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Determining Lamprey Species Composition, Larval Distribution, and Adult Abundance in the Deschutes River, Oregon, Subbasin

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DETERMINING LAMPREY SPECIES COMPOSITION, LARVAL DISTRIBUTION, AND ADULT ABUNDANCE IN THE DESCHUTES RIVER, OREGON, SUBBASIN

2004 Annual Report

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Abstract

Information about lamprey species composition, distribution, life history, abundance, habitat requirements, and exploitation in the lower Deschutes River and it's tributaries is extremely limited. Beginning in 2000, we began a multi-year study to assess the status of lampreys in the Deschutes River subbasin. The project objectives are to determine: larval lamprey distribution and associated habitats; *Lampretra* species composition; numbers of larval emigrants; adult escapement and harvest rates at Sherar's falls.

This report describes the preliminary results of data collected during 2004. We surveyed three perennial eastside tributaries to the Deschutes River (Trout, Bakeoven and Buckhollow creeks) and the mainstem Deschutes. No larval lampreys were collected in the tributaries. However larvae were present in the mainstem Deschutes River between Rkm 24 and 156. The results of 2003-2004 sampling indicate that positive relationships exist between: presence of wood ($P = < 0.001$), depositional area ($P = 0.068$), average water velocity of 0.59 ft/s flow ($P = 0.009$) and fine substrate ($P = 0.009$). Lampreys were observed as ammocoetes, macropthalmia, and adults within the lower Deschutes subbasin.

Multiple samples of ammocoetes were retained for a permanent collection to assist future Confederated Tribes of Warm Springs (CTWSRO) staff with larval lamprey identification. These samples were collected during rotary screw trap operations in Shitike Creek and the Warm Springs River. Rotary screw traps were used to determine outmigration timing in Shitike Creek and Warm Springs River. Outmigrants numbers were not estimated due to our inability to recapture marked larvae. In Shitike Creek peak ammocoete outmigration occurred during December while macropthalmia exited the river in greatest numbers during November. In the Warm Spring River peak outmigration for both ammocoetes and macropthalmia occurred during December.

The abundance of adult Pacific lamprey in the lower Deschutes River was estimated using a two event mark-recapture experiment during run year 2004. Fish were captured with a long handled dip net at Sherar's falls (Rkm 71) from June through August. Each adult lamprey captured in good condition was marked with an individually numbered Floy tag and a single strand or t-bar Floy tag and a fin clip prior to being released downstream of the falls at Rkm 68. Fish were inspected for marks at Sherar's falls during subsequent first event sampling and during tribal harvest monitoring. A modified Peterson model was used to estimate the adult population of Pacific lamprey at 6,412 with an estimated escapement of 4,854 during 2004 (95% CI= 4,749-8,737; $M = 173$; $C = 1{,}473$ $R = 39$). A tribal creel was also conducted from mid-June through August. We conducted 77 interviews with Confederated Tribes of Warm Springs tribal members and estimated the harvest to be approximately 1,558 adult lampreys during 2004 (95% CI= +/- 77).

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Introduction

There are three species of lampreys endemic to the Columbia River Basin (CRB). Two of which, Pacific lampreys and river lampreys, are anadromous (Beamish 1980). The third, western brook lamprey, completes it's lifecycle in freshwater (Beamish et al. 1982). Little information is available on the distribution and abundance of river lampreys or western brook lampreys within the CRB, although, a few studies in Canada have described their biology (Beamish 1987; Beamish 1980; Beamish and Withler 1986; Beamish and Youson 1986; Richards et al. 1982; Vladykov and Follett 1965; and Vladykov and Follett 1958). While life history information is available on Pacific lampreys there are many critical uncertainties (Beamish 1980; Beamish and Levings 1991; Close 1995; Pletcher 1963; Scott and Crossman 1973; van de Wetering 1998). Currently multiple projects are underway in the CRB to address some of these uncertainties (Bayer et al. 2000; 2001; 2002; Close et al. 1995; Close 1998; 1999; 2000; 2001; Jackson 1996; 1997).

Pacific lampreys were once widely distributed throughout the CRB (Kan 1975; Wydoski and Whitney 1979) but have dramatically declined since the 1940's (Close et al. 1995). Sparse information is available on historic lamprey numbers. Dam counts through the CRB have been used to assess declining trends in upstream migrating Pacific lampreys (Kostow 2002). In 1993, the state of Oregon listed Pacific lampreys as a sensitive species and increased their protection status in 1997 (OAR 635-044-0130) (Kostow 2002).

There are many potential factors leading to the decline of Pacific lampreys. Poor mainstem passage is cited as a major cause for the decline (CBPLTWG 1999; Kostow 2002; Long 1968; Vella et al. 1999a; Vella et al. 199b). Lack of "lamprey friendly" screening may also present a problem at hydroelectric facilities (Kostow 2002). Degraded tributary habitat including decreased flows, increased water temperatures, and poor riparian habitat may also explain the apparent decrease in abundance (CBPLTWG 1999; Close et al. 1995).

Many feel the ecological, economic, and cultural significance of Pacific lampreys has been underestimated (Close et al. 1995; CRITFC 1995; Kan 1975; NPPC 1995). For the Native American tribes of the Pacific Coast, Pacific lampreys are an important subsistence, ceremonial, and medicinal resource (Close et al. 1995; CRITFC 1995; Hunn and Selam 1991; Pletcher 1963). The people of Confederated Tribes of Warm Springs Reservation, Oregon (CTWSRO) harvest Pacific lampreys at Sherar's Falls in the lower Deschutes River subbasin. Lack of sufficient numbers of Pacific lampreys for cultural needs have forced tribal harvesters to collect lampreys at alternate spots including Willamette Falls, on the Willamette River, located in Oregon City, Oregon.

Information about lamprey species composition, abundance, habitat requirements, and exploitation in the lower Deschutes River tributaries are extremely limited (Kan 1975; Hammonds 1979; Beamish 1980). In order to formulate an effective recovery plan for Deschutes River lampreys, baseline biological information must first be collected and analyzed. The objectives of this project are to: (1) determine larval distribution and associated habitats in the lower Deschutes River subbasin; (2) determine species composition in the lower Deschutes subbasin; (3) estimate the number of lamprey emigrants, by developmental stage, from Warm

Springs River and Shitike Creek; and (4) conducting a mark-recapture study to estimate the escapement of adult lampreys over Sherar's Falls and estimate the lampreys harvest at Sherar’s Falls.

Study Area

The lower Deschutes River subbasin is located in central Oregon. It drains the east slopes of the Cascade mountain range (approximately 6,993 km^2) with 1,223 km of perennial streams and 2,317 km of intermittent streams. A series of hydro-electric dams begin at Rkm 161. 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 Buck Hollow, Bakeoven, and Trout creeks to the east.

Majority of the perennial tributaries within the lower Deschutes River subbasin originate within the boundaries of the Confederated Tribes of Warm Springs 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 kilometers and draining 54,394 ha. It is the largest tributary to the lower Deschutes River. Major tributaries to the Warm Springs River are Beaver and Mill creeks. Shitike Creek is the third largest tributary to the lower Deschutes River flowing for 48 Rkm and draining 36,000 ha.

Figure 1. Map showing the location of the Confederated Tribes of the Warm Springs Reservation, Oregon.

Section I
Larval Distribution and Habitat Associations

Methods

Larval lamprey distribution and habitat association surveys were conducted from May – August 2004, in perennial tributaries to the lower Deschutes River. Larval lamprey distribution was determined by electrofishing type-I and type-II larval lamprey habitats (Hansen et al. 2003) proceeding from the mouth upstream (Table I-1). If larval lamprey were present a hierarchical random stratified sampling design was used to determine distribution and habitat relationships. The sampling design was developed and successfully utilized by Torgersen and Close (2000) to document larval lamprey distribution and habitat in the John Day subbasin. The sampling methodology consists of three tiers: Level I-stream reach, Level II-transect, and Level III-sub-sample (Figure I-1).

Tier I Stream Reach: Perennial streams were divided into 10 Rkm reaches from the mouth to the upstream extent of perennial stream flow or impassible barriers. Reaches were identified using 1:75,000 quadrant maps digitized in ArcView®. Within each reach, one 60 m long sampling point was randomly selected. Locations of each sample reach were recorded using a Global Position System (GPS).

Tier II Transect: Six transects were located within each Level 1 survey reach. Transects were placed perpendicular to the stream flow. Each transect was located at 10 m intervals.

Tier III Sub-sample: Two sub-samples were surveyed along each Level II transect. Two one meter squared sub-samples was randomly located along each transect. When stream were less than 3 m wide (wetted channel width) sub-samples were located successively in an upstream direction with approximately 1 m between sub-samples.

An AbP-2 Wisconsin electrofishing unit was used to capture larval lamprey within each sub-sample. The unit is specifically designed to capture larval lamprey (O'Neal 1987). Shockers delivered a constant 125 V at a rate of 3 pulse/s with a pulse train of 3:1 (Pajo and Weise 1994). Two, 90 second electrofishing passes were applied to each sub-sample. Captured lamprey were anesthetized with MS-222, measured for length to the nearest mm, and weighed to the nearest $1/10^{th}$ gram. *Lampetra* species were identified (refer to objective 2). Fish were released at the sampling point after recovering from anesthesia. All other species observed during electrofishing were enumerated and recorded.

Habitat and water chemistry data was collected at each tier (Table I-2). Associations of larval lamprey presence with physical habitat characteristics was analyzed using multiple logistic regressions. Results are related to the distribution of larval lamprey to stream characteristics within the range of habitats available in the lower Deschutes subbasin. A GIS map was generated to displaying the distribution of larval lamprey within the surveyed streams (Appendix A).

Table I-1. Type-I, -II, and -III larval lamprey habitat substrate definitions used in eastside Deschutes River tributaries, 2004.

Type	Substrate
I - Preferred	Sand, fine organic matter including detritus and aquatic vegetation
II - Acceptable	Shifting sand, gravel, rubble, little or no organic matter
III - Unacceptable	Bedrock, hardpan clay with rubble and coarse gravel

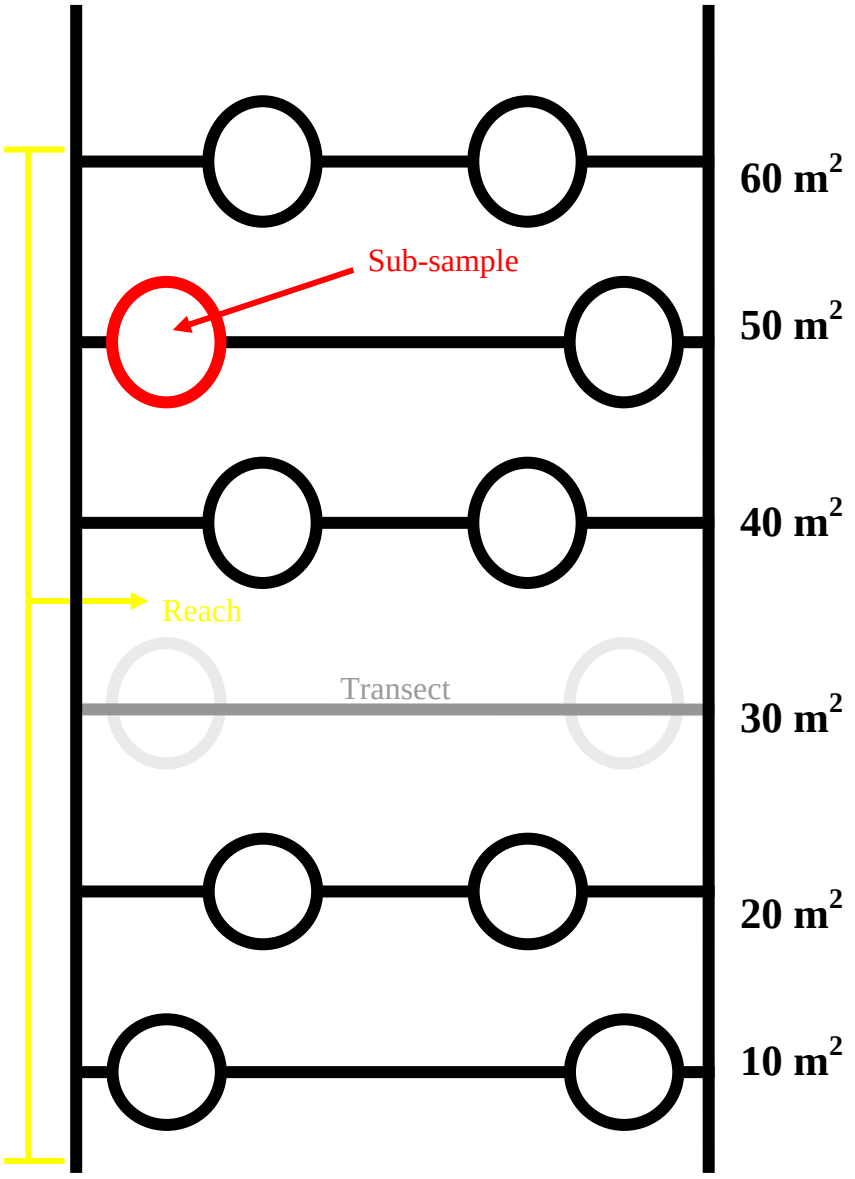

Figure I-1. Diagram of hierarchical random stratified sampling design used in the lower Deschutes River subbasin, 2004.

Results and Discussion

In 2004, eastside Deschutes River tributaries, Bakeoven, Buckhollow, and Trout creeks, were sampled for larval lamprey presence (Table I-3). In Bakeoven Creek, sampling was conducted from the mouth upstream to Rkm 0.25. Although type-I and type-II lamprey habitats were available, no larval lamprey were collected through backpack electrofishing. All type-I and type-II larval lamprey habitats in the lower 2 Rkm of Buckhollow Creek were sampled. No larval lampreys were present. Larval lamprey were also absent from samples in Trout Creek. The inability to get landowner permission to conduct sampling in eastside tributaries restricted our efforts, although, sampling efforts in the lower sections of Buckhollow and Trout creeks should have been sufficient to detect larval lamprey presence. Environmental conditions such as low stream flow and extreme summer water temperatures may explain the absence of larval lamprey from these streams. In good water years, eastside tributaries have perennial flows but in low water years downstream sections of these streams have little or no flow with only residual pools during summer. At Rkm 5.1, in Trout Creek, the Oregon Department of Fish and Wildlife operates a floating rotary screw trap. No larval lampreys have been captured through their trapping efforts to date (T. Nelson, pers. comm.).

The mainstem Deschutes River was also sampled from Rkm 24 – 161 (Table 1-3). Larval lampreys were present upstream from Rkm 24 to the confluence with Shitike Creek at Rkm 158. Above Shitike Creek, sampling was conducted in type-I habitats. No larval lamprey were present above Shitike Creek. There are no perennial streams between Shitike Creek and Rkm 161 where a series of hydro-electric dams are present with no lamprey passage. The lack of perennial streams may attribute to the absence of larval lamprey in this area.

Table I-2. Habitat and water quality data to be collected at each sampling tier in the lower Deschutes River subbasin, 2004.

Habitat and Water Chemistry Parameters	Level I Sample Reach	Level II Transect	Level III Sub-Sample
Conductivity	X		
H_2O Temperature	X		
Mean Water Depth			X
Mean Water Velocity			X
Substrate Type			X
Channel Unit Type (riffle, pool, etc)			X
Wetted Channel Width		X	
Bankfull Channel Width		X	
Channel Slope	X		
Canopy Density		X	

Table I-3. Streams, number of Rkm sampled and larval lamprey presence during larval lamprey distribution surveys in the lower Deschutes River subbasin, 2004.

Stream	Rkm Sampled	Larval Lamprey (Present/Absent)
Bakeoven Creek	0 - 0.25	Absent
Buckhollow Creek	0 - 2	Absent
Mainstem Deschutes River	24 - 161	Present
Trout Creek	0 - 6	Absent

We completed 36 sub-samples in the mainstem Deschutes River. Larval lamprey were present in 10 (27.7%). We collected 11 larval lampreys ranging in size from 21 mm – 105 mm with a mean length of 65.8 mm. Glides and pools represented 66.7% and 33.3% of the habitat sampled. No fast water or alcoves were sampled. Larval lamprey were only present in glides.

To date we have sampled 168 sub-samples in 13 perennial tributaries to the lower Deschutes subbasin as well as the mainstem Deschutes River (Table I-4). Of the 168 sub-samples, 46 (27.4%) contained lamprey. The number of larval lamprey collected at each sub-sample was highly variable. The maximum, minimum, and average number of larval lamprey per sub-sample was 19, 0, and 0.85, respectively. We collected 168 larval lampreys ranging in size from 21 mm – 145 mm with a mean length of 65.7 mm. The mean weight of all larval lampreys collected was 1.2 g with a range of < 0.1 g – 4.7 g.

Water habitat was classified into four categories: alcove, glide, pool and fast water (e.g., riffles, cascades). Within the larval lamprey distribution fast water made up majority (46.4%) of the sub-samples followed by glides (22.6%), pools (16.7%), and alcoves (14.9%). Larval lamprey densities were highest in pools, followed by alcoves, glides and fast water (Table I-5). Lamprey densities were highly variable by stream within the Deschutes River subbasin.

Multiple relationships were found between larval lamprey presence and habitat variables collected. Although relatively weak a positive relationship was found with larval lamprey presence and wood ($P = < 0.001$). Woody debris was not classified by size category (diameter breast height or length), only by presence or absence. We also found that depositional area ($P = 0.068$) may be an indicator of lamprey presence. Depositional area was characterized by the presence of soft substrate (silt or sand), generally containing large amounts of organic debris located near stream margin.

Positive relationships were also found with water velocity ($P = 0.009$) and mean depth of fine substrates ($P = 0.003$). Larval lampreys were collected in water velocities ranging from 0 – 5.47 ft/s with a mean of 0.59 ft/s. They were also collected in a wide range of fine substrate depths (0 – 455.1 mm; mean = 86.4 mm).

Table I-4. Streams, number of reaches and larval lamprey presence during larval distribution surveys in the lower Deschutes River subbasin, 2003-2004.

Stream	Year	Reaches Sampled	Larval Lamprey (Present/Absent)
Badger Creek	2003	3	Present
Bakeoven Creek	2004	0	Absent
Beaver Creek	2003	4	Present
Beaver-Butte Creek	2003	1	Absent
Boulder Creek	2003	2	Absent
Buckhollow Creek	2004	0	Absent
Indian Creek	2003	2	Absent
Mainstem Deschutes River	2004	4	Present
Mill Creek	2003	4	Absent
N. Boulder Creek	2003	1	Absent
Noisy Creek	2003	2	Absent
S. Boulder Creek	2003	1	Absent
S. Fork Warm Springs River	2003	2	Absent
Shitike Creek	2003	3	Present
Trout Creek	2004	0	Absent
Warm Springs River	2003	6	Present
Wilson Creek	2003	1	Absent

Table I-5. Density of larval lamprey per habitat type and stream sampled within the larval lamprey distribution, lower Deschutes River, 2003-2004.

	Larval lamprey/m^2			
Stream	Fast Water	Pool	Glide	Alcove
Badger Creek	0.10	1.00	1.50	0.80
Beaver Creek	0.85	2.63	2.00	*
Shitike Creek	1.64	0.00	*	*
Warm Springs River	0.48	4.00	1.25	0.89
Deschutes River	*	0.00	0.46	*
Total	0.72	1.21	0.82	0.88

* = due to randomly picked sampling areas within each stream not all habitat types were available to be sampled.

Section II
Determine Species Composition of *Lampetra*

Methods

It is currently unknown what *Lampetra* species other than Pacific lamprey are present in the Deschutes River subbasin. Species identification for larval lamprey in the field is problematic due to similar morphologies (Richards 1980, Bond 1977).

During larval distribution surveys lamprey were classified into three developmental categories (A, B and C) based upon similar external morphological characteristics described by Richards et al. (1982). In locations where larval lampreys in stage A were abundant sub-samples were sacrificed and preserved in a 4-5% ethanol solution. Stage A is defined by the presence of an eye (dark spot) and a mouth being fully surrounded by the oral hood.

Specimens of known species will be placed in a permanent collection to aid in species identification during future field surveys.

Results and Discussion

In 2004, we identified Pacific lampreys in three life phases: ammocoetes (larval lamprey), macropthalmia, and adult. Ammocoetes were identified during larval lamprey distribution efforts. Outmigrants (ammocoetes and macropthalmia) were identified in the Shitike Creek and Warm Springs River screw traps. Adult Pacific lampreys were identified at Sherar's Falls during the summer upstream migration.

Specimens were collected during operation of rotary screw traps in the Warm Springs River and Shitike Creek. All larval lampreys collected were stage A Pacific lamprey. A total of 14 samples were collected from the Shitike Creek rotary screw trap and 2 from the Warm Springs River. They will be identified to species in the laboratory at a later date. No western brook or river lampreys were identified.

Section III
Estimate the Number of Lamprey Emigrants

Methods

A 1.5 m cone diameter floating rotary screw trap was operated in Shitike Creek (Rkm 1.2) from April 2004 through January 2005, and March 2005. A 2.4 m cone diameter floating rotary screw trap was also fished in the Warm Springs River (Rkm 1.5) from April through June 2004, September - December 2004, and February - March 2005. Both traps were operated 5 days/week, 24 hrs/day and checked once per day except in high water conditions when the trap was checked more frequently to remove debris. During extreme high or low water conditions the traps were removed.

Captured lampreys were anesthetized with MS-222, identified to species, developmental stage recorded, total length measured, weighed, and checked for anomalies. After recovering from anesthesia lampreys were released below the trap site.

River flows were monitored at USGS gaging stations located in Shitike Creek (USGS gaging station 14093000) and the Warm Springs River (USGS gaging station 14097100) throughout the trapping period. This information will be used to compare emigrant timing with stream discharge to determine if there is a significant relationship among years.

Trap efficiencies were evaluated on the Shitike Creek and Warm Springs River rotary screw traps three times from April 2004 – December 2004. Multiple length classes of lampreys were collected using a backpack electrofisher. Collected lampreys were anesthetized, total length measured, weighed, marked with elastomer dye and placed in the screw trap holding boxes for 24 hours. After 24 hours, marked lampreys were recollected from the holding boxes and the number of lamprey with elastomer marks were enumerated.

Results and Discussion

Shitike Creek
2003-2004

Outmigrant lampreys were collected 65 of the 160 days the rotary screw trap was fished in Shitike Creek (Appendix A). A total of 159 Pacific lampreys were collected in the Shitike Creek trap. Of those, 150 were ammocoetes (94.3% total catch), 6 macropthalmia (3.8%), and 2 adults (1.3%) Pacific lampreys.

The maximum, minimum and mean length of lampreys collected in the Shitike Creek trap was 170 mm, 72 mm and 116 mm, respectively. The length frequency for outmigrants in Shitike Creek is displayed in Figure III-1. Pacific lamprey macropthalmia lengths ranged from 113 mm – 135 mm with a mean of 124 mm. Few macropthalmia (N = 5) may be present in the Shitike Creek screw trap because they are moving into the mainstem Deschutes prior completing their metamorphosis.

Warm Springs River

2003-2004

Outmigrant lampreys were present in the Warm Springs rotary screw trap 89 of 125 days the trap fished. In total 306 Pacific lampreys were collected. Ammocoetes made up majority of the catch at 66.7%, followed by macropthalmia (33.0%), and adults (0.3%).

The maximum, minimum and mean length of Pacific lamprey ammocoetes collected in the Warm Springs River trap was 164 mm, 34 mm and 91 mm, respectively (Appendix A). Pacific lamprey macropthalmia lengths ranged from 77 mm – 220 mm with a mean of 123 mm. Length frequencies for outmigrants can be found in Figure III-2.

Outmigration timing

Peak outmigration was observed during December 2004 for ammocoetes (5/day) and November 2004 for macropthalmia (0.25/day) (Figure III-3). Outmigrant lampreys were collected in the Shitike Creek trap all months it was operated except September 2004. Peak outmigration timing for macropthalmia (12.3/day) and ammocoetes (6/day) in the Warm Springs River was during December 2004 (Figure III-4). Outmigrant lampreys were absent from catches in the Warm Springs River during September 2004 and February 2005.

Trap Holding Efficiencies

Multiple modifications were made to the Shitike Creek screw trap to improve holding efficiencies prior to sampling during 2004. After modifications were completed seasonal (spring, summer, fall) trap holding efficiencies were determined for the Shitike Creek and Warm Springs River traps. In all cases, the holding efficiencies were zero. The number of outmigrants could not be estimated during 2004 due to the lack of trap holding efficiency.

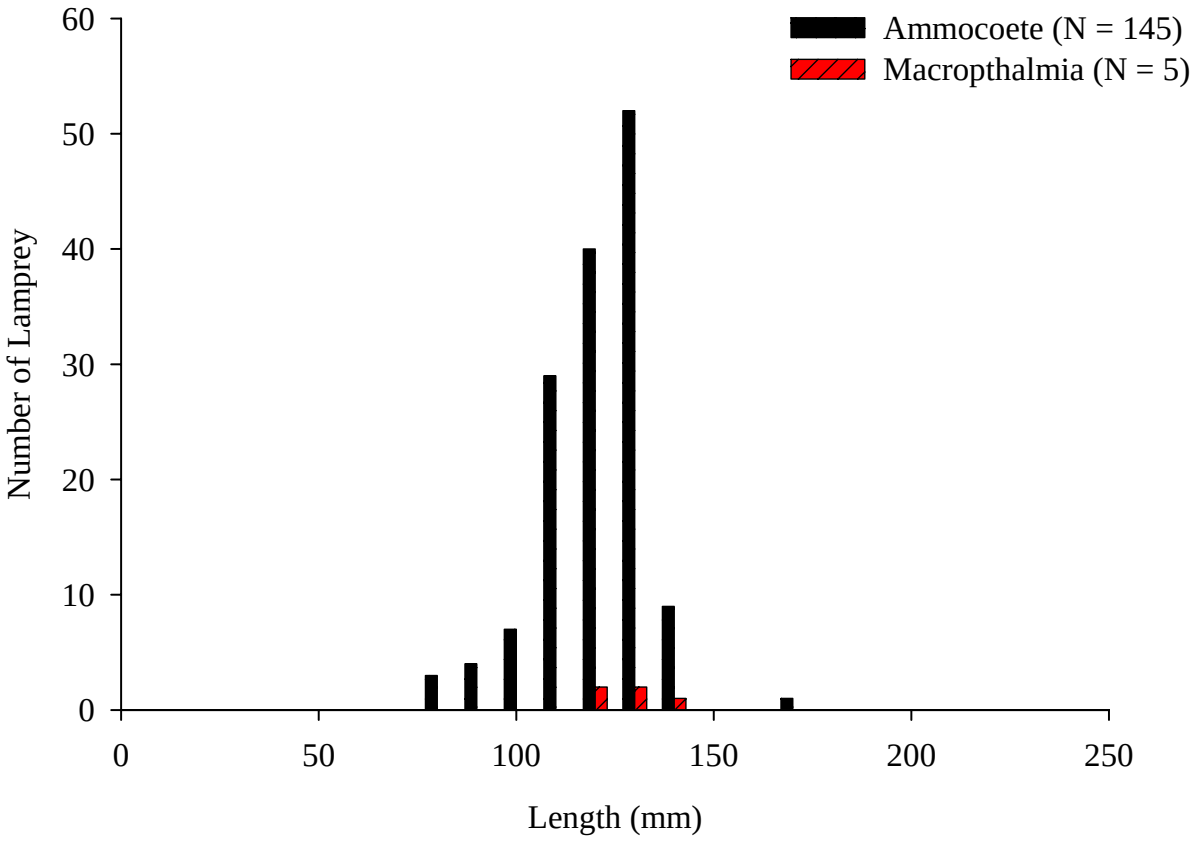

Figure III-1. Length frequency for outmigrants collected in the Shitike Creek rotary screw trap, April 2004 – March 2005.

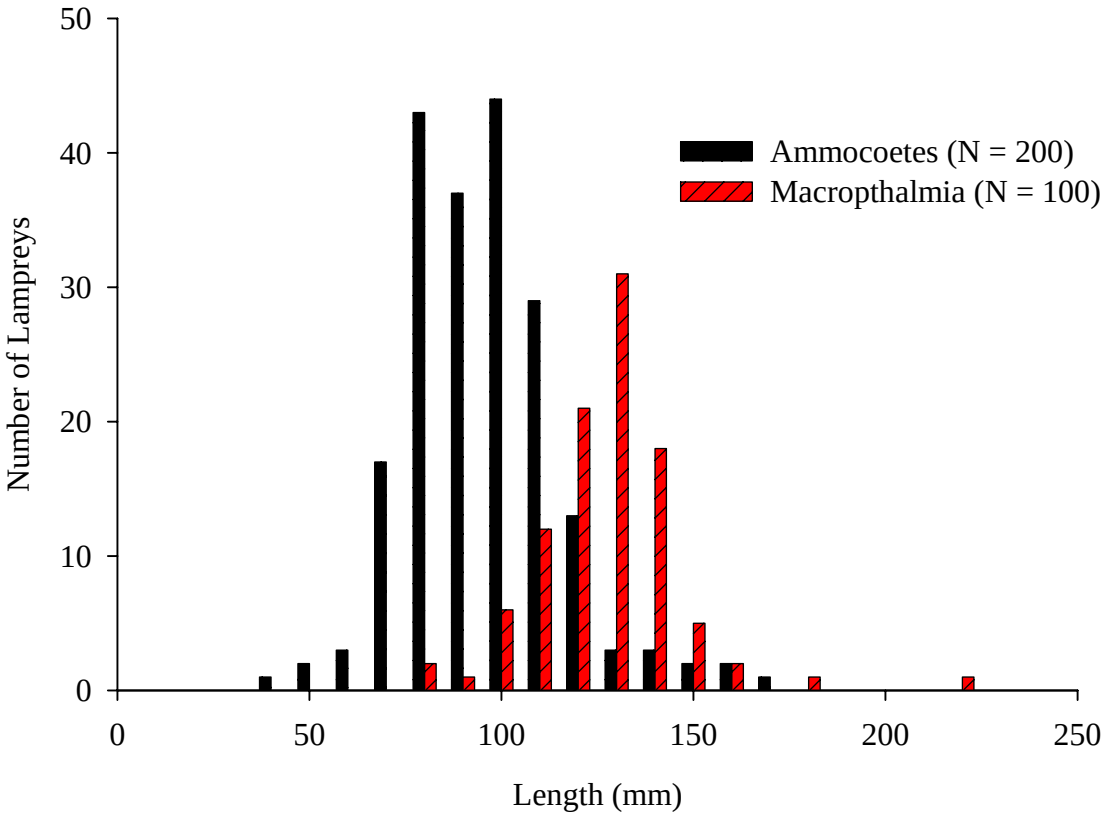

Figure III-2. Length frequency for outmigrants collected in the Warm Springs River rotary screw trap, April 2004 – March 2005.

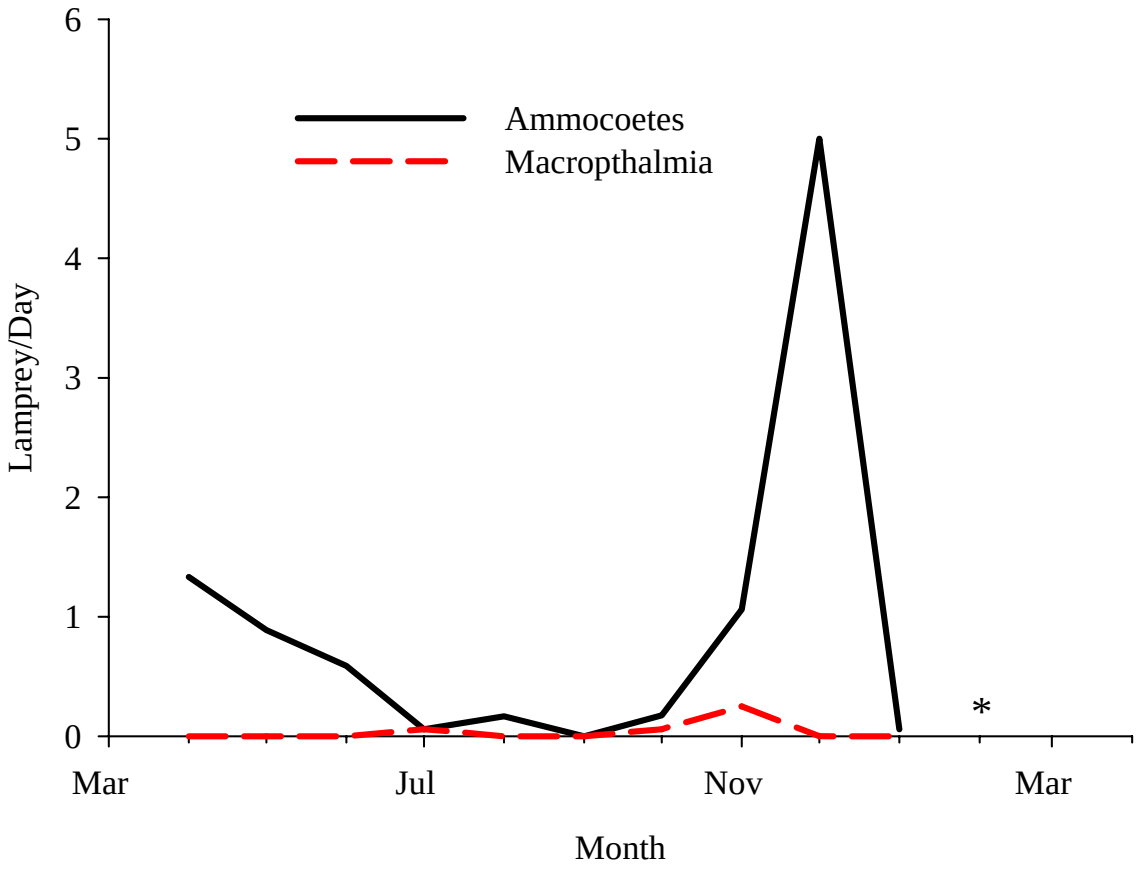

Figure III-3. Out-migration timing for ammocoetes and macropthalmia in Shitike Creek, April 2004 - March 2005. *- month the trap was not operated.

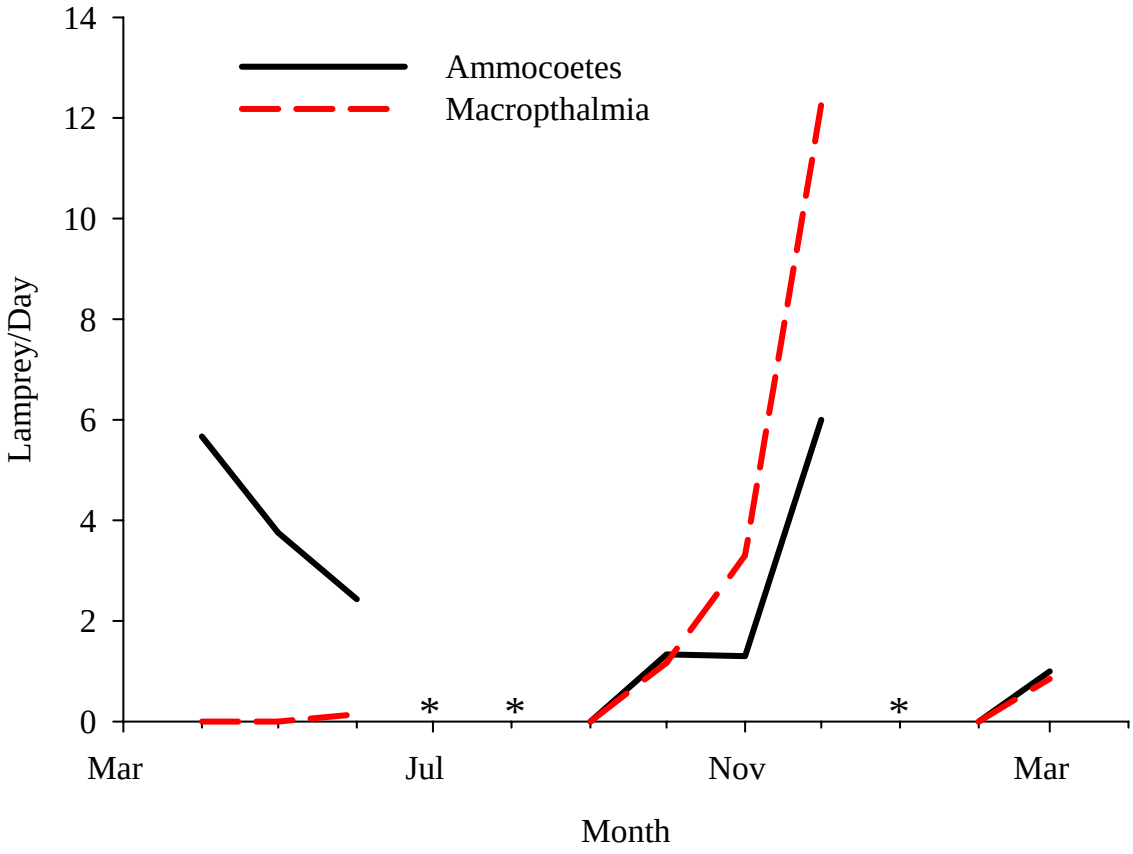

Figure III-4. Out-migration timing for ammocoetes and macropthalmia in the Warm Springs River, April 2004 – March 2005. * - months the trap was not operated

Section IV
Adult Escapement Estimation and Harvest Monitoring

Methods

A systematic approach was developed to collect adult Pacific lamprey using a long-handled dip net at the Sherar's Falls fish ladder located at Rkm 71 (Figure IV-1). Each pool of the fish ladder was dipped once per hour, 4 - 8 hours per night. Dipping occurred in the same location during each sampling event. An elapsed time dipping protocol was used to standardize effort. Sampling occurred 7 nights per week from mid June - July and 5 randomly selected nights per week in August.

Abundance of adult Pacific lamprey was estimated using Chapman's modification of the Petersen estimate (Seber 1982)**.** Estimated abundance (*N**) was:

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

calculated where *M* is number of fish marked in the first sampling event, *C* is the number of fish inspected for marks and *R* is the number of fish inspected for marks in the second event that possess marks applied in event 1.

Chapman's modified estimate uses a Poisson approximation to the hypergeometric distribution and approaches a minimum variance unbiased estimator of population size with a variance approximated by:

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

where $\mu = MC / N$

Figure IV-1. Long-handled dip net used to collected adult lampreys at Sherar's Falls, 2004.

The general assumptions that must hold true for N^* to be a suitable estimate are:

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

To test whether or not assumptions 1 and 2 were violated Mann-Whitney sum test (alpha = .05) were performed on length distributions between sampling events. All Pacific lamprey marked at the Sherar's Falls fish ladder were transported and released downstream of the fish ladder allowing them to mix with other upstream migrating lampreys (Assumption 3). Since tagging occurred throughout majority of the run, recruitment into the experimental population was minimal therefore assumption 4 was not violated. It is likely that a small number of adult Pacific lamprey may have entered the experimental population after the completion of the first event sampling. However, first event sampling ceased when the number of adult Pacific lamprey present in the fish ladder was near zero. Assumption 5 was not violated because there was no direct mortality from dipnetting. While indirect mortality cannot be evaluated we assume it was negligible because only fish in good condition were marked and released. There were no reports of deceased marked adult Pacific lamprey downstream of the first event sampling site during the marking phase of the experiment. The effect of tag loss (assumption 6) was greatly reduced by using two secondary marks. Some marked fish were recovered missing the primary tag however one of the secondary marks was always present.

In conjunction with the mark-recapture study we conducted a single, access site creel survey to estimate tribal harvest of adult Pacific lamprey at Sherar's Falls. Creeling occurred from mid-June though August. From mid June - July creeling occurred 7 nights per week and 5 randomly selected nights per week in August. Creel surveys occurred from 9 pm until tribal fisherman completed collection or 4 am, whichever occurred first. Samplers examined all harvested lamprey for marks and recorded total lengths. The number 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 harvest was expanded from each sampling day by:

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

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

Variance was approximated each sampling week by:

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

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

Study Area

Sherar's Falls is located downstream of all perennial tributaries to the Deschutes River at Rkm 71 (Figure IV-2). A fish ladder around the falls is utilized by upstream migrating adult Pacific during the summer.

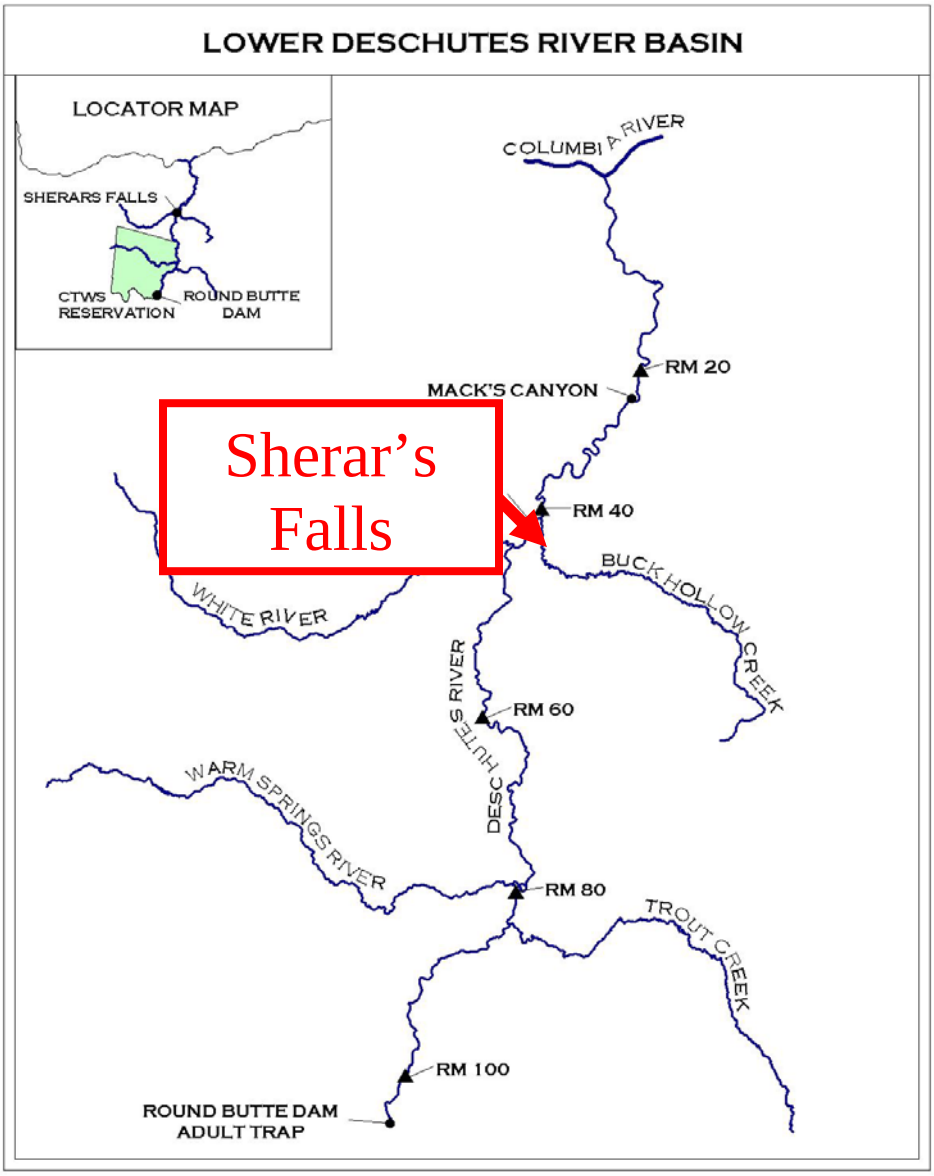

Figure IV-2. Location of Sherar's Falls within the lower Deschutes River subbasin.

Results and Discussion

Adult Pacific Lamprey Escapement Estimate

A total of 173 adult Pacific lamprey were captured from June 18, 2004 - August 13, 2004. All adult Pacific lamprey collected were in good condition during first event sampling and marked with two Floy tags and received a fin clip.

A total of 1,474 adult Pacific lampreys were inspected for marks during 2004. Of those, 39 (22.5%) lampreys were recaptured. Of the 39 recaptured, 1 (2.6%), 33 (84.6%), and 5 (12.8%) were recaptured through long-handled dipnetting, tribal creel, and tribal member tag returns, respectively.

Assumptions 1 and 2, that all adult lampreys have an equal probability of being marked or inspected for marks was met. A Mann-Whitney sum test (P = 0.99) found no significant difference between the length of adult Pacific lamprey marked and inspected (Figure IV-3).

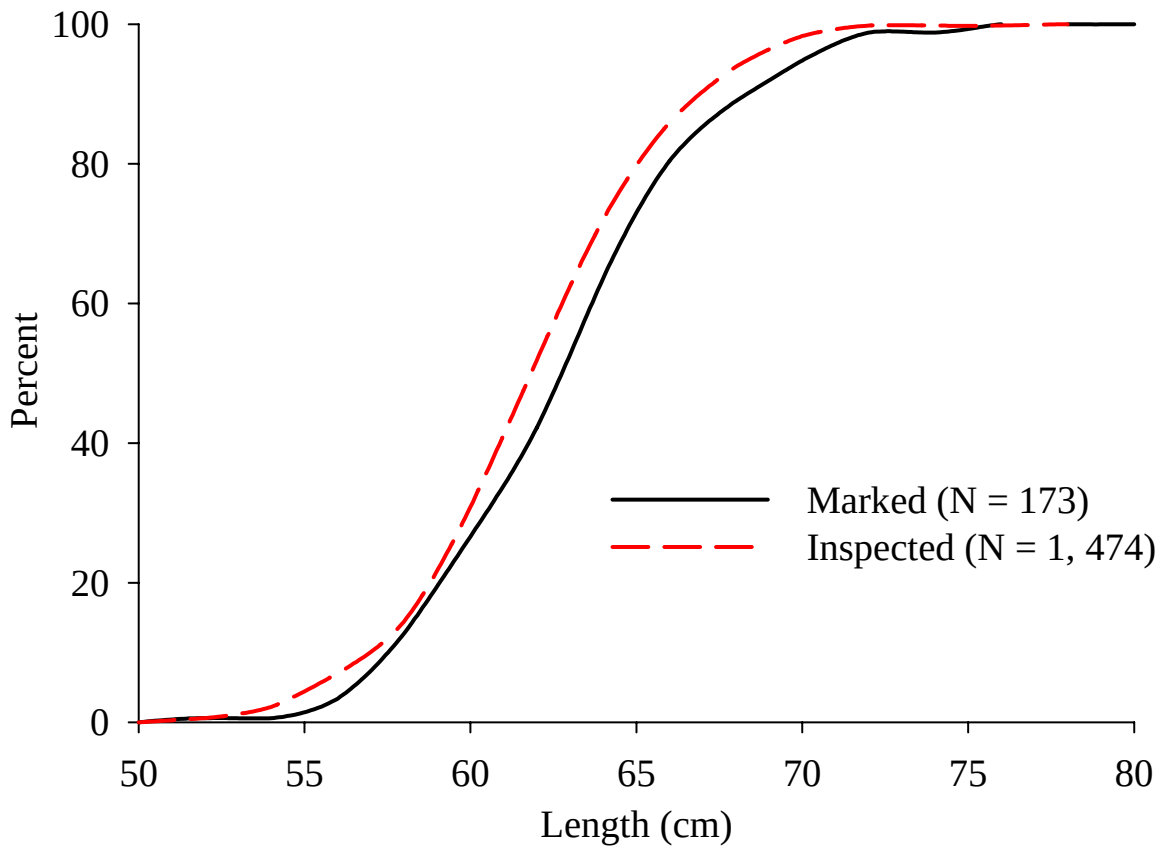

Figure IV-3. Cumulative length frequencies of adult Pacific lamprey marked versus inspected at Sherar's Falls, 2004.

The effects of tag loss (assumption 6) was greatly reduced by using multiple marks. All lamprey were tagged with a combination of individually numbered tags, t-bar tag or single strand Floy tags. Tag retention rates were calculated based on the presence of a fin clip and tag wound for adult Pacific lamprey recaptured at Sherar's Falls. Three of the 39 (7.7%) fish recaptured had lost all tags. Floy tag retentions rates for numbered, t-bar, and single strand were 84.6%, 42.9%, and 72.0%, respectively (Table IV-1). Based on recaptured fish with number tags, it is estimated that lamprey returned to Sherar's Falls 3.9 - 16.9 days after marking (Appendix C).

The population estimate for adult Pacific lampreys in the Deschutes River during 2004 was 6,412 (SE = 863) (Table IV-2). The escapement of adult Pacific lamprey at Sherar's Falls is estimated at 4,854.

Tribal Harvest Monitoring

A total of 77 interviews were conducted with tribal harvesters from June 28, 2004 – August 16, 2004 (Table IV-3). We inspected and measured 1,473 adult Pacific lampreys. Total tribal harvest of adult Pacific lamprey was estimated to be 1,558 (+/- 77). The exploitation rate was estimated at 23.0%. Descriptive statistics and length frequency histograms can be found in Appendix D.

Table IV-1. Floy tags used to tag adult lamprey at Sherar's Falls, 2004.

Tag Type	Picture	Retention
Numbered Floy Tag		84.6%
T-Bar Floy Tag		42.9%
Single Strand Floy Tag		72.0%

Table IV-2. Adult Pacific lamprey population estimate in the lower Deschutes River, 2004.

No. of Adults Tagged	No. of Adults Inspected	No. of Tag Recoveries	Population Size	Variance	Standard Error	Relative Precision
173	1,473	39	6,412	751,271	863	26.5

Table IV-3. Summary of adult Pacific lamprey tribal harvest creel at Sherar's Falls, 2004.

Dates	Interviews Conducted	Lamprey Creeled	Estimated Harvest
6/28/2003 - 8/16/2004	77	1,473	1,558 (+/- 77)

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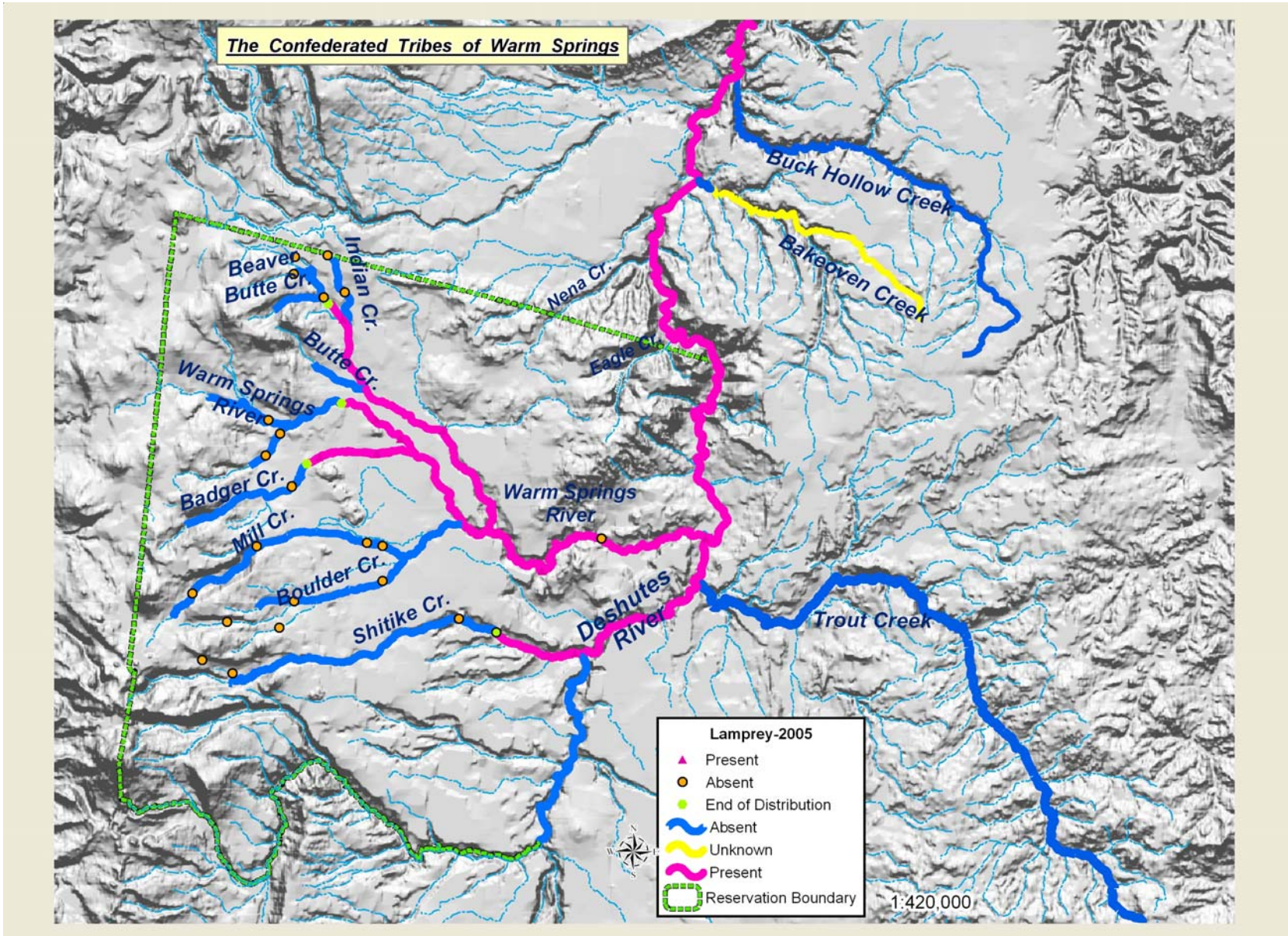
Appendix A

Larval Lamprey Distribution within the lower Deschutes River subbasin



Appendix A; Figure 1. Larval lamprey distribution in the Deschutes River subbasin, 2003-2004.

Appendix B

Outmigrant Lamprey Descriptive for the Shitike Creek and Warm Springs River Rotary Screw Traps April 2004-March 2005

Appendix B; Table 1. Length (cm) statistics for outmigrant lampreys collected in the Shitike Creek rotary screw trap, April 2004 – March 2005.

	Shitike Creek	
	Ammocoetes	Macropthlamia
Sample Size	145	5
Mean Length	115.98	124.20
Standard Deviation	12.96	8.59
Standard Error	1.08	3.84
C.I. Of Mean	2.13	10.66
Max Length	170	135
Min Length	72	113
Median Length	118	123
Skewness	-0.45	-0.02
Kurtosis	2.71	-0.92
K-S Distribution	0.10	0.16
K-S Probability	0.002	0.74

Appendix B; Table 2. Length (cm) statistics for outmigrant lampreys collected in the Warm Springs River rotary screw trap, April 2004 – March 2005.

	Warm Springs River	
	Ammocoetes	Macropthlamia
Sample Size	203	101
Mean Length	90.73	122.95
Standard Deviation	19.59	18.25
Standard Error	1.39	1.83
C.I. Of Mean	2.73	3.62
Max Length	164	220
Min Length	34	77
Median Length	90	122
Skewness	0.69	1.39
Kurtosis	1.79	7.70
K-S Distribution	0.07	0.02
K-S Probability	0.02	0.002

Appendix C

Adult Pacific lamprey movement rates from Buckhollow Landing to Sherar's Falls

Appendix C; Table 1. Recaptured adult Pacific lamprey movement rates from Buckhollow Landing to Sherar's Falls, 2004.

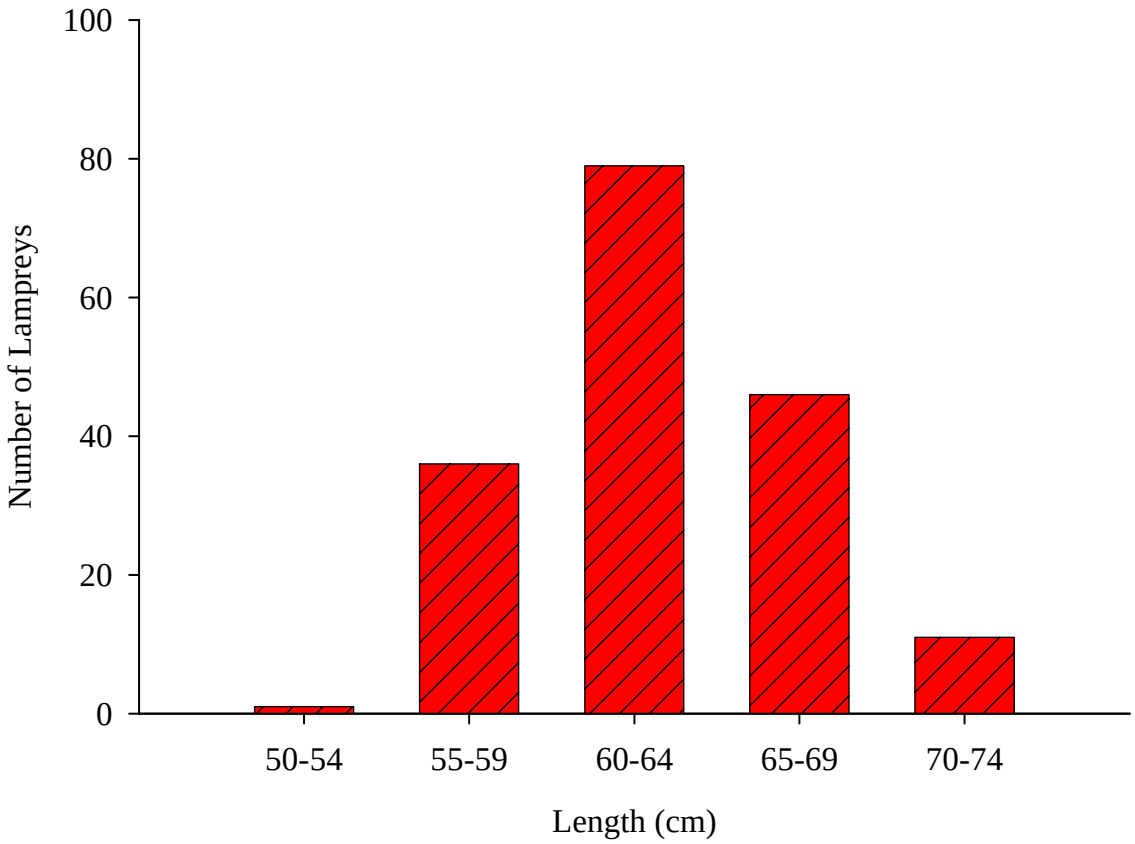
Mark Date	Tag No.	Length (cm)	Girth (mm)	Recapture Date	Days to Return	Movement Rate (Rkm/day)
06/22/04	4	62.0	106	06/28/04	6.94	0.29
06/22/04	5	59.0	107	06/28/04	6.94	0.29
06/26/04	8	65.0	120	07/12/04	16.94	0.12
07/01/04	9	66.0	110	07/09/04	8.91	0.22
07/04/04	13	66.0	118	07/09/04	4.08	0.49
07/07/04	22	60.0	100	07/15/04	8.92	0.22
07/07/04	25	62.0	115	07/11/04	4.94	0.40
07/07/04	28	63.0	102	07/11/04	4.03	0.50
07/13/04	36	57.0	104	07/18/04	4.04	0.49
07/13/04	37	64.5	105	07/19/04	6.03	0.33
07/14/04	47	63.0	100	07/20/04	6.95	0.29
07/14/04	55	59.5	110	07/18/04	3.92	0.51
07/25/04	65	64.5	114	08/02/04	7.91	0.25
07/25/04	66	65.5	107	08/07/04	12.98	0.15
07/27/04	76	63.0	101	08/03/04	7.02	0.28
07/28/04	88	65.0	115	08/02/04	5.83	0.34
07/29/04	95	60.5	110	08/02/04	4.00	0.50
07/29/04	102	64.0	100	08/11/04	12.08	0.17
07/30/04	115	61.5	112	08/07/04	8.93	0.22
07/30/04	121	62.5	98	08/13/04	13.04	0.15
07/31/04	130	56.5	100	08/03/04	3.94	0.51
08/08/04	146	71.0	120	08/14/04	5.06	0.40
08/09/04	152	66.5	105	08/14/04	4.98	0.40
08/09/04	153	71.5	110	08/13/04	3.95	0.51
08/09/04	158	61.0	96	08/14/04	4.98	0.40
08/09/04	160	68.0	102	08/14/04	4.98	0.40
08/09/04	164	63.0	110	08/14/04	4.93	0.41

Appendix D

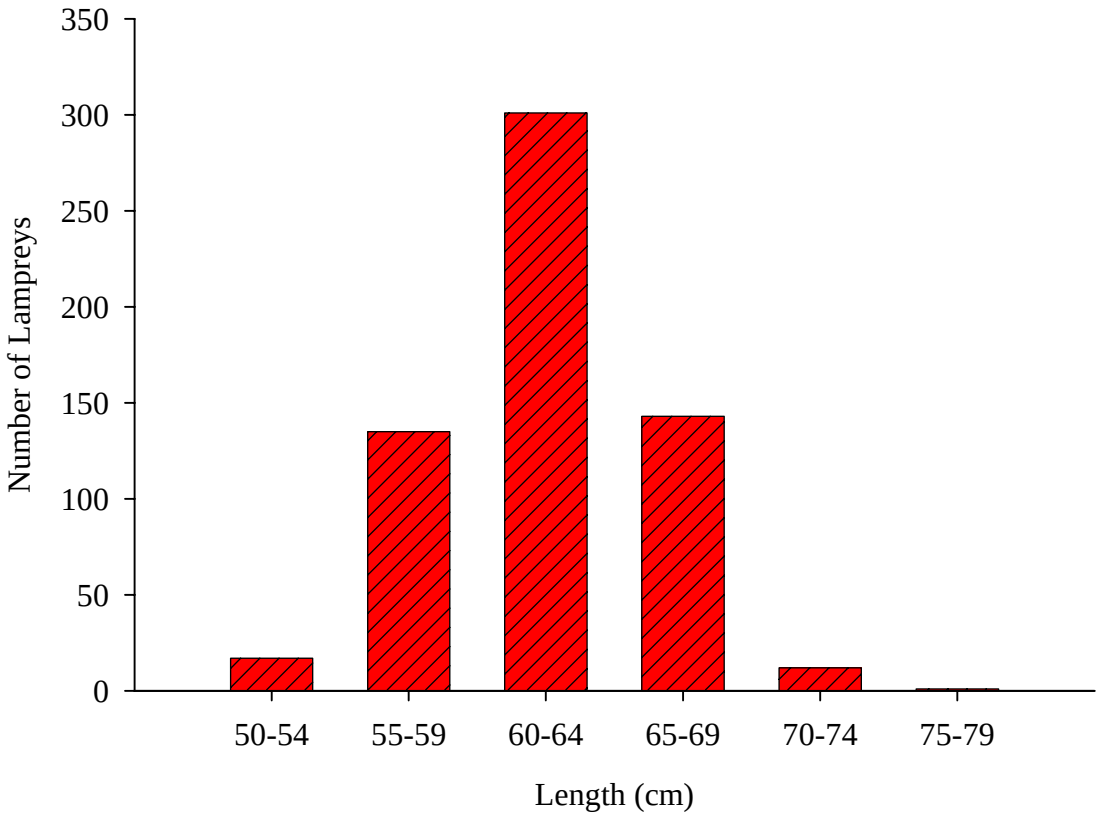
Adult Pacific Lamprey Length Statistics and Frequencies in the lower Deschutes River, at Sherar's Falls, 2004.

Appendix D; Table 1. Length (cm) statistics for adult Pacific lampreys collected at Sherar's Falls though dipnetting and tribal harvest, 2003-2004.

	Dipnetting		Tribal Harvested	
	2003	2004	2003	2004
Sample Size	199	173	543	604
Mean Length	61.89	63.08	62.10	62.22
Standard Deviation	4.51	4.09	4.52	3.82
Standard Error	0.32	0.31	0.19	0.16
C.I. Of Mean	0.63	0.61	0.38	0.31
Max Length	73	74.5	74	77
Min Length	51	52	50	51
Median Length	62	63	62	62
Skewness	-0.01	0.24	-0.18	0.01
Kurtosis	-0.67	0.01	-0.16	0.12
K-S Distribution	0.08	0.06	0.06	0.05
K-S Probability	0.003	0.13	< .001	0.005



Appendix D; Figure 1. Length frequency for adult Pacific lamprey collected using a long-handled dip net at Sherar's Falls, 2004.



Appendix D; Figure 2. Length frequency for adult Pacific lamprey collected through tribal harvest at Sherar's Falls, 2004.