Emerging and Legacy Contaminants in Juvenile Pacific Lamprey in the Columbia River Basin

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Problem/Background

After surviving several hundred million years, Pacific lamprey (*Lampetra tridentata*) have declined in recent decades to the point where regional extinction is feared imminent. Tribal people in the Columbia River Basin have relied on Pacific lamprey for food and medicine for generations. The Columbia River Inter-Tribal Fish Commission (CRITFC) has developed a Pacific Lamprey Restoration Plan focused primarily on improving understanding of the current abundance and distribution of the species, passage, habitat improvement and the role of contaminants as a potential threat to the species viability and to tribal health (CRITFC 2008). CRITFC has partnered with Oregon Department of Environmental Quality (ODEQ) to analyze for select contaminants a small number of adult Pacific lamprey from the Willamette Falls, John Day Dam, and Shears Falls (Deschutes Basin). The sampling and analytical protocols for this work are described in the project's Quality Assurance Project Plan (QAPP; CRITFC 2009). The final report from that study is not yet available, but preliminary data indicates that adult lamprey from all sample sites have high concentrations of polychlorinated biphenyls (PCBs; A. Borisenko 2010 pers. comm.). When the final report and data becomes available it may inform the work proposed here. Results of European studies will also be consulted as it has been previously noted that stocks of the European eel have declined to a point where population survival is threatened, and anthropogenic factors including contamination are thought to be causal in the declines (Geeraerts and Belpaire, 2010 and references therein).

The main focus of the effort proposed here is to provide reconnaissance-based information to improve understanding of exposure and bioaccumulation of organic contaminants in juvenile Pacific lamprey in the Columbia River Basin and to gain inferences on how those contaminants may affect life history attributes. As juveniles (ammocetes), Pacific lamprey spend several years in freshwater rivers before entering the Pacific Ocean as adults. Ammocetes primarily reside in sediments at a depth of 1-2 feet and feed on microscopic plants and animals filtered from mud and water. This feeding strategy makes the juvenile life stage particularly susceptible to bioaccumulating organic contaminants that tend to bind to sediment and organic matter (ODHS, 2005). It is not known how far they travel in their early life. It is thought that they use currents during freshet events to move downstream to new sediment areas. They may do this every few months, stopping at 4-5 spots for a period before they are large enough and make the transformation to macrothalmia (often called transfers as they are transforming in preparation to enter salt water) and go out to sea. The developmental effects of contaminant body burden in the juvenile life stages is not fully understood, but it has been shown that contaminant levels increase throughout their lives with a range of effects in adults spanning from direct mortality to a host of sublethal effects at the cellular and organism level, including endocrine disruption (Geeraerts and

Belpaire, 2010). It is likely that the most profound impact of contaminant burdens is manifested in the period of migration just prior to and during reproduction when the life-long lipid stores are metabolized in place of eating. We will focus on juveniles because it is a key life stage about which little is known as far as contaminant burden, and because adult numbers are declining so rapidly that samples are becoming hard to obtain and location-limited. Juveniles are still present in sufficient numbers for wider collection. Detailed future laboratory studies combined with statistically robust field collections will be necessary to understand the true picture of contaminant impacts at different life stages, but are beyond the scope of this reconnaissance effort.

Contaminants of concern include polychlorinated biphenyls (PCBs), polybrominated diphenyl ether (PBDE) flame retardants, organochlorine pesticides, pharmaceuticals and personal care products, waste indicators, semi-volatile organics, and others. Many of these compounds are of particular concern relative to Pacific lamprey as they have the potential to pose both an ecological threat to the organism, and a threat to human health via consumption of adult lamprey (ODHS, 2005). Geeraerts and Belpaire (2010) identified some of these compounds as likely 'key elements' in recent declines of European eel stocks.

Some of the target classes of contaminants are considered 'emerging.' Their consumer use and environmental concentrations are on the rise and they are likely to become larger problems in the future. These include the human wastewater indicator compounds (including personal care products) and pharmaceuticals. Although of heightened interest, these classes of contaminants will not be analyzed in all samples for this project for several reasons. Many of these compounds tend to be hydrophilic and not expected to associate with sediments and organic matter, and therefore do not have the high potential for bioaccumulation in high lipid organisms such as the lamprey as compared to the highly lipophilic compounds such as PCBs and PBDEs (e.g., Santillo et al., 2005). Also, many of these emerging contaminants do not have established analytical methods, especially for extraction from biological tissues. However, a surprising number of these compounds have been detected in sediments of the lower Columbia River Basin (Nilsen et al., 2007). Custom research methods have been successfully modified to determine occurrence of several of these compounds in fish tissues for other USGS projects in collaboration between Nilsen (USGS Oregon Water Science Center [OWSC]) and the USGS National Water Quality Laboratory (NWQL). Therefore we will screen a selected subset of tissue and sediment samples for wastewater indicators and pharmaceuticals as part of this effort.

Analyzing several sediment samples from the study areas for the full range of compounds will provide valuable information on whether the key study areas identified here have comparable sedimentary occurrences of compounds compared to results from the lower Columbia River Basin (e.g., Nilsen et al., 2007), and therefore whether we should focus resources on analyzing a wider suite of tissue and/or sediment samples for these compounds in future years. U.S. Geological Survey Analytical Schedules and target compounds are listed in Appendix 1. Note that included in Analytical Schedule 8093 is oxyfluorofen, the main active ingredient in Goal, the herbicide spilled into 15-Mile Creek, OR in August 2000.

This is a three year collaborative project between CRITFC and USGS who are both contributing funding and other resources.

Objectives

There are three primary objectives of the proposed study:

1. Assess contaminant concentrations in juvenile (and adult if needed) Pacific lamprey from key study areas within the Columbia River Basin

Provide an interpretive product that will help with understanding the potential threat of toxic contamination to Pacific lamprey populations at several life stages, and implications for human health

Establish collaboration between CRITFC and USGS to support future work to improve understanding of contaminant accumulation in Pacific lamprey and the effects of contaminants on lamprey habitat use, distribution, survival and life histories, as well as contaminant impacts on other Trust species

Approach

Umatilla and Yakima tribal biologists and Corps of Engineers personnel are currently collecting juvenile lamprey as part of their larger restoration planning effort, and are collecting additional samples for the work proposed here. OWSC provided certified sample jars and instructions on appropriate sample collection and preservation techniques (based on Radtke, 2005; Shelton and Capel, 1994). Samples are handled only with clean gloves, are rinsed with native water, and placed in certified organics free glass jars with Teflon closure. Samples are frozen in the field immediately after collection and stored frozen until analysis. Sample collection and handling methods described in the QAPP for the Columbia River Pacific Lamprey Toxics Study (CRITFC 2009) will be followed for the proposed study as appropriate.

Ammocetes are collected by electroshocking and netting at the surface or collected on turbine intake strainer screens (CRITFC 2009; USFWS 2010). Information is recorded on length, weight, date, time, and coordinates. Juvenile lamprey samples are selected from among the larger pool of samples collected at each of the subbasins of particular interest: Yakima, Deschutes, 15-Mile Creek, and Umatilla and additional samples are being collected at the Snake River dams from mortalities on turbine strainer screens by the Corps of Engineers (Figure 1). We are currently exploring the possibility of collecting samples from the Columbia River Estuary as well (Figure 1). We may add samples from the Clearwater or Salmon River Basin as a reference site(s) in a future year if sample numbers support the addition (Figure 1).

Depending on biomass, individuals from a study area are likely to be composited. Compositing both improves the representativeness of samples per site, and helps achieve the 5-10 g wet weight needed for the multiple analyses planned. If possible, however, several individual organisms will be analyzed to provide some information on the variability of body burden in the population at a particular site. Depending on the character of the sample pool collected from each site, different size classes of juveniles may be evaluated to estimate accumulation rates versus growth (estimated by size). To this end, we may also analyze several macrothalmia. Macrothalmia are older and larger, generally 4-5 inches in length. They would be collected at a dam so they can only be associated with a reach, as opposed to a particular site. But they would provide an age-accumulation comparison to ammocetes, and their larger biomass would allow multiple analyses as a reconnaissance for what compound classes (including emerging contaminants) are present. Any

available background information on sites will be summarized to predict expected sources of contaminants to the study areas.

At a minimum, target analytes will include more than 50 halogenated organic contaminants (including PBDE flame retardants, PCBs, dichlorodiphenyltrichloroethane [DDT], and other OC and current use pesticides), including many endocrine disrupting compounds. Selected samples will also be analyzed for anthropogenic waste indicator (AWI) compounds and pharmaceuticals, and semi-volatile compounds. Analyses will be carried out at the USGS National Water Quality Laboratory (NWQL) following all established USGS Quality Control (QC) and Quality Assurance (QA) protocols [Online at *http://water.usgs.gov/owq/quality.html* and *http://nwql.usgs.gov/quality.shtml*]. For analysis of organic contaminants, the general laboratory procedure for both sediment and tissue samples is high-pressure solvent extraction, clean up, and concentration followed by quantification by gas chromatograph-mass spectrometry (GC-MS) and/or high performance liquid chromatography-mass spectrometry (HPLC/MS). Specific procedures vary by compound suite as follows: AWI compounds are analyzed by analytical schedule (AS) 5433 (Burkhardt et al., 2005, 2006), pharmaceuticals by AS 2080/9008 (Furlong et al., 2008), halogenated compounds by custom lab code method 8079/8093 (Zaugg et al., in prep.), and semi-volatile compounds by AS 5506 (Zaugg et al., 2006). Organic carbon in sediments will be determined by loss on ignition, grain size by wet-sieve and/or SediGraph methods, and lipid content of tissues by a gravimetric method. Reporting limits, precision, and other Quality Control Criteria are explained in detail in published method reports (cited above), and are defined in general for all organics analyses performed at the NWQL in Pirkey and Glodt (1998). The published methods are modified slightly for tissue analyses, but adhere to USGS and NWQL QC/QA requirements.

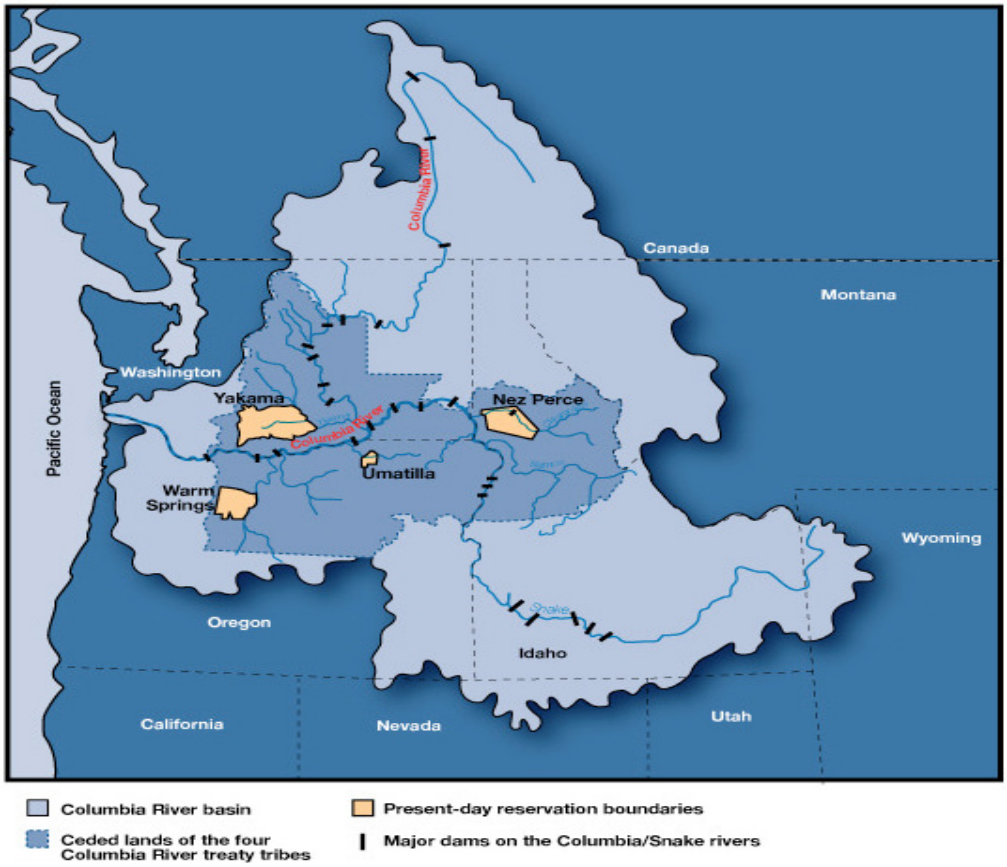

Figure 1. Map of Columbia River Basin showing juvenile lamprey sampling sites.

Reports and Products

By the end of the three-year project, we will provide an interpretive product report that will help with understanding the potential threat of toxic contamination to Pacific lamprey populations and implications for human health. We will also provide a status report at the end of the first year of the project, and an interim report at the end of the second year. We will contribute to the CRITFC Pacific Lamprey Restoration Plan as needed to support understanding the role of contaminants in management and restoration of this imperiled trust species.

CRITFC has active collaborations and ongoing projects that will directly benefit this work. We will ensure that the results from the proposed work will be considered in combination with results of related projects to coordinate the emerging large body of knowledge and support a new understanding of the role of contaminants in the health of Pacific lamprey and their human consumers. Several related projects include:

- Adult body burden analyses (ODEQ)
- Literature review of contaminant impacts on Pacific lamprey (CRITFC)
- Human health risk assessment for lamprey consumption (ODHS)
- Genetics work on lamprey populations (University of Manitoba; University of British Columbia)
- Ongoing work on lamprey life history (Warm Springs, Umatilla, and Yakama Accord tribes)
- Lamprey project in Winatchi (Fish and Wildlife Service [FWS])
- Deep water sampling of lamprey (FWS)

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