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PROJECT TITLE: Investigation of larval Pacific lamprey occupancy of the mainstem Columbia River and Willamette River.

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INTRODUCTION

The decline of Pacific lamprey *Entosphenus tridentatus* populations in the Columbia River Basin (CRB) is a concern to regional agencies, tribes and the public throughout the Pacific Northwest (Close et al. 1995; 2002). Pacific lampreys have a complex life history that includes a five to seven year larval (ammocoete) phase, followed by migratory juvenile (macrophthalmia) and adult phases (Scott and Crossman 1973; Beamish and Levings 1991). Determining the status of the larval life stage of Pacific lampreys in the CRB was identified by the CRB Lamprey Technical Workgroup as a key critical uncertainty for conservation of this species (CRB Lamprey Technical Workgroup 2005). Several studies of larval Pacific lamprey habitat use, distribution and abundance in the CRB were initiated as a result.

Larval Pacific lamprey distribution in the CRB is patchy (Moser et al. 2007) and is driven by both the availability of suitable larval rearing habitat as well as proximity to adult spawning areas (Torgerson and Close 2004, Moser et al. 2007). During the larval phase, Pacific lampreys live burrowed in fine river-bottom sediments, filter feeding organic detritus and algae before metamorphosing into a macrophthalmia and migrating to salt water (Sutton and Bowen 1994, Kostow 2002). Returning adult Pacific lampreys spawn in gravel dominated pool-riffle habitats of streams and rivers (Kostow 2002), co-occurring with Pacific salmon and steelhead. Dispersal of newly hatched ammocoetes from spawning areas is thought to be limited, discharge dependent and occur mostly in a downstream direction, as larval Pacific lampreys are poor swimmers (Kostow 2002, Luzier et al. 2006). To date, the majority of larval lamprey research in the CRB has occurred in tributaries and headwater streams, where suitable spawning habitat is abundant. The Columbia River mainstem, with its relative lack of spawning habitat, has primarily been considered a migratory corridor for juvenile and adult Pacific lampreys and not a location of larval residence. However, the mainstem of the Columbia River and other large rivers in the CRB (i.e., the Willamette River) contain an abundance of presumably suitable larval rearing habitat and have the potential to support large numbers of larval lampreys. Though largely uninvestigated, rearing habitat in mainstem areas of large rivers like the Columbia and Willamette Rivers may be important for larval Pacific lampreys and research in this area may provide information critical in planning conservation strategies for this species.

Larval Pacific lampreys inhabiting mainstem areas of large rivers like the Columbia and Willamette Rivers would be affected by a different set of risk factors than larvae in most tributaries, including channel dredging, hydropower operations and sediment contamination. Dredging activities on the Columbia River shipping channel occur year-round to facilitate deep-draft trade vessel passage from the Pacific Ocean to the Port of Portland. The impact of dredging on Columbia River salmonids is a concern to fishery scientists in the Pacific Northwest. Because larval Pacific lampreys live burrowed in river bottom sediments for periods as long as seven years, it is plausible that larval lampreys are more at risk from dredging activities on the Columbia River than any other CRB fish. Larval lamprey residence in the mainstem Columbia

River may also have implications on hydropower operations. Little is known about the migratory abilities of larval Pacific lampreys or how downstream moving ammocoetes pass Columbia River dams. Given the relatively poor swimming ability of larval lampreys, downstream passage of larval lampreys through hydropower projects on the Columbia River may be difficult. Finally sediment contamination may also pose a serious risk for bottom-dwelling organisms such as larval lampreys. For decades agricultural and municipal run-off and industrial wastewaters have been discharged into the Columbia and Willamette Rivers. As a result, harmful levels of many contaminants including metals, pesticides, PCBs and dioxin have been found in both resident fish and near-shore sediment samples from Portland Harbor in the lower Willamette River (Oregon Department of Environmental Quality 2004). River-bottom sediments with toxic concentrations of these contaminants, which persist and bioaccumulate (Pew Oceans Commission 2001) pose a serious risk to many fishes, benthic fauna communities as well as organisms at higher trophic levels. Larval lampreys may be particularly at risk from exposure to benthic sediment contamination given their extended residence in these environments. However, without knowledge of the abundance and distribution of larval Pacific lampreys in the mainstem of the Columbia and Willamette Rivers, the impacts of dredging, hydropower operations, and sediment contamination on the survival, growth, and production of this species in the CRB cannot be determined.

Rigorous investigations of larval Pacific lamprey habitat usage in the Columbia River mainstem are needed and should be a priority of future CRB lamprey research. Our study was a preliminary effort in this area and was modest in scope. Our objective was to determine whether larval Pacific lampreys occupy the mainstem Columbia River and Willamette River. This work was done as background to and in preparation for subsequent quantitative assessments of larval

Pacific lamprey distribution and abundance in the mainstem Columbia River and Willamette River.

Objective

1. Assess larval Pacific lamprey occupancy in the mainstem Columbia River and Willamette River.

Methods

General sample areas were initially identified on navigation charts of the Columbia and Willamette Rivers. Sample areas were selected where we expected to find suitable larval lamprey habitat that would be accessible by boat. In addition, to maximize the likelihood of detecting larval lamprey, many of the sample areas chosen were adjacent to the mouths of Columbia River tributaries in which lamprey were known to spawn. Locations of the sample areas in the Columbia River (Figure 1) and the Willamette River (Figure 2) are shown below. At each sample area, specific electrofishing sites were selected based on availability of suitable habitat for larval lampreys and sample-ability with a backpack electrofisher. Qualitative sampling of each site for larval lampreys was conducted by a three person team using an AbP-2 backpack electrofisher (ETS Electrofishing, Verona, WI); one person operating the electrofisher and two people handling nets (Figure 3). Electrofisher power output settings, based on those in Weisser and Klar (1990), Slade et al. (2003), and Steeves et al. (2003), are summarized in Table 1.

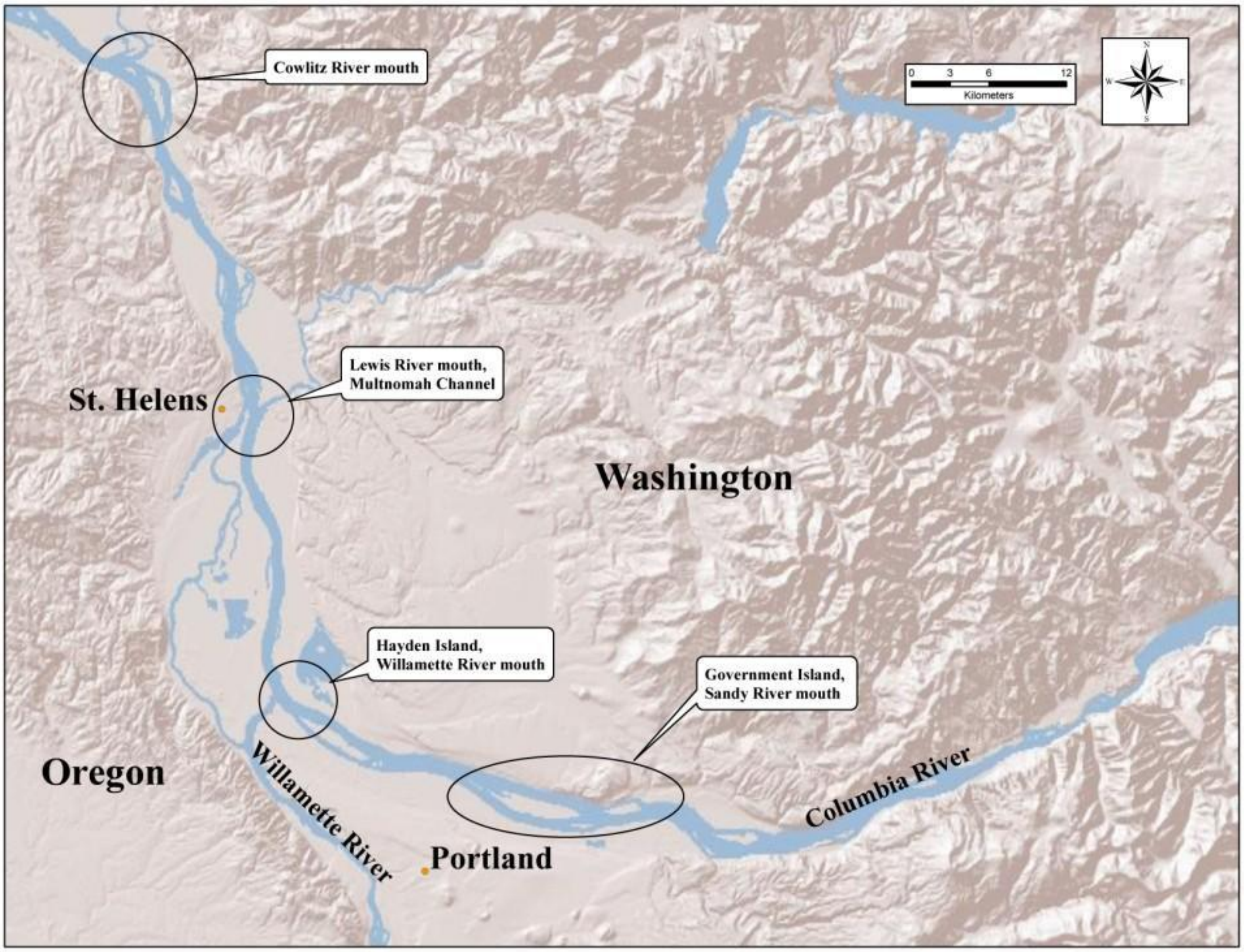

Figure 1. Sample areas on the Columbia River between the Sandy River mouth east of Portland, OR and the Cowlitz River mouth near Longview, WA.

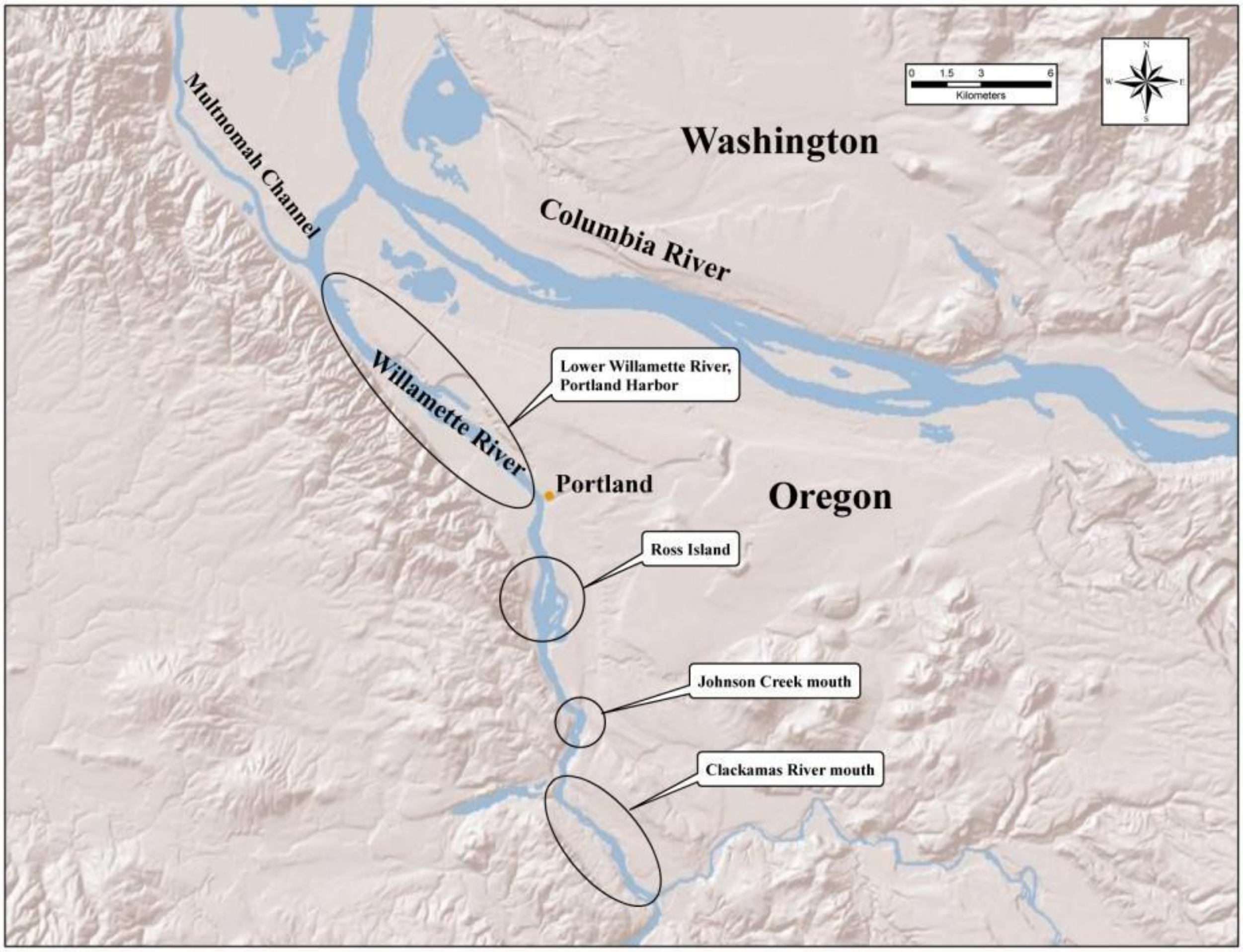

Figure 2. Sample areas on the Willamette River from the Clackamas River mouth downstream to the Columbia River.

Table 1. AbP-2 electrofisher power output settings used when sampling for larval lampreys.

	Bursted Pulse Primary Wave Form	Standard Pulse Secondary Wave Form
Voltage (v)	125	125
Pulse Frequency (Hz)	3	30
Duty Cycle (%)	25	25
Burst Pulse Train	3:1	X

Figure 3. Electrofishing for larval lampreys in the lower Willamette River near the mouth of Columbia Slough.

Electrofishing was conducted following transects approximately perpendicular to the water's edge, out to the maximum water depth possible, and then back to shore. Electrofishing effort at each site was not standardized, but varied according to the quality and quantity of available lamprey habitat. For example, sites with compacted or impervious substrates were sampled less intensively than sites with loose substrates and organic matter. Larval lampreys were netted, counted and identified to species when possible. Biological data such as total length and weight were not recorded, but categorical estimates of total length were noted. Qualitative descriptions of habitat and substrate were recorded and sites were geo-referenced with a Trimble GPS unit.

RESULTS

A total of 37 sites were sampled for larval lampreys; 21 in the Columbia River, 13 in the Willamette River, and three in Multnomah Channel. Lampreys were detected at a total of seven sites (Table 2). Descriptions of the sample sites as well as the Universal Transverse Mercator (UTM) coordinates collected at each site are shown in Table 3.

Table 2. Locations of larval lamprey sample sites. Lampreys were captured at seven of the sites sampled.

Location	# Sites Sampled	# Sites Lampreys Captured	# Sites Lampreys Not Captured
Columbia River	21	3	18
Willamette River	13	4	9
Multnomah Channel	3	0	3

COLUMBIA RIVER

Of the 21 sites sampled on the Columbia River, larval Pacific lampreys were detected at three sites (Table 3), including one site on the north shore of Government Island (Figure 4).

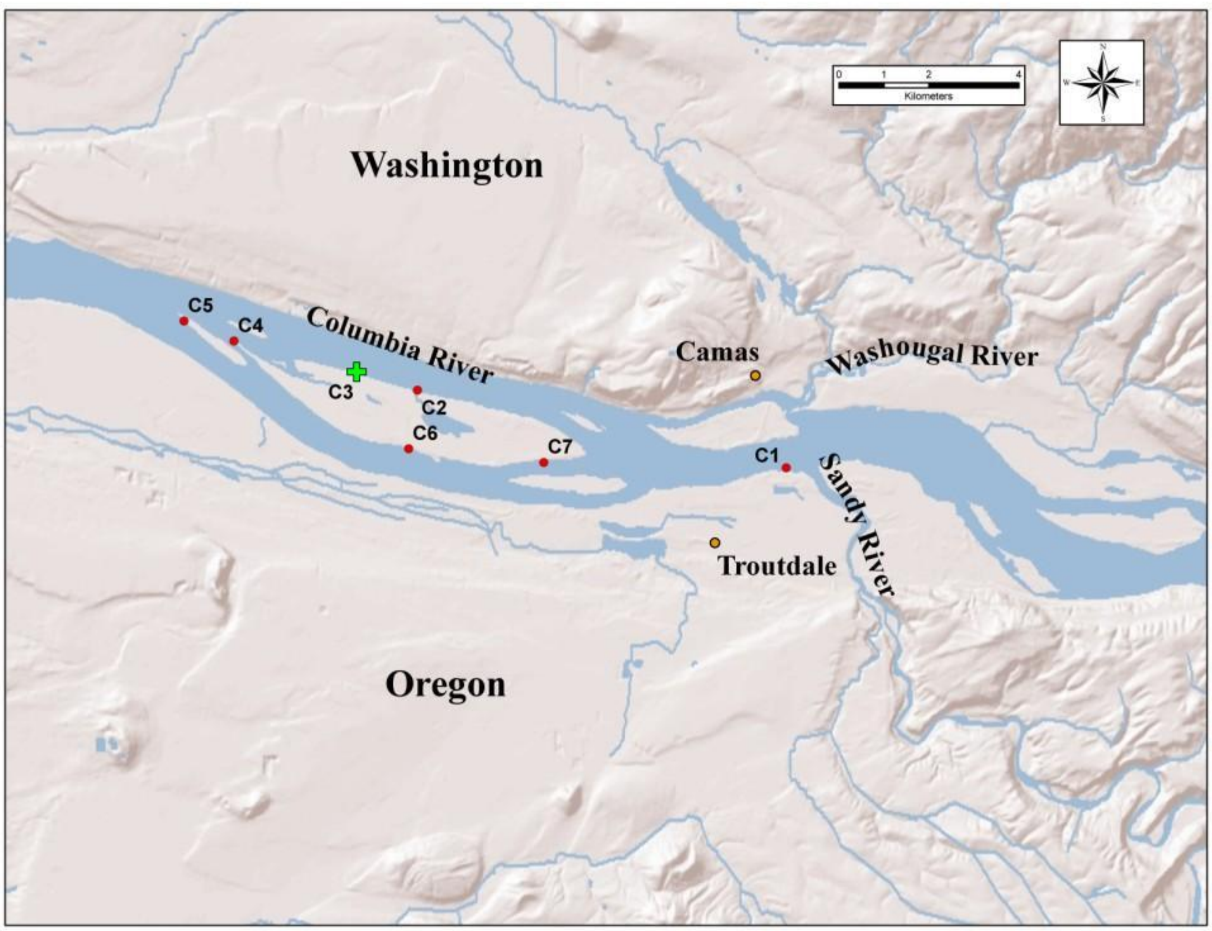

Figure 4. Sites sampled for larval lampreys below the Sandy River mouth (C1) and on Government Island (C2-C7). The green cross indicates a site of lamprey capture, while red circles denote sites where no lampreys were detected.

Table 3. Location descriptions of lamprey sample sites as well as associated UTMs and results.

River	Landmark	Site #	Northing	Easting	Lampreys Detected	Lampreys Not Detected
Columbia	Sandy R.-downstream	C1	5045987.995	546509.801		X
Columbia	Government Island North 1	C2	5047717.363	5047717.363		X
Columbia	Government Island North 2	C3	5048125.652	536947.980	X	
Columbia	Government Island North 3	C4	5048810.511	534220.755		X
Columbia	Government Island South 1	C5	5049255.599	533109.248		X
Columbia	Government Island South 2	C6	5046412.452	538108.462		X
Columbia	Government Island South 3	C7	5046107.714	541112.297		X
Columbia	Hayden Island South	C8	5054159.776	519958.792		X
Columbia	Hayden Island North	C9	5054078.227	520365.712		X
Columbia	Lake R.-upstream	C10	5076393.806	516886.787		X
Columbia	Lake R.-downstream	C11	5076624.817	517105.988		X
Columbia	Lewis R.-upstream	C12	5077594.858	517143.433		X
Columbia	Lewis R.-downstream1	C13	5078329.035	517027.898		X
Columbia	Lewis R.-downstream 2	C14	5079721.689	516766.689		X
Columbia	Lewis R.-downstream 3	C15	5081192.698	516041.561		X
Columbia	Lewis R.-downstream 4	C16	5081148.093	516149.479		X
Columbia	Cottonwood Island East 1	C17	5101877.284	509816.223		X
Columbia	Cottonwood Island East 2	C18	5102617.816	509796.539	X	
Columbia	Cottonwood Island West 1	C19	5103395.873	507806.331		X
Columbia	Cottonwood Island West 2	C20	5100357.890	509481.722		X
Columbia	Cowlitz R. mouth-upstream	C21	5104668.043	507244.867	X	
Willamette	Clackamas R. mouth	W1	5024583.575	530493.680	X	
Willamette	Oswego Ck.-upstream	W2	5027900.902	527484.069	X	
Willamette	Oswego Ck.-downstream	W3	5028526.083	526670.370	X	
Willamette	Kellogg Ck.-downstream	W4	5032123.642	527898.663		X
Willamette	Johnson Ck.-downstream	W5	5032376.453	527792.298		X
Willamette	Ross Island-west	W6	5036114.932	526285.669		X
Willamette	Ross Island-east	W7	5036523.125	526770.680	X	
Willamette	I-5 Marquam Bridge	W8	5039351.323	525681.623		X
Willamette	Fremont Bridge	W9	5044486.262	523471.834		X
Willamette	Swan Island Basin	W10	5045875.864	522413.751		X
Willamette	St. John's RR Bridge	W11	5047482.617	519905.429		X
Willamette	St. John's Bridge	W12	5049743.432	516843.523		X
Willamette	Columbia Slough	W13	5054632.332	518040.781		X
Multnomah Channel	Sauvie Island Bridge	MC1	5052187.061	514974.714		X
Multnomah Channel	Multnomah Channel 2	MC2	5076458.933	515481.693		X
Multnomah Channel	Multnomah Channel 3	MC3	5076018.344	514809.571		X

Larval lampreys were also collected at two sites near the mouth of the Cowlitz River, including six larvae at site C21 just upstream of the Cowlitz River mouth that comprised multiple size (likely age) classes (Figure 5).

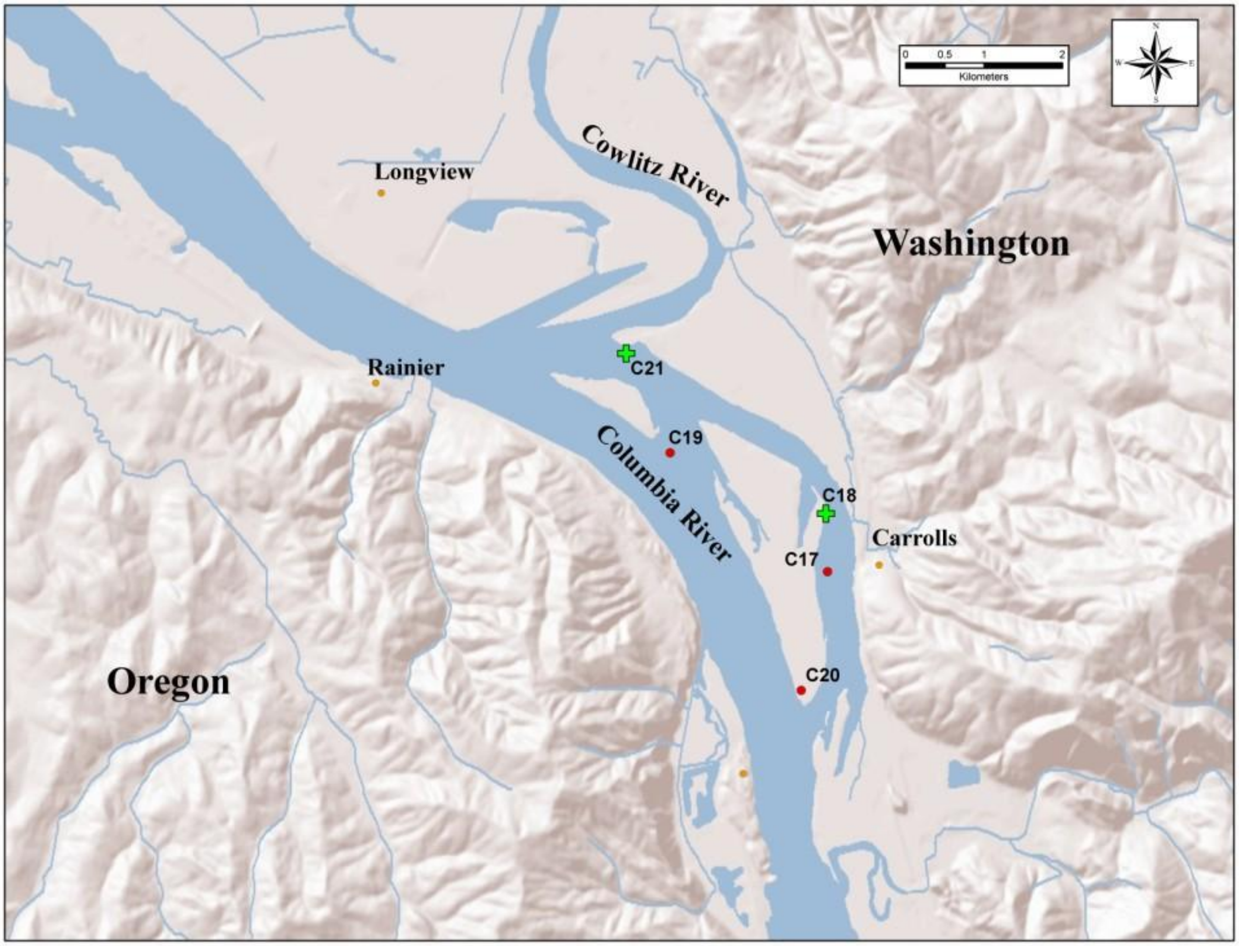

Figure 5. Sites sampled for larval lampreys on the Columbia River upstream from the Cowlitz River mouth. Green crosses denote sites of lamprey capture, while red circles denote sites where no lampreys were detected.

No larval lampreys were detected at seven sites near the mouth of the Lewis River (Figure 6) or at two sites on Hayden Island near the mouth of the Willamette River (Figure 7).

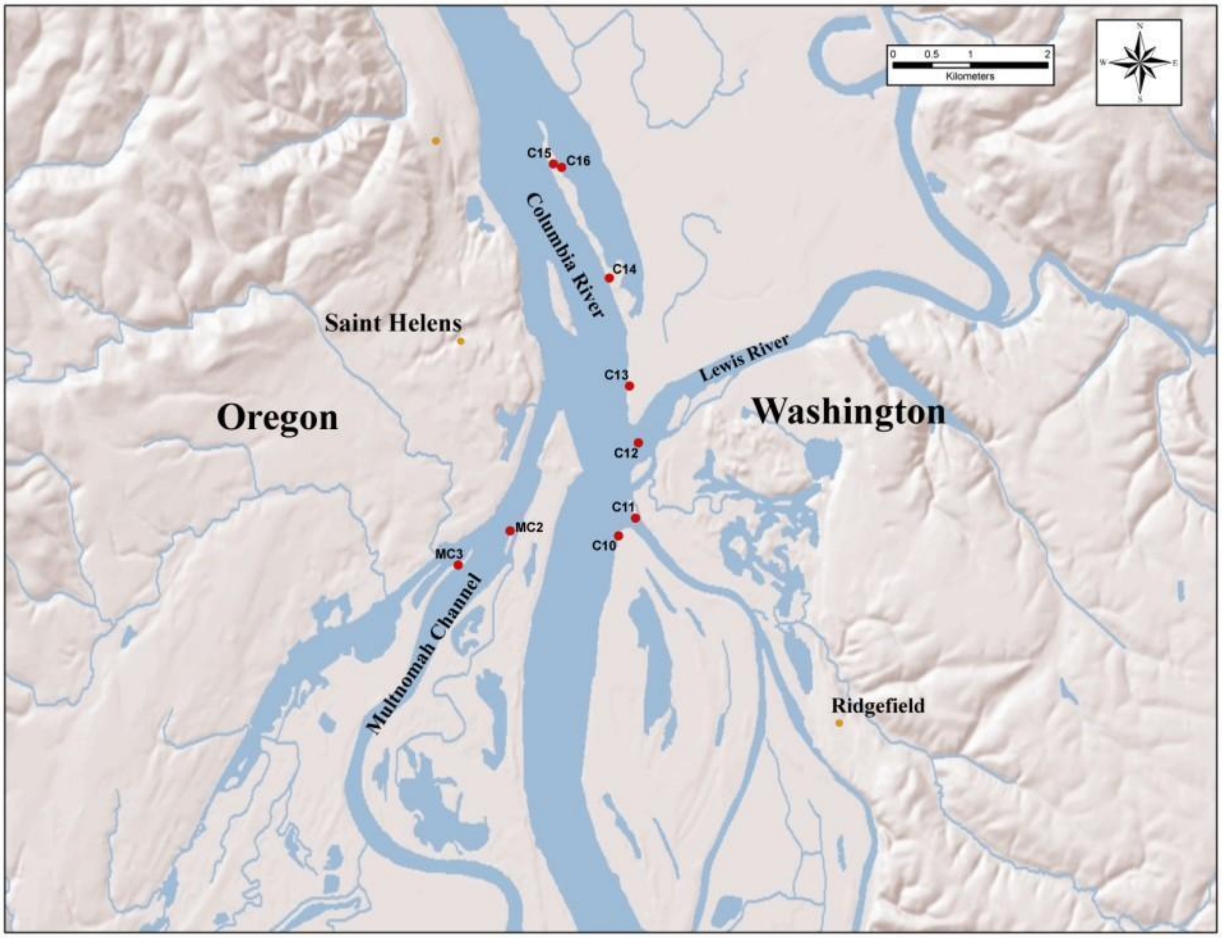

Figure 6. Sites sampled for larval lampreys on the Columbia River adjacent to the Lewis River mouth and in lower Multnomah Channel. No lampreys were captured at any of the sites in this area despite the presence of suitable habitat.

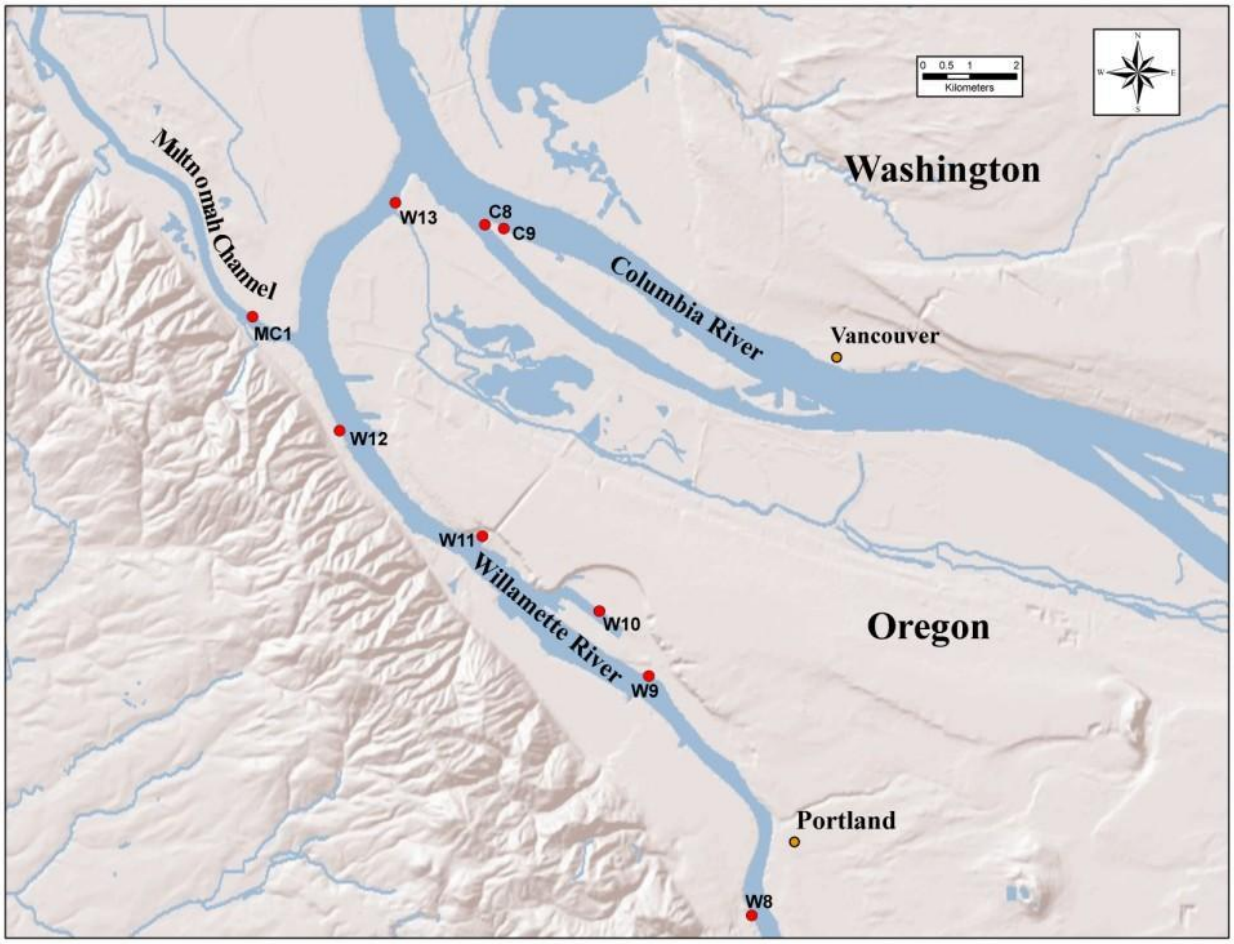

Figure 7. Sites sampled for larval lampreys on the Willamette River from the I-5 Bridge (W8) in downtown Portland to the Columbia River. Also shown are one site on upper Multnomah Channel (MC1) and two Columbia River sites on Hayden Island (C8, C9). No lampreys were found at any of the sites sampled in this area.

WILLAMETTE RIVER

In the Willamette River, larval Pacific lampreys were detected at four of the 13 sites sampled (Table 3). Lampreys were collected just downstream of the Clackamas River mouth, above and below the mouth of Oswego Creek and on the east bank of Ross Island (Figure 8). No lampreys were detected at six sites in the Superfund reach of the lower Willamette River, from the Interstate 5 Bridge in downtown Portland to the mouth (Figure 7).

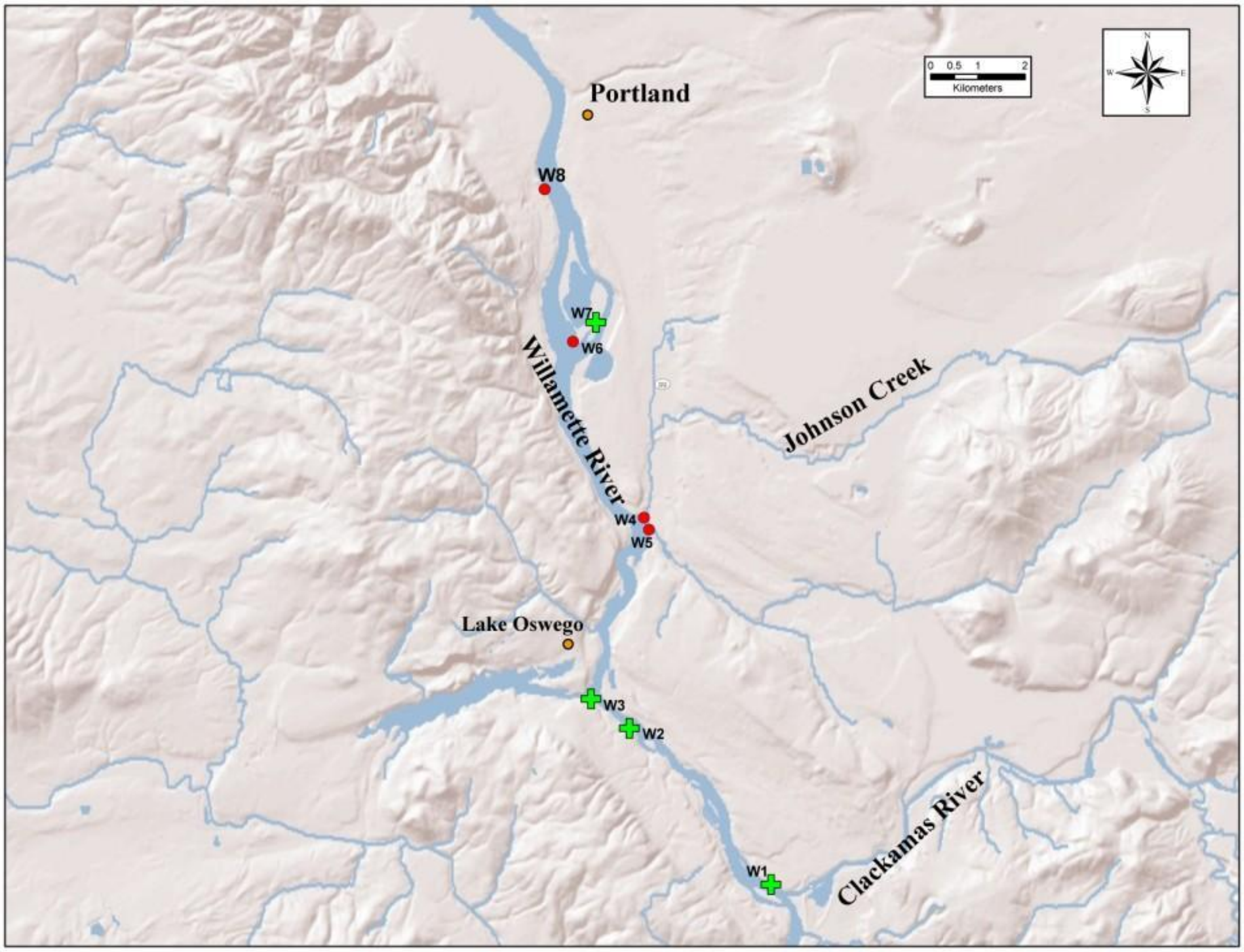

Figure 8. Sites sampled for larval lampreys on the Willamette River from the Clackamas River mouth (W1) downstream to Ross Island (W6, W7). Green crosses indicate sites of lamprey capture, while red circles denote sites where no lampreys were detected.

MULTNOMAH CHANNEL

Three sites in Multnomah Channel were sampled for larval lampreys, one at the upstream end near the Sauvie Island Bridge (Figure 7) and two near the mouth above St. Helens, OR (Figure 6). No lampreys were detected at these sites despite the presence of suitable habitat (Table 3).

FINDINGS

Larval lampreys occupied both the mainstem Columbia and Willamette Rivers and were collected at multiple locations in both rivers. Distribution of larval lampreys was widespread in both rivers, including in the Columbia River both upstream and downstream of the Willamette River confluence, and did not appear to be associated with tributary mouth proximity. Previously, larval lampreys were detected in the Willamette River in the area designated as a Superfund site (river miles 2 to 12) using a deepwater electrofisher (Windward 2005). However, we found no lampreys in the five sites sampled in this region. Based on anecdotal observations, larval lamprey detection and capture appear to be influenced by water depth, substrate type and substrate compaction. Future studies of larval lamprey mainstem habitat use should be undertaken to provide quantitative assessments of larval abundance, distribution and habitat parameters, advancing the findings presented in this report.

The presence of larval Pacific lampreys on Government Island in the Columbia River is particularly interesting. Pacific lamprey spawning occurs in gravel-dominated habitats of shallow streams, generally located in the upper catchments of large rivers in the Pacific Northwest (Kan 1975; Kostow 2002; Torgerson and Close 2004). The region of the Columbia River in the vicinity of Government Island, however, does not appear to contain habitats suitable for lamprey spawning. It is reasonable to presume that the larvae captured in this location were produced in a Columbia River tributary, the nearest of which are the Sandy and Washougal Rivers, located over 9 km upstream from the Government Island site. Thus, it would follow that larvae captured at this site migrated or dispersed, either actively or passively, considerable distances in the Columbia River mainstem. Future studies of larval lamprey migratory behavior including migration distance, dam passage routes and dam passage survival would be worthwhile.

We observed several anecdotal trends during the course of our study which may be considerations for future sampling. Larvae were more often found along underwater ledges at relatively steep drop-offs to deep water. No lampreys were found in numerous shallow, sandy flats, despite the appearance of suitable habitat. Sampling occurred in October when discharge was above annual base flow, and it is likely many of these shallow areas were dry during summer. Fluctuation in water level potentially limits the suitability of these areas for lamprey rearing, resulting in greater larval abundance near drop-offs and in deeper water. Other areas appeared to be suitable larval rearing habitat, but had severely compacted substrates. No larval lampreys were detected in areas with such substrates. The substrate in sites where lampreys were captured was generally a mix of sand, small gravel and silt, and usually contained organic matter.

Future studies of larval Pacific lamprey habitat use in the mainstem Columbia and Willamette Rivers should be designed to quantitatively assess ammocoete abundance and distribution, as well as physical habitat. An EMAP-style approach to generate random, spatially-balanced sample sites could be used to produce statistically rigorous, quantitative results. In addition, standardizing electrofishing methods would allow for calculation of larval catch per unit effort. Quantifying physical and chemical parameters may also aid development of tools for predicting larval distribution in other large river systems.

Because we were using a backpack electrofisher, only areas of wade-able depth could be safely and effectively sampled. For sampling large river habitats, an electrofisher designed for capturing larval lampreys in deep water such as that in the Great Lakes (Bergstedt and Genovese

1994) could be evaluated. The backpack electrofisher power output settings used in this study were developed for sampling larval lampreys in small rivers and streams, generally areas of lower water conductivity and shallower depth than in mainstem rivers. Testing different electrofisher settings may improve capture efficiency of larval lampreys in mainstem river habitats.

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REFERENCES

Beamish, R.J., and C.D. Levings. 1991. Abundance and freshwater migrations of the anadromous parasitic lamprey Lampetra tridentata in a tributary of the Fraser River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 48:1250-1263.

Bergstedt, R.A., and J.H. Genovese. 1994. New Technique for Sampling Sea Lamprey Larvae in Deepwater Habitats. North American Journal of Fisheries Management 14:449-452.

Close, D. A., M. Fitzpatrick, H. Li, B. Parker, D. Hatch, and G. James. 1995. Status report of the Pacific lamprey (*Lampetra tridentata*) in the Columbia River Basin. Report to Bonneville Power Administration, Contract No. 95BI39067.

Close, D.A., M.S. Fitzpatrick, and H.W. Li. 2002. The ecological and cultural importance of a species at risk of extinction, Pacific lamprey. Fisheries 27:19-25.

Columbia River Basin Lamprey Technical Workgroup. 2005. Critical uncertainties for lamprey in the Columbia River Basin: results from a strategic planning retreat of the Columbia River Lamprey Technical Workgroup. Available: www.cbfwa.org. (February 2010).

Kan, T.T. 1975. Systematics, variation, distribution, and biology of lampreys of the genus *Lampretra* in Oregon. Ph.D. dissertation. Oregon State University, Corvallis, Oregon, USA.

Kostow, K. 2002. Oregon Lampreys: Natural History, Status and Anlaysis of Management Issues. Oregon Department of Fish and Wildlife Report. Available: www.dfw.state.or.us.

Luzier, C.L., G. S. Silver, and T.A. Whitesel. 2006. Evaluate Habitat Use and Population Dynamics of Lamprey in Cedar Creek. U.S. Fish and Wildlife Service, Annual Report to BPA. Available: www.fws.gov/columbiariver. (February 2010).

Moser, M. L., J. M. Butzerin and D. B. Dey. 2007. Capture and collection of lampreys: the state of the science. Reviews in Fish Biology and Fisheries 17:45-56.

Oregon Department of Environmental Quality, Fact Sheet: Portland Harbor Superfund Cleanup. 2004. Available: www.deq.state.or.us. (May 2008).

Pew Oceans Commission. 2001. The Challenge of Toxic Contaminants. Chapter II-Marine Pollution in the United States. Available: www.mindfully.org. (May 2008).

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa.

Slade, J.W., J.V. Adams, G.C. Christie, D.W. Cuddy, M.F. Fodale, J.W. Heinrich, H.R. Quinlan, J.G. Weise, J.W. Weisser, and R.J. Young. 2003. Techniques and Methods for Estimating Abundance of Larval and Metamorphosed Sea Lampreys in Great Lakes

Tributaries, 1995 to 2001. Journal of Great Lakes Research Volume 29 (Supplement 1):137-151.

Steeves, T.B, J.W. Slade, M.F. Fodale, D.W. Cuddy, and M.L. Jones. 2003. Effectiveness of Using Backpack Electrofishing Gear for Collecting Sea Lamprey (*Petromyzon marinus*) Larvae in Great Lakes Tributaries. Journal of Great Lakes Research Volume 29 (Supplement 1):161-173.

Sutton, T. M. and S.H. Bowen. 1994. Significance of organic detritus in the diet of larval lampreys in the Great Lakes basin. Canadian Journal of Fisheries and Aquatic Science. 51: 2380-2387.

Torgerson, C. E., Close, D. A. 2004. Influence of habitat heterogeneity on the distribution of larval Pacific lamprey *Lampetra tridentata* at two spatial scales. Freshwater Biology 49:614-630.

Weisser, J.G. and G.T. Klar. 1990. Electric Fishing for sea lampreys (*Petromyzon marinus*) in the Great Lakes region of North America. In I.G. Cowx (ed) Developments in electric fishing. Fishing News Books, Oxford, pp 59-64.

Windward Environmental. 2005. Portland Harbor RI/FS: Ecological Preliminary Risk Evaluation. Prepared for the Lower Willamette Group.