New Research Proposal

EVALUATION OF EFFECTS OF PASSAGE THROUGH THE JUVENILE BYPASS FACILITIES AND RESERVOIRS ON SURVIVAL OF JUVENILE PACIFIC LAMPREY

Study Code: BPS-W-00-4

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Study Summary

A. Goal

The goal of this proposed study is to gain knowledge on factors affecting survival of juvenile lamprey at dams and in reservoirs during their downstream migration. Specifically, we focus on passage success and areas of loss for juvenile lamprey in the juvenile bypass system at McNary Dam.

B. Objectives - 2005

Component 1: Determine depth use by juvenile lamprey in the forebay of McNary dam to assess whether large numbers of juveniles are passing under the extended-length submerged bar screens (ESBS) and juvenile bypass system (JBS) collection structures.

Component 2: Compare passive integrated transponder (PIT) and coded wire tag (CWT) technologies in juvenile lamprey under biological relevant laboratory and flume conditions in a continuing effort to develop an effective marking tool for evaluating juvenile passage and survival.

Component 3: Compare detection efficiencies of PIT and CWT tagged juvenile lamprey during simultaneous releases in the collection channel, gatewells, and forebay of McNary Dam to estimate collection and passage efficiencies, compare tagging methodologies, and assess the potential for PIT-related losses on at the ESBS and JBS.

C. Methods

Component 1: We will determine depth use distributions of juvenile lamprey in the McNary forebay by collecting juveniles using opening-closing net tows at multiple depths. Sampling will be conducted during the beginning, peak, and end of the juvenile migration period and over the diel cycle within each period.

Component 2: We will use a series of laboratory, flume, and field tests to compare tagging mortality, loss, cost of tagging, and detection efficiencies in the JBS for CWT and PIT tags under a range of biologically relevant conditions.

Component 3: We will used paired release groups of juveniles released to the collection channel, gatewells and forebay to compare detection rates of PIT and CWT tagged lamprey to determine whether tagging effects contributed to low detection rates previously observed at McNary Dam in 2001.

D. Relevance

Pacific lamprey are of ecological and cultural importance (Close et al 1995, 2002), but have exhibited sharp declines in the Columbia system since the pre-1960’s levels and have consequently been petitioned for listing under the Endangered Species Act. Currently, management of lamprey in the Columbia River basin is hindered by a lack of information on juvenile migration behavior and survival, and there is concern that juvenile out-migration success is low compared to pre-dam conditions. Currently, few data exist on juvenile lamprey depth use during migration and efforts to develop an effective marking method have had mixed results.

Project Description

A. Background

Pacific lamprey (*Lampetra tridentata*) are one of four Columbia Basin lampreys; all have been petitioned for listing under the Endangered Species Act because of population declines. Pacific lamprey are anadromous. Adults migrate upstream as far as Hells Canyon and Chief Joseph dams to spawn and then die. The filter feeding larvae, ammocetes, grow in soft riverine sediments for up to 7 year before metamorphosis to the juvenile stage. Juveniles resemble adults, and they migrates downstream to the ocean from March to August, where they enter a parasitic growth stage for 1-5 years before returning to freshwater to spawn. Loss of rearing habitat, dam construction, channelization, changing ocean conditions, and decreased water quality have been identified as factors contributing to declines of Pacific lamprey (Close et al. 1995, 2002).

Juvenile bypass structures designed for salmonids currently in operation at Columbia and Snake River dams may actually be ineffective or deleterious to juvenile lamprey Juveniles appear to swim lower in the water column than salmonids (Long 1968) and consequently many probably pass under submerged traveling screens or ESBS. Those encountering screens may be impinged or become "stuck" on screens rather than passing to the JBS (Moursund et al. 2002, 2004).

In their studies of juvenile passage at McNary dam in 2001, Moursund et al. (2002) found that PIT tagged juveniles released to the forebay, gatewells or collection channels were not efficiently collected and / or passed by the JBS. At least four mechanisms could contribute to this pattern. Note these mechanisms are not mutually exclusive:

1) Again, juvenile lamprey are thought to migrate at greater depths than salmonids, suggesting many fish were not collected by the ESBS and JBS prior to dam passage.

2) The turbulent hydraulic conditions and vigorous swimming in during JBS collection may have resulted in shed tags, as suggested by Moursund et al. (2002: 28).

3) The relatively large size of PIT tags implanted in juvenile lamprey may have increased the proportion of lamprey impinged and trapped in gaps on the ESBS by increasing the intermediate axis of the fish ("body width") and / or impeding swimming ability.

4) Once in the collection channel, juveniles may be lost through small openings, gaps, and cracks.

In this proposal, we describe work that would address1-3 above by determining the proportion of juveniles traveling at depths above and below the ESBS, and conducting a series of experiments to evaluate two tagging technologies under physically and biologically relevant conditions to simultaneously evaluate tag retention, survival, and potential tagging effects on collection and passage efficiency.

B. Objectives - 2005:

<u>Component 1:</u> Determine depth use by juvenile lamprey in the forebay of McNary dam to assess the potential for juveniles to pass under JBS collection structures.

Component 2: Compare survival and tag retention and tag effects on swimming ability for juveniles tagged with either PIT or coded wire tags (CWT) under biological relevant laboratory and flume conditions.

Component 3: Compare detection efficiencies of PIT and CWT tagged juvenile lamprey during simultaneous releases in the collection channel, gatewells, and forebay of McNary Dam to estimate collection and passage efficiencies, compare tagging methodologies, and assess the potential for PIT-related losses at the ESBS and JBS.

C. Methods

Component 1: Depth use by juvenile lamprey in the forebay.

Long (1968) sampled the depth of fish as they entered the turbine intakes at the Dalles Dam and found that ~80% of juvenile lamprey were captured in the bottom two-thirds of the turbine intake, in contrast to juvenile salmonids, the vast majority were found in the upper half of the turbine intakes. Though not statistically significant, Moursund et al (2002) found that detection efficiencies declined by one third when juveniles were released 10 feet or more below the surface in the forebay of McNary dam. Collectively, these observations suggest passage efficiency of juvenile lamprey by the Juvenile Bypass System (JBS) is affected by the depth of approaching fish, decreasing with greater approach depths. Hence, quantification of the depth distribution of juvenile lampreys as they approach the dam is critical to developing an understanding of detection and passage efficiencies through the JBS at McNary dam.

Objective 1: Determine depth use of juvenile lamprey in the forebay of McNary Dam and McNary Reservoir during the migration season.

We will collect migrating juvenile lamprey at the surface, at the depth of the ESBS and below the depth of the ESBS (as near to the benthos as possible) using a boat-towed 1 m opening-closing 4 mm mesh net. Tows will be made in the forebay as close to the dam as safely possible. Three replicate tows will be conducted at each depth at 000-200 hrs, 600-800 hrs, 1200-1400 hrs, and 1800-2000 hrs to characterize diel variation in depth use because Pacific lamprey are more active at night (Moursund et al 2000, Moser et al. 2002), though the proportion of juvenile lamprey caught during day vs. night in turbine intakes at the Dalles did not differ (Long 1968). Repeated samples will be taken once a month from March-July, with weekly samples taken during the migration peak, to characterize seasonal variation in depth use. All captured lamprey will be released downstream of McNary Dam or used for other marking studies at the project. Data will be analyzed using factorial ANOVA (CPUE = (Depth, Time, Date)), and will provide a quantitative estimate of the proportion of juvenile lamprey traveling at depths below the ESBS.

Component 2: Development of an effective tagging methodology for juvenile lamprey.

Determining the passage efficiencies at individual projects and through the hydrosystem is contingent upon an effective and affordable tagging methodology. The small size of juvenile lamprey precludes the use of radio telemetry tags, and PIT tags have been used with mixed results in previous studies. Here, we propose to further test the feasibility of PIT tagging juvenile lamprey and to develop methods for tagging and detecting juvenile lamprey in the JBS using coded wire tags (CWT). We will conduct a series of laboratory and flume studies to compare survival, tag retention, and potential tagging effects on impingement on screens for juvenile lamprey.

Laboratory Experiments:

Lamprey for Objective 1 experiments will be collected from the JBS at Lower Granite and Little Goose dams and transported in aerated coolers to the University of Idaho campus. Juveniles will be randomly assigned to one of three treatments: PIT, CWT, or control. 20-30 fish will be tagged per replicate and held in separate ~100 gal tanks at 17˚C (the approximate river temperature at peak migration) for 40 days. We will use 3 replicates per treatment. PIT tagging will be conducted using the method of Schreck et al. (1999) as modified by Moursund et al. (2002) using a 22-gauge needle to insert a standard full-duplex tag into the body cavity of anesthetized lamprey. CWTs have been successfully used to tag sea lampreys (*Petromyzon marinus*) in tributaries of the Lake Huron, with estimated tag loss rates of ~1% (Bergstedt et al. 1993, 1995) and in European eels (Thomassen et al. 2000). Double length CWTs (0.25 x 2.2 mm, Northwest Marine Technologies) will be used to maximize detection distance, and will be inserted without anesthetic to the epiaxial muscle mass near the insertion of the dorsal fin as in Bergstedt et al. (1993). Control animals will be handled in a similar fashion to the PIT treatment group. Mean survival and mean tag retention will be assessed among treatments at the end of the 40 days.

Flume studies.

Objective 1) Tag retention under normal versus strenuous swimming.

Moursund et al (2002) found high tag retention (97%) under laboratory conditions, but noted some loss of detection efficiency in the field trials may have been attributable to tag loss under strenuous swimming conditions. We will conduct a 2 x 2 factorial experiment to assess tag retention by tag type and water velocity (slow = 1 ft sec-1, fast = 4.0 ft sec-1, Moursund et al. 2002). Juveniles will be tagged as above, allowed to recover for 48 hours, and placed in a recirculating flume for 10 hours, a period similar to the median travel time from forebay release to JBS detection (Moursund et al 2002). In each of 5 replicates, 20 fish of each tag type will be used. At the end of the trial each juvenile will be interrogated for tag presence, and if absent, we will attempt to determine the cause of loss. Trials will be performed overnight, during the period of juvenile activity. The differences in the cumulative number of lost tags in each tag x velocity combination will be analyzed with a 2x2 chi square test.

Objective 2) Effects of tags on impingement and entrapment by traveling screens.

PIT tags may increase either impingement or entrapment by impeding swimming ability, or through the altered morphology because the tags may increase the intermediate axis of the fish (the axis that determines the minimum mesh size a fish could pass through). If present, this tagging effect will clearly bias passage and detection efficiency estimates downward. We will use a second flume experiment to test whether juvenile lamprey are more likely to become impinged or stuck in ESBS screens. Using a similar flume, we will block 70% of the crossectional area of the flume with an angled piece of ESBS material. Individual lamprey will be placed in the flume at one of three velocities (1, 3, and 5 ft sec-

1). Trials will be conducted at night (2000-0200 hrs), and observations will be made with an infrared video camera. Each trial will continue for 15 minutes, or until the lamprey has been impinged or stuck in the screen for 2 minutes. Trials will alternate randomly among PIT, CWT, and control individuals for a minimum of 10 replicates / treatment. We will test whether the proportion impinged or stuck and the time to these events differ among tag and velocity treatments. We will also examine juveniles for shed tags.

Component 3: Comparison of PIT and CWT detection rates at the JBS

We will use a series of paired release of PIT and CWT tagged lamprey to simultaneously address whether passage-collection-detection efficiencies differ by release location, release depth in the forebay, or by tagging method. Juvenile lamprey will be collected from the juvenile bypass system at McNary Dam.

Detection of CWT in JBS:

Prior to conducting paired releases, we will install and test the detection efficiency of a Northwest Marine Technologies Model 9500 Tunnel CWT detector at the McNary Dam JBS prior to the 2005 lamprey outmigration. The detector tunnel inside dimensions are 4 5/8" x 91/2" and detects the presence of tags while fish are passed at a velocity of 5-23 ft sec^{-1}. The detectors pass fish as large as 18 kg and have been used to interrogate up to 20 tons of herring per hour. Accuracy of the detector will be tested by releasing 3 groups of 50 CWT tagged surrogate juvenile lamprey into the JBS upstream of the detector.

Paired Release Groups and Detection in the JBS

Objective 1. Determine passage of juvenile lamprey released with PIT and CWT tags.

We will use a series of paired release groups to compare detection efficiencies of the two tag types under field conditions. Prior to each trial, a group of 30-50 juveniles will be tagged with PIT tags and a similar group tagged with CWTs and held overnight. Any fish exhibiting abnormal swimming behavior or which had shed its tag will not be used. The juveniles of both groups will be placed in a mesh release cage, ferried by boat into position in the forebay and released at one of three depths: surface, a depth equal to the top of the turbine intake, and at a depth equal to the bottom margin of the ESBS. We will conduct a minimum of three trials at each depth. Similarly, three trials will release juveniles into the collection channel and three trials will release into the gatewells. Trials will be conducted at night and during the peak migration period (May). Differences in detection frequencies between tag types, among release locations and among depths will be tested using logit models (i.e. 3-way contingency tables).

Fish Behavior

Objective 2. Determine avoidance behavior of juvenile lamprey.

It is unknown if juvenile lamprey behavior affects their ability to pass, avoid, or be detected at JBS at dams. We propose to evaluate avoidance behavior of juvenile lamprey by releasing lamprey surrogates (neutrally buoyant material similar size and shape of lamprey) with PIT and CWT, similar to methods described in Objective 1 above. Differential detections of the live and surrogate lamprey will be compared for evidence that juvenile lamprey may exhibit some level of avoidance behavior (sounding, horizontal movement, etc.) when approaching dam structures. PIT tagged surrogates can be paired with live fish releases. CWT samples would need temporal separation to allow differentiation between treatments. Sample sizes and timing of releases would be similar to those described above.

Summary:
These releases will determine whether the low collection / detection efficiency was caused by a tagging effect in 2001. Moreover, these trials in conjunction with data collected in Component 1 will provide first pass quantitative estimates of how many juveniles are entrained by the JBS and detected vs. entrained and lost vs. pass under the ESBS and through the turbines. Further, while CWTs require additional infrastructure beyond the PIT facilities that are currently being developed, the CWTs are inherently better suited to juvenile lamprey studies because of their small size. Moreover, for these types of studies, simple detection of the presence of a tag is sufficient, eliminating the need for the time consuming step of reading CWT codes. Finally, the development of CWT protocols for lamprey will provide the potential to develop a more cost effective tagging program to monitor lamprey SARs.

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