COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
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May 4, 2010

David Roberts
Marcy Foster
KEWU-4
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

RE: Project 2008-524 Lamprey Passage Design

Dear Mr. Roberts and Ms. Foster:

Please find attached the final narrative for Project 2008-524, Lamprey Passage Design for the Independent Scientific Review Panel (ISRP). You will note that in the narrative we have changed the title to "Tribal Pacific Lamprey Restoration Plan Implementation," per the suggestion of the ISRP (ISRP document 2009-24) to make the project more inclusive of various lamprey restoration elements. We also linked the six narrative objectives to the lamprey life cycle, while adding linkages to tribal accord projects and other regional lamprey efforts, such as the Corps AFEP program, the USFWS Lamprey Coast wide Initiative and the CBFWA Lamprey Technical Working Group. We also attempted to respond to other comments by the ISRP and those submitted by the ISAB (ISAB report 2009-3).

We understand that this project is very ambitious with respect to actions and measures to address critical uncertainties. One of the key features of this narrative is that we are attempting to take advantage of timely collaborative relationships with other agencies and groups for both funding and resources. These are relationships that we have worked hard to establish over the first year of funding for this project.

We appreciated the opportunity to formally present this narrative to the ISRP on April 29, with special focus on our ongoing Willamette River adult lamprey migration and habitat study by Dr. Carl Schreck and Ben Clements of Oregon State University. It is very important to keep this study funded, thus, we are hopeful of a quick turnaround by the ISRP on this narrative as the project no-cost extension expires on June 1.

We also are finishing the interview process for the new lamprey project leader to assist in finalizing the *Tribal Lamprey Restoration Plan.* We also have collaborative funding/resources available with the USGS on contaminant studies awaiting our amended contract, as well as key collaborations on genetic investigations, mainstem habitat surveys, tributary screen designs for

lamprey and general regional collaboration in various fora. Until we have an amended contract, we are unable to pursue these critical actions.

We appreciate BPA's support of this project and look forward to the ISRP review of this narrative. To assure we have included enough detail in this narrative, we are attaching additional reports and proposals to the narrative.

Sincerely,

/s/

Robert Heinith
Hydro Program Coordinator

CC: Erik Merrill, NWPCC
Mark Fritsch, NWPCC

Enclosures:

Clements et al. (2010) Draft Report on Willamette River Adult Migration and Habitat Study; D.Close and E. Taylor, Assessment of gene flow in Pacific lamprey using microsatellite markers research proposal; M.Mesa, Tributary Screen Design Proposal,; C.Schreck Pacific lamprey culture preliminary proposal

200852400 CRITFC Tribal Pacific Lamprey Restoration Plan Implementation

FY 2008-2009 F&W Program Accords (MOA) Proposal Review

Narrative

Table 1. Proposal Metadata

Project Number	2008-524-00
Title	Tribal Pacific Lamprey Restoration Plan Implementation
Proposer	Columbia River Inter-Tribal Fish Commission
Short Description	This Fish Accord project provides significant resources to finalize the draft *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008) and to address six specific objectives and actions necessary to implement the Plan and achieve the Plan's vision and goal. These six objectives include: 1) Finalize the draft tribal restoration plan 2) Assess and improve mainstem and tributary lamprey passage efficiency, and survival; 3) Monitor, evaluate collect and disseminate information on lamprey population status, life histories and mainstem habitat; 4) Establish and coordinate public education and other outreach programs; 5) Evaluate contaminant accumulation and other water quality impacts on lamprey; and, 6) In collaboration with other regional entities fund, plan, develop and if appropriate, implement an experimental lamprey safety net artificial production facility for lamprey conservation. In general, this Project will be directed toward overall regional lamprey coordination/collaboration including resource sharing to achieve these objectives among CRITFC member tribal lamprey projects, Corps of Engineers' Anadromous Fish Evaluation Program lamprey projects, CBFWA lamprey technical working group functions, FERC hydro-license processes, the USFWS Pacific Lamprey Rangewide Conservation Initiative and other appropriate forums.
Province(s)	Intermountain and Lower Columbia
Subbasin(s)	Willamette, Lower Snake, Upper Middle Columbia, Lower Middle Columbia, Lower Columbia, Mid-Columbia
Contact Name	Bob Heinith
Contact email	heib@critfc.org

Information transfer:

A. Abstract

The Pacific lamprey (*Entosphenus tridentatus)* or "eel" is an ancient, anadromous, native species, valuable to the ecosystems of the Pacific Northwest and to the Native American Tribes that use this fishery for food, medicine, and ceremony (Close et al. 2002; CRITFC 2008). Pacific lamprey have declined precipitously in abundance over the last few decades and the need to acquire information to inform management and conservation initiatives is imperative if this valuable resource is to be maintained and the cultural legacy of Native Americans preserved (CRITFC 2008).

Close et al. (2005) identified four major factors that likely have caused the decline of Pacific lamprey in the Columbia Basin. These include: 1) juvenile and adult passage problems at dams, 2) poor spawning and rearing habitat, 3) pollution and chemical eradication and 4) reduction of ocean prey. In its report on critical uncertainties for lamprey, the Columbia Basin Lamprey Technical Working Group (CBLTWG 2005) prioritized lamprey status, and passage improvements, as the as a top ranked critical needs in the overall effort to restore lamprey. The CBLTWG (2005) also identified genetic delineation of lamprey populations as highly important for management and conservation, since impaired passage may have direct genetic effects. Luzier et al. (2009) through a regional lamprey workshop, identified threats to lamprey including passage, water quality degradation including temperature, and the impacts of contaminants. They also prioritized critical needs such as and identification of population structure, better information on the life cycle, and better delineation of habitat structure.

While there are key uncertainties surrounding lamprey estuary and marine life histories, as noted by the ISAB (2009), the focus of this project is on the freshwater portion of the lamprey life cycle as there are not adequate resources in this project to address the marine aspect of the life cycle or specific affects of climate change on lamprey. However, we anticipate that as part of the final Tribal Lamprey Restoration Plan, Objective 1 of this project, a literature review will be conducted focused on the marine and climate changes issues as they affect lamprey. We also expect that as regional climate models provide specific habitat changes, such as increased river temperatures for salmon populations, we may also in the future consider these impacts to lamprey restoration (Crozier et al. 2008).

The extreme challenge to restoring Pacific Lamprey in the Columbia River Basin is that little is know about critical uncertainties that affect the life history while the severe decline in lamprey abundance demands expedited actions to reduce the decline. To address this challenge, this project's objectives address critical uncertainties through collaboration and cooperation with other regional entities, such as the USFWS, Corps of Engineers, USGS, EPA, the Bureau of Reclamation and three universities and to take advantage of collaborative cost sharing wherever possible. At the same time, other objectives of this project contain specific actions to address known limiting factors and threats such as impaired adult passage at mainstem dams, and juvenile impingement on irrigation screens. This dual strategy of addressing critical uncertainties through research, monitoring and evaluation while taking actions to address known threats is being successfully implemented in other countries for other lamprey species, such as for the Arctic lamprey in Japan (Lampman et al. 2009).

Using the Pacific lamprey life cycle as an organizing paradigm, we have developed project objectives to address critical uncertainties and known threats to lamprey restoration. The ultimate goal of this project is realization of the following objectives that are parallel with the objectives of

the draft *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008).[1] These objectives are also consistent with addressing critical uncertainties and limiting factors listed in Close et al. (2005); CBLTWG (2005) and Luzier et al. (2009). The relationship of the project's objectives to the lamprey life cycle is illustrated in Figure 1.

Project Objectives

Objective 1 Finalize the *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin.*

Objective 2 Assess and improve mainstem and tributary lamprey passage efficiency and survival.

Objective 3 Monitor and evaluate, collect and disseminate information on lamprey population status, life histories and mainstem habitat.

Objective 4 Establish and coordinate public education and other outreach programs.

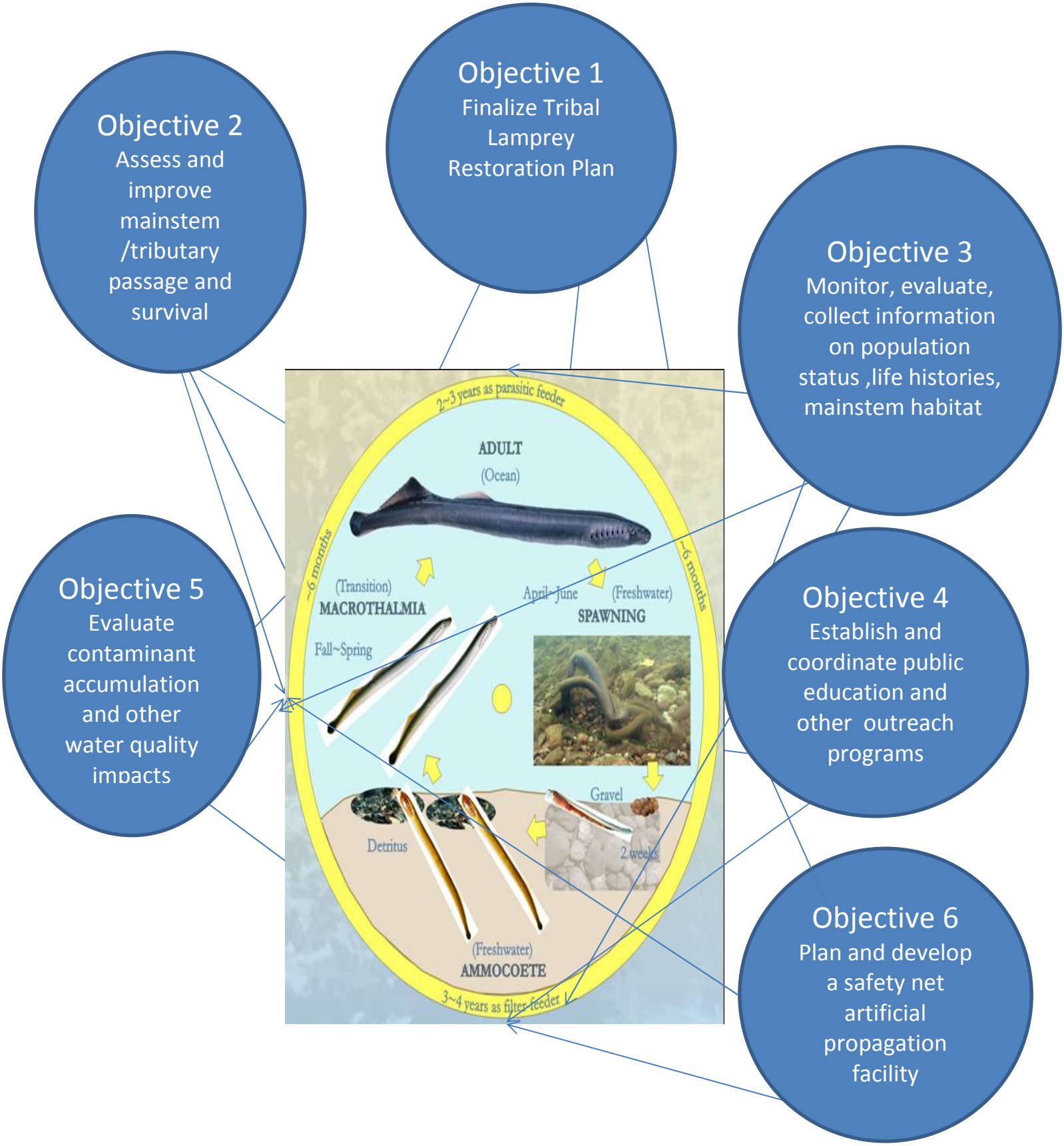
Objective 5 Evaluate contaminant accumulation and other water quality impacts on lamprey.

Objective 6 In collaboration with CRITFC member tribes and other regional entities, plan, develop and if appropriate, implement an experimental conservation artificial production facility.

This project will be closely administered and coordinated with the Accord lamprey projects being undertaken by the Umatilla, Yakama and Warm Springs tribes, and by Nez Perce Tribal lamprey restoration project. These tribal projects are focused on tributary habitat, tributary passage and life history investigations. Over the course of this project, CRITFC will collaborate with tribal lamprey projects by providing mainstem passage, habitat and life history assessments, contaminant and other water quality evaluations and by establishing a lamprey data base repository. Actions, tasks and subtasks were established to capture and break out the objectives above in more detail and their relationships to individual tribal accord projects. In this narrative, actions, tasks and subtasks in Section F. provide details and schedules for addressing project objectives over the ten year period of this project for the Willamette, Columbia and Snake Rivers.

[1] The main difference between the *Tribal Plan* objectives and the objectives for this project listed above is inclusion of finalizing the tribal restoration plan.

Figure 1. Relationship of Project Objectives to the Pacific Lamprey Life Cycle



Due to the complexity, scope and scale of this Accord project, we propose to initially focus a significant level of effort in the Willamette River Basin.[2] These efforts will include prioritizing acquisition of baseline mainstem adult passage and migration behaviors, spawning and rearing habitat preferences and genetic data. Other important work will include coordination/collaboration with other regional entities [3] to improve general passage and habitat and gain genetic information in the Columbia and Snake Rivers through acquisition of baseline data and careful monitoring and evaluation of other regional programs.[4] These actions and resulting information will be essential to plan, develop, implement and evaluate passage and habitat improvements and life history actions to address critical limiting factors to lamprey restoration. In addition, throughout the term of this project, outreach and education actions will be implemented to increase public awareness and stewardship of a little known but vital keystone aquatic species. Wherever possible, the resources of this project will be used in partnerships and cost sharing actions with other regional entities. For example, in 2010 the USGS is proposing to partner with CRITFC on lamprey contamination studies and the Yakama Nation and USFWS are proposing to partner with CRITFC on a regional workshop and plan for a lamprey conservation artificial propagation facility.

Because much remains to be learned about Pacific lamprey in the Columbia Basin, adaptive management will be an important component for our cumulative efforts as new programs come online and new information becomes available (Hilborn 1987; Sit and Taylor 1998). Adaptive management requires evaluating both the progress and effect of various regional actions. For example, structural modifications at fishway entrances may result in reducing instead of improving passage efficiency. Establishing a coordinated lamprey regional data base will improve our ability to interpret newly generated information and prioritizes future efforts and will be a key feature of this project.

B. Problem statement: technical and/or scientific background

The Pacific lamprey (*Entosphenus tridentatus)* or "eel" is an ancient, anadromous, native species that has suffered widespread decline throughout the Columbia Basin and the Northwest coast from California to Alaska. One of three lamprey species native to the Columbia River Basin, they are of greatest importance to the tribes (Close et al. 2002). In addition, Pacific lamprey are a key indicator of the ecological health of the Columbia Basin. Lamprey face many range wide threats to their life history including migration and habitat barriers, poor water quality, floodplain and flow degradation, dredging and dewatering, degraded ocean conditions (Luzier et al. 2009), human population growth in the basin (ISAB 2007-3) and climate change (ISAB 2007-2; Mantua et al. 2009; WGA 2008).

[2] The Willamette River Basin alone still holds a substantial lamprey population which is the key opportunity for tribal subsistence and ceremonial harvest. Little is know about lamprey life history and habitat utilization in the Willamette River. In 2009-10 there was the unique opportunity to collaborate and pool resources to investigate lamprey life history and limiting factors with two ongoing studies, one funded by Portland General Electric (PGE) and one funded by the Confederated Tribes of the Grande Ronde (CTGR). In 2010-2011, we again have the opportunity to combine efforts with the CTGR to address critical uncertainties for Pacific lamprey in the Willamette River.

[3] These include the Corps of Engineers, Bureau of Reclamation, FERC license holders, USGS, USFWS, USFS, state fish and water quality agencies, EPA.

[4] Corps of Engineers Anadromous Fish Evaluation Program, USFWS Rangewide Pacific Lamprey Conservation Initiative, Mid-Columbia PUD and PGE lamprey forums, and the Columbia Basin Pacific Lamprey Technical Working Group.

Lamprey appear to be a choice food for avian, marine mammals and native and non-native fish predators, and at times may be preferred by some predators over salmon smolts (Close 1995; Stansell 2006; Close et al. 1999; Nawa et al. 2003). Lamprey have contributed marine and organic nutrients to Columbia Basin watersheds for hundreds of millions of years longer than salmon. Given the long term existence of lamprey in the Basin and their contribution to the Basin's ecological foundation, we postulate that restoration of Pacific lamprey will be key to recovery of salmon populations.

Pacific lamprey historically supported significant tribal and commercial fisheries. In the 1840's, harvests of 40 – 185 tons (i.e.100,000-500,000 adults; E. Crow, 2007 pers. com) were documented for commercial 'eel' fisheries at Willamette Falls. During the late 1800's Pacific lamprey were described as "…completely covering.." Willamette Falls, Oregon (ONRC 2002). There is documentation at Willamette Falls of collection of lamprey for processing for non-tribal use of 27 tons in 1913 (E. Crow. 2007 pers. com.). Approximately 5,000 adult lamprey were estimated passing Lewiston Dam in the lower Snake River in 1950 (Cochnauer 2009). Records of adult lamprey passage began at Bonneville Dam in 1938, with counts ranging between about 50,000 and 400,000 lamprey up to 1969 (Close et al. 1995). The Corps of Engineers suspended adult lamprey counts at their dams between 1969 and 1993 (Close et al. 1995). Close et al. (2002) documented that in the early 1960's adult counts reached 300,000-350,000 at The Dalles Dam, 25,000 at McNary Dam and 17,500 at Rocky Reach Dam.

Though most Columbia Basin rivers once supported abundant populations of Pacific lamprey, most now have few or none (CRITFC 2008; Kostow 2002). Once-abundant lamprey populations have dramatically declined over the last 30 years in concurrence with urban development, habitat loss, the construction and operation of mainstem and tributary dams, and the expansion of irrigation and agricultural projects (Close et al. 1995; Moser and Close 2003; Kostow 2002; Close et al. 2009). Like other lamprey throughout the world, the Pacific lamprey's decline in abundance is likely due primarily to human factors, including dams for hydropower and flood control, irrigation and municipal water diversions, lost habitat, poor water quality, excessive mammal, avian and fish predation due to substantial changes in habitat from a free flowing river to a series of dams and reservoirs where lamprey must pass in constricted areas (Stanstell 2006; Moyle 2002; A. Evans, pers. comm. 2008; Williams et al. 1996).

The accumulation of toxic pollutants in Columbia basin watersheds documented in lamprey tissues may, as with salmon, compromise behavior, immune and reproductive systems (Ewing 1999; NOAA Fisheries 2009). Stone et al. (2003) found elevated levels of arsenic, PCBs, dioxins and mercury in adult Pacific lamprey sampled at Willamette Falls. These concentrations were enough to cause health warnings to tribal members who occasionally harvest lamprey at the falls.

Ignorance of the ecological importance of lamprey and perceived conflicts of lamprey with the social and economic value of salmon and other species deemed important also were factors in the decline of lamprey. For example, in the 1950's the State of Oregon applied chemicals to reduce undesirable fish species, including lamprey, in the Umatilla River (Close 1995; Close et al. 2009). Besides these direct effects on mortality, reproductive success has also been impacted, primarily because access to much of the historic spawning and freshwater rearing habitat has been blocked by mainstem and tributary dams and other obstacles.

The decline in Pacific lamprey abundance has not gone unnoticed. For example, in 1993, the State of Oregon listed Pacific lamprey as a state sensitive species and in 1997 lamprey were given

further legal protection (OAR 635-044-0130; Kostow 2002). In Washington State, lamprey have been placed in a monitoring status, the lowest threat level of the state's "species of concern" list. In 1994, after a precipitous decline in population numbers over a 20 year period, the United States Fish and Wildlife Service (USFWS) nominated the species for listing as a Candidate 2 species under the Endangered Species Act. In their 1994 Fish and Wildlife Program, the Northwest Power Planning Council noted the lamprey decline in the Columbia Basin and called for a status report (Close et al. 1995). The Oregon Natural Resources Council petitioned the USFWS to list the species under the Endangered Species Act (ESA) in 2002.[5] The USFWS denied consideration of the petition in 2004, finding that the petition did not present substantial scientific or commercial information to indicate the listing was warranted. Repeatedly, the USFWS has noted the lack of information regarding the status and distribution of Pacific lamprey to justify its rejection of petitions for protection of Pacific lamprey under the Endangered Species Act.

Although historical adult abundance estimates are incomplete, it is hard to deny that adult lamprey counts at mainstem dams have been in serious decline (Table 1; Figures 2 and 3) with greatest declines seen at Snake River and upper Columbia locations (FPC 2009). For example, of 45,108 adults counted at Bonneville Dam in 2008, only 49 (0.1%) passed Lower Granite Dam in the Lower Snake River, seven dams above Bonneville and seven passed Wells Dam in the upper Columbia River, nine dams above Bonneville (FPC and Corps of Engineers, 2008). During 2009, only 9 adult lamprey were counted passing Wells Dam in the upper Columbia and only 12 adults were counted passing Lower Granite Dam in the Snake River (Table 1). These meager counts and downward trend indicate that in recent times few adult lampreys have reached historical spawning areas in the upper Snake and Columbia rivers.

Millions of dollars have been spent on fishways, juvenile passage systems and irrigation screening systems that were designed to benefit adult and juvenile salmon. Unfortunately, the biological and swimming capacities of lamprey were not considered. Existing research and literature indicate that lamprey, as aguilliform type swimmers, are not as efficient as teleost-type swimmers such as salmon, particularly in high velocity areas (Mesa et al. 1999; CBLTWG 2004). For example, for adult salmon, dam fishways have an entrance criteria to maintain velocities of about 10 fps, while adult lamprey have a difficult time swimming forward in velocities over about 4 fps (Johnson et al. 2008). Other fishway features developed for salmon, such as sharp-cornered serpentine weirs, diffuser gratings with large gaps below and above submerged orifices and vertical slots also have been demonstrated to be problematic for adult lamprey passages (Moser et al. 2002; Moser et al. 2003; CRITFC 2008).

[5] ONRC (Oregon Natural Resource Council). January 28, 2002. Petition for rules to list four Pacific lamprey species as Threatened and Endangered under the Endangered Species Act.

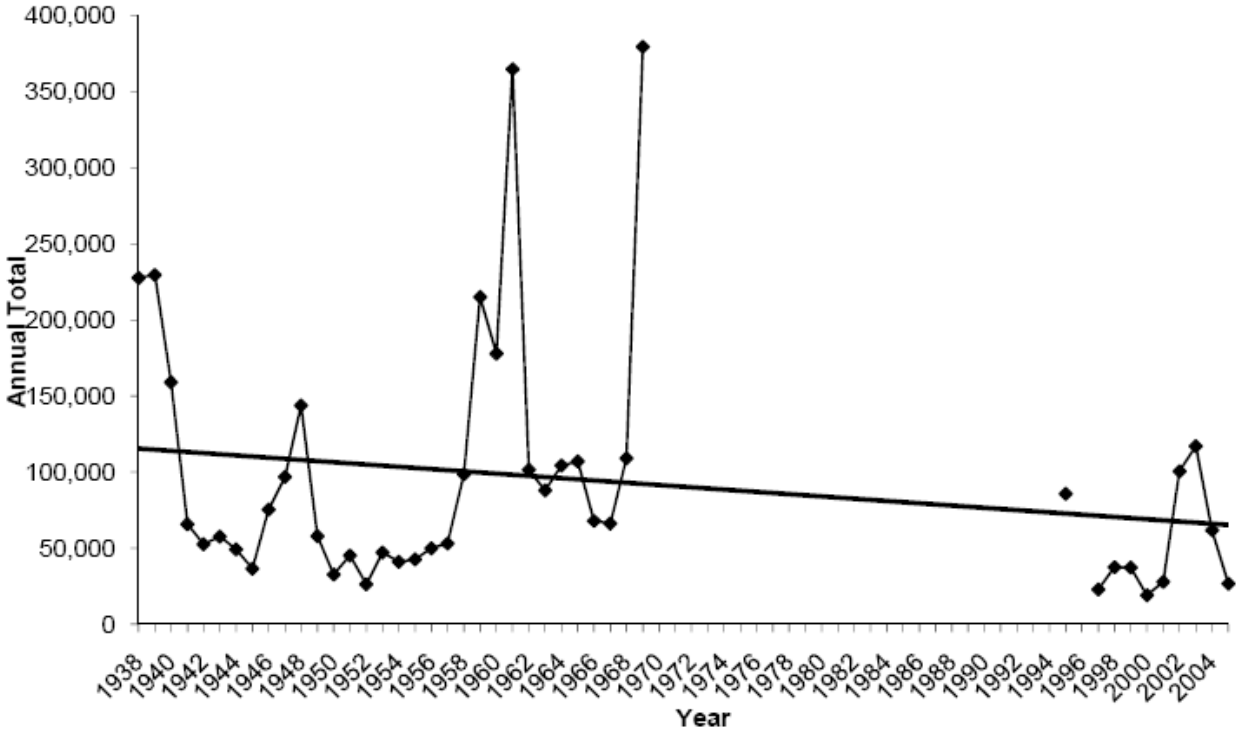
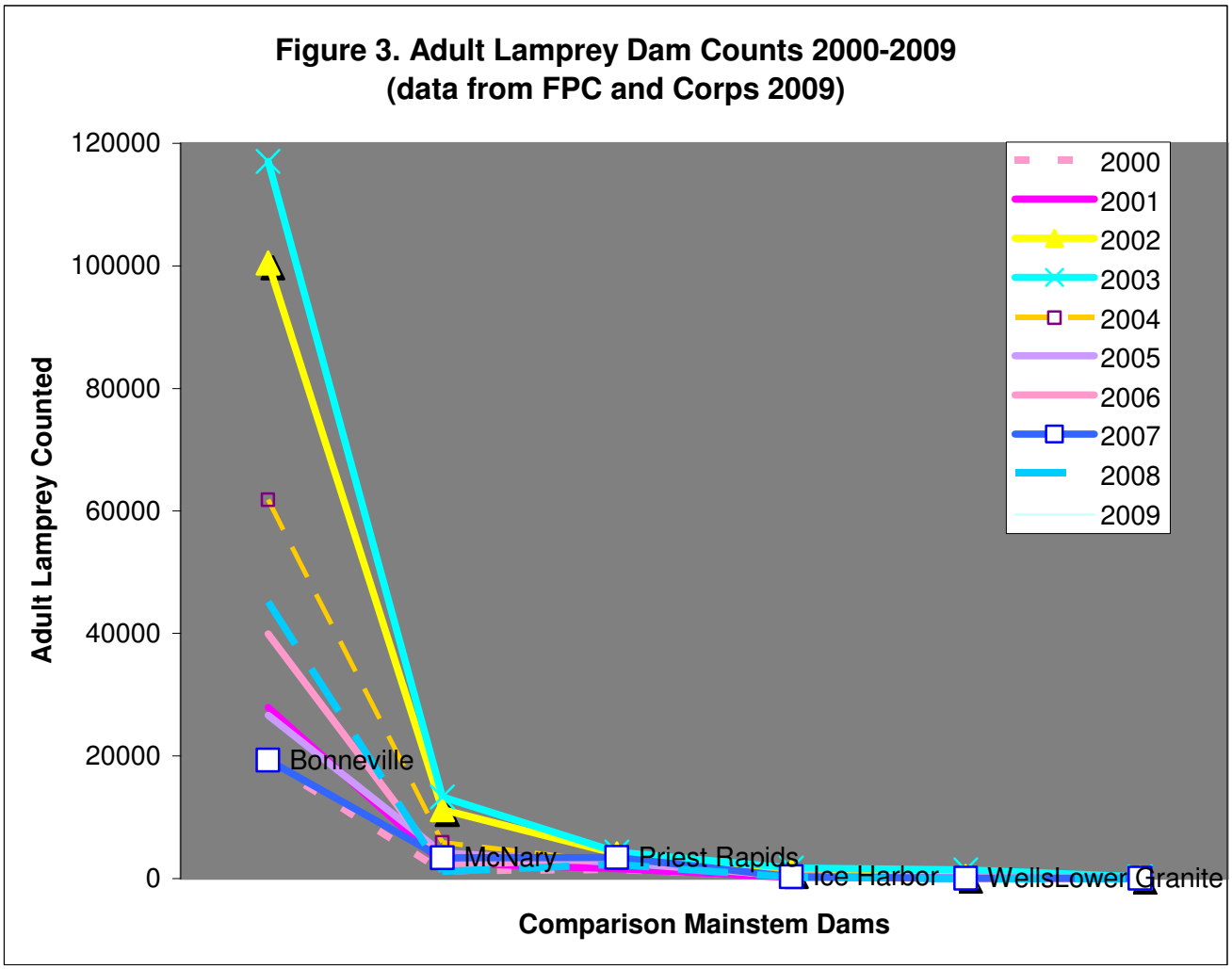


Figure 2. Adult Pacific lamprey historical daytime counts at Bonneville Dam (Corps 2006). Trend line fitted through regression. From Cochnauer and Claire 2009.

Year	Bonn	TDA	McN	Priest	Wells *	IH	LWG
2000	19,001	8050	1,281	1,468	NA	315	28
2001	27,947	9061	2,539	1,468	261	203	27
2002	100,476	23,417	6,116	1,624	338	1,127	128
2003	117,027	28,995	13,325	4,007	1,408	1,702	282
2004	61,780	14,873	5,888	4,339	291	805	117
2005	26, 625	8361	4,158	2,647	212	461	40
2006	39,925	6894	2,139	2,598	21	255	35
2007	37,170 *	6077	3,389	3,273	32	288	81 *
2008	45,104 *	4599	1530	5,083 *	7	266	61*
2009	19,429 *	2318	676	2714*	9	57	12*

Table 1. Recent adult lamprey counts at Corps and Mid-Columbia PUD dams
Asterisks indicate 24 hour counts at Bonneville, Priest Rapids, Wells and Lower Granite. All other data are 16 hour daytime counts (data from Fish Passage Center and Corps 2009).



Cummings (2007) noted that, based upon the current trajectory, Pacific lamprey will soon reach unsustainable levels through much of the Columbia Basin. The tribes believe that this is already the case.

As has been found in introduced populations of Atlantic sea lamprey in the Great Lakes (Haro and Kynard 1997) and in Europe (Laine et al. 1998), and in Japan (Lampman et al. 2009) passage impediments throughout the basin considerably impact upstream production. Considering dam count data, adult and juvenile distribution and adult tagging studies, the tribes believe that inadequate passage is the most urgent problem facing lamprey in the Columbia River Basin (CRITFC 2008). Only about 50% of adult lamprey successfully pass each mainstem dam (Moser et al. 2002b). While little is known about juvenile lamprey passage, studies have shown that significant losses of juveniles occur due to impingement on turbine intake screens and juvenile salmon raceway screens at dam transportation facilities for juvenile salmon (CRITFC 2008: Corps 2009). Entrainment and loss of juvenile lamprey also occurs in irrigation and water withdrawal facilities with and without screens since screens are not designed for protecting and excluding larval lamprey and macropthalmia (CRITFC 2008; Jackson pers comm. 2009). These mortalities and limiting factors make lamprey restoration a major challenge. Beamish and Northcote (1989) found that Pacific lamprey populations persist for only a few years above problematic barriers.

In their 1999 review of the Corps of Engineers Columbia River Fish Mitigation Program, the Independent Scientific Advisory Board of the Northwest Power Planning Council (ISAB) advocated for creating a "biodiversity standard" of which passage accommodation should be addressed for all native fishes. They recommended passage standards and targets, passage designs and evaluations that focus on protecting and restoring native biodiversity rather than target species, including designs that best fit native fish behavior patterns and river processes (ISAB 1999). The Northwest Power and Conservation Council adopted these elements in its 2000 Fish and Wildlife Program. CRITFC, through administration and coordination of this project with other regional and Federal entities (i.e. Corps of Engineers, Bureau of Reclamation, FERC licensed utilities, USFWS, state fish and wildlife agencies, CBLTWG, USGS) will prioritize, plan, design and implement juvenile and adult passage improvements at dams and tributary barriers throughout the basin .

With respect to juvenile lamprey abundances, little is known except for anecdotal observations that suggest gross declines, again, particularly in the Snake River and Upper Columbia basins. Tribal and non-tribal accounts documented plentiful juvenile abundance and widespread distribution in the 1970's (E.Crow pers.com. 2007; S. Petitt, pers. com. 2000; Close et al. 2005, Cochnauer 2009). Recent surveys by IDFG failed to detect the presence of ammocoetes in many Clearwater River tributaries known to have supported traditional lamprey fisheries (Claire 2004). Absence of smaller size ammocoetes in Clearwater River tributaries streams still containing lamprey indicate little or no recent spawning recruitment.

In addition, there is considerable empirical evidence that significant numbers of lamprey ammocetes and macropthalmia are impinged and injured or die on extended length turbine intake screens that are in place for juvenile salmon dam bypass systems (CRITFC 2008). The 40 foot turbine intake and vertical barrier screens (VBS) developed to bypass and collect juvenile salmon for transportation have been demonstrated to impinge juvenile lamprey (CRITFC 2008; Figure 4). While exact numbers are not available, it is estimated that as many as 20-25% of lamprey passing dams with these screens are lost (Corps AFEP Pacific Salmon Workgroup 2009). Similar losses may occur when lamprey collect on screens placed in raceways to hold juvenile salmon for transportation (Corps 2008). Juvenile lamprey collected at bypass facilities are often inadvertently transported on barges with salmon with unknown consequences. In addition, hundreds of juvenile lamprey have been found impinged on screens from turbine cooling intakes (Corps 2010).

Figure 4. Juvenile lamprey impinged on a mainstem dam turbine screen (CRITFC 2008).

Drum and flat plate screens installed in tributary irrigation and municipal water withdrawal structures were designed to exclude juvenile salmon with a maximum approach velocity of 0.5 fps. These velocities are in well in excess of the swimming avoidance capabilities of lamprey ammocete and macrophthalmia (Ostrand 2004). With thousands of these screens now in place or planned for installation throughout the Columbia River Basin, the challenge to design screen or other occlusion structures that protect and keep juvenile lamprey out of withdrawal structures is critical.

Logically, adult lamprey abundance is linked intimately with abundance of suitable prey in estuaries and the ocean (Close et al. 1995). Factors that affect the local abundance of lamprey's major prey base will indirectly impact rates of growth, survival, and maturation of adult lamprey, affecting run timing and strength.

In general, the migratory strategies and resulting population structure, including genetic parameters, of Pacific lamprey in the Columbia River Basin is uncertain. Reports of size differences among different river systems (e.g., Beamish 1980; Kostow 2002; Keefer unpublished data) and differences in allozyme allele frequencies between different drainages (Beamish and Withler 1986) indicate that there may be some localized adaptation and reproductive isolation among Pacific lampreys from different locations. Recent genetic data suggest that lamprey may be weakly philopatric. A study using amplified fragment length polymorphism (AFLP) analysis of DNA found significant differences in AFLP variation in Pacific lampreys from the Pacific Northwest, Alaska, and Japan (Lin et al. 2008a; Lin et al. 2008b). In contrast, using mitochondrial DNA anaylsis, Goodman et al. (2008) found few genetic differences among Pacific lampreys coastwide, suggesting a lack of reproductive isolation between locations.

Microsatellites are the marker of choice for describing population structure in closely related populations (Chistiakov et al. 2006). Up until now, Pacific lamprey microsatellite markers were not available for use but have recently been developed in the Docker laboratory at the University of Manitoba through collaboration with Dr. Timothy Whitesel (USFWS–Columbia River Fisheries Program Office). In addition, a novel AFLP based technique termed FIASCO (Fast Isolation of AFLP of Sequences Containing repeats) has been developed at the University of British Columbia for isolation of microsatellite markers to increase the number of polymorphic microsatellite loci for analysis of genetic variation within geographic areas (Close 2009).

C. Rationale and significance to regional programs

This project will obtain and supplement biological life history information and address key factors limiting Pacific lamprey productivity. It will help coordinate and facilitate expansion of existing Columbia Basin management forums and processes established for salmon restoration to include passage and habitat actions for Pacific lamprey. This includes but is not limited to the Northwest Power and Conservation Council's Fish and Wildlife Program, state programs for species of concern, license conditions issued by the Federal Energy Regulatory Commission, requirements for permits issued under the Clean Water Act, the Fish and Wildlife Coordination Act, the National Environmental Policy Act and the Corps of Engineers' Columbia River Fish Mitigation Program.

Among other things, these agencies need to work with the tribes to educate the general public about the importance of lamprey as a vital part of the Columbia River ecosystem and away from single species management, particularly salmon. Restoration of lamprey is an integral part of

restoring the Columbia River ecosystem so that it can sustainably support all native species in the face of human population and climate change stressors (ISAB 2007-2; ISAB 2007-3). Lamprey are a sensitive indicator species of overall ecosystem health. This project will greatly assist in successfully accomplishing these important tasks.

The Columbia Basin Fish Accords (Accords) are ten year agreements between the federal action agencies and states and tribes. The Accords are intended to assist the action agencies in meeting obligations under the Endangered Species Act by producing substantial biological benefits for Columbia Basin fish and they supplement the Northwest Power and Conservation Council's Fish and Wildlife Program. The Accords also acknowledge the tribes' and states' substantive role as managers of the fish resource and provide greater long-term certainty for fish restoration funding and biological benefits for fish. Ongoing projects supported, and new projects developed, under these agreements, such as those proposed here, are designed to contribute to hydro, habitat, hatchery and predation management activities required under the 2008 FCRPS Biological Opinion. In addition, projects within the agreement assist BPA in meeting its mitigation obligations under the Northwest Power Act.

The Fish Accords provide a good start toward working partnerships and actions to restore Pacific lamprey. Among other things, they mandate that the Corps of Engineers provide $50 million to improve lamprey passage at FCRPS dams and reservoirs and create a collaborative10 year passage plan with CRITFC. This project will provide funding for CRITFC and its member tribes to actively engage with the Corps and the region to assure that the Corps funds to improve lamprey passage will be prioritized, focused and effective. The Accords also mandate that the Bureau of Reclamation collaborate with CRITFC and the Accord CRITFC Tribes to develop and test new screens that prevent entrainment and injury to juvenile lamprey at tributary passage and water withdrawal structures. This project will provide funding for CRITFC to augment Bureau of Reclamation and other regional efforts to successfully research, design and implement new screening facilities to protect lamprey throughout the basin. BPA has committed $575,000 annually to implement this CRITFC lamprey project.

While the NWPCC noted lamprey as a species of ecological importance in Section 2.4.5 in its 2004 Lower Columbia Mainstem subbasin plan, restoration actions were generally limited to "Obtain the information necessary to begin restoring the characteristics of healthy lamprey populations" (NWPCC 2000). Indeed, while lamprey have been listed as a sensitive species by the State of Oregon, they are not listed as a focal species in the 2004 Willamette River subbasin plan.

To the Columbia River Treaty Tribes, restoration of lamprey populations is as necessary to the restoration of the ecological health of basin watersheds as are salmon and other native fish populations. In the Columbia River Treaty Tribes' anadromous fish restoration plan, *Wy-Kan-Ush-Mi Wa-Kish-Wit* (Nez Perce et al. 1995), the tribes' objectives were to halt within seven years the declining trends in salmon, sturgeon, and lamprey populations originating upstream of Bonneville Dam, and within 25 years, to increase Pacific lamprey populations to naturally sustainable levels capable of supporting tribal harvest opportunities.

To address the severe decline of lamprey basin wide, in 2008, CRITFC and its member tribes presented the *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin.* The plan's vision and goal:

Plan Vision: *Pacific lamprey are widely distributed within the Columbia River Basin in numbers that fully provide for ecological, tribal cultural and harvest utilization values.*

Plan Goal: *Immediately halt population declines and reestablish lamprey as a fundamental component of the ecosystem by 2018. Restore Pacific lamprey to sustainable, harvestable levels throughout the historical range and in all tribal usual and accustomed areas.*

Conservation of Pacific lamprey within the Columbia Basin has not been a fisheries management priority but instead has often been lumped into a multispecies context—it has been assumed that measures taken to restore targeted salmon species would carry along the less charismatic native species such as lamprey. Although these primitive fish share many of the same habitats as anadromous and resident salmonids listed under the Endangered Species Act and are an integral part of ecosystems on which these fish depend, the Pacific lamprey have been little more than add-ons to species preservation plans. Unfortunately, the efforts to help salmon and other native fish have provided little benefit and, some bioengineering measures to improve salmon passage, have proven detrimental to lamprey (Bleich and Moursund 2006).

Wy-Kan-Ush-Mi Wa-Kish-Wit (Nez Perce et al. 1995) recognized that lamprey restoration "*…depends on institutional structures that efficiently coordinate the actions and resources of relevant government agencies and enlist the support and energy of individuals and non-government agencies*". Redirection of funding and personnel by sovereign entities as well as local governments is needed in order to implement goals, objectives, actions, monitoring and evaluation in an active adaptive management framework (Walters 1986; Walters and Holling 1990; Hilborn 1987). When policy makers, technical experts or managers differ on restoration approaches and actions, dispute resolution processes must be timely so that progress is not stalled.

This project will increase knowledge to improve adult and juvenile passage and migration, through development, monitoring and evaluation, including but not limited to new passage designs specific for lamprey. [6] The chronology and phenology of migration run timing and spawning and environmental conditions (i.e. temperature, pollutants) that may affect these life history characterizations will be examined. Mainstem habitat types and passage impediments for and to adult and juvenile lamprey will be identified including 1) determining potential migration blocks, 2) determine the nature of these blocks, 3) determine the nature of holding and rearing habitat, 4) Determine the nature of spawning habitat, 5) develop criteria to identify the nature of habitat use (i.e. "holding habitat:, "migration corridor", "thermal refugia", "overwintering habitat", "spawning habitat," rearing habitat[7]). Information generated from this project will aid managers in identifying limiting factors and benefit lamprey populations region-wide.

D. Relationships to other projects

There is little described for Pacific lamprey in the Fish and Wildlife Program subbasin plans, except that lamprey are a "species of ecological significance" (Section 2.4.5 Lower Columbia Subbasin Plan). In the 2007-2009 Northwest Power Conservation Council's Fish and Wildlife

[6] This contrasts with substantial research in the Great lakes region to study the functional morphology of lamprey swimming in order to create passage barriers for invasive adult sea lamprey.

[7] Considering that ammocoetes spend several years in sediment substrate, it is possible that a single event such as deposition of upstream silt or dredging could destroy multiple year-classes of juvenile lamprey, causing a multi-generation loss of subsequent adults.

Program solicitation of new projects, Mesa et al. (2007b) submitted a comprehensive proposal to study the relative abundance, distribution, and population structure of lamprey in the Columbia River Basin (CRB). Unfortunately the Council did not provide funding for this project.

Pacific lamprey are related to all the BPA salmon restoration projects. The existing evidence suggests that Pacific lamprey integrate well into the native freshwater fish community and have positive ecological effects on the system. In all probability they were and continue to be a significant contributor to the nutrient supply in oligotrophic streams of the basin as adults die after spawning (Beamish 1980). Lamprey were and continue to be an important part of the food chain for many species such as sturgeon, northern pike minnow, trout, sea lions, whales, gulls and terns (Close et al. 1995). Close et al. 1995 suggested that lamprey were and are an important buffer for upstream migrating adult salmon from predation by marine mammals. From the perspective of a predatory sea mammal it has at least three virtues: (1) they are easier to capture than adult salmon; (2) they are higher in caloric value per unit weight than salmonids and (3) they migrate in schools. The lamprey is extraordinarily rich in fats, much richer than salmon. Caloric values for lamprey ranges from 5.92-6.34 kcal/gm wet weight (Whyte et al. 1993); whereas, salmon average 1.26-2.87 kcal/gm wet weight (Stewart et al. 1983).

Further, Roffe and Mate (1984) revealed that the most abundant dietary item in seals and sea lions are Pacific lamprey. As a result of dwindling lamprey stocks, marine mammal predation on salmonids may be more severe. Larval stages and spawned out carcasses of lampreys were important dietary items for white sturgeon in the Snake and Fraser Rivers (Ken Witty, ODFW retired, pers. comm.; Galbreath 1979; Semkula and Larsen 1968). Juvenile lampreys migrating downstream may have buffered salmonid juveniles from predation by predacious fishes and sea gulls (Merrell 1959).

Lamprey are found in the diets of native northern pike minnow *(Ptychocheilus oregonensis),* and channel catfish *(Ictalurus punctatus)* in the Snake River system (Poe et al. 1991). Merrell (1959) found that lampreys were 71% by volume of the diet of gulls and terns below McNary Dam during early May. Close et al. 1995 suggests that juvenile lampreys may have played an important role in the diets of many freshwater fishes. Clanton (1913) reported that ground up “eel” (lamprey) was the dietary constituent that led to the best growth of hatchery salmonid fry. Pfeiffer and Pletcher (1964) found emergent ammocoetes and lamprey eggs were eaten by salmonid fry. Close et al. 1995 speculated that wild juvenile salmonids may have found lamprey to be important prey during the spring. To supplement this existing information, CRITFC proposes to work with the USGS, USFWS and others in a collaborative exercise with the Corps of Engineers to provide a literature review of existing lamprey predation information in grey literature and other research projects. The funding provided by this Project will be used for this work.

The examination of the presence of contaminant accumulation in lamprey and the effects of contaminants on lamprey habitat use, distribution, survival and life histories is an important objective of the draft *Tribal Restoration Plan*. In 2009, CRITFC, in collaboration with EPA, BIA and Oregon Department of Environmental Quality conducted an assessment of a number of contaminants for impacts on adult lamprey health and human health. Comparative samples were collected with EPA QAPP protocols at John Day Dam, Willamette Falls and Shears Falls. Laboratory analysis has been completed and a report is expected in the near future. CRITFC agrees with the ISRP comments on the Warm Springs Tribes’ 15 Mile Creek Accord Narrative, who noted that contaminant loading in lamprey could be an important limiting factor. In 2010-2011,

CRITFC proposes to collaborate with USGS to compare contaminant levels in juvenile lamprey from 15 Mile Creek and other areas in the basin.

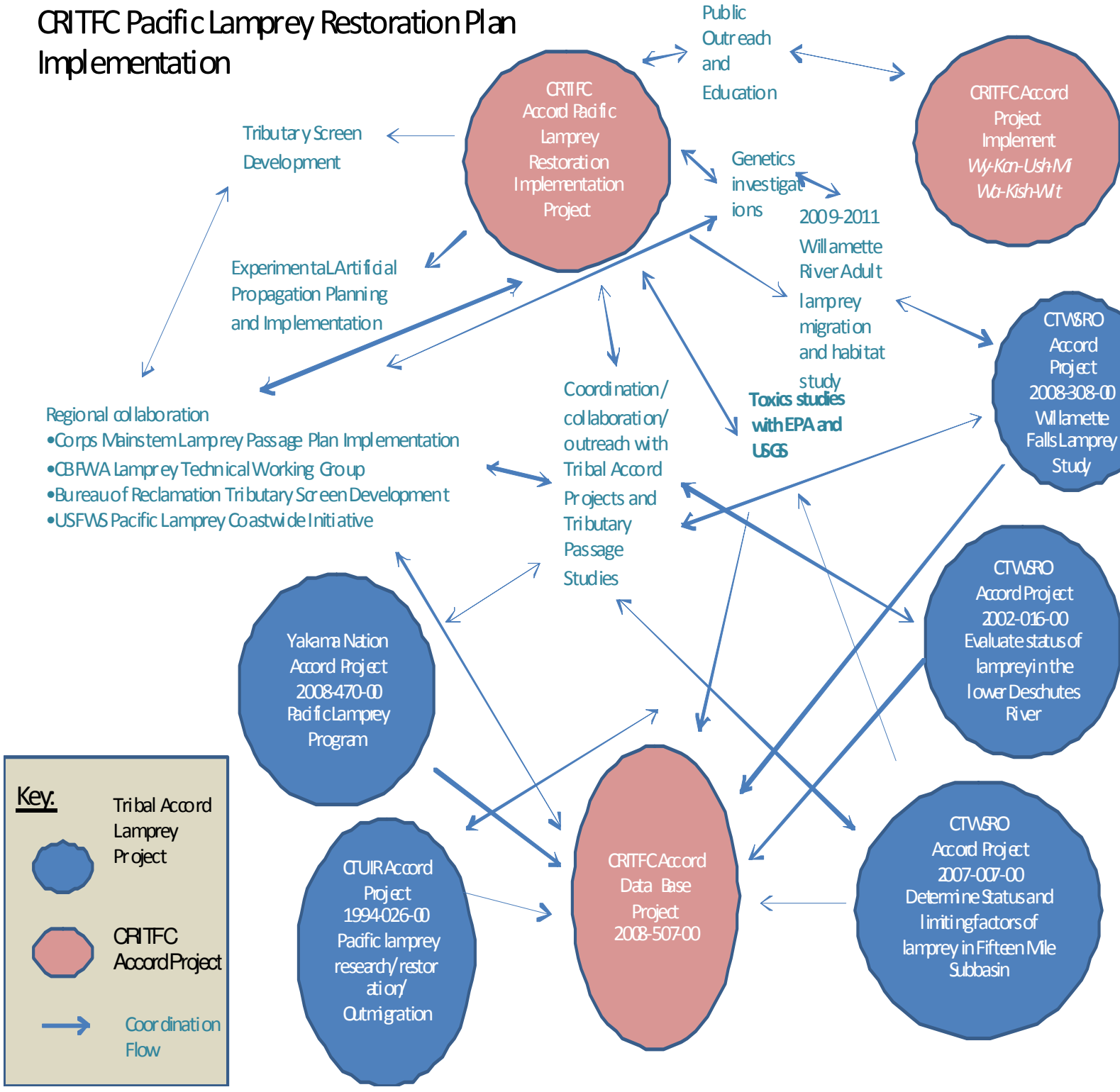
The work under this Project will be closely administered and coordinated with tributary projects by the Warm Springs, Umatilla, and Yakama Accord tribes and as appropriate, other regional entities such as federal and state agencies, private and public utilities and watershed councils (Table 2; Figure 5). In particular, this project will be closely coordinated and administered with the USFWS Pacific Lampey Rangewide Conservation Initiative process (USFWS 2009; Luzier et al. 2009). The USFWS is depending on the CRITFC tribes and this project to provide needed focus and actions for lamprey restoration specific to the Columbia Basin.

Table 2. Relationship of CRITFC Lamprey Project to Other Columbia Basin Lamprey Projects

Funding Source	Project #	Project Title	Relationship
BPA	2002-016-00	CTWSRO Evaluate the Status of Pacific Lamprey in the Lower Deschutes River	Complementary project for information exchange and coordinate/collaborate efforts. For example, new screen designs and genetic information developed under 2008-524-00 can be used for this project.
BPA	2008-470-00	Yakama Nation Pacific Lamprey Program	Complementary project for information exchange and coordinate/collaborate efforts For example, new screen designs and genetic information developed under 2008-524-00 can be used for this project
BPA	2008-308-00	CTWSRO Willamette Falls Lamprey Study	Complementary project for information exchange and coordinate/collaborate efforts. For example, lamprey trapping and tagging techniques and contaminant studies developed under 2008-524-00 can be used for this project
BPA	1994-026-00	CTUIR Pacific Lamprey research and restoration project (existing) and lamprey outmigration (expanded)	Complementary project for information exchange and coordinate/collaborate efforts. For example, new screen designs, contaminant and genetic information developed under 2008-524-00 can be used for this project
BPA	2007-007-00	Determine Status and Limiting Factors of	Complementary project for information exchange and coordinate/collaborate efforts. For example, new screen designs,contaminant studies and genetic information developed under 2008-524-00 can be used for this project

		Pacific Lamprey in Fifteenmile Subbasin	
BPA		Implement *Wy-Kan-Ush-Mi Wa-Kish-Wit*	Complements CRITFC member tribes anadromous fish restoration plan
BPA	2008-507-00	Tribal Data Network	Complements data base collection, storage and distribution of Pacific lamprey Information
BIA/ EPA	2009-2010 Columbia River Pacific Lamprey Toxics Study Tissue Investigation Willamette Falls, John Day Dam and Sherar's Falls, Oregon	Comparative analysis of contaminants in adult lamprey sampled at three basin sites	Complements ongoing toxics studies conducted by EPA, ODEQ and others

Figure 5. Relationship of Project Objectives to Tribal Accord Projects



F. Proposal biological/physical objectives, work elements, methods, and metrics

Project Objective 1. Finalize the Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin.

The first project objective is to finalize the *Plan* as recommended by the ISRP and ISAB. Numerous regional comments were received on the *Plan,* including those from the ISAB. These comments will be considered in *Plan* finalization as well as updating some background research and information. A full time lamprey project leader will be retained in the near future to focus on completing the objectives of this Project including finalization of the *Plan*.
We envision the final plan to be released in the latter part of 2010.

Action 1.1. Hire CRITFC lamprey project leader.

Action 1.2. Respond to regional comments including those from the ISAB (ISAB 2009-3) and modify plan as appropriate.

Action 1.3. Update and maintain technical information including recent work from the scientific literature and other regional processes such as the USFWS Coastwide Lamprey Conservation Initiative and the CBFWA Lamprey Technical Workgroup and tribal accord and other tribal lamprey projects.

Timeline: 2010

Project Objective 2. Improve mainstem and tributary lamprey passage efficiency, and survival

In cooperation and collaboration with other regional entities,[8] CRITFC will address the following actions and tasks. For the most part, Actions under this objective will involve participating in regional forums that will guide development of fishway modifications structures and operations designed to improve passage performance and survival of adult and juvenile Pacific lamprey at dams and through associated reservoirs. Specific tasks that would require direct funding from this program include installation of cameras and associated equipment to document numbers of fish that pass dams (Task B.iii) and development and installation of screens to reduce loss of adult and juvenile lamprey at irrigation projects in tributaries (Task D.i).

Action 2.1. Determine hydraulic and biological design modifications to existing mainstem and tributary passage barriers to improve mainstem lamprey passage efficiency, and increase both adult and juvenile survival.

[8] CRITFC member tribes, Corps of Engineers, Bureau of Reclamation (BOR), BIA, BPA, Mid-Columbia FERC entities, state and federal fish and wildlife agencies, CBFWA, and NWPCC.

Task 2.1A Track and participate in regional lamprey groups and forums to direct appropriate research and structural improvements for lamprey passage

Multiple forums currently exist that deal with efforts to improve juvenile and adult lamprey passage at mainstem and tributary projects. Primary among these are the US Army Corps of Engineers' Anadromous Fisheries Evaluation Program (AFEP), which supports goals in the Corps 10-Year Lamprey Plan, FERC processes related to relicensing mid-Columbia PUD projects, discussions within the CBFWA Lamprey Technical Work Group, and the US Fish and Wildlife Lamprey Conservation Initiative, to name a few. It is vital that CRITFC and member Tribes are represented during these discussions to develop and implement structural and operational changes to improve juvenile and adult lamprey passage. Included in these discussions should be the development of active tag technology for use with juvenile lamprey evaluations (2010-2012). Funding for this task would be used to cover labor and travels costs associated with participating in these forums.

Timeline: 2009-2018.

Task 2.1B. Determine adult and juvenile counts and passage rates for each route of passage at each mainstem dam and develop passage criteria metrics and protocols

Accurate counts of adult salmon and steelhead at mainstem dams have long been used to assess population status and evaluate management actions in the Columbia River. Current protocols for collecting counts for adult lamprey, however, are of limited use to managers because of the nocturnal nature of lamprey behavior and the unknown proportion of lamprey that are able to bypass count stations at dams. The ISAB (2009) noted that acquisition of accurate adult lamprey counts was a high priority. The following subtasks are proposed to address development of accurate and reliable counts of adult lamprey passage at mainstem dams.

Subtask(i) Collaborate with regional dam operators to develop and adapt improved adult lamprey counting methods and establish consistent 24 hour lamprey counting at Corps dams, Mid-Columbia FERC dams and Willamette Falls and assisting with Warm Springs Tribal Accord adult lamprey abundance estimation project at Willamette Falls

Currently, active counts of fish passing most mainstem dams only take place 16 hrs per day. Because lamprey are nocturnal in nature, many or most lamprey will not be counted during the 8 hrs count stations are currently not operated. Working in collaboration with partner management groups, we will develop, evaluate and implement reliable methods to eventually provide 24 hour counts of lamprey passing all mainstem dams. We propose to use video recordings in combination with automated enumeration software to provide near real time nighttime counts at count stations. The effectiveness of automated methods would be determined using manual counts from video records. Funding for this subtask would be used to collect, process and evaluate counting methods. If found effective, CRITFC would work with dam operators to install and integrate nighttime counting methods with the current daytime count program.

Subtask(ii) Develop methods to install and monitor video cameras with computer systems in mainstem dam fishways, particularly behind picketed lead sections. Focus on John Day in 2010 and add counting facilities at The Dalles, McNary and the Snake River dams in successive years

Subtask (i) above will provide 24 hr counts of adult Pacific lamprey passing dams though the count window stations. However, it is known that lamprey can bypass fish count stations by passing through picket leads (i.e. pass behind count stations) or by other routes. It is likely that the proportion of lamprey that use these alternate passage routes will vary by season and location. Currently no counts are made of lamprey using these alternate routes. Similar to Subtask(i), we propose to develop and evaluate the use of underwater video recordings in combination with automated enumeration numbers of lamprey passing upstream at these locations. This evaluation will test methods to mount and maintain cameras, provide lighting, store, retrieve and efficiently process video images. We propose to initiate studies at a single location, John Day Dam, because we believe there will be sufficient numbers of adult lamprey to provide a valid test without overwhelming current technology. Once effective methods have been developed for John Day Dam, they can be adapted to The Dalles, McNary and the Snake River projects.

Subtask(iii) Coordinate and collaborate with other entities such as WDFW, ODFW, Corps and Fish Passage Center to develop and adapt improved juvenile lamprey dam counting methods at bypass systems

Juvenile lamprey migrating downstream to the ocean can be diverted into the juvenile fish facilities at dams similar to salmonid smolts. Unlike with smolts, however, currently there are no standardized protocols on how juvenile lampreys are processed at bypass facilities. Specifically, the types and amount of data collected and reported is primarily left to the separate entities operating bypass systems. For example, do reported lamprey counts include or exclude the ammocoete juvenile stage? We propose to enter into discussions with the Corps, Fish Passage Center, Pacific States Marine Fisheries Commission, States of Oregon and Washington, USFWS, and others, to develop standardized protocols for processing and reporting information for juvenile lamprey observed at bypass systems. This process may include development and evaluation of structural modifications at bypass facilities to standardize collection methods, such as the grating spacing that can affect the number and stage of juvenile lamprey retained, etc.

Subtask(iv) Collaborate with Corps and other regional entities to establish active tagging technology for juvenile lamprey.

Information on the number of juvenile lamprey passing dams, passage routes, and route-specific fates is currently lacking. A significant limitation in obtaining this information is the small size of juvenile lamprey migrants which currently precludes use of active biotelemetry methods as is the current means to conduct comparable evaluations with juvenile salmonids. Efforts are urgently needed to develop the biological criteria and subsequent technological development for an active telemetry transmitter that would allow effective evaluations with juvenile lamprey migrants. It is supposed at this time that the preferred technology for this application would be an acoustic transmitter because acoustic signals are more easily detected

for fish deep in the water column. Funding for this subtask would be used to work with the Corps to develop the specifications for a juvenile lamprey active transmitter and to work with manufacturers to create and test demo tags. This work could involve in-house evaluations, including live fish trials, or to provide funding to other researchers to facilitate completion of this subtask.

Subtask(v) In collaboration with CBFWA lamprey technical workgroup develop/ establish passage criteria, metrics and assessment protocols such as dam passage efficiency, dam passage timing, and fallback.

The CBFWA lamprey technical work group (LTWG), is currently in process of developing standardized passage metrics, monitoring protocols and, ultimately, passage criteria for juvenile and adult Pacific lamprey for the FCRPS. CRITFC is currently a member of the LTWG but participation in the past has been sporadic at times because of time and funding constraints. Funding for this subtask will allow consistent participation at this and other formal forums (see Objective 2) dealing with lamprey technical issues.

Timeline: 2010-2018

Task 2.1C. In collaboration with other regional entities identify, prioritize and apply scheduled structural and operational improvements to achieve volitional adult passage standards approximating the best known achievable rates at mainstem dams and through reservoirs.

Working with Corps, PUDs, States, and other regional managers, we propose to develop, prioritize and help schedule implementation of detailed lists of structural and operational modifications designed to improve passage for adult Pacific lamprey at mainstem dams.

Subtask(i) In collaboration with other regional entities use passage and research information from Task B to establish adult improvement priority areas such as modifications to fishway entrances by installation of lower velocity structures, LAPS systems, plates over diffuser gratings, ramps, rounding weir corners and modifying blind corners such as auxiliary water system areas

Subtask(ii) In collaboration with other regional entities create a prioritized list of adult passage improvements for all mainstem dam fishways

Working with Corps, PUDs, States, and other regional managers, we propose to develop, prioritize and help schedule implementation of detailed lists of structural and operational modifications designed to improve passage for adult Pacific lamprey at mainstem dams. These modifications will be based on results of ongoing research funded by Corps and annual inspections of fishways and related structures used to identify potential passage problem areas.

Subtask(iii) In collaboration with other regional entities establish adult lamprey passage rates through mainstem reservoirs and research ways to reduce reservoir passage losses

PIT tag monitoring with adult lamprey have indicated that about 90% of lamprey that pass Bonneville Dam do not pass McNary Dam and that conversions between dams, and travel times (medians of about 10 to 15 km/d), are influenced by fish size, season/temperature and

flows (Keefer et al. 2009). In 2006-2007, losses were 33-37% in the Bonneville pool, 21-30% in The Dalles pool and 24-36% in John Day pool. To date, there is little information on the fates of lamprey within reservoirs. Efforts are needed to develop more effective methods to track lamprey migrants within reservoirs to better determine fates and sources of loss and to develop strategies to reduce loss.

We propose to work with the Corps, co-managers and researchers to test the use of acoustic telemetry to determine fates of adult lamprey in mainstem reservoirs. Information from resulting studies will be used by CRITFC and regional entities to identify potential management actions to reduce non-reproductive losses within reservoirs.

Subtask(iv) In collaboration with CTUIR, Warm Springs and Yakama Accord Projects link mainstem passage research with tributary passage research through the use of PIT-Tag, radio tag, acoustic tag and other appropriate technologies

The Corps and the PUDs have invested significant resources in telemetry and PIT tag monitoring of adult Pacific lamprey at mainstem dams but there has been relatively little effort to monitor these same tagged fish in tributary streams of the Columbia River. We propose to use funding for this subtask, in combination with the other Accord Projects, to expand the PIT and/or telemetry coverage into tributary streams as needed to assess numbers of fish that reach traditional spawning areas. For example, The Warm Springs Tribes have or is intending to use PIT tag stations in the Willamette and Deschutes rivers and Fifteen Mile Creek. The Yakima Tribe is considering monitoring efforts in the Yakima River and CTUIR has been intensely monitoring lamprey movements in the Umatilla River for a number of years. We will work with the Corps, Tribes, and co-managers to determine the most effective areas to add telemetry and/or PIT-tag coverage to optimize data collection. Likely sites include tributary streams in the Bonneville reservoir, John Day and Walla Walla rivers.

Timeline: 2009-2018

Task 2.1D. Develop juvenile lamprey passage designs to expedite safe, timely and effective juvenile passage through mainstem and tributary barriers.

Subtask(i) In collaboration with regional partners and CRITFC Tribes, design and new tributary screens for juvenile and adult lamprey.

System managers have recognized that screens at irrigation and tributary dam facilities initially designed for salmonids are not always effective, and may be detrimental, for lamprey. Survey work conducted by the Umatilla and Yakama tribes indicate that juvenile lamprey found behind tributary screens at many sites (CRITFC 2008). Some initial work has been funded by the USFWS to investigate screen designs but much more is needed. We propose to use funding for this subtask in partnership with BOR, USFWS and the Umatilla Tribes to support USGS in developing screening designs that will effectively exclude juvenile and adult lamprey from irrigation and other water withdrawal systems in tributary streams of the Columbia and Snake rivers. Preliminary investigations would involve exposing juvenile lamprey in a laboratory setting to vertical screens of various mesh materials and gap sizes to determine what will effectively exclude juvenile lamprey. Design features, such as overhanging lips on the tops of screens, that prevent adult lamprey from accessing and spawning in irrigation systems will also be investigated.

Subtask(ii) Establish design criteria for irrigation and other water withdrawal projects that will better protect lamprey, working with the CBFWA lamprey technical work group and BOR

Tributary barriers, such as irrigation diversion dams, can present passage obstacles to adult lamprey similar to what has been observed at mainstem dams. We propose to work with our member tribes, the CBFWA lamprey technical workgroup, BOR and other entities, to develop design criteria to improve upstream passage for adult lamprey at these structures. This subtask will include manual inspections of structures to identify potential passage problem areas at tributary dams, culverts, etc.

Subtask(iii) Coordinate with CRITFC Tribes and BOR on screening inventories in selected basins including the Yakama, Warm Springs and Umatilla projects. Assist in prioritizing areas for new tributary screen placement.

Once design criteria for tributary sites have been developed, as described above, we propose to work with co-managers to inventory and prioritize sites in need of modification. Funding will then be sought to implement modifications on a reasonable timescale, targeting highest priority sites first.

Timeline: 2010-2018.

Objective 3. Monitor and evaluate, collect and disseminate information on lamprey population status, life histories and mainstem habitat.

Action 3.1. In cooperation and collaboration with other regional entities, determine lamprey life history mainstem habitat preferences and prioritize actions to improve lamprey habitat.

The CBLTWG (2005) identified as highly important the need to increase basic information and knowledge of factors which limit lamprey population growth in the Columbia River Basin. CRITFC, through administration, collaboration and coordination with other region entities (i.e. Corps of Engineers, Bureau of Reclamation, FERC licensed utilities, USFWS, state fish and wildlife agencies, CBLTWG), will document lamprey spatial and temporal distribution and mainstem habitat preferences, and where possible attempt to evaluate the impacts of environmental stressors on lamprey growth. As has been noted, significant gaps remain in our understanding of the basic biology, ecology and life history for Pacific lamprey. For this objective, we propose several strategies to address some of the more pressing data needs.

Task 3.1A. Implement Willamette River adult lamprey migration and habitat study

We know very little on behavior, habitat use and temperature tolerances for adult lamprey during their upstream migrations in reservoirs and unimpounded river systems. To address this, we propose to use radio telemetry to investigate adult lamprey migrants in the Willamette River. The Willamette River was selected because it still contains a relatively strong lamprey population, provides ready access to lamprey for tagging at Willamette Falls and is of a size and scope to allow a manageable basin-wide evaluation. We began work as described below and in Clements et al. 2010, who issued CRITFC a draft report on 2009 findings in early 2010.

Subtask(i) Fund subcontractors Cramer Fish Sciences to trap and radio tag about 200 adult lamprey at Willamette Falls fishway throughout the migration season.

From previous work in the Willamette River, we judged that a sample size of between 200 and 300 lamprey a year, over two years, would be needed to determine a reliable distribution of lamprey though the basin and provide sufficient fish to be able to locate individuals to identify habitat use in a variety of habitats. For example, as fish move upstream, are there specific locations lamprey select for overwintering habitat? What proportion of the sample will select lower versus upper river tributaries as potential spawning areas, and what habitat characteristics are associated with these selections (see subtasks below)? We are fortunate to be conducting this evaluation at a time when two other complementary research programs are underway. In 2009, PGE was undergoing an evaluation of lamprey passage at the Willamette Falls complex, requiring them to tag a sample of 150 adult lamprey. In 2010, the Grande Ronde Tribe is planning to conduct an adult lamprey evaluation with objectives that parallel those we describe here. They have sufficient funding to tag 120-130 adult lamprey. As such, we believe we can meet the study objectives as outlined here by tagging an additional 150 lamprey per year and coordinating data collection efforts among research efforts.

Fish to be tagged would be collected using a lamprey trap operated in the Willamette Falls fishway. Starting in April and continuing through August, lamprey collected each day will be surgically outfitted with radio transmitter and released upstream of the Falls. Tagging will occur 7 days per week, using tag crews from Cramer Fish Sciences and the Grande Ronde Tribe. Transmitters will have an approximate life of 9 months, allowing monitoring through to the spawning period spring 2011.

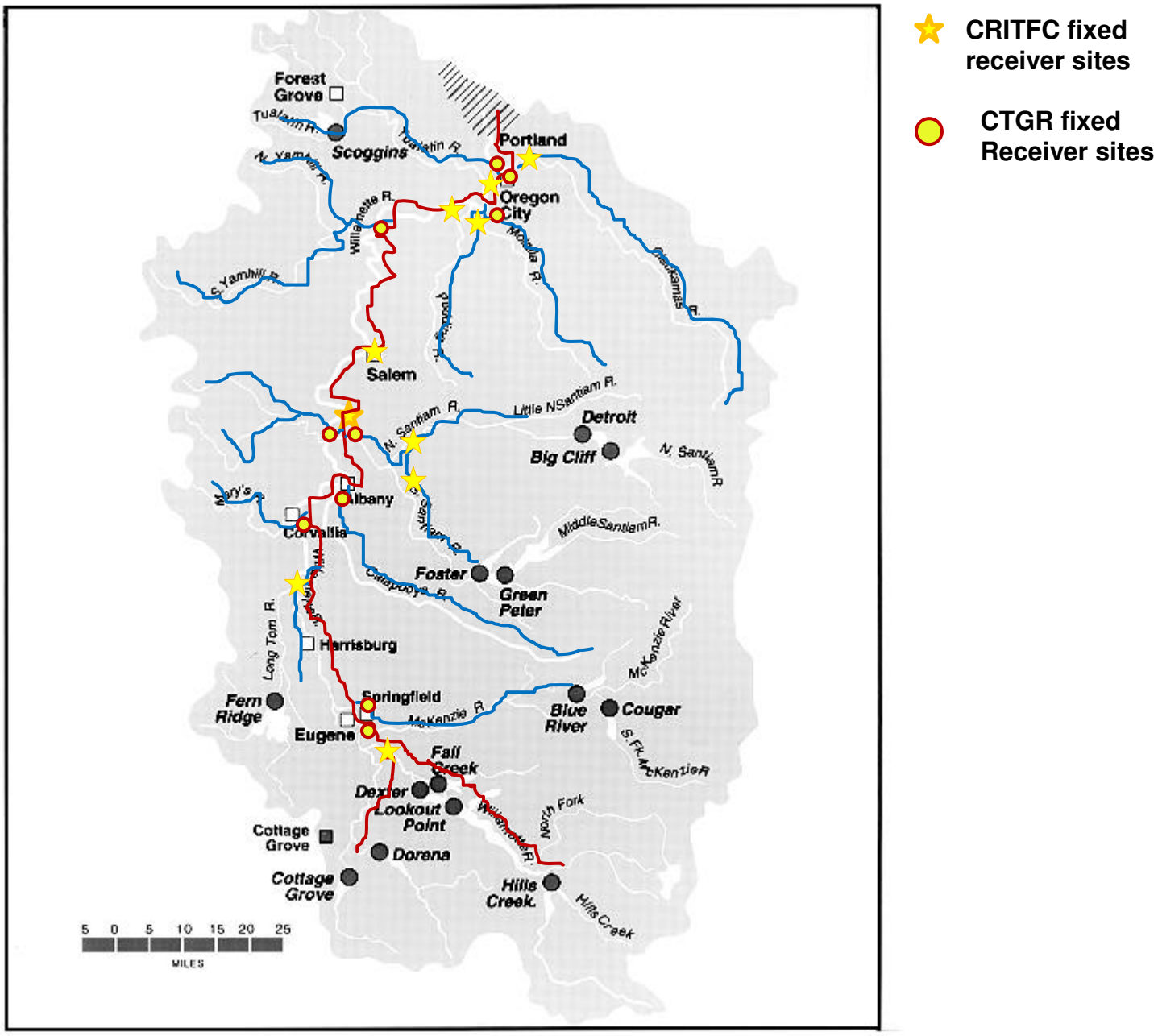


Figure 5. Location of fixed radio telemetry receiver sites established for the 2009-2011 Willamette Adult Lamprey migration and habitat study (from Cramer Fish Sciences 2009).

Subtask(ii) Fund Oregon State University and Cramer Fish Sciences to characterize adult lamprey life history stages (migration, holding, spawning) throughout the Willamette River through radio telemetry methods including fixed receivers, boat and aerial tracking.

Following release, radio-tagged lamprey will be monitored as they move upstream using a series of fixed receivers sites located at various locations on the mainstem Willamette River and at each of the major tributary streams. Fixed sites will be used to observe migration rates and distribution of adult migrants as they proceed upstream (Figure 5). Fixed sites will also be added to terminal dam sites (Detroit, Cougar, etc.) to document the extent of migration possible within the basin. Tasks of maintaining and downloading receiver sites will be shared between Cramer and the Grande Ronde Tribes. Mobile tracking (conducted by OSU) by boat and car and plan will be used to locate individual fish and identify habitat selection (Figure 6). We will record cover type (large woody debris, riprap, etc.), water depth, water temperature, substrate type, and GPS coordinates for each location. Recording thermographs will also be deployed at key locations in the mainstem and tributary streams to characterize thermal environment in the basin throughout the study period. All data will be combined into a comprehensive database to allow for system-wide analyses of fish movements and habitat use. Information generated for this subtask can potentially be used to establish conservation easements for lamprey habitat and to make improvements to the Corps' Willamette River Biological Opinion with respect to adult lamprey.

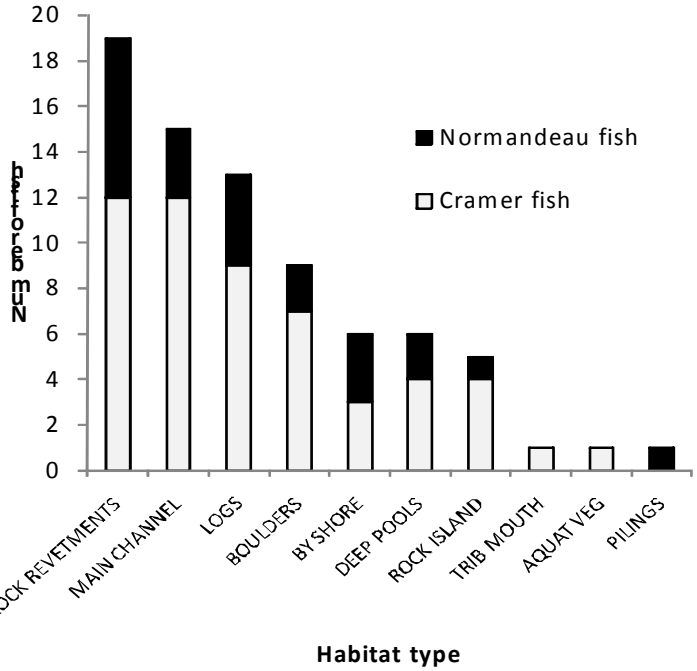


Figure 6. Numbers of lamprey that held for an extended period of time in the same location. light gray bars represent CFS fish (N = 53). From Clements et al. (2010).

Subtask(iii) Coordinate, collaborate and fund subcontractors and collaborators: Cramer Fish Sciences, Oregon State University; Portland General Electric; Warm Springs Tribes, Confederated Tribes of Grande Ronde, Corps of Engineers, Bureau of Reclamation on data sharing and reporting.

This project was prioritized due to the ability to collaborate and share data with other entities conducting concurrent adult lamprey radio telemetry research in the Willamette River and the need to establish information about adult migration and spawning uncertainties. A sizable amount of time is needed to develop subcontracts and to coordinate research and data sharing

activities between the various research and other groups involved with this study. We are in the process of developing agreements on data sharing and reporting and developing joint protocols to assure data quality. Similar agreements are already in place with PGE and their contractor Normandeau. All radio receivers used for this study are being loaned to researchers by the Corps. Trap and tagging facilities to be used are owned by the State of Oregon and operated by PGE. The trap itself is being provided on loan by PGE. Aerial flight funding is provided by the BOR. We also are involved with gaining permissions from public and private land owners for fixed receiver sites.

Subtask(iv) Contribute to annual report to BPA and the region

Each research group will address specific study objectives and be responsible for completing annual and final reports. CRITFC will be responsible for coordinating this reporting effort and combining the separate documents into a comprehensive report for submission to BPA.

Timeline: 2009-2011.

Task 3.1B. In cooperation and collaboration with other regional entities, investigate the adult and juvenile lamprey status and abundance trends by conducting inventories of adult and juvenile lamprey abundance, distribution and habitat at dams and in mainstem rivers and reservoirs.

Subtask(i) In collaboration and resource sharing with USGS, USFWS and others, plan prioritize and implement mainstem juvenile lamprey habitat inventories.

Juvenile lamprey (ammocoetes) have been observed at juvenile fish bypass facilities and it has been speculated that they may use Columbia River reservoirs as rearing habitat. Juvenile lamprey have been observed stranded in tributary deltas at the confluence of mainstem reservoirs (H.Schaller, pers. com. 2010). This is possible if adult lamprey are spawning in mainstem reservoirs or if juveniles are washed into reservoirs from tributary streams. It is important to know if larval lamprey cluster in certain areas. Beginning in the Bonneville pool in 2011, we propose to collaborate with the USFWS to use the suction /electroshocking equipment (developed in the Great Lakes for sea lamprey studies) to survey areas for presence/absence of juvenile lamprey, focusing on delta areas from tributaries entering into the mainstem (Jolly et al. 2009). Using a probabilistic sampling system, Jolly et al (2009) divided the Willamette River's lower 27 miles below the waterfall in Oregon City into some 30,000 squares measuring 30 by 30 meters each (Jolly et al. 2009). A GIS software program selects sample squares on a random basis, then re-sorts them to ensure they are spread across a wide area (Jolly et al. 2009). This method has been used successfully down to a depth of 50 ft in the lower Willamette River. In collaboration with the USFWS, we will utilize these methods and random sampling protocols (i.e purposeful sampling) as suggested by ISRP for Yakama Accord Lamprey Project for research and index sites for each reservoir. Using these and other available tools, such as GIS mapping used for salmon habitat assessments, we will create an index of lamprey priority sampling and distribution areas in reservoirs and work in an upstream direction in the mainstem Columbia in subsequent years.

Subtask(ii) Coordinate and share data with CRITFC Accord tribes on their juvenile lamprey tributary surveys

Tribal biologists are conducting, or are proposing to conduct, presence/absence, habitat and life history surveys for juvenile lamprey in selected tributary streams. This information is important to measure productivity and population status and track trends in populations over time. We propose to coordinate with tribal biologists to accumulate and archive these data with our data from mainstem surveys (see Subtask iii) to provide easily accessible clearinghouse for juvenile survey information.

Subtask(iii) Coordinate, collaborate with Corps, USFWS, Mid-Columbia PUDs and others on mainstem surveys and population studies.

Statolith microchemistry has been suggested as a potential method to define population level patterns for lamprey within the Columbia River. The theory is based on comparing the abundance of specific chemical elements in the statoliths of spawning adult lamprey to determine if there are similarities among adults within a drainage and to chemical makeup of the water in that drainage. We propose to work with region co-managers to develop funding for a proof-of-concept study for this type of evaluation. A difficulty that must be overcome is to develop methods to obtain sufficient samples of adult lamprey carcasses from spawning areas. If results appear promising we will support a larger scale study based on this technique.

Subtask(iv) Coordinate/collaborate on juvenile population studies funded by the Corps under AFEP and investigate other sources such FERC license holder investigations.

Discussions are underway related to developing methods, protocols and metrics to be used to assess status and fates of juvenile lamprey at mainstem and tributary locations. We will continue to participate in these discussions and, as plans develop, we propose to use funding to collaborate in these studies. Potential types of studies include netting and mark-recapture tests to estimate population size and survival in tributaries and at mainstem dams, PIT-tag studies, hydroacoustic evaluations, and the like.

Subtask(v) Develop comprehensive datasets on lamprey biology abundances, locations, time series, etc.

As suggested by the ISRP for Warm Springs Fifteen Mile Creek Lamprey Project Monitoring Program, we propose to develop and maintain a comprehensive database containing available information on juvenile and adult lamprey presence/distributions, abundances, timing, and other related topics. Information will be accessible to researchers and managers at a central web-based location using a format such as used at http://www.fpc.org/lamprey/lamprey_home.html.

Timeline: 2011-2018.

Action 3.2. In cooperation and collaboration with other regional entities, inventory, document and attempt to reduce mainstem avian, piscine and marine mammal predation.

Task 3.2A. With assistance from the Corps, USGS and state fish and wildlife agencies compile a literature review of known predation information and assess effects on adult and juvenile lamprey.

Subtask(i) Gather predation data from prior salmon studies throughout the region. Include data from sea lion studies, resident fish and avian predation studies. Seek information about juvenile lamprey predation in salmon transportation facilities

Timeline: 2010-2011

Subtask(ii) Use literature review to solicit Corps and other agency funding to reduce lamprey predation and/or seek mitigation action to reduce lamprey predation.

Using available information, we propose to estimate potential risks of predation for juvenile and adult lamprey. We will then enter into discussions with the Corps and other entities to develop strategies to reduce predation threats with the ultimate goal to obtain funding to implement those strategies. A potential outcome is that existing monitoring programs such as the sea lion monitoring program at Bonneville Dam, bird predation measures such as wires and harassment at dams, the northern pike minnow sport reward fishery and avian research may need to be expanded to address lamprey impacts.

Timeline: 2011-2018

Action 3.3. Determine lamprey genetic structure and gene flow through the Columbia River and Pacific Northwest by developing and expanding the use of genetic markers to clarify and define populations or aggregations of lamprey groups in the Columbia River and compare/contrast these with other Pacific Northwest lamprey groups.

The population structure of Pacific lamprey in the Pacific Northwest is not well understood. Two genetic studies for lamprey published to date (Goodman et al. 2008; Lin et al. 2008) have not indicated strong population differentiation within the Columbia River but there may be some underlying larger-scale geographic patterns. Our understanding of the genetic structure and analyses relevant for describing lamprey population structure are still developing. We propose to support this ongoing effort through coordinating collection of genetic samples throughout the basin and funding researchers at agencies and universities who are involved with developing these analytical techniques.

Task 3.3A. Fund analysis of existing juvenile and adult genetic samples to optimize suite of DNA and AFLP markers

Subtask(i) Analyze existing samples to assist in establishing gene flow trends and temporal vs geographical/spatial differences.

We possess tissue samples (n=30 per site) from adult lamprey from Deschutes, John Day Dam, North Fork Toutle, Willamette, Rogue and Klamath rivers. With funding for this subtask we propose to contract with D. Close from University of British Columbia to compare nuclear DNA among these drainages.

Deliverable will be a report to the region.

Subtask(ii) Analyze potential for subpopulation gene flow in the Willamette subbasin.

We currently possess a large sample (n = 234) of tissue from adult lamprey collected from the Willamette River. Using funding from this subtask, we propose to contract with M. Docker from University of Manitoba to investigate for the potential relatedness for adults returning to a single subbasin within the Columbia River.

Deliverable will be a report to the region

Timeline: 2010-2012.

Task 3.3B. Fund obtaining additional juvenile and adult genetic material and analyze for DNA and AFLP markers

Subtask(i) Contract through University of British Columbia to obtain collection of additional samples from areas already surveyed (n=30 samples per site) to examine temporal issues and add sites from Washington coast rivers, Elwha River, Fraser, Skeena, and Nass rivers, British Columbia, Moose River, Alaska, etc.

We propose to provide funding to support the investigation into the genetic structure of Pacific lamprey populations range-wide. This work is on-going but additional funding is necessary to expand the sample rates and sites inclusive of the natural range of Pacific lamprey and to extend analyses to be able to track temporal changes.

Timeline: 2011-2018.

Action 3.4. In cooperation and collaboration with other regional entities, establish regional data protocols for collection, storage and analysis of lamprey abundance, and habitat preferences throughout the basin. Develop a database for regional information exchange to widely access and share information.

Task 3.4A. Develop regional data protocols

Collaborate with other tribal accord projects, CBFWA lamprey technical working group, other regional entities such as USGS, USFWS and Corps of Engineers to establish standard operating protocols to collect data on juvenile and adult studies. These may include, but not limited to, count methods and metrics, collection, tagging and recovery methods, passage and survival metrics.

Task 3.4B. Establish a database for lamprey data and develop means to widely access and share lamprey data.

It will be critical to assure researchers and managers can make efficient and effective use of new information on lamprey ecology, biology, and recovery methods as it becomes available. This would be facilitated by developing and maintaining a centralized and readily available database for Pacific lamprey. In collaboration with other regional entities, including the CBLTWG and the USFWS, CRITFC will seek lamprey passage, habitat, life history, water quality, genetic and other data and information on these life histories and include them in the collaborative lamprey data base for regional information exchange.

Subtask(i) Collaborate with tribal lamprey projects, CBFWA lamprey technical working group and other regional entities

CRITFC, member tribes and the CBLTWG have suggested the need to develop a comprehensive database available to all scientists and managers involved with Pacific lamprey in the basin. While all agree such a database would be beneficial, as yet discussions have not progressed to the level of detail needed to implement such an effort. Specifically, how would the database be developed, who would be responsible to house and maintain the database, and how would access be granted and how would this effort be funded? We propose to enter into substantive discussions with regional entities on developing strategies to address this need.

Subtask(ii) Utilize CRITFC data base accord project to establish regional lamprey information data base repository

Subtask(iii) Using the data base platform coordinate with regional and outside regional entities to share data and expand data and information sets.

Through regional forums, such as CBFWA LTWG, Corps' AFEP Program, USFWS Coastwide Conservation Initiative and BPA-funded efforts, we will continually gather and share information as it becomes available to develop and maintain the lamprey database.

Timeline: 2011-2018.

Objective 4 Establish and coordinate public education and other outreach programs.

Action 4.1. Provide outreach and education programs to agencies, industries, agriculture entities, municipalities, schools and the general public about lamprey biology, status, research and importance as a keystone species for the ecological health and function of the Columbia Basin as well as a critical tribal cultural resource.

Task 4.1A. Begin program of coordinating, educating Willamette Basin Local watershed councils

Task 4.2 B. Retain tribal elders to engage in local salmon restoration events, Corps of Engineers outreach and tribal education programs, fairs and other events (i.e. Willamette Falls Eelfest, Lamprey Passage Media Event, OMSI Salmon Camp, Umatilla Tribe's Salmon Walk Multnomah Falls Salmon Festival, Oregon State Fair)

Task 4.3 C. Develop education materials such as brochures, information fact sheets, lamprey demonstration materials for public education.

Timeline: 2010-2018

Objective 5. Evaluate contaminant accumulation and other water quality impacts on lamprey.

Because of their long lives, estimated to be 5-7 years in freshwater and potentially 3 years rearing in the ocean, Pacific lamprey have to the potential to bio-accumulate significant level of water-borne toxins. Juvenile rearing primarily occurs in fine sediments, which may increase their

exposure to toxins, especially in industrialized areas. The effects of accumulated toxins on the health and survival of Pacific lamprey has not been investigated. Nor do we understand the potential effects that consuming lamprey has on the Native America populations. For this objective, we propose to begin accumulating available knowledge on contaminants in the system and how they impact Pacific lamprey in the Columbia River.

Action 5.1. Compare toxic accumulation levels between adult and juvenile lamprey from different parts of the Columbia Basin

Task 5.1A Evaluate existing data and literature on lamprey contaminants.

We propose to conduct or fund a comprehensive literature review of available information on contaminants that have been observed in Pacific lamprey and other lamprey species. This effort should include accumulating available data from existing studies, as possible, and an assessment of the potential physiological and behavioral effects for contaminants on juvenile and adult lamprey.

Task 5.1B Through funding partnerships with USGS, EPA and others, evaluate juvenile contaminants in 2-3 tributaries in 2010 and expand in future years.

The Environmental Protection Agency, the Oregon Department of Water Quality and other entities are tasked with monitoring for toxins in aquatic systems, such as at ports and industrial areas. We propose to work in partnership with these efforts, or procure new funding when possible, to include the evaluation of contaminant loads of juvenile lamprey in the environment. For 2010, we propose to initiate work in 2 to 3 keys tributaries in the lower Willamette and Columbia rivers, including 15 Mile Creek in collaboration with cost share funding from the USGS. Eventually we will expand the monitoring to include additional tributary areas over time. Juveniles will be collected using similar methods as used for conducting juvenile surveys, primarily with specialized backpack shockers or methods described above for mainstem sampling (Jolly et al. 2009). Juvenile lamprey that have died incidentally from operation of collection facilities (e.g. screw traps, juvenile dam bypass facilities, etc.) or in turbine water cooler screens may also be used for this task where appropriate. Similar monitoring of adult lamprey will be included where possible to better partition temporal patterns in contaminant accumulations.

Action 5.2. Evaluate existing data and literature on temperature, dissolved oxygen, total dissolved gas and other water quality parameters.

As with salmonids, the river environment juvenile and adult lamprey experience may influence their migration success and survival in the Columbia River. Currently, our understanding of exposure levels or tolerances for lamprey relative to water quality parameters is limited. Of particular interest are the temperature preferences for adult migrants and how this may affect tributary escapement. We propose to use funding for this Action for a literature review of available information on temperature preferences and tolerances for adult and juvenile Pacific lamprey and other lamprey species. This information will be used to guide future potential studies to fill information gaps and manage Columbia River lamprey populations relative to water quality conditions.

Timeline: 2010-2018.

Objective 6. In collaboration with CRITFC member tribes and other regional entities with resource sharing, plan, develop and if appropriate, implement an experimental safety-net lamprey artificial production facility for the conservation of the species.

Action 6.1 Develop plan for artificial production facility (Timeline: 2010-2011)
Given the serious recent decline in lamprey numbers throughout the basin, a reasonable strategy is to develop a conservation propagation facility (Lampman et al. 2009. Among other things, lamprey produced by this facility can be utilized for passage studies to avoid mining remaining natural production.

Task 6.1A Fund and expert panel with international participation to scope needs for artificial production facility (i.e. proper husbandry, appropriate siting, facilities, broodstock, gamete management, release protocols, pheromone studies etc.; Hokkaido 2008). Broodstock collection methods (i.e. funnel traps) successfully used by the CTUIR for their Accord funded translocation project may be considered.

Task 6.1B Conduct a workshop using the information gained in Task 6.1.A to develop a draft facility plan

Task 6.1C Seek collaborative partnerships between tribes, USFWS, and other regional entities to develop cost share mechanisms to fund planning for task 6.1A and 6.1B (for example Chelan PUD has some funding for lamprey mitigation projects under the new Rocky Reach FERC license).

Task 6.1D Seek regional review of conservation facility plan

Task 6.2 E Finalize conservation facility plan

Action 6.2 If warranted, based upon the plan, proceed with implementation of an experimental artificial production conservation facility and monitor and evaluate results (2012-2018)

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J. Key personnel

Project Manager: Robert Heinith, Hydroprogram Coordinator,
Columbia River Inter-Tribal Fish Commission

Will plan, coordinate, administer, manage and provide technical review/oversight for all aspects of this project .

Education: Colorado State University. B.S. Fisheries Biology 1974
Western Oregon University/Oregon State University
Masters Degree in Integrated Science and Education, 1986

Professional Experience:

Columbia River Inter-Tribal Fish Commission- Hydroprogram Coordinator and Fish Passage Specialist (1991- present) – Primary author and regional coordinator for *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008)

Point No Point Treaty Council – Water resource and fish habitat/passage biologist

Confederated Tribes of Warm Springs- Tributary habitat biologist

Wyoming Game and Fish Commission - Fish habitat and population assessment biologist

Supporting personnel:

Thomas Lorz, Fisheries Engineer, Columbia River Inter-Tribal Fish Commission

Will provide technical engineering review and participation for screen design work and passage system improvements.

Education: Oregon State University- B.S. and M.S. Civil Engineering