White Salmon River Basin: Lamprey Project

2007-2009 Annual Report

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Introduction

The White Salmon River (WSR) is in southwest Washington in the Columbia River Gorge and it originates on Mount Adams (Figure 1). The U.S. Congress designated the WSR under both the Wild and Scenic Rivers Act and the Columbia Gorge National Scenic Area Act (NMFS 2009). The WSR basin is within lands ceded to the United States government by the Yakama Nation. Historically, the WSR is believed to have supported Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, steelhead *O. mykiss*, coastal cutthroat trout *O. clarki*, bull trout *Salvelinus confluentus*, Pacific lamprey *Entosphenus tridentatus* and western brook lamprey *Lampetra richardsoni* populations (NPCC 2004). However, with the construction of Condit Dam in the early 1900's, anadromous fish production in the WSR declined drastically. After the destruction of the fish ladder by high flows in 1919, passage upstream of Condit Dam was blocked to all fishes (NMFS 2009). In addition, because of habitat loss and flow alteration caused by hydroelectric operations, little anadromous fish production occurs downstream of Condit Dam.

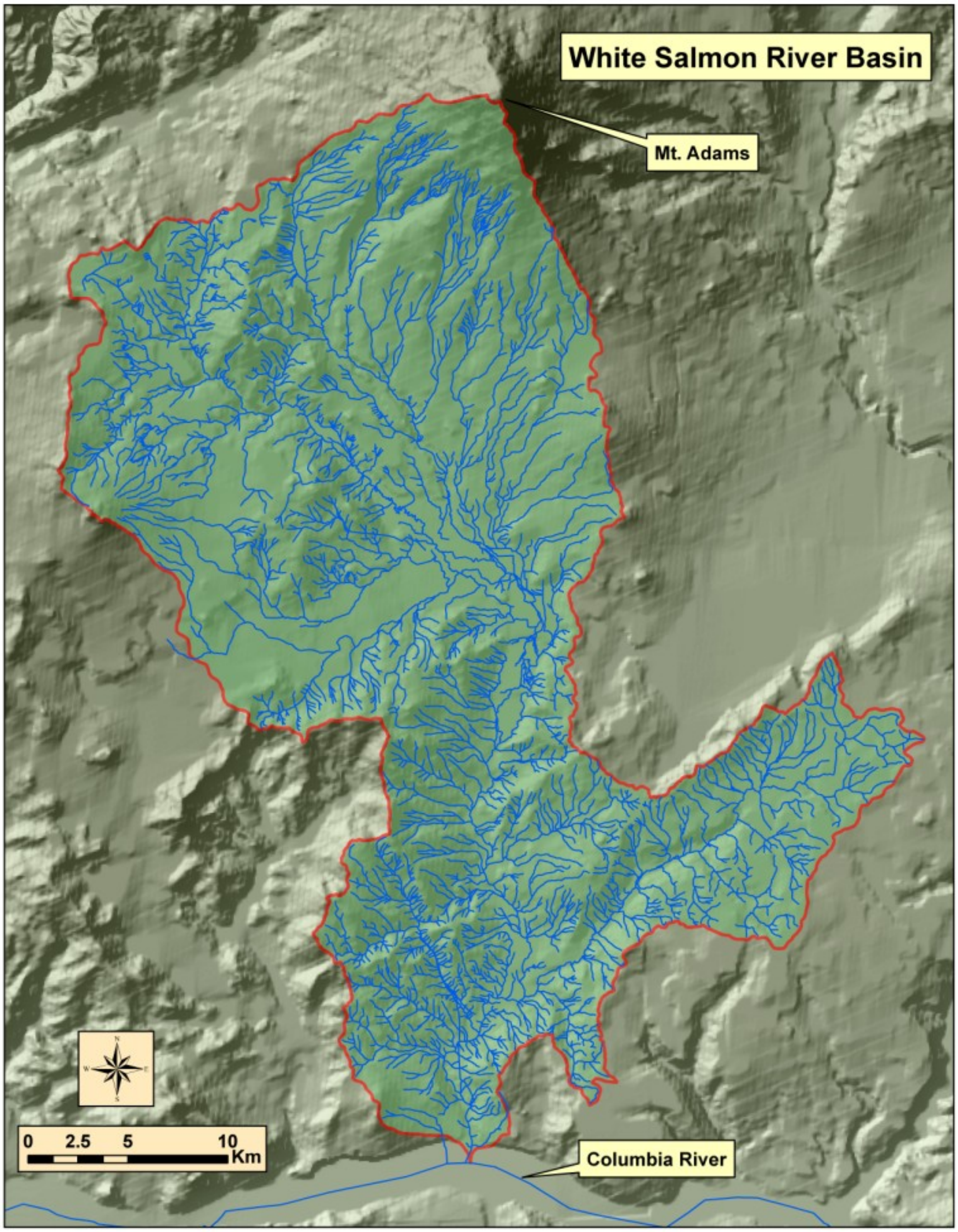

Figure 1. The White Salmon River basin, from its headwaters on Mount Adams to the Columbia River.

The Condit Hydroelectric Project, owned by PacifiCorp, includes 144-m long Condit Dam which is 38-m high, with a 38-m spillway. The 95 year-old project is located 5.3 km upstream from the confluence of the WSR and the Columbia River and is the only man-made impoundment along the river's 72 km length. Condit Dam is scheduled to be removed in the fall of 2010 reconnecting historic fish spawning habitat to the mainstem of the Columbia River (NMFS 2009). The U.S. Fish and Wildlife Service has partnered with the Yakama Nation, the U.S. Geological Survey, the Washington Department of Wildlife, NOAA Fisheries and PacifiCorp to assess the impact that the removal of Condit Dam may have on fish populations and aquatic habitats in the WSR basin. The U.S. Fish and Wildlife Service has identified Pacific lamprey, bull trout, and coastal cutthroat trout as the highest priority species for restoration in the WSR basin (R.O. Engle, USFWS, personal communication). This project is a component of the WSR assessment/restoration effort. Preliminary survey data of lamprey species in the WSR basin indicated that resident western brook lampreys (WBL) were rare above Condit Dam, while anadromous Pacific lampreys (PCL) are locally extirpated (Rawding 2000). Pacific lampreys are limited by many of the same factors as salmon and steelhead, such as dam passage and habitat loss, and populations throughout the Columbia River Basin have declined to a remnant of their historical levels (Close 2002). While resident fish (i.e., *Cottidae, Salmonidae*) appear to be the primary inhabitants upstream of the dam (Rawding 2000), habitat surveys have suggested that there is suitable habitat both downstream and upstream of the dam for spawning and rearing of anadromous fish, including lampreys (NMFS 2009; C.W. Luzier, USFWS, personal communication). Therefore, a conservation need exists to assess lamprey populations and habitats in the WSR before and after Condit Dam is removed.

The short-term justification for this project was to assess the current status and distribution of lamprey species in the WSR prior to Condit Dam removal. This baseline data will facilitate quantitative comparisons of lamprey status and distribution, and habitat conditions after dam removal. Assessments of lamprey populations in the WSR basin before and after removal of Condit Dam are imperative for evaluating the efficacy of restoration work and the need for further restoration to ensure long-term conservation of lamprey species. This project will inform efforts in the WSR basin, in particular, and efforts to reestablish Pacific lamprey in other basins. The specific objectives of this project were to: 1) identify areas in the WSR where Pacific lamprey would be likely to spawn, 2) determine the probability of detecting larval lampreys in an occupied watershed using a backpack electrofisher, 3) determine presence and distribution of Pacific lampreys and western brook lampreys before removal of Condit Dam, 4) determine if anadromous lampreys return to suitable spawning habitat after removal of Condit Dam, 5) determine the rate that anadromous lampreys may return after dam removal, and 6) determine whether Pacific lampreys become established in streams with western brook lamprey or streams without western brook lamprey. Objectives one, two and three are discussed in this annual report; objectives four, five, and six are proposed objectives that will be reported on after the removal of Condit Dam.

Methods

Sample Units

All watersheds in the WSR basin up to 3rd order in size (at 1:100,000 scale) were delineated as units of potential adult lamprey spawning and larval rearing. These watersheds were defined as the sample unit for which we would evaluate lamprey occupancy. According to these criteria, a total of 21 viable sample units were delineated in the WSR basin. Two additional areas, the White Salmon River mainstem below Condit Dam and Northwestern Lake (the area impounded by Condit Dam) were also included as sample units (Figure 2). To identify sample units in the basin that represent relatively high probability of Pacific lamprey recolonization potential after the removal of Condit Dam, we used the anadromous steelhead intrinsic spawning habitat potential in the WSR basin (D. Holzer, NOAA, personal communication; Figure 2). Spawning of Pacific lamprey and steelhead overlaps, as they select similar sized substrates (Scott and Crossman 1973; Bjornn and Reiser 1991).

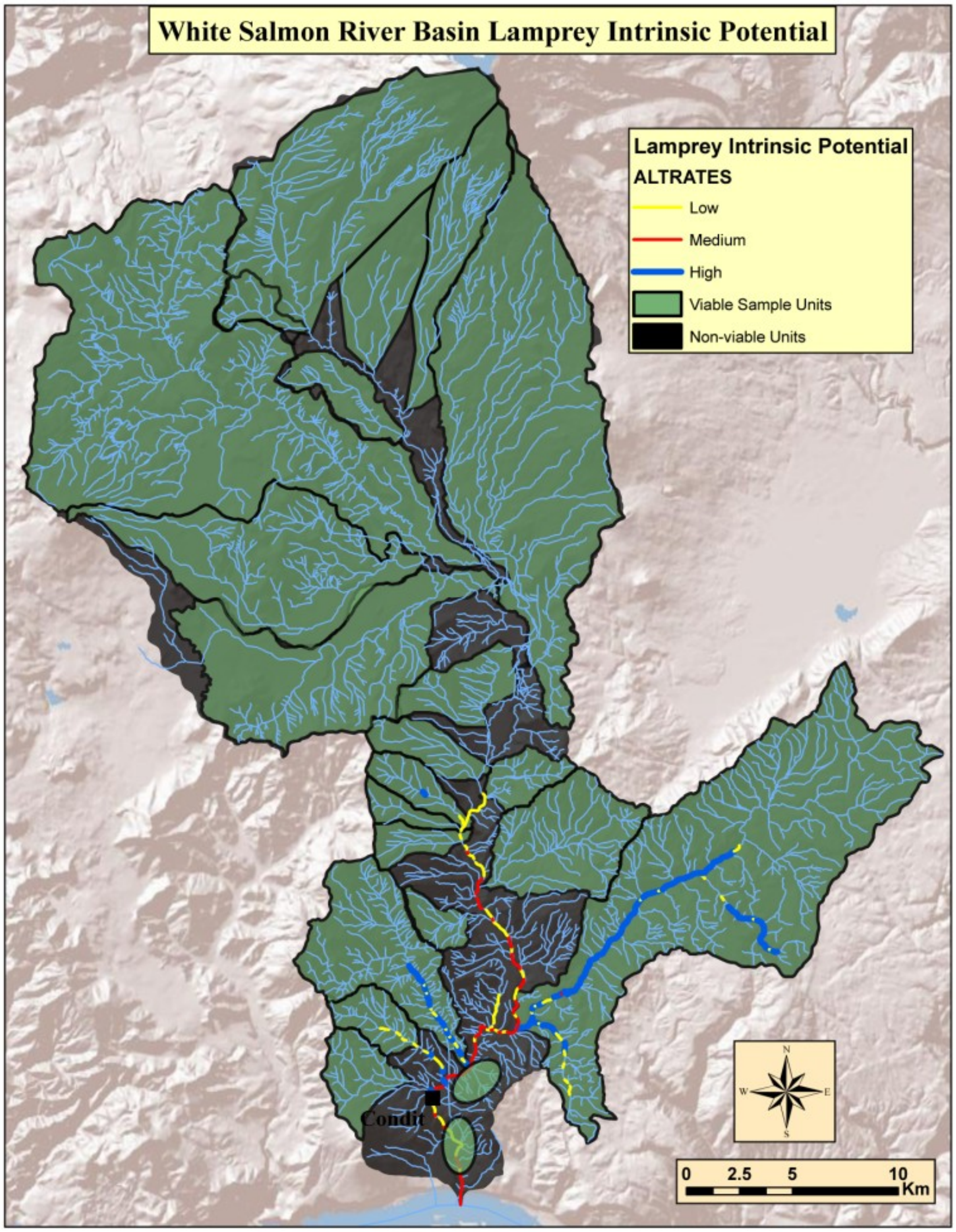

Figure 2. Sample units (n = 21) in the White Salmon River basin and intrinsic potential rankings for supporting Pacific lampreys. Rankings were generated for steelhead and applied here for Pacific lamprey. Non-viable units did not satisfy sample unit criteria.

Sample Framework

In each sample unit, randomly selected, spatially-balanced 50-m sample reaches were delineated using the Generalized Random Tessellation Stratified (GRTS) method (Stevens and Olsen 2004). On average, one 50-m reach was selected every 0.5 km of stream. The GRTS method assigns numbers to the selected 50-m reaches within a watershed and those numbers are then used as an unbiased method of ranking the priority of reaches for sampling. In this study, low numbered reaches within each watershed were designated as the highest priority for sampling (Figure 3). The reaches were sampled in non-sequential order, generally beginning with the reach lowest in the watershed and moving upstream. Sampling for larval lampreys was conducted using an AbP-2 backpack electrofisher (ETS Electrofishing, Verona, WI). If a given reach in a sample unit could not be electrofished (e.g., dewatered or inaccessible), the reach was omitted from the sample unit and the next highest priority reach was added. This technique maintained the spatial balance and randomization of sample reaches. When two lampreys differing by more than 20 mm in TL (from one species) were captured in a reach, the sample unit was considered occupied and additional reaches in that unit were not sampled.

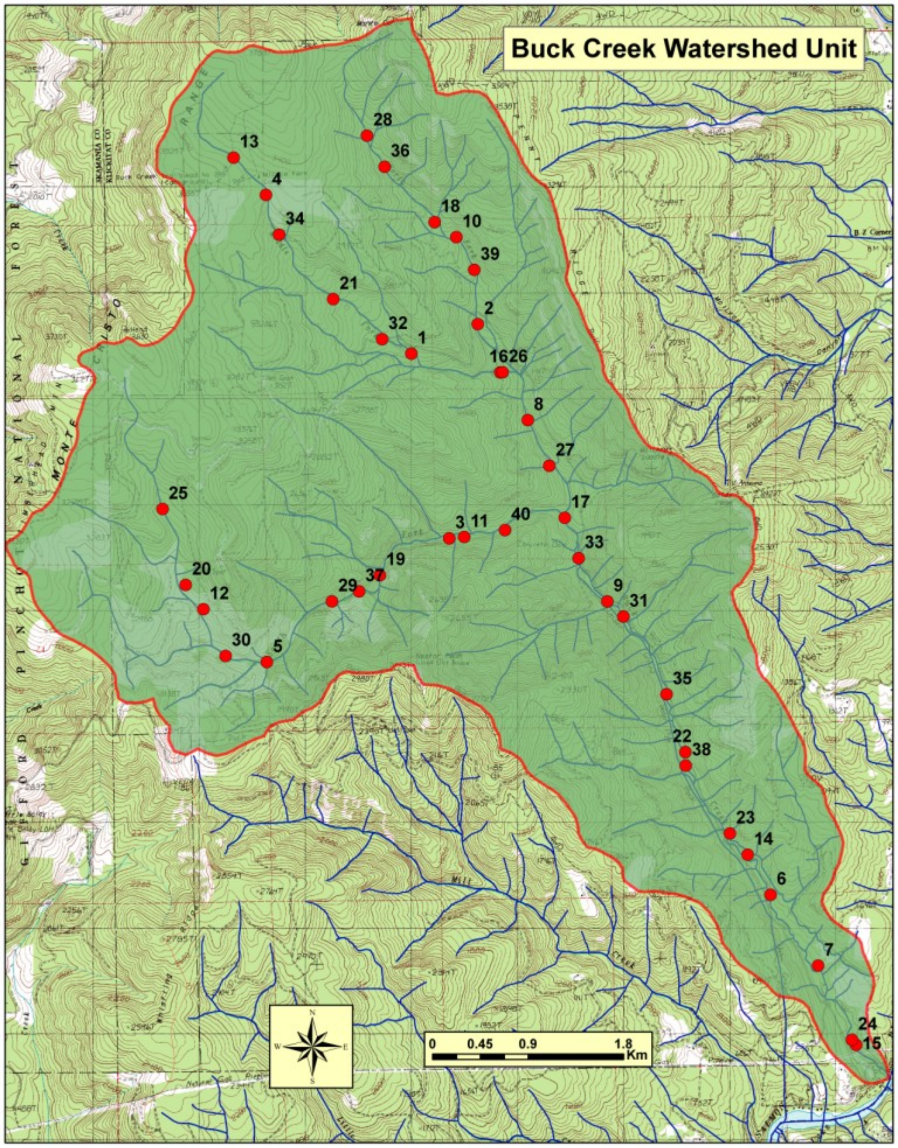

Figure 3. An example of a sample unit (Buck Creek) and randomly selected, spatially-balanced 50-m sample reaches as generated with the GRTS method. Reaches 1-21 were the highest priority and were generally electrofished beginning with the lowest in the watershed (i.e., reach 15) and moving upstream.

2007

The 21 highest priority, feasible reaches in Buck Creek and Trout Lake Creek were sampled for larval lampreys using a backpack electrofisher (Figure 4). Results of this larval lamprey sampling effort were used to calculate larval lamprey detection probability (DP) in an occupied sample unit, that is, one known to contain larval lampreys. In turn, this DP information was used to determine the number of reaches necessary to conduct a probabilistic evaluation of larval lamprey occupancy in subsequent sample units (i.e., unknown occupancy; Peterson and Dunham 2004). Sampling of Rattlesnake Creek to determine occupancy by larval lampreys was begun in 2007 as well (completed in 2009).

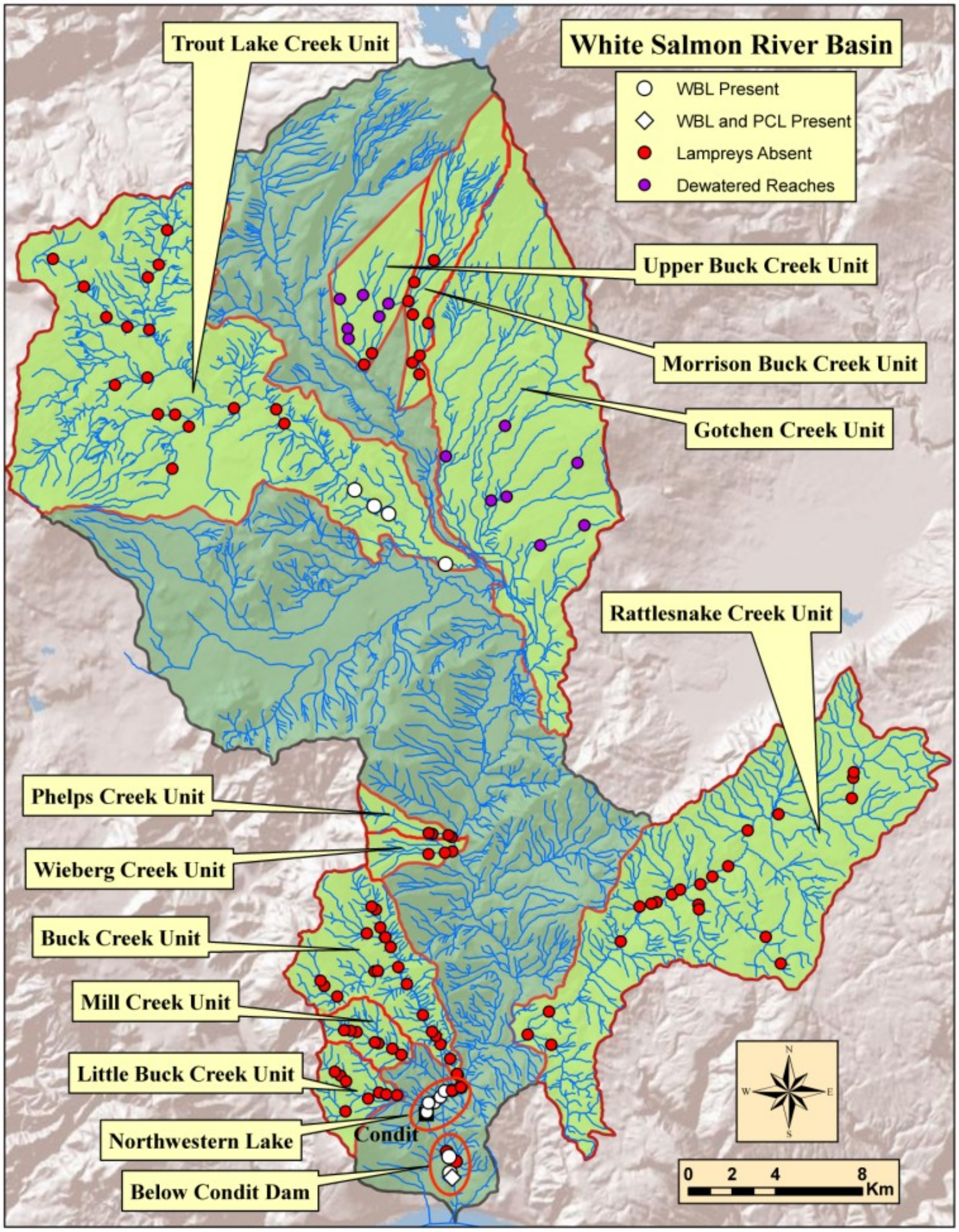

Figure 4. Sample units in the White Salmon River basin. Larval and adult western brook lampreys were captured in four reaches on Trout Lake Creek and at six sites in Northwestern Lake. Below Condit Dam, larval western brook lampreys were captured at three sites and larval Pacific lampreys at one site.

The White Salmon River mainstem below Condit Dam was also sampled for larval lampreys with a backpack electrofisher (Figure 5). This area of the river was largely within a steep canyon and was accessed using an inflatable raft launched at the Condit Dam powerhouse. The river was floated to the Highway 14 bridge near the mouth of the Columbia River. When river conditions permitted, the raft was stopped and margins of the river of wadeable depth were electrofished. A total of five sites were sampled below Condit Dam.

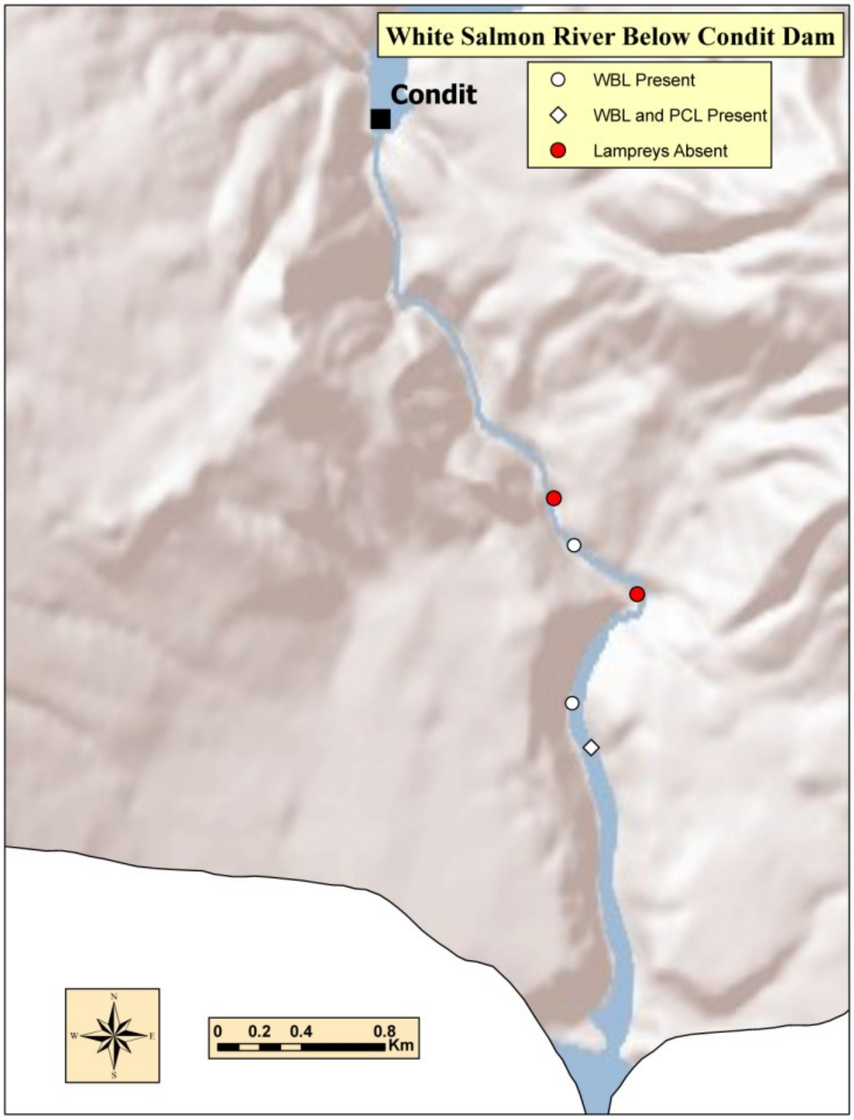

Figure 5. Sample sites on the White Salmon River below Condit Dam in 2007. In 2009, only the lowest site (white diamond) was sampled.

2008

To determine occupancy by larval lampreys, randomly selected 50-m reaches (i.e., the highest priority reaches) were electrofished in the Little Buck Creek, Mill Creek, and Morrison Creek sample units (Figure 4).

2009

To determine occupancy by larval lampreys, randomly selected 50-m reaches (i.e., highest priority reaches) were electrofished in Phelps Creek, Wieberg Creek, Gotchen Creek and Upper Buck Creek sample units (Figure 4). Additional reaches within the Rattlesnake Creek unit were sampled to complete the 21 highest priority reaches in this unit (Figure 4). The White Salmon River mainstem below Condit Dam was again electrofished for larval lampreys in 2009 as described above (Figure 5).

Northwestern Lake

Northwestern Lake, a reach of the White Salmon River impounded by Condit Dam, was also sampled to assess longitudinal distribution of larval lampreys within the approximately 3.2 km long lake (Figure 6). Eight randomly selected, spatially-balanced sample sites along the thalweg of Northwestern Lake were delineated using the GRTS method as described above (Stevens and Olsen 2004). The sites ranged from immediately above Condit Dam, upstream to the confluence with Buck Creek (Figure 3, Figure 6). Sample sites in Northwestern Lake were accessed by boat and sampled using a boat-mounted deepwater electrofisher (Bergstedt and Genovese 1994), specifically designed for capturing larval lampreys in lentic habitats.

Electrofishing methods and electrofisher settings were the same as those used in Jolley et al. (2009).

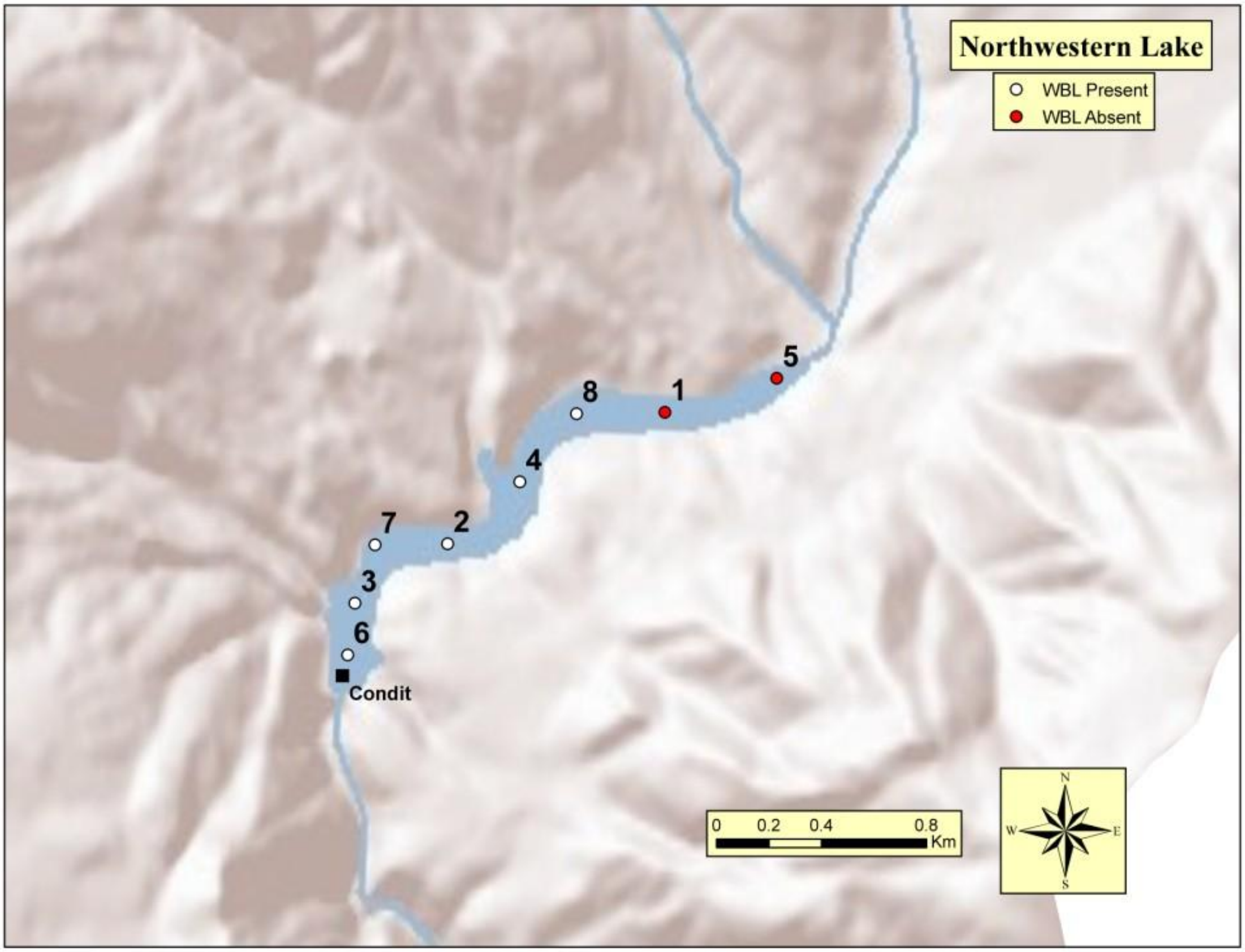

Figure 6. Sample sites in Northwestern Lake using a deepwater electrofisher.

Field Protocol

Sample reaches were accessed on foot (except in Northwestern Lake) using GPS units loaded with sample reach UTMs for navigation. Once a sample reach was located, a 50-m stream reach was measured and flagged. Water temperature and conductivity were recorded in each reach. The reach was electrofished using an AbP-2 backpack electrofisher. Power output settings for the AbP-2 were adapted from Weisser and Klar 1990 (Table 1). Electrofishing effort within each reach was targeted at preferred larval lamprey rearing habitat where depositional silt and sand substrates are dominant (henceforth Type I habitat, Slade et al. 2003), while areas with hard bedrock and boulder substrates were sampled less intensively. All larval lampreys observed were captured and placed in buckets containing stream water.

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	-

Biological data was collected from a maximum of 25 larval lampreys at each sample reach. Lampreys were removed from the holding bucket, anesthetized in a solution of tricaine methanesulfonate (MS-222), identified to species (WBL, PCL, or lamprey spp.) according to caudal pigmentation (Goodman et al. 2009) and classified according to developmental stage (i.e., ammocoete, macrophthalmia, or adult). Lampreys were measured (TL in mm) and weighed (wet weight in g) and caudal fin tissue was collected from subsample of up to 10 lampreys per site for genetic analysis to confirm species identification. Lampreys were placed in a recovery bucket of fresh stream water and released into the stream after resuming normal swimming behavior.

Results

2007

Electrofishing sampling of three sample units, Buck Creek, Trout Lake Creek, and Rattlesnake Creek was conducted in 2007 .(Table 2, Figure 4). Five sites on the White Salmon River mainstem below Condit Dam were also sampled (Table 3, Figure 5). In Buck Creek, 21 reaches were sampled and no larval lampreys were captured in any of the sample reaches (Figure 4). In Trout Lake Creek, larval western brook lampreys (n = 80) and adult western brook lampreys (n = 2) were captured at four of the 21 reaches sampled (Table 2). Lampreys ranged in size from 59 mm to 130 mm TL (mean = 86 mm, SE ± 2mm). The four sites where lampreys were captured were in approximately the lower 1/4 of the Trout Lake Creek watershed, within approximately 9 km of the confluence with the White Salmon River (Figure 4). In Rattlesnake Creek, no larval lampreys were captured at three sample reaches (Figure 4). Reach-specific DP of larval lamprey in Trout Lake Creek was 0.19. Accordingly, the estimated minimum level of sampling effort to be 80% certain that larval lamprey are absent when undetected, was eight sample reaches per unit (Peterson and Dunham 2003).

Table 2. Sample units in the White Salmon River basin in 2007, 2008, and 2009.

Sample unit	Year	# Reaches visited	# Reaches sampled	# Dewatered reaches	# Occupied reaches	Est. Prob. of Occupancy
Buck Creek	2007	21	21	0	0	< 0.02
Trout Lake Creek	2007	21	21	0	4	1.00
Rattlesnake Creek	2007	3	3	0	0	< 0.35
Little Buck Creek	2008	8	8	0	0	< 0.20
Mill Creek	2008	7	7	0	0	< 0.20
Morrison Creek	2008	8	5	3	0	< 0.30
Phelps Creek	2009	4	4	0	0	0.30
Wieberg Creek	2009	3	3	0	0	< 0.35
Gotchen Creek	2009	7	0	7	0	-
Upper Buck Creek	2009	8	2	6	0	< 0.40
Rattlesnake Creek (revisted)	2009	18	18	0	0	< 0.05
Rattlesnake Creek (total)	2007, 2009	21	21	0	0	< 0.02

Below Condit Dam, a total of 26 lampreys were captured at three of five sites sampled and were a mix of larval western brook lampreys (n = 19), adult western brook lampreys (n = 5) and larval Pacific lampreys (n = 2; Table 3, Figure 5). Lampreys ranged in size from 58 mm to 142 mm TL (mean = 108 mm, SE ± 4 mm).

Table 3. Sites sampled on the White Salmon River mainstem below Condit Dam and in Northwestern Lake above Condit Dam.

Sample Location	Site #	Year	Larval WBL	Adult WBL	Larval PCL
Below Condit Dam	1	2007	0	0	0
Below Condit Dam	2	2007	2	1	0
Below Condit Dam	3	2007	0	0	0
Below Condit Dam	4	2007	3	1	0
Below Condit Dam	5	2007	14	3	2
Below Condit Dam	5	2009	22	0	0
Northwestern Lake	1	2009	0	0	0
Northwestern Lake	2	2009	1	0	0
Northwestern Lake	3	2009	4	0	0
Northwestern Lake	4	2009	1	0	0
Northwestern Lake	5	2009	0	0	0
Northwestern Lake	6	2009	1	0	0
Northwestern Lake	7	2009	6	0	0
Northwestern Lake	8	2009	1	1	0

2008

Electrofishing sampling of three sample units, Little Buck Creek, Mill Creek, and Morrison Creek, was conducted in 2008 (Table 2, Figure 4). In Little Buck Creek, eight reaches were sampled and no larval lampreys were captured (Figure 4). In Mill Creek, seven reaches were sampled and no larval lampreys were captured (Figure 4). One additional reach in Mill Creek was inaccessible and was not sampled. In Morrison Creek, eight reaches were sampled and no larval lampreys were captured (Figure 4).

2009

Electrofishing sampling of the Phelps Creek, Wieberg Creek, Gotchen Creek and Upper Buck Creek sample units was conducted in 2009 (Table 2, Figure 4). Additional reaches in Rattlesnake Creek were sampled, totaling 21 over a two year period (Table 2, Figure 4). In Phelps Creek, no larval lampreys were detected in four reaches sampled (Figure 4). At approximately river kilometer (RKM) 2 of Phelps Creek a series of three waterfalls 3-5 m in height was encountered that was presumed to be a barrier to lamprey migration. Continued sampling upstream of the waterfalls was not conducted. Similarly, in Wieberg Creek no lampreys were detected in three reaches sampled (Figure 4). At approximately RKM 1.5 of Wieberg Creek a waterfall of approximately 25 m in height was reached that was presumed to be a barrier to lamprey migration. Continued sampling upstream of the waterfall was not conducted. The seven sites visited in Gotchen Creek were completely dewatered (Figure 4). These sites were low in the watershed and suggested that all or most of the watershed was dewatered. As such, no other feasible sites were available for additional sampling and water was not available to support lamprey. Similarly, in Upper Buck Creek, six of eight sites visited were dewatered. Two sites with water (likely intermittent flow) were electrofished and no lampreys were detected (Figure 4). At Rattlesnake Creek 18 reaches were sampled and no larval lampreys were detected (Figure 4).

Below Condit Dam, one sample site was electrofished and 22 larval western brook lampreys were captured (Table 3, Figure 5). Lampreys ranged in size from 34 mm to 140 mm TL (mean = 99 mm, SE ±7 mm).

Northwestern Lake

In Northwestern Lake, larval western brook lampreys (n = 14) and adult western brook lampreys (n = 1) were captured at 75% (six of eight) of the sites sampled using a deepwater electrofisher (Table 3, Figure 6). Lampreys ranged in size from 82 mm to 138 mm TL (mean = 101 mm, SE ±4 mm).

Findings

Western brook lamprey distribution in the WSR basin is limited to the mainstem of the WSR both above and below Condit Dam and one tributary. Of the ten sample units electrofished for lampreys above Condit Dam (Northwestern Lake and nine tributaries), western brook lampreys were detected in only two units (20%): Northwestern Lake (the mainstem WSR impounded by the dam) and Trout Lake Creek (Figure 7). Pacific lampreys are unable to pass above Condit Dam, and thus were found in the WSR mainstem below the dam only. Suitable habitat for adult lamprey spawning as well as Type I larval rearing habitat was present in each of the nine sample units and does not appear to be a factor limiting lamprey distribution in the WSR basin. Restricted distribution of lampreys above Condit Dam is likely being influenced mainly by physical migration barriers and stream flow. Waterfalls that are presumed barriers to fish (i.e., salmon) migration are found throughout the White Salmon River and its tributaries. Both Wieberg and Phelps Creeks have waterfalls at their mouths where they enter the White Salmon River (NMFS 2009) and all sample reaches in these units were above these falls. In addition, waterfalls occur at approximately RKM 1.5-2.0 on each creek and likely further restrict resident fish movements within these creeks.

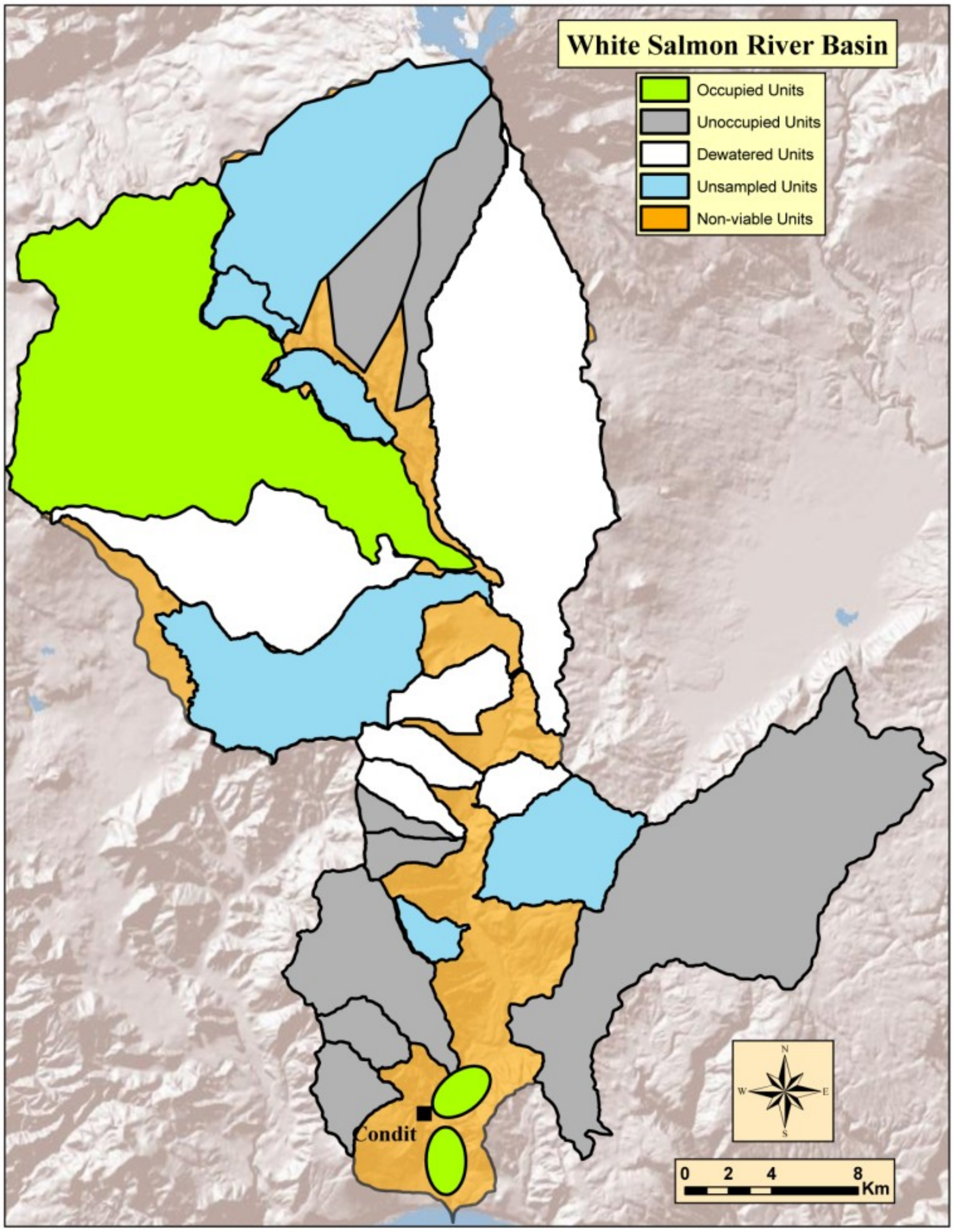

Figure 7. Status of the 21 tributary sample units in the White Salmon River basin as of May 2010. Units in green are occupied by lampreys, while lampreys are absent from gray units. Units in white were completely dewatered and not sampled. Units in blue are scheduled for sampling in 2010. Areas of orange were not viable units according to the sample unit selection criteria.

Rattlesnake Creek, a large WSR tributary with high lamprey intrinsic potential (D. Holzer, NOAA, personal communication; Figure 2), also contains multiple barrier waterfalls (NMFS 2009). A waterfall located at RKM 2.4 is thought to be a barrier to all salmonids except steelhead and possibly coho salmon (NMFS 2009), and may be a barrier to lampreys. A larger double falls (~25 m in height) at RKM 17.1 is a complete barrier to all fish migration (NMFS 2009). Of the 21 reaches sampled for lampreys in Rattlesnake creek, two reaches were located downstream from the waterfall at RKM 2.4 and 19 sample reaches were located between the falls at RKM 2.4 and RKM 17.1. No lampreys were detected in these 21 reaches. While barriers are likely restricting western brook lamprey distribution in the Rattlesnake Creek unit, the absence of larval lampreys in the two sample reaches below the falls at RKM 2.4 suggests that other factors may be limiting western brook lamprey occupancy in Rattlesnake Creek.

Low summer stream flow conditions are also likely influencing lamprey distribution in the WSR basin. Two sample units (Morrison Creek and Upper Buck Creek) located in the upper portion WSR basin were extensively dewatered during sampling in August. Additional sample units in the basin were found to be completely dewatered and no sampling was conducted in these units (n = 6; Figure 7). Stream flow in much of the WSR basin is primarily the result of snowmelt runoff and many tributaries are ephemeral (NPCC 2004). It is likely the dewatered sample units we visited are dry annually during summer and fall.

The White Salmon River mainstem is suitable for larval lamprey rearing, as evidenced by presence of western brook lamprey in the mainstem both above and below Condit Dam and Pacific lamprey below the dam. Removal of Condit Dam may allow for uninhibited movement by both species within the WSR basin. However, our analysis of western brook lamprey distribution above the dam suggests that after the removal of Condit Dam recolonization of Pacific lampreys in the WSR basin may be confined to the WSR mainstem and lower reaches of tributaries. Many of the factors limiting the distribution of western brook lampreys such as migration barriers and intermittent flow conditions will also likely limit Pacific lamprey distribution as they return to the basin. Continued work in the WSR basin includes sampling of the remaining sample units (n~6) in 2010. Future monitoring after the removal of Condit Dam is also being considered to address objectives four, five and six in this document.

References

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.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* Meehan, W.R. ed. Influences of forest and rangeland management on salmonid fishes and their habitat. American Fisheries Society Publication 19, Bethesda, Maryland.

Close, DA., 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.

Goodman, D., A.P. Kinzinger, S.B. Reid, and M.F. Docker. Morphological diagnosis of *Entosphenus* and *Lampetra* ammocoetes (Petromyzontidae) in Washington, Oregon and California. Pages 223-233 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. American Fisheries Society, Symposium 72, Bethesda, Maryland.

Jolley, J.C., G.S. Silver and T.A. Whitesel. 2010. Occurrence, detection and habitat use of larval lampreys in mainstem environments: the Lower Willamette River. 2009 Annual Report. Available: www.fws.gov/columbiariver. (April 2010).

NMFS (National Marine Fisheries Service). 2009. ESA Recovery Plan for the White Salmon River Management Unit.

NPCC (Northwest Power and Conservation Council). 2004. White Salmon River subbasin plan. Available: www.nwcouncil.org. (January 2010).

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, Volume 17, Number 4:1070-1077.

Rawding, Dan. 2000. White Salmon River subbasin summary. Prepared for the Northwest Power and Planning Council.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184, 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.

Stevens, D.L., and A.R. Olsen. 2004. Spatially Balanced Sampling of Natural Resources. Journal of the American Statistical Association 99: 262-278.

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.