200852400 CRITFC Lamprey Passage Design

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

Narrative

Table 1. Proposal Metadata

Project Number	2008-524-00
Title	Pacific Lamprey Passage Design
Proposer	Columbia River Inter-Tribal Fish Commission
Short Description	This project will improve adult and juvenile Pacific lamprey passage through mainstem and tributary blockages, and provide information and actions to reduce uncertainties with respect to mainstem lamprey distribution and abundance, habitat quality, habitat utilization and genetic characteristics. This project is a key element to successfully implement objectives 1, 2, 4 and 5 of the *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008).
Province(s)	Intermountain and Lower Columbia
Subbasin(s)	Willamette, Lower Snake, Upper Middle Columbia, Lower Middle Columbia, Lower Columbia, Mid-Columbia
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Information transfer:

A. Abstract

The Pacific lamprey (*Lampetra tridentata)* 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).

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), 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). In its report on critical uncertainties for lamprey, the Columbia Basin Lamprey Technical Working Group (CBLTWG 2005) prioritized passage improvements as a top ranked critical uncertainty in the overall effort to restore lamprey. 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 (CRITFC 2008). 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).

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) will develop and provide key passage design information to improve adult and juvenile lamprey passage basin wide.

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. For example, Beamish and Northcote (1989) found that Pacific lamprey populations persist for only a few years above problematic barriers. This project, in association with the University of British Columbia and in collaboration with other regional researchers, will increase the knowledge of lamprey population and genetic structure through supplementation of existing libraries of genetic markers such as microsatellites.

In addition, 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 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 mainstem habitat preferences, evaluate the impacts of environmental stressors on lamprey growth and survival and assess trophic relationships of lamprey within the freshwater aquatic community.

The ultimate goal of this project is to implement the following objectives of the draft *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008)[1]:

Objective 1 Improve mainstem lamprey passage efficiency, survival and habitat.

Objective 2 Protect and restore lamprey tributary habitat and passage.

Objective 4 Monitor and evaluate lamprey population status and trends

Objective 5 Establish and coordinate public education and other outreach programs

[1] Objective 3 of the tribal restoration plan, " Supplement lamprey by reintroduction and translocation in areas where they are severely depressed or extirpated", is being funded in part by BPA as tribal accord projects (see Section D, Table 2 to this narrative).

For this ten year project, ten sub objectives were established to capture and break out the *Plan* objectives above in more detail. In this narrative, Table 4 in Section F. provides a schedule for addressing the ten sub objectives over the ten year period of this project for the Willamette, Columbia and Snake Rivers. This project will be closely administered and coordinated with the Accord lamprey projects by the Umatilla, Yakama and Warm Springs tribes, and by Nez Perce Tribal lamprey restoration projects.

Due to the complexity, scope and scale of this ten year project, the initial focus for the first two years will be on prioritizing acquisition of baseline adult passage, migration, spawning and rearing habitat preferences and genetic data for the Willamette River Basin.[2] Other important work will include coordination/collaboration with other regional entities [3] to improve general passage and habitat and gain lamprey genetic information thorough acquisition of baseline data and careful monitoring and evaluation of other regional programs.[4] These actions will be important to plan, develop, implement and evaluate successful lamprey passage, habitat and life history actions while addressing the most critical limiting factors to lamprey restoration. In addition, throughout the ten year 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.

Active adaptive management will be an important consideration in out year efforts as much remains to be learned about Pacific lamprey in the Columbia Basin (Hilborn 1987). Adaptive management cannot be accomplished without measuring both the progress and effect of various project actions which must be made with the understanding that there is a severe deficit of definitive knowledge of the status, ecology and biology of this species. Developing an active adaptive management context for this project will include development of juvenile and adult lamprey abundance estimates, survival, passage metrics and standards and research and monitoring identifying mainstem habitat and evaluating other limiting factors and critical uncertainties such as population growth in the basin (ISAB 2007-3) and climate change (ISAB 2007-2; Mantua et al. 2009; WGA 2008).

B. Problem statement: technical and/or scientific background

The Pacific lamprey (*Lampetra tridentata)* 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, climate and ocean conditions, dredging and dewatering (USFWS 2009). Lamprey appear to be a choice food for avian, marine mammal and native and non-native fish predators, and at times may be preferred by some predators over salmon smolts (Close 1995;

[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 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.

Stansell 2006; Close et al. 1999; Nawa et al. 2003). Lamprey have been contributing 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, salmon recovery may not occur without Pacific lamprey recovery.

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). 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).

In addition, 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. Another cause for diminishment of lamprey populations was the application of fish eradication chemicals in certain Columbia Basin watersheds. 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). 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 are 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 and not rigorous, it is hard to deny that adult lamprey counts at mainstem dams have been in serious decline, with Snake River and Upper Columbia estimates at only a few dozen individuals (FPC 2006). These meager counts indicate that in recent times only very small numbers of adult lamprey pass the upper most dams in the Lower Snake and Upper Columbia. For example, in 2006 only 21 adult lamprey were counted passing Wells Dam in the upper Columbia and only 35 adults were counted passing Lower Granite Dam in the Snake River (Figure1 Peery et al. 2008 and Table 1, Corps and FPC 2008). In any recent year, adult lamprey counts decline significantly and sequentially moving upstream (Figures 2-5).

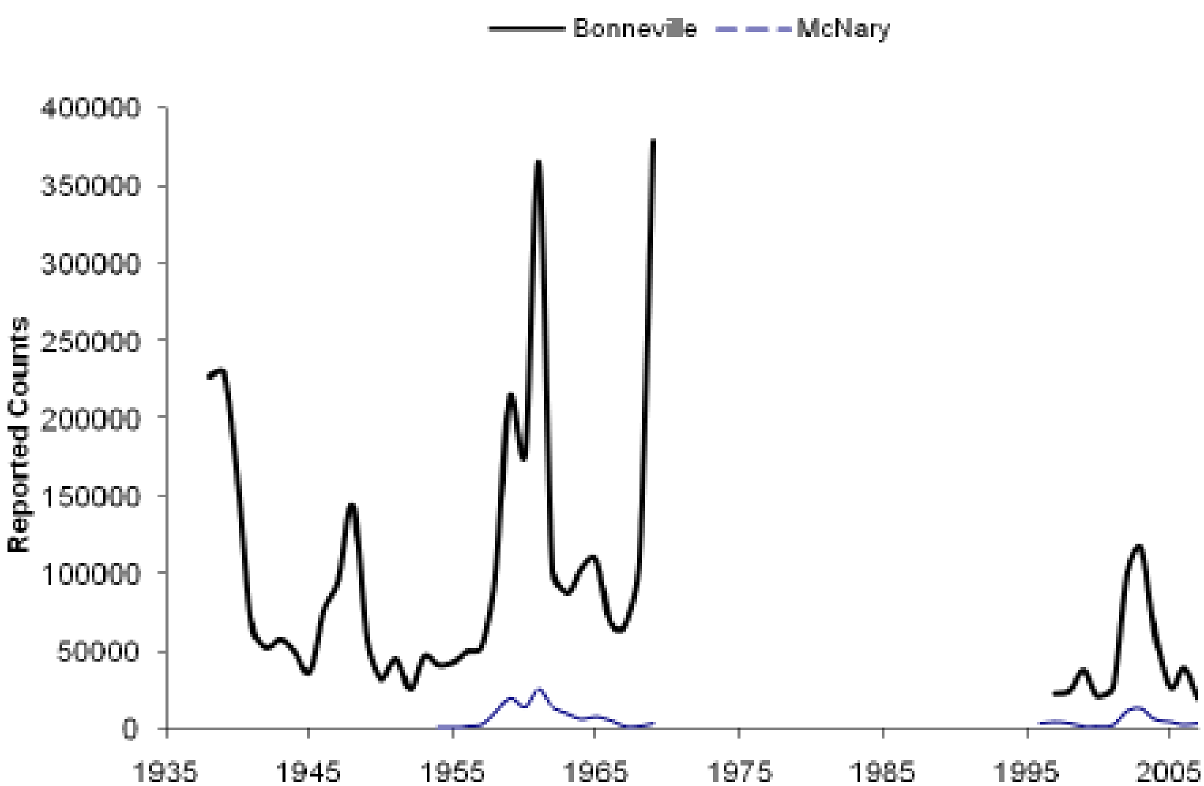
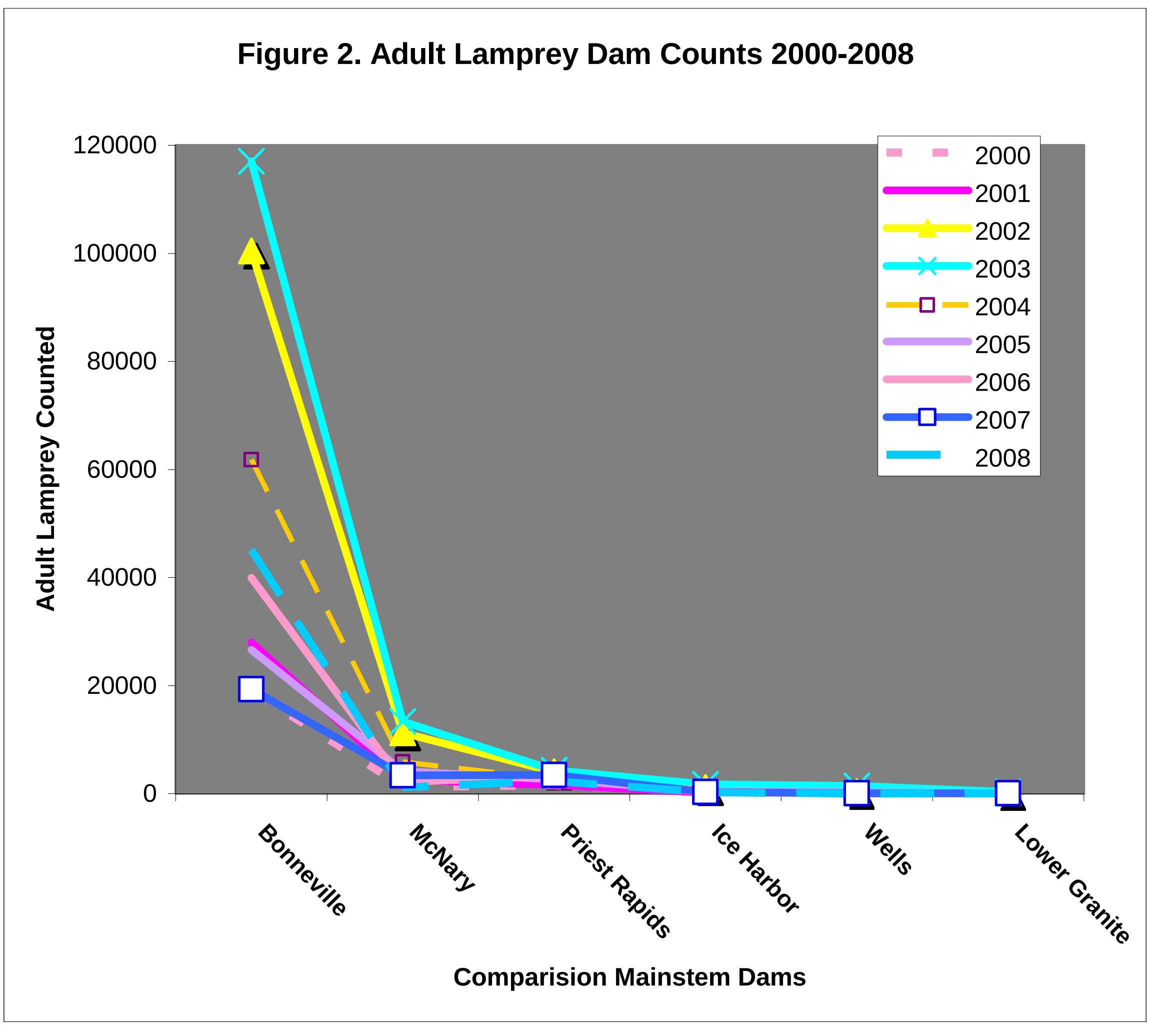


Figure 1. Annual counts of Adult Pacific lamprey at Bonneville (upper line) and McNary (lower line) dams over time. No data were collected 1970-1995.

[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.

Year	Bonneville	McNary	Priest Rapids	Ice Harbor	Wells	Lower Granite
2000	19002	1,281	1,468	315	NA	28
2001	27,947	2,539	1,624	203	261	27
2002	100,467	11,282	4,007	1,127	338	128
2003	117,027	13,325	4,339	1,702	1,408	282
2004	61,780	5,888	2,647	805	291	117
2005	26,625	4,158	2,598	461	212	40
2006	39,925	2,139	3,273	255	21	35
2007	19,317	3,389	3,419	288	32	34
2008	45,108	1,182	2,299	233	2	49

Table 1. Recent adult lamprey counts at Corps and Mid-Columbia PUD dams
24 hour counts were only available at Bonneville, Priest Rapids, Wells and Lower Granite. (FPC and Corps 2008)



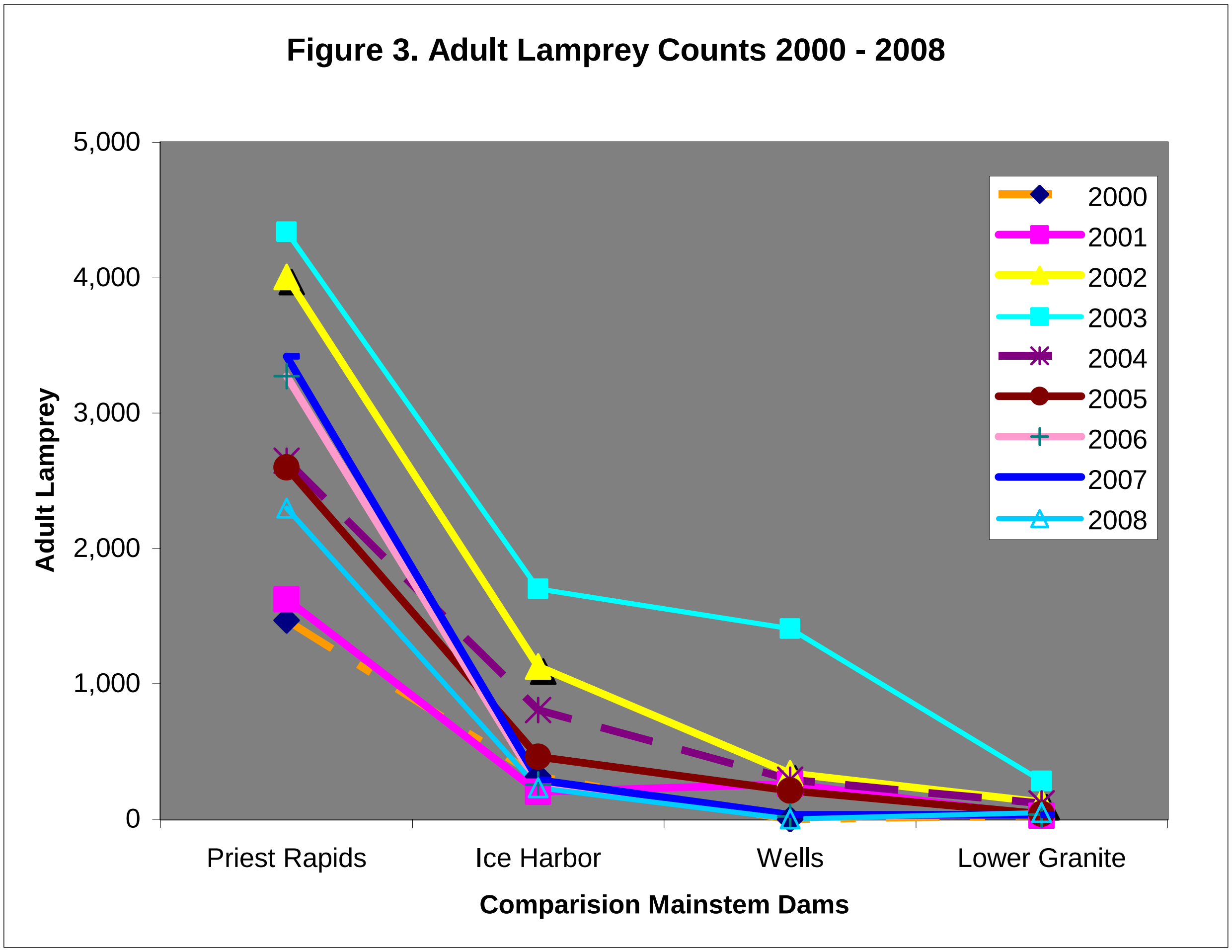


Figure 3. Adult Lamprey Counts 2000 - 2008
Adult Lamprey
5,000
4,000
3,000
2,000
1,000
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Priest Rapids
Ice Harbor
Wells
Lower Granite
Comparision Mainstem Dams

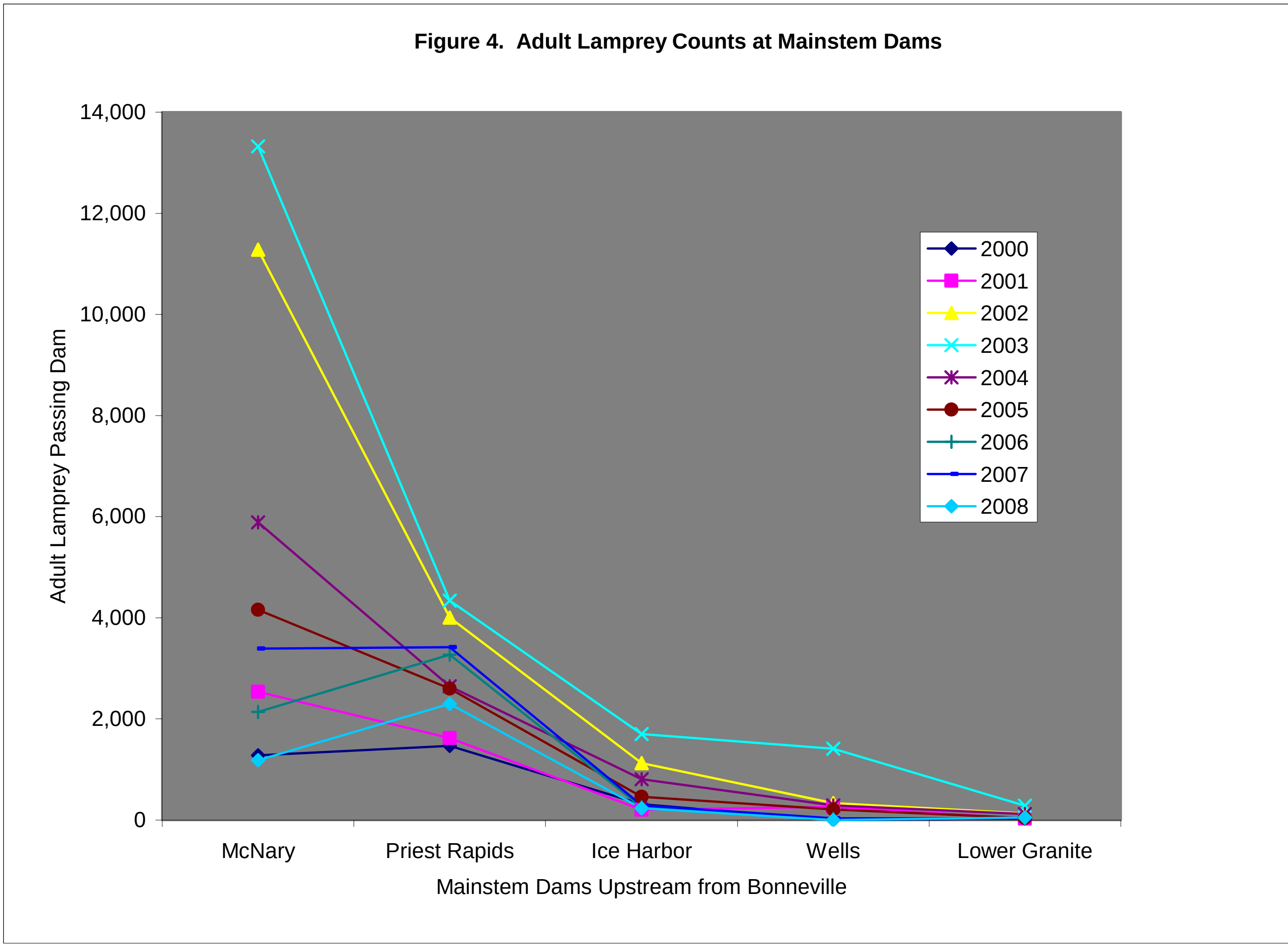
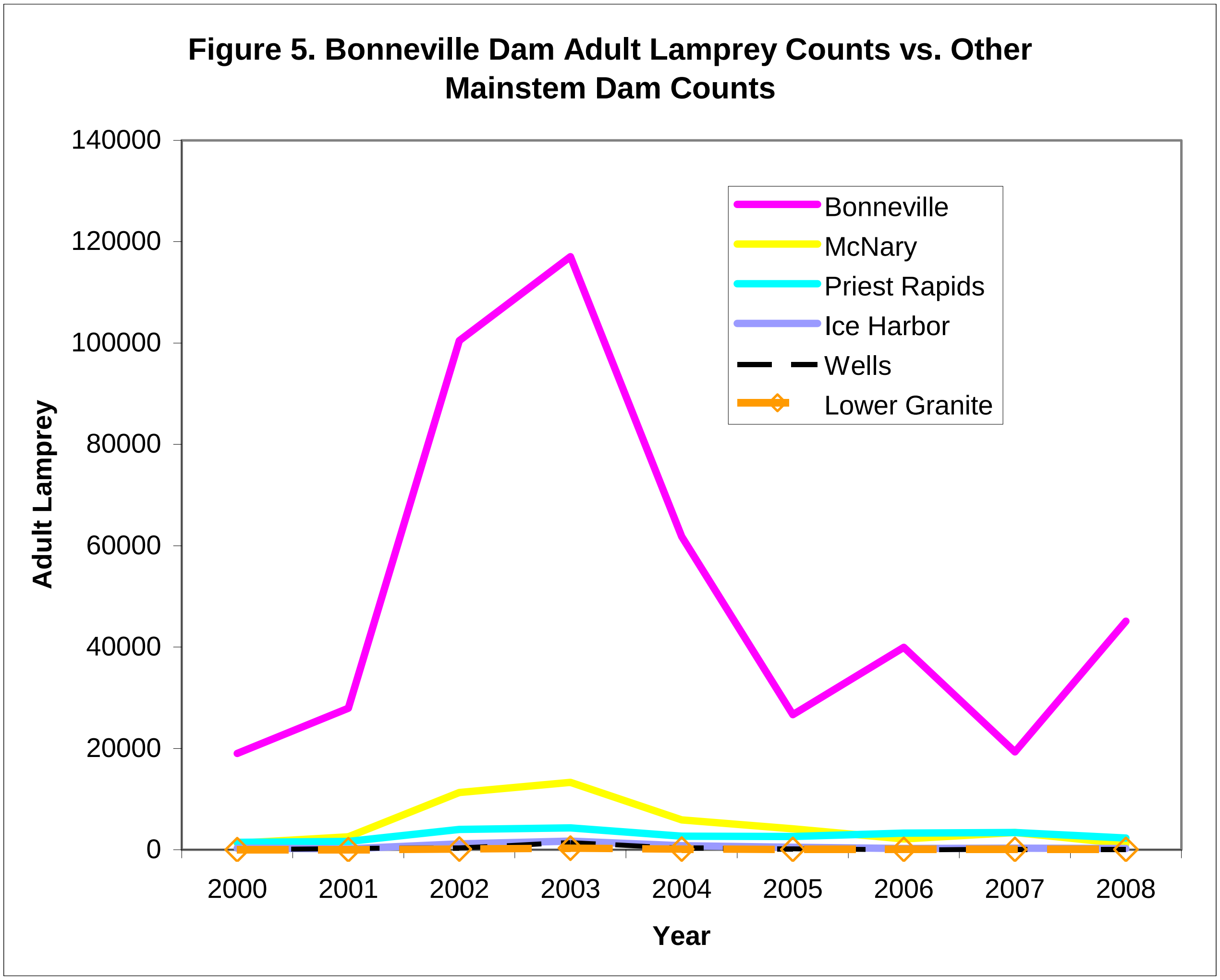


Figure 4. Adult Lamprey Counts at Mainstem Dams
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Adult Lamprey Passing Dam
2000
2001
2002
2003
2004
2005
2006
2007
2008
McNary
Priest Rapids
Ice Harbor
Wells
Lower Granite
Mainstem Dams Upstream from Bonneville



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. For example, of 45,108 adults counted at Bonneville Dam in 2008, only 49 passed Lower Granite Dam in the Lower Snake River, seven dams above Bonneville and only 2 passed Wells Dam in the upper Columbia River, eight dams above Bonneville (FPC and Corps of Engineers, 2008).

With respect to juvenile lamprey declining abundance, little is known except for grossly observed declines, 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). Total numbers of adult lamprey decrease significantly as the run moves upstream from the ocean (Table 1), due to both mortality and volitional diversion into tributaries for spawning. However, though lamprey were able to navigate natural falls within the Columbia Basin, mainstem dams represent significant obstacles to upstream migration that may decrease upstream passage rates while increasing mortality rates for adult lamprey. For example, Jackson et al. (1997) found a 65% reduction in numbers from Bonneville to The Dalles, a 72% reduction between John Day and McNary dams and a 40% reduction between Rock Island and Rocky Reach dams. Moser et al. (2002) documented about a 50% loss of adult lamprey per mainstem dam.

To enter the expansive historic spawning areas in the Snake River Basin, adult lamprey must successfully pass eight mainstem dams on the Columbia and Snake rivers. The cumulative impact of successive poor dam passage efficiencies results in very few adult lamprey annually migrating into the Snake Basin to spawn. 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. These data, together with the drastically low annual counts of adult lamprey passing Lower Granite Dam suggest a serious threat of local extirpation (Claire 2004).

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 designed for juvenile salmon (CRITFC 2008). 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 are often inadvertently transported with salmon with unknown consequences. In addressing Pacific lamprey impacts from juvenile salmon transportation and other hydrosystem impacts, the ISAB (2008) stated:

Pacific lamprey are anadromous, and as for salmon, survival to maturity is determined by factors that operate in fresh water, estuarine, and marine habitats. These factors will also influence the viability of lamprey populations. The relative impact on population viability of mortality caused by dams during juvenile downstream migration versus adult upstream migration cannot be assessed with present data. With the limited data available on the population dynamics of lamprey at all life history stages, it is difficult to determine what incremental increases in juvenile lamprey would be required to result in more adults returning to spawn. The few relevant papers in the scientific literature have focused on adult passage, and these clearly show that dams significantly impair lamprey spawning migrations. Moser et al. (2002) found that overall passage efficiency (number of radio-tagged lamprey that passed over Bonneville Dam, divided by the number that approached it; N = 755) ranged from 40 – 48 %. The cumulative adult mortality resulting from impaired downstream migration past mainstem dams on the upper Snake and Columbia Rivers is almost surely a major limiting factor for this species. Improving lamprey survival on their downstream migration by modifying screen size could lead to a decrease in the probability of extirpation, since increased numbers of juveniles successfully migrating through the three dams fitted with extended-length bar screens (Lower Granite, Little Goose and McNary) would mean there would be more juveniles heading to sea below Bonneville Dam.

Although the freshwater ecology of lamprey is poorly documented, it is widely acknowledged that data on their marine phase are weaker. Changes in lamprey survival at sea or in the estuary therefore could mask improvements in survival in fresh water. Almost nothing is known about factors in the ocean, but it may be that marine survival regimes shift for lamprey as they do for salmonids). *Changes in lamprey abundance may therefore occur coastwide. Lending support to this suggestion are the observations of lamprey declines in recent years in the Fraser River in British Columbia (McPhail, 2007) and the Klamath River in California (Lewis, 2007). It is clear that effective management of lamprey requires more knowledge of all parts of their life cycle.*

Logically, adult lamprey abundance is linked intimately with abundance of suitable prey in estuaries and the ocean. After all, 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.

Millions of dollars have been spent on dam fishways, juvenile passage systems and irrigation screening systems that were designed and constructed for adult and juvenile salmon. Unfortunately, the biological and swimming capacities of lamprey were never 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 orifaces and vertical slots also have been demonstrated to be problematic for adult lamprey passages (Moser et al. 2002; Moser et al. 2003; CRITFC 2008).

For juvenile lamprey passage, 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 6). 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.

Figure 6. Juvenile lamprey impinged on a mainstem dam VBS.

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 changes 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 this one, 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 NW 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 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 were completely absent 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. Instead, Pacific lamprey have 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 not reversed the declining trends for Pacific lamprey populations. In fact, 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] While this project will increase knowledge to improve adult and

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[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.).

juvenile lamprey mainstem habitat, population genetics, life history attributes and other limiting factors as needed to make informed decisions on measures required to reverse the serious decline and begin to move toward recovery of this important keystone species (CBLTWG 2005, CRITFC 2008).

In addition, this project will provide information that will improve understanding of the passage and migration biology and habitat use of Pacific lamprey throughout the Columbia River Basin mainstem rivers and reservoirs. The CBLTWG (2005) identified as highly important the need to increased knowledge of factors, including habitat and life history attributes, that limit lamprey population growth as highly important, in which habitat and life history attributes were included. This is also key objective of the *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin* (CRITFC 2008).

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 by this project. 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]

This work 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.

D. Relationships to other projects

There is very 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 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

[7] Considering that ammocetes spend several years in sediment substrate, it is possible that a single event such as deposition of upstream silt or dredging could destroy even multiple life histories of juvenile lamprey, causing a multi-generation loss of subsequent adult returns years later.

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.

This project work 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). In particular this project will be coordinated and administered with the USFWS Pacific Lampey Rangewide Conservation Initiative process (USFWS 2009). The USFWS is depending on the CRITFC tribes and this project to provide needed focus and actions for lamprey restoration in 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 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 and genetic information developed under 2008-524-00 can be used for this project
BPA	2007-007-00	Determine Status and Limiting Factors of Pacific Lamprey in Fifteenmile Subbasin	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

E. Project History

This is a new project.

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

Over the 10 year period of this project, the following general subobjectives will be addressed:

Sub objective 1. In cooperation and collaboration with other regional entities, 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. Determine adult and juvenile passage rates for each route of passage at each mainstem dam and develop passage criteria. Identify and apply scheduled structural and operational improvements to achieve volitional adult passage standards approximating the best known achievable rates at mainstem dams and reservoirs (i.e. 80% adult passage efficiency at The Dalles). Develop juvenile lamprey passage designs to expedite safe, timely and effective juvenile passage through mainstem and tributary barriers.

Sub objective 2. In cooperation and collaboration with other regional entities, determine lamprey life history mainstem habitat preferences and prioritize actions to improve lamprey habitat. For example, reduced reservoir ramping rates may protect juvenile lamprey that rear in nearshore sediment habitats. Confluence areas between the tributary mouths and the mainstem appear to be critical lamprey habitat areas. It may be possible to protect these focused areas with conservation easements.

Sub objective 3. In cooperation and collaboration with other regional entities, determine individual and cumulative impacts of mainstem hydroprojects including mortality, fitness, migration, spawning and rearing. Some of the tools and methods to address this subobjective are either in pilot or developing stages. For example, JSATS acoustic tag technology used for juvenile salmon will begin to be applied on adult lamprey to help determine lamprey declines between Bonneville and The Dalles dams and specific life history attributes such as spawning. Funding and research to develop active juvenile lamprey tags is being provided by the Corps for 2009-2010. Information related to lamprey morphology and migration timing between dams is still in developing stages.

Sub objective 4. In cooperation and collaboration with other regional entities, determine water quality impacts of hydroprojects on lamprey and implement actions to reduce these impacts. Potential impacts include hydraulic oil leakages into fish passage systems and reservoirs from turbine and gates and other equipment excessive temperatures in reservoirs and bypass systems and potentially high levels of total dissolved gas from forced spill. Also accumulation of toxics in lamprey may be a significant problem affecting their productivity and health of tribal members that consume lamprey as a ceremonial and subsistence use (ODHS 2004).

Sub objective 5. In cooperation and collaboration with other regional entities, investigate the adult and juvenile lamprey status and abundance trends by obtaining and compiling 24 hour adult dam count data at all mainstem dams and inventorying adult and juvenile lamprey abundance, distribution and habitat in mainstem rivers and reservoirs. Potential tools include computerized digital and video counting equipment, selective net sampling, low velocity suction equipment and electroshocking in reservoirs, samples from the dam smolt monitoring program, establishment of active and passive juvenile and adult lamprey tag technology, using statolith and elemental analysis marking technologies to identify specific subpopulations and growth rates. Tools now available such as GIS mapping and other tools for salmon habitat mapping may be useful in determining priority lamprey sampling areas.

Sub objective 6. In cooperation and collaboration with other regional entities, inventory, document and attempt to reduce quantitative estimates of mainstem avian, piscine and marine mammal predation. 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 pikeminnow sport reward fishery and avian research need to be expanded to address lamprey impacts.

Sub objective 7. Determine lamprey genetic structure by developing and expanding the use of microsatellite 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.

Sub objective 8. In cooperation and collaboration with other regional entities, establish regional data protocols for collection, storage and analysis of lamprey abundance, habitat and habitat preferences throughout the basin. Develop means to widely access and share information.

Sub objective 9. Expand existing knowledge on limiting factors and critical uncertainties to lamprey life histories and productivity. Besides focusing on documented physical passage barriers, in coordination/collaboration with tribal projects and other regional research, examine migration cues such as pheromone attraction, temperature effects on migration, spawning preferences, age class distribution, salt water life histories, establishment of an artificial production facility and other factors and uncertainties as they arise.

Subobjective 10. 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.

Table 4. Ten Year Lamprey Passage Design and Habitat Schedule for Addressing Subobjectives

	2009 (1st) *	2009 (2nd)	2010	2011	2012	2013	2014	2015	2016	2017	2018
Subobj 1	W	W/CS	W/CS	CS	CS	CS	CS	CS	CS	CS	W/CS
Subobj 2	W	W	W/CS	CS	CS	CS	CS	CS	CS	CS	W/CS
Subobj 3	W	W	W/CS	CS	CS	CS	CS	CS	CS	CS	W/CS
Subobj 4	W	W	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 5		W	W	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 6		W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 7		W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 8			W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 9		W	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS
Subobj 10	W	W	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS	W/CS

W= Willamette River
CS = Columbia and Snake Rivers

* 2009 is split into two periods. The first period addresses only the Willamette Adult Lamprey Migration and Habitat study. The second 2009 period will also include development of tributary screen and passage design, genetics work, determining adult counts at Willamette Falls, and coordination/collaboration with regional forums and entities on improving lamprey passage and habitat.

<u>General Work Elements for Ten Year Lamprey Passage Design Project</u>

Sub objectives 1-10

Work Element 162 Participate in regional efforts to investigate, implement and monitor/evaluate actions

Task 1. Regional Coordination/Collaboration. Engage in administration and coordination/collaboration of lamprey mainstem and tributary passage and life history and genetic investigations other entities such as CRITFC's member tribes and other basin tribes, the Corps of Engineers AFEP program, the Bureau of Reclamation, Columbia Basin Pacific Lamprey Technical Work Group, the USFWS Pacific Lamprey Rangewide Initiative, and FERC hydroproject license holders. There are several established regional venues that are currently salmon focused that need coordination and emphasis on lamprey restoration.

Work Element 157 Consolidate, summarize cultural and scientific information.

Task 1. Finalize the draft *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin.* CRITFC has been in the lead role in producing the draft plan for regional review and will continue to update the draft with new scientific and cultural information and address regional comments on the plan. The plan will be finalized during the second half of 2009 and another tribal lamprey summit will be held in late 2009 or early 2010. Details and hypothesis generated from the final restoration plan will provide guidance to selection of future tasks and measures for the ten year project. Professional services from the Portland State University will be retained to assist in summit preparation and subsequent follow-up on action issues. CRITFC will be hiring a lamprey project manager to assist in this task in 2009.

Work Element 114 Identify and Select Projects

Task 1. Design, plan, implement and monitor/evaluate outyear actions.

Future tasks, associated work elements and metrics are still in the planning stage. They will be guided by the final *Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin*, and results from research conducted under the Corps AFEP program, FERC license holders, Bureau of Reclamation screen development, genetic analyses from the University of British Columbia and other venues in an adaptive management process. Many future solutions to passage and other critical uncertainties may be transferable from one site or area to another. This project will help fill in holes and augment existing efforts in needed areas. For example, the 2009-2010 Willamette River adult telemetry project will add tags and receiver and tracking efforts to 2009 PGE and Grande Ronde Tribal projects to maximize knowledge of lamprey migration, holding locations and habitat preferences for the entire basin. These efforts will be fundamental to future Corps efforts under AFEP to prioritize passage and habitat restoration work for lamprey.

2009- 2010 Willamette River Adult Lamprey Passage/Migration/Habitat Study

Sub objectives 2,3,4

Work Element 119 Manage and Administer Project (Planning and Coordination)

Task Plan, Coordinate and Implement, Monitor and Evaluate Willamette River Adult Lamprey Radio-Telemetry Migration and Habitat Study

For this contract year, February 9, 2009- February 8, 2010, CRITFC will to plan, coordinate, manage, administer and provide technical review and public outreach for a major radio-telemetry study to investigate adult Pacific lamprey migration, behavior, habitat and life history throughout the Willamette River. We propose this study for a period of at least two years, depending on the information secured.

Much work has been done on the migration characteristics, mortality, and escapement levels of adult salmonids in the Columbia River Basin in relation to environmental characteristics such as river flow and temperature (e.g., see Quinn et al. 1997; Naughton et al. 2005; Keefer et al. 2004, 2005, 2007, 2008), and some work has been undertaken in the Willamette River (Schreck et al. 1994). By comparison, almost no work has been done on the migration characteristics of Pacific lamprey. In addition, this work has centered almost exclusively on passage capabilities and characteristics of adult Pacific lamprey at dams on the Columbia River (e.g., Moser 2002*a* and 2002*b*; however, see Robinson and Bayer 2005).

Very little is known about lamprey passage, migration and habitat uses in the Willamette River. The Willamette River has the last relatively abundant populations of lamprey and the last consistent harvest area in the Columba Basin for CRITFC's member tribes. With most of the Willamette tributaries blocked by Corps of Engineers dams, lamprey cannot pass into upstream habitat. The timing of this subproject is important and has been proposed to take advantage of concurring radio tagging and passage/migration studies. The study will be in collaboration with Portland General Electric and the Confederated Tribes of the Grande Ronde who are also tagging and tracking additional adult lamprey under separate funding sources.

Subcontractors for the CRITFC portion of this study are Cramer Fish Sciences and Oregon State University /USGS (Cooperative Fish and Wildlife Research Unit). The information acquired in this subproject will be used as baseline information regarding additional studies in other areas of the Columbia River Basin for the remainder of this 10 year lamprey project. Using funding from this BPA funded project,, CRITFC will participate and coordinate research as a member of the technical committees for the FERC Willamette Falls Project and as a member of the Corps of Engineers Willamette River Project management groups established by the Willamette River Biological Opinion.(NOAA 2008). Consideration of lamprey passage and habitat concerns is a key conservation recommendation in the Willamette River Biological Opinions for salmon, steelhead and bull trout. It is expected that this work will result in a peer-reviewed scientific journal report, in collaboration with all participating parties.

Tracking adult lamprey passage and migration can be a complex and challenging task (Figure 1). At the Willamette Falls Hydroelectric Project, Mesa et al. (2007a) found 35% and 23% of adults passed the dam fishway and falls in 2005 and 2006, respectively. No adults were found to have passed the falls, even during periods when flashboards were not installed. Median passage times through the Project fishways ranged from 4-74 hours.

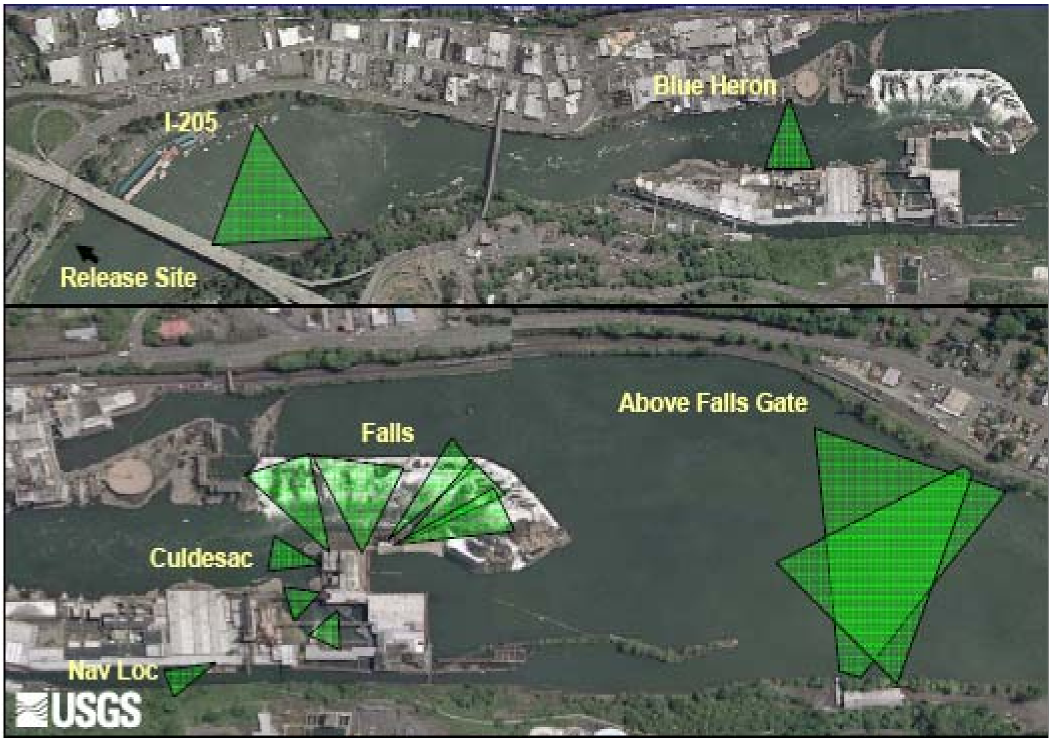

Figure 1. Radio telemetry arrays for the USGS adult lamprey study at the Willamette Falls Hydroelectric Project (Mesa et al. 2007a). Similar detection arrays will be installed at key tributaries upstream in the Willamette River for the CRITFC 2009-2010 study.

Work Element 158 Radio Tagging Willamette River Adult Lamprey

Task 1 Obtain Marking and Telemetry Equipment and Training to prepare for field work

In order to proceed, the study subcontractor Cramer Fish Sciences will purchase 150 N-2 radio tags and internally refurbish 15 radio telemetry receivers from the Corps of Engineers by Lotek Inc. This is necessary to prepare receivers for field installation in May and June 2009. There is also need to purchase miscellaneous equipment for the radio telemetry receivers to make them field ready prior to the beginning of the study and provide basic boat and vehicle training to prepare for the field work in a timely manner.

Task 2 Trap and Mark Adult Lamprey

Approximately 150 lamprey will be collected from the Willamette Falls fish ladder trap throughout the run, and released above the falls. These will complement the Confederated Tribes of the Grande Ronde (120 fish, collected from the falls and from the fish ladder trap and released above the falls), and PGE/Normandeau Associates (150 fish, collected from the ladder trap throughout the run and released below the falls). The run typically begins in May and extends through about mid-September. It is important to maximize the sample size since lamprey migration, holding and habitat information is desired throughout the 187 miles of the Willamette River.

Work Element 70 Install Fish Monitoring Equipment

Work Element 70 Review subcontractor equipment sites

Task 1. Subcontractor Cramer Fish Sciences will install 12-14 radio telemetry receivers at major tributaries in the Willamette River and will monitor the effectiveness of these receivers through the study. CRITFC will review those site for appropriateness. In a pilot Willamette River lamprey telemetry study, Clements et al. (in review) found that tributary mouths were important destination for adult lamprey with over 40% of tagged adults detected at those sites.

<u>List of Receiver Sites</u>

Clackamas River Mouth
River Mill Dam on Clackamas River
Molalla River Mouth
Newburg
Tualatin River Mouth
Yamhill River Mouth
Salem
Rickreall Creek Mouth
Luckiamute
Santiam River Mouth
North Santiam River Mouth
Low head barrier dam on North Santiam
Second low head barrier dam on North Santiam
Bill Cliff Dam- North Santiam River
South Santiam River Mouth
Low head barrier dam, S. Santiam River
Foster Dam- Santiam River
Calapooia River Mouth
Mary’s River Mouth
Peoria
Long Tom
Harrisburg
McKenzie River Mouth
Leaburg Dam- McKenzie River
Middle Fork Willamette River
Dexter Dam- Middle Fork Willamette River
Coastal Fork- Willamette River
Cottage Grove Reservoir- Coastal Fork WR

Work Element 122 Provide Technical Review (Planning and Coordination)

Task 1. Review contractor tracking methods. This project is a follow-up to earlier work in which Clemens et al. (2005) conducted aerial tracking of radio-tagged Pacific lamprey in the Willamette Basin and Mesa et al. (2007) conducted radio-telemetry studies to evaluate adult lamprey passage at Willamette Falls. In 2009, CRITFC, through its subcontractor Oregon State University/ USGS, will be conducting a much more thorough effort using aerial and ground monitoring to locate lamprey and determine migration characteristics and habitat use, up to and including the presumptive spawning date, which is inferred to be ~1 year (Beamish 1980). This equates with fish spawning anywhere from March through June/July, as has been reported for Pacific lamprey elsewhere (Brumo 2006; Brumo and Markle 2006).

Two forms of radio tracking will be used:
1) Aerial radio-tracking (gross coverage, funding supplied by Bureau of Reclamation), and
2) Boat radio tracking (fine coverage).

River reach coverage at key points in the Willamette Basin (fixed radio receiver sites) will be collaboratively conducted by Cramer Fish Sciences and the Confederated Tribes of the Grand Ronde.

Each of these forms of coverage will be used to inform the tracking strategies employed by the other forms of coverage. For example, aerial radio tracking will pinpoint where the majority of fish are found, and will direct where boat tracking should occur in order to record habitat variables associated with where fish are located. Similarly, detections from fixed receiver sites will inform whether aerial and boat tracking should focus on a specific tributary. The fixed receiver sites will also provide a relatively seamless coverage of fish movements or holding patterns within key tributaries entering the mainstem Willamette River, as well as barriers. For example, fixed receiver sites will be deployed at key locations throughout the basin, including river mouths (Clemens et al. 2005), low head barrier dams, and major dams on the tributaries to the Willamette River.

CRITFC through its subcontractors will coordinate collection of fin clips from all tagged fish and will send these fin clips to Dr. David Close at the University of British Columbia for DNA microsatellite genetic analysis.

Subcontractor OSU/USGS will conduct lamprey habitat assessments through the use of data acquired from online USGS temperature gauges, including river flow and temperature data from Harrisburg (upper Willamette), Albany (mid Willamette), and Newberg (lower Willamette). In addition, OSU/USGS subcontractors will deploy temperature loggers (I-buttons) at the locations where we have deployed. By combining data from the geographic deployment of fixed radio receiver stations and temperature loggers, we will be able to correlate the temperatures experienced by fish detected by a given receiver.

Fine scale, site-specific adult lamprey habitat variables will be assessed during boat tracking or via roads where feasible, including, but not limited to:

- Water depth
- River flow
- Temperature
- DO
- Turbidity
- Orientation of river to migration patterns.
- Riparian cover
- Light (This will change seasonally with leaf cover, sun angle, etc.)
- Elevation/stream gradient

These characteristics will be recorded along with GPS coordinates (latitude, longitude).

Clements et al. (2005) conducted three collaborative studies on the maturation and migration characteristics of adult Pacific lamprey, including 1) an aerial survey to track radio-tagged lamprey, 2) a controlled temperature experiment in the laboratory (Clemens et al. in revision), and 3) monitoring of maturation timing in the wild (Clemens et al. data forthcoming). They have found that summertime river temperatures > 20 ºC were correlated with 1) cessation of upstream migration and associations with river mouths (Clemens et al. 2005 and unpubl.), 2) significant decreases in body size and subsequently expedited maturation timing in the laboratory (Clemens et al. in revision), and 3) apparent synchronization of maturation timing to avoid > 20 ºC (Clemens et al. data forthcoming). This information is intriguing and raises questions as to whether the thermal scheme of the Willamette River is patchy (vast stretches of warm water punctuated with key locations of cool water refugia). Researchers hypothesize that if spatial and temporal aspects of thermal regimes > 20 ºC expand, then the combination of decreased migration capacity and expedited maturation of Pacific lamprey may occur, which could disconnect spawn timing with optimal locations in the upper watershed. However, this hypothesis has not been tested.

Potential study hypotheses:

Ho: River temperatures do not affect adult lamprey migration and holding habitat preferences.
Ho: Early components of the adult lamprey migration do not hold in different upstream areas than later migration components.
Ho: River temperatures during migration do not affect subsequent mortality, and/or spawner success.
Ho: Adult lamprey do not prefer to migrate to and hold below Corps of Engineers dams in Willamette system.

Work Element 157 Collect, Generate, Validate Field and Lab Data

Task 1 Data Collection and Validation. OSU/USGS will serve as the data repository for all fixed and mobile tracking efforts in the basin. Duties will include creating a website where data can be uploaded to, and also a computer program that will flag questionable entries, such as may occur from background noise, such as machinery from dam powerhouses that create interference. OSU personnel will also examine the data for errors and we will manage the data accordingly for quality assurance/quality control purposes. CRITFC will review this work.

Work Element 122 Data Analysis and subcontractor reports

Task 1. Data analysis. OSU/USGS will coordinate with CRITFC and other entities before, during and throughout the project. We will ensure that data from fixed receiver sites will be used to help inform where mobile tracking efforts should focus, and that data from mobile tracking can verify/validate data acquired from fixed receiver sites.

Task 2. OSU/USGS will lead and coordinate report writing between the other collaborators, and where appropriate, will cite fish passage information acquired by Portland General Electric and described in their separate Willamette Falls Hydroelectric Project passage report. CRITFC will provide technical review of all reports.

Work Element 156 Develop RME Methods and Designs

Task 1. CRITFC and its subcontractors will refine methods for tracking and obtaining adult lamprey migration and habitat preference data. Once developed, these methods should be transferable to other areas around the basin.

Work Element 99 Outreach and Public Education

Task 1. Develop media materials. Working with Willamette watershed councils, CRITFC will develop a tracking display and brochures that will reflect the importance of lamprey, their biology and habitat needs. These media will also include insight into the tribal heritage of lamprey.

Task 2. Present media materials and other information to public venues throughout the Willamette Basin. The display and brochures will be shown and disseminated to the general public at local community events, libraries, and the K-12 school system.

Task 3. It is expected that this research will result in at least one peer-reviewed, scientific journal article.

2009-2010 (and out years) Assess and address impacts of irrigation and other mainstem water withdrawal structures on adult and juvenile lamprey and correct deficiencies

Work Element 162 Participate in regional efforts

Work Element 119 Manage and Administer Project (Planning and Coordination)

Task 1. Coordinate and Collaborate with CRITFC tribes and other interested regional entities in developing new designs for tributary passage screens and passage facilitation over barriers to better protect juvenile and adult lamprey.

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As part of the Accords with CRITFC and three of its member tribes, the Bureau of Reclamation is obligated to provide inventories of juvenile lamprey in major tributaries in the basin that contain passage barriers. As part of salmon recovery efforts, thousands of drum and other screens in basin irrigation and other water withdrawal facilities have been installed over the last decade or more to reduce juvenile salmon entrainment into irrigation conveyance structures, such as ditches and canals, small hydroelectric facilities and other small diversion structures. Unfortunately, the exclusionary devices were not designed to protect juvenile lamprey. Ostrand (2004) conducted laboratory tests on lamprey macropthalmia on screens that met salmon fry criteria of approach velocities of 0.4 feet per second but found that lamprey tended to adhere to the screens and were likely to be crushed by cleaning devices used to clear the screens of debris. At the low water velocities tested, the screen velocity criteria seemed appropriate for juvenile lamprey, however; even then, lamprey did tend to group in areas where attachment was facilitated. In attending the regional state screen workshop last year, CRITFC made participants aware of screen impacts on lamprey and began discussions on potential screen designs to eliminate those impacts. Recently the USGS has submitted a draft proposal to evaluate new screen designs to protect juvenile lamprey for regional review.

Work Element 122 Provide Technical Review (Planning and Coordination)

Task 1. Participate, collaborate, coordinate and engage in new screen design research reviews with USGS and others. Prioritize test sites based on location, presence of lamprey, and cost factors such as resource sharing.

Work Element 157 Collect, generate/validate field and lab data

Task 1. Establish prototype screens in the field and gather biological and hydraulic data.

For this contract year and out years, CRITFC proposes to work with the USGS the Bureau of Reclamation and others to develop/fabricate and install on a pilot basis, new screening designs that will prevent lamprey from gaining entrance into tributary water diversions where thousands of juvenile lamprey have been documented to be lost (Jackson, pers comm. 2008). This will provide important baseline information that may be used for applications region-wide. Development of flat plate or belt screen technology with bubbling or spray apparatus, as well as advanced screening designs now being implemented in the Hood River Valley by the Farmer's Irrigation District may provide solutions (Bark 2008; Mesa 2009 pers. comm.)

Work Element 99 Outreach and Public Education

Task 1. CRITFC will work with the USGS, Bureau of Reclamation and others to develop media materials on tributary screen and other methods to reduce lamprey passage barriers. These materials will be presented to the media and will be available on critfc.org.

2009-2010 (and outyears) Determine genetic composition of Columbia Basin Pacific lamprey populations in relationship to other Northwest Pacific lamprey populations

Sub objective 7. Determine lamprey genetic structure

Work Element 119 Manage and Administer Project (Planning and Coordination)

Work Element 162 Participate in regional efforts

Task 1. In collaboration/coordination with other regional entities, advance genetic knowledge of Pacific lamprey in the Columbia Basin.

The draft *Tribal Pacific Lamprey Restoration Plan* call for research into the genetic makeup of the species and particularly the genetics of the remaining populations with a goal of maintaining genetic integrity of those populations.

It is uncertain how or even if lamprey home back to their natal streams. While there is some research in this area, more needs to be done (Lin et al. 2007a; Lin et al. 2007 b). Researchers at Michigan State and Humboldt State universities are investigating stream attractants perhaps driven by genes or pheromones that determine lamprey spawning locations. Adult Pacific lamprey, like sea lamprey appear to be attracted to spawning sites by pheromones released by ammocoetes based upon their production of bile acids (Bergstedt and Seelye 1995 *in* Lin et al. 2007).

Goodman (2006) analyzed 81 tissue samples from lamprey along the Pacific Ocean coastline and found no evidence of genetic variability among drainages. Lin et al. (2007a and 2007b) analyzed muscle and fin tissue from seven different Northwest rivers including four in the Columbia Basin for genetic DNA differences. While they, like Goodman (2006), found no statistically significant differences between the Columbia and Klamath basins, they found statistically significant differences among samples within those basins. They concluded that Pacific lamprey showed a geographical divergence pattern across the range of Northwest samples but there was no clear pattern of geographical structure within the Northwest, based upon the samples. They hypothesized that lamprey from different rivers disperse and mix in aggregations at sea and could be carried for hundreds of miles by prey and ocean currents. That and the absence of natal homing could lead to temporal unstable genetic differences between spawners within a basin or even subbasin. They concluded that more genetic, physiological and demographic studies of lamprey migration will assist in resolving genetic and geographical separation hypotheses. As stated by CRITFC (2008) and the USFWS in their Pacific Lamprey Rangewide Conservation Initiative, information about lamprey genetic composition is key to managing lamprey populations for recovery. Among other things, proposed lamprey translocation from lower basin to upper basin areas would benefit from genetic studies that may elucidate important life history characteristics.

Task 2. Collect lamprey fin clips from research throughout the Columbia Basin. CRITFC through its subcontractors and tribal researchers will coordinate collection of fin clips, preserve them in microfluge tubes and preserve them in ethyl or grain alcohol. These fin clip samples will be sent to the Aboriginal Fisheries Research Unit at the University of British Columbia for population genetic analysis.

To assist in resolving these genetic and population structure critical uncertainties, CRITFC proposes to complete an assessment of gene flow in lamprey using microsatellite genetic markers to determine genetic differentiation among lamprey populations throughout the Columbia River Basin. The proposed work would be coordinated and conducted by Drs. David Close and Eric Taylor at the University of British Columbia who have already assembled lamprey samples throughout the Pacific Northwest and are at the leading edge of lamprey genetic research. Tribal graduate students would be employed in the work.

Task 3. Isolate, clone, sequence, screen, optimize, and conduct final genetic analysis using candidate microsatellite markers of Pacific lamprey.

Task 4. Design primers from task 1. Use the primers to amplify microsatellite sequences to verify whether they are polymorphic or monomorphic markers from archived lamprey samples already collected.

Among other things, proposed lamprey translocation from lower basin to upper basin areas would benefit from genetic studies that could provide a better understanding of population structure.

To assist in resolving these genetic and population structure critical uncertainties, CRITFC proposes to collaborate with regional researchers using BPA project funding to complete an assessment of gene flow in lamprey using microsatellite markers to determine genetic differentiation among lamprey populations throughout the Columbia River Basin. The proposed work would be conducted by

Work Element 99 Outreach and Public Education

Task 1. CRITFC provide public education and regional outreach on information gained through genetic investigations.

2009-2010 Implement Adult Lamprey Counting At Willamette Falls

Work Element 119 Manage and Administer Project (Planning and Coordination)

Task 1. Implement 24 hour counts of adult lamprey at the Willamette Falls fishway.

The Willamette River Basin has the last relatively abundant population of Pacific lamprey in the Columbia River Basin. Unfortunately, although ODFW has counted adult salmon and steelhead passing the falls and powerhouse at the Willamette Falls fishway, lamprey have never been counted there. CRITFC proposes to examine video tapes of lamprey at the fishway counting station and enumerate lamprey numbers to establish an index count.

Some minor modifications may be need to the fishway to better count lamprey such as installation of an underwater camera in the picketed lead area behind the crowder section, installing computer software and addition cameras in the counting station.

Work will be closely coordinated with ODFW.

H. Facilities and equipment

Major equipment for the Willamette Adult Lamprey subproject includes radio receivers, radio tags and computers. For the Willamette fishway counting station, cameras and a computer system are likely to be needed. At this time, due to ongoing planning and coordination, other major equipment has not been determined.

Other laboratory equipment will likely be provided by subcontract agents.

I. References

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J. Key personnel

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

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