Corps of Engineers Plan for Addressing Pacific Lamprey Passage
DRAFT
2007-2011

1. Project Information:

- **Goal** - The goals of Pacific lamprey passage studies within the Northwestern Division of the Corps (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.

- **Authority** - The Flood Control Act of 1950 (Public Law 81-516) authorized the Federal Columbia River Power System and the Columbia River Basin Flood Control System. It also authorized mitigation for fish and wildlife affected by construction and operation of hydroelectric dams. The Columbia River Fish Mitigation (CRFM) program is a direct result of this authorization and is the primary USACE program for protecting, mitigating, and enhancing anadromous fish such as salmon and steelhead at USACE dams in the FCRPS. Pacific lamprey are an anadromous species and the CRFM program has funded lamprey research. Under this same authority, Operations and Maintenance funds have also been used to aid lamprey passage efforts at Columbia and Snake river dams.

2. Species Description and Background:

- **Species** - The Pacific lamprey is the largest lamprey species in the Columbia River Basin. This ancient species of fish spawns and rears in fresh water, but migrates to the ocean to spend its adult years where it becomes a parasite on larger fish species. In the fresh water, larvae develop in the gravel-mud substrate of tributary streams for up-to seven years before entering the main-stem rivers as juveniles to begin their downstream migration. Juvenile and adult lamprey typically limit their swimming activity to hours of darkness and spend most of the daylight hours attached to substrate. In addition, these fish lack a swim bladder, causing them to migrate lower in the water column, and downstream migration is usually associated with turbid, higher spring runoff. The combination of these factors serves to reduce the potential for predation during migration. When returning to fresh water after 2-3 years, adult Lamprey use the same fish ladders designed for adult salmonid passage to migrate upstream past the dams.

- **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 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. On January 28, 2003, the Pacific lamprey was petitioned for listing under the Endangered Species Act, however, no funds were committed in 2003 or 2004 to make a determination. As a result, an 'intent to sue' was filed in March of 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 listing, especially if their numbers continue to drop. Listing of Pacific lamprey could have a significant impact on the operation of FCRPS dams.

3. Adult Lamprey Passage – Assessment, Issues, Improvements

- **Adult Lamprey Research** - USACE has conducted studies on upstream adult lamprey passage at lower Columbia River dams since the mid-1990s. Pacific lamprey must pass up to eight or nine dams and reservoirs to reach spawning areas, up to four each in the lower Columbia and Snake rivers and up to five in the mid Columbia River. Radiotelemetry data has indicated that adult lamprey have a relatively low passage success rate at Bonneville Dam (only 40% to 50% of the fish released below the dam successfully pass). Passage rates at The Dalles Dam are considerably higher (up to 82%) and rates at John Day Dam

are intermediate. Preliminary estimates of passage success at McNary and Ice Harbor Dams have ranged between 43% - 62% and 33%- 65% respectively. In 2005 and 2006, the median travel time for PIT-tagged adults between Bonneville and Ice Harbor dams was 31 days, however one fish made the 190 mile migration in 11 days. Recent lamprey studies have also noted the following:

- Problem areas at Corps dams appear to be entrances, entrance pools, vertical slot flow control sections, and serpentine weir sections above the counting stations.
- Studies have concluded that many areas of the fish ladders at FCRPS dams, designed and modified to pass migrating adult salmon, are obstacles to adult lamprey passage. As such, a separate collection and bypass system to help lamprey pass these areas may be required for lamprey.
- Up to 20% of adult lamprey in the ladders at Bonneville Dam pass through picketed leads near the counting stations and into the auxiliary water channel.

- **Primary Adult Passage Issue** - Because fish ladders were designed to maximize salmonid passage, and lamprey are relatively poor swimmers in comparison, the ladders can serve as passage impediments. After years of research, it has been determined that it is unlikely that fish ladders can be modified to sufficiently accommodate both salmonids and lamprey; as their swimming abilities and behavior are quite different. Lamprey have difficulties with the higher flows needed to maximize salmon passage and flow criteria used in the ladders during shad passage increases the flow and head even more and coincides with the lamprey passage season. At some dams it may be more cost efficient and biologically effective to build auxiliary systems to pass lamprey by attracting them from the ladder into lamprey-friendly passage systems. Therefore, the USACE has been developing components of adult bypass systems that could be applied to dams where necessary. Funding for this work has been through the Columbia River Fish Mitigation program.

- **Other Adult Passage Issues** - Steel grating is present on the bottom of most fish ladders and serves to diffuse water supplied by the auxiliary water supply (AWS) system to the fish ladder. The grating also serves to keep fish 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 fish ladders are dewatered for inspection and repair. Lamprey are often found trapped in the chamber and must be removed by hand which is an access problem with safety concerns. Evaluations in the lab and in the JDA north ladder showed that reducing the grating size openings from 1 inch to ¾ inch would nearly eliminate passage through the gratings. This is being established as the new diffuser and intake grating criteria for the lower river through the Fish Passage Operations and Maintenance team. When gratings are scheduled for replacement, this new criteria will be used. Because lamprey lose girth as they migrate upstream these new criteria may need to be tested in the lower Snake River to ensure it is sufficient there.

  Lamprey also have trouble swimming past some areas of right angle corners as they climb the fish ladders. Areas with both very strong flows and confusing currents, such as entrances, diffusers, and serpentine weirs appear to be the most problematic. The rounding of some sharp corners at Bonneville Dam spillway fish ladder entrances and in the test lab were shown to provide some minimal assistance to lamprey through these portions of the ladder but improvements from rounding corners in the laboratory were small compared to reducing flow velocities. Judicious investigation and warranted use of rounding, including incorporating this into new designs for modifications of existing ladders, is planned. In other areas where such designs are expected to provide little improvements for lamprey but could interfere with salmonid passage, other options such as additional LPS may be used instead.

- **Adult Lamprey Passage Systems -** Alternative Lamprey Passage Systems (LPS) will continue to be developed, evaluated, and constructed at Bonneville Dam in an effort to aid in the passage of adult Pacific Lamprey. In FY03 the focus was on evaluating and improving the prototype collection and climbing sections of the system in the makeup water channel of Bradford Island. Design improvements included adjusting attraction water velocities and stream characteristics, and determining proper entrance collector orientation. Branding 100 lamprey and releasing them into the makeup channel each test week obtained efficiency estimates of up to 20%.

In **FY04** additional prototype sections (horizontal transport and egress sections) were designed, constructed, and evaluated. Over 8000 lamprey passed via the volitional egress in the Bradford Island AWS compared to around 12,000 counted passing in the ladder.

In **FY05**, we adapted these designs to build an entrance area prototype LPS at the Washington shore north downstream entrance, a major problem area for migrating lamprey. Modifications were needed to keep the ramp down against the high flows coming out of the entrance, delaying evaluations of the prototype LPS until **FY06**. Counts through the Bradford Island LPS were 9,242 compared to 10,257 counted at the Bradford Island window. Prototype half-duplex PIT antenna systems were installed and tested to evaluate the efficacy of the LPSs as well as overall passage monitoring information. In laboratory studies, a screen and grating gap size of ¾ inch was found to keep adult lamprey from moving through them. Radio and PIT tagged lamprey are also being evaluated at MCN and IHR to obtain the first meaningful passage metrics at those dams.

A double ramped permanent LPS was installed in the BON Bradford Island during the 2005-2006 in-water work period. In **FY06**, 14,975 adult lamprey passed the dam using this LPS compared to 14,862 counted at the window. During this same time, intake screens and diffuser gratings in pool 16 of the north JDA ladder were replaced with ¾ inch opening gratings and screens. Results from the ladder and in the lab found that this smaller gap was effective at keeping adult lamprey from passing through gratings. This smaller size should be considered the new grating and intake screen criteria for Portland District . Early in 2006 and 2007, modifications to the half-duplex PIT antenna systems were made at BON, TDA, and JDA to obtain better evaluations of the LPS and passage, as well to test their capability at monitoring dam to dam conversions. The first full year of the BON WA DS north shore ladder entrance area prototype LPS testing and dam passage occurred in 2006. Few lamprey found and passed into this LPS, likely because the complex structures and currents at the LPS collection area provide multiple other options for migrating lamprey.

A second year of evaluations of the BON WA shore ladder entrance prototype LPS in **FY07** is needed, with improvements to aid collection and a test of reducing entrance flows at night. Installation and evaluation of a LPS in the BON WA ladder AWS channel is also planned. Additional laboratory and field tests to optimize performance of the LPS will likely be needed. From 2008 to 2011, the designs that have been demonstrated to be effective will be permanently installed and evaluated in each of the fish ladders at Bonneville dam and at other dams. Prioritization of improvements will be based on a poor history of passage performance and the number of adult lamprey that are affected.

4. Juvenile Lamprey Passage – Assessment, Issues, Improvements

- **Juvenile Passage Research** - The USACE conducted studies on downstream juvenile lamprey passage from 2000 to 2002.The studies demonstrated that juvenile lamprey are less likely than salmon to be harmed by changes in pressure and shear conditions that occur during turbine passage and that turbine passage is likely a relatively safe route. However, they are vulnerable to impingement on surface-mounted turbine intake screens. Impingement on the screens can be a problem as documented by observations as well as field and laboratory studies. The effect on the rest of the bypass systems has not been well studied. One study at McNary dam indicated that many of the PIT tagged juvenile lamprey released into the juvenile collection channel did not show up in the juvenile fish facility. However, after new seals were replaced at the separator diversion gate, all PIT tagged juvenile lamprey released into the collection channel in 2005 were detected at the juvenile fish facility. While juvenile fish facilities located at collector projects on the Snake River collect a small number of juvenile lamprey, these fish generally congregate in the holding raceways for the transportation program and are either released back into the river or are transported and released in the Lower Columbia River below Bonneville Dam.

- **Juvenile Passage -** Because of their tendency to swim low in the water column, juvenile lamprey tend to swim under the turbine intake screens of bypass systems installed for salmonids at USACE dams. This results in juvenile lamprey tending to pass the dams through the turbines when they encounter a powerhouse.

- **Juvenile Passage Improvements –** Research regarding the turbine intake screens has indicated a need to reduce the potential for impingement. As a result, a changed spacing criteria for turbine intake screens was developed and will be implemented when new screen material is installed. In addition, impingement on tailrace screens at the collector project should be further investigated.

5. Major Activities and Tasks

Research will continue through FY07 and 08 on developing and evaluating alternative adult passage facility concepts, improving passage monitoring, and making improvements in existing ladders to reduce negative effects on adult lamprey passage.

The following long-term actions are recommended for the lamprey program:

- Auxiliary systems to pass adult lamprey past the dams should be evaluated and fully developed. In particular, the prototype systems under development at Bonneville Dam should be refined and fully tested. If the Bonneville auxiliary system is found to be successful, it should be implemented at other USACE dams as warranted. 2007-2011.
- Because entrance areas are consistently the most problematic passage location at dams for lamprey and the current difficulties with getting lamprey to use the prototype entrance LPS at BON dam, we should reevaluate reducing ladder entrance flows at night to assist with lamprey entrance passage efficiency and possibly explore alternative entrance weir designs. 2007-2011.
- Adult lampreys tend to pass through the ladders at night when fish counting is not occurring. As a result, lamprey passage counts are merely an index and should not be used to estimate upstream passage. The half-duplex PIT systems used to evaluate the effectiveness of the LPS, should be evaluated to see if they can improve adult lamprey passage estimates and dam to dam conversion estimates. These systems are being designed and installed such that they will not interfere with the salmonid PIT monitoring system's efficiency but will adequately detect lamprey for evaluations. 2007-2008.
- For the fish ladders, existing grating needs to be inventoried to determine grating type, size, condition, and history of stranding lamprey. Gratings in pools with a history of lamprey stranding and their associated intake screens (as necessary) should be prioritized for replacement with the smaller gap size. Sharp corners in and around the fish ladders should be rounded to aid passage through the fish ladders where they will be effective. Both of these measures can be done in conjunction with other work within the fish ladders. 2007-2011.
- Adult and juvenile lamprey passage needs to be evaluated at each of the projects to determine where the most significant problems exist so they can be addressed more rapidly.
- To prevent juvenile lamprey from becoming impinged on turbine intake bar screens, the bar screens should be replaced as needed with screens that have narrower spacing when replaced.
- To prevent juvenile lamprey from becoming stranded or impinged on collector project tailrace screens, a prototype juvenile lamprey separator should be developed which will aid in our ability to allow fish to pass safely through juvenile fish bypass structures.
- There is still a need to assess all juvenile lamprey passage routes at the dams. Only bypass system evaluations are practical at this time. However, as new technology is developed, spillway and turbine passage studies may become possible. As technology progresses, this will be revisited.
- USACE continues to assess new miniaturized tag technology as it becomes available to track both sub-yearling salmonid juveniles and juvenile lamprey passage at Corps dams.

2007 Tasks:

- Finalize modifications for the Bradford Island auxiliary water supply LPS.
- Install and evaluate a prototype LPS in the Washington ladder auxiliary water supply.
- Evaluate upstream dams for potential installation and evaluation of LPSs such as from below the count station to the exit area at the north JDA ladder.
- Modify the prototype WA DS North Ladder entrance LPS (attraction water capability and cover changes) and reevaluate use.

- Initiate block test evaluation of the effects of nighttime ladder entrance flow reductions on entrance and passage efficiency of radio-tagged spring Chinook by reducing entrance head to 0.5 ft. in the WA ladder.
- Prioritize diffuser pool gratings to be replaced with new smaller gap criteria gratings and if funds are available, begin implementation. Because lamprey girth is reduced as they migrate further upstream, we should evaluate if a smaller gap size is needed and if it would work hydraulically for Snake River Dams.
- Use radio-tagged and half duplex PIT tagged fish to evaluate passage efficiency at dams and locate passage problems areas at Columbia and Snake river dams.
- Initiate development of component design drawings, specs, and operating manuals for LPS systems.
- Begin development and implementation of fishway criteria for lamprey that do not negatively affect salmonid passage for use in future construction and modifications of FCRPS fish ladders.

2008 Tasks:

- Turn over Bradford Island LPS to project for future O&M.
- Second year of evaluations of prototype LPS in the Washington ladder auxiliary water supply, including any structural or operation modifications deemed necessary.
- If any upstream sites are deemed feasible for evaluations of prototype LPS, prioritize and begin construction and evaluations.
- Undertake a second year evaluation of nighttime entrance flow reductions at WA DS north ladder entrance.
- Continue replacing diffuser grates with smaller gap design.
- Investigate designs of alternative entrance weirs that could involve structural alterations to assist lamprey entrance capabilities. Such designs could possibly be incorporated into JDA north adult ladder modifications.
- Use radio-tagged and half duplex PIT tagged fish to evaluate passage efficiency at dams and locate passage problems areas at Columbia and Snake river dams.
- Continue development and implementation of fishway criteria for lamprey that do not negatively affect salmonid passage for use in future construction and modifications of FCRPS fish ladders.
- Develop a protocol to integrate daily lamprey counts at LPS with the adult passage facility counts and implement the procedure in 2008 if feasible.

6. Future Activities and Tasks

Future year tasks will depend greatly on what we learn from current evaluations. We may need to adapt our designs and objectives as we discover what works and what does not work in the features we are introducing to the ladders. It has taken decades to build and redesign ladders that work well for salmon. It is likely to take considerable time to accomplish the same for lamprey, especially considering the limitations we face in not affecting salmon passage. Each new site for an LPS will likely take 3 years to install, modify, and evaluate. Completely new concepts may be added to overcome ladder entrance obstacles. Acoustic telemetry may allow us to better understand fate of lamprey in reservoirs and new technology may allow us to adequately study juvenile lamprey passage issues.