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Evaluation of Portland Harbor Superfund Area Restoration: Larval Pacific Lamprey

2014 Annual Report

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On the cover: *Deepwater electrofisher/dredge sampling at Alder Point Restoration Site at head of the Multnomah Channel of the Willamette River. Photo taken in September 2014 by Jeff Jolley.*

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Abstract – Pacific lamprey *Entosphenus tridentatus* are declining in the Columbia River Basin. Numerous conservation efforts, including habitat restoration, are now being implemented. Larval lamprey use of restored habitats is understudied. To understand their effectiveness, actions to restore habitats associated with the Portland Harbor Superfund area remediation (focused on juvenile Chinook salmon *Oncorhynchus tshawytscha*) necessitate evaluation of Pacific lamprey before and after project implementations. We used a unique deepwater electrofisher to explore occupancy, detection, and habitat use of larval Pacific lamprey and *Lampetra* spp. at the Alder Point restoration site and Ross Island reference site in the Willamette River. We used a generalized randomized tessellation stratified (GRTS) approach to select sampling quadrats in a random, spatially-balanced order. Lamprey larvae occupied the shoreline areas of the Alder Point restoration site and the Ross Island reference site. Reach-specific detection probabilities ranged from 0.07 to 0.19.

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Introduction

Pacific lamprey *Entosphenus tridentatus* in the Columbia River Basin (CRB) and other areas have experienced a great decline in abundance (Close et al. 2002) and have been given protected status within Oregon (Kostow 2002). Lamprey are culturally important to Native American tribes, are ecologically important within the food web, and are an indicator species whose decline provides further insight into the impact of human actions on ecological function (Close et al. 2002). Much information is lacking on the basic biology, ecology, and population dynamics that is required for effective conservation and management.

Pacific lampreys have a complex life history that includes a multiple year larval (ammocoete), migratory juvenile, and adult marine phase (Scott and Crossman 1973). Larvae and juveniles are strongly associated with stream and river sediments. Larvae live burrowed in stream and river sediments for multiple years after hatching, where they filter feed detritus and organic material (Sutton and Bowen 1994). Larvae metamorphose into juveniles from July to December (McGree et al. 2008) and major migrations are made downstream to the Pacific Ocean in the spring and fall (Beamish and Levings 1991). The sympatric western brook lamprey *Lampetra richardsoni* does not have a major migratory or marine life stage although adults may locally migrate upstream before spawning (Renaud 1997). For both species, the majority of the information on habitat preference of larvae comes from CRB tributary systems (Moser and Close 2003; Torgersen and Close 2004; Stone and Barndt 2005; Stone 2006) and coastal systems (Farlinger and Beamish 1984; Russell et al. 1987; Gunckel et al. 2009).

Larval lamprey are known to occur in sediments of low-gradient streams (<5th order [1:100 scale]; Torgersen and Close 2004) but their use of larger river habitats in relatively deeper areas is not well understood. Downstream movement of larvae, whether passive or active, is observed year-round (Nursall and Buchwald 1972; Gadomski and Barfoot 1998; White and Harvey 2003). Anecdotal observations exist regarding larval lamprey occurrence in large river habitats mainly at hydropower facilities (Moursund et al. 2003; CRITFC 2008), impinged on downstream screens, in juvenile bypass facilities, or through observation during dewatering events. These occurrences are thought to be associated with downstream migration and specific collections of supposedly migrating ammocoetes have been made in large river habitats (Beamish and Youson 1987; Beamish and Levings 1991). Sea lamprey *Petromyzon marinus* ammocoetes have been documented in deepwater habitats in tributaries of the Great Lakes, in proximity to river mouths (Hansen and Hayne 1962; Wagner and Stauffer 1962; Lee and Weise 1989; Bergstedt and Genovese 1994; Fodale et al. 2003), and in the large, connecting St. Marys River (Young et al. 1996). References to other species occurring in deepwater or lacustrine habitats are scarce (American brook lamprey *Lampetra appendix*; Hansen and Hayne 1962).

In 2000, the U.S. Environmental Protection Agency declared the Portland Harbor area of the Willamette River as a Superfund site. The Superfund study area (Figure 1) extends from river kilometer 3.2 to river kilometer 18.9 and has a broader focus area (Figure 1) extending from the Columbia River to Willamette Falls. To mitigate for environmental damage that has been done, these areas are subject to various restoration activities as well as assessments of the effectiveness of any restoration. Presently, restoration activities are focused on restoration of juvenile Chinook salmon *Oncorhynchus tshawytscha* habitat. However, these activities provide an opportunity to understand how juvenile lampreys are affected by habitat restoration. It is unclear whether any of the proposed aquatic restoration activities, which are primarily focused on salmonids, will improve conditions for Pacific lamprey. As such, there is interest in monitoring the effectiveness of the restoration, in part, relative to larval Pacific lamprey.

A lamprey monitoring plan (LMP) was developed based on a set of monitoring goals and objectives that were identified by the Trustee Council and lamprey experts over two workshops held in the fall of 2011. This LMP was developed to simultaneously monitor the impact of restoration actions on juvenile lamprey populations and health in Portland Harbor, and gather information about juvenile lamprey life history, biology, and habitat requirements that may be used by the Trustee Council in the future to design and evaluate lamprey restoration projects. Since lampreys are very different from other biota, the overlap between the LMP and the general restoration monitoring and stewardship plan is not extensive. The LMP differs from the general restoration monitoring and stewardship plan, in part, because the lamprey monitoring is proposed to continue for a period of 20 years. In most cases, the metrics proposed for collection as part of the lamprey monitoring effort need to be co-located with lamprey sampling. To maximize efficiencies, the Trustee Council will use the data collected as part of the lamprey monitoring plan for the general restoration monitoring and stewardship effort as much as possible. The experts recommended monitoring lamprey for 20 years, with the goal of capturing data for 1 to 2 complete generations. Pre-implementation monitoring will be conducted to the extent practical at each restoration site. Lampreys are expected to colonize habitats rapidly. Therefore, monitoring will be conducted on a yearly basis for the first five years, and every five years thereafter.

We began to investigate and document patterns of larval lamprey occupancy and habitat use in or near restoration areas. Obtaining the information on whether lampreys use the areas in and adjacent to restoration sites is critical to understanding the effectiveness of the restoration. At present, little specific information is available on whether and how larvae will use restored areas, how quickly and which life stage colonizes these areas, and how long they use these areas. In general, the proposed work is guided by the LMP. However, due to site specific conditions and constraints, the specific metrics and timing of monitoring proposed for any given site may differ slightly from those outlined in the LMP. Our specific objectives for this phase of Superfund restoration follows:

1. Determine whether lampreys occupy restoration and reference sites.
2. Determine the types of habitat available and in which types lamprey are detected.
3. Characterize species and life history stage that occupy a site.
4. Evaluate the health of lamprey detected at each site.

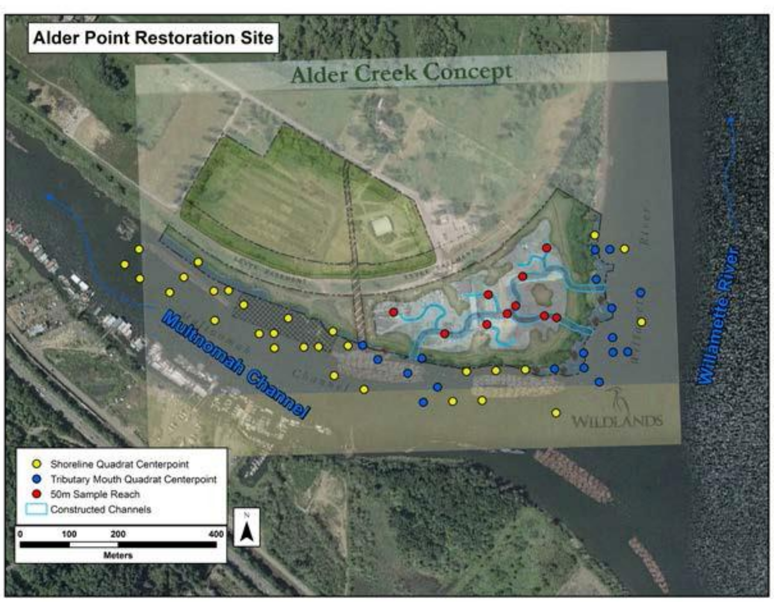

Figure 1. Proposed sample design for the restoration site, shoreline (100 m band) sample quadrats (yellow points), confluence sample quadrats (blue points) and slough sample reaches (red points).

Methods

The Alder Point restoration site is located near the mouth of the Multnomah Channel distributary of the Willamette River (Rkm 5; Figure 1). Pre-restoration monitoring consisted of sampling shoreline sites. Slough and stream habitat did not exist pre-restoration and therefore aquatic sampling in this non-existent habitat did not occur. The Ross Island reference site is located in the Willamette River (Rkm 25; Figure 2) and shoreline sites were at the upstream tip of the island.

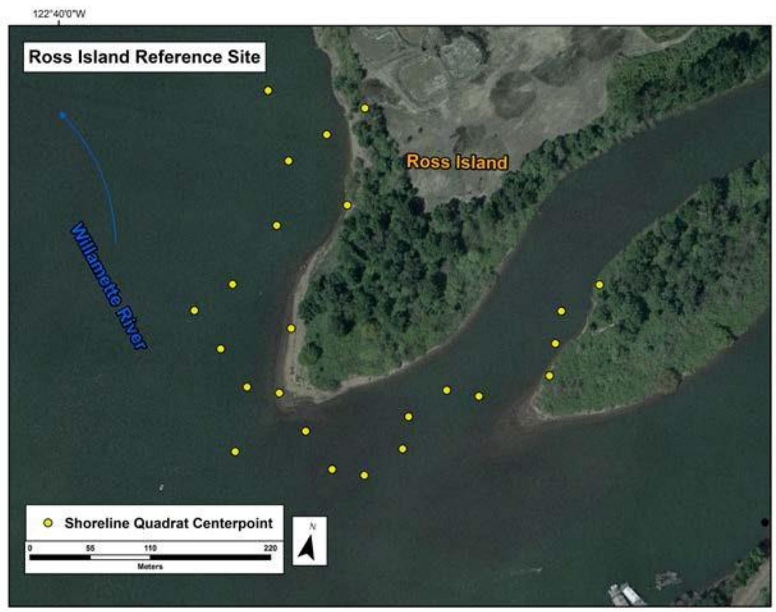

Figure 2. Proposed sample design for the reference site on the south point of Ross Island, shoreline (100 m band) sample quadrats (yellow points).

We estimated occupancy of larval lamprey in the restoration and reference sites by adapting an approach that was applied to studies of larval lamprey in the Willamette and Columbia rivers (Jolley et al. 2012, 2013a; 2013b). The approach has several requirements: 1) a site- and gear-specific detection probability (assumed or estimated); 2) the probability of presence at a predetermined acceptably low level (given no detection); and 3) random identification of spatially-balanced sample sites that allow estimation of presence and refinement of detection probabilities. A reach-specific probability of detection, d_{reach}, was calculated as the proportion of quadrats (i.e., 30 m x 30 m sampling quadrat) occupied (i.e., larvae captured) by larval lamprey in the Lower Willamette River, an area known to be occupied. The posterior probability of reach occupancy, given a larval lamprey was not detected, was estimated as:

$$(1)\ \mathrm{P}(F|C_o) = \frac{\mathrm{P}(C_o|F)\cdot\mathrm{P}(F)}{\mathrm{P}(C_o|F)\cdot\mathrm{P}(F)+\ \mathrm{P}(C_o|{\sim}F)\cdot\mathrm{P}({\sim}F)},$$

where P(F) is the prior probability of larval lamprey presence. Although we knew the Lower Willamette River was occupied with larval lamprey, P(F) of 0.5 (uninformed) was used for future study design (i.e., P[$F|C_o$]) in areas where larval lamprey presence is unknown. P($\sim F$), or 1 – P(F), is the prior probability of species absence, and P($C_o|F$), or 1 – d, is the probability of not detecting a species when it occurs (C_0 = no detection; Peterson and Dunham 2003). Patterns of occupancy by site were compared using the Chi-square test for differences in probabilities (Conover 1999).

A sampling event consisted of using a deepwater electrofisher (Bergstedt and Genovese 1994) in a 30 m x 30 m quadrat. This quadrat size was selected based on our previous experience surveying for lamprey in the Willamette River (Jolley et al. 2012). A description of the complete configuration of the deepwater electrofisher is given by Bergstedt and Genovese

(1994). The bell of the deepwater electrofisher (0.61 cm^2) was lowered from a boat to the river bottom. The electrofisher delivered three pulses DC per second at 10% duty cycle, with a 2:2 pulse train (i.e., two pulses on, two pulses off). Output voltage was adjusted at each quadrat to maintain a peak voltage gradient between 0.6 and 0.8 V/cm across the electrodes. Suction was produced by directing the flow from a pump through a hydraulic eductor, prohibiting larvae from passing through the pump. Suction began approximately 5 seconds prior to shocking to purge air from the suction hose. Shocking was conducted for 60 seconds, and the suction pump remained on for an additional 60 seconds after shocking to ensure collected larvae passed through the hose and emptied into a collection basket (27 x 62 x 25 cm; 2 mm wire mesh). The sampling techniques are described in detail by Bergstedt and Genovese (1994) and were similar to those used in the Great Lakes region (Fodale et al. 2003) and the Willamette River (Jolley et al. 2012).

Results

We sampled 29 of 30 visited quadrats at the Alder Point Restoration Site and sampled 25 of 28 visited quadrats at the Ross Island Reference Site (Table 1). The feasibility of being able to sample a quadrat in each stratum was 89% to 97%. Some quadrats were not sampled because they were not feasible (dewatered conditions). Larval lampreys were detected at both the restoration site and the reference site (Table 1); no other life stages were detected. Only lamprey larger than 60 mm TL can be confidently identified and tissue samples from those less than 60 mm TL were archived for potential genetic analysis to confirm identification. Three unidentified lamprey larvae were detected at Alder Point (TL: 14, 17, and 30 mm). At Ross Island, two larger larval *Lampetra* spp. were detected (TL: 71, 83 mm) and four unidentified lamprey larvae were detected (TL: 24, 32, 34, 45 mm; Figure 3). Larvae less than 40 mm TL are likely age-0 or age 1 while larger fish are likely older, although definitive estimates of age based on size are difficult (Meeuwig and Bayer 2005). Confirmed Pacific lampreys were not detected at either site. Detection probability was highest at Ross Island (d=0.19) compared to Alder Point (d=0.07). Detection probabilities did not differ among reaches (Fisher's Exact Test multivariate permutation technique, Brown and Fears 1981, P>0.05).

Table 1. Total number of quadrats delineated, visited, sampled, and occupied and larval species present in 2014. Unidentified lampreys are noted as "Unid".

		Quadrats								
Site	Date	Total	Visited	Sampled	Occupied	*d*	Pacific lamprey	*Lampetra* spp.	Unid	Total
Alder Point	9/24	117	30	29	2	0.07	0	0	3	3
Ross Island	9/25	95	28	26	5	0.19	0	2	4	6

At Alder Point, depths sampled ranged from 0.3 to 16.8 m and larvae were detected in depths from 0.9 to 3.0 m. At Ross Island, depths sampled ranged from 0.3 to 9.8 m and larvae were detected in depths from 1.2 to 7.6 m. The total number of larvae occupying any individual quadrat ranged from 0 to 2. Sediment descriptions including grain size, grain type, and organic content are summarized in Appendix 1. Mean water temperature was 19.3°C at Alder Point and

18.5°C at Ross Island. Mean conductivity was 89.2 µS/cm at Alder Point and 82.2 µS /cm at Ross Island. Shoreline areas were in relatively deep water and visual assessments of Type I, II, and III habitat could not be conducted.

All sampled fish were in good condition as no external abnormalities were observed.

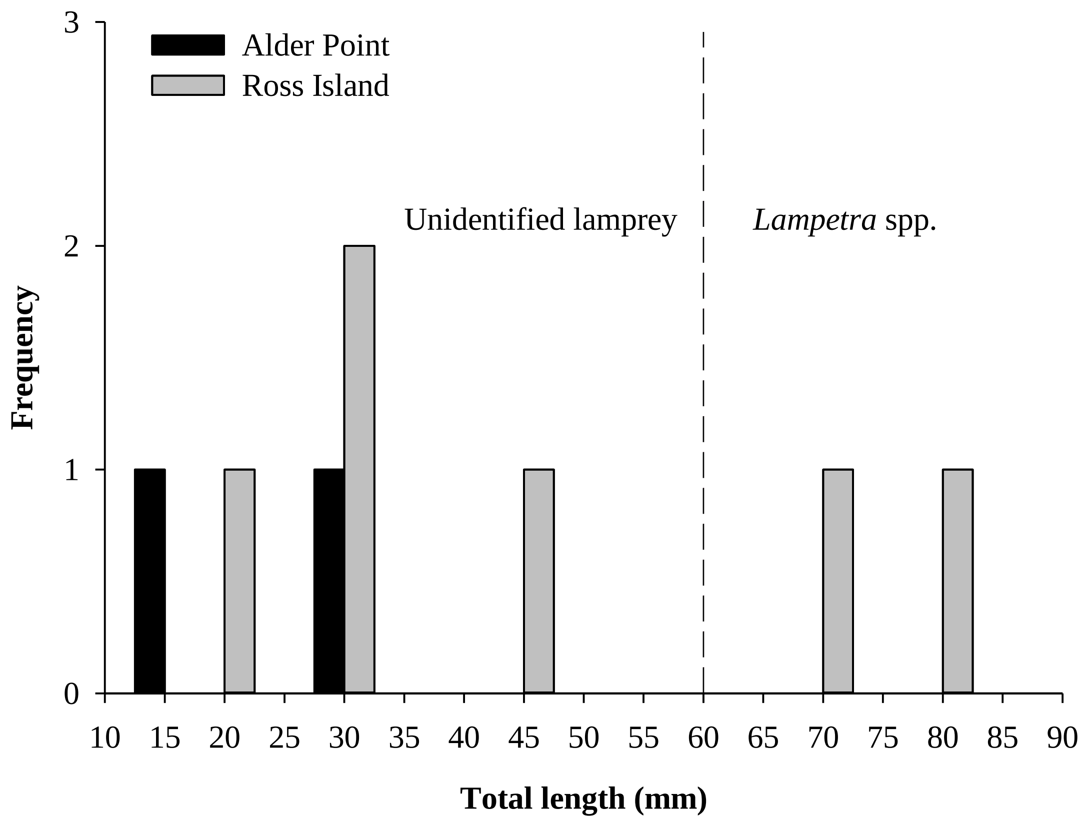

Figure 3. Length-frequency histogram of larval lamprey detected at Alder Point and Ross Island. Lamprey smaller than 60 mm were unidentified species and lamprey 60 mm or larger were Lampetra spp.

Conclusions

Larval lampreys occupied shoreline areas of both the restoration and reference sites. These larvae likely came from spawning areas located upstream, dispersed into the Willamette River, and are using these mainstem habitats for rearing. The presence of larvae in the vicinity of the Alder Point restoration site suggests a source of fish is available to colonize newly created habitats. It is unclear if Pacific lampreys occupy either site although the small, unidentified fish could be Pacific lamprey. Previous work on larval lamprey in the lower Willamette River (Jolley et al. 2012) reported that Pacific lamprey accounted for 22-42% of the larvae while *Lampetra* spp. accounted for 50-59% of the larvae. Data contained in this report will serve as the baseline for before and after monitoring of the Alder Point restoration site paired with the Ross Island Reference site.

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Appendix 1. Sediment descriptions from Alder Point and Ross Island.

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