Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River

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Acknowlegements

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Executive Summary

In 2014, trends in Pacific lamprey (*Entosphenus tridentatus*) abundance at Sherars Falls on the Deschutes River and Cushing Falls on Fifteenmile Creek increased from 2013 and were the highest on record, 16,713 and 3,239, respectively. Relative precision of both estimates were less than 20%. Escapement estimates in 2014 at Sherars Falls was 15,050 and it was 2,848 at Cushing Falls, respectively. Lamprey marked by PIT tags were used to demonstrate movement patterns, including fall back from the tagging site, over-wintering, distribution, and alternate life-history patterns. The pattern of lamprey spending two winters prior to spawning was again documented in 2014 in Fifteenmile Creek. This life-history pattern was also documented at Sherars Falls in 2014, in which lamprey tagged at Sherars Falls in 2012 returned. Distribution of ammocoetes in Reservation streams varied moderately: it was the same in Shitike and Badger creeks, upstream 6 km in Beaver Creek and 7.5 km further downstream in Warm Springs River. However, in Warm Springs River, a PIT tagged lamprey was detected in upper Warm Springs Meadows, which was 10.7 km upstream of the highest known ammocoete observed. Range expanded for Pacific lamprey recolonizing Hood River in 2014, where ammocoetes were detected 5.8 km further upstream in East Fork Hood River compared with 2013. In 2014, distribution of ammocoetes in Fifteenmile, Eightmile, and Mill creeks was similar to 2013. Ammocoete density surveys in Reservation streams indicated a wide range, as in previous years. Recent data from Badger Creek indicated a potential passage barrier as only larger ammocoetes were collected in 2012 and 2013. However, surveyors found no obvious barrier and small larvae (< 20 mm), assumed to be young-of-the-year, were observed in Badger Creek in 2014. It was expected that ammocoete densities upstream of the Warm Springs National Fish Hatchery would be lower than those downstream but that hypothesis was rejected. The U.S. Fish and Wildlife Service are planning on installing a lamprey passage system in 2016 to improve access to upstream spawning areas. In April 2014, Oregon Department of Fish and Wildlife Passage and Screening Shop in The Dalles completed a barrier-improvement project at Tenold Diversion on Fifteenmile Creek. Passage of PIT tagged lamprey increased almost three fold at this interrogation site over 2013. Tissue samples of ammocoetes were sent for genetic analysis to confirm species identification. Analysis supported prior species identification that all lamprey in study streams were Pacific lamprey. Except for Mosier Creek, which is not part of this study, no western brook lamprey (*lampetra richardsoni*) were present.

Chapter 1. Adult Pacific lamprey Abundance and Harvest at Sherars Falls on the Deschutes River, 2014

Introduction

In response to declining abundance of Pacific lamprey in the Columbia River (Close et al., 1995), the CTWSRO began developing methods for assessing population status of Pacific lamprey in the Deschutes River Subbasin and describing local ecology and biology in 2002 (Graham and Brun, 2004). Since 2004, abundance and harvest estimates of adult Pacific lamprey at Sherars Falls on the Deschutes River have been conducted annually. The primary objective is to develop trends in population abundance of Pacific lamprey in the Deschutes River to monitor population status.

Study Site

The lower Deschutes River Subbasin is located in central Oregon (Figure 1), draining the east slope of the Cascade Mountain Range (approximately 6,993 km^2) with 1,223 rkm of perennial streams and 2,317 rkm of intermittent streams. A series of hydroelectric dams begin at rkm 161. Currently, lamprey passage does not exist at these facilities. Major tributaries of the lower Deschutes River are White River, Warm Springs River and Shitike Creek to the west and to the east Buck Hollow, Bakeoven, and Trout creeks.

Majority of perennial tributaries within the lower Deschutes River Subbasin originate within the boundaries of the Confederated Tribes of Warm Springs Reservation (hereafter referred to as "Reservation"). The Reservation covers 240,000 ha on the eastern slopes of the Cascade Mountains. The Reservation boundaries are the crest of the Cascades to the north and west, Deschutes River to the east and Metolius River to the south. The Warm Springs River is the largest watershed within the Reservation, flowing 85 rkm and draining 54,394 ha. It is the largest tributary to the lower Deschutes River. Major tributaries to the Warm Springs River are Beaver, Badger, and Mill creeks. Shitike Creek is the third largest tributary to the lower Deschutes River flowing for 48 rkm and draining 36,000 ha.

This project is implemented in the mainstem Deschutes River, from its confluence of the Columbia River, to rkm 161 and includes westside tributaries flowing through the Reservation (Figure 1). Sherars Falls is located at rkm 70.4 and is a primary harvest location for CTWSRO Tribal Members. A fish ladder around Sherars Falls provides a convenient site for collecting and marking lamprey in addition to monitoring Tribal harvest.

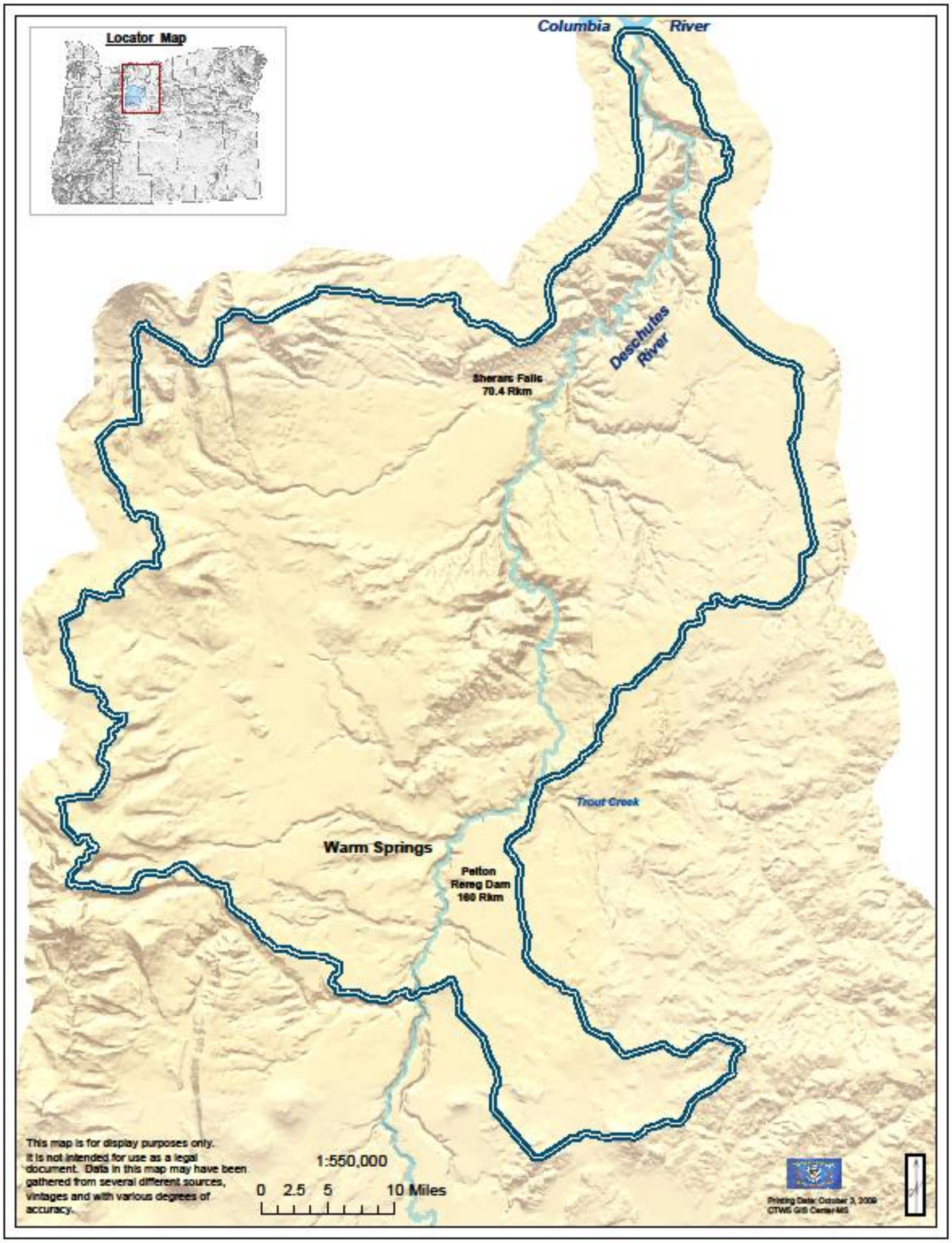

Figure 1. Map of the lower Deschutes River Subbasin, Oregon, 2014.

Methods

Abundance Estimate

Staff was present at Sherars Falls four nights per week from June 23 to October 30, 2014. During those nights, adult lamprey were either collected to be marked and/or staff conducted a creel of Tribal fishers; however, marking and creeling was not done simultaneously. Time spent at the fish ladder varied depending on the activity. When marking occurred, staff were present from dusk (approximately 21:00) until no lamprey were observed in the fish ladder for three successive dip net passes through the fish ladder or 03:00. When creeling, staff were present until fishermen had completed their trip. If fishermen were finished prior to when lamprey were no longer present in the ladder, staff would begin capturing and marking fish.

A systematic approach was developed to collect adult Pacific lamprey using a long-handled dip net at Sherars Falls fish ladder, located at rkm 70.4 in the lower Deschutes River. The fish ladder is made up of 10 pools, each of which was dipped twice per hour, for 4 – 6 hours per night. Dipping occurred in the same location during each pass through the fish ladder and stayed consistent throughout the study period.

Captured adult Pacific lamprey were fitted with either a Floy® tag (t-bar anchor tags Floy Tag & Mfc., Inc., Seattle, WA), a half duplex (HDX) passive integrated transponder (PIT) tag (23mm, Oregon RFID, Inc., Portland, OR), or both, and received a secondary mark (fin clip) and colored, monofilament-nylon flag anchor tags (hereafter referred to as flag tags, Floy Tag & Mfc., Inc., Seattle, WA). Sequentially numbered Floy® tags were anchored approximately 0.5 cm posterior of the dorsal fin and just offset of the center top. Methods for insertion of individually, uniquely coded, PIT tags in lamprey were based on procedures in the Columbia Basin Fish and Wildlife Authority tagging standards (CBFWA, 1999). Half duplex PIT tags were surgically implanted into the body cavity similarly to Cummings et al. (2008). Each lamprey received a secondary mark, which consisted of a fin clip at the posterior end of the dorsal fin. Fish were weighed (nearest g) and total length measured (nearest cm). Once marked, lamprey were transported approximately 2.1 rkm downstream to Buckhollow Landing (rkm 68.3) and released. Subsequently captured lamprey were inspected for tag presence and a fin clip. Recaptures were recorded and released upstream of the fish ladder. A primary tag retention rate was calculated based on tag presence or tag wound and fin clip.

Adult Pacific lamprey abundance was estimated using Chapman's modification of the Petersen estimate (Seber, 1982). Estimated abundance (N^*) was derived from:

$$N^* = \frac{(M+1)(C+1)}{(R+1)} - 1$$

Equation 1. (abundance)

where, M is number of fish marked in first event sampling, C is total fish inspected for marks, and R is the number of fish inspected for marks in second event sampling possessing marks. Chapman's modified estimate uses a Poisson approximation to the hypergeometric distribution and approaches a minimum variance unbiased estimator of population size with variance approximated by:

Equation 2. (variance)

$$V(N^*) = N^2\left(\mu^{-1} + 2\mu^{-2} + 6\mu^{-3}\right)$$

where $\mu = MC / N$

Confidence intervals were calculated by:

Equation 3**. (95% CI)**

$$95\%\ \mathrm{CI}\ (N^*) = \frac{(M+1)(C+1)}{(R+1.92) \pm \left(1.96\sqrt{R}+1\right)+1}$$

For N^* to be a suitable estimate the following assumptions must be met (Otis et al., 1978; White, 1993):

1. *All Pacific lamprey have an equal probability of being marked at Sherars Falls fish ladder;* ***or***
2. *All fish have an equal probability of being inspected for marks;* ***or***
3. *Marked fish mix completely with unmarked fish between sampling events;* ***and***
4. *No recruitment into the population between sampling events;* ***and***
5. *No sampling-induced behavior or mortality;* ***and***
6. *Fish do not lose their marks and marks are recognizable.*

Assumptions 1 and 2 were validated by comparing length distributions of lamprey marked during the first event and recaptured during second event sampling (Kolmogorov-Smirnov two-sample test, StatGraphics Centurion XV, vers. 15.2.06, Statpoint Technologies, Inc., Warrenton, VA). If length distributions between marked and recaptured fish are similar (H_o: length distribution of marked lamprey is equal to recaptured lamprey), the probability of capture was equal for fish of all sizes during second event sampling (Bernard and Hansen, 1992). To ensure mixing, all marked Pacific lamprey were transported and released approximately 2.1 rkm downstream of the initial capture site (assumption 3). The assumption that the population is closed (Assumption 4) was presumed to be true because adult lamprey were returning to spawn upstream. Implicit in this assumption is that marked lamprey that had once partially ascended Sherars Falls would return to ascend the falls. There is no direct mortality associated with dip netting and indirect mortality cannot be evaluated but is assumed negligible (Assumption 5). To assess tag loss (Assumption 6), lamprey were double tagged (Seber and Felton, 1981). Floy tags were tested against a non-removable mark, a dorsal clip.

Tribal Harvest Monitoring

In conjunction with marking and recapturing adult lamprey, a single access site creel survey was conducted to estimate Tribal harvest of adult Pacific lamprey. Interviews were conducted throughout the sampling period from July – October 2012. Creel surveys occurred from 21:00 until Tribal fishermen completed collection. Creelers examined all harvested lamprey for marks and recorded a subsample of total lengths. Numbers of marked (non-expanded numbers) and unmarked lamprey were recorded on datasheets. Creel numbers were expanded to estimate total harvest and 95% confidence intervals generated.

Total effort and catch was expanded from each sampling day by:

Equation 4. (total effort)

$$\hat{E} = \sum_{i=1}^{n} (e_i / \pi_i)$$

Equation 5. (total catch)

$$\hat{C} = \sum_{i=1}^{n} (c_i / \pi_i)$$

Variance was approximated each sampling week by:

Equation 6. (harvest variance)

$$Var(\hat{E}_1) \approx N_1^2 Var(\bar{e}_1)$$

Weekly variances were summed to estimate total variance of the harvest estimate.

Results

Abundance Estimate of Adult Pacific Lamprey at Sherars Falls

A total of 955 adult Pacific lamprey were marked at Sherars Falls between June 23 and October 30, 2014. Of the 955 Floy® tagged and clipped lamprey, 947 were also implanted with HDX PIT tags. Marked lamprey average 60.6 cm in length (ranged from 49 to 76 cm, n = 942). Average weight of tagged lamprey was 0.83 kg (ranged from 0.37 to 1.25 kg, n = 98). During second-event sampling, 1,922 lamprey were inspected for marks. Of those inspected, 109 were recaptured lamprey (11.4% recapture rate). Four out of the 109 recaptured lamprey lost the Floy tag) but had PIT tags and one PIT tag was ejected but the Floy tag remained. Six lamprey captured at Sherars Falls had PIT tags inserted at Bonneville Dam by University of Idaho; two were tagged in 2013 (334 and 382 days to recapture) and four in 2014 (32 to 97 days to recapture). Tagged lamprey released at Buckhollow Landing in 2014 that were recaptured at Sherars Falls returned from 1 to 110 days (average 15.5 days). One lamprey tagged in September 9, 2012 was recaptured in 2014, 674 days after tagging.

Table 1. Adult Pacific lamprey population estimate in the lower Deschutes River, 2014.

No. Tagged	No. Inspected	No. Recovered	Population Abundance	Standard Error	Relative Precision
955	1,922	109	16,713	1,451	17.0%

Tribal Harvest Monitoring and Escapement

Twenty-nine creel interviews were conducted between June 24 and October 10, 2014. A total of 971 lamprey were visually inspected during Tribal harvest. Total harvest was estimated to be 1,663 lamprey. Harvested lamprey averaged 60.6 cm (ranged from 52 to 71cm, n = 100). Descriptive statistics and length frequencies are in Appendices A and B.

Subtracting estimated harvest (1,663) from estimated abundance of Pacific lamprey at Sherars Falls in 2014 (16,713) yielded an escapement of 15,050. Estimated rate of exploitation was 10%.

Estimator Assumptions

In 2014, to determine if assumptions 1 and 2 were violated, mean length distributions between marking (dip-netting) and recapture (dip-netting, creeling) events were compared (two-sample t-test, $\alpha = 0.05$, Statgraphics Centurion XV, vers. 15.2.06, Warrenton, Virginia). No significant difference was found between mean lengths of tagged and those recaptured and creeled (t-statistic=-0.11, p-value=0.92, α=0.05). Marked lamprey averaged 60.6 cm (range 49 to 76 cm, n=942) and recaptured lamprey averaged 60.6 cm (range 50 to 71 cm, n=180). No marked lamprey from 2014 fell back and were detected at the mouth of the antenna array Deschutes River. Eleven lamprey tagged at Sherars Falls in 2013 were detected at the mouth of the Deschutes River between February 10 and June 7, 2014 (site = DRM; http://www.ptagis.org/data/quick-reports/small-scale-site-detections).

Discussion

Since 2010, Pacific lamprey abundance estimates at Sherars Falls have shown an increasing trend (Figure 2). The 2014 estimate was 2.9 times the 2004 - 2013 average of 5,789 lamprey. Annual daytime counts of Pacific lamprey at Bonneville Dam indicate increasing numbers over the same period. Estimates at Sherars Falls represent an increase from of 26% to 52% of annual lamprey counts at Bonneville Dam over the period 2010 to 2014 (Figure 2).

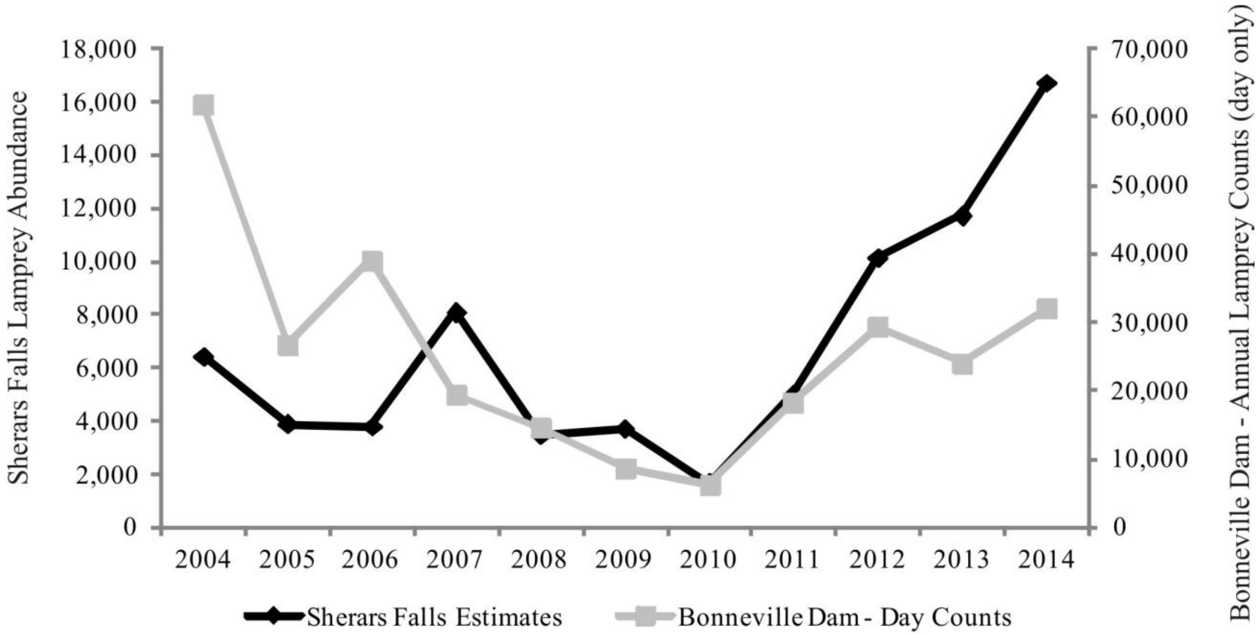

Figure 2. Trends in Pacific lamprey abundance at Sherars Falls and annual day counts at Bonneville Dam, 2004 – 2013.

The possibility of using Pacific lamprey tagged by University of Idaho (UI) at Bonneville Dam subsequently detected at the antenna array at the mouth of the Deschutes River (site DRM) to estimate the proportion of the run that may pass before sampling begins at Sherars Falls was discussed in the 2013 Annual Report (Baker et al., 2013). In 2014, there was a total of 171 PIT tagged lamprey that were detected at DRM, including 11 from Sherars Falls tagged in 2013 and 160 tagged by UI. Those tagged from UI included two tagged in 2012, 72 from 2013, and 86 from 2014. Tagged lamprey passed DRM from February 10 through October 21 in 2014; the median data of passage was June 22, 2014 (Figure 3). If PIT tagged lamprey passing the mouth of the Deschutes River represent run timing of lamprey, as much as half of the run may have entered the river before the mark-recapture effort began at Sherars Falls on June 23, 2014. Travel time between the mouth and Sherars Falls is unknown as no PIT tagged lamprey detected at DRM was captured at Sherars Falls, yet. Therefore, the proportion of the run that passed Sherars Falls before sampling began is expected to be less than half.

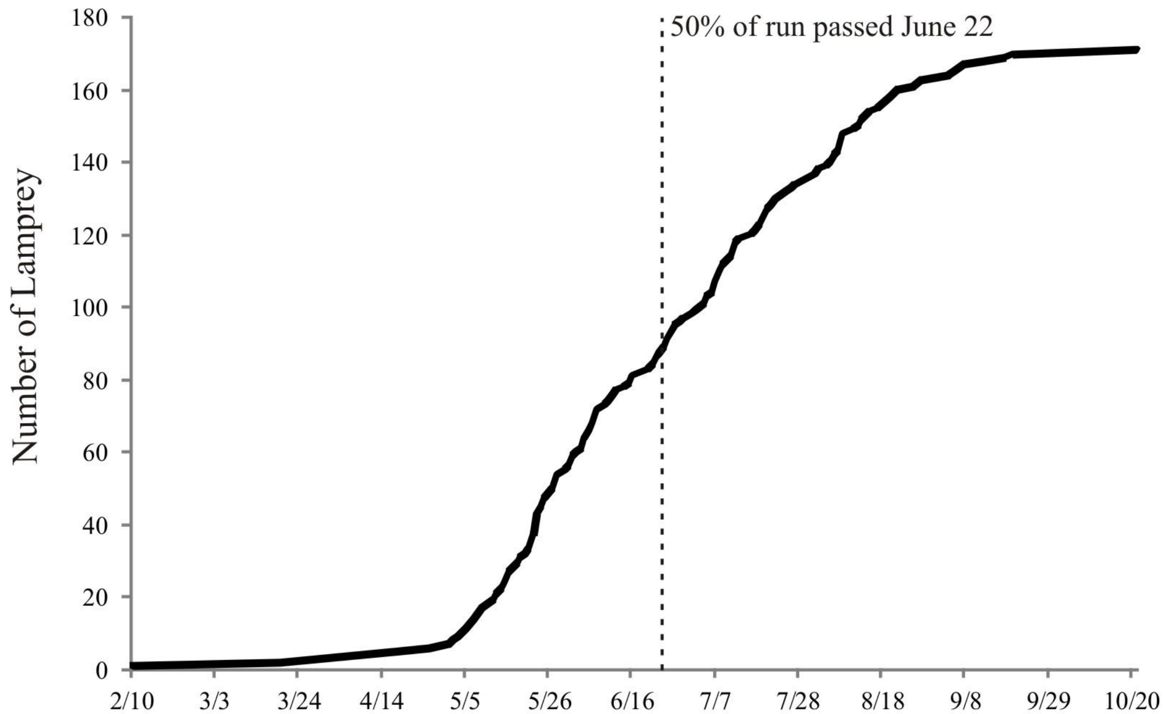

Figure 3. Cumulative PIT tagged lamprey that were detected at the mouth of the Deschutes River (site DRM), 2014.

While there are limitations to achieving an abundance estimate of Pacific lamprey ascending the Deschutes River upstream of Sherars Falls, such as the mark-recapture period fails to extend through the entire run and all possible breaches in assumptions have not been fully validated, it provides important information about population status and trends with which can be compared to similar data regionally, including Fifteenmile Creek (Chapter 4), Willamette Falls (Baker et al., 2014), and Columbia River dam counts. Conditions remain that it is unsafe to begin data collection at Sherars Falls until late June or early July. Installation of a dual PIT tag reader at the upstream end of the Sherars Falls fish ladder would provide a means to adjust the pool of marked fish if there is significant fall back of PIT tagged lamprey that fail to return to Sherars Falls. This has been documented at Willamette Falls, Fifteenmile Creek, and Bonneville Dam (Baker et al., 2013; Baker et al., 2014; Baker et al., 2015; Noyes et al., 2012). With a dual reader at Sherars Falls there would also be an increased chance of detecting PIT tagged lamprey that had been registered at DRM so that travel time could be ascertained and an appropriate correction factor for the run could be proposed.

This was the first time that a two-year over-winter lamprey had been documented in the Deschutes River. While uncommon, this life-history type has been documented in Fifteenmile Creek (CTWRSO, 2014b; CTWSRO, 2013) .

Chapter 2. Pacific lamprey ammocoete densities in Reservation streams: A comparison between Warm Springs River and Shitike Creek and relationships between environmental variables and habitat restoration

Introduction

After developing a method for standardizing ammocoete densities from electrofishing surveys (CTWSRO Natural Resources Branch Fisheries Research Dept., 2010), the CTWSRO began documenting and comparing ammocoete densities in the Warm Springs River drainage and Shitike Creek. Documenting ammocoete densities in Reservation streams began in 2009, just prior to a habitat restoration project in lower Shitike Creek for pre- and post-project comparison. Lower Shitike Creek was considered good ammocoete rearing habitat before the restoration project. The objective of the habitat restoration project was to restore floodplain connectivity and increase habitat complexity for salmonids. Another objective for the ammocoete density study in 2009 was to develop a model to relate ammocoete densities to environmental variables in the stream in order to produce a theoretical abundance estimate of Pacific lamprey ammocoetes in habitats that may be re-colonized upstream of Pelton-Round Butte Hydrological Complex at rkm 161 on the Deschutes River (CTWSRO Natural Resources Branch Fisheries Research Dept. 2012). The survey was repeated in 2012 and 2013 to validate the model developed in 2009 to relate ammocoete densities in Shitike Creek to environmental variables, compare restoration and non-restoration habitat areas in Shitike Creek, and to compare ammocoete densities among Reservation streams to determine locations of productivity and areas that appear under-seeded to advance understanding of potential limiting factors. Ammocoete density surveys in Reservation streams were repeated in 2013, although upper extent of distribution was not repeated. Pre-project ammocoete surveys in Shitike Creek indicated high densities and by 2013, the project area had been re-colonized up to pre-project levels so further comparisons of the restoration area were suspended. Objectives in 2014 focused on: 1) re-surveying upper distribution of ammocoetes; 2) comparing densities recorded summer 2014 with comparable data from a previous year(s); 3) compare densities upstream and downstream of the channel-spanning weir at Warm Springs National Fish Hatchery (WSNFH), and; 4) confirm species identification of Pacific lamprey in Reservation streams.

Study Site

Two drainages on the Reservation inhabited by Pacific lamprey are Shitike Creek and Warm Springs River, both tributaries of the Deschutes River (Figure 4). Shitike Creek flows into the Deschutes at rkm 157, and has a drainage area of 269 km^2. The upper limit of Pacific lamprey ammocoete distribution in Shitike Creek was rkm 11 in the 2003 to 2006 and the 2008 validation (Figure 3). The Warm Springs River flows into the Deschutes River at rkm 135 and has a drainage area of 1363.9 km^2. Beaver and Badger creeks are primary tributaries of the Warm Springs River. In the Warm Springs River, upper ammocoete distribution was rkm 54.1 during the period 2003 – 2006. In Beaver Creek, end of distribution was rkm 26.6 both sample periods (2003-06 and 2008). Upper distribution for lamprey in Badger Creek was rkm 12.8 in 2008.

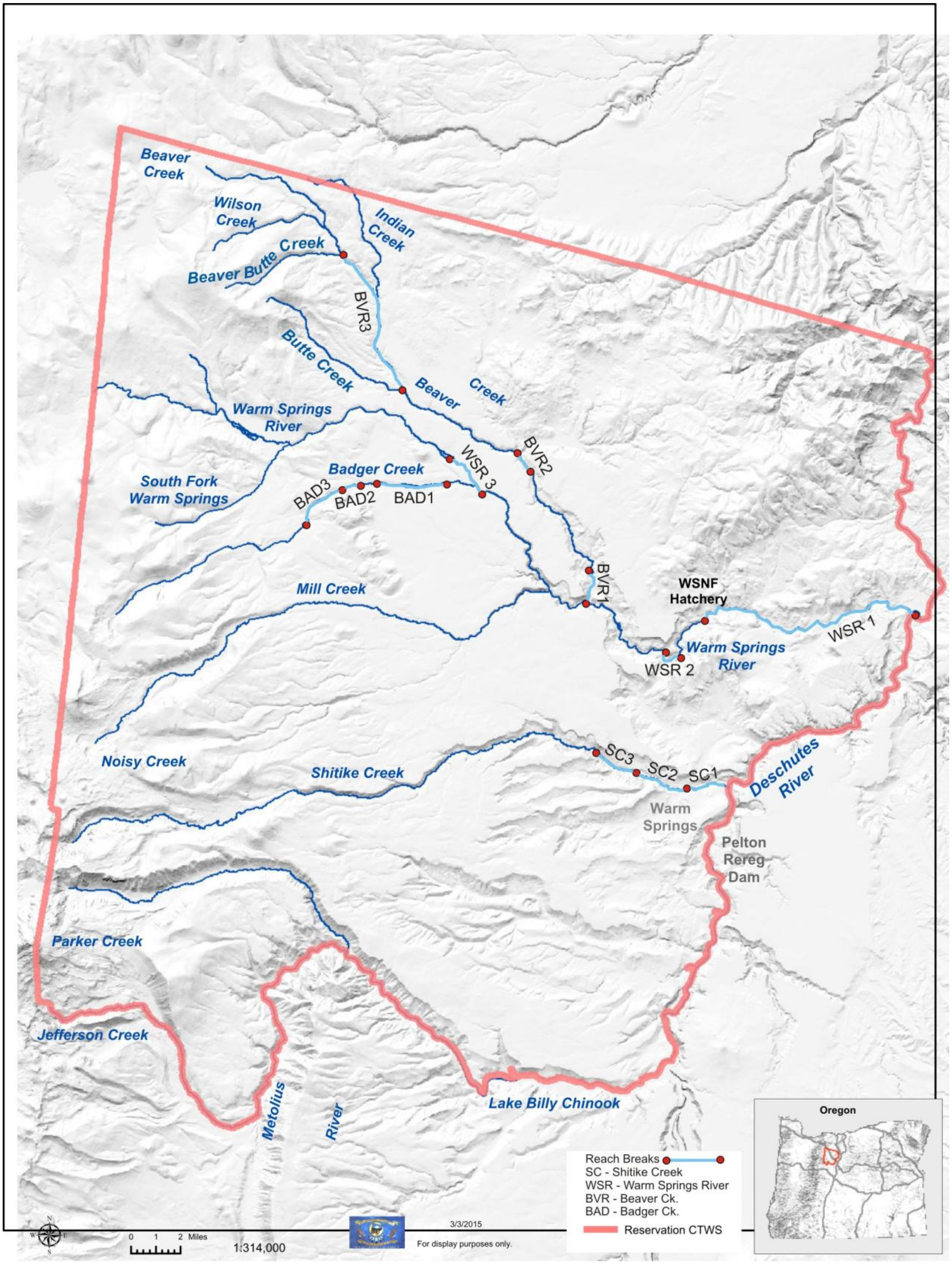

Figure 4. Study Reaches in Warm Springs River and tributaries and Shitike Creek for ammocoete densities, lower Deschutes River Subbasin, Oregon, 2014.

Methods

Site Selection

Reaches in Warm Springs River mainstem and tributaries (Badger and Beaver creeks) and Shitike Creek were stratified into three reaches per stream (Figure 4, Table 2). Except for Beaver Creek Reach 3 and Warm Springs River Reach 1, there were four random sites and one back-up site selected per stream. The back-up site was used if for some reason one of the selected sites were inaccessible or no suitable habitat was found in the vicinity. Ten sites were selected for Beaver Creek Reach 3 and 11 sites selected for Warm Springs River Reach 1 because they are longer than other reaches (Table 2).

Table 2. Study reaches for ammocoete density surveys in Warm Springs River and Shitike Creek, lower Deschutes River Subbasin, Oregon, 2013.

River/Creek	Reach	Description	Length[1] (m)	rkm
Badger	1	US 26 to B260	5,480	2.3 – 7.8
	2	Waterhole #2 to Waterhole #3	1,480	9.1 – 10.6
	3	Waterhole #3 to MP6	3,580	10.6 – 14.2
Beaver	1	Mouth to Fawn Flats	1,390	0 – 1.4
	2	Power lines to Old Bridge	1,300	12.2 – 13.5
	3	Dahl Pine to Beaver Butte Cr	12,750	22.9 – 35.7
Shitike	1	Mouth to Community Center	3,620	0 – 3.6
	2	Community Center to Thompson Bridge	4,090	3.6 – 7.7
	3	Thompson Bridge to Head Works	3,090	7.7 – 11.0
Warm Springs	1	Heath Bridge to WSNF Hatchery	16,500	1.0 – 17.5
	2	End of E-120 Road	1,570	20.9 – 22.5
	3	McKinley-Arthur to Power Lines	3,520	43.2 – 46.7

[1]Approximate length to the nearest 10 m.

To randomly select survey sites, study reaches were divided into 10 m segments in Geographic Information Systems (GIS) and assigned numbers sequentially (going upstream), according to reach length (Table 2). Using a random number generator (www.random.org), four, 10 m segments per reach were selected. For every reach an extra site was pre-selected to be used in the event that suitable habitat within 200 m of the selected locations in reaches was not found.

From randomly selected 10 m segments, mid-point Global Positioning System (GPS) coordinates were provided to the field crew. The field crew then selected the sampling site by finding the nearest location with potential lamprey habitat. Habitat characteristics with which ammocoete presence was correlated include depositional areas with fine substrates (silt/fine sand) containing organic debris, low velocity (0.18 m/s), woody debris, and canopy cover (Graham and Brun 2007). If surveyors failed to locate a site dominated by silt or sand within 200 m of the mid-point GPS coordinate, and the extra, pre-selected site was already used, it was left up to the surveyors to choose a sampling location in the randomly selected segment that held lamprey but may not have been dominated by silt or sand.

Electro-fishing

Between July 17 and August 28, 2014, selected sites were sampled. The AbP-2 backpack electrofisher (Engineering Technical Services, University of Wisconsin, Madison, WI) was used to capture lamprey ammocoetes. Sampling involved two stages, in which 125 V direct current (25% duty cycle) were delivered at three pulses•s^{-1} to induce ammocoete emergence from substrates (Moser *et al.* 2007; Pajos and Weise 1994). After emerging, larvae were stunned with a current of 30 pulses•s^{-1} for collection (Slade *et al.* 2003). The CTWSRO ammocoete electrofishing capture efficiency protocol (CTWSRO Natural Resources Branch Fisheries Research Dept. 2012) was used to convert ammocoete catch to abundance and density. According to this protocol, a 0.56 m^2 (0.75m x 0.75 m) PVC pipe was used as a visual boundary for shocking. Five electro-shocking passes over the boundary were delivered, according to capture-efficiency model protocol (Table 3). The three passes consisted of 45 s of electrofishing followed by a 30 s rest period. The fourth pass was 45 s of electrofishing followed by a 60 s rest period. The fifth pass was 180 s of electrofishing. Ammocoetes were netted as they came out of the sediment within the boundary and kept in separate buckets for each pass. If the netter missed stunned ammocoetes that originated within the boundary but swam downstream the number of missed lamprey per pass were noted and length estimated.

Table 3. Electroshocking pass shock duration and rest periods.

Electroshocking pass	Shock duration (seconds)	Cummulative shock duration (seconds)	Rest period after pass (seconds)
1	45	45	45
2	45	90	45
3	45	135	45
4	45	180	60
5	180	360	

Collected ammocoetes, held in aerated buckets, were anesthetized, measured and returned to the stream. Ammocoetes were anesthetized with clove oil (1.5 ml in 50 l water) and measured to the nearest mm. After measuring, ammocoetes were allowed to recover in fresh water then returned to the site of original collection.

Habitat measurements were recorded after electrofishing was concluded. Habitat measurements and other variables for model development included a combination of those required to adjust number of ammocoetes shocked in a sample unit to abundance (capture efficiency model, (CTWSRO Natural Resources Branch Fisheries Research Dept. 2012), Oregon Department of Fish and Wildlife (ODFW) stream survey variables (ODFW 2006), and others (Table 4). Water depth (cm) and sediment depth (cm) were measured using a depth gage in three transects within the shock boundary with three points per transect. Water velocities were measured at 60% of depth (Model 2000 Flo-mate flow meter, Marsh-McBirney, Inc., Frederick, MD). Habitat unit type (riffle, glide, pool, side channel, off-channel pond), channel type, dominant and sub-dominant substrate type and vegetation type (nearest bank or both if unit is mid-channel) was recorded according to ODFW stream survey protocols (ODFW 2006). Notes included whether the sample unit was depositional, located at the margin or in mid channel, or if woody debris was present (not size). Canopy closure (percent) was measured with a densiometer (ODFW 2006) when standing in the middle of the shock boundary. Water temperature, pH and conductivity were measured with a 300 series multi-probe (Oakton Instruments, Vernon Hills, IL). Wind speed was measured using a hand-held portable wind meter (Dwyer Instruments, Inc., Michigan City, IN). The categorical variable 'visibility' was used to indicate the degree to which the observer could see to net stunned lamprey, from capture efficiency model development. The categories were high, medium and low. Visibility is recorded 'high' when substrate is clearly visible throughout the water column, wind or water velocity does not cause surface ripples on the water, and shade and/or sun glare does not obscure visibility. Medium visibility is registered when the substrate is visible but the water surface is partially (>30% of surface) disturbed by wave action, and/or shade and/or sun glare partially impairs visibility (>30% of surface). Visibility is considered low when the substrate is not clearly visible due to turbidity, and/or when the majority (>70%) of the water surface is broken, and/or when shade and/or sun glare largely obscures visibility (>70% of surface).

Table 4. Variables for ammocoete habitat model development.

Variable	Units/Category	Data Type
Water depth[3] • average • min. • max.	Cm	continuous
Water velocity[2,3]	m·s-1 at 60% depth	continuous
Sediment depth[2,3] • average • min. • max.	Cm	continuous
Dominant substrate type[1]	Silt and fine organic matter, sand, gravel (pea to baseball (2-64 mm)	categorical
Canopy closure[1,2]	Percent	continuous
Conductivity[2,4]	μmhos·cm^{-1}	continuous
Water temperature[2]	ºC	continuous
Visibility[4]	High, medium, low	categorical
Wind speed[4]	(km/hr)/1.609	continuous
Ammocoete length[4]	Mm	continuous

[1]ODFW habitat variable (ODFW 2006); [2] Torgerson and Close (2004); [3]Presence/absence model variable (Graham and Brun 2007); [4] Capture efficiency model variable (CTWSRO Natural Resources Branch Fisheries Research Dept. 2012).

Data analysis

The capture efficiency model was developed using ammocoetes from 36 mm to 196 mm. Ammocoetes 20 mm and smaller were excluded from the density analysis because they were translucent and generally too small to capture *via* net. However, any captured were included in descriptive statistics comparing lengths among streams.

Using the electrofishing capture efficiency model to convert ammocoete catch into an abundance estimate, five equations were used, corresponding with each pass (Equations 1 – 5). For each ammocoete caught in a sample, one of five equations were used to calculate the log odds ration of capture, depending on which pass it was caught. Variables that are part of the log odds ration calculations include ammocoete length (mm), sediment depth (cm), wind speed (km·hr^{-1}/1.609), two categorical visibility variables that provide a rating of high, medium or low, and water conductivity (μS/cm). For ammocoetes that were missed, the average length of those caught for that pass (or the best ocular estimate if the only ammocoete for that pass was missed) was used for the calculation.

Equation 7. Pass 1; $y = -0.006\beta_1 + -0.027\beta_2 + 0.164\beta_3 + 0.378\beta_4 + -0.223\beta_5 + -0.009\beta_6 + 2.90$

Equation 8. Pass 2; $y = -0.011\beta 1 + -0.048\beta 2 + 0.026\beta 3 + 0.430\beta 4 + -0.257\beta 5 + -0.008\beta 6 +4.34$

Equation 9. Pass 3; $y = -0.015\beta 1 + -0.051\beta 2 + 0.348\beta 4 + -0.113\beta 5 + 4.96$

Equation 10. Pass 4; $y = -0.013\beta_1 + -0.0613\beta_2 + 0.334\beta_4 + -0.109\beta_5 + 5.28$

Equation 11. Pass 5; $y = -0.014\beta_1 + -0.068\beta_2 + 0.316\beta_4 + -0.173\beta_5 + 5.75$

y = log odds ration of an individual ammocoete for each electrofishing pass
β_1 = ammocoete length (mm); β_2 = sediment depth (cm); β3=wind (numeric value of wind speed in km-per-hour / 1.609); β_4 = high visibility (categorical); β_5 = low visibility (categorical; both are zero if conditions are medium visibility); β_6 = conductivity (μS/cm)
For each ammocoete, log odds ration, y, were converted to capture probability (CP):

Equation 12. $CP(y) = \exp(y) / (1 + \exp(y))$, where CP is between 0 and 1.

The estimate of abundance at each site was calculated by adding up all of the individual capture probabilities for that site, including ammocoetes caught and missed in each pass. Because capture efficiency is less than 100%, the capture probability (Equation 6) of each lamprey is inflated to a value slightly higher than one, depending on ammocoete length and environmental conditions at the site (Equations 1 – 5), which yields an estimate of number of ammocoetes within the boundary (0.75m by 0.75m = $0.5625m^2$). To convert to density, estimated numbers of ammocoetes were divided by $0.5625m^2$.

Significant departures from normality precluded standard statistical comparisons of means so median ammocoete densities between treatments (restoration area or non-restoration area) were compared using the Mann-Whitney W test (Statgraphics Centurian XV, Statpoint Technologies, Inc., Warrenton, VA). This rank-sum test is useful for departures from normality (skewness, kurtosis) and small sample sizes (<20), which eliminates the importance of the population distributions, and is particularly useful when there are outliers. Comparisons of densities and lengths of ammocoetes were made using the Kruskal-Wallis (K-W) one-way analysis of variance due to significant departures from normality (Statgraphics Centurian XV, Statpoint Technologies, Inc., Warrenton, VA).

Species verification

On December 4, 2014, 40 ammocoetes were collected near the mouth of Warm Springs River and 40 near the mouth of Shitike Creek. Non-lethal tissue samples were collected from snipping a small portion of the tail and placing on filter paper (Whatman™ 3MM Chr Chromatography Paper, Fisher Scientific, Pittsburgh, PA). Samples were sent to Columbia River Inter-Tribal Fish Commission Genetics Laboratory, Hagerman, Idaho, for single nucleotide polymorphism (SNP) genotyping.

Diagnostic SNPs were used to distinguish species of morphologically indistinguishable lamprey (Hess et al., 2014).

Results

Distribution of ammocoetes in 2014 in three out of four streams changed from 2012 when last documented (Table 5, Figure 5). In Shitike Creek, the end of distribution remained the same, which was at the structure known as headworks (rkm 11). In Warm Springs River ammocoete distribution was 7.5 rkm less than it was in 2012. Compared to 2012, ammocoete distribution in 2014 increased in Beaver and Badger creeks, 6 km and 0.4 km, respectively.

Table 5. Ammocoete distribution (river kilometers) in Reservation streams in 2014 compared with previous years.

Stream	2003-06	2009	2012	2014	Max. Change
Shitike Creek	11	11	11	11	0
Warm Springs River	54	55.5	50.9	43.4	12.1
Beaver Creek	31.5	32.5	26.6	32.6	6
Badger Creek	12.2	12.8	11.8	12.2	1

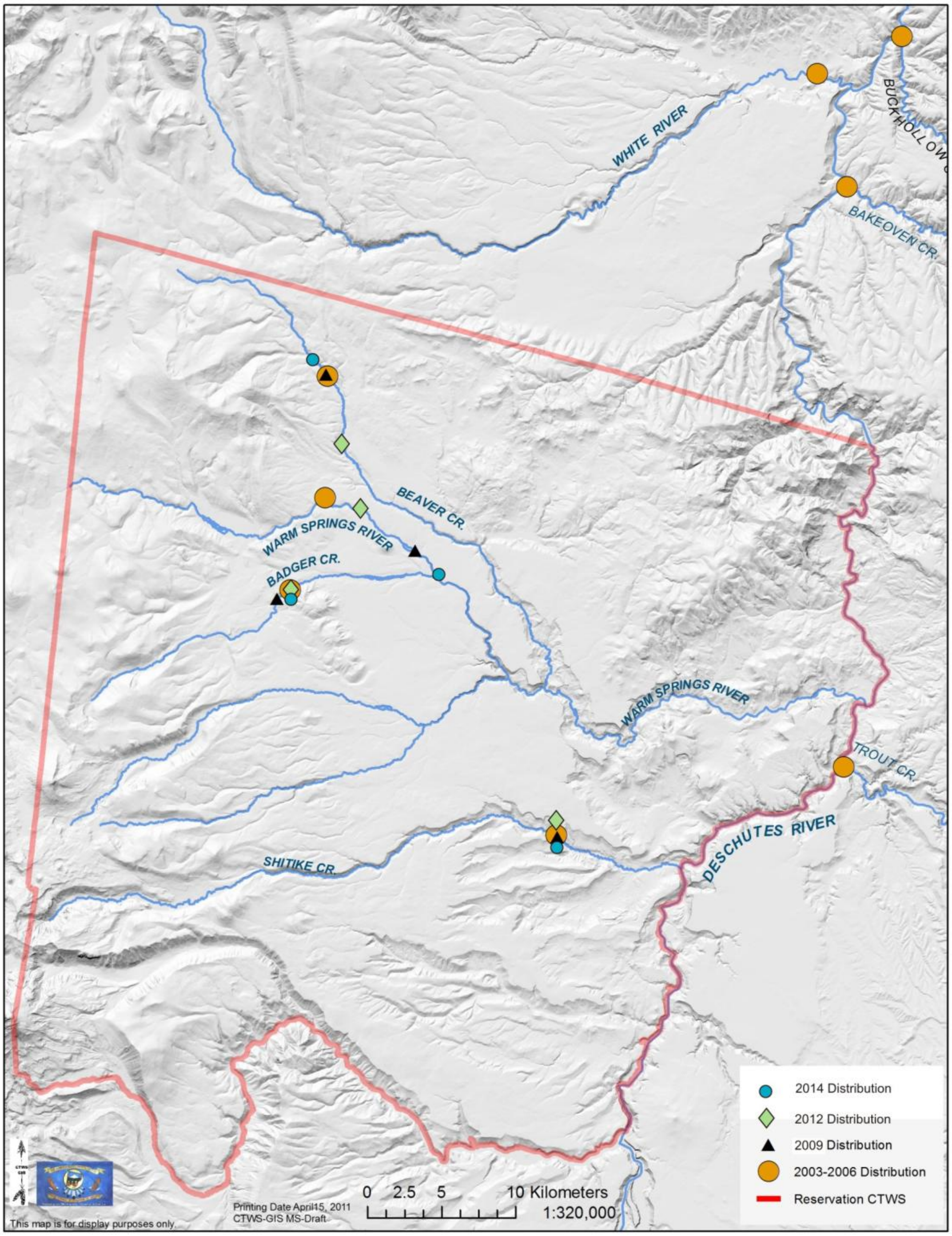

Figure 5. Ammocoete distribution in Reservation streams in 2014 compared with previous years.

All tissue samples collected from ammocoetes in Warm Springs River and Shitike Creek were confirmed to be Pacific lamprey. Mean length of ammocoetes collected in Shitike Creek was 82 mm (range 31 to 136 mm, n= 40). Ammocoete lengths in Warm

Springs River averaged 73 mm (range 25 to 122 mm, n = 40). During collection, a biologist with training in ammocoete identification determined all specimens to be Pacific lamprey (Andrew Wildbill, CTWSO Fisheries Biologist). Field identification was verified by genetic analysis as 100% Pacific lamprey (Jon Hess, Ph.D., Conservation Geneticist, Columbia River Inter-Tribal Fish Commission, Hagerman Lab, unpublished data).

Of the 61 sites in Shitike Creek, Warm Springs River, Beaver and Badger creeks selected for sampling, 56 were within the current distribution in 2014. Mean densities of ammocoetes among streams differed insignificantly (F ratio = 1.89, p-value=0.14, α=0.05, Figure 6). Comparing pairs of mean densities, Badger Creek had significantly less ammocoetes (24.9 ammocotes/m^2) than Shitike Creek (Table 6). Seven percent (4/56) of sites sampled had no ammocoetes, including two sites in Badger Creek and two in Beaver Creek.

Table 6. Range, median, and average of ammocoete densities estimated in Reservation streams, spring 2014.

		Ammocoete Densities (per m^2)			
Stream	Sample Size	Average	Median	Minimum	Maximum
Shitike Creek	13	41.0	27.8	1.9	128.5
Warm Springs River	16	25.2	21.3	1.8	72.0
Beaver Creek	18	35.8	33.7	0	101.1
Badger Creek	9	16.6	9.3	0	62.3
	56	30.9	25.7	0	128.5

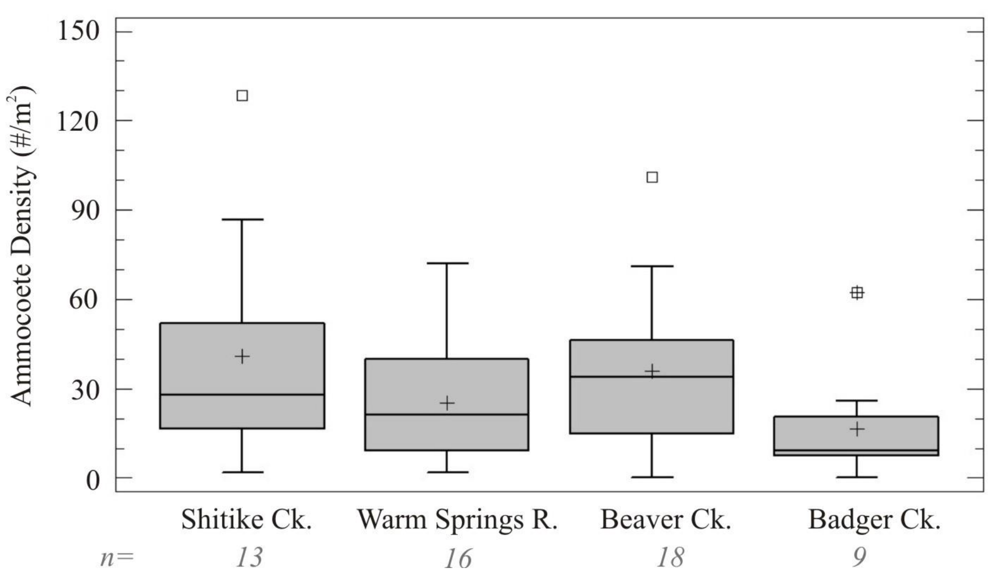

Figure 6. Box and whisker plot of ammocoete densities estimated in Reservation streams, spring 2014.

Mean ammocoete densities downstream of the WSNFH were 26% greater than mean densities upstream, 26.9 and 21.4, respectively (Figure 7). Densities downstream of WSNFH ranged from 3.4 to 72.0 fish/m^2 and upstream, the range was 1.8 to 49.8 fish/m^2.

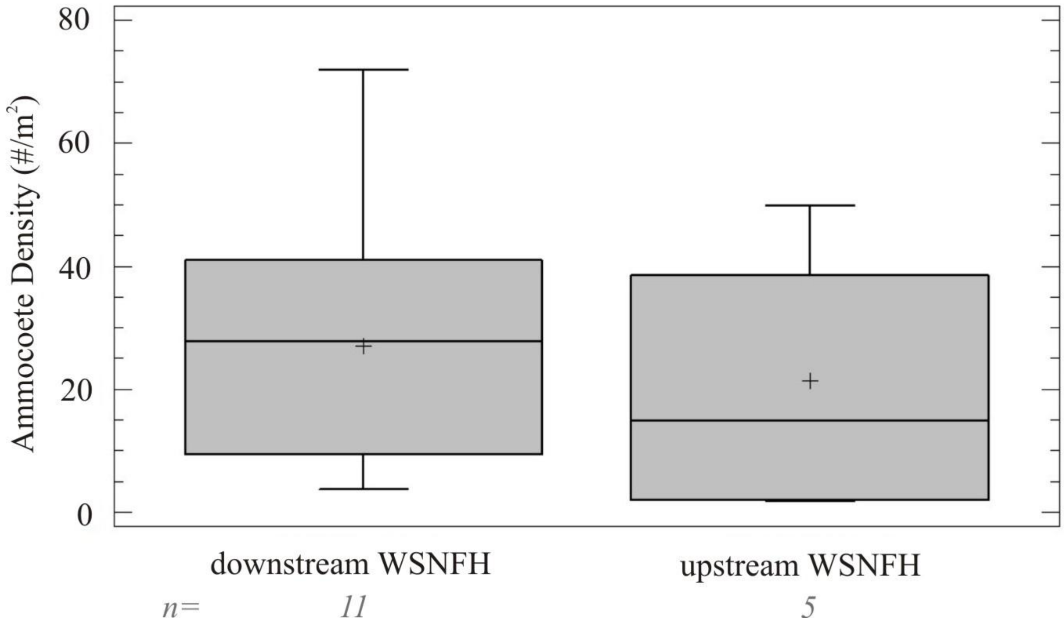

Figure 7. Comparison of ammocoete densities upstream and downstream of the Warm Springs National Fish Hatchery, 2014.

During summer 2014, ammocoete lengths used for density estimates ranged from 20 mm to 150 mm (Table 7). Median ammocoete lengths were significantly different among streams (K-W statistic 66.7, p-value<0.001, α=0.05, Figure 8). All streams had small larvae (< 20 mm) presumed to be young-of-the-year (Table 7).

Table 7. Range of ammocoete lengths (mm) in study streams, summer 2014.

Stream	Count	Average	Median	Min.	Max.	# < 20 mm[1]
Shitike Creek	283	51.2	45	20	150	1
Warm Springs River	218	51.3	48	20	121	132
Beaver Creek	347	57.5	49	20	150	57
Badger Creek	81	38.5	30	95	140	120
Total	929	52.5	45	20	150	310

[1]number of larvae sampled less than 20 mm length

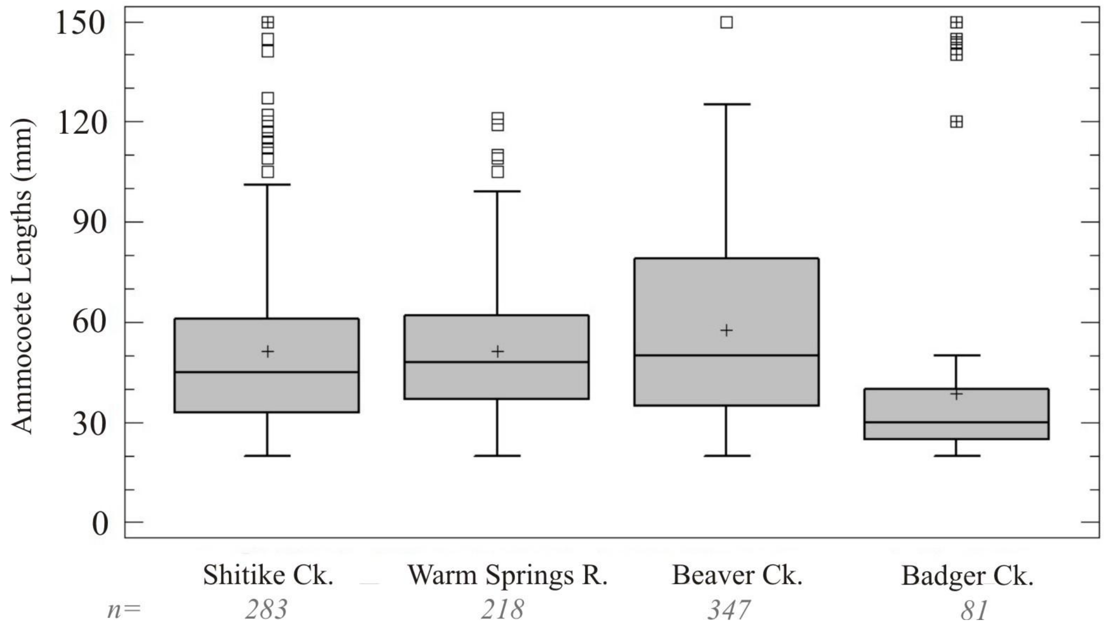

Figure 8. Ammocoete length distributions among Reservation streams sampled, spring 2014.

Typical habitat characteristics of sample sites were silt/organic substrate with a depth from 9 to 15 cm, in which water velocity was barely moving (0.02 to 0.07 m/s), with water temperature between 12.5 and 17.2 °C (Table 8). Eighty percent of sites sampled in 2014 were dominated by silt/organic matter substrate, followed by 14.5% of sites dominated by sand. The remainder had gravel (two sites) and cobble (one site) as the dominant substrate. Ammocoete densities in sites dominated by silt/organic matter were not significantly different than those dominated by sand (t-statistic = 0.03, p-value = 0.98, α=0.05).

Table 8. Habitat characteristics of sites sampled by stream, summer 2014.

Stream	Dominant Substrate [1]		Avg. Sediment Depth (cm)			Avg. Water Temperature (°C)			Avg. Water Depth (cm)			Avg. water velocity (m/s)		
	silt	sand	avg	min	max	avg	min	max	avg	min	max	avg	min	max
Shitike Creek	7/13	5/13	13.2	4.2	26.2	14.1	9.4	18.1	18.4	10.8	27.2	0.02	10.6	18.1
Warm Springs River	15/19	3/19	15.0	6.6	23.7	17.2	10.1	19.7	17.2	12.9	34.6	0.04	13.4	19.7
Beaver Creek	17/18	0/18	11.3	4.4	19.3	12.8	15.4	16.8	28.8	16.2	39.3	0.02	8.8	16.8
Badger Creek	9/11	0/11	9.0	5.2	13.9	12.5	6.7	15.6	18.2	13.2	24.2	0.07	10.9	15.6

[1] number of sites with silt/organic matter or sand as dominant substrate

Discussion

Pacific lamprey ammooete distribution appears to be stable in Shitike Creek, fluctuating between one and six kilometers in Badger and Badger creeks, and moving downstream in Warm Springs River. Recently, there has been discussion on applying occupancy modeling to improve robustness of reporting ammocoete presence-absence (Jolley et al., 2012; Reid and Goodman, 2015; Wang and Schaller, 2014). This approach generally supports methods employed by CTWSR to document changes in ammocoete distribution in which one or two additional sites are sampled if lamprey are not detected at the initial site giving detection probability of 95% or more for occupancy. Reid and Goodman (2015) found detection probability over 90% when a single site was sampled given a lamprey-specific electroshocker is used and depositional habitat in low gradient streams are sampled. Occupancy modeling studies have focused on identifying distribution across the region for the U.S. Fish and Wildlife Service Pacific lamprey Conservation Initiative (http://www.fws.gov/Pacific/fisheries/sphabcon/lamprey/lampreyCI.html). This study demonstrates stability or changes in ammocoete distribution in four streams over a decade.

In 2014, mean ammocoete densities in Reservation streams were greater than in 2013, 30 fish/m^2 and 20 fish/m^2, respectively. However, sampling in 2013 occurred in the spring when water temperatures were cooler, 10.4°C to 12.8°C (CTWRSO, 2014a). Comparing ammocete densities in summer 2014 with prior samples collected during summer 2009, grand mean densities were 30.9 fish/m^2 and 17.0 fish/m^2, respectively (Figure 9).

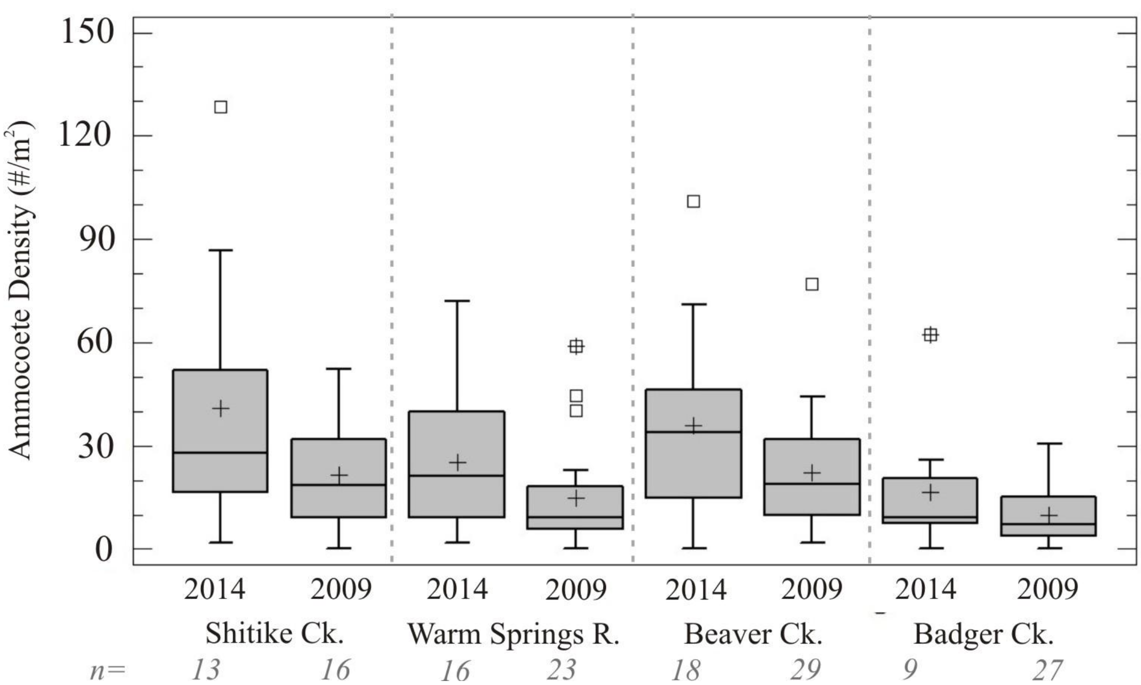

Figure 9. Comparison of ammocoete densities in Reservation streams during summer 2014 and 2009.

The presence of young-of-the-year (YOY) lamprey in all streams indicated successful spawning during spring 2014. In 2012 and 2013, all streams except Badger Creek had larvae 20 mm or less in length. It was thought that there might be a barrier to migration in Badger Creek. But, an estimated 120 larvae in the YOY size class caught in Badger Creek in 2014 resolved that concern.

Chapter 3. Migration patterns of Pacific Lamprey into Warm Springs River and Shitike Creek

Introduction

Use of HDX PIT tags for the mark-recapture experiment at Sherars Falls provides a means to determine upstream migration patterns as Pacific lamprey prepare to overwinter and spawn. This technology can be used to understand timing of lamprey movement into Warm Springs River and Shitike Creek, as well as whether a structure such as the weir at Warm Springs National Fish Hatchery in Warm Springs River (rkm 17.5) and Headworks in Shitike Creek (rkm 11) may deter or prevent upstream migration. Detections of PIT tagged lamprey along the stream or into tributaries may also indicate important areas of production.

In addition to lamprey PIT tagged at Sherars Falls, Pacific lamprey are also tagged at Bonneville Dam by the University of Idaho (UI) researchers (Noyes et al., 2012) and may ascend the Deschutes River and become available for detection at antenna sites in Reservation streams. This chapter reports detections of HDX PIT tagged lamprey in Warm Springs River and Shitike Creek and discusses migration patterns.

Study Site

Pacific lamprey were implanted with HDX PIT tags at Sherars Falls on the Deschutes River (rkm 71) by CTWSRO and at Bonneville Dam on the Columbia River (rkm 235) by UI between June and October. Since 2010, eight HDX antenna arrays have been installed in-stream on the Warm Springs Reservation (Table 8, Figure 10). In 2014, two dual readers were installed under BPA Project 2008-311-00 (Natural Production Management and Monitoring). One of the dual readers was installed at the mouth of Shitike Creek in February, near the HDX antenna, and the second was installed at the mouth of Warm Springs River in August, replacing the HDX antenna. Data from dual readers can be accessed from the PTAGIS database (http://www.ptagis.org/data/quick-reports/small-scale-site-detections using site codes for Deschutes River (DRM), Warm Springs River (WSR), and Shitike Creek (SHK).

Table 9. Half-duplex antenna sites in Warm Springs Reservation streams, 2010 - 2013.

Stream	Antenna Name	Abbreviation	rkm	Year Installed
Shitike Creek	Shitike Creek Mouth[1]	SCM	1.1	2011
	Peter's Pasture	PP	40.3	2012
	Headworks	HW	12	2013
Warm Springs River	Warm Springs River Mouth[2]	WSM	0.2	2010
	W.S. National Fish Hatchery	WSNFH	17.9	2012
	Schoolie	WSS	61.1	2010
	Upper Warm Springs Meadows	UWS	66.2	2012
Whitewater River	Whitewater River[3]	WWR	12.0	2013

[1]As of February 2014, there are two antenna at this site; one is HDX only and the other is a dual reader (full and half-duplex)
[2]August 2014 the dual reader replaced the HDX only antenna at this site
[3]This site is outside of lamprey distribution. It is in the Metolius River drainage upstream of the Pelton-Round Butte Hydrologic Complex.

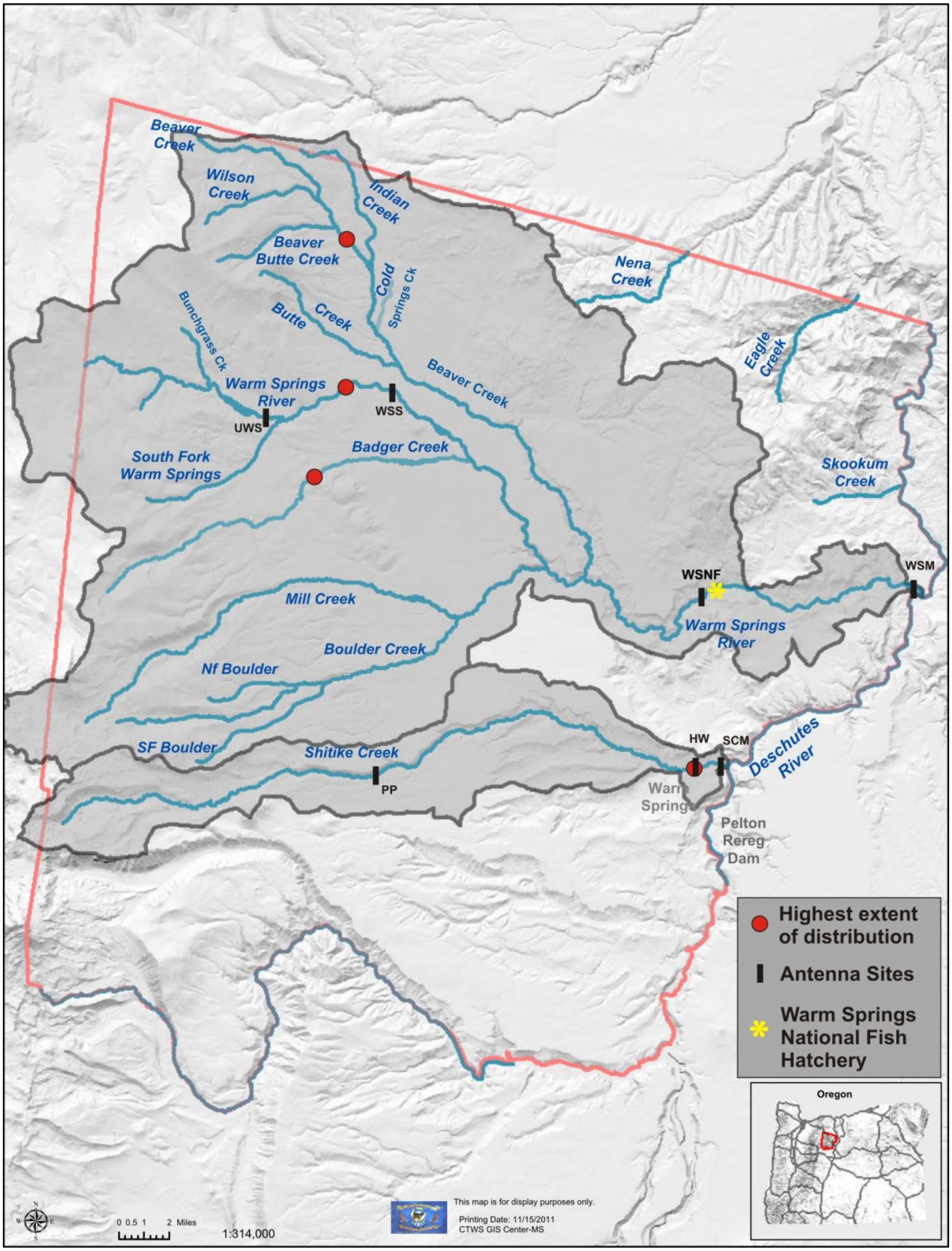

Figure 10. Half-duplex antenna sites within Pacific lamprey distribution in Warm Springs Reservation streams, lower Deschutes River Subbasin, Oregon, 2014.

Methods

PIT Tag Detections

Antenna arrays within Pacific lamprey distribution included the lower three HDX sites in Warm Springs River and site at the mouth in Shitike Creek (Figure 10). Each antenna consists of loops of copper wire housed in PVC conduit. Antennae are connected to a reader (single or multi-antenna HDX reader, Oregon RFID, Portland OR), which stores detection data, including tag number, and date and time of detection. Twelve-volt batteries are used to power antennae and recorders. Nominal read range for a 23 mm HDX tag is about 60 cm, depending on electromagnetic noise level, proximity to metal, power quality and antenna design. Antennae are tuned using remote antennae tuning boxes with capacitors (Oregon RFID, Portland, OR).

Antenna read range was tested bi-weekly and the antenna re-tuned to maximize read range, if necessary. Recorders operated continuously, year-round, and were generally downloaded to a waterproof PDA (Oregon RFID, Portland, OR) twice per week during which time 12-V batteries were also changed. Downloaded detection data were stored in a database for future queries. Tag detections at each of the HDX antenna sites were compared with tag numbers inserted into lamprey at Sherars Falls and Bonneville Dam.

Results

In 2014, antenna arrays detected 13 Pacific lamprey in Warm Springs River and two in Shitike Creek. The two lamprey detected in Shitike Creek were tagged at Sherars Falls in 2013 and detected 315 and 304 days later; one at the mouth and one at headworks. In Warm Springs River 12 were detected at the mouth and one was detected in upper Warm Springs Meadows (site UWS, Figure 10). The lamprey detected at UWS was tagged July 26, 2012 and detected April 1, 2014; 614 days after tagged. Of the 12 lamprey detected at the mouth, one was tagged at Bonneville Dam 52 days prior to reaching Warm Springs River (site WSM). The remaining 11 lamprey detected at WSM were tagged in 2013, 165 to 315 days prior to detection in 2014.

Disruptions in antenna operations were recorded by marker tags. The antenna, SCM, ran continuously from December 24, 2013 through the end of this study period, September 2014. The array at headworks had an interruption in service between February and early May and again from late August through September 2014. Warm Springs mouth antenna operated continuously through July 31, 2014, when a dual reader replaced it. The array just upstream of WSNFH was out of service from mid February through early September 2014. The antenna WSS was in continuous operation throughout the study period but UWS antenna had intermittent service.

Discussion

The lamprey detected in upper Warm Springs Meadows demonstrates novel data that can be documented by use of antenna arrays – it was a two-year over-winter lamprey that was upstream of the known distribution of lamprey. This was the second example of a Pacific lamprey in the Deschutes River that spent two years in freshwater as an adult before reaching spawning grounds. The first was mentioned in Chapter 1. This lamprey was 10.7 km upstream of the highest known ammocoete distribution in 2009 (Chapter 2). Surveys for ammocoetes in upper Warm Springs Meadows will be done in 2015 to try to document whether successful spawning and emergence occurred.

Only one of the 15 lamprey detected in Warm Springs River and Shitike Creek was tagged in 2014, the rest appeared to overwinter prior to entering the tributaries. This was a pattern documented by a radio-telemetry study in the Deschutes River between 2005 and 2008 when 74% of overwintering lamprey remained in the Deschutes River, 20% entered the Warm Springs River, and only one lamprey was found in Beaver and Shitike creeks.

Chapter 4. Adult Pacific lamprey Abundance and Harvest at Cushing Falls on Fifteenmile Creek, 2014

Introduction

In 2010, CTWSRO began a multiple year feasibility project to estimate lamprey abundance in Fifteenmile Creek, funded by the Bonneville Power Administration, through the Columbia River Accords. Prior to the project, "Determine Status and Limiting Factors of Pacific Lamprey in Fifteenmile Creek and Hood River Subbasins, Oregon," little information had been documented on lamprey in Fifteenmile and Hood River Subbasins. In order to formulate an effective recovery plan for lamprey in Fifteenmile Creek and its tributaries, baseline biological information must first be collected and analyzed. Mill Creek, located in The Dalles Watershed and a tributary of the Columbia River, was added in 2013. Overall project intent through 2017 is to assess lamprey populations for development of long-term status and trends; document distribution as lamprey re-colonize Hood River, and identify factors that may limit lamprey abundance and distribution in the two subbasins. Project objectives were: 1) estimate adult Pacific lamprey abundance and escapement in Fifteenmile Creek; 2) determine larval lamprey distribution, densities, and associated habitat in Mill Creek, Fifteenmile Creek and Hood River Subbasins; 3) develop a monitoring protocol for adult lamprey and re-colonization of Hood River Subbasin; and 4) begin to implement factors limiting Pacific lamprey production within Fifteenmile Creek Subbasin.

Developing a method to estimate the abundance of adult Pacific lamprey in Fifteenmile Creek began in 2010. Lamprey estimates the first year were poor, perhaps due to low counts of lamprey passing Bonneville Dam that year (www.fpc.org) and an Oregon Department of Transportation project that replaced a span of I-84 over Fifteenmile Creek during upstream migration of adult lamprey that may have deterred immigration. However, from 2011 through 2013, abundance, harvest and escapement of Pacific lamprey were estimated in Fifteenmile Creek.

Study Site

Fifteenmile Creek enters the Columbia River at rkm 307, just downstream of The Dalles Dam (rkm 308) and upstream of the City of The Dalles (rkm 305, Figure 71). Principle tributaries to Fifteenmile Creek include Ramsey, Pine, Dry, Fivemile and Eightmile creeks (Figure 71). The Fifteenmile Creek Subbasin drains approximately 966 km^2 of the eastern slopes and foothills of the Cascade Range. The entire Fifteenmile Creek Subbasin is located within the boundary of lands ceded to CTWSRO. Two geologic features in Fifteenmile Creek, Seufert Falls (rkm 0.1) and Cushing Falls (rkm 0.7), are release and capture locations (Figure 15).

Figure 11. Capture and release locations for mark-recapture study on Fifteenmile Creek, 2011 - 2014.

Methods

Two-event mark-recapture methods were used to estimate adult lamprey abundance in Fifteenmile Creek (Bernard and Hansen, 1992). In addition to the CTWSRO marking adult lamprey caught in Fifteenmile Creek by inserting half-duplex (HDX) Passive Integrated Transponder (PIT) tags (0.6 g, 0.1 g. Oregon RFID, Portland, OR), the University of Idaho (UI) implanted HDX tags in adult lamprey trapped at Bonneville Dam (BON). The recapture event for PIT tagged lamprey was detection at interrogation sites upstream of Cushing Falls. An interrogation site downstream of Cushing Falls was used to determine whether lampreys fell back and also used to record lampreys tagged at BON that recruited into the pool of marked fish for this study. Lampreys were inspected during creel surveys by posting an observer at Cushing Falls who counted passing lamprey.

Collection, Tagging, and Release of Adult Lamprey in Fifteenmile Creek

Returning adult lamprey to Fifteenmile Creek were collected by hand at Cushing Falls (rkm 0.6) from 21:00 – 2:00. Captured lampreys were held in 5-gallon buckets and anesthetized in a solution of Eugenol (5 mL:50 L water). All fish were measured for total length and girth (nearest cm), weighed (nearest g) and a dorsal fin clip collected for genetic analysis. Lamprey were implanted with uniquely-coded, 23 mm or 12 mm, HDX PIT tags. Lampreys with a girth size of 9 cm or greater received 23 mm HDX PIT tags surgically implanted into body cavities similarly to Cummings *et al*. (2008). Lamprey with girth size less than 9 cm received a 12 mm HDX PIT tag. Anesthetized lamprey were placed on their dorsal side and a 3 mm incision made directly below the anterior-most portion of the first dorsal fin. A HDX PIT tag was inserted into the incision and massaged into the cavity away from the incision to reduce the potential for the tag to be expelled. A fin clip was taken, as a secondary mark, on the first dorsal and helped identify CTWSRO marked fish. Lamprey were then returned to an in-stream net pen for recovery and released at dusk, approximately 490 m downstream of the collection site (rkm 0.3, Figure 11). Implanted (marked) lamprey were then detected (recaptured) at the HDX interrogation site immediately upstream of Cushing Falls above the capture location (rkm 0.7). Lamprey registered at this antenna were considered a recapture if the observer was present counting lamprey passing over Cushing Falls, considered lamprey inspected. Therefore, the number of lamprey inspected was recorded and simultaneously, lamprey possessing a HDX PIT tag, would be recorded by the antenna as a recaptured fish. Lamprey considered to be in the pool of marked fish were those that were tagged, either by CTWSRO or UI, and were recorded at any antenna upstream of Cushing Falls. Not all tagged lamprey that passed Cushing Falls were recorded at that antenna site, so there were more tagged fish in the pool of marked fish than what was recorded at the antenna at Cushing Falls. The number of recaptured lamprey were further lessened by the restriction that the tagged lamprey had to pass when an observer was present. This condition is to satisfy the model assumption that every fish has an equal probability of being captured during the second event sampling.

Researchers (University of Idaho, Pacific States Marine Fish Commission, and NOAA Fisheries) at BON used Juvenile Salmon Acoustic Telemetry System (JSATS) along with HDX PIT tags to monitor migration and final fates of adult Pacific lampreys in the Bonneville Reservoir (Noyes *et al* 2011). A number of those BON PIT tagged lampreys, considered part of the unmarked population until recorded at the HDX antennae at Cushing Falls (rkm 0.7, thus recruited into the pool of marked fish), were used to calculate an abundance estimate of lamprey. BON tagged lampreys were also detected at interrogation sites in the Fifteenmile Creek Subbasin upstream of Cushing Falls (rkm 0.7). Tagged lampreys at BON were released at three locations (downstream at Hamilton Island, upstream near Stevenson, and lamprey passage structure at BON). Release sites at BON were approximately 71 - 74 rkm downstream of HDX interrogation sites in Fifteenmile Creek.

Creel Surveys

In conjunction with the mark-recapture study, a voluntary creel survey was performed at Cushing Falls to estimate tribal harvest. Observation and creel surveys started April 18 and ended October 5, 2014. Surveys were generally conducted five days a week, from 21:00 until 3:00 or when fishermen had completed collection. All harvested lampreys that the creel clerk was allowed to handle were inspected for marks, scanned for PIT tags, and total lengths recorded. To estimate total harvest, creel numbers were expanded to seven days (actual weekly harvest average plus fishing effort), accounting for the days missed and the potential for harvest.

If no harvest occurred during one of the five days per week that a surveyor was present at Cushing Falls, lampreys were enumerated (inspected) as they passed over Cushing Falls. If lampreys crossed the uppermost weir, they were counted as passing the falls. Lampreys counted at the falls were totaled over the season for number of lamprey inspected. Night counts at Cushing Falls ended when less than two lampreys were counted for five consecutive days. Water temperature and general weather observations were recorded during observations.

Pacific lamprey abundance, harvest, and escapement in Fifteenmile Creek

Adult Pacific lamprey abundance, variance, harvest effort and catch were estimated using the same equations and assumptions given in Chapter 2. Abundance was estimated using Chapman's modification of the Petersen estimate and associated assumptions (Chapter 1, equations 1-4).

The assumption that the population is closed (Assumption 1) was compensated for by removing tagged lamprey from the pool of marked fish that failed to return to Cushing Falls or were detected upstream of Cushing Falls. This approach negates whether lamprey were tagged by CTWSRO or UI and whether CTWSRO failed to return to Cushing Falls.

Most lamprey were not handled during second event sampling since they were counted as they passed Cushing Falls and recaptured through detection at that interrogator. This precludes validating lamprey do not lose their marks (Assumption 2), however, it is the same method used at Sherars Falls (Chapter 1) where tag loss was negligible (<1%).

There is no direct mortality associated with dip netting or capture by hand and indirect, short-term mortality for PIT tagged lamprey was evaluated by Dr. Moser in an unpublished study (M. Moser, NOAA Fisheries, pers. comm., Assumption 3). Of the "or" assumptions (4 – 6) above, one must be met. Either assumption 4 or 5 will suffice in this case. To satisfy assumption 4, every lamprey has the chance of being captured and released alive, whether captured and tagged at Bonneville Dam or in Fifteenmile Creek because sampling occurs throughout the run and sampling is not size-selective (*i.e.*, no size-selective mesh). Assumption 5 is satisfied because every fish has equal probability of being captured (i.e., counted and detected) during the second sampling event since detected lamprey at the antenna just upstream from Cushing Falls is only considered a recaptured fish when and only when an observer was present counting fish for number inspected. Since lamprey are not handled during second-event sampling, assumption 6 is not possible because this is typically done by comparing length distributions (Bernard and Hansen, 1992).

In conjunction with marking and recapturing adult lamprey, a voluntary, single-access site, creel survey was conducted to estimate tribal harvest of adult Pacific lamprey. Harvesters were monitored between two and six nights per week from April to mid September, with the greatest effort during the peak. Creel surveys occurred from 9 pm until tribal fisherman completed collection or 3 am, whichever occurred first. Creel clerks examined harvested lamprey for marks and recorded total lengths when allowed. Number of lamprey collected by harvesters were easily observed and were recorded whether harvesters allowed creel clerks to inspect fish or not. Lamprey harvested during creel surveys were expanded to estimate total harvest and 95% confidence intervals generated for the harvest season (Polluck et al., 1994). Total effort and harvest was expanded from each sampling day using equations 5-7 (Chapter 1). Escapement of adult Pacific lamprey over Cushing Falls was calculated by subtracting the harvest estimate from the abundance estimate.

Environmental Data

Water temperature and stream discharge data were used to describe environmental conditions during the 2013 sampling period. Water temperatures were recorded in Fifteenmile Creek by CTWSRO data loggers (Hobo Pro v2 data loggers, Onset Computer Corp., Pocasset, MA). Stream discharge was recorded by Oregon Water Resources Department (OWRD) gage site, Fifteenmile Creek near The Dalles (14105500, www.wrd.state.or.us). To record relative stage of Fifteenmile Creek at Cushing Falls, a pressure transducer was installed (WL16 logger, Global Water Instrumentation, College Station, TX).

Results

Mark-recapture estimate in Fifteenmile Creek

A total of 1,645 adult Pacific lamprey were observed ascending the uppermost ladder at Cushing Falls (rkm 0.7) from April 30 through September 27, 2014 (Figure 12). Lamprey observed at Cushing Falls averaged 13 per night and had a high of 746, with half of the run counted by June 19. From June 17 to August 8, 2014, 201 lamprey were captured for tagging. Of the 201 lamprey caught, 198 were implanted with HDX PIT tags. Total lengths ranged from 40 to 81.5 cm (average = 61.4 cm, n = 193), fish girth ranged from 8.5 to 11.5 cm (average = 10 cm, n=193) and weight ranged from 227 to 603 g (average =380 g, n = 159).

Since HDX tagged lamprey must be detected in lower Fifteenmile Creek antenna arrays to recruit into the pool of marked fish, 72 out of the 198 (36%) lamprey PIT tagged released downstream in 2014 were detected and thus included. An additional 24 lamprey tagged by CTWSRO in 2013 recruited into the pool of marked fish for 2014 and lamprey tagged by UI at Bonneville Dam that were included as marked lamprey included 35 from 2013 and 51 from 2014. Total lamprey in the pool of marked fish for 2014 was 182.

During second event sampling in 2014, 92 lamprey were detected upstream of Cushing Falls by HDX antennas. Adult Pacific lamprey abundance in Fifteenmile Creek was estimated at 3,238 (Figure 13; 95% CI= 2,646 – 3,962; M = 182; C = 1,645; R = 92). Relative precision of the estimate was 13.8%.

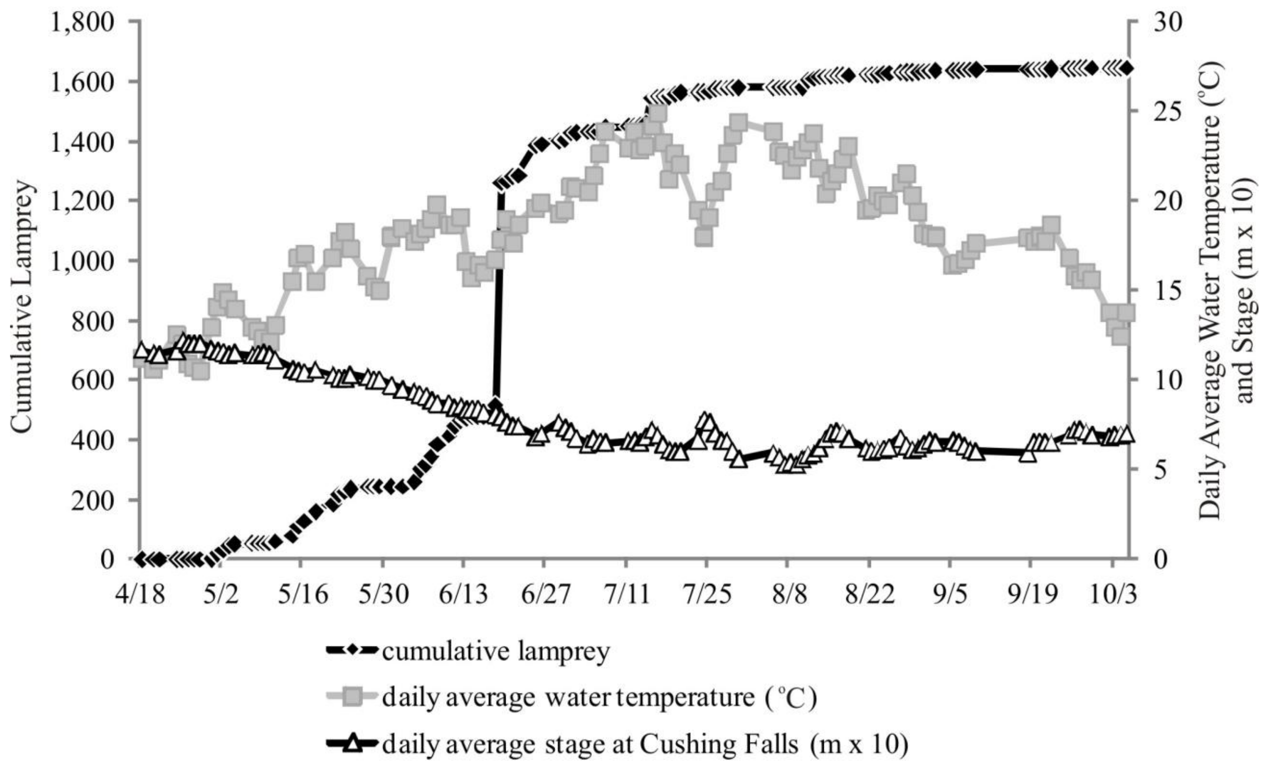

Figure 12. Cumulative counts of lamprey observed ascending Cushing Falls, April – October 2014.

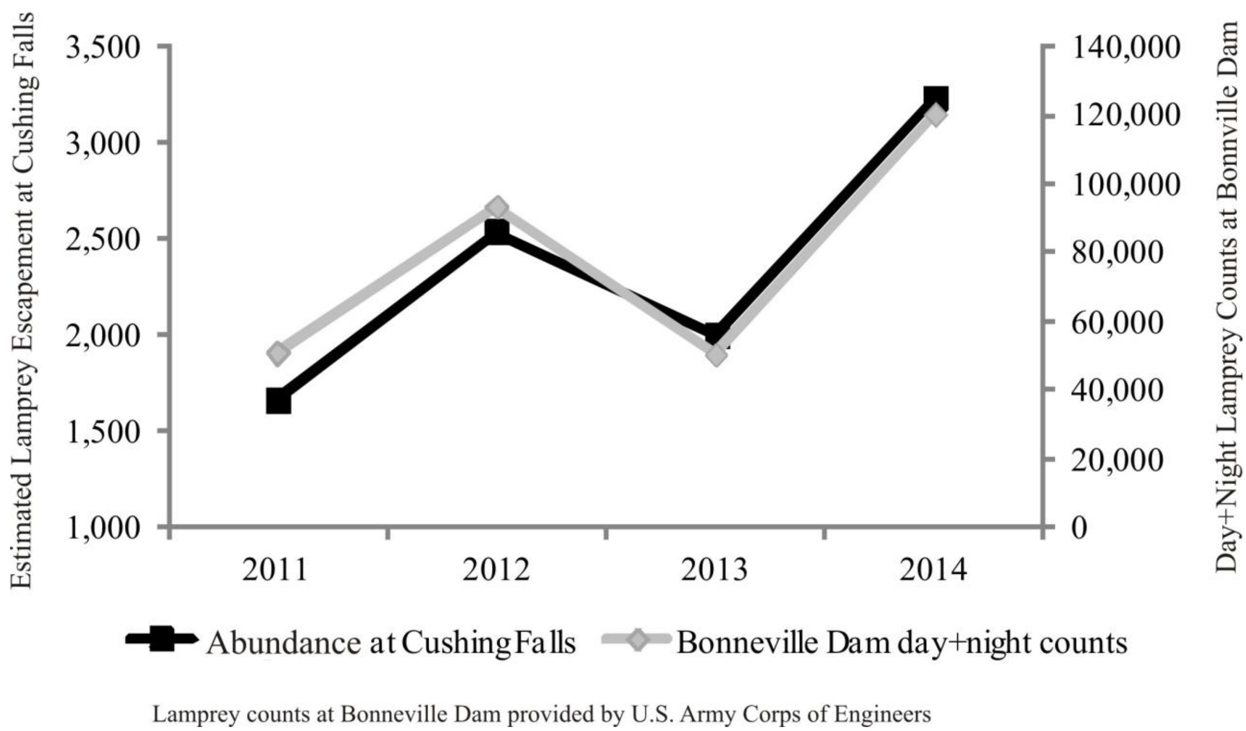

Figure 13. Estimated abundance of Pacific lamprey at Cushing Falls and day and night counts at Bonneville Dam, 2011 – 2014.

Creel Surveys

Monitoring and creel surveys started on April 18, and ended October 5, 2014 for a total of 121 nights surveys were conducted. Tribal harvest occurred on 29 nights between May 1 and August 12, 2014. A total of 303 harvested lamprey were visually inspected for marks, scanned for PIT-tags, and a sub-sample of lamprey were measured for lengths. Lengths of creeled lamprey averaged 60.5 cm and range between 51.0 and 72.5.0 cm (n = 199). Fifteen recaptures were identified during tribal harvest. Estimated harvest of Pacific lamprey at Cushing Falls in 2014, expanded to include 50 days that creel surveys were not conducted from April to October, was 390 (95% CI = 374 – 406). Expanded harvest was 12.0% of the estimated abundance at Cushing Falls. Pacific lamprey escapement over Cushing Falls was 2,848.

Fifteenmile Creek Subbasin HDX Interrogation Sites

From February through October, 256 PIT tagged lamprey were detected at interrogation sites in the Fifteenmile Creek Subbasin. Of those 256 detections, 64 were PIT tagged in 2013 (25%) and six were PIT tagged in 2012 (2%). Ninety-one (35.5%) were detected at an HDX antenna 491 m upstream of Seufert Falls release site at rkm 0.23 (Figure 14). From the total fish marked by CTWSRO (198), 110 were considered to have backed out of Fifteenmile Creek and fates unknown since going undetected. Eightmile Creek had a total of seven detections, three adults tagged by UI and 4 tagged by CTWSRO. Mill Creek detected one UI fish, on August 4, 2014; in 2013 this antenna detected only two CTWSRO fish tagged.

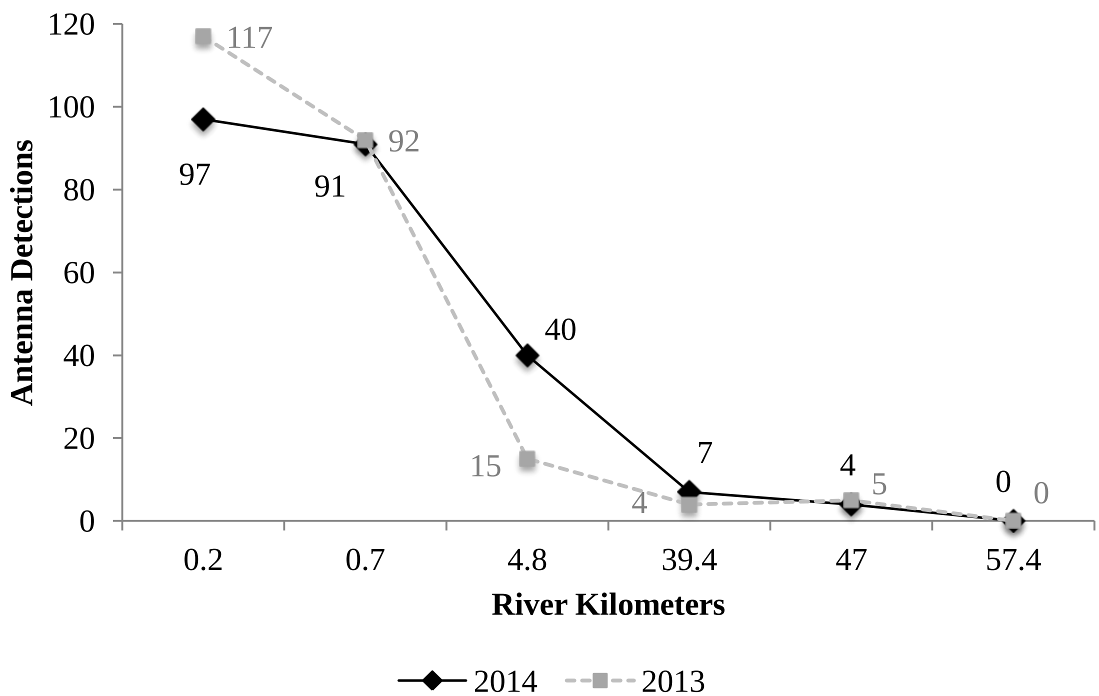

Figure 14. Individual detections of PIT tagged Pacific lamprey at interrogation sites in Fifteenmile Creek, 2013 - 2014.

Fifty-nine detections (CTWSRO = 24; UI = 35) were a result of lamprey PIT tagged at BON and by CTWSRO during summer 2013, over-wintered, and resumed migration in Fifteenmile and Eightmile creek from April 26 until June 19, 2013. University of Idaho began tagging lamprey at BON on May 15, 2014. Detections of BON tagged lamprey (*i.e.*, new migrants) began on June 9 and continued through September 14, 2014. Five CTWSO lamprey PIT tagged in 2012, were detected in Fifteenmile Creek for the first time. One 2012 CTWSO PIT tagged fish was detected in both 2013 and 2014. Detections recorded at interrogation sites were between the hours of 20:00 – 13:00.

Detection efficiency at almost all interrogation sites in Fifteenmile, Eightmile and Mill Creeks was greater than 91% (Table 10), with the exception of the Fifteenmile mouth antenna (rkm 0.2= 38%). All but one antennae in Fifteenmile, Eightmile and Mill creeks had a read range that exceeded the water surface. The Fifteenmile mouth antenna (rkm 0.2) with the lowest read range (15cm) and detection efficiency (38%) had the most detections (n = 97).

Table 10. Antenna array locations and detection efficiencies in Fifteenmile Creek, Hood River, and Mill Creek subbasins, 2014.

Fifteenmile Creek		Eightmile Creek		Hood River		Mill Creek	
rkm	Efficiency	rkm	Efficiency	rkm	Efficiency	rkm	Efficiency
0.2	38%	1.6	98%	1	60%	0.8	99%
0.7	91%	19.7	98%	11	_		
4.8	98%	29.5	100%	27	100%		
39.4	99%						
47	100%						
57.4	100%						

Hood River HDX Interrogation Sites

Seven detections were recorded by the interrogation site near the mouth of Hood River from June 6 through August 21, 2014. All detections were of BON origin, four tagged in 2013 and three in 2014. Antenna read range varied between 10 cm – 21 cm depending on discharge. The 1/0 stranded copper cable extended (46 m x 1 m) across 75% of the wetted channel, was modified in January 2013, because of the size read range and detection efficiency suffers. Both antennas above the mouth site, rkm 11 and 27 respectively, detected no fish. Despite no fish being detected at these upper sites, ODFW mainstem Hood River smolt screw trap (rkm 6.5) captured 11 adult lamprey, five were caught in 2013 at this same sight. Eight of these fish were measured (range 35.5 - 51cm) and was determined to be spawned out females, by CTWSO staff. Detection efficiency at the Hood River mouth site (rkm 1) has always been low compared to the upper most site in the East Fork (rkm 27), 60% and 100%, respectively (Table 10).

Discussion

Estimated Pacific lamprey abundance at Cushing Falls in 2014 was the highest since 2011 at 3,238. This was 70% greater than the 2013 estimate of 1,928. Compared with 2013, lamprey in 2014 were three days earlier, as indicated by the 50% cumulative catch (June 22, 2013 and June 19, 2014). While Pacific lamprey abundance in Fifteenmile Creek is two orders of magnitude less than Bonneville Dam counts, there is a close association ($r^2 = 0.94$). Harvest of lamprey in 2014 was comparable with 2013, 12.0% and 13.2% of abundance, respectively.

Pacific lamprey entry into Fifteenmile Creek was much earlier than previously recorded, when February 2014 became the earliest detection documented. This is probably because no antenna has been operated at rkm 0.2 in previous years. However, the single antenna array at this location is unable to record directionality for fish leaving or entering the tributary. It is possibile that PIT tagged lamprey that have gone undetected in the past would overwinter in the Columbia and resume movement into Fifteenmile Creek the following spring. Other factors that can possibly effect run timing and detections below Seufert falls (rkm 0.23) are the high frequency and amplitude of water–surface elevations observed at Bonneville Pool. Receding Columbia River water levels at Seufert falls can expose migrating adults to predators, such as blue heron, otter, birds of prey, and humans. When the Bonneville pool level is high, inundating Seufert Falls for short periods of time, white sturgeon and sea lions have been observed entering the lower 200 m of Fifteenmile Creek. White sturgeon >91cm in length, have been spotted at night below Seufert falls in water depths less than 61cm (CTWSRO, unpublished data). Both white sturgeon and sea lions are known to prey on lamprey during their adult migration (Beamish, 1980).

Antenna detections documented patterns of overwintering lamprey and also demonstrated improved passage following an adjustment to a diversion dam. Numbers of overwintered fish detected in 2014 (n = 64 or 25%) were higher compared to 2013 (n = 41 or 17%). This could be attributed to the addition of the mouth antenna (rkm 0.2) since fish must pass it first. In April 2014, ODFW Fish Screening and Passage Shop in The Dalles improved lamprey passage at Tenold Diversion on Fifteenmile Creek by adding flexible intake pipe to the existing pipe so that the intake on the pump could be placed deeper in the pool. This alleviated the need for the installing stop logs in the concrete structure of the dam and clear passage was maintained through the summer (Marty Olson, Northwest Field Coordinator, ODFW Fish Screening and Passage Program, pers. comm.). Lamprey passage increased almost three-fold past Tenold Diversion Dam after improvement of passage.

In the past, detection efficiencies for antennas were not documented; from 2011 – 2013, only read range was checked. Though detection efficiency was always expected to be high, documentation through the 2014 season proved this correct, with the lowest primary antenna at rkm 0.7 having the lowest efficiency of 91%. All antennas above this site had at least 98% detection efficiency. At most sites, read range exceeded surface water levels. Over the course of the past four years, pass-through antennas have had the greatest detection ability. However, when stream velocities or human activity is high, pass-over or flat panel antennas are used to ensure that equipment will not be displaced.

The Hood River mouth antenna (rkm 1) has been challenging to operate and much as been learned since installation in 2012. It is a large antenna (48 m long x 0.76 m wide) that is a pass-over type, lying on the streambed. Read range can depend on stream velocity, but the one aught THHN cable is durable. In the past three years, most of the detections were between June-October. The early part of the lamprey run, documented by ODFW rotary screw trap in 2013 and 2014, has been missed. Early migrating PIT tagged lamprey should be detected at Hood River mouth, as they are in Fifteenmile Creek. The lack of early detections has been disappointing. Hood River flows in the spring and early summer are possibly causing tuner malfunctions, since antenna tuning should be static, allowing fish to go undetected. To possibly remedy this, CTWSRO Hood River Production has recently installed the Biomark IS1001 MTS reader and multiple antennas at rkm 0.5; the MTS reader will be able to read both HDX/FDX tagged fish. In the future, the ORFID HDX reader at rkm 1 might be relocated if the new Biomark antenna array below it is able to detect Bonneville tagged lamprey.

Chapter 5. Distribution of Ammocoetes in Fifteenmile Creek, Mill Creek, and Hood River Subbasins, 2014

Introduction

Ammocoete distribution was documented in study streams for baseline information so that changes may be compared over time and to assess whether distributions may be limited by full or partial barriers. Of particular interest in Hood River is the re-colonization of Pacific lamprey after the removal of a barrier dam on the mainstem at rkm 6.5. In October 2010, the Powerdale Dam was decommissioned, which had been generating hydropower since May of 1923. Throughout the dams operation, there were several fish passage retrofits for salmon and steelhead, which included a fish elevator for sorting stocks and fish rearing facilities completed in 1995. However, passage for Pacific lamprey was not under consideration.

In addition to lamprey distribution, species identification was confirmed through genetic analysis. Because larval lamprey are morphologically indistinguishable when small (< 60 mm in length), conservation geneticist have recently developed assays for single nucleotide polymorphisms (SNPs) to identify Pacific lamprey from Western brook lamprey (*Lampetra richardsoni*) (Hess et al., 2014). Further, morphological separation of *Entosphenus* and *Lampetra* ammocoetes requires skill, experience, and good eyesight. It has been fairly recent since identification guidelines have been available (Goodman et al., 2009; Lampman and Streif, 2008). The objective of this chapter was to mark the upper extent of ammocoete distribution in study streams and confirm species identification.

Study Area

Fifteenmile Creek Subbasin is located northeast of Mt. Hood draining 970 km^2 of its eastern slopes and Tygh Ridge (Wasco County Soil and Water Conservation District, 2004). It discharges into the Columbia River at rkm 307 (Figure 15). Principle tributaries to Fifteenmile Creek include Ramsey, Pine, Dry, Fivemile and Eightmile creeks. Oregon Department of Fish and Wildlife identified barriers to lamprey passage in their most recent assessment (Loffink, 2013), which included: Tenold Diversion (rkm 3.2), Underhill Diversion (rkm 55), City of Dufur water intake and reservoir dam (rkm 64), and Lyda Dam (rkm 71) on Fifteenmile Creek, an unknown dam on Ramsey Creek (rkm 18), and Wolf Run Diversion Dam on Eightmile Creek (rkm 54).

Mill Creek has a 169.5 km2 watershed area and enters the Columbia River at rkm 305, running through the City of The Dalles (Figure 14). The lower 260 m of Mill Creek runs through an open-bottom arched concrete culvert underneath Interstate 84 before discharging into the Columbia River. Structures, including the City water pipeline, are barriers depending on flows (Wasco County Soil and Water Conservation District, 2004). The City's pipeline follows the mainstem and crosses Mill Creek at multiple points. The ODFW 2013 Fish Passage Priority List (Loffink 2013) includes Byers Diversion (rkm 2.5), an unknown dam on Mill Creek (rkm 3.0) and South Fork Mill Creek (rkm 1.7) as potential lamprey barriers. Mill Creek was a traditional lamprey fishing site as the waterfalls on South Fork (~45 m high, rkm 5.9), approximately 16 km upstream of The Dalles, provided a harvest opportunity as lamprey would climb the rocks around the falls. It is in The Dalles Watershed and is now closed to the public. In 2011, Mill Creek was sampled for ammocoetes near the mouth and were found to be present (CTWSRO, unpublished data). This site was added to the study area as it was known to bear lamprey and is one of the tributaries that flows into Bonneville Reservoir, for which lamprey tagged at Bonneville Dam or lamprey tagged in Fifteenmile Creek that backs out may ascend.

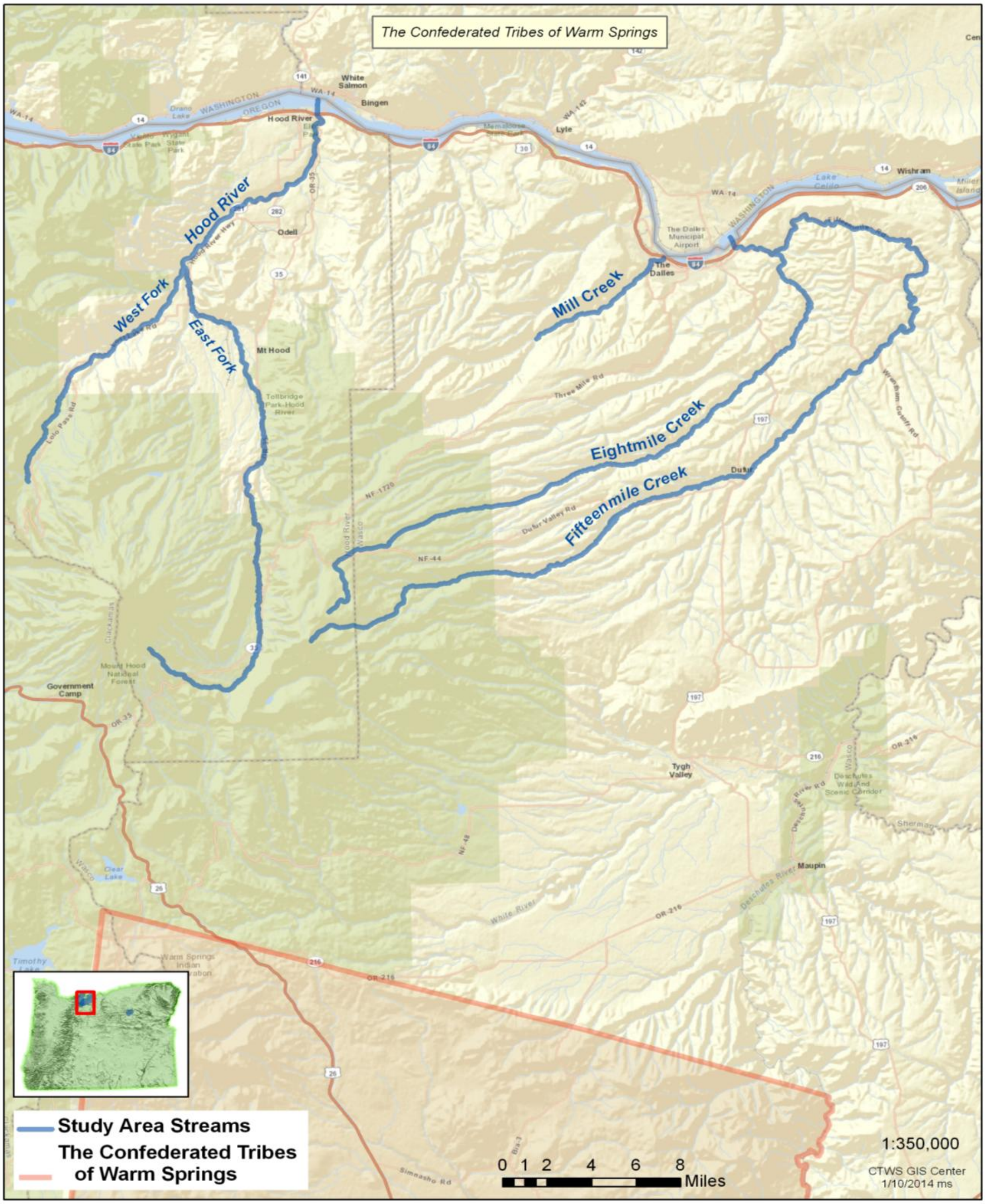

Figure 15. Pacific lamprey research conducted in Mill Creek, Fifteenmile Creek and Hood River Subbasins, 2014.

Hood River discharges into the Columbia River at the City of Hood River (rkm 273, Figure 14). Over half (52%) of the 880 km^2 watershed is in the Mt. Hood National Forest. The West, East, and Middle forks of Hood River originate on Mt. Hood and are strongly influenced by glaciers making it a very flashy river with the majority of its water being regulated by snowmelt. In addition to the Hood River mainstem and the East, Middle and West Forks, major tributaries include Green Point, Indian, Lake Branch, Ladd, Tony, Evans, Neal creeks and Dog River. After the removal of Powerdale Dam (rkm 6.5) in 2010, the ODFW 2013 Fish Passage Priority List does not identify any barriers in the Hood River Subbasin that may affect lamprey, however, recoloniziation of the subbasin is in progress. The Farmers Irrigation District (FID) of Hood River has several diversions within the basin to supply farmers, orchardists, and ranchers with water, which causes the East Fork Hood River to fluctuate dramatically from hour to hour in summer months. Under dry conditions, the East Fork Hood River becomes depleted below the East Fork irrigation diversion. The Farmers Irrigation District stops diverting hydroelectric water from the Hood River during summer months when flows drop below 7 m^3/s (250 cfs) and also annually ceases all diversion from the Hood River for the first two weeks of October, which is a critical time for fish in the Hood River (Coccoli, 2004).

Tissue samples were collected for CRITFC-Hagerman Laboratory based on sample sites from previous years, which were primarily in upper and lower Fifteenmile and Eightmile creeks. In 2014, Fifteenmile and Eightmile Creek tissue sample locations were based on two criteria; 1) site would have an HDX antenna near, 2) site would be near the middle of watershed. These criteria were based on ongoing basin wide genetic analysis, with the assumption that larger fish make it further up tributaries. The other sites, Hood River, Mill Creek, Lower Deschutes, and Moser Creek, were all taken to genetically ID and catalog lamprey samples for future analysis. Sites were chosen based on accessibility and lamprey habitat potential.

Methods

Ammocoete distribution surveys were performed by randomly selecting four 50 m transects above previously known end of distributions in Fifteenmile Creek subbasin, Hood River subbasin and Mill Creek subbasin. Once a 50m transect was selected all type I and type II lamprey habitat was electrofished with an AbP-2 backpack electroshocker (Engineering Technical Services, University of Wisconsin, Madison, WI) for a duration of 90 sec/m^2. Sampling involved two stages, in which 125 V direct current (25% duty cycle) was delivered at three pulses/s to induce ammocoete emergence from substrates (Moser et al., 2007; Pajos and Weise, 1994). After emerging, larvae were stunned with a current of 30 pulses/s for collection (Slade et al., 2003). Habitat type, area sampled, water conductivity and ammocoete presents was documented. End of distribution surveys were completed in the month of September and October.

Non-lethal tissue samples were collected from snipping a small portion of the tail and placing on filter paper (Whatman™ 3MM Chr Chromatography Paper, Fisher Scientific, Pittsburgh, PA). Samples were sent to Columbia River Inter-Tribal Fish Commission Genetics

Laboratory, Hagerman, Idaho, for single nucleotide polymorphism (SNP) genotyping. Diagnostic SNPs were used to distinguish species of morphologically indistinguishable lamprey (Hess et al., 2014).

Results

Larval Distribution

End of distribution for larval lamprey in Fifteenmile Creek was approximately rkm 56 with the upper extent of distribution in Eightmile Creek at rkm 37 (Figure 15). Distribution surveys in Mill Creek found similar results from 2013, fish were found 0.5 km below the confluence of North and South Forks. Two surveys, in the first two miles, in the forks of Mill Creek had no fish. In the Hood River sub-basin, there were no fish present in Middle or West forks. Surveys in Odell, Neal and Indian Creek also had no presents of larval lamprey. However, in the East Fork Hood River Pacific lamprey had extended their range and additional 5.8 rkm above the 2013 location (Figure 15).

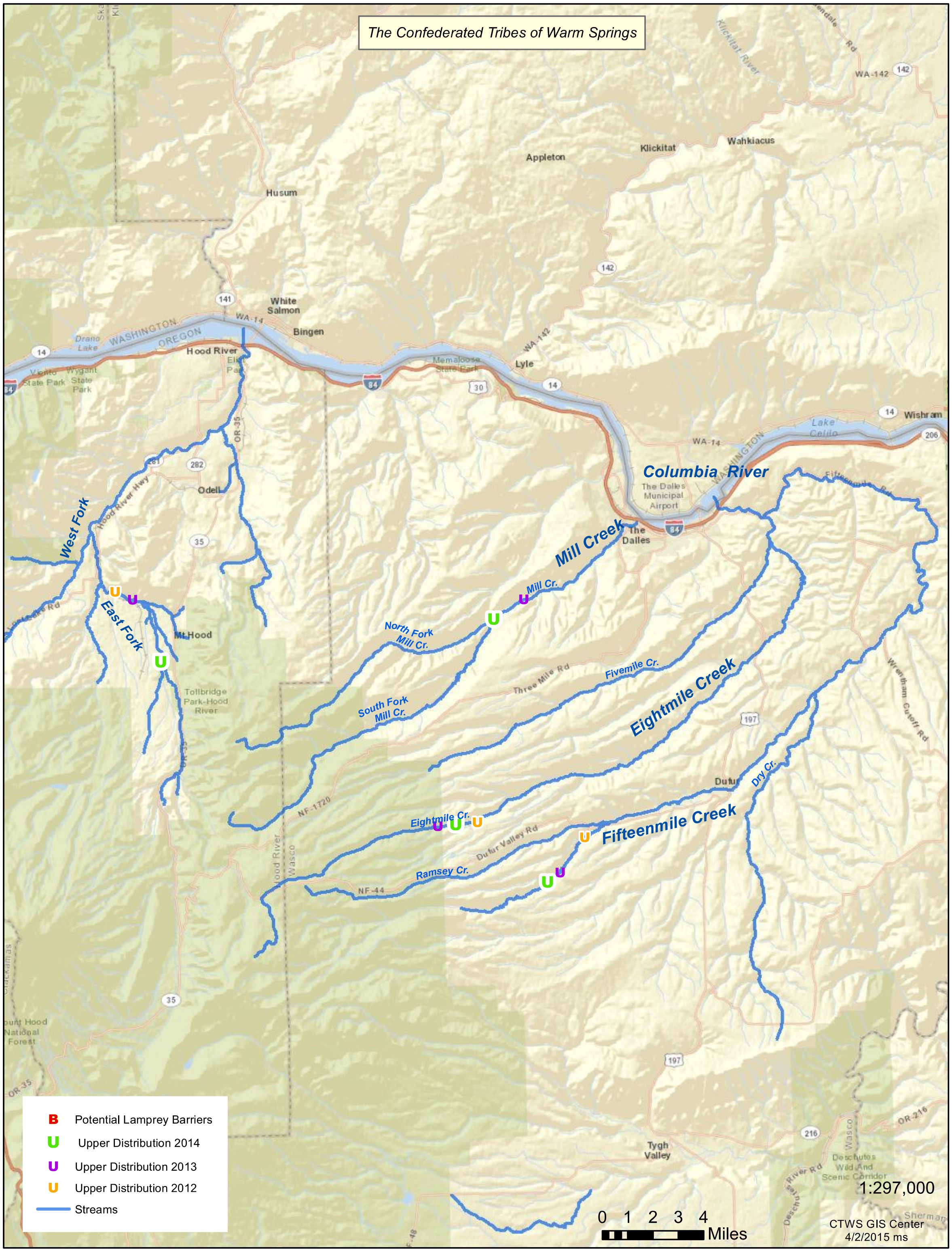

Figure 14. Lamprey distribution survey sites in Hood River, Mill Creek and the Fifteenmile Creek Subbasins, 2014.

Table 10. Results from genetic analysis of lamprey collected in study streams to confirm species identification, 2014.

Stream	Date(s) Sampled	Sample Size	Results
Fifteenmile Creek	December 9	41	41 Pacific
Eightmile Creek	December 9	42	42 Pacific
Mill Creek	December 3	40	40 Pacific
Hood River	December 1	40	40 Pacific
Mosier Creek	December 1	16	8 Pacific; 8 Western Brook
Lower Deschutes R.	December 3	41	41 Pacific

Discussion

Distribution of ammocoetes has been well documented over the course of three years (2012-2014). In Fifteenmile and Eightmile Creeks, spawning adults have been regularly passing the upper most antennas, 57.4 rkm and 29.5 rkm respectively. Though PIT tagged lamprey have not been detected above these locations, end of distribution surveys have shown that fish utilize the upper watershed. This is also true for the Hood River East Fork location, as adults continue to spawn several kilometers above the antenna. However, in Hood River antenna detections are dependent on Bonneville tagged individuals, so it is most likely that fish utilizing the upper spawning areas are unmarked. In 2015, CTWSRO will attempt tagging adults in Hood River with lamprey traps placed near the confluence with the Columbia River. This will increase tagged adult numbers and possibly give useful information as they pass upper antennas since spawning reaches are really unknown.

Genetic analysis of ammocoetes collected have proven that most species utilizing the upper reaches of Fifteenmile and Hood River sub-basins are in fact Pacific lamprey. In 2014, ammocoete distribution was nearly 7 km above the location from 2012. As ammocoete distribution continues to grow in East Fork Hood River, there is still no evidence of distribution into the Middle or West forks. All adult Pacific lamprey caught in 2012 at the ODFW mainstem screw trap were less than 51 cm in length (ODFW, unpublished data). This might possibly be caused by fitness of parental stock being unable to ascend greater stream gradients in the mid to upper reaches of the Hood River. If this is the case, only larger, more fit, adult lamprey may have accessibility. This hypothesis could possibly be addressed as efforts to capture and mark Hood River continue in the upcoming years.

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