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BPA Transmission Line Lamprey Survey in Western Washington and Oregon

2012 Annual Report

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U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
Vancouver, WA 98683

On the cover: *An electrical transmission line over an unnamed tributary to the Samish River in Skagit County, Washington. Photograph by Jeff Jolley.*

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2012 ANNUAL REPORT

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Abstract –

Pacific lamprey *Entosphenus tridentatus* are declining throughout the Pacific Northwest and the status of other native lampreys is unknown. Current efforts are underway to conserve this species and Best Management Practices have been developed to minimize adverse impacts to lamprey at in-water work sites. The Bonneville Power Administration is applying these practices at work sites of transmission line access roads at stream crossings. We developed protocols for surveying for presence of larval lamprey at these sites and additional protocols for salvage of lamprey, if present. We surveyed streams at twelve work sites in western Washington and Oregon in 2012 using a backpack electrofisher. Stream reaches were divided into 5 subreaches and surveyed for larval lamprey occupancy and detection probability. We did not detect larval lamprey at any sites. Most sites were small (1st order) and many had perched culverts, precluding fish passage upstream of the crossing. In addition, we evaluated and prioritized nineteen additional sites and qualitatively determined the probability of lamprey presence through examination of potential passage barriers, known history of lamprey in the basin, and distance from the ocean. Because no lamprey were detected at any of the work sites, it was not possible to evaluate the efficacy of our salvage methods. Pre-evaluation of potential work sites may be valuable to prioritize salvage efforts.

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Introduction

Pacific lamprey *Entosphenus tridentatus* in the Columbia River Basin (CRB) and other areas have experienced a decline in abundance, 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). The western brook lamprey *Lampetra richardsoni* and the river lamprey *L. ayresii* also occur in the Pacific Northwest and relatively less is known about the biology and ecology of these species. Pacific lampreys have declined to a remnant of their pre-1940s abundance (Close et al. 2002), while the status of the river lamprey and the western brook lamprey is largely unknown. The ecological, economic, and cultural significance of these species, especially the Pacific lamprey, is often underestimated (Kan 1975, Close et al. 2002). Though biological and ecological information for these species is available (e. g. Pletcher 1963, Beamish 1980, Richards 1980, Beamish and Levings 1991), limited studies have been conducted within the Pacific Northwest (Kan 1975, Hammond 1979). Actions are currently being considered for the recovery of Pacific lamprey populations in the Pacific Northwest (USFWS 2010b, 2012).

A Best Management Practices Guide has been developed (USFWS and USFS 2010a) help minimize impacts to all species of lamprey during stream disturbing activities. These practices are being implemented by the Bonneville Power Administration (BPA) in all of their fish and wildlife contracts. Additionally, BPA must regularly maintain, construct new, and replace transmission line access roads at stream crossings which may impact aquatic habitats. Larval lamprey may be particularly vulnerable to these disturbances due to their relatively sedentary nature, and life history phase of burrowing in stream substrates; a need exists to conserve native lampreys in these areas. Specific threats at these project sites may include

passage impairment, de-watering, channel dredging, or chemical spills all of which could impact larval lamprey which are burrowed under the substrate. We determined the presence (and probability of detection) of larval lamprey species at BPA transmission line access road construction sites. If lamprey were present we would implement salvage procedures during the construction periods for conservation of native lamprey species.

Methods

Surveys took place at twelve transmission line project areas (work sites) identified by BPA in western Washington and Oregon (Figure 1). In addition, a list of additional potential work sites was evaluated and prioritized. Table 1 summarizes characteristics of all sites. Streams were small and were mostly 1st order although three streams were 2nd order (1:100,000 scale).

Work sites on stream reaches were located using a global positioning system (GPS, Trimble Navigation Limited, Sunnyvale, California) and the stream crossing was identified (e.g., culvert, bridge, other). Digital photographs were taken at each site of important attributes such as culverts, and stream habitat and substrate (Appendix 1). At each work site, a 250 m stream reach was delineated, where half of the reach (125 m) was downstream of the work site and half of the reach was upstream of it. The reach was subdivided into 5, 50 m-long subreaches numbered sequentially with the furthest downstream site being Subreach 1. Subreach 3 at each stream reach would be bisected by the work site, resulting in 25 m downstream of the stream crossing/work area and 25 m upstream of it (Figure 2). Each subreach was demarcated with surveyor's tape and water temperature (^{o}C) and conductivity (µS/cm) were measured with a water quality multi-probe (Yellow Springs Instruments, Yellow Springs, Ohio) at each subreach.

The availability of Type 1 substrate (i.e., substrate suitable for larval lamprey burrowing; see Slade et al. 2003) was qualitatively classified as absent, moderate, or abundant. Each stream subreach was surveyed using anAbP-2 backpack electrofisher (ETS Electrofishing Verona, Wisconsin) which was developed in the Great Lakes to collect larval sea lamprey *Petromyzon marinus* (Weisser and Klar 1990) and is effective for collecting larvae of many lamprey species (Pajos and Weise 1994; Torgerson and Close 2004; Stone and Barndt 2005; McGree et al. 2008). The entire reach was thoroughly electrofished. Effort was primarily focused on areas of suitable larval burrowing and rearing habitat (Type I habitat; Slade et al. 2003) and relatively less time was spent in areas dominated by bedrock, cobble or boulder substrates or high current velocity. Any collected lampreys were anesthetized in a solution of tricaine methanesulfonate (MS-222), identified to developmental stage (i.e., larvae, juvenile, adult) and species (i.e. Pacific lamprey or *Lampetra* spp.) according to caudal pigmentation (Goodman et al. 2009), measured (TL in mm), and placed in a recovery bucket of fresh river water. Fin tissue samples were taken from all collected lamprey for subsequent species confirmation through mitochondrial DNA assays.

We estimated occupancy within a reach by employing models of detection probability (d) given presence of lamprey, a method used for larval lamprey in large river habitats (Jolley et al. 2012) as well as for fish in small tributaries (i.e. bull trout *Salvelinus confluentus;* Peterson and Dunham 2003). We assumed a reach-specific probability of detection (d_{reach}) of at least 0.75, when lampreys are present, based on previous work in wadeable tributaries (Poirier et al. 2010; J. Jolley, unpublished data). The posterior probability of reach occupancy, given a larval lamprey was not detected in any subreach, 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. Because we were uncertain whether a reach was occupied with larval lamprey, P(F) of 0.5 (uninformed) was used to inform future study design (i.e., P[$F|C_o$])in areas where larval lamprey presence is unknown. P(~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). In short, this methodology allows calculating the certainty that lamprey are truly absent when they are not detected. In situations when no lampreys are detected, and prior information on lamprey occupancy in the area is not available, it is not possible to calculate the posterior probability of presence. When larvae were detected in any subreach, the entire reach (including work site) was considered occupied.

Results

Twelve work sites were surveyed for lamprey (Table 1). Survey sites occurred in a variety of drainage basins of the Pacific Northwest including Pacific Coast, Puget Sound, and the Columbia River Basin. Site characteristics are summarized in Table 2.

No lampreys were detected in any reach at any of the 12 work sites, and therefore no lamprey salvage occurred. Coastal cutthroat trout *Oncorhynchus clarki clarki* were observed at two sites (NW-2 and NW-4), while one site was dewatered/intermittent (NW-3). Eleven of twelve sampled sites had culverts at the stream crossing of which six were perched on the downstream side (Appendix 1). One site (NW-4) had a bridge crossing with a concrete sill installed in the stream bed at an approximate 45° angle. One site (PC-1) had a rudimentary fish ladder constructed of timbers just downstream of the culvert. Given a prior probability of detection of at least 0.75 (when lampreys are present), and sampling five subreaches, the posterior probability of stream reach occupancy is <1%, when lampreys were not detected.

Low, medium, or high probability of lamprey occurrence was assigned to sampled sites prior to sampling and all unsampled sites through qualitative evaluation of potential barriers, known history of lamprey occurring in the basin, and distance from the sea. Potential for lamprey occurrence was low (16%), medium (16%), or high (68%). In general lampreys were known to occur in most of the major subbasins in this study. To our knowledge, Pacific lampreys are known to occur in the Skagit, Snohomish, Skykomish, Cedar, Green, Washougal, and Wind Rivers of Washington (Connolly et al. 1999; Goodman et al. 2008, M. Hayes, USGS, personal communication, J. Jolley, unpublished data). Pacific lampreys are known to occur in Brush Creek and the Elk River in Oregon (Goodman et al. 2008). No records of lamprey occurrence in the Sammamish River, Lyre River, or Dean Creek could be found.

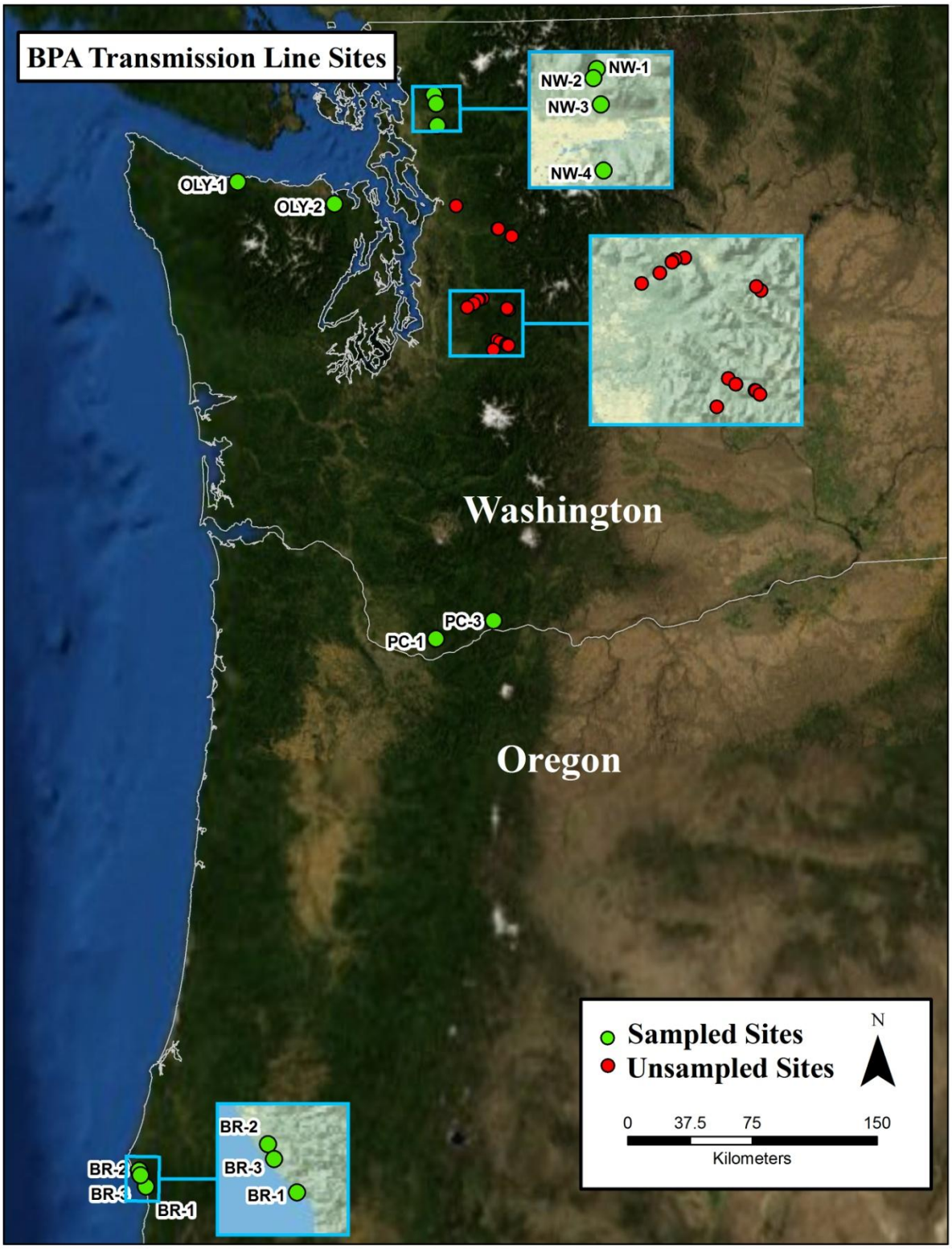

Figure 1. Transmission line access road stream crossing sites surveyed (green) and evaluated (red) in 2012.

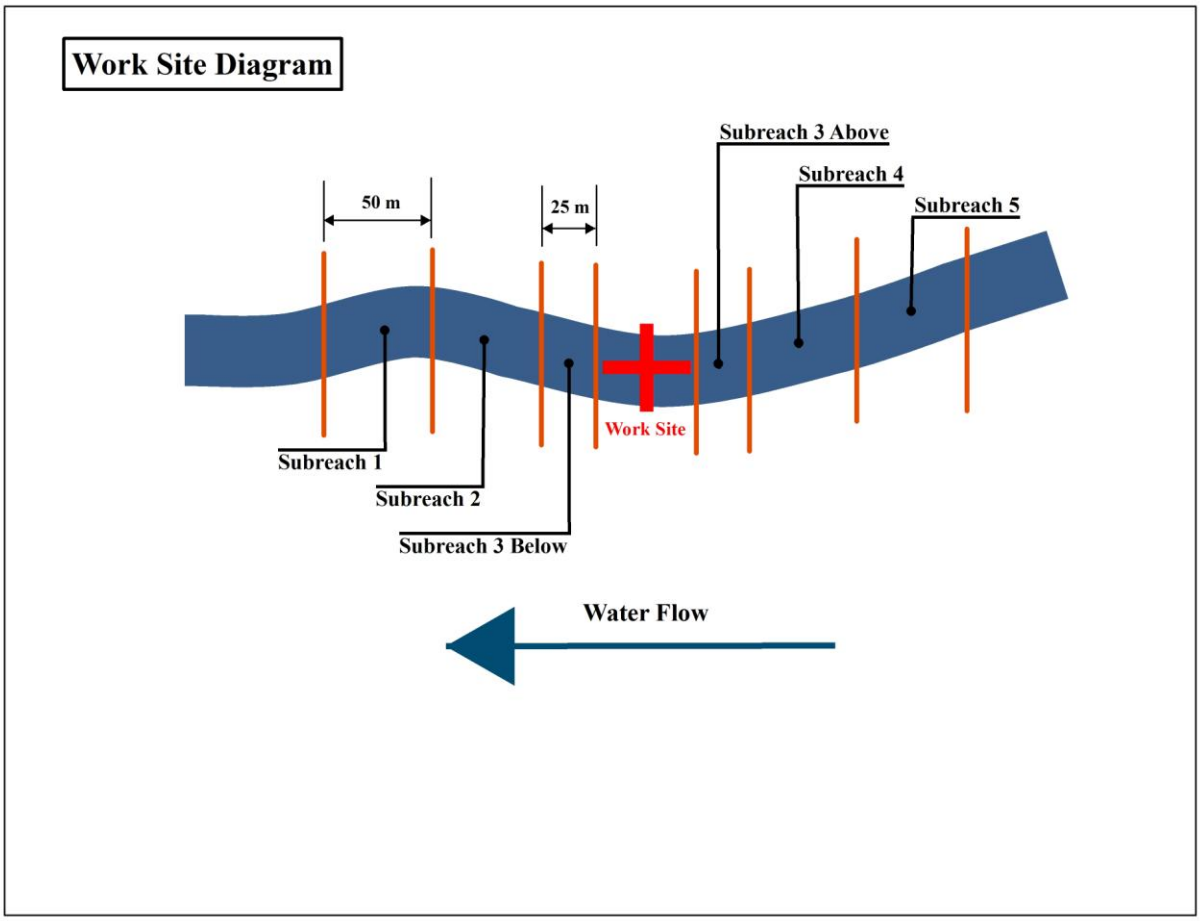

Figure 2. Diagram depicting orientation of subreaches within a reach of a generic stream crossing work site.

Table 1. BPA transmission line road access stream crossing sites, attributes, and results of lamprey surveys in 2012.

Site Number	Longitude	Latitude	State	County	Major basin	Subbasin	Stream name	Order	Major barriers	Lamprey potential	Surveyed	Lamprey present
NW-1	-122.209	48.621	WA	Skagit	Samish	Jackson Cr.	Unnamed	1st	None	Medium	Y	N
NW-2	-122.218	48.605	WA	Skagit	Samish	Unknown	Unnamed	1st	None	High	Y	N
NW-3	-122.198	48.558	WA	Skagit	Skagit	Hansen Cr.	Unnamed	1st	None	Medium	Dry	N/A
NW-4	-122.191	48.440	WA	Skagit	Skagit	Nookachamps R.	Mundt Creek	2nd	None	High	Y	N
NW-5	-122.045	48.003	WA	Skagit	Snohomish	Pilchuck R.	Unnamed	1st	None	High	N	N/A
NW-6	-121.713	47.875	WA	Snohomish	Skykomish	Wallace R.	Olney Cr.	1st	None	Low	N	N/A
NW-7	-121.712	47.875	WA	Snohomish	Skykomish	Wallace R.	Olney Cr.	1st	None	Low	N	N/A
NW-8	-121.709	47.875	WA	Snohomish	Skykomish	Wallace R.	Olney Cr.	1st	None	Low	N	N/A
NW-9	-121.601	47.833	WA	Snohomish	Skykomish	Austin Cr.	Unnamed	1st	None	Low	N	N/A
SP-1	-121.637	47.435	WA	King	Snohomish	S.F. Snoqualmie R.	Unnamed	1st	Multiple waterfalls, potential fish weir	Low	N	N/A
SP-2	-121.650	47.443	WA	King	Snohomish	S.F. Snoqualmie R.	Unnamed	2nd	Multiple waterfalls, potential fish weir	Medium	N	N/A
SP-3	-121.846	47.499	WA	King	Snohomish	Coal Cr.	Unnamed	1st	None	Low	N	N/A
SP-4	-121.873	47.496	WA	King	Snohomish	Raging R.	Unnamed	1st	None	Low	N	N/A
SP-5	-121.881	47.492	WA	King	Snohomish	Raging R.	Unnamed	1st	None	Low	N	N/A
SP-6	-121.881	47.491.	WA	King	Snohomish	Raging R.	Unnamed	1st	None	Low	N	N/A
SP-7	-121.915	47.471	WA	King	Snohomish	Raging R.	Deep Cr.	1st	None	Low	N	N/A
SP-8	-121.966	47.452	WA	King	Sammamish	Holder Cr.	Unnamed	1st	None	Low	N	N/A

Table 1. Continued from previous page.

Site Number	Longitude	Latitude	State	County	Major basin	Subbasin	Stream name	Order	Major barriers	Lamprey potential	Surveyed	Lamprey present
SP-9	-121.731	47.272	WA	King	Green	H.A. Hansen Reservoir	Unnamed	1st	H.H. Reservoir	Low	N	N/A
SP-10	-121.710	47.261	WA	King	Green	Gale Cr.	Unnamed	1st	H.H. Reservoir	Low	N	N/A
SP-11	-121.711	47.261	WA	King	Green	Gale Cr.	Unnamed	1st	H.H. Reservoir	Low	N	N/A
SP-12	-121.659	47.249	WA	King	Green	H.A. Hansen Reservoir	Sylvester Cr.	1st	H.H. Reservoir	Low	N	N/A
SP-13	-121.656	47.248	WA	King	Green	H.A. Hansen Reservoir	Sylvester Cr.	1st	H.H. Reservoir	Low	N	N/A
SP-14	-121.645	47.241	WA	King	Green	H.A. Hansen Reservoir	Cougar Cr.	1st	H.H. Reservoir	Low	N	N/A
SP-15	-121.764	47.219	WA	King	Green	H.A. Hansen Reservoir	Unnamed	1st	H.H. Reservoir	Low	N	N/A
OLY-1	-123.814	48.133	WA	Clallam	Lyre	Nelson Cr.	Nelson Cr.	1st	None	Low	Y	N
OLY-2	-123.031	48.017	WA	Clallam	Puget Sound	Dean Cr.	Dean Cr.	2nd	None	Medium	Y	N
PC-1	-122.243	45.656	WA	Skamania	Columbia	Washougal R.	Unnamed	2nd	Bonneville Dam	High	Y	N
PC-3	-121.796	45.752	WA	Skamania	Columbia	Wind R.	Brush Cr.	2nd	Bonneville Dam	High	Y	N
BR-1	-124.413	42.677	OR	Curry		Brush Cr.	Unnamed	1st	None	Low	Y	N
BR-2	-124.466	42.765	OR	Curry	Elk River	Bagley Cr.	Unnamed	1st	None	Medium	Y	N
BR-3	-124.455	42.738	OR	Curry	None	Hubbard Cr.	Unnamed	1st	None	Low	Y	N

Table 2. Physical and habitat characteristics of BPA sites surveyed in 2012.

Site Number	Date sampled	Stream name	Conductivity (µS/cm)	Water temperature (°C)	Type 1 substrate	Lamprey present	Other fish observed
NW-1	10/17/12	Unnamed	26.8	9.9	Moderate	N	N
NW-2	10/17/12	Unnamed	72	9.5	Moderate	N	Y
NW-3*	10/16/12	Unnamed	N/A	N/A	N/A	N	N
NW-4	10/17/12	Mundt Cr.	52.4	9.2	Moderate	N	Y
OLY-1	08/02/12	Nelson Cr.	116	11.4	Moderate	N	N
OLY-2	08/02/12	Dean Cr.	194	12	Moderate	N	N
PC-1	07/31/12	Unnamed	36	14.5	Moderate	N	N
PC-3	08/08/12	Brush Cr.	65.4	16.1	Absent	N	N
BR-1	08/07/12	Brush Cr.	72.2	12.8	Moderate	N	N
BR-2	08/07/12	Bagley Cr.	48.8	12.3	Moderate	N	N
BR-3	08/07/12	Hubbard Cr.	44.1	12.5	Absent	N	N

*NW-3 was completely dewatered

Proposed Salvage Methods

When lampreys have been documented as occupying a site through pre-surveys procedures for lamprey salvage will be invoked. Presence of lampreys within any of the five 50-m subreaches will indicate the general presence of lampreys in, and proximate to, the work site. Salvage would occur at the 50 m subreach at the work site, i.e., subreach 3 (25 m above and 25 m below the stream crossing). The subreach will be thoroughly electrofished with multiple passes through the subreach until catches decline (i.e., repeated pass through work site produces zero lamprey), suggesting all or most lamprey had been collected. All captured larvae are to be anesthetized, measured, and identified as described above. Salvaged lampreys are to be returned to the stream 50-100 m downstream of the work site (i.e., 50-m sample reach) into the appropriate Type 1 habitat if available. The work site should be blocked with a net on the downstream side to prevent potential migration of larval lamprey into the work site.

Conclusions

Lampreys were not detected at any of the sites sampled and we therefore did not perform salvage activities. Many of the sites surveyed were headwater tributaries with high gradient, small size, and limited quantities of Type 1 habitat and therefore are probably unsuitable for Pacific Lamprey. Furthermore, sites we did not survey generally had steeper gradients and some are likely ephemeral. Coastal cutthroat trout were detected at one site potentially indicating that physicochemical attributes were suitable for larval lamprey presence. Knowledge of predicted compared to actual occupancy was useful in evaluating other potential work sites.

Many sites surveyed had impassible barriers (i.e., perched culverts) and therefore lack of migratory lamprey detection upstream of work sites was expected. Improvement of passage conditions at these locations may be beneficial to migratory fishes including lampreys. Resident western brook lamprey populations above work sites are possible especially given the type of habitat which is more suitable to resident lamprey (Luzier et al. 2006) .

Restoration, road construction, or culvert replacement activities conducted by BPA at the surveyed locations will likely have no adverse impact on lamprey populations. Future transmission line access sites should be surveyed using the same methods to detect larval lamprey and they should be salvaged, if present. The efficacy of lamprey salvage at work sites is currently unknown and future opportunities to evaluate salvage techniques at locations of known lamprey occupancy are warranted. Pre-evaluation of potential work sites may be valuable to prioritize salvage efforts and prior knowledge of the potential for a work site to be occupied with lamprey may direct survey efforts. Salvage methods may be customized to each site and knowledge of lamprey presence at particular sites may increase efficiency of salvage. Headwater

sites, ephemeral sites, and those upstream of impassible barriers have a lower likelihood of lamprey occupancy.

Acknowledgements

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Literature Cited

Beamish, R. J. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Canadian Journal of Fisheries and Aquatic Sciences. 37: 1906-1923.

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.

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(7):19-25.

Connolly, P.J., S. James, K. Wieman, B. Bair, I. Jezorek, D. Rawding, P. Cochran, and S. Stampfli. 1999. Wind River watershed restoration project, segments I-IV, Annual Report. U.S. Geological Survey, Cook, WA.

Goodman, D.H., S.B. Reid, M.F. Docker, G.R. Haas, and A.P. Kinziger. 2008. Mitochondrial DNA evidence for high levels of gene flow among populations of a widely distributed anadromous lamprey *Entosphenus tridentatus* (Petromyzontidae). Journal of Fish Biology 72:400-417.

Goodman, D.H., A.P. Kinzinger, S.B. Reid, and M.F. Docker. 2009. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes (Petromyzontidae) in Washington, Oregon, and California. Pages 223-232 *in* L. R. Brown, S. D. Chase, M. G. Mesa, R. J. Beamish, and P. B. Moyle, editors. Biology, management, and conservation of lampreys in North America, volume Symposium 72. American Fisheries Society, Bethesda.

Hammond, R.J. 1979. Larval biology of the Pacific lamprey, *Entosphenus tridentatus* (Gairdner), of the Potlach River, Idaho. MS Thesis. University of Idaho, Moscow.

Jolley, J.C., G.S. Silver, and T.A. Whitesel. 2012. Occupancy and detection of larval Pacific lampreys and *Lampetra* spp. in a large river: the Lower Willamette River. Transactions of the American Fisheries Society 141:305-312.

Kan, T. T. 1975. Systematics, variation, distribution, and biology of lampreys of the genus *Lampetra* in Oregon. PhD dissertation. Oregon State University, Corvallis, OR. 194 pp.

Luzier, C.W., H.A. Schaller, J.K. Brostrom, C. Cook-Tabor, D.H. Goodman, R.D. Nelle, K. Ostrand and B. Streif. 2011. Pacific Lamprey (*Entosphenus tridentatus*) Assessment and template for conservation measures. U.S. Fish and Wildlife Service, Portland, Oregon. 282 pp.

Luzier, C.W., G. Silver, and T.A. Whitesel. 2006. Evaluate Habitat Use and Population Dynamics of Lampreys in Cedar Creek, 2005 Annual Report for BPA Project No. 2000-014-00. U.S. Fish and Wildlife Service, Vancouver, Washington. 32 pp.

McGree, M., T.A. Whitesel and J. Stone. 2008. Larval metamorphosis of individual Pacific lampreys reared in captivity. Transactions of the American Fisheries Society 137:1866-1878.

Pajos, T.A., and J.G. Weise. 1994. Estimating populations of larval sea lamprey with electrofishing sampling methods. North American Journal of Fisheries Management 14:580-587.

Peterson, J.T., and J. Dunham. 2003. Combining inferences from models of capture efficiency, detectability, and suitable habitat to classify landscapes for conservation of threatened bull trout. Conservation Biology 17:1070-1077.

Pletcher, F.T. 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. MS thesis, University of British Columbia, Vancouver, B. C. 195 pp.

Poirier, J., J. Johnson, J. Jolley, G. Silver, M. Hudson, S. Lohr, and T.A. Whitesel. 2010. Presence, distribution and movement of select aquatic species in Tide Creek, Merrill Creek and Deer Island Slough, Columbia County, Oregon. 2009 Progress Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office. 26 pp.

Richards, J. E. 1980. The freshwater life history of the anadromous Pacific lamprey, *Lampetra tridentata*. MS thesis, University of Guelph, Guelph, Ontario. 99 pp.

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 29 (Supplement 1):137-151.

Stone, J., and S. Barndt. 2005. Spatial distribution and habitat use of Pacific lamprey (*Lampetra tridentata*) ammocoetes in a Western Washington stream. Journal of Freshwater Ecology 20:171-185.

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

USFWS and USFS. 2010a. Best management practices to minimize adverse effects to Pacific lamprey (*Entosphenus tridentatus*). U.S. Fish and Wildlife Service and U.S. Forest Service, Portland, Oregon. 25 pp.

USFWS. 2010b. Pacific Lamprey (*Lampetra tridentata*) Pacific Lamprey (*Lampetra tridentata*) Draft Assessment and Template for Conservation Measures. U.S. Fish and Wildlife Service, Portland, Oregon. 276 pp.

USFWS. 2012. Conservation agreement for Pacific lamprey *Entosphenus tridentatus* in the states of Alaska, Washington, Oregon, Idaho, and California. U.S. Fish and Wildlife Service, Portland, Oregon. 57 pp.

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.

Appendix A: Photographic index of BPA transmission line access road stream crossings

NW-1 downstream view

NW-2 downstream view

NW-2 upstream view

NW-3 downstream view

NW-4 downstream view

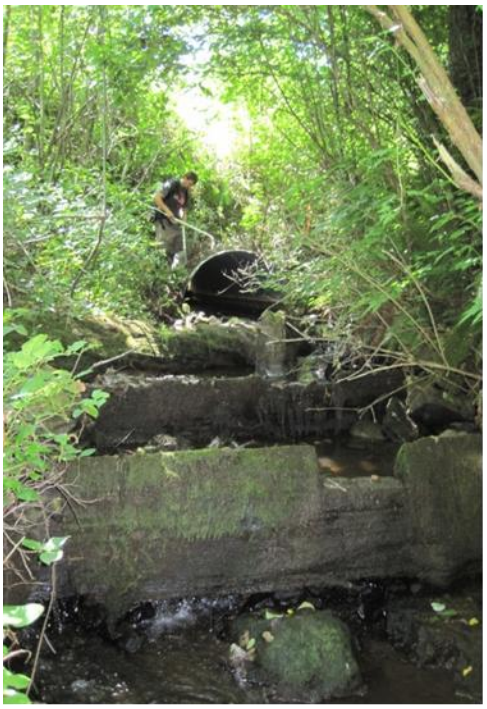
BR-1 downstream view

BR-2 downstream view

BR-3 downsstream view

OLY-1 downstream view

OLY-2 downstream view



PC-1 downstream view

PC-1 downstream view

PC-3 downstream view

PC-3 upstream view

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