Summary Assessment of Larval/Juvenile Lamprey Entrainment in Irrigation Diversions within the Yakima Subbasin, 2017

[Cover Photo: A Pacific Lamprey macrophthalmia (eyed smolt) trapped on a dewatered bank at Wapatox Diversion, Naches River on November 1, 2017]

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ABSTRACT

A total of 14 irrigation diversions were surveyed within the 2017 irrigation season in the Yakima Subbasin; six in Yakima River, one in Toppenish Creek, five in Ahtanum Creek, two in Naches River. Irrigation diversions often provide preferred refuge habitat to hundreds of thousands of larval/juvenile lampreys moving downstream, until dewatering takes place in summer or fall season. When the diversions are dewatered after the irrigation season, the entrained lampreys are left to desiccate in or on top of dried fine sediment unless salvage occurs in a timely fashion. Larval lamprey salvage surveys were conducted with the following objectives; 1) efficiently salvage as many larval/juvenile lampreys as possible and return them to their respective stream downstream of the diversion, 2) check dried banks closely for desiccated lampreys, and 3) understand lamprey distribution and densities upstream and downstream of the fish screens. In addition, we evaluated the ratio of entrained Pacific Lamprey versus Western Brook Lamprey within each of the surveyed irrigation diversion facilities. Genetic samples were opportunistically collected from Pacific Lamprey with the primary objective of monitoring the success of adult Pacific Lamprey translocation projects and from Western Brook Lamprey with the primary objective of evaluating the genetic diversity and its relationship to morphological traits.

In total, 8,234 larval/juvenile lampreys were captured and returned to the following respective rivers/streams from electrofishing surveys; Yakima (n=6,291), Ahtanum (n=1,719), Naches (n=94), and Toppenish (n=65). Captured lampreys constituted only 50.5% of all observed lampreys (i.e. approximately 49.5% of lampreys were missed). More lampreys (82.5%) were captured upstream compared to downstream (17.5%) of fish screens. However, the high ratio of captured lampreys upstream of the fish screens is primarily driven by the high numbers of captured lampreys from Wapato Diversion in 2017 (4,885). Also, surveys were focused in areas upstream of the fish screens (in areas with the highest densities of lampreys) and the total area surveyed was 2.8 times higher upstream than downstream. The maximum observed density upstream of the fish screens was at Wapato Diversion, located along the bank of the dewatered sediment (110.0 $\#/m^2$). The maximum observed density downstream of the fish screens was at Sunnyside Diversion, located in an isolated pool of water (55.0 $\#/m^2$). A total of 8,733 dead or nearly dead lampreys (51.5% of total lampreys captured) were found on dewatered banks or on top of partially wetted fine sediment from all salvage surveys.

Larval lamprey were found at 13 of 14 (92.9%) of the visited irrigation diversions. Of the diversion where lampreys were found, Pacific Lamprey was present at 11 of 13 (84.6%) diversions. The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was high at Diversion 14 (80%), Bachelor-Hatton (100%), and Upper WIP (83%) diversions in Ahtanum Creek (river km 24.8, 31.8 and 32.8, respectively). In the Yakima River, the ratio of Pacific Lamprey ranged from 4% (Selah-Moxee Diversion, river km 203.6) to 30% (Wapato Diversion, river km 176.3); the ratio at Sunnyside Diversion was also high (27%). Pacific Lamprey were also found in a high ratio (25%) at Town Diversion (located at river km 264.7, upstream of Roza Dam). The ratio of Pacific Lamprey has

been increasing steadily since 2010 at Sunnyside and Wapato diversions from approximately 0% from 2010-2013, ~3% in 2013-2014, 7.0% in 2014-2015, 15% in 2015-2016, 33% in 2016-2017 to 29% in 2017-2018. Adult lamprey translocation began in 2013 in Ahtanum Creek (which flows into Yakima River upstream of Wapato and Sunnyside diversions) and the ratio of Pacific Lamprey appears to roughly double each consecutive year since this restoration program began. A total of 6 Pacific Lamprey macrophthalmia (smolt stage with eyes) were collected from the following irrigation diversions; four from Sunnyside (Yakima River), one from Wapato (Yakima River), two from Bachelor-Hatton (Ahtanum Creek), three from Upper WIP (Ahtanum Creek), and two from Wapatox (Naches River). A total of 99 genetic samples were collected from captured larval/juvenile lamprey from diversions.

INTRODUCTION

Pacific Lamprey (*Entosphenus tridentatus*), a species of high cultural and ecological value, is declining in population abundance and distribution throughout the Columbia River Basin. One of the major threats facing Pacific Lamprey are irrigation diversions, many of which provide preferred, yet in effect misleading, refuge habitat to hundreds of thousands of larval/juvenile lampreys moving downstream. When the diversions are dewatered after the irrigation season, the entrained lampreys (which are buried in the fine sediment) are left to dry up unless salvage efforts are put in place to rescue them. In 2017, larval lamprey salvage surveys were conducted in the Yakima Subbasin with the following primary objectives; 1) efficiently salvage as many larval/juvenile lampreys as possible and return them to their respective stream, 2) check dried banks closely for desiccated lampreys, and 3) understand lamprey distribution and numbers upstream and downstream of the fish screens. In addition, we evaluated the ratio of entrained Pacific Lamprey versus Western Brook Lamprey within each of the surveyed irrigation diversion facilities. By understanding the ratio of Pacific lamprey in these diversions, we can start to assess the overall impact of irrigation diversions on Pacific Lamprey at the larval/juvenile life stages. Monitoring this impact will be crucial to improving future Pacific Lamprey management and restoration efforts.

METHODS

The Yakama Nation Pacific Lamprey Project surveyed 14 dewatered irrigation diversions within the Yakima Subbasin for larval/juvenile lampreys primarily from October 15, 2016 to November 21, 2017. Dewater electrofishing surveys were also conducted in July of 2017 in Ahtanum Creek, during the annual shut time in Ahtanum Creek. Irrigation diversions were surveyed as close as possible to the initial dewatering date to limit additional loss of lampreys from desiccation and/or predation (with the exception of some diversions that require multiple days of dewatering to access optimal lamprey habitat). Diversions which have had relatively high entrainment from past surveys were given priority. As in previous years, we focused salvage efforts at two major Yakima River irrigation diversions with known high densities of lampreys; Wapato Diversion (immediately upstream of the fish screens) and Sunnyside Diversion (immediately downstream of the fish screens). In addition to these two diversions, salvage efforts were also focused at Bachelor Hatton Diversion (both upstream and downstream of the fish screens), and Wapatox Diversion (immediately downstream of the headgate) due to large and unexpected numbers of Pacific Lamprey observed in 2015, 2016 and continuing in 2017. Additional diversions were surveyed based on dewatering schedule and available time.

An AbP-2 Backpack Electrofisher (ETS Electrofishing Systems Inc., Madison, WI), specially designed for the sampling of larval lampreys, was used to survey available (wetted) larval habitat, using standard survey methods (slow tickle pulse of 3 pulses/sec and fast stunning pulse of 30 pulses/sec, 25% duty cycle, 3:1 burst pulse train, and 125 volts). When water temperature was ~10°C or lower, the voltage was increased to a maximum of 200 volts. Another person, or sometimes several persons, equipped with a fine-mesh hand net was also present to help capture any electrofished larvae. Type I / II larval lamprey habitat (preferred and acceptable, respectively) was surveyed at each diversion, with Type I habitat given priority (Type II was surveyed primarily when Type I was limited or for subsampling and extrapolation purposes). Specific survey locations in each diversion (the area immediately upstream or downstream of the fish screens, and if time allowed, the respective canal areas) were determined based larval lamprey habitat availability.

Electrofishing surveys were conducted separately within Type I and Type II larval habitat. In many cases, multiple plots were surveyed within respective areas in order to best capture the variance in larval densities. Records of survey (shocking) time, area surveyed (m^2), and total numbers of electrofished lamprey (captured and missed) were recorded separately by habitat type. Captured lampreys were tallied by life stage and identified to species (if of identifiable length generally > 50 mm). Missed larvae were also quantified to determine the total number of observed lampreys per survey area. Lamprey density (lamprey/m^2) was obtained from the total number of observed lamprey (which is a combination of captured and missed lampreys) and the electrofished area (m^2). Catch per unit effort (CPUE) was calculated from the electrofishing time (minutes) and the number of capture lampreys.

In addition, dried sediment banks were searched for desiccating larval lamprey. Lampreys collected from dry banks were tallied separately from those collected in wetted areas. Lampreys found on the bank were tallied separately by live and dead, life stage, and if of identifiable length (and not decomposed), identified to species. Genetic samples were collected opportunistically from Pacific Lamprey from diversions in the Yakima, Ahtanum and Naches rivers/streams.

RESULTS

Table 1. Summary of larval/juvenile lamprey salvage efforts in dewatered diversions in the Yakima Subbasin. Under survey location, “Upstream” and “Downstream” includes all areas surveyed upstream or downstream of the fish screens, including respective canal areas further away, if surveyed. “Total # Observed” includes not only lampreys that were captured but also those that were observed but not captured. “Total # Dead on Bank” is the number of dead lampreys collected from dry, dewatered banks. “Total # Live on Bank” is the number of live lampreys collected from dry, dewatered banks. “Max E-Fish Density” is the maximum density of adjusted observed lampreys from all electrofishing surveys in the respective area. “Max CPUE” is the maximum CPUE (Catch Per Unit Effort) from all surveys conducted at the respective location (calculated from the number of captured lampreys and the shock time in minutes).

Watershed	Stream	Diversion Name	River km	Survey Location	# of Survey Visits	Total Survey Area (m^2)	Total Shock Time (min)	Total # Captured (E-Fish)	Total # Observed	Total # Live on Bank	Total # Dead on Bank	Total # on Bank	Max E-Fish Density (#/m2)	Max CPUE (L/min)
Lower Yakima	Yakima	Sunnyside	173.4	Upstream	2	19	18	63	77	98	41	139	7.1	7.1
				Downstream	2	93	105	977	1213	875	3736	4611	55.0	39.2
Lower Yakima	Yakima	Wapato	176.3	Upstream	9	262	227	4885	10431	1291	2101	3392	110.0	71.2
				Downstream	1	8	8	27	43	0	0	0	11.0	9.4
Lower Yakima	Yakima	Union Gap	189.8	Upstream	1	10	8	7	10	0	0	0	0.7	0.8
				Downstream	0	-	-	-	-	-	-	-	-	0.0
Lower Yakima	Yakima	Selah-Moxee	204.0	Upstream	1	55	51	124	144	0	0	0	2.4	2.6
				Downstream	1	20	15	48	55	0	0	0	2.4	3.1
Upper Yakima	Yakima	Roza	210.6	Upstream	0	-	-	-	-	-	-	-	-	0.0
				Downstream	1	28	26	117	159	0	0	0	7.8	7.9
Upper Yakima	Yakima	Town	264.7	Upstream	1	22	23	38	59	0	0	0	2.0	1.9
				Downstream	1	5	5	5	5	0	0	0	1.0	1.0
Lower Yakima	Toppenish	Olney	176.3	Upstream	2	22	22	64	96	0	0	0	6.2	6.5
				Downstream	1	2	2	1	1	0	0	0	0.5	0.5
Lower Yakima	Ahtanum	Lower WIP	16.4	Upstream	1	5	5	7	13	0	0	0	1.4	1.5
				Downstream	0	-	-	-	-	-	-	-	-	0.0
Lower Yakima	Ahtanum	Diversion 14	24.8	Upstream	1	43	34	843	2306	0	0	0	27.7	35.8
				Downstream	1	9	10	44	54	0	0	0	4.9	4.5
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Upstream	3	83	65	450	826	0	2	2	13.7	16.6
				Downstream	2	30	23	174	279	0	0	0	10.0	12.5
Lower Yakima	Ahtanum	Upper WIP	32.8	Upstream	2	22	21	183	258	64	0	64	8.9	8.9
				Downstream	1	5	12	18	38	115	10	125	3.6	1.5
Lower Yakima	Ahtanum	John Cox	~ 45.0	Upstream	1	18	12	0	0	0	0	0	0.0	0.0
				Downstream	0	-	-	-	-	-	-	-	-	0.0
Upper Yakima	Naches	City of Yakima	6.0	Upstream	1	19	15	31	43	0	0	0	1.7	2.8
				Downstream	1	8	8	34	39	0	0	0	4.3	4.1
Upper Yakima	Naches	Wapatox	29.0	Upstream	3 *	3	3	94	159	400	0	400	48.0	42.4
				Downstream	0	-	-	-	-	-	-	-	-	0.0
Total (14 Diversions Surveyed)				**Upstream**	**28**	**583**	**504**	**6789**	**14422**	**1852**	**2144**	**3996**	**24.7**	**13.5**
				Downstream	**12**	**208**	**214**	**1445**	**1886**	**990**	**3746**	**4736**	**9.1**	**6.7**
Grand Total				**-**	**40**	**791**	**719**	**8234**	**16308**	**2842**	**5890**	**8733**	**20.6**	**11.5**

Table 2. Overview of species composition of captured lampreys from dewatered irrigation diversions in the Yakima Subbasin in 2017-2018. "% Pacific Lamprey" is a ratio of identified Pacific Lamprey to the total number of lampreys identified. "Gen. Samp. (Pacific Lamprey)" is the number of genetic samples that were collected from Pacific Lamprey and it is not separated by screen location. The summary rows are a sum of presented values (for each respective area), except for "% Pacific Lamprey", which is a weighted average.

Watershed	Stream	Diversion Name	River km	Survey Location	# of Survey Visits	# Identified	# Western Brook Lamprey	# Pacific Lamprey	# of Eyed Pacific Lamprey	% Pacific Lamprey	# Gen. Samp. (Pacific Lamprey)
Lower Yakima	Yakima	Sunnyside	173.4	Upstream	2	70	51	19	4	27%	27
				Downstream	2	72	57	15	0	21%	
Lower Yakima	Yakima	Wapato	176.3	Upstream	9	240	167	73	1	30%	12
				Downstream	1	20	17	3	0	15%	
Lower Yakima	Yakima	Union Gap	189.8	Upstream	1	4	4	0	0	0%	-
				Downstream	0	0	0	0	0	-	
Lower Yakima	Yakima	Selah-Moxee	204.0	Upstream	1	55	53	2	0	4%	2
				Downstream	1	1	1	0	0	0%	
Upper Yakima	Yakima	Roza	210.6	Upstream	0	-	-	-	-	-	-
				Downstream	1	0	0	0	0	-	
Upper Yakima	Yakima	Town	264.7	Upstream	1	20	15	5	0	25%	5
				Downstream	1	1	1	0	0	0%	
Lower Yakima	Toppenish	Olney	176.3	Upstream	2	49	46	3	0	6%	3
				Downstream	1	0	-	-	-	-	
Lower Yakima	Ahtanum	Lower WIP	16.4	Upstream	1	3	2	1	0	33%	0
				Downstream	0	-	-	-	-	-	
Lower Yakima	Ahtanum	Diversion 14	24.8	Upstream	1	30	6	24	0	0.8	22
				Downstream	1						
Lower Yakima	Ahtanum	Bachelor-Hatton	31.8	Upstream	3	24	0	24	1	100%	24
				Downstream	2	15	0	15	0	100%	
Lower Yakima	Ahtanum	Upper WIP	32.8	Upstream	2	54	9	45	3	83%	3
				Downstream	1	7	4	3	0	43%	
Lower Yakima	Ahtanum	John Cox	~ 45.0	Upstream	1	0	-	-	-	-	-
				Downstream	0	-					
Upper Yakima	Naches	City of Yakima	6.0	Upstream	1	25	21	4	0	16%	0
				Downstream	1	0	0	0	0	-	
Upper Yakima	Naches	Wapatox	29.0	Upstream	3 *	43	32	11	2	26%	1
				Downstream	0	0	0	0	0	-	
Total (14 Diversions Surveyed)				**Upstream**	**28**	**617**	**406**	**211**	**11**	**34%**	**99**
				Downstream	**12**	**116**	**80**	**36**	**0**	**31%**	
Grand Total				**-**	**40**	**733**	**486**	**247**	**11**	**34%**	**-**

DISCUSSION

In total, 8,234 larval/juvenile lampreys were captured and returned to the following respective rivers/streams from electrofishing surveys; Yakima (n=6,291), Ahtanum (n=1,719), Naches (n=94), and Toppenish (n=65). Captured lampreys constituted only 50.5% of all observed lampreys. More lampreys (82.5%) were captured upstream compared to downstream (17.5%) of fish screens. However, the high ratio of captured lampreys upstream of the fish screens is primarily driven by the high numbers of captured lampreys from Wapato Diversion (4,885). Also, surveys were focused in areas upstream of the fish screens (in areas with the highest densities of lampreys) and the total area surveyed was 2.8 times higher upstream than downstream. The maximum observed density upstream of the fish screens was at Wapato Diversion, located along the bank of the dewatered sediment (110.0 #/m^2). The maximum observed density downstream of the fish screens was at Sunnyside Diversion, located in an isolated pool of water (55.0 #/m^2). A total of 8,733 dead or nearly dead lampreys (51.5% of total lampreys captured) were found on dewatered banks or on top of partially wetted fine sediment.

Larval lamprey were found at 13 of 14 (92.9%) visited irrigation diversions. Of the diversion where lampreys were found, Pacific Lamprey was present at 11 of 13 (84.6%) diversions. The ratio of Pacific Lamprey (vs. Western Brook Lamprey) was high at Diversion 14 (80%), Bachelor-Hatton (100%), and Upper WIP (83%) diversions in Ahtanum Creek (river km 24.8, 31.8 and 32.8, respectively). In the Yakima River, the ratio of Pacific Lamprey ranged from 4% (Selah-Moxee Diversion, river km 203.6) to 30% (Wapato Diversion, river km 176.3); the ratio at Sunnyside Diversion was also high (27%). Pacific Lamprey were also found in a high ratio (25%) at Town Diversion (located at river km 264.7, upstream of Roza Dam). The ratio of Pacific Lamprey has been increasing steadily since 2010 at Sunnyside and Wapato diversions from approximately 0% from 2010-2013, ~3% in 2013-2014, 7.0% in 2014-2015, to 15% in 2015-2016, 33 % in 2016-2017 and 29% in 2017-2018. Adult lamprey translocation began in 2013 in Ahtanum Creek (which flows into Yakima River upstream of Wapato and Sunnyside diversions) and the ratio of Pacific Lamprey appears to roughly double each consecutive year since this restoration began. A total of 6 macrophthalmia (Pacific Lamprey eyed smolt) were collected from the following irrigation diversions; four from Sunnyside (Yakima River), one from Wapato (Yakima River), two from Bachelor-Hatton (Ahtanum Creek), three from Upper WIP (Ahtanum Creek), and two from Wapatox (Naches River). A total of 99 genetic samples were collected from captured larval/juvenile Pacific Lamprey from diversions. The genetic samples collected from these larvae will help us understand the spawning success of translocated adult lampreys.