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Review of Pacific Lamprey Research Efforts for the U.S. Army Corps of Engineers' Anadromous Fish Evaluation Program

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Background

At the U.S. Army Corps of Engineers and the Northwest Power and Conservation Council's October 2012 request the Independent Scientific Review Panel (ISRP) reviewed five proposals and supporting documents for research of lamprey passage in the mainstem Columbia River. This research is intended to effectively inform prioritization, design, and evaluation of lamprey passage improvements. These projects are proposed for implementation through the Corps' Columbia River Fisheries Mitigation (CRFM) Program, specifically the Anadromous Fish Evaluation Program (AFEP). ISRP review of projects under this program was directed in the 1998 U.S. Congress Senate-House conference report for the fiscal year 1999 Energy and Water Development Appropriations bill. The ISRP's review responsibilities are also incorporated in the Council's 2009 Fish and Wildlife Program.

The ISRP reviewed the proposals using our standard criteria, that the project is based on sound science principles; benefits fish and wildlife; has clearly defined objectives and outcomes; and has provisions for monitoring and evaluation of results. The Corps also asked the ISRP seven questions that apply across the proposals and inform their overall lamprey plan.

Our review follows below. First, we provide general comments, answer the Corps' questions, and then provide recommendations and comments on each proposal. To complete the review, we followed our standard review process for Columbia River Fish and Wildlife Program proposals. At least three reviewers independently evaluated each proposal and provided comments. The ISRP held a teleconference and discussed the proposals and individual reviewer comments and developed answers to the Corps' questions. Lead reviewers developed recommendations and comments and distributed a draft for comments and full ISRP consensus. In addition, our review was aided by participating in the Corps' lamprey synthesis workshop held October 30, 2012 and the Lamprey Studies session of the AFEP Annual Review held November 29, 2012.

As requested, our review highlights positive attributes of the projects, as well as deficiencies that should be addressed to help the Corps ensure that limited resources are being effectively applied. This review also gives the ISRP an opportunity to see how the AFEP lamprey work meshes with the Fish and Wildlife Program lamprey projects (see ISAB 2012-3).

General Comments

The Fish and Wildlife Program's lamprey projects and plans are directed towards learning more about Columbia River Basin lamprey, their genetic structure, and general life history. The AFEP projects focus almost entirely on mainstem dam passage issues and passage behavior of Pacific lamprey. Therefore, the two programs mostly complement each other. A holistic plan, however, that can be used to coordinate these two efforts and prioritize lamprey research and recovery actions in the Columbia Basin does not exist. The ISRP suggests that the Corps, tribes, USFWS, NOAA Fisheries, and university and state-based lamprey researchers capitalize on their collegial partnerships and co-develop such a plan. Research and recovery actions will need to take place simultaneously across multiple life history stages and geographic locations for lamprey recovery to succeed. Having a plan that provides timelines and overall direction to these work efforts is needed.

Answers to the Corps' Questions

Each of the U.S. Army Corps of Engineers' (Corps or USACE) seven questions is listed below followed by ISRP comments on each question.

> *1. USACE completed the Pacific Lamprey Passage Improvements Implementation Plan in 2009. This "10 Year Plan" serves as a guiding document for meeting important commitments made in the 2008 Columbia Basin Fish Accords. All USACE-funded lamprey studies should directly or indirectly help USACE meet our specific Accord obligations. Is the approach identified in the 10 Year Plan, as reflected in research completed since 2008 and as described in the outline of anticipated future actions, commensurate with the specific commitments made?*

Yes, in general the plan systematically lists potentially needed passage improvements and gives some committed timelines to accomplish the needed modifications with testing along the way. Specifically, the 2013 proposals are generally very consistent with commitments in the 10-year plan. An exception is the commitment to modify ladders at Ice Harbor and Lower Monumental dams in 2013 (Table on page 20 of the 10-yr plan) which seems not to be addressed yet. Proposal LMP-P11-2 (Evaluation of larval … rearing in mainstem areas … impacted by dams) addresses an issue that was not given high priority in the 10-year plan, but it does address a data gap identified by the Columbia Basin Pacific Lamprey Technical Workgroup.

2. Given depressed adult lamprey runs in recent years, USACE and regional fish managers are concerned about the impacts of our adult lamprey tagging studies on the run at large. In 2009, USACE (in consultation with regional fish managers) placed a somewhat arbitrary rule that USACE-funded researchers should tag no more than 2% of the adult lamprey count at Bonneville Dam (including passage via Lamprey Passage Systems and night counts) for passage studies. Is this an appropriate cap, given the sample sizes needed to address research objectives?

Because the current population is judged to be below historical levels and declining, its productivity must be below the level required for replacement and there is no surplus production. Thus, if the handling and tagging of lamprey results in significant mortality of those fish (to be conservative say 100%) then the additional mortality can be expected to accelerate the rate of population decline by up to 2% (perhaps less depending on other limiting factors related to density, i.e., the population's capacity for compensation).

Although the 2% cap cannot be justified based on an analysis of population productivity, and seems to be quite arbitrary, it could likely be justified by considering the worst case losses against the benefits expected from greater knowledge leading to beneficial modifications in passage facilities. This position, however, is only true if study results help improve survival. Results to date appear promising. Thus, the approach of tagging adequate numbers of lamprey during a given year appears more attractive than delaying potential improvements because not enough information has been gathered to assess their efficacy.

3. Adult lamprey passage studies require handling and tagging of hundreds of animals with radio-telemetry transmitters and half-duplex PIT tags, but the information gained is used to inform critical decisions regarding performance of structural and operational changes. Some have suggested that USACE consider conducting post-construction tagging studies after a series of modifications is complete (perhaps every 2 to 3 years), rather than our current approach, in which lamprey are tagged each year to evaluate ongoing modifications. Given the inter-annual variability in passage metrics and the need to inform passage design decisions and priorities in a timely manner, we are concerned about the risks of waiting 2-3 years between telemetry studies. Given our implementation goals and the unique challenges of passage structure prototype development, what are the risks and benefits of conducting "check-in" tagging studies every 2 to 3 years rather than annually?

Studies should continue each year for several reasons. First, each return year is different and it is important to see how various operational and structural modifications function under different conditions allowing annual variation to be estimated. Second, yearly monitoring of

reactions of individual fish will likely speed up the adaptive management process. Last, results from multiple years can be statistically combined by using meta-analysis methods.

> *4. Standardized passage metrics (inter-dam conversion, passage times, passage efficiency, etc.) have not been developed for adult Pacific lamprey. Instead, USACE and others evaluate success of passage improvements in relative terms, comparing passage performance (using radio-telemetry, half-duplex PIT, and other approaches) before and after structural or operational changes are made. Is this approach appropriate, given the current state of knowledge of Pacific lamprey population structure and migration behavior? Please advise not only on the appropriateness of the current approach, but also on alternative or complementary approaches.*

The metrics for relative performance are well defined and appear to be suited for the studies being pursued. In general, before/after studies confound the treatment effect with temporal effects and BACI (or similar) designs are preferable. In some cases, before/after studies are unavoidable because "controls" cannot be established. However, when there are multiple opportunities for the same modification (e.g., different dams) then the Staircase Design (Walters et al. 1988) should be considered. Here, the same treatments are used but with a staggered implementation over time. This approach allows for a separation of temporal and treatment effects with limited control sites.

Concurrent research studies in the lab or at the Bonneville adult fish flume located would be a good complementary approach to better understand the behavioral, physiological, and swimming performance capabilities and limitations of lamprey. That is, more focus on biological criteria may add a useful perspective to the engineering design criteria commonly used.

> *5. In evaluating adult salmon passage improvements, USACE has relied (in part) on radio-telemetry technology for post-construction studies. Active telemetry requires handling and tagging hundreds of fish, but these tools allow us to track the behavior and passage success of all tagged individuals – offering a powerful window into the passage experience of the larger untagged population. This same approach has been applied to adult lamprey passage studies at FCRPS dams and results have been critical for informing priorities, evaluating modifications, and generally understanding lamprey passage behavior. Per our Accords commitments and 10 Year Plan, USACE intends to continue to make modifications at Lower Columbia and Lower Snake River dams. However, because passage numbers and system conversion from the mainstem Columbia dams to the Snake River dams is so poor, it is very difficult and risky to rely on active telemetry to evaluate passage behavior at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. Major structural and operational changes to dams are*

costly and potentially risky. For example, reducing fishway entrance flows at night may be a net benefit for passage at some structures but not others. Given the severely limited sample sizes available for active telemetry passage studies and the potential risks of generalizing results from Bonneville Dam to upriver sites, how should USACE evaluate success or failure of major modifications at the Snake River dams?

If not enough adult lamprey are available for using active tags at these four Snake River dams then the development of three-dimensional (3D) models of the fish passageways at these dams could be a possible approach (*see* proposal LMP-P-11-1 for further details). Water velocities and turbulence readings similar to those proposed in proposal LMP-P-11-1 could be taken at potential passage blockages at varying forebay and tailrace levels. Data from radio-tagged fish going through lower dams could also be used to help identify and prioritize such areas. Additionally, a hydraulic model with the capacity to predict turbulence and velocity based on structural features in fish passageways should be developed. Predicted values could be compared to those obtained by actual measurements to help validate or improve this model. Then simulated improvements to passageways could be inserted into the model to determine how or if hydraulic conditions have changed. If structural fixes are not possible then lamprey passage or flume systems or refuge boxes could be installed in perceived trouble areas. Use what is currently known to predict problem areas and perform controlled studies in flumes to evaluate how lamprey may respond to proposed modifications, then import adult lamprey from lower dams and evaluate how they navigate the fishways. This approach is not ideal, but given the low abundance of fish at these higher dams it is making the best of a bad situation. Such efforts should start now.

6. Development of a juvenile lamprey-specific acoustic tag is a specific action identified in the Accords and 10 Year Plan. The intent is to use such a tag as a tool for answering critical uncertainties regarding passage behavior and route-specific survival of juvenile lamprey at FCRPS dams. Results of downstream passage studies would inform decisions about where to focus limited resources and would help us understand the biological benefits and costs of altering structures and operations to improve juvenile lamprey passage. USACE has already funded some research to develop handling and tagging protocols and criteria in anticipation of future juvenile lamprey tagging studies. However, as with our efforts to downsize the juvenile salmon acoustic telemetry system (JSATS) tag, technological limitations on the size of tag components is a major driver of the "JLATS" tag development. Based on advancements in the technology and the successful completion of efforts to develop an injectable JSATS tag, USACE plans to proceed with development of a juvenile lamprey-specific tag in FY13. Given the anticipated development and testing schedule, a JLATS tag will likely not be available for

field studies until 2015 at the earliest. The current USACE strategy is to wait until these tags are available to initiate major investments in juvenile lamprey passage studies, given the relative value of active telemetry data relative to more indirect approaches proposed by others (passive hydroacoustics, net trawls, PIT tag studies). Is this prudent and consistent with our Accord commitments, particularly in light of other (adult) lamprey passage obligations and limited resources? What alternative juvenile lamprey RM&E path, if any, is recommended?

Juvenile passage is an important problem. The Corps and others should spend some time considering how HD-PIT tags might be used now to address some of the issues facing juvenile passage. This work could be taking place while development and testing of a JLATS tag is occurring. Given that Pacific lamprey are semelparous with a generation time >5 years, failure to reduce juvenile mortality within the next 5 years will not cause cumulative reductions in survival in the next generation, and will likely be offset by gains in adult passage over that same period.

Another possible concern about the reliance of JLATS is whether signals produced from these tags can be detected at dam passage. Air bubbles, general noise, and turbulence may interfere with signal detection. Consequently some alternative tagging or marking methods may have to be used to address all the issues associated with juvenile passage.

7. Building on Question #6 above, we anticipate that relative tag burden for juvenile lamprey telemetry studies will be relatively large, necessitating targeting of larger animals. This "high grading" of study fish can cause important biases in passage studies. How should USACE balance the need for this information (to guide management decisions by USACE and regional partners) against the potential biases of the results? Please advise on appropriate assumptions, risks, and other considerations.

The need to select larger individuals for tagging studies simply means that care must be exercised in avoiding or correcting for bias when drawing conclusions about how smaller (untagged) fish would have responded in the same circumstances. Perhaps bias effects could be estimated by examining the relative passage success of large and small juvenile lamprey using JLATS, PITs, half-tag Coded-Wire-Tags (CWTs) or external marks e.g. brand marks. Given some variation in size within the tagged group, it may be possible to correct for bias by estimating the direction and magnitude of a size effect on behavior within the tagged group. Even when a size effect is detected, or suspected, the overall response expected from the population can likely be estimated within bounds ranging from no beneficial effect to full beneficial effect for untagged sizes. The worst case scenario is that modifications that improve the performance of larger fish would reduce the performance of smaller fish. If the worst case seems likely, then a

complementary technique is needed to measure the performance of smaller fish that cannot be tagged, perhaps in a laboratory setting.

Literature Cited

Walters, C.J., J.S. Collie, and T. Webb. 1988. Experimental designs for estimating transient responses to management disturbances. Canadian Journal of Fisheries and Aquatic Sciences 45:530-538.

ISRP Comments and Recommendations on Each Proposal

Project#	Title	Project Sponsor	Meets Scientific Review Criteria?
LMP-P-11-1	Synthetic Evaluation of Adult Pacific Lamprey Passage, 2012	University of Idaho	Yes (Qualified)
LMP-P-12-4	Evaluation of Adult Pacific Lamprey Migration Behavior and Fate in Lower Columbia River using Acoustic Telemetry, 2013	University of Idaho	Yes (Qualified)
LMP-W-13-1	Evaluation of Adult Lamprey Passage Behavior in Relation to Fishway Modifications at McNary, Little Goose and Lower Granite Dams	National Marine Fisheries Service and University of Idaho	Yes (Qualified)
LMP-P-13-2, LMP-W-13-2	Synthesis of Juvenile Lamprey Migration and Passage Research and Monitoring at Columbia and Snake River Dams	U.S. Fish and Wildlife Service and U.S. Geological Survey	Yes (Qualified)
LMP-P-11-2	Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams	U.S. Fish and Wildlife Service	No

Synthetic Evaluation of Adult Pacific Lamprey Passage, 2012 (LMP-P-11-1)

The goal of this University of Idaho study is to continue efforts to develop a framework for cataloging structures, ladder modifications, and hydraulic conditions that may affect adult Pacific lamprey passage in fishways through use of a consistent and novel reporting method (3D modeling). Work in 2012 (Year 1) will provide a synthesis of available literature and telemetry data and develop 3D models for BON Washington Shore Fishway.

ISRP Recommendation

Meets Scientific Review Criteria (Qualified)

The ISRP commends the sponsors for proposing the use of 3D models to help visualize fish passageway features. This appears to be a novel and promising approach. Moreover, when structural attributes within the models are provisionally named or labeled, the community of users can change, accept, or edit these identifiers and create a common nomenclature for dam features. The incorporation of water velocity and turbulence layers into the models is another important feature since both will be useful in helping determine where potential blockages may exist. The sponsors also indicate that swimming performance data obtained from published investigations and from some proposed flume studies will be used to estimate passage difficulties.

The ISRP, however, has several qualifications regarding the proposal. Information should be provided on:

1) How adult lamprey size and condition will be considered when possible blockages are being identified.
2) The ranking system that will be used to assign levels of certainty to: a) identification of lamprey passage problem areas, b) the feasibility of correcting these sites, and c) the likelihood that the proposed modifications will actually resolve passage problems.
3) How model outputs associated with blockage identification will be verified.
4) Whether there will be a central repository for the 3D maps produced by the project. The logistics of map upgrading and dissemination also need to be developed and explained.
5) The citations of papers and reports referred to in the proposal, as none were provided.

ISRP Comments

Study summary

It is unclear in the Study Summary what other dam passageways will be modeled in future years. The sponsors also do not give an overview of why Google Sketchup was chosen as the 3D modeling tool. The pros and cons of alternative software choices were not presented in the proposal nor was information provided on how the 3D maps are to be distributed to potential users.

A. Background

The proposed effort to gather information is clearly justified. Currently, there is no central location where knowledge and documentation of fishway structures in FCRPS dams can be found. The production of 3D maps based on architectural plans and onsite measurements will help resolve this problem. Hydraulic modeling often uses estimated values and therefore typically provides a relatively coarse view of expected velocities, shear flows, and turbulence at specific points in a passageway. The sponsors plan on performing actual measurements of velocity and turbulence at differing forebay and tailrace levels. This will create a more refined view of the conditions lamprey face as they navigate through a passageway.

It would have been helpful if the background section of the proposal had included material on how adult lamprey behavior at varying water velocities will be used to identify potential bottlenecks. Also information about the track record of using hydraulic models to help with fishway design or modification should have been included. Although no direct reference to the proposed work appears in the Corps' ten-year plan to improve lamprey passage (USACE 2009), the plan does contain 3D representations of the new Cascade Island fishway entrance (see Figures 6a and 6b in the ten-year plan). These figures show the modifications made at this location to help adult lamprey passage. Were these figures produced by the sponsors? If so, the proposal would be strengthened by indicating how their proposed work supports the Corp's ten-year plan.

B. Objectives

The deliverables of this proposal need further clarification. The project has two major objectives:

1) To create 3D models of fishways and work with USACE staff and regional fish managers to compile a prioritized list of potential modifications. This work would only be done on fishways in the lower three dams. Presumably the same approach (inventory/modeling/measurement of velocities and turbulence would be needed at

other dams as well, but this possibility is not stated. The feasibility of recommended modifications and how successful they are expected to be is supposed to be estimated by some measure of certainty. How this value or estimate will be calculated is not described.

2) To ensure that the 3D models can be updated when: a) structural changes have occurred, b) lamprey passage systems are installed, and c) dam operations have been changed. However, where the models will reside, how they will be backed up- and disseminated, who will be responsible for upgrading them, and how this process will occur were not described.

Methods

The software and methods used to produce the proposed 3D models and to populate them with photographs are generally described. Using colors to highlight potential passage blockages in the models is a worthwhile addition. The inclusion of water velocity and turbulence data collected at the dams significantly increases the values of the models. Another positive aspect is the fact that these data will be collected whenever possible at the same location at different forebay and tailrace heights. However, how the models will be calibrated with biological information, e.g., with lamprey swimming and burst speeds, climbing behavior, and reactions to velocity barriers and different types of substrates is not described. Additionally, further information on the criteria used to rank proposed modifications in fishways and on the ranking procedure itself is needed.

Furthermore, it is not clear whether the impacts of proposed fish passage modifications on flow and turbulence can be estimated by the models. Will the 3D model, for example, be capable of extrapolating new flow regimes after modifications have been made? If it cannot, the ISRP encourages the sponsors to collaborate with hydraulic modelers to produce such a model. It would help identify the potential value of proposed modifications and also assist in prioritizing where future work should occur. The time-line shown under Objective 2 indicates that fishways at Bonneville, The Dalles, and John Day dams will be mapped over the next two years. An explanation for how and why these passageways were chosen should be included in the methods.

D. Facilities and equipment

These appear to be adequate.

E. Impacts of study on Corps projects and other activities

Documentation, 3D modeling, and measurement of water velocities in fish passage structures at the lower three dams may help identify opportunities for improvements. However, the Corps

needs to consider whether all the detail in the 3D models is worthwhile, if there is a trade-off between money available for 3D modeling (at lower three dams only) versus other projects that implement and test modifications or gather empirical information about adult lamprey migratory behavior. Additionally, it is not clear whether researchers and biologists experienced with lamprey behavior at fishways and other structures will be part of the groups that identify and rank potential modification sites. Their inclusion would benefit the project. Finally, some coordination with Corps personnel for crane time will have to occur along with getting access to fishways and organizing meetings to rank possible modifications. No other significant impacts are expected to occur.

F. Biological effects

Biological effects are expected to be minimal.

ISRP comments on past project results (retrospective analysis, if applicable)

This is a new study, but it would be important for the ISRP to see a report on results and progress made during 2012. Also as mentioned above, it is not clear if the use of models is more useful than a detailed review of the performance of existing lamprey passage structures, such as lamprey ramps.

Literature Cited

United States Army Corps of Engineers (Portland District). 2009. Pacific lamprey passage improvements implementation plan 2008-2018. 19 pp. with Appendices A – J.

Evaluation of Adult Pacific Lamprey Migration Behavior and Fate in Lower Columbia River using Acoustic Telemetry, 2013 (LMP-P-2012-4)

The goal of this University of Idaho study is to use JSATS telemetry to determine the behavior and fate of upstream migrating adult lamprey in the lower Columbia River, focusing on the Bonneville Dam reservoir and tailrace.

ISRP Recommendation

Meets Scientific Review Criteria (Qualified)

The proposal builds a reasonable rationale for using acoustic tags to gain information on behavior and migration patterns of adult lamprey. Acoustic tags have some definite advantages over radio and PIT tags and the 2010-2011 preliminary studies with acoustic tags provide a good basis for their use.

However, the ISRP has two qualifications regarding the proposal.

1) There are questions regarding the potential biological effects of triple-tagging lamprey. We know that effects of double tagging lamprey have been evaluated but are there any data regarding triple-tagged lamprey? Even PIT tags alone have been shown to have effects on lamprey migration performance. Consequently, some concern about applying three tags to individual fish was indicated by the sponsors. The ISRP would expect to see laboratory studies or field tests performed prior to their use in the field.
2) The proposal fails to include details of how data collected during the study will be statistically analyzed or otherwise examined. A short section describing the statistical designs and analytical approaches chosen should be included in the proposal.

ISRP Comments

Study summary

The background portion of the proposal adequately presents the primary goal and objectives of the study. It indicates that numerous lamprey entering FCRPS reservoirs may not pass succeeding upstream dams. Previous radio telemetry work, for example, showed that many lamprey captured, tagged, and released below Bonneville did not resume their upstream migrations. In the past, radio telemetry has been used to track and follow tagged lamprey over dams, in tailraces and reservoirs. However, the deep water in the large reservoirs above Bonneville Dam is not ideal for radio telemetry. Moreover, radio tags appear to influence survival and may also have unintended behavioral effects. Consequently, to reduce possible tag effects and to obtain more information on migration behavior, possible entry into tributaries, and spawning in tailrace areas, the sponsors will largely use JSATS tags. The sponsors also wish to explore the possible use of these tags in dam fishways. The final objective is to use historical radio telemetry, HD-PIT, and JSATS tag data to determine how environmental and operational conditions in the Columbia River influence the migration patterns of adult lamprey

A. Background

The background section of the proposal does a good job of explaining why the questions being addressed by the proposal are important. For example, radio telemetry and HD-PIT tag data both indicate that over 50% of the lamprey that pass Bonneville Dam do not pass The Dalles Dam. Their fate is largely unknown. The pros and cons of the tags (Radio, HD-PIT, and JSATS) that have been used to document adult lamprey migration behavior in the past are presented, giving a rationale for why JSATS may be the tag of choice for determining lamprey fate in reservoirs. Additionally, the sponsors intend to use triple-tagged lamprey to determine if JSATS tags can be detected and subsequently used to track adult behavior in dam fishways. New

developments in acoustic receivers now make it possible to track routes of tagged fish in three dimensions. The sponsors plan on capitalizing on this capacity by producing 3D tracks of adult lamprey in tailrace areas. These tracks will be used to help understand how fishway entrances may influence migrating adults, to discover where or if adults aggregate in specific areas, and to guide where entrances to Lamprey Passage Systems may be situated in the future.

B. Objectives

Two of the objectives, numbers 2 and 4, are almost identical to two objectives presented in proposal LMP-P-13-1. Due to the complexity and multiple objectives in LMP-13-P-1, the ISRP recommends that these objectives should be placed entirely within this proposal. All four objectives address significant information targets identified in the Council's Fish and Wildlife Plan (Council 2009) and the Corps ten-year lamprey passage improvement plan (USACE 2009).

C. Methods

Gaining an understanding of the potential use of tributaries by adult lamprey and their entry into tributaries would require detection of either radio tags or acoustic tags several months after tag application. The same thing can be said about discovering the possible use of in-reservoir and tailrace spawning areas as well as assessments about some mortality events in reservoirs. It is not clear that the operational life-times of tags currently available are long enough for such detections. New tags with two batteries or that operate in an intermittent fashion are being developed. These tags are supposed to last long enough to detect lamprey migration behavior associated with spawning. The status and availability of these tags was not mentioned. What contingencies will be taken if these tags are not available for the 2013 field season?

Approximately 350 to 400 adult lamprey will be tagged with JSATS and all of these fish will also receive HD-PIT tags. Seventy-five of these fish are also scheduled to receive radio tags. The primary use of the 75 triple-tagged fish is to evaluate detection rates of the same fish by two different tag types as they migrate through fishways. Concerns about the potential biological effects of triple tagging are expressed in the proposal. Since the major purpose of triple tagging is to see if JSATS tags can be used to evaluate fishway passage, we suggest that an alternative approach be considered. The same research team that is developing 3D maps of fishways and also measuring velocity and turbulence in fishway segments is responsible for this current proposal. Would it be possible to attach or locate JSATS and possibly radio tags in fishway segments while velocity and turbulence are being measured? In this manner, tag detection rates under known conditions in a wide array of fishway segments could be determined without using live lamprey.

Three major release areas for JSATS/HD-PIT tagged fish will be used, each having two adjacent release spots. The justification for using multiple release spots is clearly stated. Importantly, the fate of fish tagged and released in the two major release locations below Bonneville Dam will be compared to the fate of fish that were released above Bonneville Dam at the Stevenson/Cascade location. The energy expenditures, potential injuries, and temporal migration delays caused by dam passage on adult lamprey have apparently not been assessed in past studies. The investigators plan to compare the fate of these fish by collecting a variety of response variables (proportion of the tagged sample using tributaries, migration distance, fall back rates, migration rates, overall distribution, passage over the Dalles Dam, etc.) from fish representing each group. In this manner, estimates of the biological consequences of passing over the Bonneville Dam can be made. However, the analytical or statistical methods that will be employed to make these comparisons were not described and should be included in the proposal (Qualification #2 above).

Similarly, comparisons between the behavior of lamprey released at tail race locations (Tanner Creek and Hamilton) and those released 7 to 8 km lower in the Columbia River (Skamania/Dodson) are planned. Apparently the tailrace behavior and post-handling recovery rates of the fish released at these two different locations will be compared. The response variables that will be collected and the analytical methods that may be used to perform these comparisons were not described.

The planned effort to test the range of the acoustic detection arrays and mobile tracking system prior to doing fieldwork is an excellent idea. Mobile detection equipment will be used to follow individual fish. The vessel with this gear will also be equipped with a GPS unit and bathymetric maps making it possible to place tracked fish in space and to classify the depth and shoreline profiles they migrate through. Mobile tracking will occur above and below the Bonneville Dam and is being performed to examine tailrace behavior as well as migratory behavior in Lake Bonneville. A suite of behavioral parameters will be generated from the tracking efforts including migration rate and direction, migration depth, turning rate, turning angle, diel activity patterns, habitat use, and post-tagging behavior. Again, no information is provided about how such data will be used to categorize lamprey behavior or how it might be utilized to compare lamprey released from different sites.

Coordination among other JSATS users in the Columbia River and with the Corps appears to be excellent. Detection data obtained on tagged lamprey picked up by other researchers using fixed or mobile arrays will be shared with the sponsors at the end of each field season. They in turn will share any ancillary tag detection data they have gathered. All tagging and downloading of data from acoustic receivers will be coordinated with the Columbia River JSATS user Group

(CBJUG). The sponsors will also work closely with PNNL personnel when fixed arrays are established at the Bonneville tailrace.

The sponsors are unsure if lamprey with three tags can be used in some of their experimental work because of the potential biological effects of triple tagging a single fish. However, almost as good information could be obtained by an incomplete-block approach where all three combinations of 2-tag types are used. For example, a comparison of tag types A and B can be obtained directly from the paired measurements on lamprey with tags A and B, but also indirectly from the two paired comparison of A vs. C and B vs. C. As previously mentioned, the main purpose of triple tagging was to see if JSATS could be detected in fishways. The approach chosen was to have both JSATS and radio tags placed into the same fish and then use a paired analysis to see if detection rates differed on the same fish due to tag type. Have the sponsors considered placing JSATS into fishways and estimating tag detection rates in this manner? If this is a feasible approach triple tagging would not have to occur.

The fate of a fish is defined as its last detected location. However, if survey effort is much greater in one tributary than the other, it will affect the relative chances of detecting the lamprey. Unless some adjustment for detection efficiency is made, the last known fate of a lamprey is indicative, but not definitive of the actual migration pattern. Furthermore, if a fish is detected in a tailrace area how will potential alternative fates be assigned, e.g. did it spawn or die there?

In Table 1, a breakdown of the number of fish tagged is presented. However, the proposal does not present detection efficiencies from past work to evaluate if this sample size is adequate to meet objectives. What is the targeted precision for estimates of the proportion using various tributaries, escapement, post-release downstream movement, or migration rates (mentioned just under Table 1; Page 12). What magnitude of a difference in passage metrics can be reliably detected using the three metrics? Many of these questions can be answered using the methods presented in Devineau et al. (2006).

In the multi-year analyses, there will be factors that vary from year to year while other factors will vary (often considerably) within each year. It is unclear how the analyses will take account of the latter because of the need to match the individual lamprey with the relevant factor that it was exposed to within a year. For example, how would you know which forebay elevation is applicable to each lamprey within a year? Does the historical data have enough resolution to enable this matching to occur?

D. Facilities and equipment

The proposal makes it clear that refinements in how fish are located and followed will take place as the project proceeds. Efforts should be made, whenever possible prior to fieldwork, to test and evaluate new tags, detection arrays, software, new attachment booms for hydrophones, and such. In particular, the life times of double battery JSATS tags needs to be determined. Furthermore, JSATS that are designed to operate intermittently will need to be tested to determine failure rates and overall tag life times. One of the goals expressed in the proposal is to track individual fish over one or more diel periods. A vessel will be needed that can accommodate mobile tracking gear, changing weather conditions, and relatively lengthy operational periods.

E. Impacts of study on Corps projects and other activities

None. This study will be well coordinated with other Corps projects.

F. Biological effects

No mortality is expected from the marking and release operations, but it is common practice to hold some tagged fish to determine post-release immediate mortality. We assume that will be done.

Literature Cited

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Evaluation of Adult Lamprey Passage Behavior in Relation to Fishway Modifications at McNary, Little Goose and Lower Granite Dams (LMP-W-13-1)

The goal of this National Marine Fisheries Service and University of Idaho study is to develop and evaluate aids to passage and survival of adult Pacific lamprey *Lampetra tridentata* at mainstem hydropower dams.

ISRP Recommendation

Meets Scientific Review Criteria (Qualified)

This is a major adult lamprey passage and survival monitoring project in the AFEP program and it has many objectives and sub-objectives. The proposal addresses many of the commitments made by the Army Corps of Engineers in their ten-year Pacific lamprey passage improvement plan (USACE 2009). Proposal objectives also align closely with portions of the Council's Fish and Wildlife Plan for lamprey. The recent Synthesis Report (Keefer et al. 2012) is quite helpful for a good overview of this work, but the individual annual reports must sometimes be consulted for the details needed to track the multiple studies at multiple dams with often complex fish passage facilities. This study should be considered for frequent review by the ISRP similar to the CSS and NOAA Fisheries transportation and system/reach survival studies. Prior to ISRP review, a briefing by the project sponsors would also be very helpful, considering the size, scope, and history of this study.

Overall the ISRP finds that the proposal meets scientific review criteria. The reporting and publication of peer-reviewed papers is excellent and the study and monitoring designs are sound. However, the ISRP found several areas of the proposal lacking detail and direction, and thus has qualifications that should be considered.

Qualifications

1) In many instances, the proposal does not include sufficient procedural details to describe how the studies will be performed nor does it state how results from before and after manipulations or structural additions will be quantitatively evaluated. Below in the methods section, the ISRP has provided detailed comments regarding the expected descriptions of the statistical approaches or designs that would be implemented for each before-and-after comparison being proposed to provide assurance that the data being collected will be adequate for testing predetermined hypotheses. This proposal would be significantly improved by providing a detailed description of the analytical approaches that will be employed to address the questions posed in the proposal.

2) Thus far, the focus of the study has been on trying to find passage modifications at mainstem dams to facilitate Pacific lamprey adult passage. More attention should be devoted to developing biological criteria for passage in addition to focusing on engineering design criteria. The proposed studies in the Bonneville Dam adult fish facility/flume (Objectives 6, 7.2, and 8) are examples of the kind of studies that will help determine lamprey swimming performance and passage behavior.

Another call for better understanding lamprey behavior and limitations was in the data synthesis report by Keefer et al. (2012). They pointed out in their literature review (Section 2) that there were many unknowns and information gaps regarding lamprey behavior during dam passage, including diel effects on passage efficiency:

- site-specific information on the mechanisms of lamprey passage failure, and specifically whether hydraulic, structural, or other features like predator presence affect turn-around behavior at individual fishway passage bottlenecks
- identification of water velocity thresholds where lamprey performance is restricted, especially at fishway openings, in serpentine weirs, and at other sites where velocity is routinely > ~1.5 m/s
- identification of sites where water turbulence rather than simply velocity negatively affects lamprey behavior
- the role of poor attraction flow inside low-velocity fishway segments such as junction pools and transition pools
- the influence of white sturgeon on lamprey passage efficiency through lower fishway segments (i.e., collection channels, junction pools, transition pools)
- identification of additional sites where structures (including steps and corners), diffusers, and dead-end features deter lamprey passage
- identification of sites where high water velocity and/or turbulence coincide with limited opportunities for lamprey attachment.

The project should explore ways to address these information gaps through biological approaches as well as experimental testing via fishway modifications.

Justification should be provided for the second part of Objective 6 in light of the recent lamprey synthesis produced by Keefer et al. (2012), which appears to have accomplished the purpose of the proposed data mining exercise.

Other ISRP Comments

Study summary

The study summary adequately presents the overall goal of the project and its eight associated objectives. The brief methods portion in the summary describes how the work would be done. It also emphasizes the importance of developing and refining tools like DIDSON that can be used to evaluate the migratory behavior of lamprey as they encounter different environmental conditions in discrete segments of fish passageways. The ISRP agrees with the sponsors that the use of non-invasive methods to decipher migratory behavior of lamprey through fish passageways in FCRPS dams is an important objective. Such tools will potentially increase our understanding of the features in passageways that impede lamprey and how their impacts may be ameliorated. Additionally, the recognition that structural and operational changes designed to facilitate lamprey passage efficiency must not impede other migrating species, e.g., ESA-listed salmonids, is appreciated, as are the parts of the proposal designed to evaluate unintended consequences of structural and operational changes on migrating salmonids, for example lifting picket barriers to facilitate lamprey entrance into portions of fishways.

The proposal addresses a number of information needs identified by the Corps in their ten-year Pacific Lamprey Passage Improvement Plan (USACE 2009). The sponsors also note that passage over dams was ranked as the highest priority by the Columbia Basin Pacific Lamprey Technical Workgroup for lamprey recovery. Consequently, the proposal is addressing information needs identified by the Corps, the Council's Fish and Wildlife Plan, by Tribal entities and others concerned with lamprey recovery.

A. Background

The background information in the proposal adequately puts the work and questions being addressed into context. Previous studies are reviewed and areas where lamprey passage appears to be hindered by current conditions are identified, for example at some fishway entrances, collection channel/transition areas, and vertical slot and serpentine weirs. Surprisingly, a recent synthesis dealing with lamprey passage over FCRPS dams was not cited. This document by Keefer et al. (2012) presents two tools that prioritize where lamprey passage research should occur, by dam and also by segments within specific passageways associated with a dam. The priority tools in the synthesis (Keefer et al. 2012) support the sponsor's choices of working on passage issues at Bonneville and John Day dams. Additionally, they largely support the priority the sponsors have placed on specific passageway problems at each dam.

The background section also describes proposed solutions to perceived blockage points, and therefore offers a rationale for the fieldwork that is being planned.

B. Objectives

The proposal has eight objectives and many of these have sub parts or sub objectives. All are directed toward addressing information needs identified by the USACE in their ten-year lamprey passage improvement plan (USACE 2009). The proposed work also addresses some of the lamprey passage objectives of the Council's Fish and Wildlife Program (NPCC 2009). Consequently, the work being proposed has the potential to make important contributions to the issues surrounding adult lamprey passage over FCRPS dams.

However, the ISRP noted that some of the eight objectives can naturally occur together, but that some could/should be separated into individual studies. For example, the use of the DIDSON to evaluate lamprey behavior at specific structures could certainly be a separate study. An explanation of why all these objectives are combined and not developed into separate studies would be helpful.

C. Methods

In general, the methods section describes the questions that are being addressed but sometimes lacks specifics on how the work will be performed and how the statistical procedures will be implemented. What follows is a review of the methods section, objective by objective, and the ISRP recommendations for additional information under each objective that would help clarify the work that is being proposed.

Objective 1 of the proposal is designed to evaluate recent and planned modifications to fishways at the Bonneville and John Day dams. It has four subparts. The first one evaluates the effects of a lamprey flume system that will be installed at Bonneville. The goal is to compare overall values of passage efficiency at the Bonneville Dam after the flume system is in place with corresponding values observed prior to flume installation. Additionally, other passage metrics, entrance efficiency, passage time, proportion of entrances on first approach, and distribution of approaches per entrance will be compared. How each of these values will be calculated needs to be described, along with the statistical methods that will be used to compare them. The authors state that newly installed structures commonly are not immediately used by lamprey, perhaps because of chemical residues or lack of biofilms on newly installed metal structures. Because of this avoidance they remain undecided about using radio-tagged fish in the first year to evaluate flume effectiveness and therefore ask for a three-year period for this evaluation. Given that passage rates can vary from year to year and that chemical residues from new structures may inhibit passage it is doubtful that realistic

improvements will be detected in the short time period of the experiment. Sub Part 1 in Objective 1 also mentions that some fish will be triple tagged with radio, PIT, and JSATS tags to see if fish with JSATS can be detected in fish passageways. Details on how this might be done are lacking. Table 1 which projects the number of radio-tagged lamprey that may reach dams upstream of Bonneville needs further explanatory information, such as the estimated overall passage efficiency at each dam along with the expected survival of tagged lamprey from the top of a lower dam to the tailrace of the next preceding structure. Inclusion of this information would help the reader understand how the values in the table were produced. The table also appears to have some typos throughout the entire second column.

The goal of Sub Part 2 of Objective 1 is to determine appropriate flow rates in the lamprey flume system that will be installed at the Bonneville Dam by randomizing flow treatments in 0.5 ft/s increments throughout the migration season. The following basic questions were not addressed: 1) what is the range of the flow rates that will be tried 2) what is the duration of each flow period, 3) how will the relationship between flow rate, entrance efficiency, and number of lamprey caught at the terminus of the flume system be statistically analyzed to produce appropriate flow rate regimes, 4) how will the effect of "seasoning" or weathering be considered in the above analysis, and 5) how will flow in the flume be measured? Also given the small sample sizes of lamprey that will be present in a particular week, is there a reasonable chance of detecting a useful change?

Sub Part 3 of Objective 1 is designed to evaluate the effect of changes in the North Ladder fish passageway entrance at the John Day Dam. A variable-width weir, bollards, the removal of three transition weirs, a new auxiliary water system, and pumps were recently installed at this location. Also a lamprey passage system will be put in place during the winter of 2013. Clarification of the comparisons that are being planned and the procedures that will be used to make them are needed. Will overall dam passage efficiency under this new regime be compared to that previously seen at the John Day Dam? Or will comparisons be restricted to passage efficiencies through the new lamprey passage system and the North Ladder itself? Or will both types of comparisons be performed?

The purpose of Sub Part 4 of Objective 1 is to examine the effects of newly created refuge boxes. The boxes were installed to provide lamprey with dark and low current refuges during daylight hours as they migrate upstream through a fishway. The boxes will be installed either in the serpentine weir or turn pool in the North Shore fish passageway. The percentage of lamprey in the passageway and how long they stay in boxes will be recorded. However, no mention is made of the questions these data will help answer or of the statistical procedure(s) used to handle the resulting data.

Objective 2 also has four sub parts which are directed at modifying and evaluating the lamprey passage systems (LPS) at Bonneville and John Day dams. Sub Part 1 calls for extending the LPS at Cascade Island and providing it with a release box equipped with an underwater camera. The camera will be used to count lamprey leaving the box. No mention is made on how such counts might be made, e.g. have the sponsors thought of sampling video images as recommended by the ISRP in their review of the Willamette Lamprey experiments or using the newly developed "Cyborg Vision" system? Fifty lamprey adults with radio and PIT tags will be released into the LPS to evaluate passage efficiency and fall back rates. Again how these metrics will be determined is not stated nor is there any discussion about how the accuracy and precision of counts from the underwater camera might be determined.

The objective of Sub Part 3 is to determine the best type of opening for refuge boxes. Currently, some lamprey are able to leave the boxes, and the sponsors want to test alternative designs to prevent this from happening in the future. The fate of lamprey using the boxes is not mentioned. Although mentioned in the background section, the effects of refuge box entrance widths and configurations on migrating adult salmon are never addressed. Sub Part 4 states that University of Idaho researchers will monitor adult lamprey passage at the John Day Dam North Fishway but does not mention what questions this monitoring effort is designed to answer.

The purpose of Objective 3 is to use historical radio-telemetry data to examine the relationships between lamprey passage metrics and the presence of sea lions, various environmental parameters, and dam operations. In these analyses, there will be factors that vary from year to year while other factors will vary (often considerably) within each year. It is unclear how the analyses will take account of the latter because of the need to match the individual lamprey with the relevant factor that it was exposed to within a year. For example, what forebay elevation is applicable to each lamprey within a year? Do the past data have enough resolution to enable this matching?

Objective 4 examines the utility of using DIDSON acoustic imaging and video or other alternative non-invasive methods to examine the behavior of migrating lamprey at known problem areas. A variety of metrics, holding time, swimming speed, swimming orientation, depth of travel, entrance efficiency, time required entering a fishway, and entrance location will be collected on individual fish. How these potentially useful behavioral data will be used is not discussed. Will these metrics be associated with physical attributes such as velocity and turbulence? Additionally, DIDSON analysis will generate a large amount of raw data (10 frames/second times multiple days – lots of images to examine). Do the sponsors have the capacity or a program for analyzing this large amount of data?

The goal of Objective 5 is to identify potential trapping areas for adult lamprey below the Bonneville Dam and to try new trap designs. This objective is not well defined as no mention is made of the trap designs that might be tried, where potential sites might be located, or how trap efficiency will be measured.

Objective 6 is designed to identify the mechanisms that are responsible for adult lamprey passage failure and bottlenecks to passage. An artificial flume located at Bonneville will be used to address four questions – how does turbulence affect passage across a range of velocities; what is the relationship between water velocity and passage length on passage success; how does surface roughness influence passage success across a range of velocities; and does orientation of transition surfaces (e.g. vertical serpentine weirs vs. horizontal overflow weirs) affect passage success? A brief explanation for how the flume work will be conducted would have been useful. The random variables that will be produced from each study were not identified nor were expected sample sizes for each study mentioned. The types of data analyses that will be used to address each of the above questions were not described. Although lamprey size will be a covariate in the analyses, how will other factors such as water temperature and migratory experience be controlled or accounted for? The second part of Objective 6 was a data mining exercise that would examine past radio telemetry data to uncover bottlenecks to lamprey passage. However, the recent lamprey synthesis produced by Keefer et al. (2012) appears to have accomplished this goal, and consequently, we recommend that this part of Objective 6 be removed.

The purpose of Objective 7 is to ascertain opening or gap criteria for lamprey and sockeye salmon. It was discovered that lamprey were entering auxiliary water systems (AWS) in passageways and getting trapped. LPS systems were then installed in AWS locations and gains in lamprey passage were realized. Typically, picket barriers are used to prevent fish from entering auxiliary water systems, however, because they can facilitate lamprey passage an effort was made to ease lamprey entrance into these areas by raising picket barriers. Unfortunately, when barriers were raised, migrating sockeye also entered these locations and became trapped. To determine the appropriate gap that should be used to allow lamprey entrance but prevent salmonids from entering an AWS, the sponsors plan to use an underwater video system and record the number of attempts sockeye make to enter an AWS when picket barriers are set at known heights above the floor of a passageway. The plan is to raise a picket 1.2 cm per week and record the number of attempts sockeye make at entering the AWS. It appears the results will be confounded with time in that fish returning later could have a different “preference” than earlier returning fish. Is it possible to modify the experiment so that, for example, paired experiments are performed in each week with different heights? An incomplete-block design could control for the week effect and give good information.

The second part of Objective 7 is to determine an optimal gap height for adult lamprey when they pass underneath a vertical barrier, e.g., a picket barrier. Moser et al. (2008) found that a gap of at least one inch is required. The artificial flume at Bonneville will be used to determine an ideal gap distance for adult lamprey. The sponsors state that methods similar to those used by Keefer et al. (2010) will be used. A brief description of how this work will take place should be presented including replications used, experimental conditions such as flow rate, water temperature, duration of a test, and how the resulting data would be analyzed to establish an optimum gap.

Objective 8 addresses how non-invasive tools like camera systems and associated software can be used to obtain accurate counts of adult lamprey escaping past FCRPS dams. The work being proposed is a "first step" effort to test the accuracy and precision of adult lamprey counts as they move through a cylinder. Video and motion detection methods will be used to make the counts. As in many of the other objectives of this proposal, a concise description of how this work will actually take place is needed along with a description of how the resulting count data will be analyzed to assess accuracy and precision of counts.

Other specific questions and comments on methods

It is unclear how route selection will be estimated. Lamprey would have to be released well below the dams so that they can then "choose" their route. But if these lamprey will be collected typically after they already have chosen a route (in boxes on the structures), how will it be determined that subsequent route selection is not influenced by previous route selection? More details are needed on where the lamprey will be captured.

The proposal includes attempts to compute statistical power, but these efforts may need to be revisited. It appears that a baseline of 25% with an average n of 113 is used to compute power. However, this computation ignores year-to-year variation in entrance efficiency (Figure 6 in Keefer et al. 2012) and this year-to-year natural variation will make it much more difficult to detect differences. The actual power may be considerably lower, and consequently, many more than two years will be required to detect changes. The proposal should also specify the alpha level (0.05?) used in the power computations. Figure 6(b) indicates that the historical entrance efficiency was 82% but uses 80% in the graph?

Based on reports of work presented at the 2012 AFEP Annual Review it is not clear if more work is needed on objectives 7 and 8.

D. Timeline and scope of work

How the work will be apportioned between University of Idaho and NMFS researchers is clearly stated. The time line for when work will begin and be completed appeared to have numerous typos. The ISRP recommends that the sponsors produce a time x task matrix table, in which each row identifies an objective or sub part objective and each column represents a separate month, beginning with the first month of the project and ending with the last month of the project. This matrix will clearly show when work is expected to occur on each objective and should help the sponsors plan for expenditures and activities during the course of their work.

E. Facilities and equipment

Facilities and equipment are adequate.

F. Impacts of study on Corps projects and other activities

The sponsors have worked closely with the Corps in developing the objectives of their proposal. They have also coordinated with the Corps for access to dams and passageways, and when necessary, for crane time. They are also asking Corps personnel to provide a technical review of their proposal. Given this type of communication, impacts on other Corps projects and activities should be known and will likely be minimal.

No mortality of tagged lamprey is expected after release, but this should be evaluated with a holding study.

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Moser, M.L., H.T. Pennington, and J.M. Roos. 2008. Grating size needed to protect adult Pacific lamprey in the Columbia River Basin. North American Journal of Fisheries Management 28:557-562.

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Draft Synthesis of Juvenile Lamprey Migration and Passage Research and Monitoring at Columbia and Snake River Dams (LMP-P-13-2, LMP-W-13-2)

The goal of this study is to synthesize existing information related to the migration and passage of juvenile Pacific lamprey in the Columbia River Basin hydrosystem and estimate survival for use in a potential population dynamics model for Pacific lamprey.

ISRP Recommendation

Meets Scientific Review Criteria (Qualified)

The sponsors should consider and describe:

1) whether any population dynamics models of life history already exist for Pacific lamprey or for other species of anadromous lamprey in the Columbia River Basin or elsewhere.
2) who will create the population dynamics model for the entire life cycle, and who will take ownership of the product of this proposal and assume responsibility for the next steps?
3) how technically sophisticated the model will be (i.e., conceptual, simulation, deterministic, etc.).

ISRP Comments

Study summary

The summary describes the intent of the work well.

A. Background

The background section is well done.

B. Objectives

The objectives are consistent with the USACE 10-year plan as the first step needed to mitigate juvenile passage mortality. Overall the proposal describes a good first step in the development of a population model. However as noted in the qualifications, the ISRP recommends that the proposed work be put in the context of life history models for the entire life cycle. As well, the

ISRP suggests the sponsors consult ISAB report 2012-3 (Review of Lamprey Synthesis Report) for thoughts on the type of information needed to populate a life cycle model for this species.

C. Methods

See above qualifications concerning methodologies.

D. Facilities and equipment

Facilities are available.

E. Impacts of study on Corps projects and other activities

The sponsors will have to spend a fair amount of time with Corps staff when data mining. It is likely there are many reports in the grey literature to be found.

F. Biological effects

None.

G. Technology Transfer, Deliverables

Technology transfer plans seem reasonable.

Literature Cited

ISAB. 2012-3. Review of "Synopsis of Lamprey-Related Projects funded through the Columbia River Basin Fish and Wildlife Program. Memorandum to the ISAB Administrative Oversight Panel, 9pp.

Evaluation of Larval Pacific Lamprey Rearing in Mainstem Areas of the Columbia and Snake Rivers Impacted by Dams (LMP-P-11-2)

The goal of this U.S. Fish and Wildlife Service proposal is to document and describe larval Pacific lamprey rearing in Columbia and Snake river mainstem areas influenced by dams.

ISRP Recommendation

Does Not Meet Scientific Review Criteria

It is not clear how merely documenting the presence or absence of larval lamprey in pools and tailraces affected by dam operations would benefit recovery planning for Pacific lamprey. The information gained appears to be small and not very useful relative to the cost. As written, the project seems to have only limited ties to other projects. The ISRP recommends that the project

be redesigned so as to estimate larval lamprey density and habitat suitability for larval lamprey, by strata. Background information should indicate how findings would be integrated into the overall recovery program for lamprey, perhaps by assessing the extent to which stranding of larval lamprey could limit the population's recovery.

ISRP Comments

Study summary

The goal of this study, "to document and describe larval Pacific lamprey rearing in Columbia and Snake rivers mainstem areas influenced by dams," is not identified as a high priority within the USACE 10-year plan, but it is consistent with the need to fill specific knowledge gaps identified by the Columbia River Pacific Lamprey Technical Workgroup. Dam passage issues aside, the potential for recovery of lamprey populations in the Columbia River might be greatly enhanced if mainstem habitat created by dams (pools or tailraces) was found to be suitable for larval rearing. Moreover, as stated in the proposal, "little specific information is available on how many ammocoetes use these areas, when and how long they use these areas and whether they tend to be found in specific locations. This information can be used to help inform how reservoir and tailwater levels are regulated and, in turn, help to minimize any negative impact to lamprey populations." Unfortunately, the present proposal focuses just on presence or absence ("occupancy") rather than the extent (density and duration) of habitat utilization or the suitability of dam-influenced habitat. The use of presence/absence data could be strengthened by collecting data on important covariates thought to influence occupancy.

A. Background

Background information should provide a better explanation of why the study is necessary. The rationale seems to pivot on the conclusions of Young (2009) that larval lamprey in the Klamath River are susceptible to effects of stranding. To help gauge how serious stranding might be for lamprey recovery in the Columbia River, it would be helpful to provide more detail on this issue in the Klamath River and to compare the frequency and magnitude of potential stranding events in the Klamath and Columbia rivers.

B. Objectives

The objectives and expected outcomes are narrowly focused on determining presence or absence (occupancy), as opposed to estimating density and habitat suitability by strata in dam-influenced habitat. As proposed, detection of a single larva in an entire pool would provide the same outcome (occupancy) as detection of a high density of larvae in the pool. Some modification of the sampling plan would be needed to estimate density. Distribution across habitats is possible using presence/absence data but requires a suitable sampling design to

accomplish (See the following link for more information: www.uvm.edu/rsenr/vtcfwru/spreadsheets/?Page=occupancy/occupancy.htm.)

C. Methods

The proposed sampling device, an electrofishing bell with a suction device for collecting specimens, seem well suited to documenting the distribution of larval lamprey, and appears to have been applied successfully in the Willamette River. The actual dimension (i.e., sampling area on the ground) of the bell is not mentioned. Is the equipment to be used in this study the same size as in the study by Bergstedt et al. (1994), in which the base of the unit measures 0.85 m x 0.72 m, giving a sampling area of 0.61 m^2?

The diving bell is unlikely to be 100% efficient in extracting the larvae from the bottom. Bergstedt et al. (1994) sent divers down to the sampled area and made a concerted effort to extract the additional larvae that were missed by the bell. They found that the bell efficiency was around 75% and that efficiency declined as the size of larvae increased. A similar type of calibrated experiment might provide more useful information about density in the Columbia River.

Further description or evaluation of how the diving bell and suction device would work in a tailrace with strong currents would be helpful. Strong currents could cause the boat to drift, and even if the boat is anchored, the currents could prevent the device from "sealing" flat to the bottom, such that larvae might be lost from the suction device. In addition, the nature of the substrate might affect sealing, and hence the sampling efficiency within a quadrat. Sampling would likely be less effective on coarse than fine substrates. Inefficient sampling might not be obvious to technical staff, so that data from only partially effective samples might be included and mixed with data from more effective samples.

The computation of 80% certainty that no larvae are present if larvae are not detected in 34 quadrats depends critically on an assumption about the density and detectability of larvae where they do occur. This assumption would only be reasonable if habitats were either suitable or not suitable, and the number of larvae available to seed the habitat was not limiting. These conditions do not seem likely. Nor does it seem likely that the detection probability (that must depend on the density of larvae) would be the same in different rivers or habitats. Consider, for example, the case in which only one larva is present in the entire pool, so that by definition, the pool is occupied. It is obvious in this extreme case that a sample of 34 quadrats could not possibly provide an 80% posterior probability that no larvae are present! Alternatively, by determining the efficiency of the sampling system (see above), it should be possible to calculate upper and lower bounds on the density, which is of greater interest.

There is great deal of confusion in the proposal about detection probability. The sponsors define detection probability as the proportion of quadrats in which larvae are detected. This is not reasonable because the bell is not 100% efficient in extracting the larvae, and consequently, false negatives cannot be distinguished from true absences. A detection probability must be conditional upon a larva being present at the time of sampling. Note that the definition of *d* in this proposal differs from that in Jolley et al. (2012), which is properly conditioned. Jolley et al. (2012) sampled from an area that was known to contain larvae. In this proposal, the presence of larvae is unknown. A more complete description of how the occupancy data will be analyzed is needed.

If the goal is to estimate the probability of occupancy, that is the proportion of quadrats in a pool with at least one larva, then the standard occupancy modeling framework of Mackenzie et al. (2006) should be followed. That framework requires multiple samples from some (preferably all) quadrats, as in Jolley et al. (2012). For example, suppose that three samples were taken by the bell in each quadrat. In some quadrats, the detection sequence might indicate that larvae were detected on the first and third sample, but not the second. This "101" sequence of detections reveals that no larvae were detected on the second sampling even though at least one larva must have been present, thereby providing a mechanism to distinguish false negatives from real negatives, and a basis for estimating the real probability of detection. Such an occupancy study would provide less useful information than a real density study, but it would provide a measure larval distribution across the entire pool rather than just a simple yes/no result for the entire pool, as in the present proposal.

The intent to immediately discontinue sampling at sites where larval lamprey are detected (cell defined as "occupied") would reduce biological impact and save time, but the approach seems inconsistent with a more important objective – to investigate the features of dam-influenced habitat that can be shown to be suitable for larval rearing. An inherent problem in identifying the suitability of dam-influenced habitat is distinguishing absence due to unsuitable habitat from absence due to a paucity of larvae available for seeding. Even so, suitability might be judged by examining the density in nearby areas expected to receive the same larval recruitment and size (growth) of larvae relative to density.

D (&G). Facilities and equipment (and Key Personnel)

Facilities and equipment are well organized, and key personnel have good experience with lamprey studies.

E. Impacts

USACE may have to adjust flow to allow sampling.

F. Biological impacts

The impact on the lamprey population would likely be negligible as all collected specimens will be released after identification and measurement. The sponsors claim that previous use of this methodology (Jolley et al. 2009) suggests that captured larval lamprey experience little or no injury and mortality following release. However, the reference for Jolley et al. (2009) is not included in the proposal, and further evaluation of the mortality rate following release may be warranted.

No information is given on when the work will be done. Salmonid populations might be affected if electrofishing is conducted when juvenile salmonids are overwintering in the river as they are found in the substrate at this time. Further information on this potential problem is required.

H. Technology Transfer

A technology transfer plan is in place.

ISRP comments on past project results (retrospective analysis, if applicable)

The sampling methods appear to have been applied successfully in the Willamette River (Jolley et al. 2012).

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Mackenzie, D.I., J.D. Nichols, J.R. Royle, K.H. Pollock, L.L. Bailey, and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Academic Press, Burlington MA.

Young, R. J., G. C. Christie, R. B. McDonald, D. W. Cuddy, T. J. Morse, and N. R. Payne. 1996. Effects of habitat change in the St. Marys River and northern Lake Huron on sea lamprey (*Petromyzon marinus*) populations. Canadian Journal of Fisheries and Aquatic Sciences 53 (Supplement 1):99-104.