) from this single introduced predator.

RN 5.4.2A Identify the key predator species that contribute to unnaturally high predator impacts and proscribe effective solutions for Pacific lamprey

RN 5.4.2B Quantify predation (i.e., number of lamprey mortalities) by the key predator species to estimate the overall "take"

RN 5.4.2C Assess key locations where unnaturally high predation occurs

RN 5.4.2D Evaluate key timing (season, time of day) when unnaturally high predation occurs

RN 5.4.2E Identify potential solutions for curbing predation impacts and evaluate their efficacy

5.5 Actions: Water Quantity, Quality and Contaminants

TRIBAL OBJECTIVE

Evaluate and significantly reduce (eliminate) contaminant accumulation and improve water quality and quantity for all lamprey life stages.

PURPOSE AND NEED

The purpose of these actions is to strengthen Pacific lamprey restoration and conservation efforts by improving the aquatic environment (water quantity and quality) and reducing contaminant accumulation in Pacific lamprey and our riverine habitats.

There remains a great need to strengthen and expand our partnerships, to update water quantity (flow), water quality and contaminant information, and to immediately reduce and eliminate pollutants and contaminants in our waterways. In many areas throughout the CRB, we are misusing and abusing the very resources we all depend and thrive upon. This will require additional monitoring in many parts of the basin along with innovative actions to clean areas already contaminated and capture pollutants before they enter the water. Climate change will negatively influence our ability to improve water quantity and quality and limit contaminant accumulation; actions must consider these forecasted changes.

> **"We drink the water to remind us who we are."**
>
> **— CTUIR Water Code**

BACKGROUND

Degraded water quality, low flows, and the presence of contaminants are of major concern and need to be addressed if Pacific lamprey restoration is to be successful. Collaboration with stakeholders will be necessary to identify and implement actions that address and mitigate the impacts of poor water quality, insufficient water quantity, and contaminants/pollutants.

Poor water quality in the CRB (and throughout the range of Pacific lamprey) stems from increasing water temperatures, degraded water chemistry (e.g., low dissolved oxygen, increased nitrate), increased sedimentation, pollutants, and climate change. High water temperatures impact all life stages and can result in increased susceptibility to disease, poor growth rates, developmental abnormalities, and die-offs (Nilsen et al. 2015).

Insufficient amounts of water during seasonal low flows are exacerbated by dams, dredging, and hydrosystem management, and stem from water withdrawals, irrigation, forest management practices, and climate change. Maintaining or increasing minimum flow requirements is imperative for all lamprey life stages and affects all other limiting factors (e.g., dam passage, entrainment, predation, water quality, contaminant exposure).

Pacific lamprey are exposed to contaminants in water and contaminated sediments. Contaminants are released during dredging and lamprey can also ingest contaminants from their hosts in the ocean. All life stages are potentially exposed, and contaminants accumulate over a wide geographic area due to the extent of lamprey migration, their extended residence time in freshwater, lack of homing, and their position at the top of the food chain.

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Contaminants enter the aquatic environment through multiple pathways, from urbanization and encroachment, pesticide and herbicide use on agricultural and forest lands, sewage discharges, heavy metals in manufacturing, mining, firefighting chemicals, pharmaceuticals, chemicals from road surfaces and tires, and burning fossil fuels.

Contaminants in fish tissue not only affect the health of the species and their predators, but also their human consumers. Health advisories now include lamprey consumption and represent a social, environmental, and treaty rights issue (OHA 2022, C. Smith, USGS Oregon Water Science Center, 2023 Information Exchange, personal communication).

Climate change will increase water temperatures, concentrate contaminants as water levels decrease, reduce access to prime habitats and/or cold water refugia, and alter hydrographs. Changes in snowpack, timing of snow melt, and magnitude of high flow events will alter the migration and spawn timing of lamprey. Altered flow regimes may scour spawning beds, dislodge eggs, and push larvae and juveniles downriver before they are ready to migrate. Flow alternations could also impact attraction flows and olfactory cues that initiate and guide upstream migration.

5.5.1 Important Actions

5.5.1.1 Work with stakeholders to increase water quality monitoring and retain adequate flows in lamprey-bearing rivers and streams

Inadequate water supply exacerbates all other limiting factors and has far reaching consequences in water-poor environments (Clemens et al 2023). Areas with too little water in summer to support larvae, too little water passing over dams to allow adult passage, or low flows and sedimentation that threaten adult spawning habitat need to be identified. The Tribes must lead the way to partner with stakeholders and keep water in rivers and streams that Pacific lamprey rely upon. Constant attention to maintenance or increase of minimum flows is needed, particularly as the climate warms.

5.5.1.2 Increase awareness of lamprey needs for high water quality in the mainstem, tributaries, estuarine, and marine environments in partnership with other entities

Raising awareness of lamprey needs for clean, cold, and abundant water is needed throughout their range; particularly in tributary streams that suffer from water withdrawals, inattention to maintenance of minimum flows, and sedimentation. For example, Schultz et al. (2014) suggested that poor water quality impedes passage of adult lamprey into the Tualatin River because Pacific lamprey were present in relatively low numbers despite favorable habitat conditions for spawning and rearing. Educating and updating partners about the need to increase monitoring of water quality is warranted, as basic monitoring (e.g., substrate type, temperature, oxygen, turbidity) in lamprey habitats often falls through the cracks. In addition, Jackson (2023) suggested that water flow management in the Umatilla River has had detrimental effects on larval lamprey rearing habitat throughout the Umatilla River Basin Project as lamprey have failed to establish in this area since the inception of restoration actions.

5.5.1.3 Partner with action agencies to clean up contaminants in lamprey-bearing waters and sediments

All lamprey species are sensitive to contaminants and pollution (Moser et al. 2021). Recent studies have revealed that larval Pacific lamprey avoid contaminated sediments when possible (Unrein et al. 2016). If exposed, they experience both lethal and sublethal effects (Linley et al. 2016). Larvae occur at lower densities in highly contaminated sites (Jolley et al. 2012) and levels of tissue contaminants in larvae from the Yakima, Umatilla, and Pudding rivers are particularly high (Nilsen et al. 2015). Moreover, Smith (2012) found that exposure to Atrazine altered pheromone perception in adults. The Tribes must push action agencies to clean up contaminated sediments where larvae and juveniles accumulate and regulate polluters to protect clean, cold waters that Pacific lamprey (and all freshwater biota) need.

5.5.1.4 Increase monitoring of contaminants in adult Pacific lamprey and reassess consumption advisories and risks associated with tribal consumption on a regular basis

Pacific lamprey of all life stages are impacted by contaminants; this puts them at risk and makes them potentially unsafe for tribal consumption. Because lamprey feed at the top of the food chain, they are likely to accumulate and sequester contaminants from host body fluids, further increasing their exposure. Tribal fishers have expressed concern over the body burdens of contaminants that make adult lamprey unsafe to eat (Sheoships, 2014). The inability to eat lamprey due to their health risks infringes on tribal treaty rights. Consumption advisories need to provide timely and accurate information to protect lamprey consumers, while avoiding unnecessarily conservative approaches that unduly impact use of this resource.

5.5.2 Critical Uncertainties and Research Needs

A systematic review of water quality limitations to lamprey production is needed to focus attention on abiotic factors that are most problematic (Clemens et al. 2023). Pacific lamprey can tolerate reduced water quality more readily than salmonids (e.g., high temperature, low dissolved oxygen); however, they too have tolerance limits. In addition, high temperature and low oxygen can restrict translocation efforts and stress larvae during salvage operations (Liedtke et al. 2023; Moser et al. 2023).

An understanding of the chemical contaminants that are most detrimental to lamprey for all life stages is needed to focus efforts on clean up and/or remediation. Basic toxicological work can be conducted on artificially propagated Pacific lamprey to reduce effects on wild fish (Moser et al. 2019b). For adult lamprey, studies like that of Smith (2012) can help improve awareness of sublethal effects of specific chemicals. Regular monitoring of adult lamprey from tribal harvest could also help to build an understanding of the body burdens that lamprey can tolerate and whether high contaminant loads are associated with lamprey gender, size, stock, or life history type.

RN 5.5.2A Evaluate direct and indirect effects of contaminants on Pacific lamprey of all life stages and the consequences of insufficient flows and/or poor water quality, particularly in summer

RN 5.5.2B Continue assessing effects of mainstem, tributary, estuarine, and marine water quality and contaminants on Pacific lamprey

RN 5.5.2C Investigate the relationship between contaminant loads and stock-specific prey preferences

RN 5.5.2D Assess upper thermal temperature tolerance for adult and juvenile life stages (in addition to larval life stage)

RN 5.5.2E Evaluate minimum flows that adult Pacific lamprey require to successfully hold and spawn in tributaries

5.6 Actions: Supplementation

TRIBAL OBJECTIVE

Supplement Pacific lamprey populations by using adult translocation and reintroduction of all life stages into areas where they have severely declined or are extirpated.

PURPOSE AND NEED

The purpose of supplementation is to provide an interim boost to abundance and distribution of Pacific lamprey in primarily interior CRB tributaries while fixes to passage and habitat are made. The Tribes do not prefer and have been reluctant to use translocation and artificial propagation, but these are desperate times, and such stopgap measures are necessary to mitigate unacceptable lamprey losses.

The Tribes intend to use adult translocation (Ward et al. 2012), along with structured, strategic, and phased releases of artificially reared Pacific lamprey to reintroduce, augment, and/or supplement populations within select subbasins (CRITFC 2018). These actions are needed to help restore Pacific lamprey (and their ecosystem services) to healthy, harvestable, self-sustaining levels. As threats to lamprey diminish and with increased numbers of volitionally returning adults, supplementation efforts will be revised or phased out.

Tribal Guidelines for Supplementation

Guidelines for collection of adult Pacific lamprey used for supplementation are periodically reviewed by the CRITFC Lamprey Committee and revisions are approved by the CRITFC Commission. The guidelines are subsequently updated and include recommendations for collection of adults for each of the member Tribes, and temporal/spatial collection goals designed to obtain a representative mix of the lamprey phenotypes available.

BACKGROUND

Adult translocation efforts began in the early 2000s. Adult Pacific lamprey collected at lower Columbia River dams (BON, TDA, JDA) were transported and released into tributaries further upstream in the Columbia and Snake river basins. Fish are collected in proportion to the run size to capture any genetic diversity that may occur with run timing. By hauling adults past dams and releasing them in suitable streams, translocation efforts augment production and bolster pheromone cues for in-river adults seeking suitable spawning areas. Successfully implemented by three CRITFC member tribes (CTUIR, YN and NPT), this work includes rigorous genetic monitoring, which has demonstrated that translocation boosts abundance of all life stages (Hess et al. 2022).

Starting in 2021, supplementation efforts have also included the release of artificially propagated larvae in select locations. The continued decrease in abundance or hypothesized extirpation in some subbasins, despite restoration actions, indicates that artificial propagation may be required in conjunction with other actions. Pacific lamprey in some subbasins may need to be supplemented so that recovery can occur in a timeframe consistent with existing restoration plans. In addition, lamprey aquaculture efforts also serve to provide artificially propagated larval and juvenile lamprey for research projects to evaluate critical uncertainties and limiting factors. Having lamprey larvae in culture also supplements information needed to manage this species in the wild (Moser et al. 2019b; Lampman et al. 2021).

The Tribes consider all supplementation actions to be mitigation that provides an interim boost to lamprey abundance. These activities have been rigorously peer-reviewed and approved by the ISRP and Northwest Power and Conservation Planning Council. In 2018, a Master Plan for the Supplementation of Pacific lamprey was developed (CRITFC 2018). This plan outlines: development of the laboratory culture methods (Phase 1), experimental release of laboratory-reared fish and monitoring with multiple metrics (Phase 2), evaluation of field experiments (Phase 3), to inform full scale production (Phase 4).

5.6.1 Important Actions

5.6.1.1 Continue and expand translocation in accordance with tribal guidelines

Recent genetic evidence has confirmed that tribal translocation programs have boosted not only larval lamprey abundance but have also augmented the outmigrant population (Hess et al. 2022) and have confirmed that adult offspring return successfully to BON from all three tribal translocation programs (Hess et al. 2023a). Until impediments to adult lamprey migration are fixed, the Tribes intend to continue to translocate lamprey upstream from mainstem obstacles in accordance with established protocols.

The Tribes recognize a need to expand the use of translocation to new areas including river segments above the Willamette Valley System dams using adults collected from the Willamette Basin. To date, the translocation efforts conducted above BON has served to contribute to adults that preferentially return to BON rather than to areas within the Willamette River basin (Hess et al. 2023a). This observation underscores the need to expand translocations within the Willamette Valley System dams to increase local larval and juvenile production that may, in turn, return more adults to the Willamette subbasin. This action will ensure the persistence of the species in key areas where lamprey would likely not be present otherwise.

5.6.1.2 Continue and expand artificial propagation and phased release of artificially propagated larvae and juveniles

Pacific lamprey do not appear to be as philopatric as anadromous salmonids because they disperse widely across their range (Hess et al. 2014). For these reasons, artificial propagation does not require matching donor populations of Pacific lamprey to wild counterparts in the same geographic area. Nevertheless, tribal biologists have sought to obtain Pacific lamprey broodstock from upstream migrating populations in the Columbia River drainage. These fish are captured at mainstem dams and transported to tribal holding facilities (Ward et al. 2012, Lampman and Beals 2016) where they are overwintered (Moser et al. 2019b).

Adult lamprey used for translocation and artificial propagation (broodstock) are given a prophylactic antibiotic treatment and are screened for disease using established protocols (Jackson et al. 2019). In spring they start to show signs of reproductive maturation (Lampman et al. 2016) and are propagated using methods established by tribal biologists and their partners (Lampman et al. 2021, Moser et al. in review). Larvae and juveniles produced using these methods are screened for disease prior to release (Jackson et al. 2012).

5.6.1.3 Continue monitoring efficacy of adult and larvae/juvenile supplementation efforts

Genetic samples of all broodstock and subsamples of their offspring are archived to permit identification of artificially produced larvae and larvae produced by translocated adults (as in Hess et al. 2022). In addition, eDNA sampling is conducted in receiving water bodies to monitor the success of outplanted progeny and their persistence over time (Carim et al. 2017). This monitoring should continue as outlined in the Pacific Lamprey Supplementation Framework and the Master Plan (CRITFC 2018).

5.6.1.4 Identify and develop needed facilities for future work on production of all life stages of Pacific lamprey

As outlined in the Pacific Lamprey Supplementation Framework and the Master Plan (CRITFC 2018), artificial propagation and rearing of Pacific lamprey requires a great deal of space. Larvae rear in sediment and their spatial requirements are much greater than that of teleosts (Lampman et al. 2016; 2021). As needs for artificially propagated lamprey increase, so must the dedication of facility space for their production. This is particularly important because rearing in high density has been shown to reduce growth and likely will result in more incidence of disease (Jackson et al. 2019; Lampman et al. 2021). Adequate space and provision of high-quality water is critical to the success of scaled-up production. With the desire for development of other life stages (larvae/juvenile and adults), provision of saltwater may be necessary, and no facilities are currently available for increased production of these life stages.

5.6.1.5 Organize and sponsor the 2nd Annual Symposium for the Propagation and Restoration of (Pacific) Lamprey

The use of artificially produced lamprey for research, restoration, and control of invasive sea lamprey (*Petromyzon marinus*) is on the rise (Moser et al. 2019b). With the need for scaled-up production and development of other life stages (larvae/juvenile and adults), it will be important to learn from the successes and failures of others working in this arena. Sponsoring a symposium on this topic will bring together lamprey culturists from around the world, provide opportunities to collaborate and exchange information, and contribute to the development of networks for communication of future results, while highlighting tribal advances in this area.

5.6.2 Critical Uncertainties and Research Needs

Starting in 2021, Pacific lamprey were released into the wild in carefully coordinated studies to understand the success of these fish while monitoring impacts to wild fish. This should include determination of life stages with highest survival after release, development of methods to reduce mortality of outplanted lamprey, and determination of carrying capacity for receiving streams. Development of a lamprey cell line is also needed to research lamprey-specific disease organisms and ensure that future hatchery production of Pacific lamprey does not endanger wild populations (Jackson et al. 2019).

Lamprey aquaculture efforts can also provide artificially propagated larval and juvenile lamprey for research projects to evaluate and, potentially, predict the effects of climate change on early life stages. Moreover, a regular source of artificially propagated fish will ensure that there are donor animals available to reseed areas extirpated during climate-related events.

RN 5.6.2A Develop methods to capture lamprey below BON and other areas (e.g., Willamette Valley System dams) where they are blocked and aggregate

RN 5.6.2B Research the most effective methods for preserving genetic and demographic representation in adults used for translocation

RN 5.6.2C Continue research to improve artificial propagation and outplanting methods

RN 5.6.2D Develop a lamprey cell line and research lamprey-specific diseases

RN 5.6.2.E Research the most effective methods for preserving genetic and demographic representation in adults used for artificial propagation

RN 5.6.2F Research methods to improve translocation success

RN 5.6.2G Increase research and monitoring of Pacific lamprey productivity and the role of supplementation in light of climate change

RN 5.6.2H Quantify the effective number of spawners from each translocation using genetic techniques

RN 5.6.2I Evaluate factors that contribute to effective spawner populations size (e.g., number of fish translocated, habitat, genetic composition, sex ratio)

RN 5.6.2J Investigate new areas above impassable dams that could benefit from lamprey re-introductions

5.7
Actions: Climate Change

TRIBAL OBJECTIVE

Implement appropriate mitigation, resilience, and adaptation actions to protect lamprey populations and their environments from climate change.

PURPOSE AND NEED

The resilience of Pacific lamprey populations is supported by promoting healthy, and diverse (biologically and structurally) river and floodplain habitats throughout its range. Historically, Pacific lamprey was ubiquitous, and, like the beaver, it is a "key" or "cornerstone" species that greatly supports other species and ecosystems. Without the lamprey the natural world is neither whole nor is it healthy.

"Here are my friends."

© David Herasimtschuk, Freshwaters Illustrated

FIGURE 26. The late Elmer Crow, NPT, who dedicated the final years of his life to help restore his "eels."

> **"The changes already observed have been substantial, and by the end of the century we will be likely facing unprecedented changes to our natural environment and the economies that depend upon it."**
>
> **— Clearwater River Subbasin Plan,** Nez Perce Tribe

Although there have been notable efforts to understand the effects of climate change on Pacific lamprey, many significant unanswered questions remain. Substantial effort and resources are needed to understand these impacts and to restore and maintain strong and resilient aquatic ecosystems that protect lamprey. Importantly, the CRITFC and member Tribes along with partners must continue:

- to work independently and with local, state, and federal governments at both policy and technical levels to research, monitor, and refine analyses of mainstem and tributary hydrologic and water quality changes,
- to implement and/or advocate for restoration, protection, and mitigation actions to address these environmental changes,
- to prioritize and develop climate change action strategies and adaptation tools that protect Pacific lamprey and their ecologies,
- to track and/or participate in regional and national forums that complement tribal climate change research, monitoring, and project implementation.

BACKGROUND

Much has been written about climate change impacts on fishes and ecologies within the CRB. Reduced to its simplest terms, there will be changes in flow, chemistry, and temperature in most creeks, rivers, and the ocean. These changes will undoubtedly impact Pacific lamprey, their food sources and habitats. The following discussion highlights some of what we might expect from climate change.

Lamprey have been on earth for over 400 million years; they know about climate change. They are more resilient to high temperature than salmonids and are able to shift to new habitats when conditions deteriorate in their traditional range. Traditionally, the Tribes would have moved with them. That can no longer happen, potentially limiting future interactions with this cultural stronghold. Through their wide distribution, Pacific lamprey have developed multiple life history expressions (Wang, et al. 2021). Although the Tribes believe that lamprey populations in the CRB may be at severe risk, we are hopeful that through this resilience they can again be plentiful.

In the mid-and upper CRB, most climate projections predict that streams will switch from being snowmelt-dominated systems toward rainwater-driven, with an overall decrease in annual stream discharge (Panye et al. 2004; YN Climate Action Plan, 2021; CTUIR Climate Adaptation Plan, 2023). Hence, with reduced annual flow, we expect warmer stream temperatures in the summer months. Collectively, this will translate to warmer water temperatures and reduced flow in lower mainstem streams throughout the CRB. This will impact lamprey directly and indirectly, as the aquatic biota will also change. The best

Courtesy of USFWS, John Heil / Public Domain

ways to reduce these impacts are to ensure (1) structural diversity and complexity within the stream, (2) healthy and diverse riparian habitats, and (3) a strong connection between the stream and its floodplain. Healthy streams offer resilience to changes in climate.

Although the thermal tolerance of Pacific lamprey is not well known, evidence from multiple studies suggests that early development may be influenced by high water temperature. Meeuwig et al. (2005) found that survival of larval Pacific lamprey was significantly lower at 22°C (72°F) than at lower rearing temperatures, and increased abnormalities were observed with higher rearing temperature. Similarly, sea lamprey (a close relative of Pacific lamprey) hatch success and survival is negatively related to incubation temperature (Rodríguez Muñoz et al. 2001), with a precipitous drop in post-burrowing survival above 23°C (73°F). Elevated temperature may also inhibit metamorphosis in sea lamprey (Holmes and Youson 1998). Climate change already influences the timing of adult migration and spawning, which shifts earlier with warming river and stream temperatures (**FIGURES 16** and **FIGURE 21**; Keefer et al. 2009; Mayfield et al. 2014a; Schultz et al. 2014).

Beyond the direct impacts to lamprey (i.e., increased water temperatures) we can expect indirect effects such as increased pathogens, changes to freshwater ecologies, and altered food web dynamics. Importantly, predation by northern pikeminnow (*Ptychocheilus oregonensis*) and warmwater non-native fishes may pose an increasing threat to Pacific lamprey at multiple life history stages (CRITFC 2011; Sharma et al. 2017; Cucherousset and Olden 2011; Arakawa and Lampman 2020). As stream discharge is reduced by diminishing natural streamflow and the increased pressure from water withdrawals, larvae will be subjected to increasing concentrations of stream contaminants (e.g., Littlewood 1992). Increased water withdrawal may also lead to desiccation or entrainment and loss associated with water delivery systems (Moser et al. 2015b; Lampman and Beals 2019). Scour and loss of fine rearing sediment may occur as watersheds switch from snowmelt- to rain-driven systems.

Finally, climate change will likely influence marine productivity across multiple spatial scales and trophic levels, and these changes might influence the marine life history of Pacific lamprey (e.g., Brander 2007; Murauskas et al. 2013, Clemens et al. 2023).

A fundamental teaching from the native people of this continent was to make decisions with the seventh generation in mind. Another was that it is humanity's duty to be the voice for the earth and everything on it.

Climate change happened because people didn't abide by these two teachings.

5.7.1 Important Actions

All actions identified in **SECTION 5** contribute to Pacific lamprey climate resilience and will not be repeated here. We advocate for the following basin-wide analyses to support our growing understanding of climate change effects.

5.7.1.1 Implement climate change plans developed by CRITFC and member tribes to support mitigation, resilience and adaptation to future changes

Tribal climate action plans are in place (e.g., YN Climate Action Plan, 2021; CTUIR Climate Adaptation Plan, 2023, CRITFC Climate Change Scientific and Technical Resources, *https://critfc.org/fish-and-watersheds/climate/climate-change-scientific-and-technical-resources/*) and it is important to implement these plans as outlined.

5.7.1.2 Protect and enhance future water resource requirements for Pacific lamprey populations

Treaty rights must be fully exercised as climate changes. Needs for anadromous species, including lamprey, must be considered and protected.

5.7.1.3 Estimate changes in runoff, temperature and precipitation pattern, and changes at the subbasin level

Monitoring and analyzing changes in hydrology due to climate warming is the first step, followed by development of mitigation and adaptation tools to address these changes. Include databases and analyses of tributary temperatures and flows that will occur with future water depletions. Water rights will become increasingly contentious with climate change and estimates of predicted effects will help in water resource planning.

5.7.1.4 Include effects on Pacific lamprey in ocean climate models

Impacts of climate change on lamprey survival and growth at sea must be considered along with other predicted changes to both the abiotic and biotic marine environment.

5.7.1.5 Communicate the need for healthy Pacific lamprey populations as a primary means to establish self-sustaining populations in light of climate change

In all discussions of climate change and its current and future effects, considerations for Pacific lamprey habitat needs and the consequences of failure to achieve self-sustaining production should be included along with other freshwater biota.

Courtesy of CRITFC

5.7.2 Critical Uncertainties and Research Needs

Streams will switch from being snowmelt-dominated systems to rainwater-driven, with an overall decrease in annual stream discharge. The specific effects on Pacific lamprey should be modeled for future planning and protection of key refugia.

> **"Climate change is the catastrophe to end all other catastrophes."**
>
> **Fatima Bhutto,** *Washington Post, October 16, 2023*

Aquatic biota will change with changes in flow and water temperature. A better understanding of how such changes will impact Pacific lamprey is needed. Stress on ecosystem resources will likely lead to increased pathogens and promote changes to freshwater ecologies and food webs. Both native and non-native warm water fish species may cause impacts across increasing ecological scales including genetic, individual, population, community, and ecosystem levels.

Profound changes in food webs are also likely to occur in the ocean. Latitudinal shifts in marine species distributions may affect those species that Pacific lamprey rely on as hosts and to follow those shifts in prey, Pacific lamprey may also shift their distribution northward. While larval growth might increase in warming waters, changes in ocean entry may create a mismatch with traditional host occurrence.

RN 5.7.2A Model likely changes in aquatic biota to predict changes in Pacific lamprey food, predator, and pathogen interactions

RN 5.7.2B Analyze alterations in Columbia, Snake, and Willamette river basin hydrology and water quality in relation to Pacific lamprey

RN 5.7.2C Model likely changes to Pacific lamprey phenology

5.8 Actions: Outreach and Education

TRIBAL OBJECTIVE

Conduct Pacific lamprey outreach and education by coordinating with public and private institutions and using a variety of forms to reach all age groups of tribal and non-tribal people.

PURPOSE AND NEED

There is an overarching need to raise awareness of the cultural importance of Pacific lamprey and the healthy ecosystem it requires. Our purpose is to ensure a long-term understanding and appreciation for the importance of Pacific lamprey to tribal culture and to the natural world we all share and value. The Tribes urge all outreach and education campaigns associated with lamprey to emphasize the following messages:

- Pacific lamprey has a unique history and life cycle unlike any other fish species,
- Pacific lamprey has an important role in tribal diets and cultures,
- We all have a cultural responsibility to protect Pacific lamprey from extinction,

Courtesy of YN Fisheries

FIGURE 27. Local outreach programs involving both youth and adults.

The Tribes are addressing Pacific lamprey decline through regional policies, planning, and on-the ground lamprey research, protection, and restoration,

Failure to prevent the extinction of the Pacific lamprey would have unacceptable ecological, cultural, and economic consequences.

BACKGROUND

One of the more important factors limiting Pacific lamprey populations is the ***lack of public awareness*** of their existence. Unfortunately, these fish are often negatively associated with invasive sea lamprey in the Great Lakes. This is one example of a fundamental barrier that must be overcome for regional restoration of lamprey populations to be successful.

Outreach is public engagement: it is the communication to the region of the importance of these fish to our tribal culture, our communities, and to our people. Not only for past generations but for our children and the future. Lamprey are a gift from the Creator. They greatly contribute to the Tribe's natural wealth and our environmental richness. The region must understand that Pacific lamprey populations are very depleted and in many areas are completely gone.

CRITFC and its member tribes will continue to reach out to various communities — in schools, in the field, and in various public and professional forums. We intend to reach all age classes and convey the importance of lamprey as an essential member of our environment and that it is our *common* obligation to honor and protect, and we ask our partners to contribute as well.

5.8.1 Important Actions

5.8.1.1 Continue to establish a variety of learning networks

The Tribes have been successful in reaching a broad range of audiences. Expanding on this outreach effort will require targeting of new audiences, employing new means of communication, and training additional staff and leadership to support this effort.

5.8.1.2 Continue interviews and other methods to preserve traditional knowledge from tribal elders so this information is not lost to future generations

Interviews with tribal elders must continue to capture and archive their knowledge and wisdom before it is too late.

5.8.1.3 Continue to secure additional institutional commitments for participation in outreach and education (for tribal members and the public)

New media and learning materials to expand outreach must be age-appropriate and culturally effective. Only with a regular source of funding and commitments from partners will development of new materials and their dissemination to new audiences be possible.

© Courtesy of USACE

5.8.1.4 Communicate the importance of lamprey to the CRB and the consequences of failure to act

Every media event and outreach coordinator should be able to answer the question "What are they good for?" The public must be allowed to understand that if lamprey are lost we lose the ecosystem services that they provide, in addition to tribal cultural connections.

5.8.1.5 Continue using Pacific lamprey as an important means toward restoration of tribal culture

It is critical to communicate the importance of lamprey to tribal culture and how lamprey harvest and ceremonies form an essential part of this culture. A guide for tribal youth could include methods for preparation and cooking of lamprey and their role in community and ceremony. This connection must not be lost.

5.8.1.6 Increase coordination between the CRITFC and member tribes toward development of outreach and education that will reach federal, state, and local partners

A more comprehensive outreach and education program will be developed by CRITFC and member tribes that will address cultural, biological, and ecological aspects for Pacific lamprey for each life history stage throughout its range. This product is intended to offer a unified message for use with a variety of learners (federal partners, states, NGOs, etc.) and will draw from existing materials and evolve as our knowledge increases.

Courtesy of CTWSRO

5.8.2 Critical Uncertainties and Research Needs

Research is needed to evaluate the effectiveness of ongoing public outreach and to inform development of new tools for reaching multiple age groups at larger spatial scales.

RN 5.8.2A Monitor, periodically evaluate, and report on successes and failures in public education and outreach to tribal leadership

RN 5.8.2B Investigate new tools for reaching multiple age groups at large spatial scales as technology expands

RN 5.8.2C Access and analyze available research and data on public awareness and perceptions of Pacific lamprey and other communication trends

RN 5.8.2D Access and learn from elder interviews and assess regional variation in tribal use of lamprey

5.9 Actions: Effective Population Size and Structure

TRIBAL OBJECTIVE

Ensure that the distribution, total abundance, and effective number of spawners of Pacific lamprey in the CRB continues to grow to levels that are self-sustaining and can support tribal harvest and ecological contributions.

PURPOSE AND NEED

Pacific lamprey populations are extirpated from many upriver sites in the CRB. This could fundamentally harm lamprey genetic structure and diversity. We need to expand our understanding of population dynamics and demography that supports healthy lamprey populations while providing regional harvest opportunities.

Assessment of status and trends in Pacific lamprey abundance can identify areas of recruitment failure or extirpation. Actions to evaluate effective population size and structure are needed to understand where sources of production are highest (to protect them) and lowest (to restore them). Along with the development of abundance-based goals for each drainage, additional research is needed to understand when a population is reaching carrying capacity. Obtaining the maximum abundance of lamprey that a stream can support (carrying capacity) supports all TPLRP goals.

BACKGROUND

Maintaining healthy Pacific lamprey population size, distribution and structure is implicit to recovery of this species in the CRB. However, recent insights arising from the establishment and maintenance of a genetic database for CRB Pacific lamprey (e.g., Hess 2021; 2022; 2023) have highlighted the need to continue this monitoring and establish or maintain other methods to assess distribution, effective population size, and structure. In particular, there is a critical need to select key index sites for each watershed/RMU (preferably at the subbasin (HUC4) level to implement long-term monitoring of abundance (for all life stages) and associated genetic sample collection.

Not only do genetic methods allow for computation of effective spawning stock sizes, but they could provide vital information about sources and sinks of Pacific lamprey production in the CRB and beyond. This information could be used to protect areas that produce the most fish and focus restoration efforts in areas where recruitment routinely fails. Moreover, a primary tribal goal is for Pacific lamprey to approach and attain carrying capacity in habitats that they occupy. Research is needed to understand when abundance approaches carrying capacity and what factors constrain it.

5.9.1 Important Actions

5.9.1.1 Continue and expand genetic sampling

There has been an exponential increase in information pertinent to lamprey recovery with the development of genetic methods in the CRB (e.g., Hess et al. 2016; 2021; 2022; 2023a). The funding to support sample collection, archiving, processing, and interpretation must be at least maintained at current levels. These data will continue to reap such benefits as assessment of translocation/supplementation program success, information for improving these programs, and predictions of lamprey returns to the CRB, and colonization success rates in new habitats (Hess et al. 2021; 2022; 2023a). Expanding this data collection (e.g., to include virtually every lamprey handled during routine monitoring range wide) would yield more information on basic life history, sources and sinks of Pacific lamprey production, and a better understanding of stream carrying capacity.

5.9.1.2 Maintain and expand baseline population monitoring of Pacific lamprey within the CRB

If the goal is to assess status and trends in Pacific lamprey abundance, it is crucial that existing monitoring (both tribal and non-tribal) is maintained at established index sites throughout the CRB. These sites must be sampled in a consistent, standardized way to allow interannual comparisons, in addition to evaluation of abundance trends and demographic patterns. Index site sampling, whether via electrofishing for larvae, collection of larvae and juveniles in screw traps, smolt bypass collections, and/or adults and their nest counts should be a priority for funding basin wide. Currently there is inadequate staff to accomplish this sampling in many RMUs. In addition, expanding to more index sites is critical to making these assessments even more robust.

5.9.1.3 Develop life cycle modeling for Pacific lamprey and use the results to inform passage required at each dam, and implementation of all actions to support tribal harvest goals

The recent development of a life cycle model for Pacific lamprey has opened the door for work to assess sensitivity of the model to various inputs and its use to make predictions relative to management. For example, such modelling efforts could estimate adult lamprey passage required at each dam to achieve tribal harvest goals or assess impacts from supplementation on lamprey population growth.

5.9.2 Critical Uncertainties and Research Needs

RN 5.9.2A Continue pursuit of the elusive genetic sex marker along with physiological assays for determining sex

RN 5.9.2B Use SNPs to refine species identification of lamprey of the Columbia River, characterize life history variants and document new lineages

RN 5.9.2C Identify status and trends in lamprey population size and structure

RN 5.9.2D Determine effective population size and the minimum viable population size for the CRB

RN 5.9.2E Quantify homing of adults to their natal tributaries (e.g., Yakima, Umatilla, Snake, and Willamette rivers)

RN 5.9.2F Identify local and regional sources and sinks of Pacific lamprey production

RN 5.9.2G Conduct research to assess carrying capacity for Pacific lamprey and factors that control it

RN 5.9.2H Collect data to improve parameterization of life cycle models

5.10 Actions: Research, Monitoring, Adaptive Management

TRIBAL OBJECTIVE

Develop and implement regional Research, Monitoring, and Adaptive Management to (1) inform tribal and regional policy about priority actions and research and (2) accelerate our ability to implement important actions that will return lamprey populations to historic abundance and distribution.

PURPOSE AND NEED

There is a need to develop a holistic, structured, regional process using adaptive management to coordinate priority work and to maintain reasonable progress toward our stated goals. Currently, this process is not in place. Its purpose is to establish policy, maintain tools that are working, and evaluate successes and failures.

The Tribes call on the region's co-managers to support this formal process for Pacific lamprey, which will consist of policy representation from both tribal and non-tribal entities, and will be immediately developed and implemented to guide long-term restoration of Pacific lamprey, as discussed below and further detailed in SECTION 6.3 (Framework for Research, Monitoring and Adaptive Management).

Four basic questions must be regularly addressed by the region's co-managers: (1) are we implementing/planning research and priority actions in a timely, coordinated and comprehensive manner?, (2) are we appropriately monitoring, evaluating and learning about the efficiency and effectiveness of actions?, (3) are we using this information to adaptively manage?, and (4) are we appropriately funding lamprey restoration to achieve our objectives in a timely manner? Addressing these and other important questions requires greater regional coordination than currently exists.

BACKGROUND

The Tribes and the region's other co-managers have not yet developed a Research, Monitoring and Adaptive Management process. Here we offer a framework and call for regional collaboration so that it can be operational by 2027. The Tribes view adaptive management as a useful means to identify, prioritize, and measure regional progress and we support many of the principles associated with adaptive management and adopted by the Northwest Power and Conservation Council.

Adaptive management continues to be used within the CRB for management of many fish and wildlife species, especially anadromous fishes. In its most simplified form, the Tribes view Pacific lamprey adaptive management as described below and illustrated in FIGURE 28:

1. Results from **Research and Monitoring** provide the basis for **Evaluation** of the biology, ecology and/or performance of Pacific lamprey within their natural environment or stemming from management.
2. The **Evaluation** (and associated periodic reports) leads to and is described in a **Status and Trend Annual Report** which informs policy discussions and decisions for future **Actions** determined within the annual **Adaptive Management** process.

Adaptive Management defined:

A scientific policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing fish and wildlife program actions (projects) as vehicles for learning. Projects that implement the program are designed and implemented as experiments so that even if they fail, they provide useful information for future actions. Monitoring and evaluation are emphasized so that the interaction of different elements of the system is better understood.

Northwest Power and Conservation Council, December, 2014

3. The process is cyclical and is repeated annually.

Furthermore, adaptive management is the approach necessary to gain a regional understanding and adoption of two uniquely different but nevertheless difficult discussions concerning "Abundance Based Goals" throughout the CRB and "Lamprey Passage Standards" for mainstem and tributary dams. Regional consensus and definition of either of these goals or standards is not currently available, but given additional efforts and a more focused, regional process, consensus can be achieved in the foreseeable future.

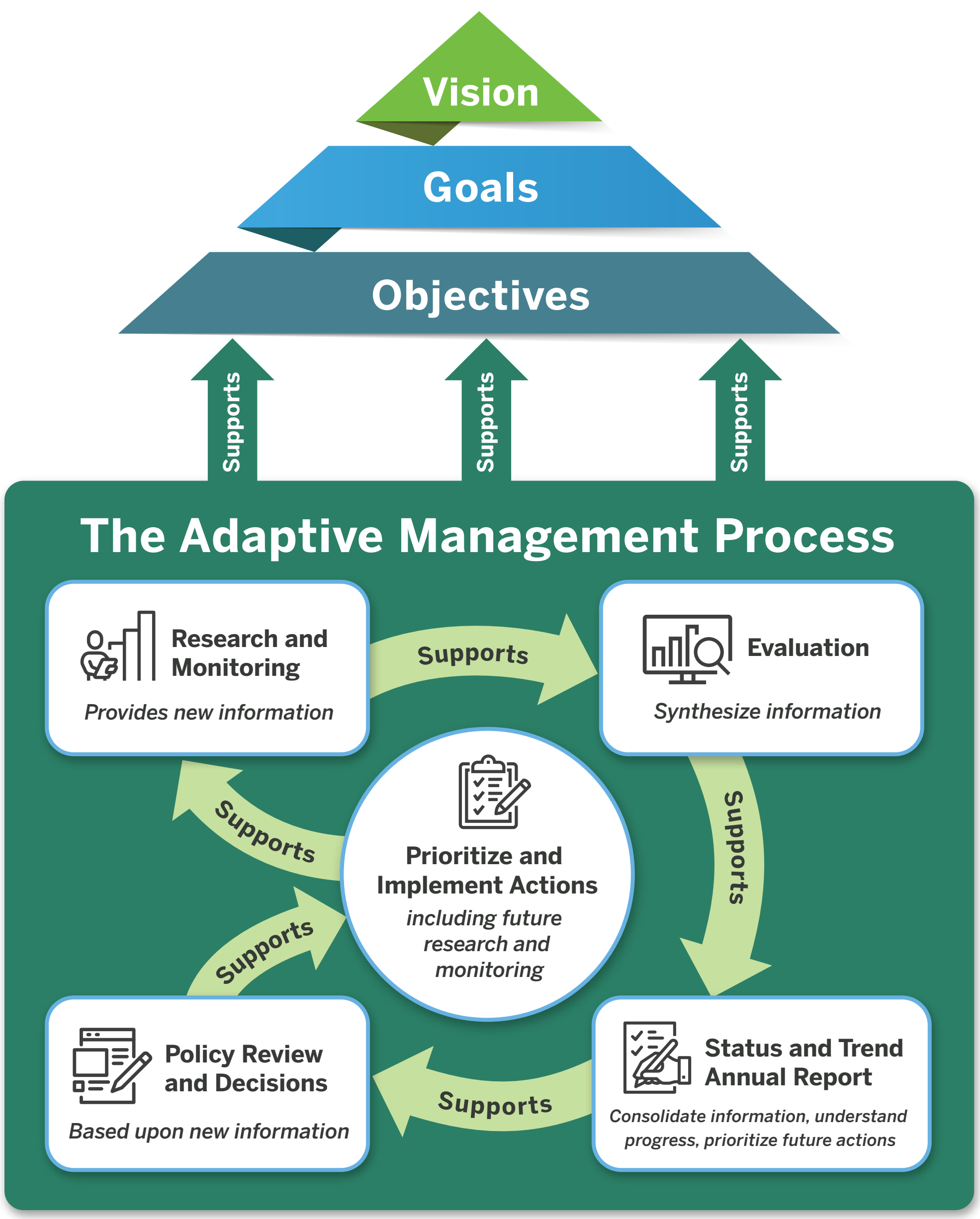

FIGURE 28. Adaptive Management Framework proposed for Pacific lamprey Restoration. *Note: Visions, Goals and Objectives are discussed in* SECTION 2 *of this document.*

Two important points fundamental to the process proposed:

1. Various aspects of the restoration process require multiple timeframes, and it is not useful to report annually on all aspects. For example, adult counts at mainstem dams can be provided daily, while fixes to specific passage obstacles may take several years to implement and evaluate. Appropriate and timely analysis and reporting will be discussed and resolved by technical and policy workgroups on a case-by-case basis.
2. Tribal, federal, state, and local entities often have unique roles within lamprey restoration and already produce annual or periodic progress reports that can be incorporated into a more holistic Status and Trend Annual Report for Pacific Lamprey. A priority action over the next two years is to identify these existing reports and consolidate their findings in a manner leading to holistic regional reporting. It is the Tribes' intent to not necessarily create more work or duplicate effort, but to use existing reporting in a manner that supports an adaptive management process.

5.10.1 Important Actions

5.10.1.1 Adopt an Adaptive Management strategy for the CRB that involves regional participation in the year 2027

A great amount of effort and materials are already being provided by various entities throughout the CRB but an adaptive management process has not been established. Regional coordination formally listing and collecting the necessary work would support this annual process.

5.10.1.2 Develop and adopt a tribally and/or regionally supported Status and Trend Annual Report template

A significant component of the adaptive management process is the annual reporting (to managers and researchers) of recent information used to help determine future actions. This Status and Trend Annual Report will require several years to develop in a manner that can be used annually in a clear, consistent, and comprehensive manner. It will not be necessary to report annually on all actions. However, specific sites (Key Index Sites) need to be identified throughout each of the RMU's so that annual habitat conditions and population trends can be monitored and tracked over time.

5.10.2 Critical Uncertainties and Research Needs

The following lists all Critical Uncertainties discussed in **SECTIONS 5.1–5.9**, above. They are summarized here for convenience.

(5.1) Mainstem Habitat and Passage

A. Continue research to obtain accurate real-time reporting of adult passage at all mainstem dams

B. Identify areas that obstruct or delay adult Pacific lamprey at mainstem dams

C. Identify and implement fixes that have the most "bang for the buck" at mainstem dams

D. Identify hydraulic conditions that favor adult lamprey passage (e.g., TDA north fishway)

E. Investigate effects of "shad mode" operation on adult Pacific lamprey (BON, TDA, JDA)

F. Conduct adult Pacific lamprey trap-and-haul feasibility study for mainstem and tributary dams of the Columbia, Snake, and Willamette rivers

G. Identify critical habitats used by adults for migration, holding, and spawning in reservoirs and the estuary

H. Develop and refine larval and juvenile counting methodologies in two to three reservoirs and expand to the entire river

I. Investigate new technologies to improve estimates of larval and juvenile lamprey abundance at mainstem dams (e.g., PNNL prototype collector)

J. Identify larval and juvenile mortality rates associated with mainstem dam passage (as in the Juvenile Lamprey Study, PNNL at LGR)

K. Research the use of existing juvenile transport (e.g., barge, truck) to facilitate downstream transport of larvae and juveniles

L. Evaluate efficacy of larval and juvenile transport programs

M. Continue to investigate appropriate ways to dewater side channels to minimize lamprey losses

N. Explore using water depth at canal intakes to keep lamprey out of irrigation facilities

O. Identify larval and juvenile mortality rates associated with mainstem dam passage (reference the Juvenile Lamprey Study, PNNL at LGR)

P. Identify sources of larval and juvenile lamprey mortality in estuarine habitats

Q. Investigate optimal timing of juvenile entry to the estuary

R. Identify larval and juvenile mortality rates associated with mainstem dredging, water abstraction, and dewatering

(5.2) Tributary Passage and Habitat

A. Research novel methods to monitor adult lamprey passage at barriers in tributaries

B. Identify areas that obstruct or delay adult lamprey at tributary dams

C. Identify sources of mortality for larval and juvenile lamprey at tributary dams, irrigation diversions, and pump intakes

D. Research methods to improve salvage of larvae during diversion canal drawdowns and other dewatering

E. Identify irrigation canals where redesign of intakes to reduce entrainment would benefit juvenile and larval lamprey

(5.3) Oceans

A. Estimate both direct and indirect mortality of Pacific lamprey that results from fishery bycatch

B. Continue to research the distribution and population genetics of Pacific lamprey at sea

C. Characterize stock-specific marine distribution, prey preference and migration patterns in the ocean

D. Identify important feeding areas and how lamprey get to and from them (long distance migration movements)

E. Study the effects of marine pathogens on Pacific lamprey in the laboratory

F. Increase understanding of how oceanographic regimes and climate change affect distribution, host use and survival of lamprey at sea

G. Model effects of major ocean regime changes on important host species for Pacific lamprey

H. Develop and implement a research plan to determine effects of alternative energy developments (e.g., wave energy facilities) on Pacific lamprey

(5.4) Predation

A. Identify the key predator species that contribute to unnaturally high predator impacts and proscribe effective solutions for Pacific lamprey

B. Quantify the predation (i.e., number of lamprey mortalities) by the key predator species to estimate the overall lamprey "take"

C. Assess key locations where unnaturally high predation occurs

D. Evaluate key timing (season, time of day) when unnaturally high predation occurs

E. Identify potential solutions for curbing predation impacts and evaluate their efficacy

(5.5) Water Quantity, Quality and Contaminants

A. Evaluate direct and indirect effects of contaminants on Pacific lamprey of all life stages and the consequences of insufficient flows and/or poor water quality, particularly in summer

B. Continue assessing effects of mainstem, tributary, estuarine, and marine water quality and contaminants on Pacific lamprey

C. Investigate the relationship between contaminant loads and stock-specific prey preferences

D. Assess upper thermal temperature tolerance for adult and juvenile life stages (in addition to larval life stage)

E. Evaluate minimum flows that adult Pacific lamprey require to successfully hold and spawn in tributaries

(5.6) Supplementation and Artificial Propagation

A. Develop methods to capture lamprey below BON and other areas where they are blocked and aggregated

B. Research the most effective methods for preserving genetic and demographic representation in adults used for translocation

C. Continue research to improve artificial propagation and outplanting methods

D. Develop a lamprey cell line and research lamprey-specific diseases

E. Research the most effective methods for preserving genetic and demographic representation in adults used for artificial propagation

F. Research methods to improve translocation success

G. Increase research and monitoring of Pacific lamprey productivity and the role of supplementation in light of climate change

H. Quantify the effective number of spawners from each translocation using genetic techniques

I. Evaluate factors that contribute to effective spawner populations size (e.g., number of fish translocated, habitat, genetic composition, sex ratio)

J. Investigate new areas above impassable dams that could benefit from lamprey reintroductions

(5.7) Climate Change

A. Model likely changes in aquatic biota to predict changes in Pacific lamprey food, predator, and pathogen interactions

B. Analyze alterations in Columbia, Snake, and Willamette river basin hydrology and water quality in relation to Pacific lamprey

C. Model likely changes to Pacific lamprey phenology

(5.8) Outreach and Education

A. Monitor, periodically evaluate, and report on successes and failures in public education and outreach to tribal leadership

B. Investigate new tools for reaching multiple age groups at large spatial scales as technology expands

C. Access and analyze available research and data on public awareness and perceptions of Pacific lamprey and other communication trends

D. Access and learn from elder interviews and assess regional variation in tribal use of lamprey

(5.9) Effective Population Size and Structure

A. Continue pursuit of the elusive genetic sex marker along with physiological assays for determining sex

B. Use SNPs to refine species identification of lamprey of the Columbia River, characterize life history variants (i.e., ecotypes), and document new lineages

C. Identify status and trends in lamprey population size and structure

D. Determine effective population size and the minimum viable population size for the CRB

E. Quantify homing of adults to their natal tributaries (e.g., Yakima River, Umatilla River, and Snake River)

F. Identify local and regional sources and sinks of Pacific lamprey production

G. Conduct research to assess carrying capacity for Pacific lamprey and controlling factors

H. Collect data to improve parameterization of life cycle models

Yakama tribal members collecting lamprey at Willamette Falls.

Courtesy of CRITFC / Laurie Porter

6 Appendices

Section 6 is a part of the 2025 TPLRP but is distinct because it is the "living" portion of the document; it is an acknowledgement that conditions will continuously change and through research, monitoring, and adaptive management important knowledge will be learned and numerous details will need to be updated. These changes will be revealed through our evolving knowledge of technology, Pacific lamprey life history, population trends, and research results. This will be reflected in future selection of priority actions, research, and monitoring. With these changes anticipated over the course of the next 10–15 years, the Tribes do not intend to update the entire 2025 TPLRP, but will update Section 6, as appropriate to reflect these changes.

SUMMARY Section 6 provides additional information for the following important topics: (6.1) Actions and specific tasks for implementation; (6.2) Near-term actions by CRITFC and each of the member tribes; (6.3) Research, monitoring, and adaptive management; (6.4) Updated life history of the Pacific lamprey; (6.5) Tribal translocation guidelines; (6.6) Summary of limiting factors for each of the Columbia River Regional Management Units (provided by each of the local RMUs); (6.7) Glossary of terms; and (6.8) Literature cited in this document.

6.1

Actions, Prioritized Specific Tasks and Research Needed to Restore Pacific Lamprey

INTRODUCTION:

SECTION 6.1 is an extension of SECTION 5; it provides both the **Important Actions** described in SECTION 5 (in **bold font**), and *Specific Tasks* (*in italics*) associated with completing that **Action**. The associated *Specific Tasks* are listed below each of the **Actions**. For clarity, the numbering system in SECTION 6.1 references the numbering system used in SECTION 5.

The list of **Important Actions** and *Specific Tasks* is intended to provide direction toward completing the **Actions**, ***but it is not intended to be complete***. It is impossible to identify and list all **Actions** at this time and all *Specific Tasks* necessary to complete them.

All **Actions** identified in these tables are considered High Priority. Similarly, research in support of these **Actions** is not given a timeline for completion. However, the Tribes recognize that some *Specific Tasks* are of greater urgency. Hence, under "Time Frame" a "1" indicates that the *Specific Task* should be completed within 1–5 years; a "2" indicates the *Specific Task* is anticipated within 1–10 years; a "3" indicates that a *Specific Task* is to be done opportunistically within the next 1–15 years.

5.1	Mainstem Passage and Habitat	**TRIBAL OBJECTIVE:** Fix passage, survival, and habitat for Pacific lamprey in the mainstem Columbia, Snake and Willamette rivers.

BENEFITS

- Accurate and timely adult lamprey passage estimates will help to prioritize, guide and evaluate fixes at each dam. These data also provide a useful abundance index.
- Fixing fishway areas that impede or kill lamprey is critical to providing access to spawning habitat for adults and providing safe passage for larvae and juveniles.
- Passage standards for lamprey commensurate with those of listed salmonids will support achievement of recovery goals.
- Mainstem habitats must be better understood and protected to support population growth and resiliency.

5.1.1 ACTION #	TIME FRAME	Important Actions for Adult Lamprey — Mainstem *and Specific Tasks*
5.1.1.1	**Obtain accurate 24-hour passage estimates for adult lamprey at mainstem dams**	
a	*1*	*Improve timeliness and accuracy of adult lamprey counts at BON*
b	*2*	*Improve timeliness and accuracy of adult lamprey counts at all other mainstem dams*
c	*1*	*Implement regular HD-PIT tagging at BON to allow passage efficiency estimation at all dams*
d	*2*	*Implement periodic radiotelemetry studies to assess efficacy of fixes at specific dam locations*
Research Need	**Continue research to obtain accurate real-time reporting of adult passage at all mainstem dams**	
5.1.1.2	**Fix areas that are known to obstruct or delay adult lamprey at mainstem dams**	
a	*2*	*Replace 1" diffuser grating and trash racks with ¾" material to exclude lamprey from dead ends and danger zones*
b	*2*	*Upgrade LPS components to increase efficacy and capacity (e.g., extend BON Cascades Island exit structure, upgrade BON Bradford Island and JDA pumps, complete JDA north exit, etc.)*
c	*1*	*Install new passage structures (including LPS, surface collectors or wetted wall elements) at bottlenecks to passage (e.g., BON WA-shore entrance, junction pool and serpentine weir areas, TDA east entrance, etc.) Focus near-term work at PUD structures and BON, TDA, JDA, MCN, and IHR)*
d	*1*	*In coordination with the USACE, develop and implement novel approaches to collect adults for translocation (e.g., immediately implement the Lamprey Emergency Assisted Passage Program (LEAPP) where needed and immediately start implementation for the Willamette Valley System river segments)*

Research Need	**Identify areas that obstruct or delay adult Pacific lamprey at mainstem dams**	
	Identify and implement fixes that have the most "bang for the buck" at mainstem dams	
	Identify hydraulic conditions that favor adult lamprey passage (e.g., TDA north fishway)	
	Investigate effects of "shad mode" operation on adult Pacific lamprey (BON, TDA, JDA)	
	Conduct adult Pacific lamprey trap and haul feasibility study for mainstem and tributary dams of the Columbia, Snake and Willamette rivers	
5.1.1.3	**Use adult counts at dams to estimate escapement to upstream sites and losses between dams (conversion rates)**	
a	*1*	*Identify and agree upon dams and key tributary locations that will be used for long-term monitoring and conversion rates estimation.*
b	*1*	*Identify and agree on monitoring methodology for the dams identified in 5.1.1.3a*
5.1.1.4	**Update regional passage standards for adult lamprey at mainstem dams**	
a	*1*	*Make passage standards commensurate with salmon and steelhead standards*
5.1.1.5	**Protect mainstem habitats used by adults for migration, holding and possible spawning**	
a	*1*	*Identify and protect habitats used by adults for migration, over wintering, holding and spawning*
b	*3*	*Include adult lamprey observations in mainstem and estuary sampling conducted by agency partners*
Research Need	*Identify critical habitats used by adults for migration, holding and spawning in reservoirs and the estuary*	
FUTURE ACTIONS TO BE ADDED AS NEEDED		
5.1.1 ACTION #	TIME FRAME	**Important Actions for Larval and Juvenile Lamprey** *and Specific Tasks*
5.1.1.6	**Monitor dam passage and reservoir survival for larvae and juveniles using best available science**	
a	*1*	*Obtain route specific passage information at all dams*
b	*2*	*Use acoustic tag technology to understand occupancy juveniles in the estuary environment*
5.1.1.7	**Obtain annual larvae/juvenile abundance estimates**	
a	*1*	*Extend juvenile bypass monitoring to capture the entire lamprey outmigration period*
b	*1*	*Annually estimate migrating juvenile abundance in the Columbia River (beginning at RRH, LGS, LGR, MCN, BON and Willamette Falls)*
c	*1*	*Provide a winter estimate of larvae/juvenile outmigration numbers at all dams, starting with JDA*
5.1.1.8	**Identify areas above impassable dams that would benefit from lamprey re-introduction**	
a	*1*	*Establish pilot re-introduction programs to assess potential for lamprey production (e.g., Willamette Valley dams)*
b	*2*	*Assess habitat availability, downstream migration risk and other factors to target dams where re-introduction of lamprey is needed (e.g., Willamette Valley dams*

5.1.1.9	**Fix mainstem water diversions and screens to protect larvae and juveniles**	
a	*1*	*Fix screens at pump intakes to protect larval and juvenile lamprey*
b	*2*	*Employ novel technologies to reduce larval and juvenile entrainment and impingement at water withdrawal sites*
5.1.1.10	**Fix areas that are known to impede or kill larval and juvenile lamprey at mainstem dams**	
a	*1*	*Fix turbine cooling water strainers to eliminate this as a source of larval and juvenile mortality (initial focus: LGR, LMN, IHR, LGS, and MCN)*
b	*2*	*Improve smolt bypass tailscreens and other infrastructure to protect larval and juvenile lamprey and allow entry onto barges*
c	*1*	*Reduce bar screen dimensions to reduce larval and juvenile lamprey impingement*
d	*1*	*Evaluate the feasibility for capturing and transporting (barging or other transport) larvae/juvenile from various dams*
Research Need	**Develop and refine larval and juvenile counting methodologies in 2–3 reservoirs and expand to the entire river**	
	Investigate new technologies to improve estimates of larval and juvenile lamprey abundance at mainstem dams (e.g., PNNL prototype collector)	
	Identify larval and juvenile mortality rates associated with mainstem dam passage (as in the Juvenile Lamprey Study, PNNL at LGR)	
	Research the use of existing juvenile transport (e.g., barge, truck) to facilitate downstream transport of larvae and juveniles	
	Evaluate efficacy of larval and juvenile transport programs	
5.1.1.11	**Document larval and juvenile lamprey in the reservoir and estuarine habitats**	
a	*2*	*Limit rapid dewatering of side channels and other larval and juvenile lamprey holding areas in mainstem and estuary habitats*
b	*2*	*Protect larval and juvenile lamprey at any site where mortality is known to occur (including restoration sites for salmonids)*
Research Need	**Continue to investigate ways to dewater side channels to minimize lamprey losses**	
	Explore using water depth to keep lamprey out of irrigation facilities	
	Identify larval and juvenile mortality rates associated with mainstem dam passage (reference the Juvenile Lamprey Study, PNNL at LGR)	
	Identify sources of larval and juvenile lamprey mortality in estuarine habitats	
	Investigate optimal timing of juvenile entry to the estuary	
5.1.1.12	**Apply Best Management Guidelines for mainstem/estuarine dredging, dewatering, and other disturbances**	
a	*1*	*Fix practices shown to injure or kill larvae and juveniles and monitor to ensure improved outcome*
Research Need	**Identify larval and juvenile mortality rates associated with mainstem dredging, water abstraction and dewatering**	
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.2	Tributary Passage and Habitat	**TRIBAL OBJECTIVE:** Fix passage problems and protect/restore important habitats in tributaries including the Willamette Valley System dams.

BENEFITS

- Accurate passage estimates at barriers to lamprey in tributaries help to prioritize actions needed at each structure and provide a useful abundance index.
- Fixing structures that impede or kill lamprey is critical to providing access to spawning habitat for adults and protecting larvae and juveniles for long-term species recovery.
- Protecting spawning and rearing habitat supports population growth and resiliency.

5.2.1 ACTION #	TIME FRAME	Important Actions for Adults — Tributaries *and Specific Tasks*
5.2.1.1	**Obtain accurate passage estimates of adult lamprey at tributary dams, facilities, and road crossings**	
a	*2*	*Develop and implement adult passage rate standards at all tributary dams, facilities, road crossings, culverts or other passage obstructions*
b	*2*	*Develop run size predictions for tributaries based on main stem dam counts (e.g., predictions for the Umatilla River)*
c	*3*	*Develop models to estimate seasonal passage efficiency needed at individual obstacles*
Research Need	**Research novel methods to monitor adult lamprey passage at barriers in tributaries**	
5.2.1.2	**Identify and implement structural and/or operational fixes at tributary dams, irrigation facilities and other obstructions to adult lamprey passage**	
a	*2*	*Implement measures such as flow alteration, culvert replacement and other methods to aid passage*
5.2.1.3	**Implement Best Management Guidelines, as described by the Pacific lamprey TWG, especially those that "mimic" features in naturally occurring bypass systems**	
a	*1*	*Employ nature-like bypass elements to improve adult lamprey attraction and passage.*
Research Need	**Identify areas that obstruct or delay adult lamprey at tributary dams**	
5.2.1.4	**Monitor and implement measures that protect holding and spawning habitat in tributaries**	
a	*1*	*Identify and monitor the availability and abundance of high-quality adult holding and spawning habitats*
b	*1*	*Accelerate restoration and protection of adult holding and spawning habitat*
c	*2*	*Identify excessive sedimentation that threatens adult holding or spawning habitat*
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.2.1 ACTION #	TIME FRAME	Important Actions for Larvae/Juveniles — Tributaries *and Specific Tasks*
5.2.1.5	**Monitor mortality of larval and juvenile lamprey at tributary dams, irrigation diversions, pump intakes and all other sources of mortality**	
a	*1*	*Inventory all sources of mortality and prioritize future monitoring needs*
b	*1*	*Monitor and regularly report mortalities caused by tributary dams, irrigation facilities, pump intakes and other sources of mortality*
Research Need	**Identify sources of mortality for larval and juvenile lamprey at tributary dams, irrigation diversions, and pump intakes**	
5.2.1.6	**Implement structural and operational fixes at areas where larval and juvenile lamprey are entrained and/or killed**	
a	*1*	*Implement measures to eliminate larvae/juvenile passage obstruction or death (e.g., minimizing flow alteration, reducing ramping rates, and installing protective screens, or other measures)*
5.2.1.7	**Protect larvae during dewatering and dredging**	
a	*1*	*Identify methods and implement measures that protect larvae/juveniles from dewatering where this occurs*
b	*2*	*Identify methods and implement measures that protect larvae/juveniles from dredging where this occurs*
Research Need	**Research methods to improve salvage of larvae during diversion canal drawdowns and other dewatering**	
	Identify irrigation canals where re-design of intakes to reduce entrainment would benefit juvenile and larval lamprey	
5.2.1.8	**Increase monitoring of temporal and spatial use of tributaries by larvae and juveniles to identify actions that limit rearing habitat**	
a	*1*	*Identify and monitor the availability and abundance of high-quality larvae/ juvenile habitats in areas susceptible to changes in river morphology*
5.2.1.9	**Develop improved restoration designs for salmonid recovery that also maximize larval and juvenile lamprey habitats and benefits**	
a	*1*	*Ensure that depth, substrate size and channel morphology are suitable for lamprey rearing*
b	*1*	*Facilitate wood placement and other methods to create low velocity areas with silty/sandy substrate for larval rearing in areas that are not dewatered*
5.2.1.10	**Accelerate the rate of actions to restore and protect riverine habitat complexity and diversity**	
a	*2*	*Increase pressure on action agencies to fund and complete projects that increase or protect habitat complexity*
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.3	Oceans	**TRIBAL OBJECTIVE:** Ensure that Pacific lamprey and their hosts are protected in the estuary and ocean and improve water quality and reduce (eliminate) contaminants.

BENEFITS

- Reducing threats to Pacific lamprey in the ocean may significantly increase abundance. We need to understand these threats and take action to protect lamprey at sea.
- Reducing contaminant body burdens will make lamprey safer to eat.
- Risks to Pacific lamprey from marine pathogens are unknown and could be a significant problem worthy of investigation.

5.3.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.3.1.1	**Document and estimate bycatch mortality or other fishery effects on Pacific lamprey**	
a	*1*	*Continue to foster partnerships with NOAA to expand on studies of Pacific lamprey at sea (e.g., bycatch mortality, stable isotopes)*
b	*2*	*Work with NOAA observers to obtain data on lamprey (and lamprey scars) that are seen during routine surveys*
Research Need	**Estimate both direct and indirect mortality of Pacific lamprey that results from fishery bycatch**	
	Continue to research the distribution and population genetics of Pacific lamprey at sea	
	Characterize stock-specific marine distribution, prey preference and migration patterns in the ocean	
5.3.1.2	**Monitor availability of hosts**	
a	*2*	*Identify host species that are most important for Pacific lamprey growth and survival and obtain abundance estimates for them from NOAA*
Research Need	**Identify important feeding areas and how lamprey get to and from them (long distance migration movements)**	
	Study the effects of marine pathogens on Pacific lamprey in the laboratory	
	Increase understanding of how oceanographic regimes and climate change affect distribution, host use and survival of lamprey at sea	
	Model effects of major ocean regime changes on important host species for Pacific lamprey	
5.3.1.3	**Monitor contaminant body burdens of important Pacific lamprey hosts and whether this is a significant route of exposure for Pacific lamprey**	
a	*3*	*Identify important hosts for Pacific lamprey, their contaminant loads and whether these contaminants are transmitted to lamprey during feeding*

5.3.1.4	**Monitor pathogens of important Pacific lamprey hosts and their effects on Pacific lamprey**	
a	*3*	*Identify important hosts for Pacific lamprey, their pathogens and whether these pathogens are transmitted to lamprey during feeding*
5.3.1.5	**Continue to employ existing technology (PIT tagging) or emerging tools (acoustic or pop off tags) to determine migration routes and behavior of Pacific lamprey in the ocean**	
a	*3*	*Partner with NOAA and other marine survey networks to tag Pacific lamprey at sea to determine migration pathways and behaviors*
Research Need	**Develop and implement a research plan to determine effects of alternative energy developments on Pacific lamprey**	
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.4	Predation	**TRIBAL OBJECTIVE:** Monitor, evaluate, and control excessive bird, fish, and mammal predation.

BENEFITS

- Information on impacts of human-induced predation on lamprey life stages will inform actions to curtail unnaturally high predation.
- Reducing mortality rates of vulnerable life stages (upstream or downstream migrants) will increase overall river escapement.

5.4.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.4.1.1	**Develop and implement long-term programs necessary to reduce excessive predation on lamprey adults and juveniles/larvae**	
a	*1*	*Reduce avian predation on juveniles in the lower Columbia River and expand studies on bird colonies known to target lamprey*
b	*1*	*Reduce marine mammal predation on adult lamprey in the lower Columbia River where they are aggregated (e.g., BON and Willamette Falls)*
c	*2*	*Evaluate and implement as needed "predator blocking" as a control for predation in some areas*
Research Need	**Identify the key predator species that contribute to unnaturally high predator impacts and proscribe effective solutions for Pacific lamprey**	
	Quantify predation (i.e., number of lamprey mortalities) by key predator species to estimate the overall "take"	
	Assess key locations where unnaturally high predation occurs	
	Evaluate key timing (season, time of day) when unnaturally high predation occurs	
	Evaluate potential solutions for curbing predation on lamprey and their efficacy	
5.4.1.2	**Monitor for timing, location, life stage and natal origin of lamprey most affected by unnaturally high predation**	
a	*2*	*Design predation studies that incorporate a broader scope both in time and space to accommodate multiple objectives at differing sites*
b	*2*	*Establish a prioritized list of predators, locations and time-of-year various measures can be implemented to reduce predation on lamprey*
5.4.1.3	**Control or eliminate unnaturally high predator impacts on Pacific lamprey**	
a	*2*	*Establish long-term funding, staff capacity and resources needed to effectively reduce unwanted predation and monitor the results*
c	*1*	*Investigate and fix high adult lamprey mortality in the Bonneville pool and other locations identified in* TABLE 10, SECTION 5
d	*2*	*Evaluate and employ new technologies to evaluate lamprey predators*
e	*1*	*Engage the States to revamp sport-fishing regulations on species known to be lamprey predators, such as Smallmouth Bass and Walleye*
f	*1*	*Encourage States to implement a streamlined process for permitting to catch predators (Walleye, Bass, etc.) and evaluate program success*
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.5	Water Quantity, Quality and Contaminants	**TRIBAL OBJECTIVE:** Monitor, evaluate, and control Tribal Objective: Evaluate and significantly reduce (eliminate) contaminant accumulation and improve water quantity and quality for all lamprey life stages.

BENEFITS

- Improving water quantity/quality and reducing contaminant loads in Pacific lamprey will increase population abundance and make lamprey more available for tribal consumption.

5.5.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.5.1.1	**Work with stakeholders to increase water quality monitoring and retain adequate flows in lamprey-bearing rivers and streams**	
a	*1*	*Maintain or increase minimum flow requirements and water quality monitoring to support Pacific lamprey health and productivity*
b	*1*	*Develop partnerships to conduct toxicology studies and reduce contaminant effects on lamprey*
5.5.1.2	**Increase awareness of lamprey needs for high water quality in the mainstem, tributaries, estuarine/marine environments in partnership with other entities**	
a	*2*	*Ensure that lamprey requirements for water quality are considered in water monitoring and discharge permitting processes*
5.5.1.3	**Partner with action agencies to clean up contaminants in lamprey-bearing waters and sediments**	
a	*2*	*Update literature review on the effects of mainstem, tributary, estuarine and marine water quality/quantity and contaminants on Pacific lamprey*
b	*1*	*Identify key contaminants and evaluate their occurrence and persistence in lamprey juveniles and adults*
Research Need	**Evaluate direct and indirect effects of contaminants on Pacific lamprey of all life stages and the consequences of insufficient flows and/or poor water quality, particularly in summer**	
	Assess upper thermal temperature tolerance for adult and juvenile life stages (in addition to larval life stage)	
	Evaluate minimum flow that adult Pacific lamprey require to successfully hold and spawn	
5.5.1.4	**Increase monitoring of contaminants in adult Pacific lamprey and reassess consumption advisories and risks associated with tribal consumption on a regular basis**	
a	*2*	*Significantly diminish contaminants from tribal consumption of Pacific lamprey*
b	*2*	*As appropriate, use artificially propagated Pacific lamprey for toxicology work to reduce impacts on wild fish*
c	*2*	*Develop and evaluate methods to measure toxin levels in adult lamprey that are relatively quick to apply and do not sacrifice the individual.*
Research Need	**Continue assessing effects of mainstem, tributary, estuarine, and marine water quality and contaminants on Pacific lamprey**	
	Investigate the relationship between contaminant loads and stock-specific prey preferences	
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.6	Supplementation/ Artificial Propagation	**TRIBAL OBJECTIVE:** Supplement Pacific lamprey populations by using adult translocation and reintroduction of all life stages into areas where they have severely declined or are extirpated.

BENEFITS

- Providing an interim boost to abundance and distribution of Pacific lamprey in CRB tributaries while fixes to passage and habitat are made will aid lamprey recovery.
- Reducing use of wild Pacific lamprey for toxicology and passage survival studies or other lamprey research will support population growth.

5.6.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.6.1.1	**Continue and expand translocation in accordance with tribal guidelines**	
a	*1*	*Following guidelines in Phase 2 and 3 of the Tribal Supplementation Master Plan, continue to expand translocation as needed*
b	*2*	*Improve infrastructure to support translocation (e.g., improved holding facilities at main stem dams, adequate staffing during run peaks, etc.)*
Research Need	**Develop methods to capture lamprey below BON and other areas (e.g., Willamette Valley System dams) where they are blocked and aggregate**	
	Research the most effective methods for preserving genetic and demographic representation in adults used for translocation	
5.6.1.2	**Continue and expand artificial propagation and phased release of artificially propagated larvae and juveniles**	
a	*1*	*Following guidelines in Phase 2 of the Master Supplementation Plan, continue to expand release of artificially propagated lamprey*
b	*2*	*Expand supplementation and associated monitoring in other subbasins as needed*
Research Need	**Continue research to improve artificial propagation and outplanting methods**	
	Develop a lamprey cell line and research lamprey-specific diseases	
	Research the most effective methods for preserving genetic and demographic representation in adults used for artificial propagation	
5.6.1.3	**Continue monitoring efficacy of adult and larvae/juvenile supplementation efforts**	
a	*1*	*As specified in Phase 2 and 3 of the Master Supplementation Plan, evaluate the efficacy of outplanting artificially propagated lamprey*
b	*1*	*Evaluate the effects of lamprey supplementation on wild lamprey*
c	*2*	*Expand supplementation and associated monitoring in other subbasins as needed*

<table>
<tr><td rowspan="5">Research Need</td><td colspan="2">Research methods to improve translocation success</td></tr>
<tr><td colspan="2">Increase research and monitoring of Pacific lamprey productivity and the role of supplementation in light of climate change</td></tr>
<tr><td colspan="2">Quantify the effective number of spawners from each translocation using genetic techniques</td></tr>
<tr><td colspan="2">Evaluate factors that contribute to effective spawner populations size (e.g., number of fish translocated, habitat, genetic composition, sex ratio)</td></tr>
<tr><td colspan="2">Investigate new areas above impassable dams that could benefit from lamprey re-introductions and determine priorities for actions</td></tr>
<tr><td>5.6.1.4</td><td colspan="2">Identify and develop needed facilities for future work on production of all lamprey life stages (Phase 3 and 4 Master Supplementation Plan)</td></tr>
<tr><td>a</td><td>2</td><td>Provide sufficient facilities and capacity to increase productivity consistent with mitigation needs</td></tr>
<tr><td>b</td><td>2</td><td>Work with state and federal partners to communicate supplementation practices needed for restoring Pacific lamprey populations</td></tr>
<tr><td>c</td><td>2</td><td>Use Adaptive Management to inform future actions and additional facilities envisioned in Phase 4 of the Supplementation Master Plan</td></tr>
<tr><td>5.6.1.5</td><td colspan="2">Organize and sponsor the 2nd Symposium for the Propagation and Restoration of (Pacific) Lamprey</td></tr>
<tr><td colspan="3">FUTURE ACTIONS TO BE ADDED AS NEEDED</td></tr>
</table>

5.7	Climate Change	**TRIBAL OBJECTIVE:** Implement appropriate mitigation, resilience and adaptation actions to protect lamprey and their environments from climate change.

BENEFITS

- The inclusion of Pacific lamprey in all climate projections and plans will help to ensure their persistence in the face of ever-changing environmental conditions.

5.7.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.7.1.1	**Implement climate change plans developed by CRITFC and member Tribes to support mitigation, resilience and adaptation to future changes**	
a	*1*	*Use climate change planning that is already in place to achieve resiliency goals for Pacific lamprey*
5.7.1.2	**Protect and enhance future water resource requirements for Pacific lamprey populations**	
a	*1*	*In the face of ever-increasing demands on freshwater, ensure that minimum flows needed for Pacific lamprey are met*
Research Need	**Model likely changes in aquatic biota to predict changes in Pacific lamprey food, predator and pathogen interactions**	
5.7.1.3	**Estimate changes in runoff, temperature and precipitation pattern, and changes at the subbasin level**	
a	*2*	*Use existing and ongoing analyses of Columbia River hydrology and water quality changes to protect key lamprey habitats*
Research Need	**Analyze alterations in Columbia, Snake, and Willamette river basin hydrology and water quality in relation to Pacific lamprey**	
	Model likely changes to Pacific lamprey phenology	
5.7.1.4	**Include effects on Pacific lamprey in ocean climate models**	
a	*2*	*Develop a model that helps determine impacts of climate change on lamprey growth and survival at sea*
5.7.1.5	**Communicate the need for healthy Pacific lamprey populations as a primary means to establish self-sustaining populations in light of climate change**	
a	*2*	*Ensure that the needs of Pacific lamprey are included in all climate change planning*
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.8	Outreach and Education	**TRIBAL OBJECTIVE:** Conduct Pacific lamprey outreach and education by coordinating with public and private institutions to reach all age groups of tribal and non-tribal people.

BENEFITS

- Support for Pacific lamprey restoration will more effectively proceed with the collective understanding of their importance and their plight.
- Funding for actions needed to recover Pacific lamprey is reliant on the clear perception that there is a serious problem and the consequences of failure to act affect us all.

5.8.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.8.1.1	**Continue to establish a variety of learning networks**	
a	*2*	*Identify social media outlets, school and community learning centers where the importance of lamprey to tribal culture can be taught.*
5.8.1.2	**Continue tribal interviews and other methods to preserve traditional knowledge from tribal elders so this information is not lost and is conveyed to future generations**	
a	*1*	*Develop key messages, target audiences and various means for communication*
b	*1*	*Identify information sources and other communication methods (including local leadership)*
c	*1*	*Train additional leaders and key staff to increase effectiveness in public education and outreach*
5.8.1.3	**Continue to secure additional institutional commitments from for participation in outreach and education (for tribal members and the public)**	
a	*1*	*Develop and secure various funding mechanisms to implement and maintain a robust and sustained outreach program*
b	*1*	*Identify age and culturally effective media and learning materials for development and dissemination*
c	*1*	*Develop citizen scientist program ("lamprey watch") for tribal members and the public.*
Research Need	**Monitor, periodically evaluate, and report on successes and failures in public education and outreach to tribal leadership**	
5.8.1.4	**Communicate the importance of lamprey to the CRB and the consequences of failure to act**	
a	*2*	*Elevate the urgency of messaging regarding the loss of cultural connections and ecological services if Pacific lamprey disappear*
b	*1*	*Collaborate with communicators from the Great Lakes Fishery Commission and other partners to ensure that messaging is not negatively impacting each other*
Research Need	**Investigate new tools for reaching multiple age groups at large spatial scales as technology expands**	

5.8.1.5	**Continue using Pacific lamprey as an important means toward restoration of tribal culture**	
a	*2*	*Emphasize the stories and presence of Tribal Elders within the various outreach and educational forums*
b	*2*	*Develop materials and outreach opportunities to demonstrate the importance of lamprey to tribal cultures and river ecology*
c	*2*	*Demonstrate how to prepare and cook lamprey for ceremonial and community purposes*
5.8.1.6	**Increase coordination between the CRITFC and member Tribes toward development of outreach and education that will reach federal, state, and local partners**	
Research Need	**Access and analyze available research and data on public awareness and perceptions of Pacific lamprey and other communication trends**	
	Access and learn from elder interviews and assess regional variation in tribal use of lamprey	
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.9	**Effective Population Size and Structure**	**TRIBAL OBJECTIVE:** **Ensure that the distribution, total abundance, and effective numbers of spawners of Pacific lamprey in the CRB population continues to grow to levels that are self-sustaining and can support tribal harvest and ecological contributions.**

BENEFITS

- Understanding population structure and responses to actions are critical to achieve sustainable lamprey population levels.
- Genetic information is fundamental to successful restoration, understanding supplementation actions, and assessing population health.
- Tracking population size allows identification of recruitment failures and relative efficacy of management actions.
- Accurate information on sex, species, and life-history diversity are needed to aid the restoration of lamprey in the CRB.

5.9.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.9.1.1	**Continue and expand genetic sampling**	
a	*1*	*Maintain genetic sampling of Pacific lamprey*
b	*1*	*Expand genetic sampling and research for Pacific lamprey*
c	*1*	*Genetically sample adult Pacific lamprey captured by partners during normal operations at dams to represent the full diversity of these runs*
d	*1*	*Genetically sample juvenile and larval lamprey captured during routine electrofishing surveys by partners to represent seasonal variation of these runs*
e	*1*	*Genetically sample larval and juvenile outmigrant Pacific lamprey at screw traps operated by partners and at Juvenile Bypass Facilities operated at mainstem dams to represent seasonal variation of these runs*
Research Need	**Continue pursuit of the elusive genetic sex marker along with physiological assays for diagnosing sex**	
	Use SNPs to refine species identification of lamprey of the Columbia River, characterize life history variants (i.e., ecotypes), and document new lineages	
5.9.1.2	**Maintain and expand baseline population monitoring of Pacific lamprey within the CRB**	
a	*1*	*Maintain baseline monitoring of Pacific lamprey within the CRB*
b	*2*	*Expand baseline monitoring of all life stages of Pacific lamprey within the CRB*
c	*1*	*Ensure that all entities performing research and/or monitoring activities summarize and share information in a meaningful and prompt manner*
d	*3*	*Identify and quantify larval and juvenile lamprey captured at screw traps operated by partner agencies — summarize and share this information in a meaningful and prompt manner*
e	*2*	*Identify agency representatives and processes to develop lamprey regional data structure and data archiving*
f	*2*	*When appropriate, expand use of multi-species or ecosystem management to illustrate lamprey contributions to environmental health.*

Research Need	*Identify status and trends in lamprey population size and structure*	
	Determine effective population size and the minimum viable population size for the CRB	
	Quantify homing of adults to their natal tributaries (e.g., Yakima, Umatilla, Snake and Willamette rivers)	
	Identify local and regional sources and sinks of Pacific lamprey production	
	Conduct research to assess carrying capacity for Pacific lamprey and factors that control it	
5.9.1.3	**Develop lifecycle modeling for Pacific lamprey and use the results to inform passage required at each dam, and implementation of all Actions to support tribal harvest goals**	
a	*1*	*Conduct sensitivity analysis to determine what model inputs drive results and identify those that need to be refined*
b	*1*	*Use the resulting model to estimate adult passage needed at each main stem dam to achieve tribal harvest goals.*
c	*1*	*Use the resulting model to estimate the impacts from supplementation (adult translocation and outplanting of early life stages)*
Research Need	**Collect data to improve parameterization of life cycle models**	
FUTURE ACTIONS TO BE ADDED AS NEEDED		

5.10	Research, Monitoring and Adaptive Management	**TRIBAL OBJECTIVE:** Develop and implement regional Research, Monitoring and Adaptive Management to (1) inform tribal and regional policy about priority actions and research and (2) accelerate our ability to implement important actions that will return lamprey populations to historic abundance and distribution.

BENEFITS

- A major limiting factor to Pacific lamprey restoration has been and continues to be our lack of understanding of their biology, their population structure, and the specific threats to their existence. With this information, we can move forward with more effective and efficient recovery actions.

5.10.1 ACTION #	TIME FRAME	Important Actions *and Specific Tasks*
5.10.1.1	**Adopt an Adaptive Management strategy for the CRB that involves regional participation in the year 2027**	
a	*2*	*Develop and maintain a library of resources on research and monitoring studies and actions associated with lamprey protection and restoration*
b	*1*	*Define key management and research questions to be addressed and develop consistent protocols and formats for data collection, evaluation, and reporting*
5.10.1.2	**Develop and adopt a tribally and/or regionally supported Status and Trend Annual Report template**	
c	*1*	*Identify and annually update a list of the regional entities implementing lamprey funded restoration actions, research, monitoring and reporting to contribute to the Status and Trend Annual Report*
d	*1*	*Identify Key Index Sites throughout the CRB that will be monitored over time to establish population status and trends and population responses to restoration actions*

NOTE to reader: the following Research Needs (RN) are summarized, for convenience, from those previously identified in SECTIONS 5.1–5.9.	
Section *Reference*	**Research Needs**
RN 5.1.2	**Mainstem Passage and Habitat**
A	*Continue research to obtain accurate real-time reporting of adult passage at all mainstem dams*
B	*Identify areas that obstruct or delay adult Pacific lamprey at mainstem dams*
C	*Identify and implement fixes that have the most "bang for the buck" at mainstem dams*
D	*Identify hydraulic conditions that favor adult lamprey passage (e.g., TDA north fishway)*
E	*Investigate effects of "shad mode" operation on adult Pacific lamprey (BON, TDA, JDA)*
F	*Conduct adult Pacific lamprey trap and haul feasibility study for mainstem and tributary dams of the Columbia, Snake and Willamette rivers*
G	*Identify critical habitats used by adults for migration, holding and spawning in reservoirs and the estuary*
H	*Develop and refine larval and juvenile counting methodologies in 2–3 reservoirs and expand to the entire river*
I	*Investigate new technologies to improve estimates of larval and juvenile lamprey abundance at mainstem dams (e.g., PNNL prototype collector)*
J	*Identify larval and juvenile mortality rates associated with mainstem dam passage (as in the Juvenile Lamprey Study, PNNL at LGR)*
K	*Research the use of existing juvenile transport (e.g., barge, truck) to facilitate downstream transport of larvae and juveniles*
L	*Evaluate efficacy of larval and juvenile transport programs*
M	*Continue to investigate ways to dewater side channels to minimize lamprey losses*
N	*Explore using water depth to keep lamprey out of irrigation facilities*
O	*Identify larval and juvenile mortality rates associated with mainstem dam passage (reference the Juvenile Lamprey Study, PNNL at LGR)*
P	*Identify sources of larval and juvenile lamprey mortality in estuarine habitats*
Q	*Investigate optimal timing of juvenile entry to the estuary*
R	*Identify larval and juvenile mortality rates associated with mainstem dredging, water abstraction and dewatering*
RN 5.2.2	**Tributary Passage and Habitat**
A	*Research novel methods to monitor adult lamprey passage at barriers in tributaries*
B	*Identify areas that obstruct or delay adult lamprey at tributary dams*
C	*Identify sources of mortality for larval and juvenile lamprey at tributary dams, irrigation diversions, and pump intakes*
D	*Research methods to improve salvage of larvae during diversion canal drawdowns and other dewatering*
E	*Identify irrigation canals where re-design of intakes to reduce entrainment would benefit juvenile and larval lamprey*

RN 5.3.2	Oceans
A	*Estimate both direct and indirect mortality of Pacific lamprey that results from fishery bycatch*
B	*Continue to research the distribution and population genetics of Pacific lamprey at sea*
C	*Characterize stock-specific marine distribution, prey preference and migration patterns in the ocean*
D	*Identify important feeding areas and how lamprey get to and from them (long distance migration movements)*
E	*Study the effects of marine pathogens on Pacific lamprey in the laboratory*
F	*Increase understanding of how oceanographic regimes and climate change affect distribution, host use and survival of lamprey at sea*
G	*Model effects of major ocean regime changes on important host species for Pacific lamprey*
H	*Develop and implement a research plan to determine effects of alternative energy developments on Pacific lamprey*
RN 5.4.2	**Predation**
A	*Identify unnaturally high predator impacts and effective solutions for Pacific lamprey*
B	*Quantify the predation (i.e., number of lamprey mortalities) by the key predator species to estimate the overall "take"*
C	*Assess key locations where unnaturally high predation occurs*
D	*Evaluate key timing (season, time of day) when unnaturally high predation occurs*
E	*Identify potential solutions for curbing predation impacts and evaluate their efficacy*
RN 5.5.2	**Water Quantity, Quality and Contaminants**
A	*Evaluate direct and indirect effects of contaminants on Pacific lamprey of all life stages and the consequences of insufficient flows and/or poor water quality, particularly in summer*
B	*Continue assessing effects of mainstem, tributary, estuarine, and marine water quality and contaminants on Pacific lamprey*
C	*Investigate the relationship between contaminant loads and stock-specific prey preferences*
D	*Assess upper thermal temperature tolerance for adult and juvenile life stages (in addition to larval life stage)*
E	*Evaluate minimum flows that adult Pacific lamprey require to successfully hold and spawn in tributaries*
RN 5.6.2	**Supplementation/Artificial Propagation**
A	*Develop methods to capture lamprey below BON and other areas (e.g., Willamette Valley System dams) where they are blocked and aggregate*
B	*Research the most effective methods for preserving genetic and demographic representation in adults used for translocation*
C	*Continue research to improve artificial propagation and outplanting methods*
D	*Develop a lamprey cell line and research lamprey-specific diseases*
E	*Research the most effective methods for preserving genetic and demographic representation in adults for artificial propagation*

F	*Research methods to improve translocation success*
G	*Increase research and monitoring of Pacific lamprey productivity and the role of supplementation in light of climate change*
H	*Quantify the effective number of spawners from each translocation using genetic techniques*
I	*Evaluate factors that contribute to effective spawner populations size (e.g., number of fish translocated, habitat, genetic composition, sex ratio)*
J	*Investigate new areas above impassable dams that could benefit from lamprey re-introductions*
RN 5.7.2	**Climate Change**
A	*Model likely changes in aquatic biota to predict changes in Pacific lamprey food, predator and pathogen interactions*
B	*Analyze alterations in Columbia, Snake, and Willamette river basin hydrology and water quality in relation to Pacific lamprey*
C	*Model likely changes to Pacific lamprey phenology*
RN 5.8.2	**Outreach and Education**
A	*Monitor, periodically evaluate, and report on successes and failures in public education and outreach to tribal leadership*
B	*Investigate new tools for reaching multiple age groups at large spatial scales as technology expands*
C	*Access and analyze available research and data on public awareness and perceptions of Pacific lamprey and other communication trends*
D	*Access and learn from elder interviews and assess regional variation in tribal use of lamprey*
RN 5.9.2	**Effective Population Size and Structure**
A	*Continue pursuit of the elusive genetic sex marker along with physiological assays for diagnosing sex*
B	*Use SNPs to refine species identification of lamprey of the Columbia River, characterize life history variants (i.e., ecotypes), and document new lineages*
C	*Identify status and trends in lamprey population size and structure*
D	*Determine effective population size and the minimum viable population size for the CRB*
E	*Quantify homing of adults to their natal tributaries (e.g., Yakima, Umatilla, Snake and Willamette rivers)*
F	*Identify local and regional sources and sinks of Pacific lamprey production*
G	*Conduct research to assess carrying capacity for Pacific lamprey and factors that control it*
H	*Collect data to improve parameterization of life cycle models*
FUTURE RESEARCH TO BE ADDED AS NEEDED	

6.2
Near-Term Actions: CRITFC and Member Tribes

The following describes actions taken by the individual Columbia Basin Fish Accords-signatory tribes and CRITFC throughout the CRB. The Objectives and Actions noted here are "near-term." Some are intended to be completed within the next few years (2025–2030), some will occur for many years. Other new actions will be developed and implemented over time.

6.2.1 Confederated Tribes of the Umatilla Indian Reservation

PROJECT TITLE

Pacific Lamprey Research and Restoration Project

SUBBASIN(S)

Umatilla, Ceded Areas

The goal of this project is to recover Pacific lamprey to self-sustaining, and harvestable levels and to provide essential information from the implementation of recovery actions for Pacific lamprey in the CTUIR ceded area streams. To date, studies have provided critical and valuable information on the biology and ecology of Pacific lamprey throughout the CRB. The objectives outlined below will provide information that will be useful for restoration efforts elsewhere in the CRB where lamprey may be declining or extirpated, such as the Grande Ronde, Walla Walla, and Tucannon basins as we have planned here.

INTERIM OBJECTIVES

Umatilla River

- Increase larval abundance in the Umatilla River by translocating/trap-and-hauling adult lamprey.
- Estimate lamprey abundance at index sites in the Umatilla River and Meacham Creek.
- Estimate the number of upmigranting adults entering the Umatilla River.
- Estimate the number of outmigrating lamprey (larvae and metamorphosed) from the Umatilla River and continue juvenile PIT tag evaluations.
- Monitor migration to spawning behavior and passage routes over low-head irrigation diversions of Pacific lamprey using radio telemetry.

- Refine adult lamprey passage structures at irrigation diversions on the Umatilla River.
- Report results to the funding agency.
- Publish findings in peer-reviewed journals and attend professional conferences.
- Complete monitoringresources.org protocols for related work elements.

Ceded Area Surveys

- Continue to re-establish larvae/juvenile index sites (incorporating those from our 1999 surveys) in the Tucannon, Walla, Walla, John Day, and Grande Ronde basins.
- Conduct larval electrofishing surveys at the index sites.
- Collect eDNA samples from tributaries within the ceded area. This data will help provide presence/absence and distribution information.

Supplementation/Master Plan Objectives

- Continue to advance (laboratory only) work related to artificial propagation research.
- Spawn, incubate, and rear up to 1 million prolarvae for release in the Tucannon River and monitor survival.
- Establish and estimate lamprey (pre- and post-reintroduction) abundance at index sites in the Walla Walla and Tucannon basins with genetic tissue samples collected from any larvae for future analysis.
- Coordinate with agencies that are operating outmigration screw traps and conducting salmonid spawning surveys to properly identify and collect biological data for individuals sampled. Provide support as needed.
- Coordinate with local, state, tribal, and federal agencies for any necessary permits.

Confederated Tribes of the Warm Springs
Indian Reservation of Oregon

6.2.2a Confederated Tribes of the Warm Springs Reservation of Oregon

PROJECT TITLE

Evaluate Status & Limiting Factors of Pacific Lamprey in the Lower Deschutes River, Fifteenmile Creek, and Hood River Subbasins

SUBBASIN(S)

Deschutes, Fifteenmile, and Hood River

INTERIM OBJECTIVES

Consistent with those identified by the Columbia Basin Pacific Lamprey Technical Work Group

TITLE OF WORK ELEMENT DETAILS

Task	Action
A 165	*Deschutes, Fifteenmile, Hood — Complete Environmental Compliance Requirements*
B 157	*Deschutes River (DR): 2023–2024 Record tributary water temperatures for lamprey life history*
C 162	*DR: Manage and summarize water temperature data (2022–2023) to characterize lamprey habitats*
D 158	*2024 Tag lamprey to estimate abundance at Sherars Falls*
E 157	*DR: Collect lamprey abundance and harvest data to estimate escapement at Sherars Falls 2023*
F 162	*2024 Estimate Pacific lamprey escapement upstream of Sherars Falls*
G 157	*DR: Collect data from dual reader PIT sites on CTWSRO reservation*
H 156	*Study feasibility for a mark-recapture estimate of lamprey in Warm Springs River*
I 156	*DR: Study feasibility of Ne and age of migration of larval lamprey in Warm Springs River*
J 162	*Fifteenmile (FM): Manage and summarize water temperature data (2023–2024)*
K 157	*FM: 2024 Field activities to estimate Pacific lamprey escapement estimate upstream of Cushing Falls*
L 158	*FM: Tag lamprey at Cushing Falls for escapement estimates*
M 162	*FM: Calculate lamprey escapement upstream of Cushing Falls*

Task	Action
N 162	*FM: Analysis of tissue samples from larval and adult lamprey*
O 157	*FM: Record PIT tagged lamprey in Fifteenmile Creek*
P 157	*Hood River (HR): Collect data from half-duplex site in Hood River*
Q 157	*Document presence/absence and end of distribution of lamprey in Hood River subbasin*
R 157	*HR: Collect larval lamprey density data within Hood River and its tributaries*
S 157	*FM: Collect larval lamprey density data within Fifteenmile and Eightmile creeks*
T 157	*DR: Collect larval lamprey density data from the Deschutes River and its lamprey-bearing tributaries*
U 162	*DR, FM & HR: Analyze 2023 larval lamprey surveys (end of distribution and densities)*
V 159	*DR, FM & HR: Enter HDX PIT tag information into CTWSRO database*
W 162	*DR, FM & HR: Summarize data collected from PIT tag arrays*
X 189	*DR, FM & HR: Participate in regional planning and recovery actions for Pacific lamprey*
Y 119	*Manage project*
Z 132	*Submit progress report*
AC 132	*Periodic status reports for BPA*

Confederated Tribes of the Warm Springs
Indian Reservation of Oregon

6.2.2b Confederated Tribes of the Warm Springs Reservation of Oregon

PROJECT TITLE

Willamette Falls Lamprey Escapement Estimate

SUBBASIN(S)

Willamette

INTERIM OBJECTIVES

This project estimates escapement of lamprey through fish ladders at Willamette Falls, is working towards quantifying escapement over the "horseshoe" portion of the falls, including the historic fishway, and conducts creel surveys to document harvest.

TITLE OF WORK ELEMENT DETAILS

Task	Action
A 165	*Complete environmental compliance requirements*
B 157	*Install video cameras for lamprey ramps and the old fishway and HDX antenna in old fishway*
C 162	*Video review for lamprey recorded passing old fishway and lamprey ramps*
D 157	*Collect and examine lamprey to calculate adult escapement*
E 162	*Analyze PIT tag detections from antenna arrays in WFFL, old fishway, and Abernethy Creek*
F 158	*HDX tag adult Pacific lamprey at Willamette Falls*
G 156	*Collect tissue samples from ammocoetes near tributary mouths and rearing habitats in the mainstem Willamette River downstream of Willamette Falls*
H 157	*Conduct creel surveys*
I 162	*Record and report harvest*
J 157	*Collect tissue samples from ammocoetes*
K 162	*Analysis of tissue samples from larval lamprey*
L 191	*Participate in Willamette Falls Pacific Lamprey Technical Working Group (WFPLTWG)*
M 119	*Manage project*
N 132	*Submit progress report*
O 132	*Submit progress report*
P 132	*Submit progress report*
Q 185	*Periodic status reports for BPA*

6.2.3 Confederated Tribes and Bands of the Yakama Nation

PROJECT TITLE

Yakama Nation Ceded Lands Lamprey Evaluation and Restoration

SUBBASIN(S)

Yakima, Wenatchee, Methow, Mainstem, Big White Salmon, Wind, Entiat, Klickitat

The goal of the Yakama Nation Pacific Lamprey Project (YN PLP) is to restore natural production of Pacific lamprey in the YN ceded lands, specifically, the Yakima, Klickitat, White Salmon, Little White Salmon, Wind, Rock, Wenatchee, Methow, and Entiat river systems. The primary objectives include (1) provide regional leadership in the implementation and promotion of lamprey restoration, (2) implement and lead reintroduction and supplementation, (3) conduct research to support the development of management actions associated with adult and juvenile productivity, (4) rigorous exploration of solutions and resolution of critical uncertainties that are known or likely to limit productivity, and (5) actively pursuing a strong outreach and education program.

INTERIM OBJECTIVES

- Continue adult translocation in the Yakima, Wenatchee, Methow, and other subbasins of interest for reintroduction and supplementation of depressed subpopulations.
- Continue development of artificial propagation science and pursue and evaluate applications for restoration (such as reintroduction/supplementation and conservation hatchery) as well as research (such as juvenile survival studies and limiting factors analysis). Implement the Master Plan starting in 2018–2019.
- Continue the research on limiting factors and refine solutions for existing threats to lamprey, such as adult passage, larvae/juvenile entrainment in irrigation diversions, river management impacts on adult and larval migration and rearing, toxics in larval tissue and habitat, and predation by invasive species. Use all tools available to achieve these goals, including genetic analyses, eDNA, radio and acoustic telemetry, PIT and VIE tagging, artificially propagated larvae/juvenile, etc.
- Continue the development and implementation of solutions through matching funds and strong and creative

partnership. Focus will be on adult passage (tributary dams, such as Horn Rapids, Prosser, Sunnyside, Wapato, Roza dams on Yakima River and Tumwater Dam in Wenatchee River as well as lower and upper Columbia River dams) and larvae/juvenile entrainment (Dryden Diversion in Wenatchee subbasin and various diversions within the Yakima Subbasin).

- Continue documenting status and trends of larvae, juvenile, and adult returns within tributary streams. Continue characterizing and documenting habitat capacity (existing and potential) relative to larvae/juvenile use and productivity. Continue monitoring spawn timing and success and recruitment abundance primarily in translocation streams. Develop population models that guide our understanding and management for Pacific lamprey species based on life stage-specific survival rates and biology.
- Continue rigorous outreach and education for youth/students, teachers, general public, as well as agency biologists and managers. Also, incorporate Traditional Ecological Knowledge into our program through interviews with tribal elders and ensure that our management direction is in accordance with the historical perspectives stemming from YN tribal members and the ceded lands.

LONG-TERM PROJECT OBJECTIVES

- Consolidate and summarize current and historical information related to Pacific lamprey distribution and abundance within the YN ceded lands.
- Monitor larvae/juvenile production using a variety of monitoring tools (e.g., genetics, screw traps, VIE and PIT tags, length and weight data, etc.).
- Identify current habitat strongholds for larvae/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 larvae/juvenile growth and production in key (or index) watersheds.
- 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.).
- 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.
- Identify actions that can be taken to restore or enhance adult holding and spawning.
- Identify adult and larvae/juvenile lamprey migration characteristics.
- Identify known and suspected passage barriers (i.e., irrigation diversions and dams) and key limiting factors that prevent adult and larvae/juvenile lamprey from successfully migrating (or spawning).
- Initiate small-scale reintroductions 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.

TITLE OF WORK ELEMENT DETAILS

Task	Action
A 165	*Ensure Environmental Compliance Requirements have been met*
B 174	*Produce Propagation, Rearing, & Outplanting Plan*
C 157	*Larvae/Juvenile Lamprey Surveys in the YN Ceded Lands (*with eDNA laboratory analyses) and Other Field/Lab Data*
D 28	*Lamprey Survey and Rescue in Irrigation Canals*
E 99	*Participation in Public Outreach*
F 161	*Participate in Local and Regional Efforts*
G 158	*PIT and Floy Tag Adult Lamprey*
H 158	*PIT, VIE & Acoustic Tag Larvae/Juvenile Lampreys*
I 196	*Conduct the 3-Step Process for Lamprey Artificial Propagation Activities (with CRITFC)*
J 176	*Rearing — Research into Artificial Propagation and Early Life Stage Rearing*
K 157	*Release — Early Life Stage Lamprey Outplanting Monitoring*
L 66	*Translocate Adult Lamprey from the Columbia River*
M 66	*Collect Adult Lamprey for research into artificial propagation*
N 162	*Data Input and Analysis*
O 186	*Maintain and monitor lamprey passage structures*
P 141	*Other Reports for BPA*
Q 183	*Produce Journal Articles*
R 119	*Manage and Administer Project*
S 132	*Submit Annual Report*
T 132	*Submit Annual Report*
U 132	*Submit Progress Report for CY2024 (Jan 2024) to (Dec 2024)*
V 185	*Periodic Status Reports for BPA*

6.2.4 Nez Perce Tribe

PROJECT TITLE

Regional coordination with CRITFC and CRITFC member tribes regarding Pacific lamprey issues and larval lamprey surveys in the Snake River basin

SUBBASIN(S)

Snake River basin; focus on Salmon, Clearwater, and Grande Ronde subbasins

INTERIM OBJECTIVES

The first objective of this project is to support and monitor timely implementation of the suite of TPLRP mainstem actions that address/improve adult and juvenile passage at Columbia and Snake river dams.

The second objective of this project is to continue conducting larval lamprey surveys in the Snake River basin in support of TPLRP Objective 1 (Supplementation/Augmentation) and TPLRP Objective 6 (Research, Monitoring, and Evaluation).

The third objective of this project will be to summarize the results of larval Pacific lamprey presence/absence surveys from 2023 in the Snake River basin by the Tribe.

TITLE OF WORK ELEMENT DETAILS

Task	Action
1	*Attend periodic regional planning, coordination and implementation meetings and periodic dam/fishway inspections.*
2	*Attend Tribal lamprey technical workgroup, Tribal-USACE lamprey workgroup (CT-LAW), CRITFC Lamprey Task Force, PLCI and other related meetings.*
3	*Attend FCRPS meetings including but not limited to FPOM, FFDRWG, SCT, SRWG, AFEP, etc.*
4	*Conduct systematic larval lamprey surveys in the Snake River basin of ID, WA, and OR according to existing, standardized methods in translocation and non-translocation streams.*

Task	Action
5	*Summarize the results of larval Pacific lamprey presence/absence surveys in the Snake River basin by the Nez Perce Tribe.*
6	*Participate in educational outreach at all levels, in support of tribal restoration efforts, as this is increasingly a priority for the NPT Pacific Lamprey Translocation Initiative.*
7	*Participate in "Lamprey-in-the-classroom" events and host tours of Lamprey Building at Nez Perce Tribal Hatchery, held as part of biology classes, senior projects, and science field trips.*
8	*Continue monitoring and evaluation of the Tribe's existing lamprey supplementation efforts (i.e., translocation).*
9	*Continue compiling, tracking, and managing larval and juvenile lamprey bycatch data and tissue samples for PBT analysis from rotary screw traps operated by other NPT DFRM salmonid projects, and coordinate collection of PBT samples from other agencies (IDFG, ODFW, WDFW).*
10	*Track and report new information resulting from genetic analysis of progeny of adults translocated from the lower Columbia dams to target tributaries by the Nez Perce Tribe's program.*

Columbia River Inter-Tribal Fish Commission

6.2.5 Columbia River Inter-Tribal Fish Commission

PROJECT TITLE:

Implement Tribal Pacific Lamprey Restoration Plan

SUBBASIN(S):

Columbia River Basin

INTERIM OBJECTIVES

- Improve lamprey mainstem passage, survival, and habitat.
- Improve tributary passage and identify, protect, and restore tributary habitat.
- Supplement/augment lamprey populations by reintroduction and translocation of adults and juveniles into areas where they are severely depressed or extirpated.
- Evaluate and reduce contaminant accumulation and improve water quality for lamprey in all life stages.
- Establish and implement a coordinated regional lamprey outreach and education program within the region.
- Conduct research, monitoring and evaluation of lamprey at all life history stages.

TITLE OF WORK ELEMENT DETAILS

Task	Action
A 165	*Obtain environmental clearance — NEPA, ESA, etc.*
B 162	*Use a multifunctional SNPs panel for genetic monitoring of CRB lamprey species.*
C 157	*Genetic monitoring of CRB lamprey species — adult lamprey tissue collection.*
D 157	*Genetic monitoring of CRB lamprey species — pre-adult lamprey tissue collection.*
E 157	*Determining the presence/absence of Pacific lamprey in the Snake River Basin.*
F 66	*Facilitate the collection of adult lamprey from the Columbia River.*
G 61	*Maintenance and repairs (Art. Prop Facilities).*
H 162	*Assess emerging and legacy contaminants in Pacific lamprey in the CRB, etc. opportunistic sampling of existing samples (e.g., larvae/juvenile/adult mortalities collected at mainstem dams, etc.).*

Task	Action
I 162	*Utilizing existing datasets to address critical uncertainties.*
J 189	*Regional coordination with CRITFC member tribes regarding Pacific lamprey.*
K 189	*Regional coordination of matters concerning Pacific lamprey.*
L 99	*Outreach and education regarding Pacific lamprey to regional agencies and schools.*
M 174	*Development of tribal and regional coordination, collaboration, and planning documents.*
N 119	*FY22 contract and budget management, FY23 contract package prep.*
O 132	*Submit progress report.*
P 185	*Periodic status reports for BPA.*

6.3 Framework: Research, Monitoring and Adaptive Management

INTRODUCTION:

The extirpation of Pacific lamprey populations in many CRB watersheds is the culmination of numerous environmental insults. Pacific lamprey occupy a wide range of habitats and have multiple life stages that feed on and interact with many different organisms. They are indeed a "canary in the coalmine" with regards to environmental health. Restoring the population back to "healthy and harvestable" numbers in a timely manner will take a well-coordinated and disciplined adaptive management approach requiring efficient implementation of actions discussed in **SECTION 5** and **SECTION 6** of this 2025 TPLRP.

The general adaptive management process is diagramed in **FIGURE 28** and illustrated again below for convenience. Although interagency policy and technical decisions occur throughout the year, regional policy discussions and decisions — the backbone of adaptive management — will occur annually.

The Tribes understand that regional adoption of either Abundance Based Goals and Lamprey Passage Standards is necessary to our restoration efforts for Pacific lamprey. Yes, these decisions will be difficult and controversial. However, we have only to look at the array of metrics and population goals established for salmonids, other commercial and game fish, and many wildlife species to recognize their importance. Working collectively, the region's co-managers will be able to establish, adopt and implement these goals and standards by 2035 using a well-defined adaptive management process from which to measure our progress and accomplish our vision, goals and objectives — as discussed in **SECTION 2** of this document.

The key elements of the adaptive management process are discussed below.

6.3.1 Policy Discussions and Decisions

Within the CRB, a substantial amount of new information concerning lamprey restoration is annually available (e.g., Le et al. 2020). Much of this is of interest to the general public and essential for those directly involved with lamprey/natural resource restoration. It is important to communicate this information in a timely manner and in a way that can be commonly understood. But this material is not just for discussion. It must be formatted and presented in a way that will fully inform policy representatives about annual decisions for future actions.

6.3.2 Prioritize and Implement Actions

An extensive list of actions has been developed and presented in **SECTIONS 5** and **6** of this 2025 TPLRP. All of these actions are important, although some are more urgent than others. The Tribes recognize that near-term priority actions (1–5 year timeframe) will change over time and additional actions will be prioritized as they are identified.

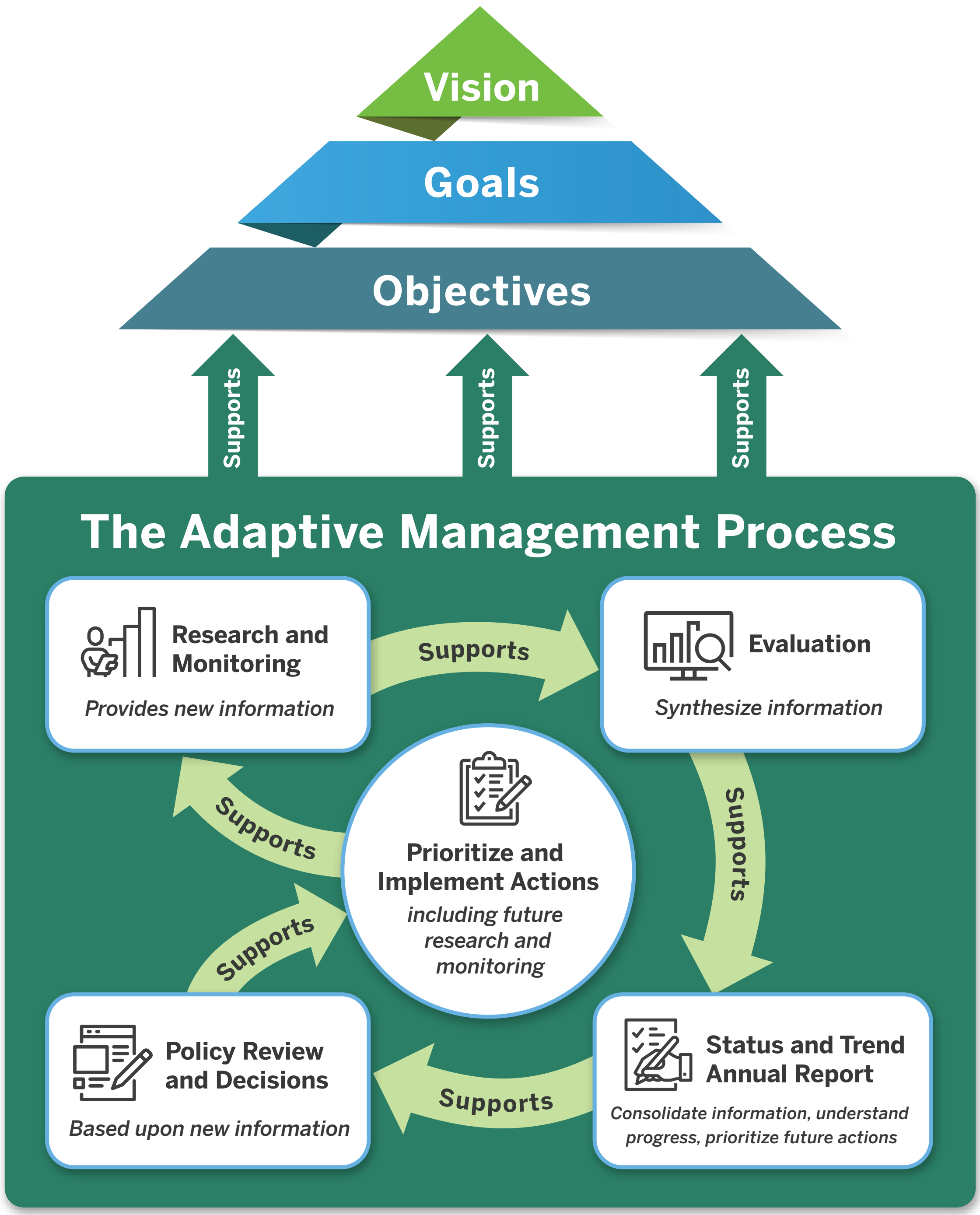

FIGURE 28 (repeated from SECTION 5.10). Adaptive Management Framework proposed for Pacific lamprey Restoration.

6.3.3 Research and Monitoring

Many actions are expected to take multiple years of planning, research, implementation, monitoring, and evaluation. Multiple partnerships may be involved with various sources of funding. Timely implementation requires accountability at both technical and policy levels. This is an area, the Tribes believe, that has substantial potential for improvement in the CRB. Decision making, annually or otherwise in an adaptive management framework includes considerations for both timely implementation of priority actions and accountability for all partners in the process.

Also, a key limiting factor for restoration of Pacific lamprey continues to be a lack of critical information. Increasing the amount and rate of research and monitoring will advance our understanding of threats and inform and prioritize actions needed for species recovery. The adaptive management process is simply the evaluation of existing information captured in a status and trend report on which decisions about future actions are based. Much of this information relies upon results from both research and monitoring. This will include lamprey biology and ecology, yes, but also regional progress toward timely implementation of needed work.

RESEARCH AND CRITICAL UNCERTAINTIES

Research informs our understanding of Pacific lamprey biology, ecology, and their needs for recovery. It is also the most important way to identify the best (efficient and effective) actions to implement within a given situation. Many Critical Uncertainties are included within this 2025 TPLRP (see SECTION 5.1–5.10), indicating the types of research (and their associated future restoration actions) that are important in the coming years. As old questions are answered, new ones will emerge.

MONITORING IMPLEMENTATION PROGRESS AND LOCAL/ WATERSHED POPULATION RESPONSE

Substantial resources are being invested in implementation of Actions. Monitoring both the progress of implementation and the population response, at the appropriate temporal and spatial scale, is central to our continued learning. Some level of monitoring and reporting should occur for each project implemented in a manner consistent with regional standards.

6.3.4 Evaluation

The importance of careful evaluation of research and monitoring results cannot be overstated and this topic has been well described in many regional natural resource publications over the years. Most research and monitoring projects provide for an evaluation; but this is not always conducted in a timely manner. This must change to better support restoration efforts.

Two important components, discussed below, will build a foundation for the adaptive management process: (1) a status and trend annual report, and (2) life cycle modeling. The Tribes envision the focus of the evaluation will be contained in a periodic, comprehensive Status and Trend document discussing both Pacific lamprey population responses to Actions implemented, research and monitoring results, and also regional cooperation. Much of this technical information will be presented in a manner that supports the application and continued development of life cycle modeling. Each of these topics are discussed below.

STATUS AND TREND ANNUAL REPORT

To efficiently communicate our progress and future work needs to managers, researchers and the public, a detailed status and trend annual report must be developed and maintained. This report, built by all regional participants, will focus on:

- research results and needs,
- actions and monitoring results that are ongoing and needed,
- the current status and trends of larval, juvenile, and adult lamprey populations, and
- an assessment of progress throughout the CRB.

Annual evaluation of progress must be based on a well-defined set of measurements of lamprey population response that are comparable across time and space. Most of these measures are used currently but are not necessarily regionally standardized or adopted. This can be done. It is also important to track regional funding and commitments towards research, monitoring, and implementation of priority actions to ensure appropriate involvement and timely results.

One important milestone is to obtain a population size within the CRB, which is the sum total of local populations within each of the RMUs. Three key metrics of lamprey abundance are (1) Distribution, (2) Demography, and (3) Abundance relative to stream carrying capacity for all life stages. Standardized assessment of these metrics is needed at all key sites (index sites) identified for each of the RMUs (by knowledgeable people within the RMU). Status and trends in abundance will rely on accurate estimation of: (1) the available amount of Good–Excellent spawning and rearing habitat, (2) adult and larval use of these habitats, and (3) annual recruitment to each key site in each watershed. In addition, timely information on larvae/juvenile and adult releases from the ongoing supplementation program and dam passage metrics will be available and summarized each year.

A second important milestone is the annual computation of dam-to-dam conversion rates in the Columbia, Snake, and Willamette rivers. These measures provide a summary of escapement at individual mainstem dams in these drainages and allow for interannual comparisons of passage success. Ideally, real-time computation of conversion rates (the percentage of adults counted at a given dam divided by the number counted at the next dam downstream) would allow rapid identification of passage failures or seasonal shifts in run timing.

The Tribes do not intend to develop and annually manage the entirety of a Pacific Lamprey Status and Trend Annual Report. We look to the region's co-managers for collaboration and support in developing various components. For it to be adopted, it must be developed by the region. For example, much information will be or is already being developed and evaluated by the various RMUs. Other federal and state entities and public utility districts have unique obligations and currently report annually. These annual or periodic reports will contribute to the larger effort. It is the Tribes intent that these efforts be coordinated, consolidated and, over time, refined to support the adaptive management process, herein described.

For clarity, the Tribes offer an example of a proposed Table of Contents for the Status and Trend Annual Report (TABLE 11).

TABLE 11. Proposed Table of Contents for the future Status and Trend Annual Report.

Achievements	Reporting Period	Lead Entities
Policy Achievements	Annual	PLCI
TPLRP 2025 Priority Achievements	Annual	Tribes
Annual Funding		
■ Current Funding	Annual	All
■ Past 3 Years	Annual	PLCI
■ Projected	Annual	All
Harvest Update		
■ Primary Harvest Locations	Annual	Tribes
■ Numbers Reported	Annual	Tribes
■ Contaminant Information	3 Years	USGS
Mainstem Passage and Habitat		
■ Ongoing Actions/Research by Dam	Annual	USACE Tribes
■ Adult Counts (Columbia, Snake and Willamette)	Annual	USACE Tribes
■ Conversion Rates	Annual	USACE Tribes
Mainstem Columbia/Snake RMU		
■ Focal Tributary Dams/Progress	Annual	RMU
■ Long-Term Index Sites • Area Selected Rationale • Adult Density/Habitat Specific Density • Juvenile Density/Abundance • Larvae Density • Statistical Methods/Certainty	3 Years	RMU
■ Restoration Actions • Priorities — Planning — Funded — Implementation — Monitoring	Annual	RMU
Snake RMU		
■ Repeated items from Mainstem Columbia/ Snake RMU	Annual	RMU
Upper Columbia RMU		
■ Focal Tributary Dams/Progress	Annual	RMU

(Continues next page)

Achievements	Reporting Period	Lead Entities
Mid-Columbia RMU		
■ Focal Tributary Dams/Progress	Annual	RMU
Willamette RMU		
■ Focal Tributary Dams/Progress	Annual	RMU
Lower Columbia RMU		
■ Focal Tributary Dams/Progress	Annual	RMU
Oceans	2 Years	NOAA Fisheries
■ Text Account: including abundance from various prey species as available (e.g., Pacific hake) ■ Adult Information/Recoveries/Locations ■ Juvenile Information/Recoveries/Locations		
Predation	3 Years	States
Water Quantity Quality and Contaminants	3 Years	States; USGS
Supplementation	Annually	Tribes
■ Adults Translocated Number (From Where to)	Annual	
■ Larvae Supplemented Number; (From Where to)	Annual	
■ Primary Research; Rationale; Initial Conclusions	Annual	
■ Master Plan: Overview	3 Years	
■ Facilities: Overview (Existing Planned Production)	3 Years	
Climate Change	3 Years	USFWS
■ CRITFC	3 Years	
■ NPT	3 Years	
■ YN	3 Years	
■ CTUIR	3 Years	
■ CTWSRO	3 Years	
Outreach and Education	Annually	PLCI; Tribes
Effective Population Size and Structure	3 Years	RMU; Tribes
Research, Monitoring and Adaptive Management	Annually	Tribes PLCI USACE USFWS

LIFE CYCLE MODELING

A draft model, already well into initial development by the U.S. Geological Survey[1], exists and is designed to be user-friendly and readily available. Funding for this development was provided by the Pacific Lamprey Conservation Initiative and Bonneville Power Administration. All parameters used (see **TABLE 12**, below) are easily and intuitively adjusted to test outputs for various hypotheses. For more-advanced users, the mathematics used to drive the modelling are transparent and can be modified as desired. In short, the model is designed in a manner allowing users to change and/or add parameters, to test hypotheses and run sensitivity analysis — all of which are important for use in the adaptive management environment.

Enough is known about the life history of Pacific lamprey to develop and begin using a life cycle model (model) within an adaptive management context. The Tribes understand that initially, in many cases, assumptions (and ranges) will be used for preliminary input. The model will have an important, albeit limited use in the near term, but with a coordinated research and monitoring strategy it will evolve quickly and serve as a central element for longer-term applications. The model can be found online at*: https://doi.org/10.5066/F7CV4H1T* (Gomes, D.G., 2024, Lamprey life cycle model: U.S. Geological Survey Software Release.)

Short-term applications of the life cycle model will include:

- prioritization of research, monitoring, and actions through sensitivity analysis from the modeling inputs,
- increased understanding of potential lamprey population responses following passage improvements at various mainstem and tributary dams,
- evaluation of supplementation efforts (both adult translocation and artificial propagation programs),
- increased understanding of carrying capacities within the RMUs and associated management directions.

Longer-term applications will include:

- prioritization of actions to increase resilience of habitats and Pacific lamprey populations in the face of climate change,
- identification of priority areas for habitat and passage restoration,
- estimation of population goals to support sustainable harvest, and
- development of passage standards at individual dams and other obstructions to optimize population growth.

[1] Affiliations include the USGS Forest and Rangeland Ecosystem Science Center (Corvallis, OR.), USGS Forest and Rangeland Ecosystem Science Center (Boise, ID.), Oregon Department of Fish and Wildlife, and the Yakama Nation.

The general concept of the model is illustrated below (**FIGURE 29**) with additional information about life stage parameters (related to **FIGURE 29**) provided below in **TABLE 12** (Gomes, et al. 2024).

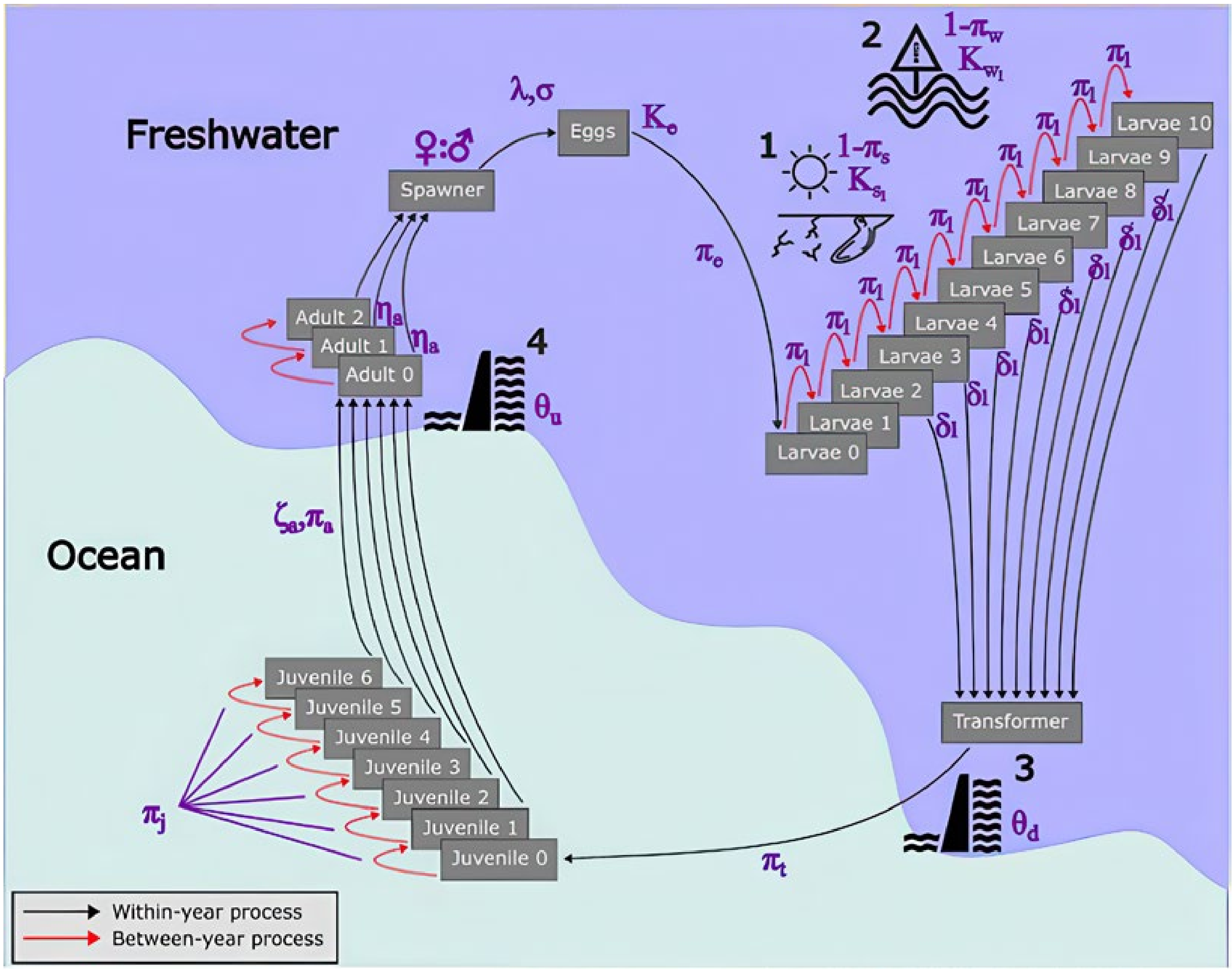

FIGURE 29. Illustration of the Pacific lamprey life history model.

TABLE 12. Draft Pacific lamprey life cycle model parameters by life stage.

DRAFT Pacific Lamprey Population Modeling Parameters by Life Stage		
Life Stage Modeled	**Parameter**	**Notes**
Fresh Water Life Stages		
Juvenile/Adult	Probability to swim upriver	in years 0–6
Adult	Return to River Survival	mean value and expected standard deviations
Adult	Probability to Spawn in Year 0	first year entering river
Adult	Probability to Spawn in Year 1	one year after entering river
Adult	Reproduction	spawner sex ratio fecundity egg — larvae survival
Egg–Larval	Freshwater Rearing Capacities	carrying capacity; spawning capacity; summer/winter habitat capacity
Larvae/Juvenile	Larval Survival and Transformation	density dependent larval survival probability for year classes 0–10
Marine Life Stages		
Juvenile/Adult	Ocean Entry Survival and Annual Marine Survival	mean value and expected standard deviations
Management Considerations		
Adult	Upstream Barriers	mainstem and tributary
Larvae/Juvenile	Downstream Barriers	mainstem and tributary
Adult/Larvae	Hatchery Releases	Numbers released by watershed
Larvae	Drought and Flooding	additional summer/winter estimated larval mortality
Simulation Settings		
NA	Number of Simulations	up to 1,000+
NA	Simulation Lengths	in years
NA	Burn-in	in years
NA	Extinction Threshold	50 spawning adults currently

6.4
Pacific Lamprey Life History

The Pacific lamprey life cycle was described in the 2011 TPLRP. Since that time much has been learned. In addition, other reviews are available at:

Coastal Columbia and Snake Conservation Plan for Lampreys in Oregon. Oregon Department of Fish and Wildlife February 2020 and

Pacific Lamprey *Entosphenus tridentatus* Assessment U.S. Fish and Wildlife Service February 1, 2019.

While these two documents offer great detail in regard to various aspects of Pacific lamprey life history, the 2025 TPLRP provides the following summary with a focus on information obtained since publication of the 2011 TPLRP.

Adult Migration (Bonneville Dam – Spawning Streams)

Pacific lamprey migrating to spawning areas in the CRB encounter large hydropower dams, low-head dams, irrigation, diversions culverts, and other obstacles. The Columbia River hydropower system has been well studied and numerous changes have been implemented to aid lamprey passage.

Most adult Pacific lamprey passage at BON occurs between May and late August. Daily passage rates peak in July but much of the population passes into September. Moving upstream, peak passage at MCN generally occurs in late July and peak passage at each of the Snake River dams takes place a week later with the few that pass LGR doing so in late August (McIlraith et al. 2015).

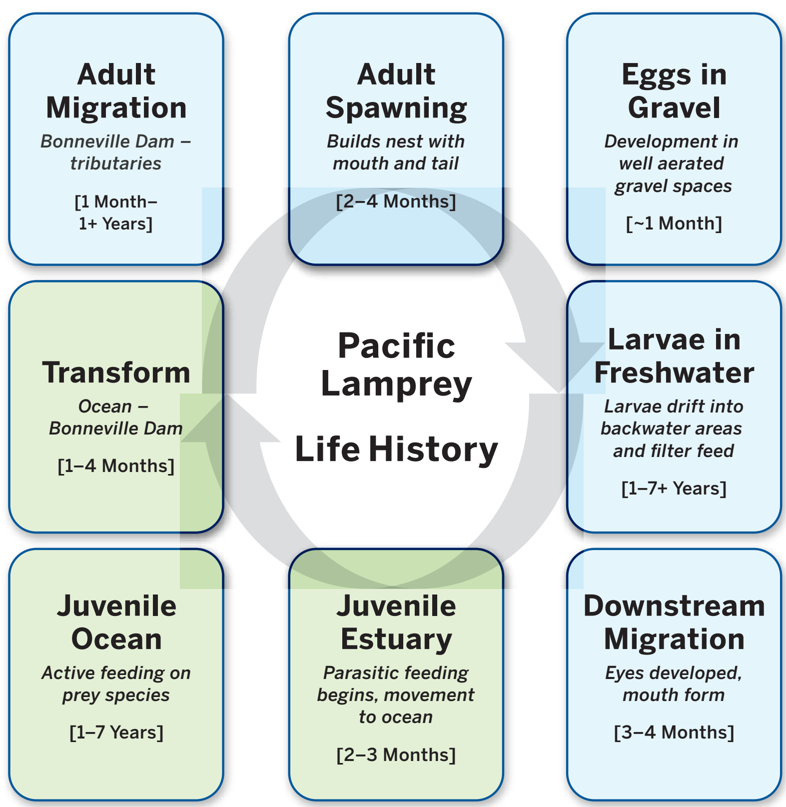

FIGURE 30. Life cycle of Pacific lamprey.

Run timing appears to be delayed in the Columbia River upstream of MCN relative to the Snake River (Fish Passage Center; *www.fpc.org*). Peak passage is generally in mid-August at PRD, late August at RIS and what few remain pass WEL into September. From these data it appears that lamprey typically take about two months to migrate through the Columbia River system.

Many Pacific lamprey overwinter in the mainstem Columbia River and actively migrate into tributaries in spring (March–July) prior to spawning (Lampman et al. 2017). At some tributary dams such as Prosser Dam on the Yakima River and Three Mile Falls Dam on the Umatilla River, spring counts are typically higher than in fall.

Passage over Mainstem Dams. Passage efficiency for tagged lamprey (e.g., 46%–77% in 2019 Keefer et al. 2020) is in stark contrast to salmonids which generally exceeds 95% at each dam on the mainstem. At lower Columbia River dams, passage efficiency was generally lowest during high discharge. Certain fishway segments, notably the lower elevation and serpentine weir sections, were especially problematic for lamprey (Keefer et al. 2013a). Areas with high velocities and right-angle vertical steps were also likely to impede lamprey migration (Keefer et al. 2010). In general passage by adults through mainstem dams appears to select for larger individual fish, which has been confirmed by radiotelemetry and genetic studies (Keefer et al. 2009; Hess et al. 2014).

Individual dam escapement varies, but the cumulative effects are profound (Figure 2, Keefer et al. 2020). Passage rates for individual passage attempts are even lower (14–34% per attempt Keefer et al. 2013a; 2013c). Dam passage at MCN ranges 65–75% and more fish move into the middle-Columbia River rather than the Snake River, after passing MCN (Keefer et al. 2013b). Passage at Snake River dams ranges 41–65% (Stevens et al. 2016). Passage efficiency at mid- and upper Columbia and Snake river dams is generally higher than at lower Columbia dams. For example, passage at Priest Rapids and Wanapum dams ranged 60–75% in most years (Le et al. 2020).

Passage at Willamette River. Although adult Pacific lamprey historically ascended the bedrock portion of Willamette Falls, tagging studies have revealed that under current conditions the majority now pass through the fishway, with passage rates ranging 22–34% (Mesa et al. 2010; Clemens et al. 2012). There are 13 Army Corps of Engineers-operated dams on six major Willamette River tributaries that block Pacific lamprey passage. However, River Mill Dam on the Clackamas River was retrofitted for lamprey and now has passage efficiency of over 90% (Ackerman et al. 2019).

Passage in Tributary Streams. At low-head dams and diversions, passage efficiency has ranged from 0–82%. In the Yakima River, passage efficiency for five irrigation diversion dams ranged from 0% at Roza Dam to 75% at Wapato Dam with a mean of 55% (Johnsen et al. 2011; Johnsen et al. 2013; Grote et al. 2014; Grote et al. 2016; Lampman et al. 2016a). In the Umatilla River, passage efficiency improved after Boyd's Diversion was breached; passage increased from 32% to 82%. When flow was augmented at Three Mile Falls in 2007, passage efficiency increased from 17% to 50% (Jackson and Moser 2013). Other passage improvements in the Umatilla River since 2011 include installation of a Lamprey Passage System at Three Mile Falls Dam and breaching of the Dillon Diversion Dam.

Despite these improvements, passage by Pacific lamprey at irrigation dams and diversions remains low and the cumulative effects of multiple dams can result in low overall escapement into the upper reaches of spawning tributaries. Jackson and Moser (2013) estimated that out of every 100 lamprey that entered the Umatilla River in 2005 and 2006, only two would be able to pass the fourth irrigation dam on the river.

Passage through the Reservoirs. In the Columbia River system adult lamprey appear to move through reservoirs very quickly (i.e., up to 50 km/day Noyes et al. 2012). However, passage through John Day Reservoir appears low (i.e., 34%) compared to the BON and TDA reservoirs (i.e., 60% Keefer et al 2020) and larger fish are more likely to migrate farther upstream (Hess et al. 2014). Presumably some fish initiate holding at mainstem dams (within fishways), as they are frequently not detected upstream (Keefer et al. 2013a). Robinson and Bayer (2005) tracked Pacific lamprey in the John Day River and found that individual fish migrated 1.0–20.9 km/day (exclusively at night); holding was initiated coincident with high water temperature and occurred in boulder cover and movement resumed in the spring. Moser et al. (2013) detected temperature effects on the individual rate of migration through reservoirs.

In the Snake River reservoirs, adult lamprey generally moved 1–20 km/day (up to 35 km/day), moved primarily at night, and appeared to select for the Clearwater River over other Snake River tributaries (McIlraith et al. 2015). In this study, individual fish were detected as high as the Lochsa and Selway rivers as well as much of the Salmon subbasin. Fish also appeared to demonstrate over-winter holding but movements generally resumed in February and March with the farthest upstream detections occurring after this holding period (McIlraith et al. 2015). Despite the relatively high apparent survival and fast travel time through the system, it is estimated that less than 1% of the original run at BON migrates past Ice Harbor or Priest Rapids dams, greatly limiting potential production in the upper basin (Keefer et al. 2020).

Passage through the Willamette River. Following passage at Willamette Falls, migrating adults distributed relatively evenly through the subbasin and migration distance was unrelated to lamprey length. Individual fish traveled between 1.6 and 18.6 km/day. The timing of migration appeared to be temperature dependent with a cessation of migration when river temperatures exceeded ~24°C (Clemens et al. 2013). Clemens et al. (2009) also found that water temperature helped to trigger final sexual maturation. Following initiation of these holding periods most (~70%) migrating adults overwintered in the mainstem Willamette River. Overwintering locations typically were in deep pools with rock cover such as revetments and riprap areas (Clemens et al. 2012b). Movement resumed in the spring to final spawning locations.

Migration patterns in the Willamette River are like those that have been observed in other systems with Pacific lamprey. In the Smith River (Oregon Coast Range), Starcevich et al. (2013) found that fish moved primarily at night initiated holding during low baseflow and maximum summer stream temperatures and held in glides with boulder cover. Similar migration and survival patterns have also been observed in the North Umpqua River (Lampman 2011) and the Deschutes River (Baker et al. 2016).

Adult Spawning in Freshwater

Following overwinter holding, Pacific lamprey undergo a short migration to ultimate spawning locations (Robinson and Bayer 2005; Starcevich et al. 2013). However, there may be life history variation in spawn timing such that some Pacific lamprey may not require overwintering (ocean-mature ecotype; Parker et al. 2019, Clemens et al. 2013). Also, there may be some adults that overwinter for consecutive years before spawning. This delayed spawning was reported at rates of ~9% in the Snake River (Hess et al. 2022). Adult Pacific lamprey do not exhibit great fidelity to spawning location and as a result "*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)".

Spawning in tributaries to the Willamette River usually takes place between mid-April and June when water temperature is increasing (10–15°C) and discharge is decreasing and can occur in a variety of stream sizes and possibly even mainstem rivers (e.g., Willamette River Mayfield et al. 2014a; Schultz et al. 2014). Spawning surveys for steelhead (*Oncorhynchus mykiss*) frequently detect Pacific lamprey nests in the Clackamas subbasin and the Oregon and Washington coasts (E. Brown ODFW unpublished data), but due to high stream flows, surveys generally end before the peak of Pacific lamprey activity (Mayfield et al. 2014a). Spawning surveys in the Umatilla River drainage have been conducted in June and July (Ward et al. 2012) because that was when water temperature is suitable in snowmelt dominated systems.

Adults usually spawn in pairs or aggregations of multiple individuals (Wyss et al. 2013) and use reach-scale habitat features that are like those used by salmonids (e.g., gravels in pool tailouts riffles runs; Mayfield et al. 2014a). These spawning patterns have been observed in other river basins including the Smith River (Gunckel et al. 2009) and Coquille River (Brumo et al. 2009). Others (i.e., Russel et al. 1987) have also reported Pacific lamprey spawning in lentic systems (lakes or ponds) in British Columbia, but this appears to be relatively uncommon.

Female fecundity can be very high, ranging 30,000 — to over 200,000 eggs (USFWS 2019 Assessment). This allows lamprey populations to grow rapidly when environmental conditions are right. Like anadromous salmon, lamprey adults die soon after spawning.

Across the entire Willamette subbasin, spawning adults tended to select areas composed of alluvial underlying geology. However, within individual tributaries spawning habitat selection for underlying geology was neutral (Mayfield et al. 2014a). These patterns suggest that Pacific lamprey exhibits a 'periodic generalist' life history strategy (Clemens et al. 2012). Underlying geology also influenced the spatial distribution of nests. In areas with mostly alluvial underlying geology, nests were fairly evenly distributed across survey segments (Mayfield et al. 2014a, 2014b). The clustering of nests is particularly important in the context of designing surveys for monitoring Pacific lamprey (Mayfield et al. 2014b). Work in the Willamette subbasin and elsewhere has demonstrated the utility of spawning survey data (Brumo et al. 2009; Gunckel et al. 2009; Mayfield et al. 2014a 2014b; Whitlock et al. 2017).

Eggs in Gravel

Eggs deposited during spawning remain in the gravel for 10–14 days before hatching (Yamazaki et al. 2003; Lampman et al. 2016c). Other research provides estimates ranging between 18 and 49 days (Brumo 2006; Scott and Crossman 1973), with hatching times being dependent upon water temperatures (Moser et al. 2019, USFWS 2019).

Large cobble substrates are believed to be important settling habitat for newly emerged larval lamprey before they drift downstream to suitable burrowing sediments (Type I or II habitats) for the 3–10-year larval phase (Aronsuu and Virkkala 2014).

Larvae in Freshwater

Pacific lamprey larvae are filter feeders. Movement is typically only downstream. Larvae move downstream during freshets, in response to water temperature, and when larval density is high (Derosier et al. 2007 USFWS 2018). Sampling in the Willamette and Klickitat rivers suggests that larvae grow to 12–30 mm in their first year (Wyss et al. 2013; Luke 2010) and seldom exceed 150 mm prior to metamorphosis in these systems (Luke 2010; Jolley et al. 2012; Schultz et al. 2014). In contrast larval Pacific lamprey frequently exceeded 180 mm in the middle- and upper- CRB (R. Lampman, Yakama Nation personal communication) and up to 171 mm in the Snake River basin (Cochnauer and Claire 2009). Long-term genetic monitoring of the translocations to the Snake River has made it possible to determine age and size-at-age information for a large number of larvae and juveniles (Hess et al. 2022). This Snake River dataset showed that larval collections were composed of a range of ages (0.3–11.5) and juveniles were on average 6.7 years of age (range 3.4–11.5; Hess et al. 2022).

Using a combination of existing age data (i.e., Meeuwig and Bayer 2005) and length frequency distribution information, Schultz et al. (2014) estimated that larval Pacific lamprey survival rates were very high (74–81%) relative to other fish populations. However, analyses were restricted to larvae >60 mm because suitable keys for field identification of smaller lamprey have not been developed (Goodman et al. 2009).

Larval Pacific lamprey are widespread throughout wadable habitats in the Willamette subbasin (Schultz et al. 2014). Larvae have also been detected in the lower Willamette River near Portland (Jolley et al. 2012). Across the CRB, larval Pacific lamprey are found in habitats typical of other lamprey species; catch rates were highest in areas with accumulated deep, fine substrates (Torgersen and Close 2004; Stone and Barndt 2005; Clemens et al. 2017). In particular, off-channel habitats (e.g., side channels and backwaters) contained up to 40 times as many larvae as pools and riffles (Schultz et al. 2014). Catch rates and site occupancy of larval Pacific lamprey in the Willamette subbasin appears to be much higher than in areas upstream from BON (Schultz et al. 2014).

Larvae in the Upper Tributaries. Work in Idaho confirmed that Pacific lamprey along with all other anadromous fishes have been extirpated from habitats above Dworshak Dam on the North Fork Clearwater River (Cochnauer and Claire 2009). Statler (2014) found that larval lamprey in the Snake River basin were collected primarily from streams where translocations had occurred and the length frequency of lamprey suggested an absence of natural recruitment for multiple years in the early 2000s (Cochnauer and Claire 2009). Lampman et al. (2014) found relatively few larval Pacific lamprey on the ceded lands of the Yakama Nation and suggested that lamprey are severely depleted in the Yakima River especially in the upper portions of the subbasin. Adult translocation since 2014 has increased recruitment. The extremely low counts at Wells and Lower Granite dams (< 50 annually) in many years further suggested that few adult lamprey were entering the upstream reaches of the CRB (Cochnauer and Claire 2009; Rose et al. 2012).

Not all rivers in the interior CRB are in this dire condition. For instance Pacific lamprey were found up to 85 km up the Selway and Lochsa rivers in Idaho as recently as 2015 (USFWS unpublished data). Because of the upper location and excellent environmental condition of these rivers this supports the hypothesis that the Clearwater River is also an important location for lamprey (McIlraith et al. 2015).

Lower in the CRB, Pacific lamprey populations appear to be maintaining a more consistent presence. Larvae were present in the lower portions of Hood River and most of Fifteenmile Creek. The distribution has expanded in the Hood River with the recent removal of Powerdale Dam (CTWSRO 2014).

Factors Limiting Larval Survival. One of the primary factors limiting the distribution of Pacific lamprey in the CRB appears to be the presence of barriers to adult migration (Luzier et al. 2011; Jackson and Moser 2012; Schultz et al. 2014; Clemens et al. 2023).

Stream dewatering due to hydropower and irrigation might be another important limiting factor for Pacific lamprey larvae. Dewatering leaves suitable habitats without water and larvae that cannot move to watered habitats are likely to perish (Liedtke et al. 2023). Modeling results for the Bonneville Reservoir indicated that reservoir levels could fluctuate up to 1.2 m in a roughly five-hour period, desiccating many delta habitats (Mueller et al. 2015). Follow-up studies are currently being conducted to understand the physiological implications of dewatering to individual fish and the occurrence of larvae in habitats most likely to be impacted by water level fluctuations (Leidtke et al. 2015; 2023; R. Meuller PNNL personal communication).

Habitat restoration or dam repairs can also quickly dewater reservoir habitats and strand larval lamprey (e.g., Lampman 2011; Le et al. 2020). Several reservoirs in the CRB have utilized drawdowns in the fall to flush sediments and operate reservoirs similar to natural hydrographs (e.g., Keefer et al 2012a). The implications of these drawdowns to lamprey have not been evaluated, even though larval lamprey in affected substrate are likely stranded in dewatered habitat (Liedtke et al. 2023).

Additionally larval and juvenile entrainment into irrigation canals can be a threat to downstream migrants. Many fish are eventually lost in irrigation canals because of dewatering of these otherwise suitable habitats (Lampman et al. 2013a 2014 2015a and 2016a). Screening of irrigation diversions can help reduce the risk of entrainment to larvae and metamorphosed lamprey (Moser et al. 2015b); however, screening is not effective for lamprey < 50 mm in length (Rose and Mesa 2012; Lampman et al. 2014).

Metamorphosis and Downstream Migration in Freshwater

Pacific lamprey appear to initiate metamorphosis (transformation) from July–December (Clemens et al. 2017) and appear to be fully transformed within 2–4 weeks (Wyss et al. 2013). Metamorphosed lamprey apparently use habitat with slightly faster water and larger substrate than observed for larvae (Wyss et al. 2013). External changes in transformed juveniles include a lighter silvery color, formation of developed eyes, and a disc-shaped mouth with developed teeth and a rasping tongue to facilitate parasitic feeding. At this stage juveniles will emigrate from the Columbia River and move into the estuary and ocean environments.

Outmigrants are believed to move primarily at night and utilize high discharge events to facilitate downstream movement during the late fall and winter (Goodman et al. 2015). Outmigrating lamprey are frequently caught in screw traps (Close et al. 2009; Goodman and Reid 2015) and they are currently enumerated at several CRB mainstem dams (Moser et al. 2015b). Collections at BON indicate that there is a large winter (January-March) peak in outmigrants, a slightly smaller spring peak (~June) and significantly fewer fish in July and August (Moser et al. 2015a; Fish Passage Center www.fpc.org). Metamorphosed lamprey have been collected in the Columbia River estuary from January to March, commonly in benthic habitats (L. Weitkamp NOAA personal communication). Entry into saltwater may extend into June in other areas (Frazer River, Beamish 1980). Diets of Caspian terns (*Sterna caspia*) and other seabirds have included lamprey during June and July (Roby et al. 2003) so it is possible that some outmigrants either spend a substantial amount of time in estuarine habitats or migrate during other times of the year.

Factors Limiting Larvae/Juvenile Survival. Numerous anthropogenic factors can influence mortality timing and migration efficiency of Pacific lamprey. Laboratory work has suggested that passage through dam turbines may not be as harmful to Pacific lamprey as it is to other fishes due to their lack of a swim bladder (Colotelo et al. 2012). However lamprey are still susceptible to abrasion, direct and indirect blade strikes, and predation (Moser et al. 2015b). Moreover downstream migrating juveniles and drifting larvae are susceptible to impingement in water diversions or turbine screens and entrainment in diversion canals (Moursund et al. 2001; Dauble et al. 2006; Moser et al. 2015b). Laboratory experiments suggest that wire-cloth screen materials are especially likely to cause entrainment and impingement while perforated plate designs were most suitable for preventing impingement (Rose and Mesa 2012).

During downstream migration, metamorphosed lamprey also appear to be particularly vulnerable to predators. In the Umpqua River Schultz et al. (2017) estimated that ~600 smallmouth bass (*Micropterus dolomieu*) in a single pool consumed ~10,000 larval lamprey in a two-month period. Although these estimates were based on large extrapolations, they indicate the order of magnitude of predation that this non-native fish can have on larval and metamorphosed lamprey.

Smallmouth bass, walleye and native northern pikeminnow are prevalent in the Columbia River and prey on native fishes (Zimmerman 1999; Fritts and Pearsons 2004). A laboratory study using native and non-native predators from the Yakima subbasin showed that common carp (*Cyprinus carpio*) white sturgeon, yellow bullhead (*Ameiurus natalis*), smallmouth bass, and northern pikeminnow consumed the highest percentages of larval lamprey (Arakawa and

Lampman 2020). Smallmouth bass and sculpin could eat larval lamprey that were close to 100% of their own body length and consume > 25% of their starting body mass in lamprey.

Although predation is limited when fine sediment is present during a two-day study (17%), bottom feeding predators such as white sturgeon and common carp were able to consume considerably more lamprey when the study period was extended to four days (62%) (Arakawa and Lampman 2020). Although no predation studies have been conducted in the Willamette River, the recent increase in smallmouth bass populations in the lower and middle Willamette River (S. Gregory and R. Wildman OSU unpublished data) may pose a threat to outmigrants. Other areas might also see increases in non-native species due to climate change.

Juvenile — Estuary

Unlike western river lamprey (*Lampetra ayresii*), Pacific lamprey juveniles and adults in the estuary were clearly differentiated by size. This indicates that they left the estuary and came back after ocean residence (Weitkamp et al. 2015). In contrast western river lamprey formed one continuous size distribution, suggesting less extensive marine movements. Pacific lamprey juveniles were most abundant in the estuary in December, but occurred there through June (Weitkamp et al. 2015). Depth in the water column also differed by lamprey species. Higher catches of Pacific lamprey juveniles occurred in bottom trawls compared with catches in purse seines. This suggests that they are demersal (or attach to demersal hosts).

Juvenile — Ocean

It is currently understood that juveniles remain in the Pacific Ocean for approximately 18–40 months (CalFish website *https://www.calfish.org/FisheriesManagement/SpeciesPages/PacificLamprey.aspx*) or even five years as reported by the U.S. Fish and Wildlife Service. During this time, lamprey will parasitize a variety of species including, but not limited to, salmon, walleye pollock, and Pacific hake. It is not well understood how far lamprey move through the ocean environment. Murauskas et al. (2019) reported the transoceanic migration of a PIT-tagged Pacific lamprey from the Bering Sea to the Deschutes River. The U.S. Fish and Wildlife Service reports that individuals "have been caught at depths ranging from 300 to 2,600 feet and as far off the U.S. west coast as 62 miles in ocean haul nets" (*https://www.fws.gov/species/pacific-lamprey-entosphenus-tridentatus*).

Murauskas et al. (2013) argued that the abundance of Pacific lamprey in the Columbia River is at least partially controlled by the abundance of their primary hosts (Pacific hake and walleye pollock) in the ocean. Ocean productivity undoubtedly has profound effects on lamprey growth and survival at sea (Clemens et al. 2019).

While in the ocean, some juveniles will begin sexual maturation (mid-winter through late spring), become an adult, and return to freshwater to spawn. These ocean-type individuals are believed to spawn lower in the Columbia Basin and relatively soon (months) after returning to freshwater. In contrast, maturation can occur within the freshwater environment (stream-type) and these individuals are believed to move much higher into the interior Columbia Basin and spawn in the following spring or summer after freshwater entry.

Juvenile/Adult Spawning Migration (Ocean — Bonneville Dam)

Pacific lamprey adults had the highest densities in the Columbia River estuary in January and February, but were present through May (Weitkamp et al. 2015). This suggests that adults spend multiple months in estuaries before moving into freshwater habitats, as has been found in European river lamprey (*Lampetra fluviatilis*) (Moser et al. 2015a). Adult Pacific lamprey are readily caught in pelagic purse seines suggesting that they or their hosts are in the midwater column while in the estuary, as observed of juveniles in ocean collections (Weitkamp et al. 2015; 2023). Pacific lamprey are not thought to feed during spawning migration and rapidly lose mass from the time of collection in the ocean (Moser et al. 2015a).

Factors Limiting Adult Survival. During migration, lamprey are subjected to predation by birds (Roby et al. 2003), sturgeon, and sea lions (*Zalophus californianus*) (Wright et al. 2014). At Willamette Falls, Pacific lamprey predation by sea lions was estimated to be ~500 individuals (Wright et al. 2014) which is a very small fraction of the total run available (~250,000 individuals; Baker et al. 2015). Sea lions also actively consume lamprey near BON but the relative impacts on adult returns are currently not quantified. Just the presence of predators may deter Pacific lamprey migration and passage (Keefer et al. 2012a). Hence, aggregation of adult lamprey by BON and other obstacles may have both direct and indirect effects on lamprey fitness.

6.5 Tribal Translocation Guidelines

In 2022, the CRITFC Commission passed an action to adjust the guidelines for translocation. Sections 4.3.1–3; 4.3.4.a,b,e; and 4.3.5–6 remained unchanged. The changes that were made included deleting section 4.3.4.d, f, g and changing 4.c and 4.h to read:

- c. Target collections of adult lamprey at Columbia River dams (e.g., Bonneville, The Dalles, John Day, etc.) by the CRITFC Tribes shall occur during the annual active migration period (approximately May–September) to collect the range of phenotypes that may be encountered. We will deploy traps when fish arrive at Bonneville Dam and cease trapping when the migration season slows down. Migration timing may vary from year to year; especially as climate change continues to impact migration patterns. If fish arrive earlier, or migrate longer, in any season, collections will be adjusted according to the biological timing of the fish (thus traps may be deployed earlier or later than May and trapping may cease earlier or later than September).

All other sections of the guidelines remained the same.

- h. The CRITFC Lamprey Committee will review Bonneville Dam counts and CRITFC Tribes' collections for an in-season run size update each year mid-season (e.g., June/July). Collection levels may be adjusted at that time (e.g., add or remove some traps).

The original version of the Guidelines for Translocation can be found in the CRITFC TPLRP (2011).

6.6
Summary of Limiting Factors for each of the Columbia River Regional Management Units

TABLE 13. Summary of Key Limiting Factors (high priority threats for the CRB Regional Management Units).

Regional Management Units (last update)	Tributary Passage	Dewater/Flow Mgt.	Stream/Floodplain Degradation	Water Quality	Predation	Small Population Size	Lack of Awareness	Climate Change	Mainstem Passage
Lower Snake RMU (2023)	M	L	M	M	M	H	H	H	H
Clearwater RMU (2023)	L	L	L	L	L	H	L	M	H
Salmon RMU (2023)	L	L	L	L	L	H	M	M	H
Upper Columbia RMU (2022–2023)	M	M	M	M	M	H	M	M	H
Mid-Columbia RMU (2023)	M	M	M	H	NA	M	M	H	H
Lower Columbia RMU (2023)	M	M	M	M	NA	NA	H	H	NA
Willamette RMU (2022–2023)	M	H	H	H	M	NA	L	H	M
Mainstem Columbia/Snake RMU	NA	NA	NA	NA	NA	NA	NA	NA	NA
North Pacific Ocean RMU (2022)	Key threats include: (1) climate change, (2) unfavorable oceanographic regimes, (3) influences of interactions between climate change and oceanographic regimes, and (4) pollution.								

6.7
Summary of Costs for Pacific Lamprey Restoration

To be developed at a later date.

6.8
Glossary

acoustic telemetry: Remote measurement and reporting of information using sound waves.

adult life stage: Lamprey that have reached sexual maturation or are in the process of maturing.

aggregation: A group of organisms of the same or different species living closely together but less integrated than a society.

allele frequency: The percentage of all alleles for a particular genetic marker in the gene pool of a population (or other group of individuals of interest represented by a given allele).

allele: An alternative form of a genetic marker; markers can be proteins (enzymes or DNA) segments specific to a location (locus within coding or noncoding regions of the genome).

allozyme (or alloenzyme): Any of the variants of an enzyme that are determined by alleles at a single genetic locus.

ammocoetes: The larval stage of a lamprey.

anguilliform: Having the shape or form of an eel.

anthropogenic: Caused or produced by humans.

benthic: Of or pertaining to the bottom of a body of water and to near shore or splash zones in the marine environment or to the organisms that live there.

bioaccumulation: Referring to substances especially toxins that build up within the tissues of organisms.

biodiversity: Diversity among and within plant and animal species in an environment for a given set of characters — morphological physiological behavioral genetic etc.

bioengineering: The use of engineering applications such as physics, mathematics, and computer science to understand or solve problems associated with biological organisms or processes.

biogeographic: Species and organisms in regions or particular environments.

biota: The animals plants fungi etc. of a region or period.

cavitation: The formation of empty cavities or bubble-like spaces in a liquid by high forces and the immediate implosion of them.

CE: QUAL2: A two-dimensional water quality model.

climate change: A long-term change in the earth's climate especially due to an increase in the average atmospheric temperature.

diatoms: Any of numerous microscopic single-celled marine or freshwater algae having cell walls containing silica commonly used in water quality studies.

DIDSON: Dual Frequency Identification Sonar. A multi-beam underwater acoustic camera. A DIDSON repetitively emits sets of sound beams and uses a unique patented lens to resolve the reflections of objects passing in the water column within its field of view into two-dimensional images.

dioxin: A general name for a family of chlorinated hydrocarbons typically used to refer to a byproduct of pesticide manufacture: a toxic compound that is carcinogenic and teratogenic (a cause of birth defects in certain animals.

Effective Population Size: The development of genetic baselines for parentage and sibship identification also permits the calculation of effective population size. Effective population size is the size of an idealized lamprey population that has the same level of genetic drift and inbreeding as the actual lamprey population (Waples 1989). It is possible to determine how effective population size changes over time using genetic markers of lamprey demographics.

electroreception: The biological ability to perceive natural electrical stimuli.

endocrine disruption: Interference with endocrine (or hormone system) in animals including humans via exposure or ingestion of certain chemicals.

ESA: Endangered Species Act.

extirpation: Complete elimination or extermination.

fecundity: The measure of an organism's ability to produce offspring. Among fishes typically refers to the total number or number per unit weight of eggs within a female.

genetic stock identification: Use of genetic information to assign fish to a region or stock.

hydroacoustic: The study of sound traveling through water.

hydrograph: A graph of the water level (or rate of flow) of a body of water over time that shows the seasonal change.

hydrophilic: Having a strong liking for water.

impinge: To strike dash or collide.

ingestion: To take as food into the body.

invertebrate: Of or pertaining to creatures without a backbone.

JSATS: Juvenile Salmonid Acoustic Telemetry System. This system utilizes acoustic telemetry to track fish using sound and vibration.

juvenile life stage: Stage of life following metamorphosis and before sexual maturation.

larval life stage: Stage of life from hatching to metamorphosis.

lipid: Any of a group of organic compounds that are greasy to the touch incapable of dissolving in water but capable of dissolving in alcohol and ether. Lipids comprise the fats and other compounds with similar properties.

LPS: Lamprey Passage Structure. This structure consists of a series of ramps and metal boxes connected to a consistent flow of water which allows lamprey to efficiently ascend vertical barriers.

macropthalmia: The juvenile stage of a lamprey; characterized by large eyes.

metabolized: Change brought about by the physical and chemical processes of living organisms.

metamorphosis: A profound change in form from one stage to the next in the life history of an organism, as from caterpillar to pupa and from pupa to adult butterfly.

metrics: Parameters of quantitative assessment used for measurement.

microsatellite DNA marker: Short repeats of nucleotide (units of RNA and DNA sequences) present throughout a complete set of genes in an organism (or genome) which exhibit variations within a population a tandem array of a short (typically 2 to 6 base pairs).

model: A standard or example for imitation or comparison.

molecular: Of or pertaining to or caused by molecules; a molecule is the smallest particle of a substance that retains all the properties of that substance and is composed of at least two atoms.

monomorphic: Having only one form.

morphological: Branch of biology dealing with the form and structure of organisms.

olfactory: Of or pertaining to the sense of smell.

oligotrophic (of a lake): Characterized by a low accumulation of dissolved nutrient salts supporting only a sparse growth of algae and other organisms and having a high oxygen content due to the low organic content.

otolith: Part of the internal ear of vertebrates and composed in part of calcium carbonate.

parentage assigned (PA): Use of genetic tools to assign offspring to individual parents.

pelagic: Of or pertaining to the open seas or oceans.

philopatric: The tendency of a migrating animal to return to a specific location in order to breed or feed.

physiological: Of or pertaining to the study of functioning of living things.

PIT: Passive Integrated Transponder. PIT tags are implanted into fish for the purpose of identifying and tracking individual fish using radio waves.

planktonic: The collection of passively floating drifting or somewhat motile organisms occurring in a body of water primarily comprising microscopic algae and protozoa.

plasticity: The capability of being molded receiving shape or being made to assume a desired form.

population dynamics: The branch of life sciences that studies short- and long-term changes in the size and age composition of populations and the biological and environmental processes influencing those changes.

ratios: The relation between two similar magnitudes with respect to the number of times the first contains the second.

refugia: An area where special environmental circumstances have enabled a species or a community of species to survive after extinction in surrounding areas.

salinity: The saltiness or dissolved salt content of a body of water.

sibship: Offspring having the same parents.

sibship assigned (SA): Use of genetic tools to identify siblings from the same set of parents.

statolith: Small movable pieces of calcium carbonate found in balance sensory receptors or statocysts. See *otolith*.

synergistic: Pertaining to characteristic of or resembling synergism which may be described as an instance where an outcome may be greater than the sum of individual component changes.

teleost: Belonging or pertaining to the Teleostei a group of bony fishes including most living species.

toxicology: The science dealing with the effects antidotes detection etc. of poisons.

translocation: Relatively large movement from one source of high abundance to a distant place (>20 km) that has low abundance.

trap-and-haul: Relatively short movement from below a barrier to above using a relatively short time period (hours) holding the fish in tanks during the process.

trophic: Of or pertaining to nutrition; concerned with nutritive processes.

viability: The ability of living, developing or reproducing under a given set of conditions.

6.9
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Photo by Raymond Matheny / Courtesy of CRITFC

Charlie McKinley mending a net on Big Island, Celilo Falls, 1952

"Tribes have a history since time immemorial that links lamprey to the people. Lamprey are our food and our medicine. They need to live in clean water. We need to live in a clean environment. We will continue to value and use lamprey. They are important, especially to our children."


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