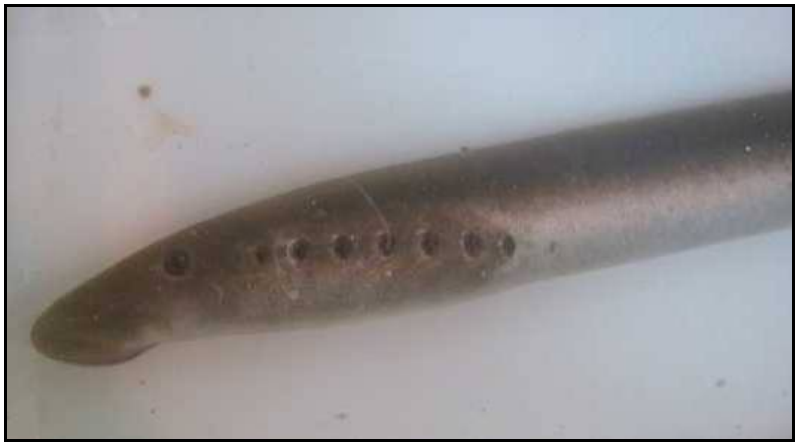
US Army Corps of Engineers ®
Portland District

Pacific Lamprey Passage Improvements Implementation Plan 2008 - 2018



July 2009 Final Report

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ACRONYMS AND ABBREVIATIONS

AL	adult lamprey
AWS	auxiliary water supply
BON/BONN	Bonneville Dam
CI	Cascade Island Ladder
CJD	Chief Joseph Dam
cm	centimenters
Corps	U.S. Army Corps of Engineers
CRFM	Columbia River Fish Mitigation
CRITFC	Columbia River Inter-Tribal Fish Commission
ESA	Endangered Species Act
FGE	fish guidance efficiency
FRPS	Federal Columbia River Power System
HHD	Howard A. Hanson Dam
ICH	Ice Harbor Dam
JDA	John Day Dam
JDANFL	John Day North Fish Ladder
JL	juvenile lamprey
LGR	Lower Granite Dam
LPS	lamprey passage system
LWSC	Lake Washington Ship Canal
MCN	McNary Dam
mm	millimeters
MMD	Mud Mountain Dam
MOA	Memorandum of Agreement
NMFS	National Marine Fisheries Service
O&M `	operation and maintenance
OP	overall program
PIT	Passive Integrated Transponder
PRD	Priest Rapids Dam
TDA	The Dalles Dam
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

INTRODUCTION

In May 2008, a Memorandum of Agreement (MOA) between the Action Agencies, the Accord Treaty Tribes (Umatilla, Warm Springs, and Yakama) and the Columbia River Inter-Tribal Fish Commission addressed actions to protect Pacific lamprey, *Lampetra tridentata* (see http://www.salmonrecovery.gov/Biological_opinions/FCRPS/2008_biop/docs/3-tribe-AA-MOA-Final.pdf). Specific to the U.S. Army Corps of Engineers (USACE), the MOA requires collaboration with the tribes and the U.S. Fish and Wildlife Service (USFWS) to develop a 10-year lamprey plan, provides a proposed funding stream and total cost of implementing improvements, and identifies specific actions to be considered to improve lamprey passage and survival. The following is a summary of the Corps commitments to improve Pacific lamprey passage as a part of the 10-year action agency commitments for projects to benefit fish affected by the Federal Columbia River Power System (FCRPS). The USACE will:

<u>Overall Program (OP)</u>

1. Employ an adaptive management approach.
2. Work with the tribes and USFWS towards developing its existing 5-year lamprey plan into a 10-year plan, covering both adult and juvenile lamprey passage issues.
3. Program $1.8 million in 2008 with funding ramping up to $2 to $5 million per year for 10 years.

<u>MOA Adult Lamprey (AL)</u>

1. Address adult lamprey passage in the mainstem hydropower projects using PIT/radio-telemetry to determine overall effectiveness.
2. Develop numerical passage metrics through the Lamprey Technical Workgroup.
3. Conduct site inspections of each dewatered fish ladder.
4. Evaluate, fully develop and implement as warranted lamprey auxiliary passage systems (LPS).
5. Evaluate reducing entrance flows at night to assist lamprey entrance passage; and as warranted, expand through FCRPS mainstem dams.
6. Complete keyhole entrances at Cascade Island 2009 and John Day North 2010-2011, then implement, as warranted, throughout FCRPS mainstem dams.
7. Inventory all picketed leads, fish way cracks, blind openings and ladder exits. Begin replacing existing grating with new ¾-inch grating in most identified problem areas.
8. Round sharp corners, as warranted.
9. Develop feasibility, techniques, and protocols for counting.

<u>MOA Juvenile Lamprey (JL)</u>

1. Continue to monitor the passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities.
2. Replace with smaller gap screens as warranted when turbine intake bar screens are in need of replacement.
3. Consider lifting extended length screens (primarily at McNary but also at Columbia and Snake River dams) in consultation with the National Marine Fisheries Service (NMFS) and the tribes.
4. Develop prototype lamprey separators.
5. Work actively with industry to further miniaturize active tags then determine passage routes, out migrant timing and survival of lamprey through FCRPS mainstem dams.

The USACE preliminary plan for addressing the Memorandum of Agreement is discussed below and a preliminary schedule is located at the end of this report. For example, the commitments are abbreviated **MOA AL 1**, which means that USACE is addressing MOA Adult Lamprey (AL) 1 on page 1, "Address adult lamprey conditions in the mainstem hydropower projects using PIT/radio-telemetry to determine overall effectiveness."

Included is a summary of past research and implementation action that have led us to this strategy. This document is only a starting point. It will take all Parties working together in a cooperative and adaptive management mode to succeed at making meaningful and long-lasting improvements to Pacific lamprey passage. Beginning in 2008, the Action Agencies and the MOA Treaty Tribes will meet periodically to discuss the lamprey implementation and funding issues, including priorities and impediments. The Parties agree that being proactive for lamprey is critical to seek to avoid Endangered Species Act (ESA) listing.

GOAL

The goal of the Pacific lamprey passage program within the Northwestern Division of the USACE is to improve both juvenile and adult lamprey passage and survival through the FCRPS as a part of a regional effort to immediately arrest the decline of Pacific lamprey populations within the Columbia Basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range.

FUNDING

Columbia River Fish Mitigation (CRFM) is the primary USACE program for protecting, mitigating, and enhancing anadromous fish such as salmon and steelhead at USACE dams. Through CRFM, USACE is funding lamprey research. Operation and maintenance (O&M) funds have also been used to aid lamprey passage efforts at Columbia and Snake River dams.

BACKGROUND

Pacific lamprey is the largest native lamprey species found in the Columbia Basin. They generally migrate upriver during March to October in the year prior to spawning, overwinter in deep pools, and spawn in the spring (April to July) when water temperatures reach 50° to 59°F in areas of fine gravel and silt by excavating shallow depressions. One female lamprey deposits from 40,000 to 238,000 eggs depending upon body size. The eggs generally hatch into larvae after 2 to 3 weeks, residing for 4 to 7 years in low velocity areas within silt/mud substrates. They feed by filtering the passing water for microscopic plants and animals. These larvae develop no eyes or teeth until the time they are physiologically transforming to leave freshwater for seawater. At this stage, they develop a sucker-like mouth and become parasitic, attaching to other host fish and feeding on body fluids.

Juvenile and adult lampreys become more active during the hours of darkness and spend much of the daylight hours attached to substrate. Because lamprey lack a swim bladder, they are typically found low in the water column. Downstream migration is usually associated with turbid, higher spring runoff, the combination of which serves to reduce the potential for predation during migration.

When returning to fresh water after 2 to 3 years, adult Pacific lamprey use the same fishways as adult salmonid to migrate upstream past the FCRPS dams (Table 1). Because these fishways were

designed and modified to maximize salmonid passage, lamprey face conditions that are not optimal and often are impediments to the way they swim and move upstream. During shad passage season, head over weir criteria is increased by 0.3 feet to ensure efficient movement of the large numbers of migrating shad up the ladders and prevent blockages, which in turn can delay salmon passage. This action coincides with adult lamprey passage season and increases entrance velocities, which are already a major challenge to Pacific lamprey.

Table 1. 2000 - 2008 Adult Annual Lamprey Daytime Window Counts at Bonneville (BON), The Dalles (TDA), John Day (JDA), McNary (MCN), Priest Rapids (PRD), Ice Harbor (ICH), and Lower Granite (LGR) Dams. 2008 data tallied through 22 September. No corrections for night video or LPS counts are included.

Year	Adult Pacific Lamprey Passage Index (window counts only)						
	BON	TDA	JDA	MCN	PRD	ICH	LGR
2008	14,562	4,599	6,625	1,530	5,083	264	61
2007	19,313	6,085	5,731	3,454	6,593	290	34
2006	38,938	6,894	9,600	2,456	4,381	277	35
2005	26,664	8,361	8,312	4,158	2,598	461	40
2004	61,780	14,873	11,668	5,888	2,647	805	117
2003	117,029	28,995	20,922	13,325	4,339	1,702	282
2002	100,476	23,417	26,821	11,282	4,007	1,127	128
2001	27,947	9,061	4,005	2,539	1,624	203	27
2000	19,002	8,050	5,844	1,281	1,468	315	28

Since the 1960s, Pacific lamprey numbers have declined in the Columbia Basin. Scientists have attributed the decline to several causes including pollution, habitat loss, irrigation, intentional removal, ocean conditions, and dam passage. This decline has lead to significant regional concern regarding lamprey populations in the Columbia Basin. In 1993, the Oregon Department of Fish and Wildlife designated Pacific lamprey at risk of being listed as threatened or endangered. The tribes have repeatedly voiced concern about the decline of Pacific lamprey, a culturally important species. On January 28, 2003, the Pacific lamprey was petitioned for listing under the ESA. However, no funds were committed in 2003 or 2004 to make a determination. As a result, an “intent to sue” was filed in March 2004 for failing to act on the petition and in June the suit was filed. In January 2005, a “finding of insufficient information to evaluate status” was determined by the USFWS. It is possible that Pacific lamprey will again be petitioned for ESA listing, especially if their numbers continue to decline.

LAMPREY PASSAGE IMPROVEMENT EVALUATION AND IMPLEMENTATION STRATEGY

Because there are many gaps in the knowledge concerning Pacific lamprey behavior, passage, and life cycle, an adaptive management approach will need to be followed to accomplish the evaluations leading to useful modifications at the projects. Over the next 2 years, research on the prototype entrance to the LPS at Cascade Island fishway at Bonneville Dam and the development of entrance designs for McNary and John Day dams will be critical steps to understanding what improvements to passage can be expected, and if implementing such an entrance at other dams is the best way to move forward.

ADULT LAMPREY IMPLEMENTATION

Pacific lamprey are less capable swimmers in high velocity flows when compared to salmon. Nearly all salmon-based velocity criteria in the fish ladders may be too high for lamprey to navigate without repeatedly burst swimming, reattaching, and resting. Because of these vast differences in swimming style and behavior, the modifications that can be made to improve hydraulic conditions for lamprey are limited while keeping the fish ladder functional for ESA-listed salmon.

The current approach focuses on getting adult Pacific lamprey out of the salmon fishways and into a LPS and over the dams as quickly as possible. This will occur through modifications to ladder entrances, adding velocity-reducing structures that lead to LPS collection ramps, and the installation of LPS that bypass passage problem areas in the ladder from the entrance area to the ladder exit or forebay. The current goal is to divert as many lamprey as possible into LPS with a preliminary target of 50%; however, the USACE understands and expects that not all lamprey will be diverted.

USACE Team Disciplines

The USACE disciplines anticipated to be needed for this effort include fishery biology, environmental resources, hydraulics, structures, cost estimating, construction, and specific Project personnel; considerations will need to be assessed dam by dam. Concurrently, system-wide programmatic environmental clearance discussions are underway with salmon managers about implementation of the lamprey plan. Since ladder modifications would occur within existing concrete dam structures, real estate issues are not anticipated. The short in-water-work periods at the ladders present challenges that will need to be addressed and may be mitigated through prefabrication of key components. All information provided below is subject to refinement with on-going research, team project development, and monitoring and is provided for internal agency use, dialogue, and deliberation.

10-YEAR PLAN PRIORITIZATION

It is critical to determine and agree on prioritization of problem areas, research needs, and implementation of improvements to ensure the most efficient use of time and money toward improving Pacific lamprey passage. The Columbia Basin Pacific Lamprey Technical Workgroup (a subgroup of the Columbia Basin Fish and Wildlife Authority Anadromous Fish Committee) has identified the need to improve adult lamprey passage at Columbia River hydropower dams as one of the highest priorities for Pacific lamprey recovery. Deciding where to prioritize efforts to improve lamprey passage should be based on two simple but critical factors: (1) where passage efficiency is the poorest, and (2) where the affected numbers of Pacific lamprey are the highest. This approach will maximize the improvements for both upper and lower Columbia Basin Pacific lamprey. Based on these two factors and the current state of knowledge on dam passage, the preliminary prioritization at FCRPS dams would be:

1. Bonneville Dam
   - Cascade Island entrance modification that includes entrance weir, rock floor, PIT reader, and lamprey passage system (LPS) - Prototype 2009.
   - March 2009-2010 evaluation/modification.

2. Washington Shore Ladder Entrance Modification - 2011 to 2012.
   - Design development beginning in 2009.

3. John Day Dam
   - North Ladder exit section modification with lamprey improvements; winter 2009-2010 installation.
   - North Ladder entrance modifications - 2010 to 2012.
   - Design work ongoing.

4. McNary Dam
   - Oregon shore ladder entrance modifications - 2011 to 2013.
   - Design development beginning in 2009.

5. Snake River Dams
   - Ladder entrance modifications - 2014 to 2017.

6. The Dalles Dam
   - No activities planned until other dams are addressed because of existing high passage rates (74%) compared to other dams.

A more detailed USACE implementation schedule is located at the end of this report.

Deciding which features or locations at specific dams need to be addressed first should also be based on the same simple criteria – when the data is available, where passage efficiency is poorest, and where the most lamprey are affected. Based on these criteria, improving ladder entrance efficiencies would rank highest with serpentine weir areas, then cul-de-sacs and diffuser gratings. This prioritization is likely to change as improvements are made and as more is learned about the behavior of lamprey at specific dams. For instance, if modification in the entrance area can direct large numbers of adult lamprey into a LPS, additional modifications may not be needed further upstream in the ladder.

A major challenge to all potential Pacific lamprey designs and operations is the ability to ensure that ESA-listed salmon are not negatively affected, or that hydraulic conditions at dams set up to aid in salmonid passage are not negatively altered. Major changes to existing structures, such as changing entrances to fixed-weir systems or research sampling related to evaluating juvenile passage must go through ESA consultation processes and be proven to not negatively affect salmon passage. The approach and challenge to engineering Pacific lamprey improvements is to make new designs that actually aid both lamprey and salmon passage.

At present, there is no specific target or goal for performance of Pacific lamprey passage and there is great uncertainty about how to meaningfully establish such a standard. In September 2007, the Lamprey Technical Workgroup was tasked with trying to develop such performance standards but admits that, “In general, information is not currently adequate to develop long-term objectives for either life stage” (September 24, 2007 meeting minutes, Lamprey Technical Workgroup Passage Subgroup). Even with this uncertainty, the USACE is working to improve passage efficiencies at dams by at least 10% to 20% through operational and structural modifications.

Smaller scale, modification such as adding ramps, plates, or rounding at specific problem sites at FCRPS dams can and will occur separate from the large project timeline, depending on availability of funding. The USACE is developing a list of sites for these types of modifications for each dam. Site visit to either identify additional locations of concern or to examine the results of ongoing modification will occur annually or as requested.

Prioritization schedules will be determined and potentially modified over the years in consultation with Accord Treaty Tribes and other regional representatives, and will be dependent on the success of prototype evaluation being undertaken over the next two years and later newly installed systems.

In order to accomplish evaluations of prototype systems and improvements, adequate numbers of test fish will need to be available for tagging. This may limit where such prototypes can be tested to areas far enough downstream and with the capability to capture and tag required sample sizes, such as at Bonneville Dam. This does not mean that installation of specific features known to benefit lamprey should not occur at upriver priority dams if there are known specific problem areas and large benefits. Adding lamprey design features to any ongoing or planned work in the fishways should also occur regardless of where they stand on the priority list.

ANNUAL REPORTING

An annual report summarizing the progress to date will be provided, which will include research, implementation, all adaptive management decisions and fiscal year expended costs. The Bonneville Power Administration and Bureau of Reclamation will be encouraged to provide concurrent summaries which will be incorporated into one summary.

BASELINE ADULT LAMPREY PASSAGE DATA 1997-2002

Radio-telemetry work in 1997 to 2002 showed that adult Pacific lamprey passage efficiency at Bonneville Dam (the percentage of lamprey that successfully passed over the dam of those that approached the dam base) was less than 50% in all years (Moser et al., 2002b, 2005b; Figure 1). This occurred despite approximately 90% of the lamprey tagged in all years of study returning to the base of the dam after release downstream, which indicates migrational motivation and low tagging or tailrace predation effects (Moser et al., 2002a). Passage efficiency for lamprey that approached The Dalles Dam was consistently higher than at Bonneville Dam, while passage efficiency at John Day Dam was similar to that at Bonneville Dam. Passage efficiency at The Dalles north ladder (> 80%) was higher than passage efficiency through any other entrance evaluated. This may relate to the natural rock structure inside much of the north ladder and that there is no serpentine weir section in the exit area. Based on 2000-2002 radio-telemetry research, passage efficiencies at Bonneville, The Dalles, and John Day averaged 47%, 74%, and 53%, respectively.

Delay of lamprey below Bonneville Dam may subject them to increased predation pressure from sea lions and sturgeon (R. Stansell, USACE, personal communication). Lamprey passage rates at both Bonneville and The Dalles indicated that during the course of the summer, lamprey passage rates increased and delays decreased (Moser et al., 2005c). These data suggests that fish are most delayed during the early part of the season (May-June) and that higher river flows, lower water temperatures and large numbers of sea lions below Bonneville Dam may be contributing factors.

Of particular concern is poor performance of lamprey at fishway entrances, through collection channels/transition areas, and past vertical slot fishways at the top of the fishways at Bonneville Dam (Moser et al., 2002b). Tracking results indicated that lamprey pass the count window, but are obstructed in the section of the fishway ladder containing the vertical-slot weirs upstream from the count stations (Moser et al., 2003). Previous years of radio-telemetry indicated that providing lamprey with an alternative route of passage through this area (Figure 2) could increase overall lamprey passage efficiency by approximately 33%.

Figure 1. Overall passage efficiency (percent of lamprey that passed over each dam of those that approached each dam) for Bonneville, The Dalles, and John Day dams in 1997-2002.

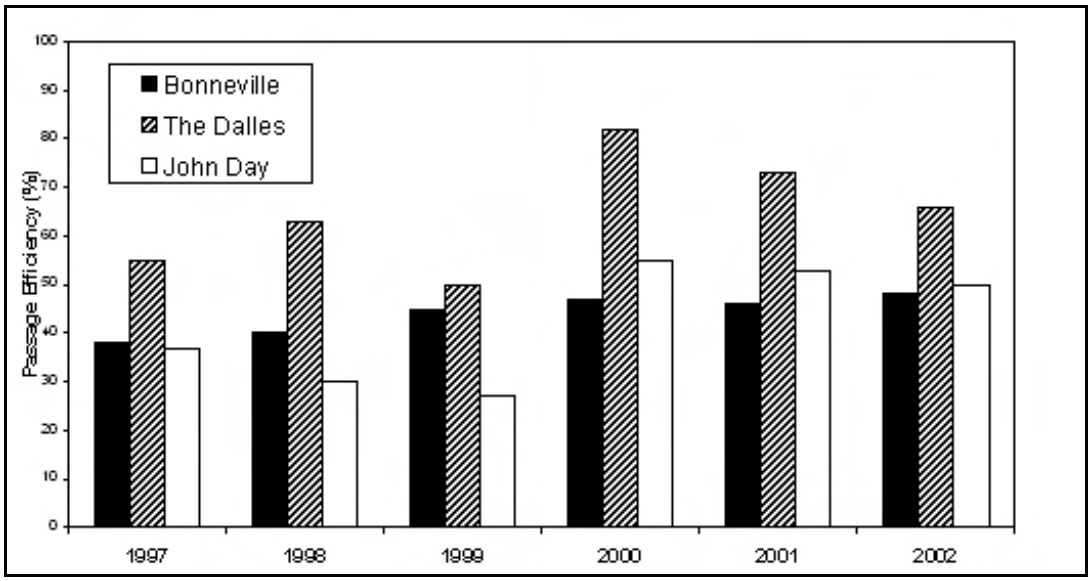
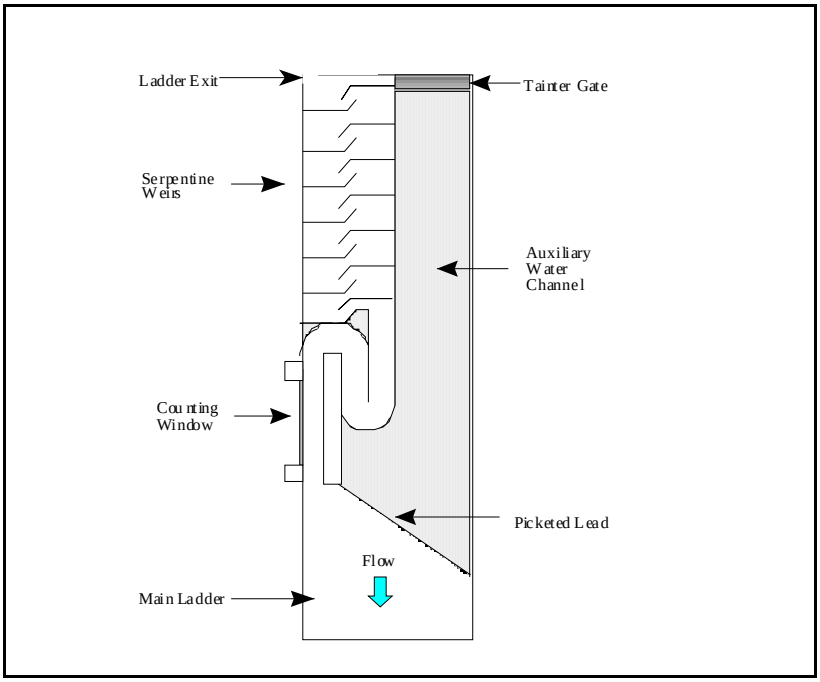


Figure 2. Overhead diagram of the top of the fishway at Bonneville Dam and the auxiliary water supply channel.



LAMPREY PASSAGE SYSTEMS

Radio-telemetry results and visual observations showed that lamprey obstructed in the serpentine weir section at the top of the fishway can accumulate in the adjacent auxiliary water supply (AWS) channel (Figures 2 and 3). Because this area poses a significant threat to lamprey passage, two prototype bypass collectors were developed in 2002 to determine if lamprey could be collected from the AWS channel at the top of the Bradford Island fishway at Bonneville Dam (Figure 2; Moser et al., 2005b). Testing of passage alternatives for lamprey at this location was done without impacting salmon passage in the main fishway. Initial testing of the lamprey collectors showed that lamprey use them. Further design refinement and testing in 2003 resulted in collector efficiencies of up to 20% and catch rates of over 250 lamprey/night (Moser et al., 2005a).

Figure 3. Bradford Island LPS ramps in the auxiliary water supply channel near the exit to the Bradford Island ladder at Bonneville Dam.

In 2004, the LPS was extended to exit directly into the Bonneville Dam forebay. With this extension, lamprey could move directly from the AWS to the forebay. This LPS was used from the day it was installed by over 8,300 lamprey in 2004 and over 9,200 lamprey in 2005. In both years, this represented a significant percentage of the total count of lamprey at the Bradford Island count station (Table 2). Consequently, a more permanent installation of the LPS with dual collection channels was installed in 2006. In 2007, monitoring lamprey use of this LPS was continued using both a lamprey-activated counter and a half-duplex PIT tag detection system (Figure 4). In 2007, a similar LPS was installed at the Washington shore AWS and its efficacy was assessed (Figure 5).

Table 2. Pacific lamprey counts at the Bradford Island count window and through the auxiliary water supply channel.

Year	# at Count Station	Estimated Total	Bradford Island AWS	
			LPS Count	% of Estimated Total
2004	11,971	35,913	7,490	21
2005	10,257	30,771	9,242	30
2006	14,862	44,586	14,975	34
2007	6,473	19,420	7,387	38

Figure 4. 2007 Pacific lamprey counts at Bradford Island count window and at the Bradford Island ladder auxiliary water channel LPS.

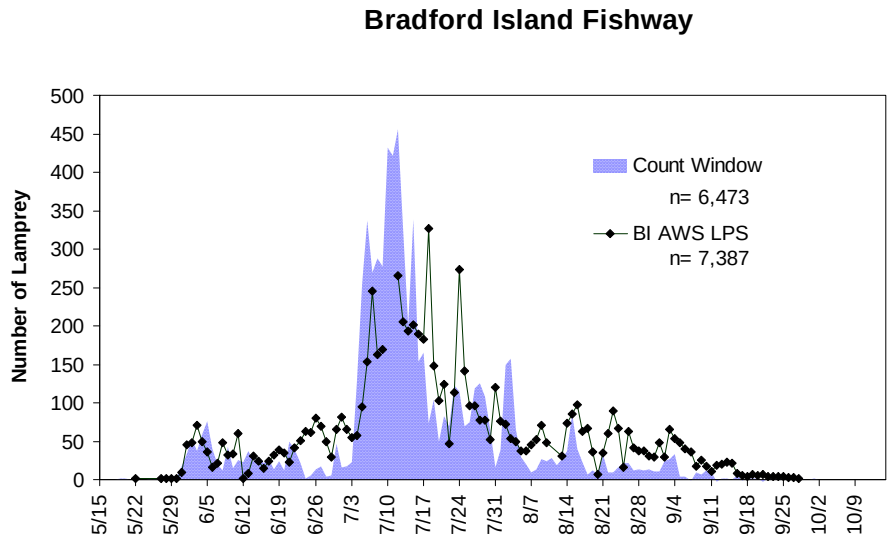
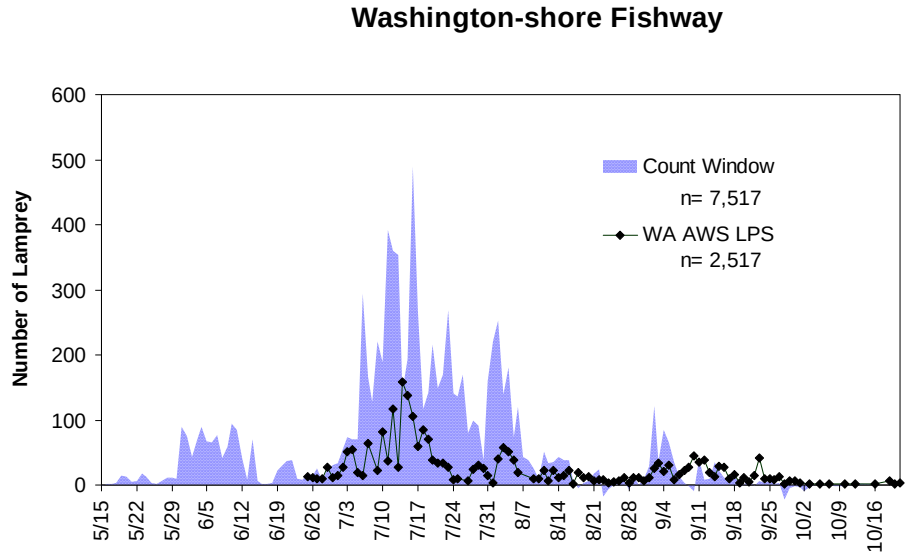


Figure 5. 2007 Pacific lamprey counts at Washington-shore count window and at the Washington-shore ladder auxiliary water channel LPS.



FISHWAY ENTRANCES

Radio-telemetry studies and fishway experiments have demonstrated that lamprey have difficulty entering fishways. Telemetry studies at Bonneville Dam in 1998 through 2002 indicated that lamprey entrance efficiency was particularly low at the north downstream entrance to the Washington-shore fishway (Moser et al., 2005b). During this period, less than 40% of the lampreys that approached this entrance successfully entered the fishway (Moser et al., 2005b). High flow velocities (usually 8 feet/second or higher) may be the primary constraint for lamprey at fishway entrances.

Nighttime Ladder Entrance Velocity Reduction Evaluations

A potential solution we are studying is to lower ladder entrance velocities at night when lamprey are most active (**see MOA AL 5 on page 1)**. In 2007, a test was conducted using blocked treatments of standard versus lowered nighttime entrance velocities at Bonneville Second Powerhouse (Johnson et al. 2009; see https://www.nwp.usace.army.mil/pm/e/afep_docs.asp). By reducing the volume of water added into the lower ladder through the AWS, entrance head was reduced to 0.5 feet and velocities to around 4 ft/sec between 10PM and 4AM one night of each block. By monitoring radio-tagged lamprey, the utility of using lowered velocities to improve fishway entrance rates for adult lamprey was evaluated. Results of the 2007 data showed an increase in passage efficiency at both the north and south entrances but that the relative change in the actual number of fish entering varied. The south entrances showed a net reduction in the number of fish entering the ladder during nights with reduced velocities as a result of a reduction in attraction to the entrance, likely related to the reduced flows. At the north entrance, where normal flow velocities are considerably higher than the south entrances, both entrance efficiency and numbers entering increased. This block test evaluation will be repeated in 2009 with a larger number of blocks to increase the strength of the analysis.

In 2009 NWW engineers are exploring another way to reduce entrance velocities without reducing the volume of water to conduct a similar block test at MCN. This methodology would drop entrance velocities by lowering the entrance weir rather than reducing the supply of auxiliary water.

Concerns have been raised about the extra wear and tear the mechanical systems supplying water to the lower ladder diffusers by repeatedly changing their operation but such operations may be a short term alternative until major entrance modifications can be implemented, if reducing these velocities prove to be of value.

Major Entrance Structural Modifications

Ladder entrance efficiency is the major passage problem at most of the FCRPS projects (Moser et al., 2005b). At the Bonneville Dam north downstream Washington-shore ladder, where large numbers of adult Pacific lamprey first approach the dam, entrance efficiency was only around 40% from 1998-2002. In 2003, a test LPS was placed just downstream of this entrance to see if it could attract and collect many of the lamprey that were not entering the fishway. Annually, only 5% or less of the lamprey approaching this entrance have used this LPS. The lack of success is likely related to the limited attraction flow and small size of the LPS, as well as the large numbers of alternative flows and routes to explore in the area immediate downstream of the entrance.

Another approach to improving entrance efficiency is to modify the existing entrance weir and floor to reduce velocities to make it easier for adult Pacific lamprey to enter the fishways (**see MOA AL 6, page 1**). At the mouth of the fishways, structures can be installed to reduce floor velocities and to guide lamprey to a LPS. The first year of testing of a prototype system in the Cascade Island Fish Ladder entrance is occurring in 2009, using 600 radio-tagged and 1000 PIT tagged adult Pacific lamprey. A similar design is being developed as part of the John Day North Fish Ladder modifications Phase 2 and at Bonneville second powerhouse WA shore north entrance. In 2009-2010, a similar but new floor velocity reduction system design is being evaluated by the Walla Walla District for use at MCN and potentially at other dams.

Bonneville Cascade Island Fish Ladder - Entrance Modifications MOA AL 1, 4, & 6

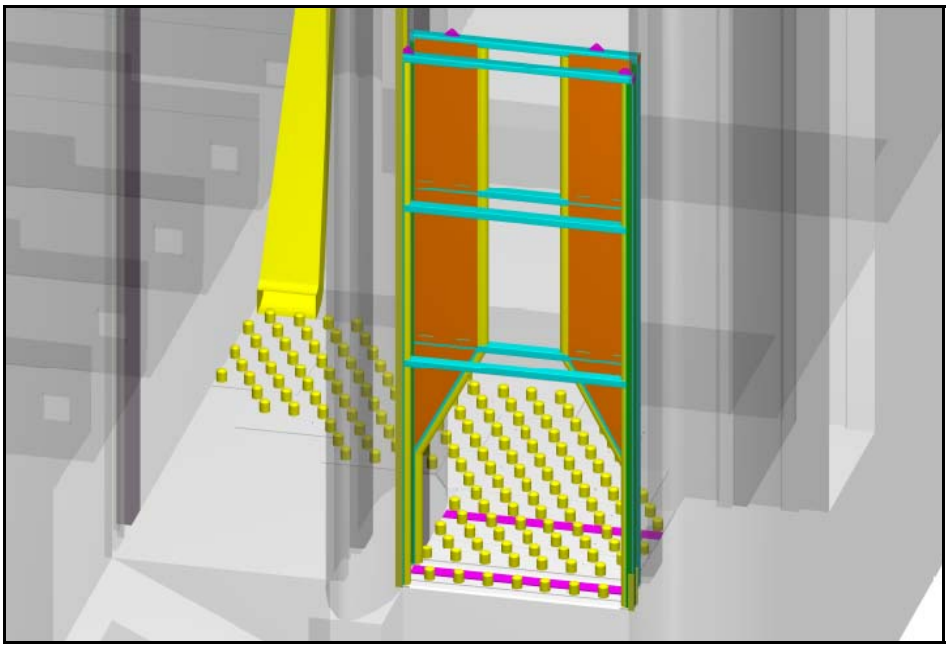
This project is an evaluation of a modified fixed-weir entrance at Cascade Island ladder at Bonneville Dam as a prototype of an entrance redesign being planned for the John Day North Ladder modifications in 2010-2011. Fish ladder entrances on the lower Columbia River are known to cause difficulty for lamprey trying to migrate up the Columbia River. Changes to the entrance will come in two forms (Figures 6a and 6b): (1) the entrance shape will accommodate many different tailrace elevations with variable width and rounded edges in order to facilitate lamprey movement, and (2) structural elements will be added to the floor just inside the entrance to simulate a rock floor that reduces velocities for lamprey to move through, which were tested in the research flume. The floor structure will be placed to lead lamprey to a LPS.

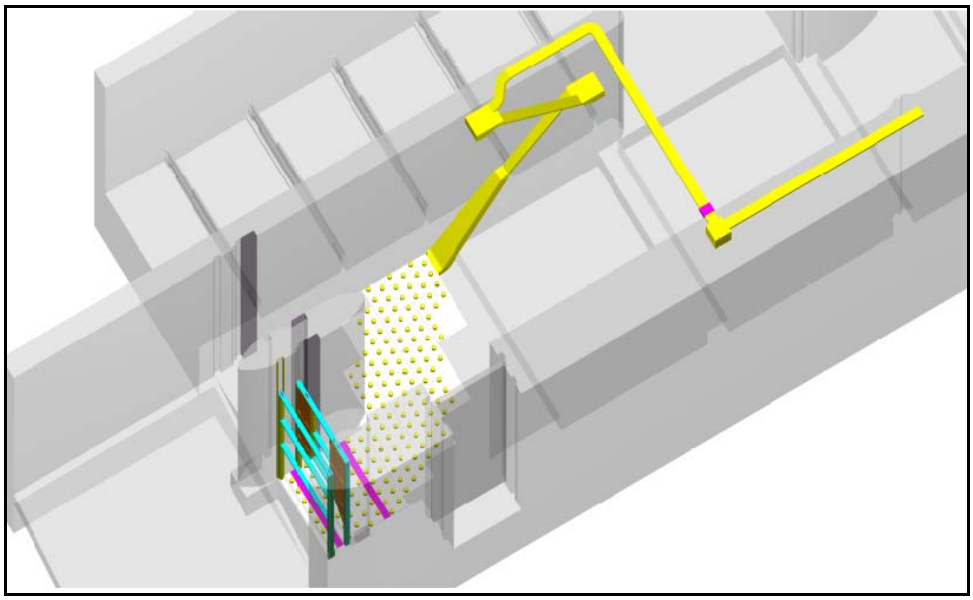
John Day North Fish Ladder - Entrance Modifications MOA AL 1, 4, & 6

The Portland District is developing a Detailed Design Report to increase the entrance discharge and improve the overall performance of the lower ladder section of the John Day north fish ladder including the entrance, AWS, transition channel, and lower fishway weirs (**see MOA AL 1, 4, & 6 on page 1**). The planned construction date for the potential improvements is the 2010-2011 in-water work period. A primary feature in all of the alternatives is the replacement of two existing 12-foot-wide modulating entrance weirs by a single fixed entrance weir similar to the design to the modification described for the Bonneville Cascade Island entrance.

Changes to the entrance will come in three forms: (1) the entrance shape will accommodate the specific flow requirements at the different tailrace elevations with the variable width; (2) edges will be rounded at least 4-inch radius to facilitate lamprey movement; and (3) structural elements will be added to the invert to simulate a rock floor that reduces velocities and provide crevices for lamprey to hide in and move through. It is planned to have the floor structure attempt to lead lamprey to a potential LPS that would remove the lamprey from the ladder and provide an easier passage route. The width of the proposed fixed weir will vary from about 15 feet at the floor to 7 feet at the top. The floor will match the existing entrance invert elevation.

Figures 6a and 6b. Cut away 3-D models looking upstream through the new Cascade Island entrance fixed weir at the velocity reducing structures on the ladder bottom leading to the collection ramp of a LPS.





ADULT LAMPREY COUNTS AT DAMS - MOA AL 9

Pacific lamprey counting at most dams occurs only during daylight hours using tabulation of up and down movements through the count windows in all fishways. Because many lamprey are more active at night and because there are numerous routes available for lamprey to pass dams and not be detected at the count windows (e.g., through picketed leads and trash racks, AWS channel, LPS, and others), existing counts are a rough index of passage. Research is ongoing (2007-2009) at several FCRPS dams using nighttime video counts, lamprey PIT detection, and LPS counts to develop a more accurate counting methodology. Preliminary 2007 results at TDA and BON indicate that significant percentages of adult lamprey pass the count windows at night except at BON 2 where the net overall count was negative at night. The 2008 data are being evaluated and a final technical report will be available in 2009. Nighttime counting is expected to continue at several of the FCRPS dams with a potential subsampling methodology being developed for counting at high volume ladders. A more meaningful estimate of passage will allow better evaluation of the overall population status.

Table 2. Preliminary 2007 Ladder Window Counts at BON and TDA dams tabulated by video at night and by counters during the day (BON 1 counts through Aug 7, BON 2 counts through Sept 7, TDA counts through Sept 3).

Ladder	Night	Day	Total	Night %
TDA N	3,137	3,246	6,383	49.1
TDA E	1,008	2,545	3,553	28.4
BON 2*	-439	9,931	9,492	< 0
BON 1*	18,352	8,430	26,782	68.5

* BON 1 peaked in July with a 12,398 night video count; BON 2 count was not always negative with a night video tally of 5,294 in July.

Reservoir Fates

Large numbers of adult Pacific lamprey are unaccounted for as they migrate upstream based on the differences in counts from dam to dam. Very little is known about overwintering, mainstem spawning, or tributary turnoff. Because of the depth at which lamprey swim and rest, standard radio-telemetry techniques are not well suited to fate determination. New acoustic tags and monitoring systems (nodes and mobile tracking systems) can detect lamprey at depth and are being developed through competitive contracting to better investigate the fate of adult lamprey in reservoirs. It is expected that a prototype JSAT mobile tracking receiver system will be developed and may be available in fall of 2009.

JUVENILE LAMPREY

The USACE conducted studies on downstream juvenile Pacific lamprey passage from 2000 to 2002. Based on fyke net evaluations of run-of-the-river fish at John Day, McNary, Bonneville, and other dams, the majority (> 70%) juvenile lamprey appeared to move downstream low in the water column under the turbine intake screens of bypass systems installed for salmonids at USACE dams (BioAnalysts Inc. 2000; Moursund et al., 2003; Monk et al., 2004; Moursund et al., 2006). This results in the majority of juvenile lamprey tending to pass the dams through the turbines when they encounter a powerhouse. The USACE-funded laboratory studies with Pacific Northwest National

Laboratory that demonstrated juvenile lamprey unlike juvenile salmon were not injured or killed in test chambers by changes in pressure and shear conditions that occur during turbine passage (1,220 to 1,830 cm/sec/cm; Moursund et al., 2000, 2003). Spillways are assumed to be a safe passage route.

Turbine Unit Screens MOA JL 2 & 3

The 20% or more of juvenile lamprey that approach powerhouses and encounter turbine intake screens are vulnerable to impingement. Impingement on the screens can result in mortalities under certain conditions as documented by field observations, as well as field and laboratory studies, and that a gap reduction from 1/8 to 2/29 inch virtually eliminated impingement (Moursund 2003, 2006). As a result, the USACE has changed screen spacing criteria for new screens to minimize impingement (MOA JL 2) such that as extended screens need replacing the smaller size gap will be used. These screens can last up to 30 years. Accelerating screen replacement is expensive with a cost estimate of around $1 million per screen. To better monitor the impingement of juveniles on screens we are exploring if we can routinely enumerate them as they are removed for cleaning and maintenance.

Another strategy being considered (MOA JL 3) is to remove screens when juvenile lamprey outmigrate past a project. Unfortunately, there is considerable overlap in the peak of passage with ESA listed salmon juvenile species allowing very little opportunity to remove and reinstall screens considering the time it takes to perform these operations. By examining passage timing of juvenile fish passage at MCN, a dam of particular concern regarding juvenile lamprey passage because of the extended screens at the turbine units, it was determined after regional review that installation of the MCN screens could be delayed until mid April to reduce impingement for downstream passing juvenile lamprey. Similar screen installation timing changes may be able to occur at other dams.

Bypass System Screens MOA JL 4

At times, juvenile bypass fish facilities can collect thousands of juvenile lamprey that may cause screen clogging, lamprey injury and mortality, and move lamprey into transportation barges. Federal facilities with smolt monitoring facilities enumerate juvenile lamprey, separating them into “brown” and “silver” categories, as well as adults that fall back through this system. This data is summarized and available at http://www.fpc.org/lamprey/lamprey_home.html and are used as a measure of outmigration timing for juveniles.

At juvenile salmon transportation collector projects, collected fish are routinely held in raceways for up to two days awaiting transportation. Lamprey held in the raceways can become impinged on the tail screens, complicate removing salmon from the raceways, and feed on the salmon. The USACE is investigating the feasibility of modifying the tail screens to allow juvenile lamprey to pass out of the raceways and return to the river without increasing the likelihood of impingement of juvenile salmon on the tail screens.

In 2008, experiments with macrophthalmia were conducted in a flume supplied with ambient Columbia River water at the McNary Juvenile Bypass Facility. For each 1 hour experiment, five replicates using 10 lamprey each were done with two different screen materials: 6.5 mm square stainless steel woven mesh and stainless steel plate with staggered 6 × 25-mm oval perforations. For each material, we tested the screen in horizontal, angled (9°), and vertical orientations. We found that the macrophthalmia moved most readily through materials oriented vertically (both the mesh and the plate) and were reluctant to move through an angled or horizontal separator. We conducted longer (24 h) experiments using both macrophthalmia and ammocoetes to determine whether fish

would volitionally move either vertically or horizontally through a variety of materials (6.5 mm – 12 mm openings). The results of this work confirmed that macrophtalmia were resistant to moving downward, while ammocoetes readily moved in a downward direction. Both groups moved horizontally through all materials. Based on these findings, we designed, built and installed a lamprey-friendly raceway screen at the McNary Juvenile Bypass holding raceways. The new screen was oriented vertically and made from 6.5 mm square stainless steel woven mesh. Preliminary sampling of raceways with and without the lamprey-friendly screen indicated that fewer juvenile lamprey were retained or impinged by the lamprey-friendly material.

Tag Development MOA JL 5

Little is known about the basic biology of juvenile lamprey, in particular, not much is known about juvenile migration. There is a need for methods to study juveniles in mainstem habitats and their migration, and to better understand the abundance of juvenile outmigrants and how successful they are at passing through dams. Historically, this type of data has been obtained for salmonids using active tags, first, with radio tags and recently with acoustic tags.

At present, no active tag is available for use in juvenile Pacific lamprey due to their very small size and girth. Active tags are essential to clearly evaluate and understand basic downstream dam passage parameter such as route specific passage and survival. A tag development program is being funded and undertaken as part of the juvenile salmon FCRPS research program and objective are being added to this development to include adult and juvenile lamprey capabilities.

Considering the uncertainty how quickly an affordable miniature juvenile lamprey tag can be developed, we may need to explore other potential means of field capture and recapture techniques to gain additional information about the passage routes and survival of juvenile salmonids at dams. For proposed new techniques to be of use they must have adequate capture efficiencies and detection probabilities, and minimize potential negative effects on listed juvenile salmonids. Techniques using PIT tags, fyke nets, and towed arrays are being discussed. Obtained unbiased data will be essential if we are to obtain useful information on which to base any structural or operational modifications.

LADDER MODIFICATION

Lamprey friendly features are being incorporated as a part of the John Day North Fish Ladder adult salmon modifications. Through this process, the USACE is developing acceptable lamprey criteria that still allow the ladder to remain in salmon operational criteria. These criteria include a 4-inch radius for rounding, smooth contiguous floor surfaces, no right angles in high velocity areas, and a ¾-inch gap for diffuser gratings. Potential lamprey problem areas have been identified during ladder dewatering inspections and are compiled in Appendix B**.** By comparing areas of the ladder with know delay or other passage problems obtained from radio telemetry studies to this list of potential problem sites, the USACE can prioritize which modifications are most likely to be of benefit.

Diffuser Gratings MOA AL 7

The fish ladders on the lower Columbia River dams typically have diffuser systems that supply auxiliary water to maintain salmon hydraulic criteria in the ladders under varying forebay and tailwater elevations. They consist of AWS that feed water to bubbler beams that move flow through the diffuser gratings consisting of 1-inch steel gratings. The gratings were designed to keep adult salmon from entering the AWS system. When adult lamprey encounter the diffuser grating, they

may go through the grating into the underlying chamber and become trapped. This is particularly true when the fishways are dewatered for inspection and repair. Up to several hundred stranded lamprey have been found trapped in these chambers and had to be removed by hand. Improvements to dewatering and salvage operations that include ensuring sufficient time and equipment to handle fish and better management of draining and pooling of water to assist with the logistics have been established to reduce the numbers of lamprey likely to move through the gratings, but strandings and mortalities still occur.

Evaluations in the laboratory and in the John Day North Fish Ladder showed that reducing the grating size openings from 1 inch to 0.75 inch would basically eliminate lamprey passage through the gratings (Moser et al., 2007). A 0.75-inch gap size for new diffuser and intake gratings has been adopted as the new criteria for the lower river by the Fish Passage Operations and Maintenance Team. Even though lamprey lose girth as they migrate upstream, these new criteria should be effective as the critical dimension appears to be the size of the head which does not vary as girth changes (M.L. Moser, NMFS, personal communication). Consequently, the new gap-size criteria will be used when gratings are replaced.

A letter report was completed by the USACE in May 2008 that determined that the diffuser gratings in the fish ladders should be replaced with 0.75-inch powder coated galvanized steel grating or best material available (a companion report identifying issues, priorities, and costs for the McNary and Snake River projects is currently under development). The recommended grating material is similar to the existing diffuser grating porosity; thus, there would be no changes to hydraulic conditions in the ladder. The trash racks in the fish ladders also need to be upgraded to match the 0.75-inch gap grating to avoid debris issues underneath the diffuser gratings. This, in turn, may result in needs to improve trash rack cleaning systems, as we are finding at Bonneville second powerhouse. Replacing the diffuser gratings at many ladders will also requires the replacement of the grating support systems with stainless steel to avoid corrosion, and because many of the diffuser grating support systems were not designed to carry the required structural loads for walkways and platforms, and have to be redesigned to meet current standards.

Rounding of Corners MOA AL 8

After the installation of rounding modifications to the Bonneville spillway entrance bulkheads in 2000, there was a corresponding small increase in passage efficiencies (44% - 57% to 60% - 65%) at those entrances from 2000-2002 (see Table 2 in Moser et al., 2003). The passage efficiency for the collection section of the ladders just above the entrances increased even more for those same years (54% - 60% to 89% - 96%) and may indicate other factors influenced entrance improvements beside the bulkhead shape modifications.

University of Idaho laboratory evaluations of the effectiveness of rounding corners showed a significant relationship between rounding bulkheads and an increase in night-time passage rates in the test flume from 32.5% to 50.8%, and a reduction in passage times from a mean of 3 minutes to 1.4 minutes (see Table 9 and Figure 17 in Daigle et al., 2005). However, these improvements were small when compared to those that occurred when head and velocity were reduced.

Both of these evaluations focused on rounding at entrances where entrance efficiency is low and rejection is high. Researchers emphasized that the entrances should be the priority location to attempt to round structures, and that efforts elsewhere may not be needed. Some areas of the fishways with high velocities and unrounded surfaces, such as the main ladder portion of the Washington shore and Bradford Island fishways, have good passage times and passage efficiencies

of about 90% or better. The serpentine weirs in the exit sections may also benefit from rounding. The installation of the adult fish PIT readers in the top of the fishways included rounding of all corners as a required feature. Rounding of orifices and slots is a design feature in all facets of the John Day north fish ladder modifications.

One factor that may be important in determining where rounding may be most useful is the added presence of confusing or alternative flows where high velocities exacerbate the problem. The major locations of passage difficulties at most dams are entrances, transition pools, serpentine weirs, and AWS; all are areas with confusing flows (swirling flows in serpentine weirs, optional flows from diffusers or to the sides of entrances that may be enticing when confronted with high velocity for the major upstream movement). Lamprey are attracted to high flows as is indicated by their passage distribution relative to flows at Bonneville, but may be searching for the complex structures of a normal river environment to find holdfasts and low flow pockets to work their way over difficult high flow passage areas such as rapids and falls or dams. Typically, dams do not offer that sort of complexity of options for passage and those that are present, such as moving into lower flow diffuser gratings, can be problematic.

Auxiliary Water Supply Channels/Cul-De-Sacs

Large numbers of Pacific lamprey searching for a way over a dam may avoid the higher velocity areas in fishways and move into and congregate in dead-end side channels at dams. Many of these fish may never pass the dam. This behavior can be managed either by blocking off the entrance to these dead ends by installing smaller gap-picketed leads or screens, or this behavior can be exploited to improve passage by the deployment of a LPS.

Installation of a LPS in the AWS channels at Bonneville Dam has proved very successful at passing large numbers of Pacific lamprey. Construction drawings and O&M manuals for this LPS are nearly completed. Ramps similar to those developed with the LPS are being evaluated to assist adult lamprey upstream passage at low head irrigation dams on the Umatilla River.

PREDATION

Predation by birds, fish, and sea lions on both Pacific lamprey and salmon in the vicinity of dams is a concern. Implementation of predation control measures such as harassment, avian lines, avian colony management, the pikeminnow bounty program, and sea lion removal efforts, although planned for salmon, are also expected to benefit Pacific lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.

CONCLUSION

Working in collaboration with treaty tribes, states, and federal agencies, the USACE has developed a 10-year lamprey plan based on adaptive management which will address specific actions to be considered to improve lamprey passage and survival and will provide an annual summary of accomplishments.

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Updated Conceptual Lamprey 10-Year Plan

Updated CONCEPTUAL Lamprey 10-year Plan	MOA OP 2)	Fiscal Year 2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Adult Biological Studies		Biological Studies											
Adults Lower Columbia River Dams													
Lamprey Technical Work Group-Establish Goals	AL 2)												
Walk Ladders with MOA Treaty Tribes- NWP and NWW	AL 3)												
Develop Counting Protocols	AL 9)												
BONN Cascade Island- Prototype Entrance Mod.	AL 4), 6)												
				Yes-Proceed to upstream ladders No- Adaptive Management- Critical Ladder Modifications									
BONN Washington Shores	AL 4), 6)												
BONN Bradford Island A	AL 4), 6)												
BONN Bradford Island B	AL 4), 6)												
JDA North Fish Ladder	AL 4), 6)												
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
McNary	AL 4), 6)												
Adult studies													
Short Term Ladder Improvements													
Ladder Entrance Modification													
Lamprey Adult Passage System (LAPS)													
Operational Modifications/ night time flow reduction													
Diffuser grating analysis													
Night Time Video													
Ice Harbor													
Ice Harbor-Prototype Entrance Mod.	AL 4), 6)												
Short Term Ladder Improvements													
Ladder Entrance (and LAP) analysis and installation if warranted (As appropriate)													
Operational Modifications/night time flow reduction													
Night Time Video													
Lower Monumental	AL 4), 6)												
Short Term Ladder Improvements													
Ladder Entrance Modification (as appropriate)													
Operational Modifications	???												
Night Time Video													
Little Goose	AL 4), 6)												
Short Term Ladder Improvements													
Ladder Entrance Modification (as appropriate)													
Operational Modifications													
Night Time Video	???												
Lower Granite	AL 4), 6)												
Short Term Ladder Improvements													
Ladder Entrance Modification (as appropriate)													
Night Time Video	???												
Operational Modifications	???												
TDA East	AL 4), 6)									R&D?|P&S			
Adaptive Management-Critical Ladder Modifications	OP 1) and AL 7)		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	
Juvenile Lamprey		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
Juvenile Studies/Implementation		Studies and Implementation											
Bypass System Monitoring	JL 1)												
Transducer Tag Development	JL 5)												
Intake Screen Modification/Replacement Feasibility	JL 2)			◆Decision Point-Implement?									
McNary Screen- Lifting or Replacement- TBD	JL 2) , 3)												
Little Goose and Lower Granite- Bar Screen Mods- TBD	JL 2)												
Separators Protoype Field Feasibility	JL 4)			◆Decision Point-Implement? Yes									
McNary Prototype- TBD	JL 4)												
Snake River Dams Prototypes- TBD	JL 4)												
		Subject to change in consultation with MOA Treaty Tribes and if ESA listing occurs											
Legend				Research			Implementation			Post Testing and Monitoring			

Appendix A
Timeline of Pacific Lamprey Research and Implementation, 1994 - 2008

1994

Based on regional concerns about the diminishing numbers of Pacific lamprey, the Pacific Lamprey Passage Studies Program was initiated in June 1994 with requests issued by the USACE for preliminary proposals.

Study Results

1. USACE Fishery Field Unit reviewed the literature and historic passage records to characterized run timing, diel passage, and passage numbers, and compiled areas of potential problems for adult and juvenile passage based on observations and discussions with researchers.
2. Underwater camera observations of fish through orifices in BON2 ladder section found some lamprey spent substantial time in or near orifices.

References

Beck, L.M. 1995. Fish behavior at submerged orifices, overflow weirs, and vertical slots in the fish ladder at Bonneville second powerhouse 1993-1994. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

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1996

Study Results

1. 85 radio-tagged lamprey released below BON to evaluate passage upstream:
   - 94% returned to dam;
   - Top of ladder detection problems limited meaningful passage estimates.

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Vella, J.J., L.C. Stuehrenberg, and T.C. Bjornn. 1999. Radio-telemetry of Pacific lamprey (*Lampetra tridentata*) in the lower Columbia River 1996. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

1997

Study Results

1. 147 radio-tagged lamprey released below BON:
   - 88% returned to BON dam;

- 38% BON passage efficiency - 1 fallback fish;
- 55% TDA passage efficiency;
- Too few fish at JDA for meaningful passage estimates.

References

Vella, J.J., L.C. Stuehrenberg, M.L. Moser, and T.C. Bjornn. 2001. Migration patterns of Pacific lamprey (*Lampetra tridentata*) in the lower Columbia River 1997. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

1998

Study Results

1. 205 radio-tagged lamprey released below BON to evaluate passage upstream:
   - 89% returned to BON dam;
   - 40% BON passage efficiency - 1 fallback fish;
   - 63% TDA passage efficiency - 4% fallback;
   - Too few fish at JDA for meaningful passage estimates;
   - 1 fish found in Klickitat River, 3 in Fifteen Mile Creek, and 8 in Deschutes River.

References

Ocker, P.A., L.C. Stuehrenberg, M.L. Moser, A.L. Matter, J.J. Vella, B.P. Sanford, T.C. Bjornn, and K.R. Tolotti. 2001. Monitoring adult Pacific lamprey (*Lampetra tridentata*) migration behavior in the lower Columbia River using radio-telemetry, 1998-99. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

1999

Study Results

1. 197 radio-tagged lamprey released below BON to evaluate passage upstream:
   - 92% returned to BON dam;
   - 45% BON passage efficiency - 4 fallback fish;
   - 50% TDA passage efficiency;
   - Too few fish at JDA for meaningful passage estimates;
   - 4 fish found in Hood River and 2 in the Deschutes River.
2. Lab tests found adult lamprey critical swim speed of 0.86 m/sec, burst speed to 2.1 meters/sec, and that they recovered quickly from a single stressor exposure (USGS-Cook).
3. NMFS found a fish guidance efficiency (FGE) of 1.4% for juvenile lamprey in fyke net catches at John Day Dam Powerhouse with 86% of the juveniles captured in the bottom four net levels.

Passage Improvement Design and Implementation

1. Adult experimental fishway:
   - Baseline passage rates under normal fishway ladder conditions were established;
   - Adding velocity refuges reduced passage times, did not affect success.

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2000

Study Results

1. 299 radio-tagged lamprey released below BON:
   - 87% returned to BON dam;
   - 47% BON passage efficiency - 3.3% (4) fallback;
   - 82% TDA passage efficiency - 35 fish detected in Deschutes River, 13 in John Day River;
   - 55% JDA passage efficiency - 17% fallback.
2. Lab and field test found count window lighting did not affect adult passage.
3. 1999-2000 field and lab **juvenile lamprey** swim behavior studies (PNNL) found:
   - Impingement problems (15% - 75%) at 1/8-inch extended length bar screens that increased with flow rates and time, but little problem with 1/8-inch traveling screen mesh or 3/32-inch bar screen.
   - Exposure to simulated shear and pressure changes indicate turbine passage may be fairly benign as no injuries to juveniles were found.
   - Light from the sides or above eliciting a diving response in lab studies of juveniles.
4. Oregon State University studies on juvenile tagging protocols found existing active tags are too large, external tags are poorly tolerated by the animal, short term PIT tag studies on larger sized juveniles (>150 mm) may work, and fungus growth on handled juveniles are a problem.

Passage Improvement Design and Implementation

1. Adult experimental fishway:
   - Daytime passage was less successful than nighttime passage; artificial nighttime light could reduce passage success.
   - Adding a 20.3-cm step at the base of an orifice reduced passage rates from 69% to 49%.
   - Diffuser gratings slowed passage but this difference disappeared when a plate was attached.
   - Simulated count windows found no effects on passage with or without simulated count window lights or picketed lead weirs.

References

Daigle, W.R., C.A. Peery, S.R. Lee, and M.L. Moser. 2005. Evaluation of adult Pacific lamprey passage and Behavior in an experimental fishway at Bonneville Dam. Technical Report 2005-1. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

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2001 (a drought year - very low flow and reduced spill)

Study Results

1. 298 radio-tagged lamprey released below BON:
   - 93% returned to BON dam;
   - 46% BON passage efficiency - 12% fallback;
   - 73% TDA passage efficiency - 7% fallback, 8 fish detected in Deschutes River, 4 in John Day River;
   - 53% JDA passage efficiency - 36% fallback.
2. 2000-2001 evaluations at Cascade Island researchers concluded that rounding of entrance bulkheads improved entrance efficiency based on a 11% increases over previous 2 years (51.5% vs. 62.5%).
3. 2000-2001 evaluations of reduced flow at spillway entrances found no passage improvements but controlling entrance test velocities was problematic.
4. High passage efficiency exists through ladder sections; entrances, collection, transition areas and serpentine weirs are problematic.

References

Moser, M.L., D.A. Ogden, S.G. McCarthy, and T.C. Bjornn. 2003. Migration behavior of adult Pacific lamprey in the lower Columbia River and evaluation of Bonneville Dam modifications to improve passage, 2001. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

2002

Study Results

1. 201 radio-tagged lamprey released below BON:
   - 96% returned to BON dam;
   - 48% BON passage efficiency - 1 fallback fish;
   - 66% TDA passage efficiency - 1 fallback fish, 2 fish detected in Deschutes River, 1 in John Day River;
   - 50% JDA passage efficiency - 35% fallback.
2. Limited underwater and acoustic camera investigations (FFU) of floor plates on diffusers between weirs in BON 2 transition pools found no evidence of preferential use of orifices with plates and limited use of the plates, suggesting adult lamprey may move laterally to the walls.
3. In 2001, 41 cm wide plates over diffuser gratings in BON2 ladder transition section resulted in an increase in passage efficiency through that section (weir 1-10) compared to 2000 (72% vs.82%) but efficiency dropped to 74% in 2002.
4. Field and lab evaluations of **juvenile lamprey** at JDA and PNNL found:
   a. Juveniles contact (78%) and may be impinged on extended bar screens at high rates, but most are able to continue to move along the screen face and that reducing the bar spacing to 1.75 mm prevented impingement.
   b. 52% of PIT-tagged juveniles released to contact the screens were unaccounted for and likely assed through the gap at the top of the screen. The remaining fish passed efficiently through the JBS.
   c. 78% of run of river juveniles were captured in the 2nd, 3rd and 4th fyke nets from the bottom and would have passed beneath extended screens and into the turbines.
   d. Mean maximum burst speed for untagged juveniles was 2.5 ft/s.
   e. Sustained swim speed for untagged juveniles was 1.38 ft/s.
5. Serpentine weirs and the area immediately downstream of weir 1 in BON2 transition section of the ladder were found to be major passage problems.
6. Evaluations of yearly chemical/hormonal cycle of adult Pacific lamprey (USGS-Cook) found no differences between fish that did or did not pass; that there were few indications of any migratory related changes.
7. Of the 711 juvenile lamprey collected in the gatewell and fyke nets at BON2, 75% were caught in net levels 3 and 4 (from elevation -0.3 m to -5.1 m MSL). This was comparable to results seen previously at BON Dam First and Second Powerhouse. In all cases, most juvenile lamprey were well below an area where they were susceptible to interception by the STS.

Passage Improvement Design and Implementation

1. Lamprey passage systems (LPS):
   - First prototype sections of an LPS designed and installed in the Bradford Island exit;
   - AWS channel show some promise to pass fish.
2. Adult experimental fishway:
   - Tests on a simulated entrance weir found increases in passage rates from 4% with 45.7 cm of head to 78% with 15.2 cm of head;
   - Rounding the bulkhead shape increased passage rates from 34% to 41%;
   - Offering a side channel with reduced velocities increased passage from 3% to 44%.

References

Daigle, W.R., C.A. Peery, S.R. Lee, and M.L. Moser. 2005. Evaluation of adult Pacific lamprey passage and behavior in an experimental fishway at Bonneville Dam. Technical Report 2005-1. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

Monk, B.H., B.P. Sandford, D.A. Brege, and J.W. Ferguson. 2004. Evaluation of turbine intake modifications at the Bonneville dam second powerhouse, 2002. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

Moser, M.L., D.A. Ogden, and C.A. Peery. 2005. Migration behavior of adult Pacific lamprey in the lower Columbia River and evaluation of Bonneville Dam modifications to improve passage, 2002. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

Moursund, R.A, M.D. Bleich, K.D. Ham, and R.P. Mueller. 2003. Evaluation of the effects of extended length submerged bar screens on migrating juvenile Pacific lamprey (*Lampetra tridentata*) at John Day Dam in 2002. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

Nagy, W.T. 2004. Assessment of steel floor plates installed on diffuser gratings to facilitate passage of adult Pacific lamprey through fish ladders. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

2003

Passage Improvement Design and Implementation

1. Lamprey passage systems (LPS) - Bradford Island AWS channel:
   - Three prototype collection structures were built and evaluated in both an upstream and downstream configuration to evaluate effectiveness at collecting adults;
   - 5,458 adults were collected and 1089 were marked and re-released in the channel to estimate treatment efficiency;
   - Downstream-oriented ramps performed the best, recapturing 18%.
2. Bradford Island ladder exit area vertical slot adult PIT installation:
   - Installation designs incorporated lamprey features; chamfering of right angle corners, reduction of gap tolerances for antennae inserts, and less roughness for concrete.
3. Diffuser grating:
   - Preliminary tests of grating gap size found adults pass readily through 1-inch gap but do not in ¾-inch gap openings.
4. Dewatering procedures:
   - Methods altered to reduce impacts to lamprey; diversion pipes from upper diffuser chambers to tailwater (JDA), use of orifice blockers to sustain pools above weirs at key points to keep fish is water for salvage, more equipment and personnel, start salvage early in the week.

References

Moser, M.L., D.A. Ogden, B.J. Burke, and C.A. Peery. 2005. Evaluation of a lamprey collector in the Bradford Island makeup water channel, Bonneville Dam, 2003. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

2004

Passage Improvement Design and Implementation

1. Lamprey passage systems (LPS) - Bradford Island AWS channel:
   - System was extended to include PIT readers, resting boxes a volitional egress section to forebay;
   - 7,500 adults (21% of Bradford Island passage) passed via LPS from mid-June to mid-September;
   - 25% of tagged fish released in AWS passed via LPS; median time of 1 hour from first rest box to exit.
2. Adult experimental fishway - LPS collection test ramp evaluations found:
   - Passage efficiency (88% +) did not differ among flows but mean passage times were considerably faster with reduced flows.
   - Passage efficiency (90% +) did not differ among flows but mean passage times were slowest (0.84 hr) for 35° ramp that 45° and 60° slope ramps (0.31 and 0.40 hrs, respectively).
   - Adding adults above the ramp as a potential olfactory attractant did not improve passage.
3. Washington shore ladder exit area vertical slot adult PIT installation:
   - Installation designs incorporated lamprey features; chamfering of right angle corners, reduction of gap tolerances for antennae inserts, and less roughness for concrete.

References

Keefer, M.L., W.R. Daigle, C.A. Peery, and M.L. Moser. 2008. Adult Pacific lamprey bypass structure development: tests in an experimental fishway, 2004-2006. Technical Report 2008-10. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

Moser, M.L., D.A. Ogden, D.L. Cummings, and C.A. Peery. 2006. Development and evaluation of a lamprey passage structure in the Bradford Island auxiliary water supply channel, Bonneville Dam, 2004. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

2005

Study Results

1. Half-duplex PIT tag readers were installed at Bradford Island auxiliary water channel, at the entrance to BON Washington shore ladder, and at MCN and IHR ladder entrances and exits. Initial efforts involved testing detection rates and refining systems.
2. PIT data (Table A-1):

Table A-1. Adult lamprey reach conversion estimates for 2005. All estimates should be considered minimums due to incomplete coverage at all monitored dams and removal of monitoring sites in late summer.

Site	Minimum past (*n*)	Detected (%)	Reach conversion Reach	(%)
Release	841		Release-Bonneville top	53.0%
Bonneville top	446	95.7%	Release-McNary	6.3%
McNary	53	86.8%	Release-McNary top	4.8%
McNary top	40	80.0%	Release-Ice Harbor	1.5%
Ice Harbor	13	100%		
Ice Harbor top[1]	2	100%	Bonneville top-McNary	11.9%
			Bonneville top-McNary top	9.0%
			Bonneville top-Ice Harbor	2.9%
			McNary-McNary top	75.5%
			McNary top-Ice Harbor	32.5%

[1] No upstream site to assess missed detections

3. Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish (mean weights of 570 vs. 508 grams). Condition factor declined as fish migrated from BON to MCN and ICE.
4. MCN and IHR study:
   - 40 dual tagged (radio and PIT) released below MCN, 20 released below IHR;
   - 52.5% returned to MCN tailrace, 45% returned to IHR tailrace;
   - 61.9% (13 of 21) dam passage efficiency at MCN; 33.3% (3 of 9) at IHR.
   - Fish had problems passing ladder areas similar to other dams; entrances, transition sections, and exit areas associated with auxiliary water channels.

<u>Passage Improvement Design and Implementation</u>

1. Lamprey passage systems (LPS) - Bradford Island AWS channel:
   - No changes in passage metrics were found between 2 flow levels tested in the LPS;
   - 8,889 (29% of Bradford Island passage) lamprey passed using the LPS;
   - 42% of tagged fish released in AWS passed via LPS; median passage time through complete LPS was 1.5 hrs.
2. Lamprey passage systems (LPS) – Washington shore ladder entrance:
   - Prototype LPS installed downstream in late August of entrance in tailrace to evaluate attraction near but outside of ladder.
3. Adult experimental fishway - LPS collection test flume evaluations found:
   - When presented with 3 alternative choices (left wall, mid channel, and right wall) with varying flow rates, lamprey preferred routes adjacent to walls; increasing flows differentially to mid channel could increase its use but with increased passage times.
4. Diffuser grating:
   - In NMFS vertical gap size volitional passage testing, 100% of adult lamprey (mean length 67.5 cm) passed 2.5 cm gaps, 47% through 2.2 cm gap, and none passed 1.9 cm gaps.

     Cordie. USACE Memorandum for the Record: Lamprey protection for The Dalles and John Day Dam fishways. 21 June 2003.

References

Cummings, D. L., W. R. Daigle, C. A. Peery. 2008. Direct and indirect effects of barriers to migration – Pacific lamprey at McNary and Ice Harbor dams in the Columbia River Basin. Report for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla WA.

Daigle, W.R., M.L. Keefer, C.A. Peery, and M.L. Moser. Evaluation of adult Pacific lamprey passage rates and survival through the lower Columbia River and hydrosystem: 2005-2006 PIT-tag studies. Technical Report 2008-12. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

Keefer, M.L., W.R. Daigle, C.A. Peery, and M.L. Moser. 2008. Adult Pacific lamprey bypass structure development: tests in an experimental fishway, 2004-2006. Technical Report 2008-10. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

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Moursund, R.A, and M.D. Bleich. 2006. The use of PIT tags to evaluate the passage of juvenile Pacific lamprey (*Lampetra tridentata*) at the McNary Dam juvenile bypass system, 2005. Final Report to U.S. Army Corps of Engineers, Walla Walla District, Walla Walla WA.

2006

Study Results

1. PIT conversions:
   a. Half duplex PIT systems added to tops of ladders at BON2, TDA, and JDA.

   b. PIT conversion and detection data (Table A-2).

   c. Median travel times from dam top of ladder to dam top of ladder were:
      - 5.1 days BON – TDA
      - 4.1 days TDA – JDA
      - 12.8 days JDA – MCN

   d. Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish (mean weights of 541 vs. 504 grams).

   e. Eleven fish tagged in 2005 over-wintered and were detected at dams in 2006; 5 at BON.

2. Hydraulic analysis of adding lamprey PIT antenna in the exit area of JDA north ladder found no problems; a increased head differential of 0.01 to 0.02 feet depending on forebay elevation with no measurable effects downstream.

Table A-2. Adult lamprey reach conversion estimates for 2006. All estimates should be considered minimums.

Site	Minimum past (*n*)	Detected (%)	Reach conversion Reach	(%)
Release	2000		Release-Bonneville	50.1%
Bonneville	1001	86.6%	Release-Bonneville top	41.1%
Bonneville top	822	79.3%		
The Dalles top	558	69.4%	Bonneville-Bonneville top	88.1%
John Day top	381	99.0%		
McNary	130	96.2%	Bonneville top-The Dalles top	67.9%
McNary top	80	75.0%	Bonneville top-John Day top	46.4%
Ice Harbor	29	100.0%	Bonneville top-McNary	15.8%
Ice Harbor top[1]	5	100.0%	Bonneville top-McNary top	9.7%
			Bonneville top-Ice Harbor	3.3%
			Bonneville top-ice Harbor top	0.6%
			The Dalles top-John Day top	68.3%
			The Dalles top-McNary top	14.3%
			The Dalles top-Ice Harbor	5.2%
			John Day top-McNary	34.1%
			John Day top-McNary top	21.0%
			John Day top-Ice Harbor	7.6%
			McNary-McNary top	61.5%
			McNary top-Ice Harbor	36.3%

[1] No upstream site to assess missed detections

3. MCN and IHR study:
   - 40 dual tagged (radio and PIT) released below MCN, 20 released below IHR;
   - 45% returned to MCN Dam, 65% to IHR Dam;
   - 61% (11 of 18) dam passage efficiency at MCN, 77% (10 of 13) at IHR;
   - Fish had problems passing ladder areas similar to other dams; entrances, transition sections, and exit areas associated with auxiliary water channels;
   - Condition factor declined as fish migrated from BON to MCN and ICE.

<u>Passage Improvement Design and Implementation</u>

1. Lamprey passage systems (LPS) - Bradford Island AWS channel:
   - A two-ramp design collection system was installed for the AWS channel LPS;
   - 14,975 (34% of Bradford Island passage) lamprey passed using the LPS.
2. Adult experimental fishway - LPS collection test ramp evaluations found:
   - Passage behavior, efficiency, and times were not altered or different by the addition of either or 2 rest box design;
   - Using water jets, air bubbles, and waterfall action to attract fish to base of ramp did significantly improve passage.

3. Diffuser grating:
   - In NMFS dewatering simulations, 86% of adult Pacific lamprey (mean length 67.5 cm) passed through a grating with 2.5-cm bar spacing but none passed through a 1.9-cm bar spacing.
   - A ¾-inch (1.9 cm) gap diffuser grating was installed at pool 16 just above the JDA north ladder count station. No adult lamprey were found beneath it during winter dewatering even though it has a history of stranding.

References

Cummings, D. L., W. R. Daigle, C. A. Peery. 2008. Direct and indirect effects of barriers to migration – Pacific lamprey at McNary and Ice Harbor dams in the Columbia River Basin. Report for U.S. Army Corps of Engineers, Walla Walla District, Walla Walla WA.

Daigle, W.R., M.L. Keefer, C.A. Peery, and M.L. Moser. Evaluation of adult Pacific lamprey passage rates and survival through the lower Columbia River and hydrosystem: 2005-2006 PIT-tag studies. Technical Report 2008-12. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Report for U.S. Army Corps of Engineers, Portland District, Portland OR.

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Moser, M.L., H.T. Pennington, and J.M. Roos. 2007. Grating size needed to protect adult lamprey in the Columbia River Basin. Final Report to U.S. Army Corps of Engineers, Portland District, Portland OR.

2007

1. Summary of 1997-2002 and 2007 radio-tagged fish data for BON, TDA, and JDA (Tables A-3, A-4, and A-5):
   - Fish tagged in 2007 were considerably smaller;
   - 75% TDA passage efficiency. 29% fallback fish (highest percent ever);
   - 82% (9 of 11) JDA passage efficiency**;** 2 (22%) fallback fish; both entered the John Day River.

Table A-3. Number of lamprey released below Bonneville Dam from 1997-2002 and in 2007; mean lamprey length and weight, number of lamprey detected at Bonneville Dam, proportion of tagged fish recorded passing the dam (% passage efficiency), the number of fish falling back over the dam (%), and the median travel time (days) to pass the dam. Pre-2007 data from Moser et al., 2002, 2003, 2004, and 2005.

	1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2007*
# Released	147	205	199	299	298	201	398
Mean Length (cm)	70	70	71	70	77	72	66
Range	60-80	59-79	65-78	62-80	62-82	60-80	53-86
Mean Weight (g)	-	545	571	570	588	612	466
Range	> 450	420-830	475-755	405-825	380-880	440-790	256-810
Detected at Bonneville	88%	89%	92%	87%	93%	96%	68%
Passage Efficiency*	38%	40%	45%	47%	46%	48%	31%
Fallback	< 1%	< 1%	2%	1%	-	1%	28%
Median Dam Passage	4.9 d	5.7 d	5.5 d	4.4 d	11.0 d	9.0 d	3.0 d

* navigation lock not monitored in 2007.

Table A-4. Number of unique radio-tagged lamprey that passed through each area within each fishway at Bonneville Dam in 1997-2002 (as reported in Moser et al, 2005) and in 2007. Passage efficiency (number of lamprey that passed through the area/number that approached x 100) is in parenthesis.

	Year						
Area	1997	1998	1999	2000	2001	2002	**2007**
				PH1			
Entrance	47 (60%)	78 (80%)	63 (72%)	97 (74%)	71 (74%)	54 (76%)	**44 (76%)**
Collection	36 (77%)	63 (81%)	55 (87%)	85 (88%)	59 (83%)	41 (76%)	**29 (66%)**
Transition	32 (89%)	61 (97%)	50 (91%)	82 (96%)	58 (98%)	38 (93%)	**26 (90%)**
Ladder	27 (78%)	59 (97%)	49 (98%)	71 (86%)	52 (90%)	35 (92%)	**26 (100%)**
Count station	21 (78%)	37 (63%)	38 (78%)	63 (89%)	45 (86%)	25 (71%)	**25 (83%)**
				PH2			
Entrance	50 (69%)	78 (81%)	87 (80%)	109 (78%)	100 (85%)	157 (77%)	**114 (67%)**
Collection	30 (60%)	50 (64%)	79 (79%)	63 (72%)	94 (60%)	84 (77%)	**66 (58%)**
Transition	25 (83%)	32 (64%)	43 (54%)	43 (68%)	72 (77%)	54 (64%)	**30 (45%)**
Ladder	24 (96%)	29 (91%)	43 (100%)	38 (88%)	71 (99%)	52 (96%)	**30 (100%)**
Count station	21 (88%)	25 (86%)	35 (81%)	32 (84%)	57 (80%)	42 (81%)	**39 (98%)**
				Spillway			
Entrance	33 (54%)	35 (44%)	41 (57%)	69 (60%)	55 (65%)	66 (62%)	**57 (54%)**
Collection	19 (58%)	21 (60%)	22 (54%)	63 (91%)	53 (96%)	59 (89%)	**51 (89%)**
Transition	14 (74%)	12 (57%)	11 (50%)	37 (59%)	39 (74%)	37 (63%)	**26 (51%)**
Ladder	11 (79%)	11 (92%)	10 (91%)	32 (86%)	36 (92%)	35 (95%)	**26 (100%)**
Count station	6 (54%)	9 (82%)	8 (80%)	24 (75%)	26 (72%)	25 (71%)	**32 (94%)**

*count window efficiencies is the number detected on the antenna above the count window / number detected on the antenna downstream of the count window

Table A-5. Number of unique radio-tagged lamprey that passed through each area within each fishway at The Dalles Dam in 1997-1998, 2000-2002 (as reported in Moser et al, 2005), and in 2007. Passage efficiency (number of lamprey that passed through the area/number that approached x 100) is in parenthesis.

	Year					
Area	1997	1998	2000	2001	2002	**2007**
			East fishway			
Entrance	41 (85%)	22 (73%)	52 (87%)	71 (89%)	46 (78%)	**18 (83%)**
Collection	34 (83%)	21 (95%)	47 (90%)	67 (94%)	43 (93%)	**20 (100%)**
Transition	27 (79%)	12 (57%)	41 (87%)	52 (78%)	29 (67%)	**17 (76%)**
Ladder	24 (89%)	12 (100%)	37 (97%)	48 (96%)	28 (100%)	**[1]13 (100%)**
Count station	24 (100%)	12 (100%)	37 (97%)	48 (96%)	28 (100%)	**n/a**
			North fishway			
Entrance	18 (67%)	15 (94%)	44 (94%)	34 (77%)	32 (100%)	**15 (75%)**
Collection	14 (78%)	15 (100%)	42 (95%)	34 (100%)	32 (100%)	**13 (100%)**
Transition	11 (79%)	13 (87%)	36 (86%)	24 (71%)	25 (78%)	**13 (62%)**
Ladder	11 (100%)	12 (92%)	33 (92%)	22 (92%)	18 (72%)	**[1]8 (100%)**
Count station	11 (100%)	12 (100%)	33 (100%)	22 (100%)	18 (100%)	**n/a**

[1] Because the count stations were not monitored in 2007, the ladder estimate was calculated from the last transition pool record to the top-of-ladder exit.

Study Results

1. Nighttime entrance velocity reduction test:

   Passage efficiency increased at both the north and south entrances with velocities reduced to approximately 4 fps with 0.5 ft of head differential; however, increases in the total number of fish entering only occurred at the north entrances which had higher velocities under normal conditions. The south entrances showed a net reduction in the number of fish entering as a result of a reduction in attraction to the entrance, likely related to the reduced flows. At the north entrance, where normal flow velocities are considerably higher than the south entrances, both entrance efficiency and numbers entering increased.

PH2 South	**HI Flow**	**LO Flow** (0.5 ft head differential)
Entrances	26	10
Approaches	49	15
Ent Efficiency	**53%**	**67%**
PH2 North		
Entrances	5	16
Approaches	65	36
Ent Efficiency	**8%**	**44%**

2. PIT data:
   a. Reach conversions and detection rates (Table A-6):

Table A-6. Adult HDX-PIT tagged lamprey reach conversion estimated for 2007. All estimates should be considered minimums. 'Top' refers to top-of-ladder antenna sites.

Site	Minimum past (*n*)	Detected (%)	Reach conversion Reach	(%)
Release	757		Release-Bonneville	62.9%
Bonneville	476	93.7%	Release-Bonneville top	51.9%
Bonneville top	393	86.5%	Release-The Dalles	37.1%
The Dalles	281	96.1%	Release-The Dalles top	32.5%
The Dalles top	247	81.7%	Release-John Day top	17.0%
John Day top	129	97.7%	Release-McNary	6.9%
McNary	52	100.0%	Release-McNary top	4.6%
McNary top	35	94.3%	Release-Ice Harbor	1.1%
Ice Harbor	8	100.0%	Release-Ice Harbor top	0.7%
Ice Harbor top[1]	5	100.0%		
			Bonneville-Bonneville top	82.6%
			Bonneville top-The Dalles top	62.8%
			Bonneville top-John Day top	32.8%
			Bonneville top-McNary top	8.9%
			Bonneville top-ice Harbor top	1.3%
			The Dalles top-John Day top	52.2%
			The Dalles top-McNary top	14.2%
			The Dalles top-Ice Harbor top	2.0%
			John Day top-McNary top	27.1%
			John Day top-Ice Harbor top	3.9%
			McNary top-Ice Harbor top	14.3%

[1] No upstream site to assess missed detections

b. Median travel times from dam top of ladder to dam top of ladder were:
- 4.0 days BON – TDA
- 4.3 days TDA – JDA
- 8.8 days JDA – MCN

c. Radio-tagged based conversions were much lower than PIT based conversions pointing to possible radio-tag effects or failures.

d. Lamprey that successfully migrated to upstream sites were significantly larger than unsuccessful fish.

3. Preliminary 2007 ladder window counts at BON and TDA dams tabulated by video at night and by counters during the day (BON 1 counts through Aug 7, BON 2 counts through Sept 7, TDA counts through Sept 3):

Ladder	Night	Day	Total	Night %
TDA N	3,137	3,246	6,383	49.1
TDA E	1,008	2,545	3,553	28.4
BON 2*	-439	9,931	9,492	< 0
BON 1*	18,352	8,430	26,782	68.5

* BON 1 peaked in July with a 12,398 night video count; BON 2 count was not always negative with a night video tally of 5,294 in July.

4. Pheromone tests:
   a. NMFS built a Y-maze and did initial testing of the effects of current velocity, ambient larval pheromone, and ammocoete washings on lamprey movements. Final research results and report pending.

5. MCN study:
   - 59 dual tagged (radio and PIT) released below MCN;
   - 28% returned MCN Dam;
   - 86% (12 of 14) dam passage efficiency at MCN;
   - Sampled fish were smaller on average the in previous studies.

Passage Improvement Design and Implementation

1. Lamprey passage systems (LPS) - Bradford Island AWS channel:
   - 7,387 (38% of Bradford Island passage) lamprey passed using the LPS.
2. Lamprey passage systems (LPS) – Washington shore AWS channel:
   - A dual ramped LPS similar to the final Bradford Island design was installed by late June; 2,517 lamprey passed via this route.
3. JDA north ladder modifications:
   The new exit section and count station were evaluated in a 1:5 scale physical model at ENSR Corporation's laboratory. There were five lab site visits; two were with agency representatives during which the final configuration design was established. The proposed changes to the upper ladder section that are expected to aid lamprey are summarized below:

   - Remove 1st (upstream) vertical slot and sill baffle in forebay transition section.
   - Modify 2nd baffle (remove 2.5-foot sill and add orifice) in forebay transition.
   - Remove all 18 serpentine weirs + holey wall and replace with 23 lamprey friendly JDAS-type weirs with 15- to 18-inch vertical slots and 18- x 18-inch orifices.
   - Smooth contiguous floor surface through all orifices from count station to exit.
   - Raise Count Station floor one foot to match invert at new weir 1 (holey wall site).
   - Add 12-inch-wide metal strip over left side of floor diffuser 16.
   - Remove 23-inch ramp through count slot and lower viewing window.
   - Replace antiquated crowder, adding new transition farings and horizontal vanes.

4. Diffuser grating:
   - In-ladder inspections found most ladder floor diffuser gratings are not supported adequately to hold required load and will need modification.
   - Intake trash racks leading to diffuser pools will also need to be replaced with ¾-inch gaps if diffusers are changed to prevent debris build up below diffusers.
   - BON, TDA, and JDA develop list of diffuser gratings with history of lamprey strandings and mortalities.

5. TDA and JDA put together list of potential minor ladder modification to assist lamprey passage based on structural inspections of dewatered ladders. See Appendix C.

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2008

Study Results

1. Lamprey Passage Systems (LPS) - Preliminary results:
   - 6,441 (42% of Bradford Island passage) lamprey passed using the LPS;
   - 1,985 lamprey passed via the Washington shore ladder LPS;
   - 12% of all tagged fish passed BON using an LPS.

2. PIT data:
   - Twice as many PIT tagged fish made it from release to the top of BON dam compared to radio-tagged fish (26% vs. 52%), 12% more from top of BON to top of TDA, and 23% more from top of TDA to top of JDA, indicating radio-tagging negatively effects adult performance . This tagging effect and smaller median sized fish being captured at BON makes it more difficult to assess relative passage improvements related to modifications. As was found over the last several years, larger fish were more likely to pass farther upstream.

3. Nighttime entrance velocity reduction evaluation (0 feet head):
   - PH2 fishway velocities at Bonneville Dam were manipulated by placing fish units on standby to float debris off the trash racks. Shutting off fish units occurred only at night (typically between 2200 and 0430) to minimize potential effects on adult salmonid passage.

This created 0 feet of head dif and minimum velocities at the entrances. Passage during the 0 head dif condition was compared to nights with normal head. Preliminary results indicate that passage efficiency may be negatively affected by this operation.

4. Radio-tag study results (Table A-7):

Table A-7. Number of lamprey released below Bonneville Dam from 1997-2007 and in 2008; mean lamprey length and weight, number of lamprey detected at Bonneville Dam, proportion of tagged fish recorded passing the dam (% passage efficiency), the number of fish falling back over the dam (%), and the median travel time (days) to pass the dam. Pre-2008 data from Moser et al., 2002, 2003, 2004, and 2005 and Johnson et al., 2009.

	1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2007*	*2008*
# Released	147	205	199	299	298	201	398	595
Mean Length (cm)	70	70	71	70	77	72	66	66
Range	60-80	59-79	65-78	62-80	62-82	60-80	53-86	49-79
Mean Weight (g)	-	545	571	570	588	612	466	464
Range	> 450	420-830	475-755	405-825	380-880	440-790	256-810	284-706
Detected at Bonneville	88%	89%	92%	87%	93%	96%	68%	74%
Passage Efficiency*	38%	40%	45%	47%	46%	48%	31%	32%
Fallback	< 1%	< 1%	2%	1%	-	1%	28%	17%
Median Dam Passage	4.9 d	5.7 d	5.5 d	4.4 d	11.0 d	9.0 d	3.0 d	3.8 d

* navigation lock not monitored in 2007 and 2008.

5. MCN study:
   - Study results pending report.

<u>Passage Improvement Design and Implementation</u>

1. JDA north ladder modifications:
   - Exit section modifications move to final DDR phase;
   - Entrance section design development move to alternative evaluation report phase and includes many lamprey features; fixed weir, improved AWS water distribution, floor velocity reducing structures, smaller gapped diffusers in all alternatives.

2. Diffuser grating:
   - New designed ¾-inch diffuser gap grating developed that does not alter flows or ladder hydraulics;
   - Concerns about large quantities of galvanized steel grating being replace at one time leads to adding powder coating to new grating design criteria.

3. Cascade Island entrance modifications:
   - Developed designs for a prototype lamprey-friendly modified entrance; fixed weir, floor velocity reducing structures, and a tailwater to forebay LPS to be installed and tested in 2009.

4. Bradford Island LPS:
   - As-built drawing of Bradford Island LPS completed and available.

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Appendix B
Bonneville Dam Prioritization for Diffuser Grating Replacement

If ¾-inch gap grating is determined to be acceptable for use as diffuser grating, the project would like to replace all diffuser grating in the following order of importance:

1. WA shore ladder between weirs 33 and 19. We have observed lamprey caught under gratings in this section after dewatering.
2. The entrance of Cascades Island ladder. Lamprey observed under grating during ROV inspection. FG 6-16 through FG 6-20. Many tagged lamprey observed in this ladder according to NOAA lamprey researchers.
3. The entrance of B-Branch ladder. FG 3-29 through FG 3-33.
4. Cascades Island diffusers FG 6-5 through FG 6-15.
5. B-Branch diffusers FG 3-18 through FG 3-28.
6. A-branch diffusers FG 3-3 through FG 3-9.
7. Downstream of weir 19 and triangle section at WA shore.
8. Powerhouse 2 collection channel.
9. Powerhouse 1 collection channel.

Minimizing the gaps between any structure such as diffuser shafts and grating should be a priority when designing new grating. Lamprey traveling along walls could enter below grating at the existing gaps as water levels drop during dewatering.

Appendix C
Proposed Lamprey Passage Improvement List for The Dalles and John Day

The Dalles East

1. Grating – All 1" gap. New grating also 1" gap. Need to determine if ¾" can be used effectively against wall where lamprey travel. New 1" gap grating on site to be installed in junction pool and east entrance. Reducing gap requires hydraulic analysis (velocity and volume), structural analysis and risk analysis in the event of zebra/quagga mussels.

Prioritization for ¾" installation:

a. Lower east #L6 thru L15 and north #N5 thru N15 ladder grating exposed during dewatering.
b. Junction pool #J1 thru J8 and L1 thru L5.
c. East #E1-1 thru E1-6, West #E2-1 thru E2-4, South #E3-1 thru E3-8 and North #1-A thru 1-H and #N-1 thru N-5 entrance equal priority value.

2. Junction pool bulkhead stub walls – Used to prevent debris accumulation under bulkhead slot. Lamprey commonly found in this area during dewatering. Bulkheads not used here for at least 15 years. Options: ramp or removal. Picture below.

3. Step up on first ladder weir – Needs a ramp; will be a challenge due to grating. Could be chamfered. Picture below.

4. Step up on 180 bend upstream weir – Needs ramp. Can be done by Project during winter outage. No picture.

5. Weirs 154-147 – orifices raised various distance from floor. Options: new design or modify with ramp. Worn seals to be replaced to prevent lamprey entry into guide and potential crushing. Picture below.

6. Entrance and exit weir guides – Provide hiding place for lamprey. Potential crushing when weir makes adjustments. Lamprey observed pinched by lift beam extension. Option: install brush to deter lamprey entry. No picture.

7. South entrance depression – 3' floor depression immediately upstream of weirs. Option: ramp upstream edge of pool. Picture below.

8. Collection channel depressions – Approximately 20 floor depressions that are 3'-deep in channels. Even floor along sides may allow easier lamprey passage by these areas.

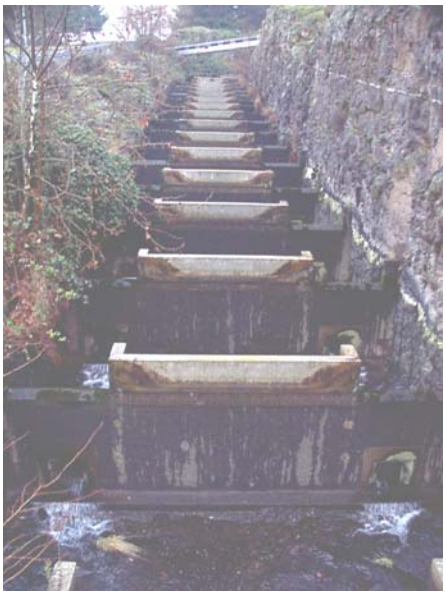
The Dalles North

1. Grating – Same as above.

2. Lower weir pools with rock pools – Floor raise up to 3' to weir orifice. Option: ramp. Would require additional pumping for remove water from pool. Picture below.

3. North entrance depression – Same and south entrance depression above.

4. Rock channel in ladder – Not smooth, but may not be detrimental to lamprey passage. Routinely find lamprey in these areas during dewatering. May also be beneficial lamprey staging area. Picture below.



5. Count station diffuser grating – Due for replacement. No evidence of lamprey trapping during dewatering. Option: install design change along wall.

6. Entrance weir guides – same as above.

John Day South

1. Grating – Same as above. Prioritization for ¾" grating:

   a. South ladder upper diffuser #17.
   b. South ladder dewater exposed grating #9 to #16.
   c. North ladder dewater exposed grating #7 to #15.
   d. South entrance and south collection channel grating.
   e. Remainder of collection channel.
   f. Remainder of north fishway.

2. South entrance depression – Immediately upstream of SE1 weir. Approximately 12' depression. Option: round upper edge. Ramp not feasible due to grating and distance.

3. Wall diffuser – Chain link grating. No longer used. Should be plated over. Picture below.

4. Upper diffuser grating – 1” gap. Known lamprey trapping area. Change to ¾” same as north.

5. New exit flow control weirs hydraulic sills – Option: design change.

6. Exit stub wall – 6” raise in floor under road deck located at half duplex antennae. Option: ramp. Picture below.

7. Entrance weir guides – same as above.

John Day North

1. Grating - same as above.

2. Upper diffuser grating – Changed to ¾". Seemed to be effective in preventing lamprey entrapment. Floor raise approx 1' still exists at first upstream weir. Grating for the south upper diffuser is comparable to the north and will be replaced with ¾".

3. Exit hydraulic sills – Option: design change. Picture shows sills open. Normal operate with sills closed.

4. Exit stub wall – same as above. Picture below.

5. Orifice raised upstream of count station – Option: chamfer orifice floor. Picture below.

Appendix D
NWW Dams Prioritization List

12-April-2009

Adult Pacific Lamprey Passage
NWW Dewatered Fish Ladder Inspections
2007-2009
U.S. Army Corps of Engineers
Walla Walla District

Background

Pacific lamprey have declined in numbers since the 1960s. Scientists have attributed the decline to several causes, including pollution, habitat loss, irrigation, intentional removal, ocean conditions, and dam passage. This decline has lead to significant regional concern regarding lamprey populations in the Columbia River Basin. In 1993, the Oregon Department of Fish and Wildlife designated Pacific lamprey at risk of being listed as threatened or endangered. Columbia River treaty tribes have repeatedly voiced concern about the decline of Pacific lamprey, a culturally important species.

The goals of Pacific lamprey passage studies within the Northwestern Division of the USACE are to provide the necessary information on fish passage behavior and structural design of facilities to improve lamprey passage through the Federal Columbia River Power System (FCRPS) to a level such that it does not negatively affect population viability. A 10-year plan is being developed to address lamprey passage on the Lower Columbia and Snake River Dams. Specifically in FY08, final implementation at Bradford Island Lamprey Passage System is being completed, nighttime flow reduction is being implemented in order to reduce velocities for a second year, a Bonneville flume is assisting in design of entrance at Cascade Island Ladder and a team is investigating system-wide, ¾-inch grating replacement.

Purpose of Dewatered Ladder Inspections

Passage of adult Pacific lamprey through existing fish ladders on lower Columbia and Snake River dams is problematic. The ladders, designed primarily for salmonid passage, present various obstacles and conditions which affect efficient lamprey passage. Adult Pacific lamprey have lower swimming performance relative to adult salmonids, and areas within the adult fish ladders that adult Lamprey have difficulty passing include: ladder entrances, sections of the ladder floor with diffuser gratings, high velocity orifices meant to attract and pass adult salmonids.

The purpose of dewatered ladder inspections is to identify potential lamprey passage problem areas visually, as ladders are only dewatered during the winter for repair and maintenance. Additionally the USACE is investigating the potential replacement of diffuser gratings with new lamprey-friendly gratings to aid ladder passage success. Thus, these inspections are being used to develop diffuser grating replacement priorities as well as prioritize other improvements like rounding orifice corners, building lamprey ramps where submerged orifices or vertical slot orifice are not flush with the fishway floor. The following is a list of each project that was inspected with photos and ladder

maintenance schedules to aid the USACE in development and implementation of passage improvements for the benefit of Pacific lamprey.

McNary Dam - The Oregon Shore Fishway

Upper ladder tilting weir submerged orifices: sharp angles with no attachment points for lamprey. Recommend welding or bolting plate metal around all sides of the orifice up from the floor to aid lamprey passage. Recommend building "moveable" orifice ramps that can slid back and forth with the weirs (Figure D-1).

a. Old juvenile fish bypass flume-potential location for lamprey to enter. It is unknown at this time weather this old flume is a problem location or weather it aids passage of lampreys. Recommend monitoring the exit (entrance) with RT and/or HD-PIT to determine effectiveness. Need to get drawings of this to verify where the exit is and what the flume design looks like. Need regional discussion of whether this system can be closed to exclude adult lamprey (Figure D-2).

b. Diffuser grating upstream of orifices: recommend replacement of grating with new lamprey friendly grating in all locations where grating is immediately upstream of a submerged orifice. Alternatively, construct lamprey "runways" or plate metal strips be bolted to the grating from the orifice to the wall of the ladder to aid lamprey attachment points immediately upstream of submerged orifices. These runways have already been tested at Bonneville Dam and could be implemented at NWW projects (Figure D-3).

c. Diffuser grating in the collection channel, junction pool, and transition pools: recommend replacing with new lamprey friendly gratings.

d. Fishway entrances: recommend development of key-hole weirs with low water velocity passage structures leading to LPS structures to aid with lamprey entrance efficiencies.

e. Nighttime ladder entrance velocities: recommend further development and testing of reducing entrance velocities at night to aid lamprey passage for FY09 and FY10.

Figure D-1. Tilting weirs at McNary north and south shore ladders.

Figure D-2. Old juvenile salmon bypass flume at the McNary Oregon shore fish ladder.

Figure D-3. Diffuser grating above submerged orifice at the McNary Oregon shore fish ladder.

Ice Harbor Dam

a. Diffuser grating upstream of orifices: recommend replacement of grating with new lamprey friendly grating in all locations where grating is immediately upstream of a submerged orifice. Alternatively, construct lamprey "runways" or plate metal strips be bolted to the grating from the orifice to the wall of the ladder to aid lamprey attachment points immediately upstream of submerged orifices. These runways have already been tested at Bonneville Dam and could be implemented at NWW projects.

b. Diffuser grating in the collection channel, junction pool, and transition pools: recommend replacing with new lamprey friendly gratings.

c. Fishway entrances: recommend development of key hole weirs with low water velocity passage structures leading to LPS structures to aid with lamprey entrance efficiencies.

d. Nighttime ladder entrance velocities: recommend further development and testing of reducing entrance velocities at night to aid lamprey passage.

Figure D-4. Ice Harbor Dam fishway submerged orifice with diffuser grating upstream of the orifice. Half-duplex PIT antenna configuration also illustrated.

Lower Monumental Dam

a. Diffuser grating upstream of orifices: recommend replacement of grating with new lamprey friendly grating in all locations where grating is immediately upstream of a submerged orifice. Alternatively, construct lamprey "runways" or plate metal strips be bolted to the grating from the orifice to the wall of the ladder to aid lamprey attachment points immediately upstream of submerged orifices. These runways have already been tested at Bonneville Dam and could be implemented at NWW projects.

b. Diffuser grating in the collection channel, junction pool, and transition pools: recommend replacing with new lamprey friendly gratings.

c. Fishway entrances: recommend development of key hole weirs with low water velocity passage structures leading to LPS structures to aid with lamprey entrance efficiencies.

d. Nighttime ladder entrance velocities: recommend further development and testing of reducing entrance velocities at night to aid lamprey passage.

e. Submerged orifices: recommend building lamprey ramps for orifices that are not flush with the floor of the fishway. Generally, these types of orifices are only in the upper 1/3rd (5 or 6 weirs) of the ladder (Figures D-5 and D-6).

f. Fish count window picketed leads: recommend lifting picketed leads off the fishway floor by 2 inches during the fish passage season to aid in lamprey passage (Figure D-7).

Figure D-5. Lower Monumental fish ladders near the top of the ladder with orifices and slots off the floor of the fishway.

Figure D-6. Lower Granite fish ladder near the top of the ladder. Orifices and slots off the floor of the fishway.

Figure D-7. Typical fish count window entrance and picketed leads.

Little Goose Dam

a. Diffuser grating upstream of orifices: recommend replacement of grating with new lamprey friendly grating in all locations where grating is immediately upstream of a submerged orifice. Alternatively, construct lamprey "runways" or plate metal strips be bolted to the grating from the orifice to the wall of the ladder to aid lamprey attachment points immediately upstream of submerged orifices. These runways have already been tested at Bonneville Dam and could be implemented at NWW projects.

b. Diffuser grating in the collection channel, junction pool, and transition pools: recommend replacing with new lamprey friendly gratings.

c. Fishway entrances: recommend development of key hole weirs with low water velocity passage structures leading to LPS structures to aid with lamprey entrance efficiencies.

d. Nighttime ladder entrance velocities: recommend further development and testing of reducing entrance velocities at night to aid lamprey passage.

e. Submerged orifices: recommend building lamprey ramps for orifices that are not flush with the floor of the fishway. Generally, these types of orifices are only in the upper 1/3rd (5 or 6 weirs) of the ladder.

f. Fish count window picketed leads: recommend lifting picketed leads off the fishway floor by 2 inches during the fish passage season to aid in lamprey passage.

Lower Granite Dam

a. Diffuser grating upstream of orifices: recommend replacement of grating with new lamprey friendly grating in all locations where grating is immediately upstream of a submerged orifice. Alternatively, construct lamprey "runways" or plate metal strips be bolted to the grating from the orifice to the wall of the ladder to aid lamprey attachment points immediately upstream of submerged orifices. These runways have already been tested at Bonneville Dam and could be implemented at NWW projects.

b. Diffuser grating in the collection channel, junction pool, and transition pools: recommend replacing with new lamprey friendly gratings.

c. Fishway entrances: recommend development of key hole weirs with low water velocity passage structures leading to LPS structures to aid with lamprey entrance efficiencies.

d. Nighttime ladder entrance velocities: recommend further development and testing of reducing entrance velocities at night to aid lamprey passage.

e. Submerged orifices: recommend building lamprey ramps for orifices that are not flush with the floor of the fishway. Generally, these types of orifices are only in the upper 1/3rd (5 or 6 weirs) of the ladder.

f. Fish count window picketed leads: recommend lifting picketed leads off the fishway floor by 2 inches during the fish passage season to aid in lamprey passage.

Appendix E
CRITFC Comments and How Addressed

DRAFT
Memorandum

To: Natalie Richards, David Clugston, Derek Fryer, Corps of Engineers
From: Bob Heinith, Hydro Program Coordinator, CRITFC
Date: February 20, 2009

RE: Comments on Corps' Draft Pacific Lamprey Passage Improvements Implementation Plan: 2008-2018

General Comments

The 10 year Plan has been extensively rewritten incorporating most of the region's comments. Text had been expanded with more graphics and several appendices have been added to address specific areas such as future planning and a clear and concise history of lamprey research and implementation actions. We appreciate your comments and commitment to making meaningful improvements to passage at FCRPS dams for Pacific lamprey.

As called by the Columbia Basin Accords ("MOAs"), the Corps'draft 10 year lamprey implementation plan is much appreciated by CRITFC and its member tribes as a very good step in the right direction to improve lamprey passage that is considered the number one issue for restoration. We appreciate the concept of a Corps' "lamprey team" to address the complex lamprey passage issues. We also appreciate and are impressed by the Corps technical staffs who have demonstrated: 1) expediting the implementation of new, creative approaches to lamprey passage and, 2) making significant efforts to coordinate these actions and future planning with CRITFC and tribal lamprey staff.

With respect to lamprey passage at the Corps dams, the principle comment that we continue to hear from the tribes is that there are not enough structural and operational actions in the near term for improvements at upriver Corps dams. The severe depressed status of lamprey populations in the Columbia River Basin warrants these actions. While we hope that some of the federal stimulus funding can be used immediately to implement needed actions, we realize that limitations on funding may constrain some of these actions to future years. As actions at downstream dams show merit, they will be expediently implemented at upstream Corps dams. However, based upon recent fishway inspection tours, we believe that there are a number of structural modifications that should be made to Walla Walla District dams over the next two years.

We understand the urgency to do more at as many dams as possible but we are limited first in our knowledge of the specific behavior challenges to the fish at a given dam and second, even when we begin to understand specific problems and have designed modifications for one dam, we still have unique dam specific design development and regional coordination to undertake to get an okay to make major operational or structural modifications. When we can, we are moving ahead quickly, as illustrated by the speed with which we modified the BON Cascade Island entrance to test out our design to help lamprey get into the ladders.

We agree that there are opportunities for small scale fixes within specific dams that can be modified relatively quickly and inexpensively. For example, designs for ladder modifications at McNary Dam are being put planned for implementation next winter. Lamprey features such as rounding, smoothing, and gap size limits were incorporated into the retrofitting of the adult salmon PIT detectors at both BON ladders, as well. Extensive lamprey features are incorporated into both phases of the JDA north ladder modifications and phase 1 will be done next winter. We are beginning preliminary design work for two other FCRPS ladder entrance modifications for lamprey one at MCN and the second at BON PH2.

We believe that in the spirit of the 2008 MOAs, the Corps and tribal restoration plans should attempt to be closely aligned with respect to passage actions at Corps dams and reservoirs. While the 2008 MOAs required a number of specific actions and measures, the actions in tribal restoration plan has gone beyond those. In these comments, we have suggested some changes in the Corps plan in order to better meet this objective. We also recommend that the Corps create specific objectives and tasks with a schedule in the 10 year plan and establish some sort of qualitative/quantitative measuring or accounting as to which were achieved and which were not.

The focus of the scope of our 10 year plan is currently defined by the Tribal Accord agreements. The items listed in that scope are considerable and will be a challenge to undertake in this 10 year plan. In updating the 10 year plan this year we are adding a more detailed planning timeline to actions we want to take during the next 10 years. This will expand the existing appendix A. A second appendix will have a list of potential lamprey passage impediments based on inspections at the projects. We also are planning another appendix with a timeline of what we have accomplished starting from the mid 90s when the USACE first begin undertaking research and modification testing to assist lamprey passage at FCRPS dams. We are also updating the main text to include more data and graphics, as well as addressing other issues of concern.

In general, the Corps needs to address some significant "holes" or omissions in the draft 10 year plan to bring it more in line with the Tribal Pacific Lamprey Restoration Plan. The Corps notes some of these shortfalls in their draft plan. We recommend that the Corps make the following revisions to the draft plan:

- Include a short but detailed history of lamprey passage at Corps dams. For example, when did the Corps first address the issue, and what actions did the Corps take based upon what input from the region?

This is being incorporated into a new appendix.

- Add a specific scope, ten year schedule of actions and related costs for adult and juvenile passage improvements for the Walla Walla District dams. There is much concern from the tribes that the Corps is not taking enough assertive actions at the Walla Walla District dams over the 10 year period. We believe additional discussions are warranted on this issue between the tribes and Corps.

Appendix A is being expanded to address these issues.

- Include a detailed scope, schedule, and costs for adult and juvenile lamprey passage objectives, tasks and actions at all Corps dams, similar to what is offered in the Tribal Restoration Plan. Corps staff have already developed a Portland District and McNary dam by dam detailed research statement of work and budget for lamprey actions from 2007-20011. This should be expanded for future years and included in the 10 year plan.

Appendix A is being expanded to address these issues.

- Establish measureable, qualitative and numerical passage goals and benchmarks for adult lamprey over the 10 year plan period for each dam and the federal hydrosystem as a whole, and for juvenile lamprey as additional information becomes available. Among other things, these should include passage efficiency metrics such as over all passage success, reduction of passage times through dams, establishment of benchmark passage times through reservoirs, establishment of passage rates into fishway entrances and fallback rates over the dam.

- Provide additional tables, graphs, engineering diagrams/figures and pictures for passage actions. Many of the passage actions are complex and these additions would help to clarify actions, particular to tribal and other regional policy makers.

- Provide a section that addresses possible water quality impacts of Corps dams on lamprey passage. This should include information on the relationship between temperature and passage, the potential for hydraulic oil or other pollutants (i.e. toxic sites near or in dams) to impact lamprey passage and other water quality issues and include possible actions to address the impacts.

- Some of the information in the draft plan is dated. We suggest the Corps bring the document up to date from the latest research results. This will help provide a reasonable foundation for subsequent annual reports.

- Some reorganization of the document should be considered. Monitoring, research and in some cases actions appear all together, some separation of these would help clarify the distinctions.

- An additional section to address lamprey predator-prey relationships and actions to reduce lamprey predation from fish, birds and marine mammals should be included. Avian research on salmon should be expanded to include lamprey.

Specific Comments

Page 4

<u>Implementation Plan Goal</u>

The overall goal of the Corps plan should be "to improve lamprey passage to the extent as if the dams were not in place". This has been referred to as "no net impact" in FERC licenses and settlement agreements with the Mid-Columbia PUDs. The draft 10 plan goal, "to improve lamprey passage through the FCRPS to a level that it does not negatively affect population viability and ultimately contributes toward recovery of the species," infers that the dams can continue to impact lamprey passage at some unspecified level. Because there is so little know about lamprey populations it may never be know for some time what consists of lamprey "population viability" or even what a lamprey population may consist.

We have incorporated new language for the goal as follows; "The goal of the Pacific lamprey passage program within the Northwestern Division of the U.S. Army Corps of Engineers (USACE) is to improve both juvenile and adult lamprey passage and survival through the FCRPS as a part of a regional effort to immediately arrest the decline of Pacific lamprey populations within the Columbia

Basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range.

We also feel that addressing the viability of a species at a population level with regards to passage focuses us on the critical issues the USACE need to deal with at FCRPS dams realizing we have limited effect or control over many of the life cycle issues and unknowns that exist for Pacific lamprey. It is difficult to believe that dams or any large scale human landscape modification can in effect have no impact, rather we must be diligent to ensure that those impacts are small enough that we can maintain and continue the species at a sustainable level. The Lamprey Technical Workgroup has been reorganized and tasked with developing meaningful passage and population goals to sustain the species. We believe this group of regional lamprey experts will provide the region with meaningful goals toward improving passage conditions for lamprey. We all realize the difficulties involved with making such estimates when so many aspects of the population dynamics are unknown. We intend to improve passage efficiency and survival of Pacific lamprey as they pass through the FCRPS and will set some interim goals realizing these are confounded by our limited knowledge and that they will need to be modified as we learn more.

The 10 year plan really needs measureable objectives that will, over time in a stepwise fashion, improve both adult and juvenile lamprey passage to eventually meet the overall goal of a transparent system of dams.

Page 6

Adult lamprey implementation

Adult Pacific lamprey are good swimmers except in high velocity areas, as exhibited in radio telemetry studies where they can swim many river miles in a single day. The statement that they are "poor swimmers" should be modified.

This language has been modified.

It probably is not going to be possible to get all lamprey into LPS systems so other improvements to fishways need to be made as appropriate.

COE Team Organization

We concur with using the "team" approach of personnel with different expertise to tackle lamprey passage problems. We have been impressed thus far with Corps personnel working on specific adult passage problems.

10 Year Plan Prioritization

We concur that prioritization of efforts is needed, particularly given funding limitations. We generally agree with the Corps overall plan paradigm that initially one fish ladder at each dam should be prioritized for lamprey passage improvements as quickly as possible, based upon the ladder of choice from existing passage studies. Part of the prioritization effort is expedited installation of structures (i.e. LPS systems; keyhole entrances, reduction of gaps in diffuser gratings). However, while additional study and engineering implementation is warranted for structural actions it is possible that modified ladder operations, such as reduced nighttime fishway flows, could be applied

to all fishways at a particular dam as an immediate action. Actions that have been successfully implemented at downstream dams need to be duplicated at upstream dams in an expedited manner.

The effects of reducing entrance flows at night on adult lamprey passage are being tested a second year at Bonneville dam in 2009. Also in 2009, McNary dam is exploring ways to operate the entrance of its ladders to reduce flows to undertake a similar evaluation of adult entrance passage. A request to test this operation has just been distributed through FPOM for review. Test results are being evaluated for potential block test design study of effects for either 09 or 10.

There is a tendency to "over research" passage fixes for salmon and we stress that lamprey populations do not have enough time for this paradigm. The case that a passage priority exists at dams where lamprey numbers are lowest, because this may indicate where substantial passage problems actually occur and the need to better protect lamprey that have managed to migrate upstream. In general, however, we believe priorities for actions should occur at fishways where, based upon extant passage studies, the largest number of adults approach from the tailrace at each dam.

We realize the numbers are very low in the Snake River, that the majority of adult lamprey continuing upstream above McNary Dam stay in the Columbia River. The history of tributary water management, habitat changes, non-salmon fish poisoning programs, installation of dams, and other potential issues are likely involved with this severe reduction in numbers. Realizing our knowledge is imperfect and more is known about lower river system dams, we have chosen to prioritize sites where known passage problems exist, where passage efficiencies are poor, and large numbers of adults are being affected. Our assumption is that improving passage downstream will make more adults available to pass all upstream dams that the number of those choosing to move upstream through the Snake River will also increase. With this approach, we believe we can make improvements that should benefit the most Pacific lamprey possible. If we find there are specific indications of passage problems causing poor passage efficiency at low count dams than the priorities may change.

For juvenile passage we have stressed that give the unusually abundant adult lamprey counts in 2002-2003, as compared to other recent years, we would expect that the progeny from these migrations are now moving downstream through the hydro system over the next few years and it is very important to increase the survival of these year classes through the hydrosystem. We continue to recommend that the Corps consider removal of turbine intake screens to better protect these year classes during the peak periods of the juvenile migration.

We have worked with FPOM to change installation dates for extended screens at MCN, postponing installation several weeks later than had been occurring. We can look at similar fine tuning of screen use at other. NMFS has clearly stated that they see benefits to ESA listed salmonids with the screens installed during outmigration of juveniles at MCN and do not want them removed.

In 2008, for the first time, we have more or less complete 24 hour counts of adult lamprey at Bonneville (45,104) and The Dalles (9,938) dams (Clabough et al. 2008). We do not know what happened to the large number of lamprey that did not appear at The Dalles. From passage studies, it does not appear that many of them move into tributaries in the Bonneville pool. We believe this is a high priority to find out where these animals go. While from past passage research, passage efficiencies at The Dalles appear to be the highest on the river, it may warrant reexamining these metrics and accelerating entrance modifications at The Dalles.

We also believe it is a high priority to assure that significant lamprey numbers are not passing areas that have not been monitored, such as gaps around fishway counting stations, sides of spill gates and navigation locks. Researchers and the Corps should make increased efforts to monitor these areas.

We are working to improve our count estimates and to get a realistic count at all our dams with a focus on Bonneville and McNary Dams as critical population check in points for lamprey moving upstream. This involves using nighttime video cameras, LPS counts, and investigating the number of fish passing around the count station undetected. Other techniques such as automated counting video systems may make nighttime counting faster and less expensive as well. By having solid estimates at key dams we can use conversion rates based on PIT tag and RT data to correct less accurate counts at other dams while we also try to improve counting methods there.

We appreciate the Corps scheduling ladder walk throughs with CRITFC and tribal staffs. We urge the Corps to facilitate the presence of lamprey passage researchers on these inspections. We think these inspections are very valuable to continue to pinpoint problem areas for lamprey passage and prioritize improvements. The MOA requires the Corps to provide complete inventories of potential passage problems for each ladder. We urge the Corps to establish detailed reports with pictures/diagrams for each of these ladder inspections and offer the tribes the opportunity to review and comment on these reports. The information in the reports will be invaluable in determining and adjusting passage action priorities.

We also encourage the Corps to have fishway entrances and exits outfitted with half –duplex receivers at all Corps dams, to establish a monitoring baseline. Hopefully this can be completed in 2009 but no later than 2010.

We are working to outfit dams with adequate PIT detection system. Not all entrances have them yet. Some are included as part of the entrance modifications designs and will be installed as the entrances are installed.

As required by the MOA, closure of the McNary Oregon ladder false exit opening remains an issue that needs expedited resolution.

NWW is developing a list of small scale fixes in the MCN ladders this year for implementation next winter. At this time it is unknown whether or not the old juvenile bypass flume at the top of the Oregon shore ladder at McNary is a passage location for adult lamprey. There are opening on both sides of the ladder where lamprey can enter. It is unknown if lamprey entering these flumes can exit the flume or if they return to the main ladder to exit the fishway. This issue has been discussed at two of last three years of ladder inspections. This flume was designed to allow juvenile salmonids to enter the fish ladder as a bypass system. However this system is no longer maintained. A regional coordination and consultation needs to take place before this system can be closed off to restrict access for adult Pacific Lamprey. This will be on the list of potential fixes for next winter at McNary dam.

We believe that if necessary for increased sample sizes for passage research, adult lamprey should be trapped at downstream dams and released below upstream dams. It is important to establish where passage impediments occur at upstream dams as a very high priority over the short term so that improvements can be expedited.

Moving test fish upstream very far can lead to significant changes in behaviors if fish are using river cues to determine their final destination. They may move downstream, or fail to be motivated to pass as a result of such handling and transportation. Such alterations in behavior may already be occurring in fish moved from MCN to the tailrace of IHR. Care must be taken in how far and where you move test fish. Another alternative is to get more fish tagged and released at downstream locations such as JDA.

Strategy Limitations

We do not believe that changes to fishways to expedite adult lamprey passage need to be "proven" to not negatively affect salmon passage. If the best available information indicates that lamprey modifications will not impact adult salmon passage, the modifications should be implemented.

We have changed some of our wording in the plan however we are required by the ESA to consult with NMFS on potential effects on listed salmon.

As we stated in our general comments, the Corps needs to establish passage goals and objectives. We recommend that the overall interim passage objective for each dam and the system of dams and reservoirs should be the best existing passage at any mainstem dam. For example, the high end of the adult passage rate at The Dalles Dam is about 82% (Daigle et al. 2007), thus, this should be the interim passage goal for all Corps dams. Establishing passage goals is important to determine where, what and when passage priority actions should be established

See above comments regarding this issue.

The CBFWA Lamprey Technical Workgroup has been inactive for a considerable time. While we supported it in the past, with respect to mainstem passage actions it now appears to be super ceded by the MOA relationship including the recent, excellent technical exchange between the tribes and Corps. In general, others in the region have not shown the interest in participating in devising and expediting lamprey actions as much as the Corps and tribes. We believe it is important for the Corps and tribes to be leaders on lamprey passage in the basin and bring along others as they may express interest and participation. This applies to establishment of passage goals and numerical criteria at mainstem dams and reservoirs as well as to other passage actions.

See above comments regarding this issue.

Annual Reporting

The Corps should establish firm dates for annual reporting. The reports should specify progress at each dam and through the system of dams and reservoirs and provide accountability in meeting the goals, objectives and tasks of the 10 year plan. We suggest that the draft report be submitted to the tribes at the end of January of the year following the report period, and the Corps establish a formal meeting to review the draft with the tribes. The tribes should be offered 30 days for comment on the draft plan, and the Corps and tribes should meet to review the comments, which should be included in the final report as appropriate. The final report with recommendations for future actions should be due to the tribes and region on March 15 of each year to allow time for planning of that years' passage actions and research.

We agree with establishing dates and protocols for annual updates but the dates may need to be pushed back a month or so to allow data to be updated and proposed objectives to be incorporated into the process, unless it is acceptable to have most items a year behind.

Pacific Lamprey Life Cycle

We wonder why fishway flows are increased during the shad passage period which is a peak passage period for lamprey. Shad are an introduced exotic fish species, and increasing fishway velocities probably increase passage problems for lamprey.

This was established to ensure shad did not pile up in our ladders and block listed salmon migration upstream as shad do not like plunging flow over the weirs. NMFS would have to concur with these type of changes to ops. Velocity increases occur at entrance areas.

This section could benefit from some additional information on the lamprey life cycle.

Baseline lamprey passage data 1997-2002

We are unaware of specific lamprey passage "models". These need to be described in more detail.

This section has been changed and should be clearer.

Corps lamprey research notes that elevated temperatures may impede lamprey passage. More information on this relationship needs to be presented in this section.

All fish have threshold levels for increased water temperatures; as these levels are approached behaviors change, whether they are in the mainstem or in tributaries. Lamprey tend to be more tolerant of higher temperatures than salmon but we are not sure if when given a choice between two different temperature levels of water, such as occurs at the Snake-Columbia confluence, how or if they make choices based on that factor.

Fishway Entrances

MOA Action – Reduction in Fishway Entrance Head and Flow

Reducing fishway night flows has been promoted as an immediate, rough and ready measure that can be quickly implemented to reduce entrance and weir orifice velocities which have been demonstrated to be lamprey passage barriers, until structural measures, such as keyhole entrances, can be installed. We are encouraged by the extant study results that indicate the measure appears to facilitate ladder passage and reduce passage times. We acknowledge some reduction in passage entrance success, and wear and tear on fishway pumps, but overall we still believe that the operation warrants additional testing and implementation at Bonneville and also other dam fishways in 2009 and 2010, in particular McNary and John Day south shore, since it will be several years before structural measures can be implemented at these fishways.

The effects of reducing entrance flows at night on adult lamprey passage are being tested a second year at Bonneville dam in 2009. Also in 2009, McNary dam is exploring ways to operate the entrance of its ladders to reduce flows to undertake a similar evaluation of adult entrance passage. A request to test this operation has just been distributed through FPOM for review. Test results are being evaluated for potential block test design study of effects for either 09 or 10.

MOA Action - John Day North Shore Entrance

We concur with the Corps action and schedule for expedited installation of a keyhole entrance with lamprey "pillars" in 2010. In addition, we recommend, not only at this fishway, but at other, the installation of metal plates at least 16-18 inches wide along the sides of the fishways over floor diffuser sections and above and below each weir orifice (2 feet of plating above and below each orifice) to facilitate lamprey holding, velocities and passage. Installation of an LPS near the fishway entrance may attract some lamprey, but not others, hence the need for the floor diffuser plates. In addition, all weir orifaces that are located off the floor should be evaluated for lamprey passage by installation of underwater cameras at a sample of those orifaces. If passage is determined to be problematic, floor ramps should be installed.

Upon inspection of the dewatered John Day North Shore ladder counting station on January 9, 2009 for installation of cameras for night counting, we noticed there were gaps under the crowder and the bottom of the count ramp and plastic covers over bolts over the window were not well suited for lamprey passage. We also are concerned with the picketed lead section with respect to potential lamprey passage delay and the fact that lamprey can pass undetected through this section and would not be counted. This is an example of a lamprey passage problem that may exist at other Corps dam fishways that can only be discerned from dewatered ladder inspections. We note that the video and human counting station being installed at Grant PUD fishways does not have a crowder and those does not have these problems. We wonder if crowders are really necessary and recommend that the Corps and tribes further investigate and resolve these issues.

The north counting window at JDA is being extensively redesigned as part of the next in-water work period modifications. At times it may be wiser to assist lamprey passage through the picketed leads and trashrack than forcing them to go through the counting slot and figuring out a way to estimate those going through that section through the use of the exit PIT readers to get conversions that can correct ladder counting.

From the February 2009 McNary and Lower Monumental and Little Goose fishway inspection, some key problems were noted, including but not limited to long vertical slots, and offices 6 inches to a foot off the fishway floor, problematic count station areas with large gap picketed leads large floor diffuser areas at fishway entrances, curved fishway areas where lamprey tend to delay and orifaces with angled corners. We urge the Corps to work with the tribes to develop a priority list with a goal to fix these structural problem areas at McNary and the SR dams by 2011.

<u>Monitoring to Research and Development</u>

MOA Action- Lamprey Counts

Twenty four hour adult lamprey counts are an important objective of the Tribal Restoration Plan as the foundation of essential information to gauge passage priorities and successes or failures as well as establishing population trends. We suggest the Corps update the adult count data for each dam by year and specify whether or not 24 hour counts were provided. The Corps should provide 24 hour counts for Lower Granite Dam as the data is available since night counts there are required under the salmon FCRPS Biological Opinion. CRITFC is still engaged in compiling 24 hr counts for McNary Dam in 2007 from WDFW video. We are working with WDFW to engage in a subcontract to expand lamprey night counts to John Day and McNary and maybe Ice Harbor in 2009, provided the Corps increases their subcontract with WDFW for these additional actions. The Corps plan should set a schedule for implementing 24 hour counting capability at the index dams (Bonn, TDA, JD, McN, IH, LWG) as soon as possible but at the latest year 5 of the ten- year plan.

We concur that lamprey can get by counting stations through picketed leads and crowders and reiterate the need either to eliminate crowders or install narrower screens in these areas to both prevent lamprey from getting around counting stations undetected and to provide areas where lamprey passage may be delayed.

Juvenile Lamprey

MOA Action- Removal of Turbine Intake Screens

Despite laboratory studies with simulated turbine passage, with respect to actual turbine passage there are no juvenile lamprey survival data. Thus, it is premature to state that "turbine passage may be a relatively safe route." As a start, CRITFC has suggested the use of Hi-Z tag technology as a interim step to measure turbine survival until tag technology can be developed, realizing that the Hi-Z tag technology could compromise juvenile lamprey passage behavior.

External tags have proven to be problematic on lamprey as they often wrap their flexible body around it and knock them off. At the least it will certainly affect their swimming behavior and likely their orientation as they pass the dam. There is no way to obtain a control group so it would not be possible to determine tagging effects from passage route effects.

While there is evidence that juvenile lamprey pass through the bottom of turbine intake screens, several studies indicate that juvenile lamprey may be uniformly distributed as they enter turbine intakes. As stated in the Tribal Lamprey Restoration Plan:

For many years the common assumption was that most juvenile lamprey travel along the bottom of the river during their approach to dams and pass through turbine intakes under turbine intake screens (Figure 17). Among other things, this conclusion arose from the fact that juvenile lamprey lack a swim bladder, in contrast to juvenile salmon. However, in several cases, data from lamprey trapped on fyke nets placed in turbines behind turbine intake screens and on the screens themselves indicate that they travel higher in the vertical water column than previously believed. For example, fyke net tests at Priest Rapids Dam indicate that juvenile lamprey were found nearly equally distributed from the top to the bottom of the turbine gatewell slot (Carlson 1995 unpublished data). **Have not seen this data so I cannot comment on it.** *Moursund et al. (2003) found that 86% of juvenile lamprey found on the John Day Dam extended length turbine screens were within the top 10% and bottom 10% of the screen face (Figure 18).* **This is what the data indicated for those that came in contact with the bar screens, however, the vast majority of juvenile run-of-the-river fish (78%) were below these screens.** *They also documented 91% of PIT-tagged lamprey and 14% of run-of-river lamprey were captured at fyke net levels 1-4 behind the turbine intake screen.*

JUVENILE PACIFIC LAMPREY DEPTH DISTRIBUTION AT POWERHOUSES

Following is a collection of excerpts from reports dealing with depth of run-of-river juvenile lamprey as they approach powerhouses on the Columbia River. Results are based on fyke net sampling.

WHITE PAPER: Passage of Juvenile and Adult Salmonids Past Columbia and Snake River Dam. Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 2725 Montlake Boulevard East, Seattle, Washington 98112-2097. April 2000. Page 86.

During FGE studies, NMFS researchers have consistently observed juvenile lamprey to be distributed near the bottom of turbine intakes. Results from FGE studies at Bonneville Dam in 1998 are typical. Monk et al. (1998) captured a total of 308 juvenile lamprey in turbine intake fyke nets from April 25 through May 21. No fish were captured in the gatewell, therefore ESBS FGE was estimated to be zero. Of the 308 fish caught, approximately 70% were caught in the lower 4 nets, of nine nets total. Similarly, Long (1968) found juvenile lamprey were concentrated near the center and bottom of turbine intakes at The Dalles Dam in 1960 (fish guidance screens were not installed in the intakes).

BONNEVILLE DAM

From a September 2004 Research Report (available on our webpage at http://www.nwp.usace.army.mil/pm/e/reports/afep/bon/BON2_Turb_02.pdf

EVALUATION OF TURBINE INTAKE MODIFICATIONS AT THE BONNEVILLE DAM SECOND POWERHOUSE, 2002
Bruce H. Monk, Benjamin P. Sandford, Dean A. Brege, and John W. Ferguson

Juvenile Lamprey
Of 711 lamprey collected, one was collected from the gatewell and eight from the gap net (Figure 6; Appendix Table 5). The remaining fish were caught in the fyke nets, with 75% caught in net levels 3 and 4 (from elevation -0.3 m to -5.1 m msl; Figure 3). This was comparable to results seen previously at Bonneville Dam First (Monk et al. 1999b, 2001) and Second Powerhouse (Monk et al. 2002). In all cases, most juvenile lamprey were well below an area where they were susceptible to interception by the STS.

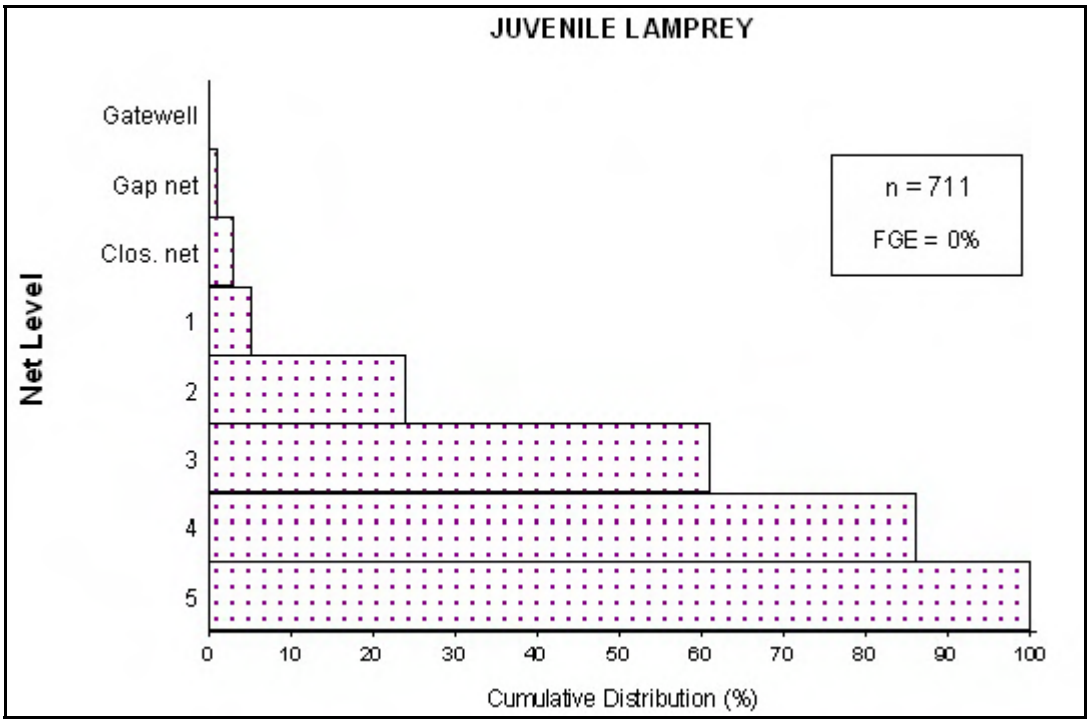


Figure 6. Cumulative distribution of juvenile lamprey caught in gatewell and fyke nets during fish guidance efficiency tests.

JOHN DAY DAM

Following excerpts are from PNNL Report 14160 Evaluation of the Effects of Extended Length Submerged Bar Screens on Migrating Juvenile Pacific Lamprey. R. A. Morsund et al. March 2003. See COE webpage for full text.

https://www.nwp.usace.army.mil/pm/e/reports/afep/jda/EvaluationoftheEffectsofExtendedLengthSubmergedBarScreensonMigratingJuvenileLampreyatJohnDayDamin2002.pdf

Greater than 78% of the run of the river lamprey recovered from the fyke nets were in the second, third and fourth nets from the bottom.

Table 3.3. Total Numbers Run of the River Lamprey Caught in Fyke Net over Three Days

	North	Middle	South	Total
Level 1	0	2	0	2
Level 2	3	4	5	12
Level 3	12	3	3	18
Level 4	2	1	2	5
Level 5	15	8	19	42
Level 6	47	46	37	130
Level 7	14	17	18	49
Level 8	1	1	0	2
Total	94	82	84	260

Evaluation of the Effects of ESBS on Migrating Juvenile Pacific Lamprey at John Day Dam in 2002

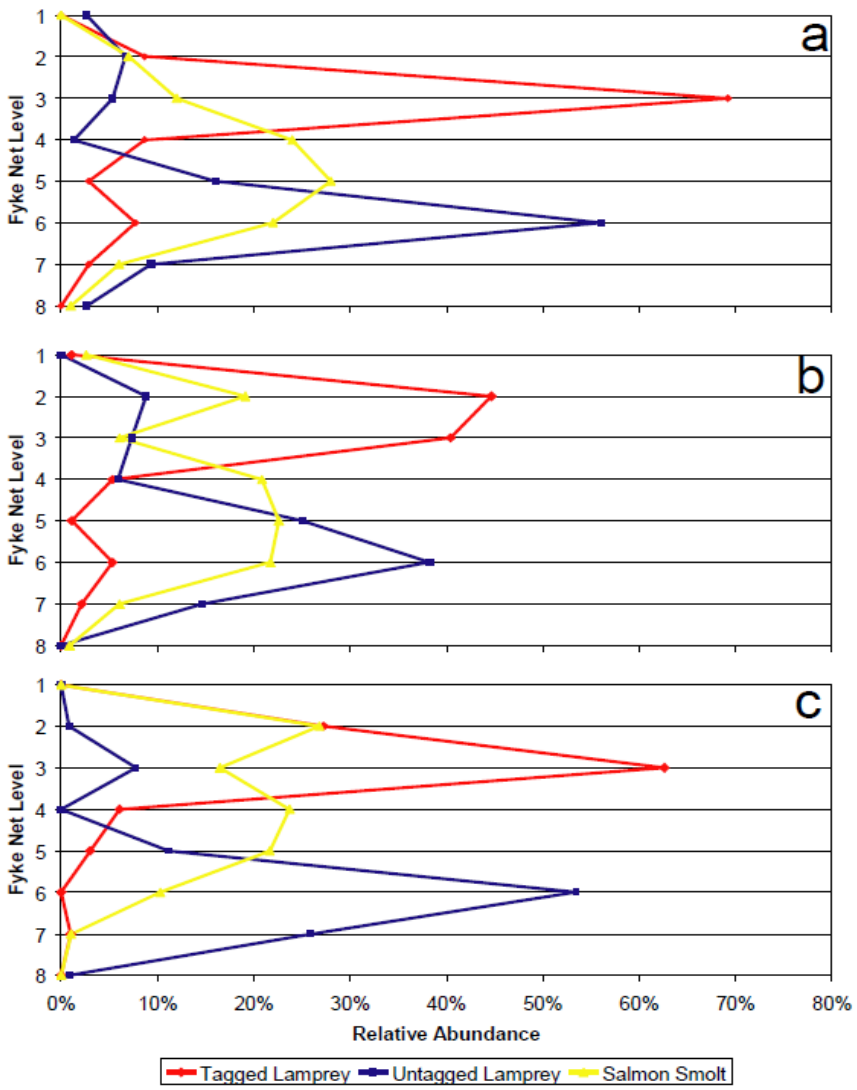


Figure 3.11. Vertical Distribution of PIT-Tagged Lamprey Released in the Forebay at 5 ft (panel a), 10 ft (panel b), or 15 ft (panel c) Below the Intake Ceiling Depth, Run of the River Untagged Lamprey, and Run of the River Untagged Salmonid Smolts as They Were Recovered from the Fyke Nets. These smolt data only represent the catch over the same time period as the lamprey releases. Data provided by NOAA Fisheries.

WELLS AND ROCKY REACH DAM

Young adult lamprey migrate in the lower portions of the water colunm (Close et al. 1995). This is probably because they lack a swim bladder and cannot easily regulate their location in the water column (Moursund et al. 2000). At Wells Dam, fyke nets set in deep water (>90 ft) most often captured lamprey (Table 3-2). This is consistent with fyke net sampling at Rocky Reach Dam (C. Peven, Chelan PUD, personal communication). These observations support the work of Long (1968), who found that most migrating lamprey enter turbine intakes near the center and bottom. Long (1968) found that migrating lamprey and juvenile salmonids were spatially separated, with only minor overlap at the mid-point area of the turbine intake. Excerpt from Rocky Reach Report

A percentage of lamprey do migrate high in the water column and are intercepted by screens during ESBS FGE testing. Of these, some have become impinged on the ESBS when debris brush sweeps were not functioning properly. For example, at The Dalles Dam in 1993 the debris sweep on a prototype ESBS was disabled to mount video cameras on the screen to observe juvenile salmon behavior near the screen face. The screen was operated in this condition for a 7-day period, raised for inspection, and 50 to 100 dead lamprey juveniles were observed. Similarly, Monk et al. (1998) found that when a test ESBS at Bonneville was raised for inspection, the debris sweep on one of the screens was not adjusted properly. The top foot of the screen was not being cleaned and two juvenile lamprey were observed in this section.

Although the above studies suggest that the vast majority of juvenile lamprey encountering the powerhouse (>70%) travel below the screens and likely enter the turbines, there still remains 20-30% that may encounter screens. This was considered a significant enough number to initiate a new replacement screen gap criteria to limit impingement and mortality. The longevity of the existing screens and the cost of replacement has limited and will likely limit the installation of smaller gap criteria screens in the near future.

Regardless of the exact number of juvenile lamprey that are impinged by turbine screens, the existing evidence indicates that it is a considerable problem for juvenile lamprey and needs to be reduced or eliminated. While the Corps has developed new screen criteria that should prevent juvenile lamprey impingement, the cost of constructing these new screens to replace existing screens appears prohibitive. Turbine screens were originally designed to prevent juvenile salmon passing through turbines. Because juvenile salmon are not transported from McNary Dam during the spring lamprey migration period, the tribes have recommended that the extended length bar turbine screens not be installed at McNary Dam until the summer juvenile salmon migration which begins around June 20.

Recently the Corps provided a survival analysis of juvenile yearling Chinook and steelhead passing through different routes (turbine/spill and screen bypass systems) at McNary Dam with data from Adams and Plumb 2008). The analysis was based solely on juvenile salmon direct survival rates through the different dam passage routes. The Corps concluded that juvenile salmon survival was higher with the screens in place.

The Adams and Plumb (2008) study indicated that about 60% of river flow would substantially increase juvenile salmon and steelhead spillway passage efficiency. If this was provided, a much smaller number of salmon would pass through the powerhouse.
The Corps suggested a delayed implementation of the screens beginning May 6 with final installation on May 17 to allow the beginning of the juvenile lamprey population passage at McNary without screens.

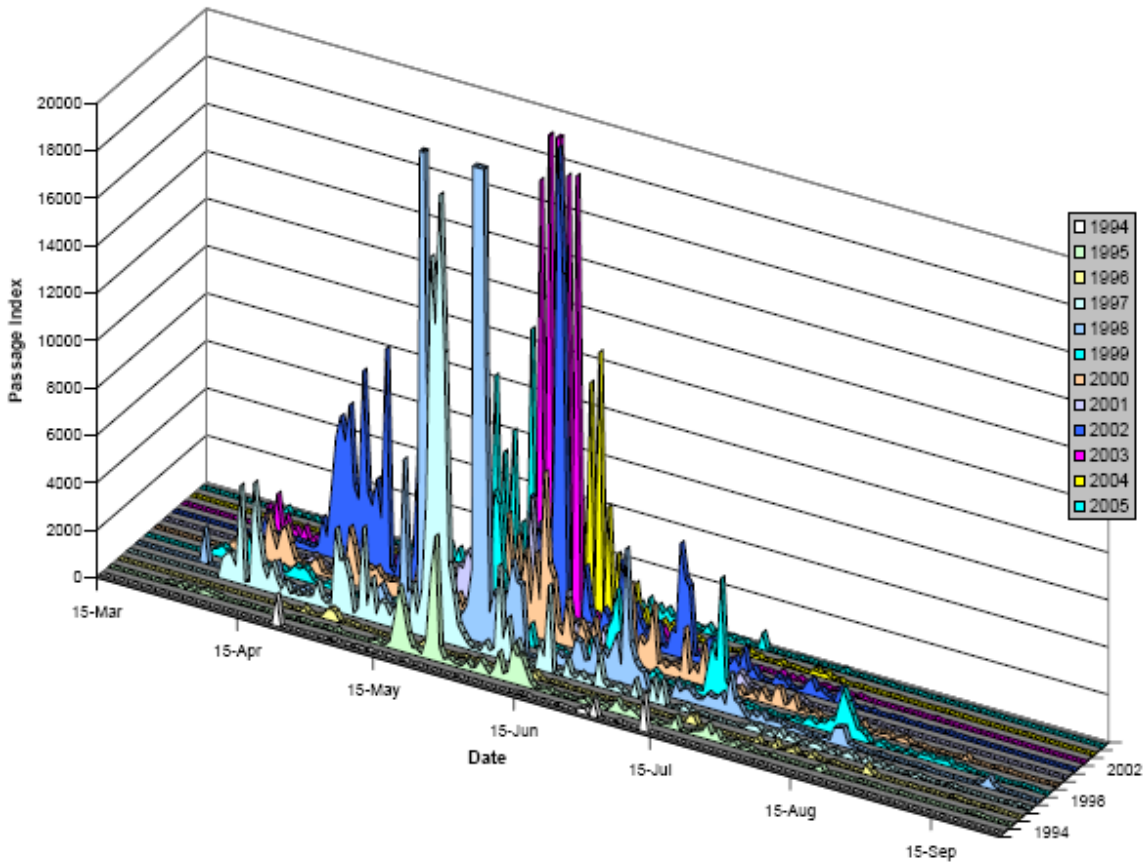


Figure 1. Juvenile lamprey run timing at McNary Dam from 1994-2005 (from CRITFC 2008 - Bleich and Moursund 2006).

Existing data indicates that the peak of the juvenile lamprey migration over many years is about the middle of May. Installing the screens during this period would increase the probability of lamprey impingement on the screens.

CRITFC reviewed comparative smolt-to-adult survivals (SARs), for yearling spring Chinook and steelhead that travel through the various passage routes at McNary Dam over a number of years. In regional technical meetings during the BiOp remand, the region agreed that SARs are the most important performance survival metric because they incorporate delayed or latent mortality from dam passage that may not manifest itself until well after passage through a particular dam and the fact that increasing adult returns is the key regional goal.

In reviewing the SAR research conducted by NOAA Fisheries over the recent past years for yearling Chinook and steelhead, we found that in most cases SARs were lower or similar for Chinook and steelhead that passed through the screen bypass system compared to SARs for a combination of spill and turbine passage (i.e. "non-detected" passage; Table 1. data from Marsh et al. 2005, 2006, 2007, 2008).

Thus with respect to SARs it appears better for spring salmon migrants to avoid screen bypass passage. Considering this and other data, such as the benefits for salmon SPE by increasing spill, we continue to believe that the McNary screens should not be deployed for the spring lamprey migration as the action will help lamprey and not be a detriment and may even increase salmon adult returns.

The SAR data in Table 1 mostly reflect the difference between spill and bypass passage and survival since most undetected fish pass through the spillway, particularly in the spring. Also, the SAR data are not clearly one way or the other. Some years the bypass is better, particularly for steelhead. Since we lack turbine specific passage SAR's we have to make decision on the route specific survival estimates and these clearly and consistently show higher bypass survival for all the species we have evaluated.

Again, due to the large adult migration of lamprey in 2003 and the extended lamprey freshwater rearing life history, we would expect their progeny to be migrating downstream this year. It is critical to protect this productivity which may be the last opportunity to rebuild basin lamprey populations. We ask the Corps to reconsider this issue based upon the SAR data and provision of increased spill at McNary.

Table 1

McNary Dam Spring Salmon Smolt-to-Adult Returns (SARs)

Steelhead SARs	2006	2007	2008
Screen Bypass	1.94	1.51	1.98
Turbines and spill (non-detected)	2.45	1.56	1.95

Yearling Chinook SARs	2005	2006	2007
Screen Bypass	0.40	0.27	0.19
Turbines and spill (non-detected)	0.32	0.43	0.36

MOA Action- Screen Bypass Separator

We concur with the Corps that the raceway tailrace screens should modified at all salmon transport collector dams to avoid lamprey impingement. Transportation of juvenile lamprey should be avoided as juvenile salmon may prey upon them and the action interrupts the lamprey rearing-migration life history. Lamprey caught in raceways should be safely transported to tailrace areas and distributed to avoid bird or fish predation “hot spots”.

MOA Action- Juvenile lamprey tag development

We fully support the Corps efforts to develop tag technology and recommend that it be accelerated if possible.

MOA Action- Reservoir Fates

We support the Corps efforts in applying new acoustic tag technology to determine the fate of adult and in the future, juvenile lamprey in reservoirs. As mentioned earlier in these comments, based upon 24 hour counts, the considerable loss of adult lamprey between Bonneville and The Dalles dams is a significant issue and needs to be resolved. We recommend the Corps expedite installation of acoustic systems in the Bonneville pool in 2009 if possible to address this key uncertainty.

We expect to have a prototype JSAT mobile tracking receiver to start evaluating in 2010.

Juvenile Passage Research

We support the concept of beginning examining juvenile migration and dam passage research. For 2009, more effort needs to placed at smolt monitoring sites to obtain additional data. Additional PIT-tag migration studies need to be implemented. More effort on juvenile tag development is needed. Benthic surveys in reservoirs should be conducted. More discussion is needed in these areas.

Discussion on this topic in the plan has been expanded. Improve SMF monitoring at dams may need to go through FPOM for changes.

Potential Future Actions- Critical Ladder Modifications

MOA Action- Diffuser Gratings

We support installation of the ¾ inch gap screens to prevent adult lamprey entrance into AWS systems and blind areas. While we understand that powder coated galvanized steel is cheaper than aluminum or stainless steel, we are concerned about corrosion of the galvanized steel, particularly when it comes in contact with grating supports or the installation of metal plates in corners, along sides of fishways and through submerged orifices. More discussion is needed on this issue.

Discussions about the priority of grating changing definitely need to occur as we continue to find escalating associated actions and costs.

MOA Action- Rounding of Corners

From the research cited, it appears that rounding corners in certain fishway areas facilitates adult lamprey passage, and that it may not be necessary to round off corners of all orifaces and other areas, which suggests a prioritization exercise is warranted at all Corps dam fishways. This is an area where initial ladder inspections during dewaterings could assist in prioritizing areas. Additional telemetry receivers above and below questionable areas and hydraulic assessments using velocity meters in questionable areas could be useful to prioritize rounding corners.

Agree. Many of these actions have been done and the rest we are working to accomplish.

MOA Action- Auxillary Water Supply Channels/ Cul-de-sacs

This is an area where initial ladder inspections during dewaterings could assist in prioritizing areas. Additional telemetry receivers above and below questionable areas could assist in revealing problem areas and prioritization of fixes.

Conclusion

CRITFC appreciates the opportunity to comment on the Corps draft 10 year lamprey passage implementation plan. We appreciate the Corps' efforts to collaborate with the tribes on these actions and look forward to the final, formal Corps 10 year passage implementation plan. We suggest meeting with Corps staff to review these comments in the near future.

Appendix F
Nez Perce Comments and How Addressed

Memorandum

To: Natalie Richards, David Clugston, Mark Smith, Derek Fryer , Corps of Engineers
From: Dave Statler, Nez Perce Tribe, DFRM
Date: March 12, 2009
RE: Preliminary Technical Comments on Corps' Draft Pacific Lamprey Passage Improvements Implementation Plan: 2008-2018

Comments

a) The stated goal of the Corps to "...improve both juvenile and adult lamprey passage through the FCRPS such that potential passage issues do not negatively affect population viability contributing toward recovery of the species," appears to set the bar too low, seemingly having an ESA-like VSP intent. Further, to date there has been no evidence that separate lamprey populations exist in the Columbia Basin, so the "population viability" criteria as applied to listed salmon and steelhead probably does not apply the same way to Pacific lamprey.

b) The Corps recognizes that, "Because there are many gaps in the knowledge concerning Pacific lamprey behavior, passage, and life cycle, an adaptive management approach will need to be followed to accomplish the evaluations leading to useful modifications at the projects." The Corps has been testing, evaluating and refining the LAPS at Bonneville Dam since 2002. There needs to be many more actions taken in a shorter time frame than what would appear to be possible under the Corps' application of "adaptive management." The lamprey in the Snake River portion of its range sorely need substantive mainstem passage improvements now, necessitating more aggressive action in the face of certainty.

c) The plan states that deciding where to prioritize efforts to improve lamprey passage should be based on two simple but critical factors:

(1) where passage efficiency is the poorest
(2) where the numbers of Pacific lamprey affected are the highest.

Based on these criteria and the Corps' emphasis on the LAPS as the cornerstone of their adult passage improvement program, work continues to be focused at Bonneville Dam, and successive passage improvements are addressed dam by dam moving upstream. This delays passage improvements at the 4 lower Snake River dams to 2014-2017 (years 6 through 9 of the 10-year MOA). Concurrent improvements need to be implemented at both downstream and upstream mainstem dams to address common and most pressing passage impediments. Frontloading of the planned $50,000,000 expenditures is warranted based on the critical status Pacific lamprey in the Snake River Basin.

d) The Corps states that, "A major challenge to all potential Pacific lamprey designs and operations is the ability to ensure that ESA-listed salmon are not negatively affected, or that hydraulic conditions at dams set up to aid in salmonid passage are not negatively altered." Major changes to existing structures, such as changing entrances to fixed-weir systems or research sampling related to

evaluating juvenile passage must undergo ESA consultation processes and be proven to not negatively affect salmon passage. The approach and challenge to engineering Pacific lamprey improvements is to make new designs that actually aid both lamprey and salmon passage. (This is problematic due to vast differences in swimming and behavioral characteristics. If it is engineeringly possible, it will likely take a long time to figure it out.)

At least two improvement measures, the reduction of ladder entrance velocities and rounding of corners in fishways, have already been delayed and/or postponed due to ESA concerns. This issue has had and will likely continue to be an obstacle to timely implementation of needed lamprey passage actions.

e) Some MOA identified actions are apparently planned over an extended time frame; probably well after the MOA period. These actions include comprehensive replacement of fishway diffuser screens, surface mounted turbine intake screens, and tag development for juvenile lamprey. These actions may be beneficial in the long-term, but are unlikely to offer immediate help for lamprey migrating to or from the Snake River Basin.

f) The commitment to conduct fishway inspections at dams to identify critical passage problem areas is useful to comprehensively document the per dam passage impediments and to have lamprey "experts" and Corps staff brainstorm potential fixes. However, multiple fishway inspections have occurred to date at several facilities, and many passage problems repeatedly identified.

Follow-up documentation of passage problems identified and solutions discussed or proposed at individual dams is paramount. In consideration of the critical status of Pacific lamprey in the Snake River Basin, we must take full advantage of near-term, relatively simple, low-cost passage fixes at individual dams that would individually and cumulatively improve system passage efficiency.

<u>Recommendations</u>

a) A preferred alternative goal, taken from the Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin is *restoration of Pacific lamprey to levels supportive of their unique cultural and ecosystem values*

b) The adaptive management approach to mainstem passage improvements for Pacific lamprey needs to be based on proceeding with actions to improve the most pressing passage impediments at the dams based on the best available data and knowledge, knowing that information is lacking and uncertainty exists, and applying follow-up monitoring and evaluation to gauge effectiveness and modify those actions, if needed.

Pre-action studies and evaluations should not delay needed actions to the detriment of our focal goal, restoration of the Pacific lamprey.

c) Concurrent improvements need to be implemented at downstream and upstream mainstem dams, rather than a progressive march upstream, to address common and most pressing passage impediments.

Because problems with fishway ladder entrance efficiencies are generally recognized and documented as a major problem for adult lamprey passage that is generic to dam fishways, actions to address this problem should be pursued immediately *and* concurrently.

Passage improvements on the lower Columbia River may not necessarily translate to increased movement of adults to upstream areas if upstream dam passage impediments detour adults to alternative spawning areas, effectively halting upstream movement. Relatively weak pheromone attractant signals from sparse ammocoete densities in upper basin areas may exacerbate this problem.

Actions to address other major passage impediments, such as serpentine weirs, cul-de-sacs and diffuser gratings should addressed in a similar similarly with a downstream/upstream concurrent approach.

d) It will be necessary to temper ESA deference to listed salmonids and provide more latitude to implement lamprey passage improvements. In this context, it is appropriate to consider that, due to ecosystem values provided by Pacific lamprey, passage improvements leading to lamprey restoration are also beneficial to listed salmonids.

e) Given that a portion of the actions identified in the MOA are presently on an extended long-term time frame, expeditious implementation of passage improvement actions that are possible in the shorter-term is paramount to effect needed passage improvements in the time frame demanded by the status of Pacific lamprey above Lower Granite Dam.

f) Follow-up, formal documentation and accountability of lamprey focused fishway inspections are essential. The following procedure for documentation is recommended to improve accountability and follow-up:

- A draft inspection report, including passage specific problems identified and fixes recommended or discussed, needs to be prepared by the appropriate Corps of Engineers District and circulated to parties present at the inspection within two weeks after the inspection.
- Parties that were present at the inspection will have two weeks to review and edit the draft inspection report and provide such edits to Corps staff compiling the report.
- The Corps of Engineers District will incorporate edits of the draft received and distribute the final draft inspection report to parties present at the inspection within two weeks after receiving the suggested edits. Substantive edits to the final draft inspection report will be forwarded to the District for incorporation in the final inspection report.

Results of the inspections, as documented in the inspection reports, shall be presented and discussed at an upper management and/or policy level during the quarter following issuance of the final inspection report. Follow-up actions including implementation schedule, based on the inspection report, will be identified at that time.

Appendix G
Letter to Mr. Samuel N. Penney, Chairman

June 29, 2009

Mr. Samuel N. Penney, Chairman
Nez Perce Tribal Executive Committee
P.O. Box 305
Lapwai, Idaho 83540

Dear Mr. Penney:

Thank you for your comments and recommendations on the Corps of Engineers' Pacific Lamprey Passage Improvements Draft Implementation Plan. I want you to know that we share your concern for the current plight of the Pacific Lamprey.

Through our agreements with the Accord Tribes, we have committed to a substantial funding increase for lamprey passage improvements and have developed a long-term plan to accomplish these improvements. We've recently installed a nearly $2 million prototype ladder entrance and connecting lamprey passage system at Bonneville Dam in 2008 and have started evaluating its effectiveness. If the new prototype entrance system proves effective, we'll move fast to implement additional new entrance modifications at John Day and McNary dams, as well as adding another Bonneville Dam entrance. In the future, we'll be looking to do the same at our Snake River projects. We'll continue to test how we can alter flow velocities at entrances during the night to facilitate passage; start testing for a second year at Bonneville; and begin to evaluate another method at McNary and Ice Harbor Dams. We expect our ladder inspections and continuing research will result in even more improvements for both the downstream passage of juvenile lamprey and upstream passage of adults.

We believe that similar to salmon, there are multiple factors responsible for the recent decline in Columbia Basin Pacific Lamprey. We agree that lamprey passage at Corps of Engineers Dams is one of those factors. However, it is far from certain that fixing lamprey passage at Corps Dams will recover this species. Aside from this lack of understanding about the balance of limiting factors for Pacific Lamprey, we are limited by the number of lamprey available to test improvements, the lack of appropriate technology available to answer difficult questions about juvenile lamprey, and funding. To help us work within these limitations, we have sought and will continue to seek input from the Tribes, including the Nez Perce.

Again, thank you for your comments and suggestions. I have provided responses to these in a separate attachment. In addition to our responses, I wanted to let you know that we truly appreciate the diligent participation and contributions in our lamprey technical meetings by Mr. Elmer Crow and Mr. Dave Statler.

Sincerely,

Attachment A - Responses to

Nez Perce Tribe
Comments and Recomendations on the Corps of Engineers'
Pacific Lamprey Passage Improvements Draft Implementation Plan: 2008-2018
May 7, 2009

Comments

a) The stated goal of the Corps to "...improve both juvenile and adult lamprey passage through the FCRPS such that potential passage issues do not negatively affect population viability contributing toward recovery of the species," appears to set the bar too low, seemingly having an ESA-like VSP intent. Further, to date there has been no evidence that separate lamprey populations exist in the Columbia Basin, so the "population viability" criteria as applied to listed salmon and steelhead probably does not apply the same way to Pacific lamprey.

Response to Comment a:

We have changed the goal to the following;

"**GOAL**
The goal of the Pacific lamprey passage program within the Northwestern Division of the U.S. Army Corps of Engineers (USACE) is to improve both juvenile and adult lamprey passage and survival through the FCRPS as a part of a regional effort to immediately arrest the decline of Pacific lamprey populations within the Columbia Basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range."

We feel that addressing the viability of a species at a population level with regards to passage focuses us on many of the critical issues the USACE need to deal with at FCRPS dams realizing we have limited effect or control over many of the life cycle issues and unknowns that exist for Pacific lamprey. It is difficult to believe that dams or any large scale human landscape modification can in effect have no impact, rather we must be diligent to ensure that those impacts are small enough that we can maintain and continue the species at a sustainable level. The Lamprey Technical Workgroup has been reorganized and tasked with developing meaningful passage and population goals to sustain the species. We believe this group of regional lamprey experts will provide the region with meaningful goals toward improving passage conditions for lamprey. We all realize the difficulties involved with making such estimates when so many aspects of the population dynamics are unknown. We intend to improve passage efficiency and survival of Pacific lamprey as they pass through the FCRPS and will set some interim goals realizing these are confounded by our limited knowledge and that they will need to be modified as we learn more.

b) The Corps recognizes that ," Because there are many gaps in the knowledge concerning Pacific lamprey behavior, passage, and life cycle, an adaptive management approach will need to be followed to accomplish the evaluations leading to useful modifications at the projects." The Corps has been testing, evaluating and refining the LAPS at Bonneville Dam since 2002. There needs to be many more actions taken in a shorter time frame than what would appear to be possible under the Corps' application of "adaptive management." The lamprey in the Snake River portion of its range sorely need substantive mainstem passage improvements now, necessitating more aggressive action in the face of certainty.

c) The plan states that deciding where to prioritize efforts to improve lamprey passage should be based on two simple but critical factors:

(1) where passage efficiency is the poorest
(2) where the numbers of Pacific lamprey affected are the highest.

Based on these criteria and the Corps' emphasis on the LAPS as the cornerstone of their adult passage improvement program, work continues to be focused at Bonneville Dam, and successive passage improvements are addressed dam by dam moving upstream. This delays passage improvements at the 4 lower Snake River dams to 2014-2017 (years 6 through 9 of the 10-year MOA). Concurrent improvements need to be implemented at both downstream and upstream mainstem dams to address common and most pressing passage impediments. Frontloading of the planned $50,000,000 expenditures is warranted based on the critical status Pacific lamprey in the Snake River Basin.

Response to Comment b and c:

We realize the numbers are very low in the Snake River, that the majority of adult lamprey continuing upstream above McNary Dam stay in the Columbia River. The history of tributary water management, habitat changes, non-salmon fish poisoning programs, installation of more dams, and other potential issues are likely involved with this severe reduction in numbers. Realizing our knowledge is imperfect and more is known about lower river system dams, we have chosen to prioritize sites where known passage problems exist, where passage efficiencies are poor, and large numbers of adults are being affected. Our assumption is that improving passage downstream will make more adults available to pass all upstream dams; that the number of those choosing to move upstream through the Snake River will also increase. With this approach, we believe we can make improvements that should benefit the most Pacific lamprey possible.

We understand the urgency to do more at as many dams as possible but we are limited first in our knowledge of the specific behavior challenges to the fish at a given dam and second, even when we begin to understand specific problems and have designed modifications for one dam, we still have unique dam specific design development and regional coordination to undertake to get an okay to make major operational or structural modifications. When we can, we are moving ahead quickly, as illustrated by the speed with which we modified the BON Cascade Island entrance to test out our design to help lamprey get into the ladders and by our evaluation of our capabilities of reducing nighttime entrance velocities at BON, MCN and ICE.

We agree that there are opportunities for small scale fixes within specific dams, including Snake River dams, that can be modified relatively quickly and inexpensively. For example, designs for

ladder modifications at McNary and possibly Ice Harbor Dams are being put planned for implementation over the next two winters.

d) The Corps states that, "A major challenge to all potential Pacific lamprey designs and operations is the ability to ensure that ESA-listed salmon are not negatively affected, or that hydraulic conditions at dams set up to aid in salmonid passage are not negatively altered." Major changes to existing structures, such as changing entrances to fixed-weir systems or research sampling related to evaluating juvenile passage must undergo ESA consultation processes and be proven to not negatively affect salmon passage. The approach and challenge to engineering Pacific lamprey improvements is to make new designs that actually aid both lamprey and salmon passage. (This is problematic due to vast differences in swimming and behavioral characteristics. If it is engineeringly possible, it will likely take a long time to figure it out.)

At least two improvement measures, the reduction of ladder entrance velocities and rounding of corners in fishways, have already been delayed and/or postponed due to ESA concerns. This issue has had and will likely continue to be an obstacle to timely implementation of needed lamprey passage actions.

Response to comment d:

We are bound by our other obligations under the hydrosystem BIOP and ESA to consider listed salmon and steelhead when we implement actions and modifications at our dams. We cannot abrogate these responsibilities but are constantly working to ensure that modifications to structures or operations improve passage for both lamprey and salmon whenever possible.

e) Some MOA identified actions are apparently planned over an extended time frame; probably well after the MOA period. These actions include comprehensive replacement of fishway diffuser screens, surface mounted turbine intake screens, and tag development for juvenile lamprey. These actions may be beneficial in the long-term, but are unlikely to offer immediate help for lamprey migrating to or from the Snake River Basin.

f) The commitment to conduct fishway inspections at dams to identify critical passage problem areas is useful to comprehensively document the per dam passage impediments and to have lamprey "experts" and Corps staff brainstorm potential fixes. However, multiple fishway inspections have occurred to date at several facilities, and many passage problems repeatedly identified.

Follow-up documentation of passage problems identified and solutions discussed or proposed at individual dams is paramount. In consideration of the critical status of Pacific lamprey in the Snake River Basin, we must take full advantage of near-term, relatively simple, low-cost passage fixes at individual dams that would individually and cumulatively improve system passage efficiency.

Response to comments e and f:

Our 10-year implementation plan to improve Pacific lamprey passage outline how we will take action with the increased funding commitments we have made. We have many challenges to face to accomplish the goals incorporated into this document and have set up a process that closely links the Tribes with prioritization and decision making regarding implementation of these actions.

Because there are many gaps in the knowledge concerning Pacific lamprey behavior, passage, and life cycle, an adaptive management approach will need to be followed to accomplish the evaluations leading to useful modifications at the projects. Over the next 2 years, research on the prototype entrance to the LPS at Cascade Island fish way at Bonneville Dam and the development of entrance designs for McNary and John Day dams will be critical steps to understanding what improvements to passage can be expected, and if implementing such an entrance at other dams is the best way to move forward. Fishway inspections have documented locations within the fish ladders that may be difficult for lamprey to pass, The Corps is working vigilantly to improve these conditions by making modifications to the ladders that will aid and improve lamprey passage. These near term, low cost fish ladder modifications are being planned for this winter at McNary Dam and at all the other Snake River dams over the next 2 to 3 years.

Appendix H
Yakama Nation Comments and How Addressed

The Yakama Nation appreciates the opportunity to provide comments to the U.S. Army Corps of Engineers (USACE) on the document entitled "Pacific Lamprey Passage Improvement Draft Implementation Plan: 2008 – 2018." In the spirit of the Columbia Basin Fish Accords, we look forward to working closely with the USACE, the US Fish and Wildlife Service and other lower Columbia River Tribes developing and implementing a Final Implementation Plan.

The Yakama Nation views the Draft Implementation Plan (Draft) as a good starting point, but there is still much work to be done. We recognize the difficulty in defining priorities and specific actions required within the FCRPS to adequately address passage and predation issues. This difficulty is exacerbated by inadequate and uncertain budgets. We remain very concerned that the current estimated annual budget allocations of $2,000,000 to $5,000,000 limits our ability to effectively research, evaluate and implement needed actions in a timely manner. The Yakama Nation strongly believes that passage issues at the mainstem Columbia River hydro-electric projects is the one key factor that will either substantially promote restoration of Pacific lamprey populations, or will continue to be the primary cause of rapid extirpation in many geographic areas.

First, the Yakama Nation recommends the Goal of the Final Implementation Plan (Final) should be to "*immediately arrest the decline of Pacific lamprey populations within the Columbia Basin and to quickly and substantially contribute towards rebuilding these populations to sustainable, harvestable levels throughout their historic range*".

We will adopt this new goal in our 10-year plan.

Further, we recommend the Final recognize and support the need to "protect, mitigate and enhance" for lost production of Pacific lamprey due to the operation of the FCRPS (Page 22, Section C.2 of the 3-Treaty Tribes – Action Agency Agreement, April, 2008). This would include supporting efforts not specifically related to passage over FCRPS Projects. To provide mitigation for ongoing impacts to the resources, the Yakama Nation recommends the USACE consider supporting the Tribes in their efforts 1) to translocate fish into the headwaters whose populations have been depleted by mainstem passage problems and 2) to develop artificial production and supplementation techniques that will improve productivity in watersheds where little, if any currently exist.

BPA and CBFWA with ISRP review have taken a lead role with regard to this issue by funding of initial feasibility evaluations of translocation and artificial propagation. Many regional issue regarding the potential positive and negative population level effects of these practices are ongoing. For the USACE, our focus and mission with regard to Pacific Lamprey recovery and the Accord is to improve passage through the hydrosystem for both adults and juvenile fish. We do currently supply excess captured fish to the Tribes for uses related to translocation.

The Yakama Nation appreciates the well written and concise nature of the Draft. Unfortunately, the document is nearly silent on each of the Projects other than Bonneville and John Day. Each of the mainstem Projects significantly affect lamprey passage, so each of the Projects should develop a research and implementation schedule demonstrating reasonable progress towards lamprey passage. We recognize Appendix A (Conceptual Lamprey 10-Year Schedule) as a reasonable first approximation but request substantially more information to support development of a more comprehensive table.

We recommend the Introduction of the Final Implementation Plan contain three sections:

- detailed information pertaining to critical obstacles that challenge both adult and juvenile passage over individual Projects and reservoirs (fishway entrances, weirs and corners, AWS systems, screens, etc),
- a Project by Project inventory of known and suspected adult migration challenges, and
- a Project by Project inventory of known and suspected juvenile challenges.

This additional Project-specific information will be useful in supporting the rationale and conclusions contained within the Final.

We have incorporated nearly all of these more detailed sections as additional or expanded appendices. The only detailed inventory lacking is the juvenile inventory as what we know is so limited. The know problems are discussed in the main body of the plan and a later update focusing on juveniles will likely be needed.

Following the Introduction outlined above, the Final Implementation Plan should contain a section providing a detailed Implementation Schedule, encompassing the four Columbia River and four Snake River FCRPS Projects. This Implementation Schedule should describe the full suite of anticipated actions and estimated costs for each of the FCRPS Projects, including associated research, monitoring and evaluation. The Final should also describe a brief cost – benefit – risk analysis associated with individual actions and with each of the individual Projects. If no actions are scheduled to be implemented within a given timeframe, this would be clearly illustrated as well. It is expected that substantially more precision in describing actions and cost estimates would be indicated in the near-term (2-3 years) than in the longer-term (5-10 years). The intention of this approach is provide a map and explicit rationale for a near-term and longer-term funding strategy, which is also lacking in the current Draft.

We are only now getting meaningful cost estimates of many of the components of the 10 year plan. As we get these cost estimates, we will share them with our Tribal partners and together we can prioritize, reprioritize, and plan the best path forward. If we feel we have legitimate cost needs in any given year, we can request them but we will be competing with many other regional BIOP required elements and we have no guarantee of full funding.

The Yakama Nation clearly recognizes the very high level of uncertainties associated with determining appropriate site-specific actions and estimating costs. However, this more systematic and comprehensive inventory would provide a "framework" to better understand the opportunities and limitation inherent in this work and would better demonstrate to decision makers the range, or rate of progress associated with budgetary decisions.

Finally, through the development and the implementation of the Final Implementation Plan regional coordination is essential, especially with the Mid-Columbia Public Utility Districts and other entities engaged in radio or acoustic tracking. There is a great need to track these fish as they move trough the Projects and the tributary streams. But we must continue to improve our ability to maximize the amount of information we can gain from each fish tagged while minimizing the total number of fish we disrupt.

We agree that ensuring good communication and sharing of data and tagged fish information is critical to ensuring we maximize what we can learn and how fast we can improve things.

Appendix I
USFWS Comments Received

Summary of USFWS detailed comments Pacific Lamprey Passage Improvements Draft Implementation Plan: 2008-2018

Page: 4
Subject: Sticky Note Date: 2/26/2009
add: web link for document, if possible

Subject: Sticky Note Date: 2/24/2009
add: per year

Subject: Sticky Note Date: 2/24/2009
add: passage

Subject: Sticky Note Date: 2/24/2009
You use "Lamprey Auxiliary Passage System (LAPS)" here, but use LPS elsewhere in the document, including the acronym list. Pick an acronym and be consistent.

Page: 5
Subject: Sticky Note Date: 2/24/2009
add: numbers, timing, and mortality

Subject: Highlight Date: 2/24/2009

Subject: Sticky Note Date: 2/24/2009
as warrented? Is there some numerical trigger, or do you mean as a matter of policy to replace with smaller gap screening ? - clarify.

Subject: Sticky Note Date: 2/24/2009
I know it's in the MOA and it's being considered for the early part of April at McNary, but there are lots of conflicts, as you know, for implementation system wide.

Subject: Sticky Note Date: 2/24/2009
add: and survival

Subject: Highlight Date: 2/24/2009

Page: 6
Subject: Sticky Note Date: 2/24/2009
This is vague. What's it measured against? Why not pick a target as the goal ... 60%, 75%, 90% ... ? Say we will attempt to reach some point.

Page: 7
Subject: Sticky Note Date: 2/24/2009
add: as based on the current state of knowledge as augmented by new study results in the future

Page: 8
Subject: Sticky Note Date: 2/24/2009
Numbers would be difficult to determine, but initial percentage goals could be stated, or a generalized goal of reversing the declining trend of returning adults to numbers seen
in pre-Snake River Dam days.

Subject: Sticky Note Date: 2/24/2009
add: adult and juvenile

Subject: Sticky Note Date: 2/24/2009
insert list here, or as an appendix

Subject: Sticky Note Date: 2/24/2009
add: , and USFWS biologists if available,

Subject: Sticky Note Date: 2/24/2009
This section should be moved to the Background section above, and references should be added to substantiate the information presented.

Subject: Highlight Date: 2/24/2009

Page: 9
Subject: Sticky Note Date: 2/24/2009
Lower than what? All fish with air bladders, or specifically here, migrating juvenile salmonids? Reference?

Subject: Highlight Date: 2/24/2009

Subject: Sticky Note Date: 2/24/2009
studies dated after 2002 are referenced here, clarify

Subject: Highlight Date: 2/24/2009

Page: 12
Subject: Sticky Note Date: 2/24/2009
A proportion analysis may also be useful for Figures 4 & 5.

Page: 13
Subject: Sticky Note Date: 2/24/2009
Remind the reader where this comes from ... reference page 4 list. Add MOA-AL and MOA-JL to the acronym list for quick referencing.

Subject: Sticky Note Date: 2/24/2009
add reference

Subject: Sticky Note Date: 2/24/2009
add the % or numbers

Subject: Sticky Note Date: 2/24/2009
add the % or numbers

Subject: Sticky Note Date: 2/24/2009
add reference

Subject: Sticky Note Date: 2/24/2009
add the % or numbers

Subject: Sticky Note Date: 2/24/2009
add the % or numbers

Subject: Sticky Note Date: 2/24/2009
Is it not done ? or completed? If it's done say so and reference. If it's not done what is the new due date?

Subject: Highlight Date: 2/24/2009

Page: 14
Subject: Sticky Note Date: 2/24/2009
replace with "of ", "for" ?
Should this section be re-titled to something else?

Subject: Cross-Out Date: 2/24/2009

Subject: Sticky Note Date: 2/24/2009
how much, % ?

Page: 15
Subject: Sticky Note Date: 2/24/2009
VBS ? or something else, ESBS, STS? How can it be mounted on the surface and be deep??? Re-write. Add to acronym list.

Subject: Highlight Date: 2/24/2009

Subject: Highlight Date: 2/24/2009

Subject: Sticky Note Date: 2/24/2009
from what to what ?

Subject: Sticky Note Date: 2/24/2009
Is there a target goal or just ambiguously lower than the current mortality?

Subject: Sticky Note Date: 2/24/2009
Where? Do you mean ahead of normal replacement schedule from wear and tear?

Subject: Sticky Note Date: 2/24/2009
Is there a standard protocol for all projects to follow when screens are pulled that assess screen impacts on lamprey (number impinged, area of impingement …)? If not there should be, and the data recorded and made available to the fish managers.

Subject: Sticky Note Date: 2/24/2009
add reference

Subject: Sticky Note Date: 2/24/2009
add reference

Subject: Sticky Note Date: 2/24/2009
delete

Subject: Cross-Out Date: 2/24/2009

Page: 17
Subject: Sticky Note Date: 2/24/2009
Reference item 1 in the 10-Year Plan Prioritization section above (about Cascade fishway entrance "rocks") as a current investigation.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Columbia River Fisheries Program Office
1211 SE Cardinal Court, Suite 100
Vancouver, Washington 98683-9658

February 26, 2009

U.S. Army Corps of Engineers
Northwest Division
Attn: David Clugston
P.O. Box 2946
Portland, OR 97208-2946

Dear Mr. David Clugston:

The U.S. Fish and Wildlife Service (Service) would like to thank the Northwestern Division of the U.S. Army Corps of Engineers (USACE) for the opportunity to comment on the latest draft of the Pacific Lamprey Improvements Implementation Plan: 2008-2018 (PLIIP). The following are general comments on the PLIIP.

- The Service appreciates the adaptive management approach of the PLIIP reflecting the need for more information on lamprey and your willingness to modify the program as knowledge gaps are filled and other needs arise. The time span of the plan demonstrates an understanding that lamprey issues are long term and shows your willingness to incorporate lamprey needs for at least the next ten years. The Service commends your annual monetary commitment to this historically low funded species.

- The PLIIP generally recognizes the need for prioritization of problem areas, research needs and implementation of improvements to ensure the most efficient use of time and money toward improving Pacific lamprey passage.

- The PLIIP recognizes and is committed to ameliorate common passage issues such as AWS passage and entrance to fishways as well as more complex ones such as the development of passage metrics and counting protocols. The development of the latter issues would greatly improve the evaluation of adult passage and status monitoring. Additionally, the Service appreciates the plans recognition that test fish are not limitless.

- The Service appreciates the inclusion of juveniles in the plan and your commitment to aiding their passage success and improving survival through the hydrosystem. Especially positive is the discussion of development of an active tag for juveniles which would greatly improve the state of juvenile lamprey research.

- While the Service agrees that research needs and implementation should be prioritized, the method proposed by the plan, where passage efficiency is poorest and where numbers of lamprey affected are the highest, is somewhat difficult to determine. There is a general lack of knowledge regarding these metrics as well as seasonal and temporal variations. Additionally, the plan states that for specific dam features and locations, preliminary priority areas of concern have been determined but these areas were not identified in the plan.

- The PLIIP states the need for prioritization of implementations but it has actions planned when unknowns are present. While the Service appreciates the implementation of actions known to benefit lampreys, others should be evaluated before implementation (e.g., gap screens).

- There are several instances where references are not cited (e.g., PNNL laboratory research that juveniles are less impacted by pressure and shear; significant mortalities through impingement on screens). Directing the reader to this literature would be helpful.

- In general specific numbers and percentages are not reported for changes seen in passage of adults and juveniles resulting from modifications to dam operations (e.g., percent increase in entrance efficiency associated with reduction in fishway entrance head and flow. For others see specific comments.). Values should be calculated and included to gauge effectiveness of the modification.

Specific comments are annotated in the separately attached draft plan (*Lamprey10-yearPlan_Sept262008-FWS edits 02-24-09.pdf*). Also attached in a separate document are some revised comments on the proposed 2009 lamprey projects funded by the Columbia River Fish Mitigation program (*USFWS Comments on Individual 2009 AFEP Lamprey Proposals.pdf*). Comments had previously been provided to the SRWG late last year.

The Service is optimistic that the plan written by the USACE in cooperation with the Service and tribes will be the first of many successful collaborations on conserving lamprey in the Columbia Basin. We are looking forward to working with the Corps and the tribes on this important endeavor.

Sincerely,

Howard Schaller, Ph.D.
Project Leader

Enclosure(s)

cc: Dan Diggs, USFWS
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