Continuing Research Proposal

Development of Alternative Means to Pass Adult Pacific Lamprey Around Dams

Study Code: ADS-P-00-8

Project Leaders

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Study Summary

A. Goals

The goal of this study is to develop and evaluate aids to passage of adult Pacific lamprey *Lampetra tridentata* at Bonneville Dam.

B. Objective - 2005

1. Modify and evaluate performance of a structure to pass adult Pacific lamprey from the Bradford Island makeup water channel (MWC) to the forebay at Bonneville Dam.

2. Develop and evaluate a prototype lamprey collector at a Bonneville Dam fishway entrance.

3. Develop and evaluate use of half-duplex passive integrated transponder (PIT) detection systems for monitoring lamprey passage at Bonneville Dam

4. Evaluate lamprey behavior and use of prototype lamprey fishway configurations in the experimental fishway.

C. Methods

The prototype lamprey collector and bypass in the Bradford Island MWC will be tested with a variety of flow conditions to optimize lamprey delivery into the Bonneville Dam forebay. The efficacy of this device will be assessed by both a half-duplex PIT detection system, a lamprey-activated event recorder, and video evaluation. Lamprey tagged with half-duplex PIT tags will be released into the MWC and both bypass efficiency and the time lamprey require to pass through the device will be tested under high and low flow treatments.

A prototype collector will also be deployed at a main entrance to the fishway on the Washington-shore at Bonneville Dam. Lamprey tagged with half-duplex PIT tags will be released below Bonneville Dam and we will install a half duplex PIT detector at the fishway entrance. Lamprey use of the collector will be documented with video and the half-duplex PIT detection system will provide an estimate of entrance collector efficiency. In addition, we propose to initiate half-duplex PIT tag monitoring of lamprey passage at the Bradford Island MWC and both exits to Bonneville Dam fishways.

Tests will continue using the experimental test facility at Bonneville Dam to evaluate swimming performance and behavior of adult lamprey with various fishway configurations. We will focus on testing effectiveness of various flow and structural elements used to pass and seclude lamprey from other species both within fishways and at high velocity entrances.

D. Relevance

A petition to list Pacific lamprey as a federally-endangered or threatened species was submitted in 2002 to the U.S. Fish and Wildlife Service and is currently under review. In addition, the Columbia Basin Pacific Lamprey Technical Workgroup (a subgroup of the CBFWA Anadromous Fish Committee) has identified the need to improve lamprey passage at Columbia River hydropower dams as the highest priority for lamprey recovery efforts. This project will address concerns raised by tribal agencies, the U. S. Army Corps of Engineers (COE), and the Northwest Power Planning Council in section 7.5F of the 1994 Columbia River Basin Fish and Wildlife Program, related to effects of FCRPS projects on passage of Pacific lamprey in the Columbia and Snake rivers. Declines of lamprey (an important cultural resource) have heightened concern among tribal agencies throughout the Columbia River basin (Close et al. 2002). This project will specifically address the issue of improving adult lamprey passage at dams which has been raised repeatedly by Columbia River tribes.

Project Description

A. Background

Pacific lamprey are anadromous and adults must pass up to eight or nine dams and reservoirs, four each in the lower Columbia and Snake rivers and five in the mid Columbia River, to reach upstream spawning areas historically used by the species (Close et al. 1995) . This project was initiated to gain information on migration behavior of adult lamprey, and to improve their passage at Columbia and Snake River dams.

Development of this proposal was prompted by requests for preliminary proposals issued by the COE in June of 1994 and subsequent years, and it addresses concerns raised by the COE, the Northwest Power Planning Council in section 7.5F of the 1994 Columbia River Basin Fish and Wildlife Program. This proposal was developed via consultation with the COE, and in response to the high priority assigned to adult passage research in the Columbia and Snake rivers by the former Fish Research Needs and Priorities subcommittee of the Fish Passage Development and Evaluation Program, and the current Anadromous Fish Evaluation Program.

Radiotelemetry work in 1997 – 2002 indicated that adult Pacific lamprey passage efficiency (the percentage of lamprey that successfully passed over the dam of those that approached the dam base) at Bonneville Dam was less than 50% in all years (Moser et al. 2002b). This occurred in spite of the fact that approximately 90% of the lamprey tagged in all years of study returned to the base of the dam after release downstream, indicating migrational motivation and low tagging 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 usually lower than at Bonneville Dam. These data indicated that lamprey passage is restricted by the dams and that these projects may be contributing to declines in basin-wide lamprey abundance.

Models of lamprey passage rates at Bonneville and The Dalles dams further support the observation that lamprey pass more easily at The Dalles Dam than at Bonneville Dam (Moser et al. In Press). Delay of lamprey below Bonneville Dam may subject them to increased predation pressure from sea lions and sturgeon (R. Stansell, U.S. Army Corps of Engineers, personal communication). Models of lamprey passage rates at both Bonneville and The Dalles dams indicated that lamprey delay decreased with time of year (Moser et al. In Press). These data suggest that lamprey are most delayed during the early part of the season when sea lion abundance at the base of Bonneville Dam is highest.

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). By providing lamprey with an altrenative route of passage through this area (Figure 1), overall lamprey passage efficiency could be increased by approximately 33%.

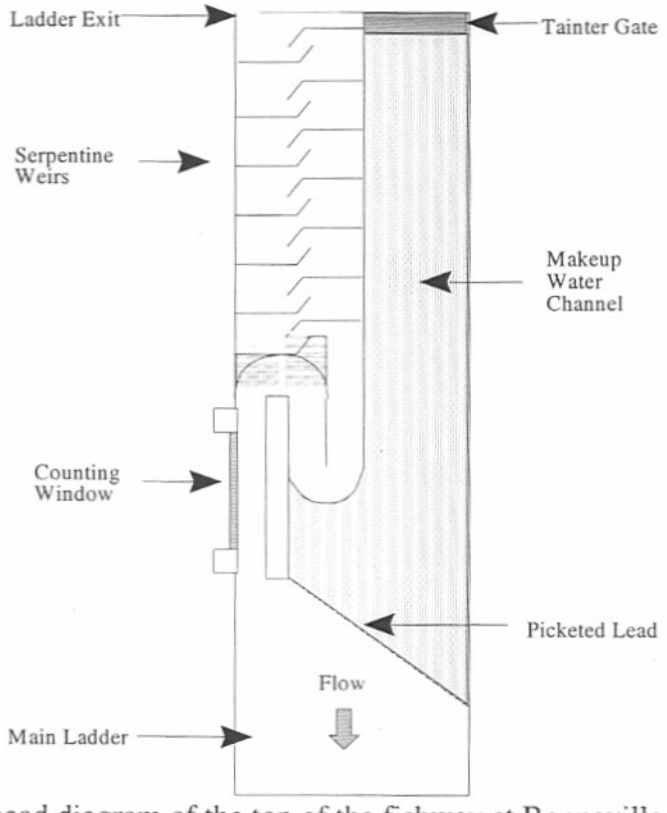


Figure 1. Overhead diagram of the top of the fishway at Bonneville Dam.

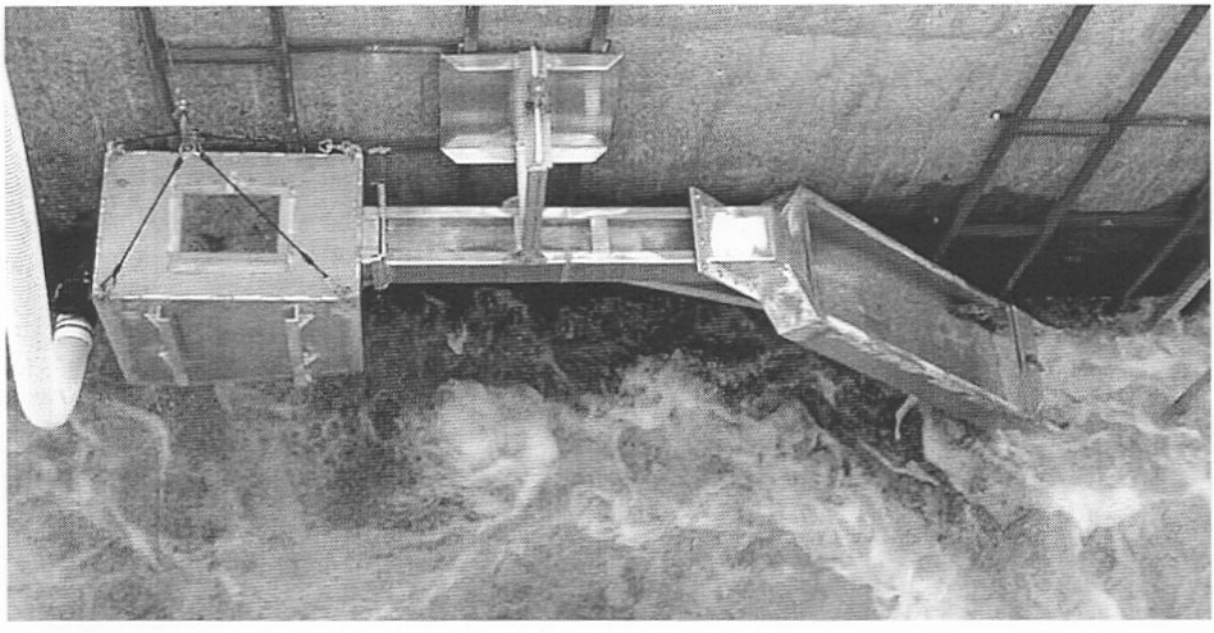
Radiotelemetry results and visual observations indicated that lamprey obstructed in the serpentine weir section at the top of the fishway can accumulate in the adjacent makeup water channel (MWC) (Figure 1). Because this area poses a significant obstacle to lamprey passage, we developed two prototype bypass collectors in 2002 to determine if lamprey could be collected from the makeup water channel at the top of the Bonneville Dam Bradford Island fishway (Figure 2). Tests of passage alternatives for lamprey at this location can be made without impacting salmon passage in the main fishway. Initial testing of the lamprey collectors indicated that lamprey would use such a device. Further design refinement and testing in 2003 resulted in collector efficiencies of up to 20% and catch rates of over 250 lamprey/night.

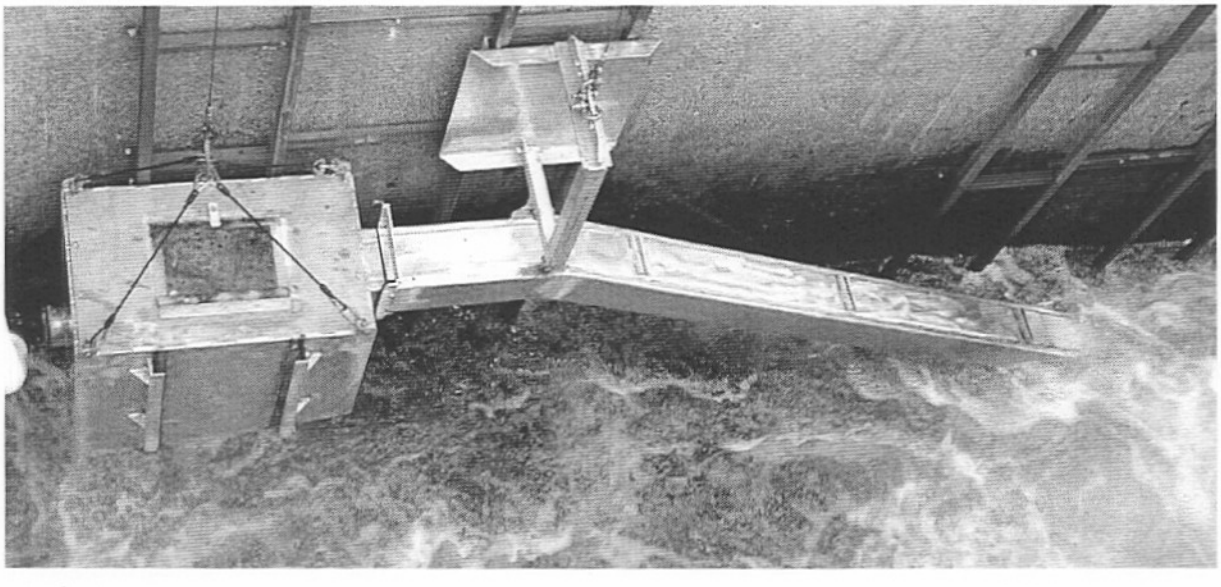
In 2004 we extended the bypass so that lamprey could exit directly to the Bonneville Dam forebay. With this extension, lamprey could bypass the MWC and count window/verticle slot fishway segments and volitionally exit into the forebay. This device was used by lamprey from the day it was installed and has resulted in the passage of thousands of lamprey to date. Concurrent experiments in the experimental fishway at the Adult Fish Facility (AFF) at Bonneville Dam have provided preliminary evidence that reducing flow rates through the bypass extension may hasten lamprey passage, although this may be offset by reduced attraction into the collector. To test this idea and to maximize efficiency of the MWC bypass device in 2005, we will conduct experiments to: 1) determine lamprey passage rates under different flow conditions, 2) determine collection efficiencies under different flow conditions, and 3) examine the roll of sheet flow interupters on bypass inclines where flow is maximized. This testing will provide information on the types of structures that are most effective for lamprey collection and transport. Such information will be needed for future development of passage structures in other areas.

Radio telemetry studies and test flume experiments have demonstrated that lamprey have difficulty entering fishways. Telemetry studies at Bonneville Dam in 1997 through 2000 have shown entrance efficiencies of 27 to 48 % at main entrances and efficiencies of less than 10 % at orifice entrances (Moser et al. 2002a). In 2005, we propose to install a prototype entrance collector at a main entrance to the Bonneville Dam fishway on the Washington shore. Design elements will be drawn from our experience in development of the MWC collectors and from behavioral observations in the experimental lamprey fishway.

In 2002, a simulated entrance was installed in the experimental lamprey fishway to determine the effects of specific stuctural flow modifications. The main factor affecting passage efficiency in these tests was the amount of water flowing through the entrance. During nighttime tests, only 4 % of lamprey successfully passed the entrance bulkhead with 46 cm of head (~2.7 m/s) at the weir; passage efficiency increased to 72 % when the head was lowered to 15 cm (~1.3 m/s). By dividing the entrance slot into two sections, one with high flow and one with lower flow, we were able to achieve a relatively high passage efficiency (53 %) while maintaining high flows through a portion of the entrance.

Figure 2. Prototype lamprey collectors tested in the Bradford Island MWC in 2002.





With a divided entrance, it was possible to maintain strong attraction flow while still providing a low velocity entry route. In 2002, flow in each of the two sections was manipulated by controlling the inflow of water to each of the channels differentially. While this method worked within the confines of the test flume, it cannot be practically applied at a working fishway entrance. Another way of manipulating flow is through the addition of weirs. In this way, the total number of pools increases, but the head level at each weir is lowered. Dividing an entrance into sections, one with a single entrance weir and one with multiple weirs in series, may be a practical way of getting lamprey to enter fishways. Whether or not such a design would work hydraulically and how lamprey would react to it behaviorally still needs to be tested. This type of stucture may also have implications for separating lamprey out from other species and getting them to enter a lamprey-specific bypass structure. Continued testing of lamprey in the experimental flume will focus on development of the most efficient and practical entrance collector design.

Objectives for Lamprey Study - 2005:

1. Modify and evaluate performance of a structure to pass adult Pacific lamprey from the Bradford Island makeup water channel (MWC) to the forebay at Bonneville Dam.

2. Develop and evaluate a prototype lamprey collector at a Bonneville Dam fishway entrance.

3. Develop and evaluate use of half-duplex PIT detection systems for monitoring lamprey passage at Bonneville Dam.

4. Evaluate lamprey behavior and use of prototype lamprey fishway configurations in the experimental fishway.

Methods

1. Modify and evaluate performance of a structure to pass adult Pacific lamprey from the Bradford Island makeup water channel (MWC) to the forebay at Bonneville Dam.

Previous telemetry results indicated that lamprey are delayed and fall back at the vertical slot fishways upstream of count windows at Bonneville Dam. Current velocities through the vertical slots, lack of attachment areas in critical stretches, turbulence, or illumination from visitor windows may contribute to lamprey delay in this area. Lamprey are able to move directly into the makeup water channel (MWC) at the top of the Bradford and Washington-shore fishways at Bonneville Dam from the adjacent vertical

slot fishway via grates in the wall or via picketed leads at the downstream end of the MWC (Figure 1). Lamprey that enter the Bradford Island MWC either fall back downstream or pass through the Tainter gate to reach the forebay of Bonneville Dam.

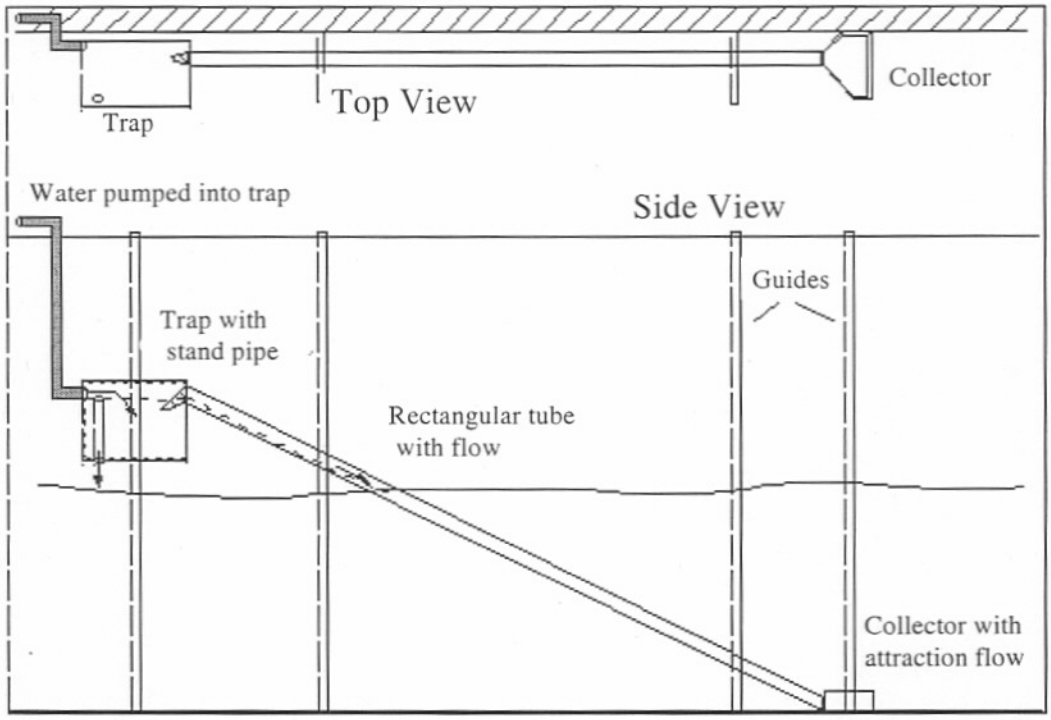
In 2002, we designed, built, and installed two prototype structures to collect adult lamprey from the MWC at Bradford Island for passage to the forebay of Bonneville Dam (Figure 3). The first design had a submerged entrance collector connected to a rectangular tube passing water at low velocity (< 4 fps). A trap deployed at the top of this tube collected lamprey and allowed assessment of bypass performance. Preliminary tests indicated that lamprey used this collector at a rate of around 0.7 lamprey/h. The second design incorporated an inclined plane entrance with water passing down the surface (Figure 3) as a method to attract lamprey to the bypass tube. Further refinement of both collectors in 2003 resulted in catch rates of over 20.0 lamprey/h.

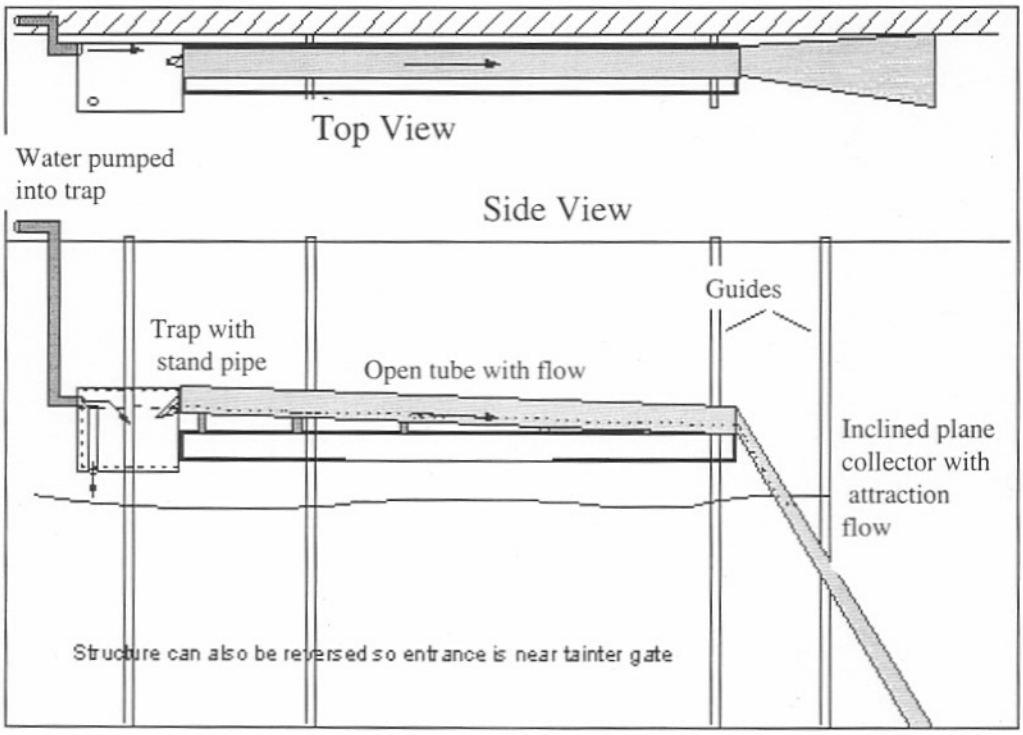
In 2004, we extended the bypass tube from the collector in the MWC to pass lamprey directly into the Bonneville Dam forebay. The open ramp collector passed lamprey from the MWC to a resting box at the same location as the trap in Figure 3. The resting box was designed to discourage lamprey fallback and provide lamprey passage to the next open ramp (Figure 4). At the top of the second ramp, lamprey entered a second rest box that was baffled to help prevent fallback. From this point the bypass featured a shallow inclined open ramp followed by a series of low elevation tubes that transported lamprey to an exit at the Bonneville Dam forebay. One rest box was positioned in this section to help discourage fallback and allow further monitoring of lamprey passage.

Lamprey use of the bypass extension in 2004 was monitored by a series of half duplex PIT tag detectors. PIT-tagged lamprey were released into the first rest box, and their rate of progress through the extension was monitored via PIT detectors that were positioned just downstream of each successive rest box (Figure 4). In addition, we installed a detector downstream of the first rest box to detect lamprey that fell back out of the bypass and into the MWC (Figure 3). The time and date of passage were recorded for each PIT-tagged lamprey by each PIT detector, so we were able to compute passage times for specific sections of the bypass device. In addition, we designed both a video recording and lamprey-activated event recording system to count the total number of lamprey that successfully exited into the forebay through this device. To date an estimated total of 5000 lamprey have used the bypass.

In 2005, we plan to modify and further evaluate the bypass design to maximize lamprey passage efficiency and speed through this device. To this end, we plan to: 1) determine lamprey bypass passage rates under different flow conditions, 2) determine collection efficiencies under different flow conditions, and 3) examine the role of sheet flow interupters on bypass inclines where flow is currently the highest. This testing will use the existing monitoring equipment (half duplex PIT detectors, video and event recorders) to provide information on the types of structures that are most effective.

Figure 3. Lamprey collectors and bypass tube configurations tested in 2002 and 2003 at the Bradford Island MWC at Bonneville Dam.

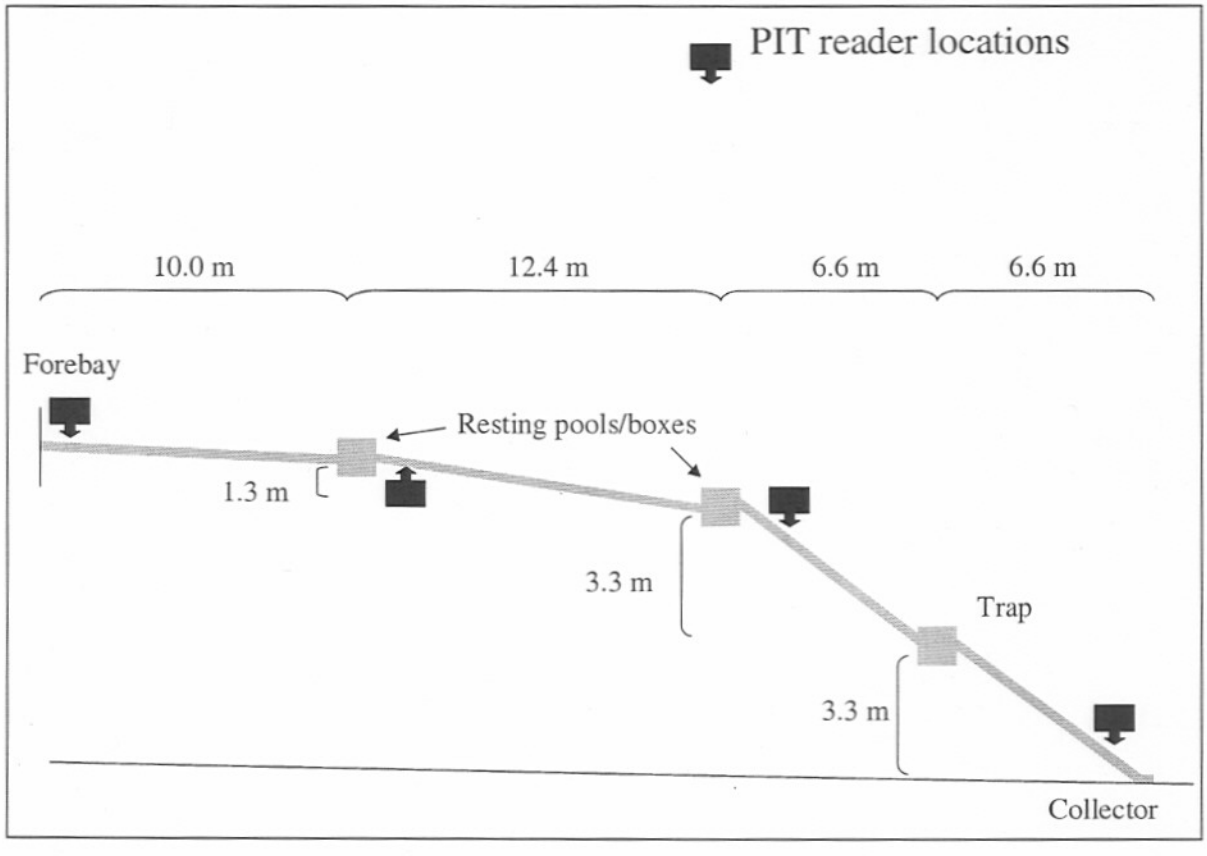




Preliminary testing of lamprey behavior in the experimental flume in 2004 has indicated that lamprey may be able to pass up inclined ramps more easily under reduced flow conditions, but that this might be offset by the inability of lamprey to locate the collector during low flow. To test this idea, we plan to modify the existing bypass to allow operation under half the flow produced in 2004. This will involve making some slight changes to the exit design to allow sufficient water levels through the exit area.

During the low flow experiments, we will determine entrance efficiency and rates of passage through the bypass sections using the PIT detection system developed in 2004. A total of 1000 lamprey will be tagged with half duplex PIT tags and released into the MWC. These fish will be detected by both the PIT detectors on the bypass and also by an antenna positioned at the downstream end of the MWC (to allow enumeration of lamprey that leave the study area). This will allow direct comparison of lamprey entrance efficiency (the number that enter and use the bypass divided by those tagged) and lamprey passage rates (m min^{-1}) for the two treatments: high and low flow. In addition, we will make visual observations of lamprey behavior during the two flow regimes and maintain counts at the exit area using both video and the lamprey-activated event recorder. In the event that low flow conditions do not improve lamprey performance on the inclined ramps, we will experiment with the addition of sheet flow interrupters (raised bumps on the inclined ramps that provide areas of lower flow).

Figure 4. Lamprey bypass at the Bradford Island Makeup Water Channel in 2004.



2. Develop and evaluate a prototype lamprey collector at a Bonneville Dam fishway entrance.

Previous studies have demonstrated that lamprey have difficulty negotiating fishway entrances. Experiments at the spillway entrances at Bonneville Dam fishways in 2000 and 2001 indicated that providing attachment areas for lamprey at these entrances improved lamprey entrance efficiency (Moser et el. 2002a). However, even when the spillway entrance bulkheads at Bonneville Dam were rounded in 2000 and 2001, entrance success did not exceed 60% (Moser et al. 2003). In 2005, we propose to install a prototype entrance collector at a main entrance to the Bonneville Dam fishway on the Washington shore. This collector will be designed to be both attractive to and easily entered by adult lamprey. At the same time, the design will exclude other fish to avoid impacting listed salmonids and other species that use the fishway. Design elements will be drawn from our experience in developing the MWC collectors and from behavioral observations in the experimental flume. We envision a slotted entrance adjacent to the main downstream entrance on the Washington-shore (Figure 5).

Evaluation of the prototype entrance collector will be accomplished using the video recording and lamprey-activated event recording system developed in 2004. In addition, to test the efficiency of the entrance collector, we propose to implant 1000 lamprey with half duplex PIT tags and to release them below Bonneville Dam. A PIT detector will be incorporated into the entrance collector. A large, half duplex antenna will also be needed to monitor approaches of PIT-tagged lamprey that do not use the collector. This will not only allow computation of collector efficiency, but will also provide a basis for comparing results of PIT detections to entrance efficiencies obtained in previous years of radiotelemetry at the same fishway entrance. The half duplex antenna array will be shielded and sited to avoid any potential interference with existing full-duplex PIT detection at Bonneville Dam. A likely location would be at the currently unused bulkhead slot that is just inside the main downstream entrance to the Washington-shore fishway (Figure 5).

3. Develop and evaluate use of half-duplex PIT detection systems for monitoring lamprey passage at Bonneville Dam.

In spite of the fact that there are ongoing changes that might effect lamprey passage at lower Columbia River dams, there has been no monitoring of lamprey passage since 2002. This is largely due to the fact that studies employing radiotelemetry are costly. We propose to investigate the potential for using half duplex PIT detection to evaluate passage efficiency of lamprey at Bonneville Dam. This would involve installation of PIT detectors at the exits to both the Washington-shore and Bradford Island fishways. The antennas at these locations would be shielded and sited to prevent any interference with existing full duplex PIT detection. The 1000 lamprey released below Bonneville Dam for Objective 2 would be used to compute overall passage

efficiency for lamprey in 2005 (lamprey use of the navigation locks is negligible; Moser et al. 2002b). We will thereby evaluate this technique for use at other dams in the future.

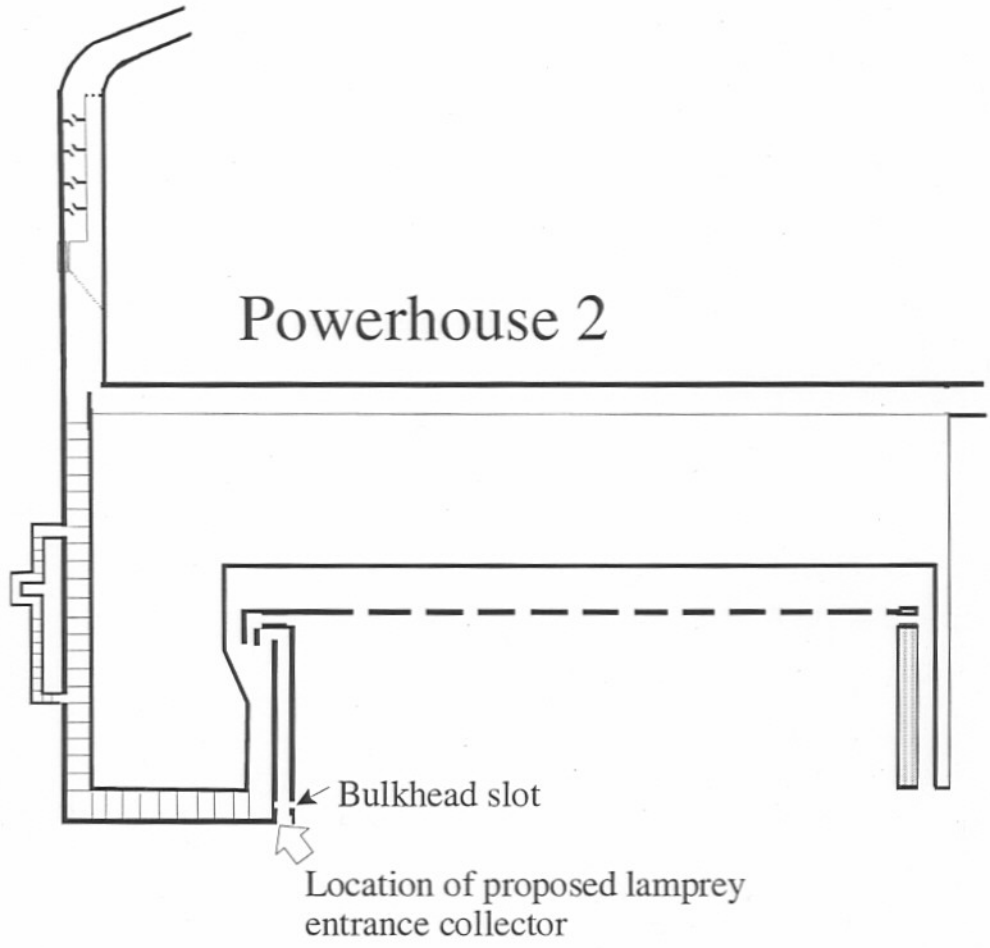


Figure 5. Position of the proposed lamprey entrance collector.

4. Evaluate lamprey behavior and use of prototype lamprey fishway configurations in the experimental fishway.

Tests completed at the Bonneville Dam experimental facility in 2000 included an evaluation of lamprey behavior at night using infrared lighting, effects of diffuser grating that spanned the floor of the test ladder between weirs, lamprey passage at orifices having a lip on the downstream edge, and an evaluation of lamprey behavior at a simulated count station. No tests were conducted in 2001. In 2002, we evaluated swimming performance and behavior of adult lamprey with various fishway entrance configurations. Results will be used in the development of a prototype lamprey fishway for Columbia River dams and to refine elements of the make-up channel bypass structure. No tests were conducted in 2003. In 2004, we continued studies in the AFF test facility to evaluate the effectiveness of a potential fishway entrance structure and determine the optimal design for a lamprey fishway. Design features tested included, the size, length, and slope of a lamprey fishway, and optimal flow and water velocities within the fishway. We propose a contimuation of this work in 2006 to design an entrance structure effective at collecting lamprey during variable tailrace and forebay elevations.

D. Facilities and Equipment

Construction of bypass modifications, repairs to bypass guides, and installation of PIT antennas will be conducted during the winter maintenance periods at dams, and will be completed prior to commencement of trapping lamprey in the spring of 2005.

E. Impacts of study on Corps projects and other activities

Division or district Corps personnel will be needed to provide technical review of research proposed for 2005.

Assistance from project personnel will be required as follows:

1. Provide access to the Adult Fish Facility (AFF) adjacent to the Washington shore ladder at Bonneville Dam during daytime and at night from late May through October for lamprey collection.
2. Provide access to dewatered bypass ladder to allow repairs and alterations to lamprey trap.
3. Provide access to the dewatered make-up water channel to allow repairs and maintenance to the bypass structure guides.
4. Provide access at night to make-up water channel area to release and retrieve lamprey and make modifications to the test passage structure.
5. Provide access to the Washington-shore fishway entrance, Bradford Island MWC and fishway exit areas for installation and operation of prototype collector device and download of PIT detection equipment

Biological Effects:

Procedures for trapping and marking lamprey at Bonneville Dam in 2005 will be similar to prior years. Fish will be collected using the lamprey traps at the AFF during night only. The trap box is hoisted from the bypass ladder adjacent to the Washington-shore fishway and fish are transferred into a water-filled plastic tank. The fish are then anesthetized, measured, and weighed. Fish used in the evaluations of the make-up water bypass will be marked at this time. We expect no mortality from the marking and release operation. Some marked fish will be released downstream from Bonneville Dam, imparting a migration delay as those individuals approach and reascend the dam's fishways.

Key Personnel

Project planning, administration, reporting:
M. Moser and C. Peery

Work plan preparation, protocols, permits:
M. Moser, NMFS
C. Peery, U of I
M. Jepson, U of I

Equipment specifications and purchase:
M. Moser, NMFS
W. Daigle, U of I

Design and evaluation of MWC bypass, entrance collector, PIT detectors, and flume tests:
M. Moser, J. Simonson, and D. Ogden, NMFS
D, Cummings, PSMFC
C. Peery and W. Daigle

PIT database development and processing
B. Burke and K. Frick, NMFS

Analysis of data and preparation of report segments:
M. Moser, C. Peery

Technology Transfer

Information and analyses from this study will be provided regularly to managers via reports and verbal presentations. Information that is appropriate will be published in technical journals. Special efforts will be made to provide information for managers as needed.

References

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