Occurrence, Detection, and Habitat Use of Larval Lamprey in Columbia River Mainstem Environments: The Lower Columbia River.

2010 Annual Report

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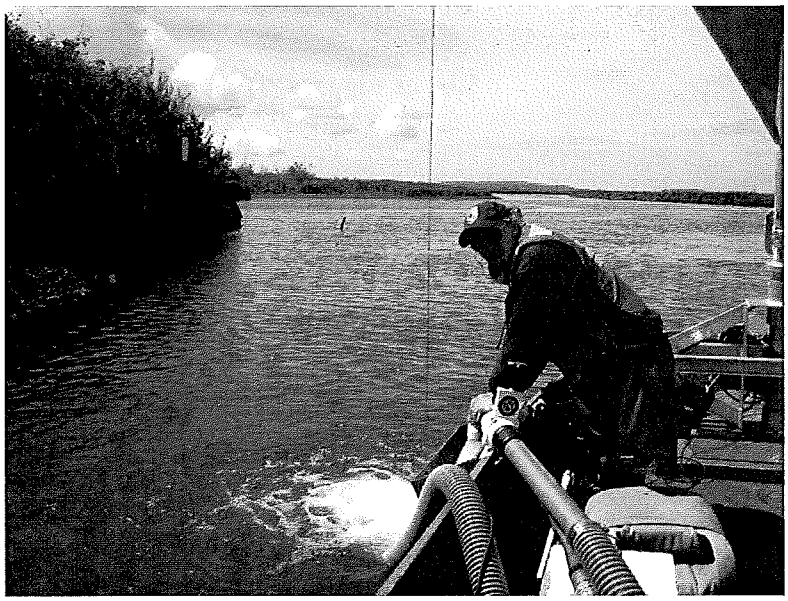

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Introduction

Pacific lamprey *Entosphenus tridentatus* have experienced a great decline in abundance (Close et al. 2002), specifically in the Columbia River Basin (CRB) 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). Information is lacking on basic biology, ecology, and population dynamics required for effective conservation and management.

Larval lampreys are generally thought to be stenohaline and obligatory to fresh water (Reis-Santos et al. 2002; Bartels and Potter 2004). However, recent laboratory experiments indicated that larval Pacific lampreys may be able to tolerate moderate salinity for some period of time (Jolley et al. 2011a). Although we knew that larval lamprey could likely be found in the Lower Columbia River, we did not know if lamprey occupied areas with different salinity histories. That is, we did not know if lamprey would occur in areas where they would be exposed to tidally influenced increases in salinity (greater than freshwater concentrations).

Pacific lampreys have a complex life history that includes a three to seven year larval (ammocoete), migratory juvenile (macrophthalmia) and adult marine phase (Scott and Crossman 1973). Ammocoetes and macrophthalmia are strongly associated with stream and river sediments. Ammocoetes live burrowed in stream and river sediments for periods up to seven years after hatching, where they filter feed detritus and organic material (Scott and Crossman 1973; Sutton and Bowen 1994). Ammocoetes metamorphose into macrophthalmia from July to December (McGree et al. 2008) and migrate downstream to the Pacific Ocean. The sympatric western brook lamprey *Lampetra richardsoni* do not have a migratory or marine life stage but are also likely under similar population threats (ODFW 2006; Mesa and Copeland 2009).

For Pacific lamprey and western brook lamprey, 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). Lamprey ammocoetes are known to occur in sediments of shallow streams but their use of larger river (i.e., >4th order [1:100 scale]) habitats in relatively deeper areas is unknown. Anecdotal observations exist regarding

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larval lamprey occurrence in large river habitats mainly at hydropower facilities or in downstream bypass reaches (CRITFC 2008), impinged on downstream screens, or through observation during dewatering events. Occurrences at hydropower facilities are generally 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). Furthermore, larval Pacific lamprey apparently rearing in nearshore areas of large rivers has also been observed (Silver et al. 2008). Sea lamprey *Petromyzon marinus* ammocoetes have been documented in deepwater habitats in tributaries of the Great Lakes and 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*b*). References to other species occurring in deepwater or lacustrine habitats are scarce (American brook lamprey *Lampetra appendix*; Hansen and Hayne 1962).

Sampling of ammocoetes in deepwater areas is a challenge because of specialized gear requirements as well as presumed patchy distributions. Successful sampling of deepwater areas for sea lamprey ammocoetes has occurred in tributaries to the Great Lakes using a modified electrofisher with suction (Bergstedt and Genovese 1994). This technique has shown promise in pilot studies in the Lower Willamette River (Windward Environmental 2005, Jolley et al. 2010). In addition, electrofishing in increased conductivity water (e.g., brackish) is extremely problematic as these conditions render electrofishing ineffective.

A problem encountered when sampling for distribution and abundance of infaunal organisms is associated with the uncertainty in detection probabilities and capture efficiencies. In part, statistical robustness can be improved by determining detection probability (DP). Knowledge of detection probabilities can inform sample design (e.g., required site visits giving 80% certainty of lamprey absence when not detected) and data analysis.

We previously conducted a study of lamprey distribution in the Lower Willamette River, using a boat-mounted, deepwater electrofisher in 2009 (Jolley et al. 2010). The sampling required for 80% confidence of lamprey absence when they were not detected was 17 quadrats (in the reach) and 6 subquadrats (in a quadrat). Differences in lamprey detection by depth were not detected. A wide range of sizes was collected (20-144 mm TL) indicating the likely occurrence of multiple ages of larvae. Our study documented the first quantitative information on larval Pacific lamprey and *Lampetra* spp. occupancy in mainstem river habitats. This study

established our ability to effectively use the deepwater electrofishing technology and apply a statistically robust and rigorous sampling scheme to explore patterns of distribution, occupancy, and detection. Furthermore, these quantitative techniques formed a foundation for comparisons of lamprey occupancy and detection in other mainstem areas; the GRTS approach provides the venue for statistical inference.

We sampled mainstem areas of the Lower Columbia River to further document the presence of larval lampreys and examine the influence of salt water on lamprey distribution. In general, we attempted to document presence or absence of larval Pacific and *Lampetra* spp. throughout the Lower Columbia River and determine detection probabilities using a deepwater electrofisher. Our specific objectives were as follows:

1) Document presence lamprey ammocoetes throughout the Lower Columbia River in areas of varied salinity history.
2) Determine the probability of detecting larval lamprey in the Lower Columbia River with a deepwater electrofisher.
3) Describe the age (i.e., size) distribution of larval lamprey.
4) Describe the species composition of larval lamprey.
5) Describe zones with different salinity histories that lamprey may/may not occupy.

Methods

We estimated occupancy of larval lamprey in the Lower Columbia River within several explicit spatial scales by adapting an approach used by Peterson and Dunham (2003) and refined by the U.S. Fish and Wildlife Service (USFWS 2008) to evaluate patch occupancy and detection probability for bull trout *Salvelinus confluentus*. We used this approach in a previous study (Jolley et al. 2010). 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, 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 Columbia River, d_{reach}, an area presumed to be occupied. The posterior probability of reach occupancy, given a larval lamprey was not detected, was estimated as

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

where P(F) is the prior probability of larval lamprey presence. Although we knew the 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($\sim F$), 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 (Peterson and Dunham 2003).

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 the previous experience of sea lamprey researchers in the Great Lakes (M. Fodale, USFWS, personal communication) as their sampling approach evolved from a systematic to adaptive approach (Fodale et al. 2003*a*). A description of the complete configuration of the deepwater electrofisher is given by Bergstedt and Genovese (1994) and techniques were similar to Fodale et al. (2003*b*). The bell of the deepwater electrofisher 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 ammocoetes 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 ammocoetes passed through the hose and emptied into a collection basket (27 x 62 x 25 cm; 2 mm wire mesh).

We used a Generalized Random Tessellation Stratified (GRTS) approach to select sampling quadrats in a random, spatially-balanced order (Stevens and Olsen 2004). We developed a layer of 30 m x 30 m quadrats using ArcMap 9.3 (Environmental Systems Research Institute, Redlands, California) which was overlaid on the Lower Columbia River (Figure 2). We selected 54 quadrats from the downstream end of Puget Island (RKm 61) downstream to

near Astoria, OR (RKm 24). The Universal Trans Mercator (UTM) coordinates representing the center point of each quadrat were determined. The GRTS approach was applied to all quadrats to generate a random, spatially balanced sample design that would allow the quantification of detection probabilities. The quadrats were ordered sequentially as they were selected in the GRTS approach and the lower numbered quadrats were given highest priority for sampling. Previous work in the Lower Willamette River mainstem indicated a sampling effort of 17 quadrats were required to be 80% confident that larval lamprey were absent when undetected. The Lower Columbia River was sampled from 8 August 2010 to 27 August 2010, from the vicinity of the downstream end of Puget Island (RKm 61) to near Dahlia, WA (RKm 42; Figure 1). Sampling occurred in late summer when water velocities were presumably the lowest and most conducive to sampling.

Collected lampreys were anesthetized in a solution of tricaine methanesulfonate (MS-222), identified as Pacific lamprey or *Lampetra* 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 caudal fin tissue was collected and preserved in 95% ethanol for subsequent genetic analysis to confirm genus identification. Lampreys were placed in a recovery bucket of fresh river water and released after resuming normal swimming behavior.

Concurrent to each sampling event bottom salinity was measured with a handheld electronic meter (model 85, Yellow Springs Instruments, Yellow Springs, Ohio) and a sediment sample was taken from the river bottom by using a Ponar bottom sampler (16.5 cm x 16.5 cm). A 500 mL sample was labeled, placed on ice, and returned to the lab. Samples were oven-dried for 12 hours at 100° C to remove all water. Sediment size was characterized by weighing the component portions of the sample that collected on a set of sieves (opening sizes: 37.5 mm, 19 mm, 9.5 mm, 1 mm, 0.5 mm, and remainder less than 0.5 mm). Percent organic content of replicate samples was determined using loss-on-ignition methods (Heiri et al. 2001) by combusting organic material at 500°-550° C for six hours.

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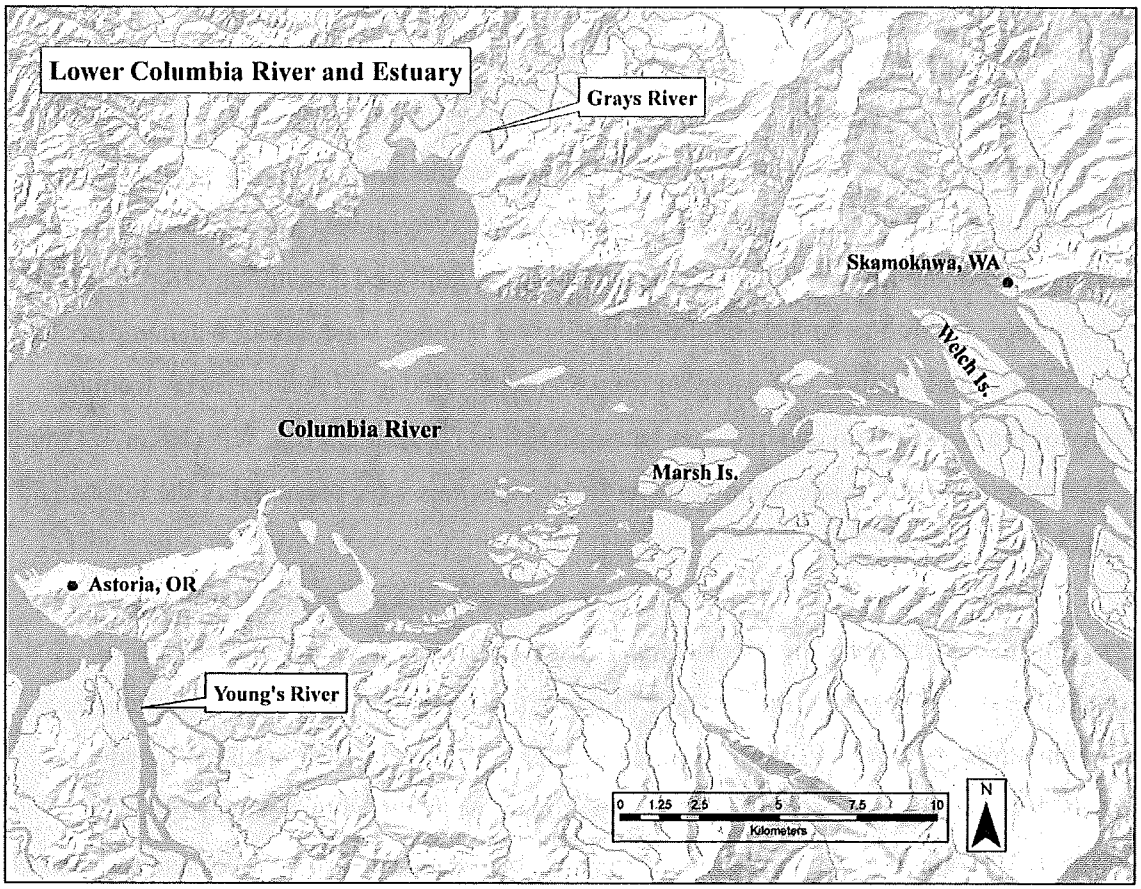

Figure 1. Map of the study area of the Lower Columbia River in 2010.

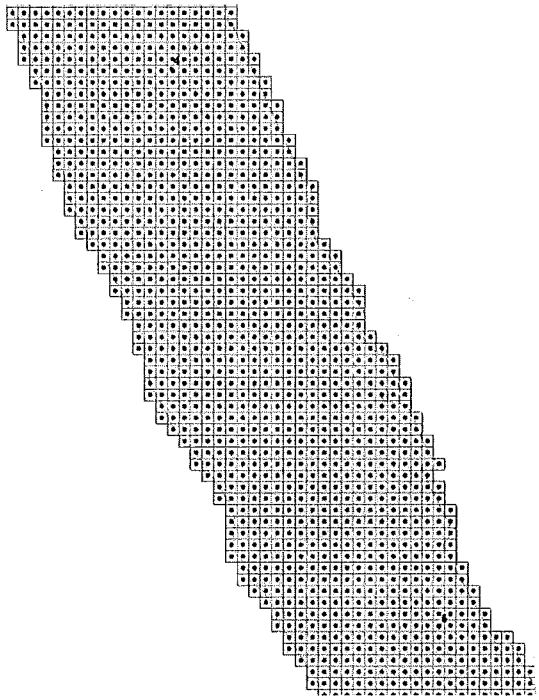

Figure 2. A schematic showing a section of the Columbia River divided into 30 m x 30 m quadrats and associated UTM center points.

Results

A total of 16 quadrats were visited in the Lower Columbia River of which, 15 (94%) were sampled and 1 (6 %) was not sampled because it was not feasible (e.g., dewatered tidal flat). No larval lampreys were detected. Sampling for this project is ongoing. To date, we have only sampled in areas that were considered to have a constant freshwater history (i.e., <2‰) based on climatological data (Figure 3; CMOP 2011).

In the Lower Columbia River, 13 sediment samples were analyzed. Mean percent organic content was 1.4% (SE ± 0.3). The mean percent sediment particle sizes (mm) were 0% (>37.5 mm), 0% (37.5-19.0 mm), 0% (19.0-9.5 mm), 2.6% (SE ± 1.5; 9.5-1.0 mm), 7.0% (SE ± 3.2; 1.0-0.5 mm), and 90.4% (SE ± 3.6; <0.5 mm). Bottom salinity was 0.0‰ at all locations when sampled.

Findings

To date, we have not detected any larval lamprey downstream of Skamokawa. However, we are in the preliminary phases of this ongoing study. The probability that larval lamprey were present when we failed to detect them is relatively high (>40%) based on recent information garnered from a recent concurrent project in Bonneville Reservoir where detection probability was 0.02 (Jolley et al. 2011b). The GRTS approach provided a statistically robust probabilistic technique for estimating the required sampling effort at either the reach scale. The majority of substrates were characterized as fine or silt substrates.

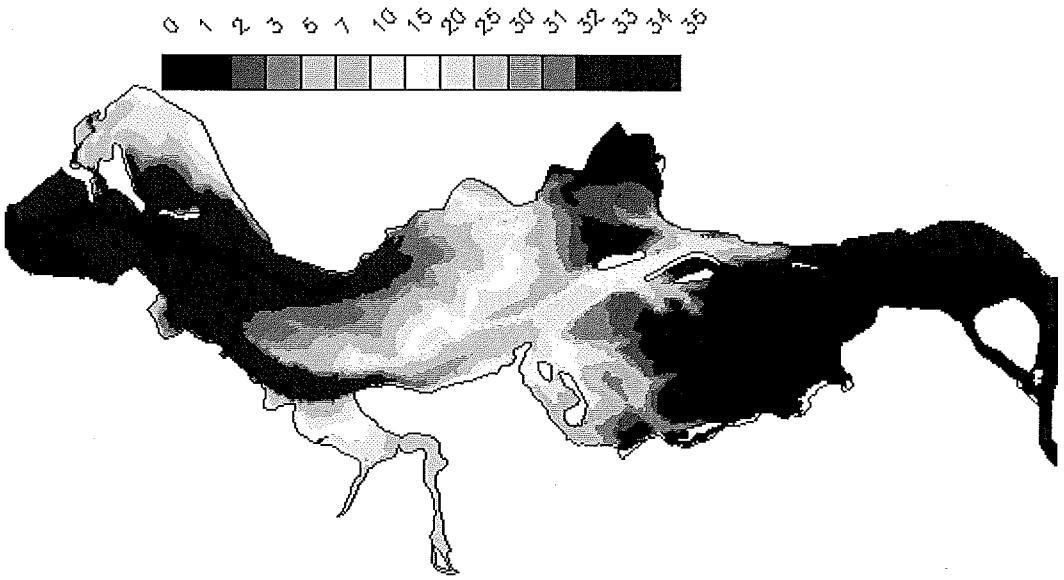

Figure 3. Maximum bottom salinity (PSU) in the Columbia River Estuary from 1999-2006. Figure taken from Center for Coastal Margin Observation and Prediction (CMOP 2011).

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