Use of Adult Pacific Lamprey Passage Structures at Bonneville Dam

2022 Letter Report

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On the cover: Bradford Island-AWS LPS exit slide with optical sensors.

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Introduction

This report summarizes the enumeration of adult Pacific Lamprey (*Entosphenus tridentatus*) passing Bonneville Dam in 2022 using conventional and alternative fishways designed to pass these fish. Three alternate Lamprey Passage Structures (LPSs) have been added to fishways at Bonneville Dam to increase upstream lamprey passage as they migrate to spawning grounds. Our objectives were to maintain the reporting of lamprey counts and to improve LPS count accuracy. We provide corrected and validated lamprey passage counts obtained from mechanical counters at the Bradford Island auxiliary water supply (AWS) LPS referred to as BI-AWS, Cascades Island Entrance (CI-ENT) LPS, and the Washington shore AWS LPS (WA-AWS) (Figure 1). We combine these counts with the window counts from the fish count stations to determine the estimated total number of lampreys passing Bonneville Dam in 2022. In addition, we present data of the newly installed optical sensor counters at BI-AWS LPS exit along with those at the WA-AWS LPS exit and compare these data with the mechanical counters.

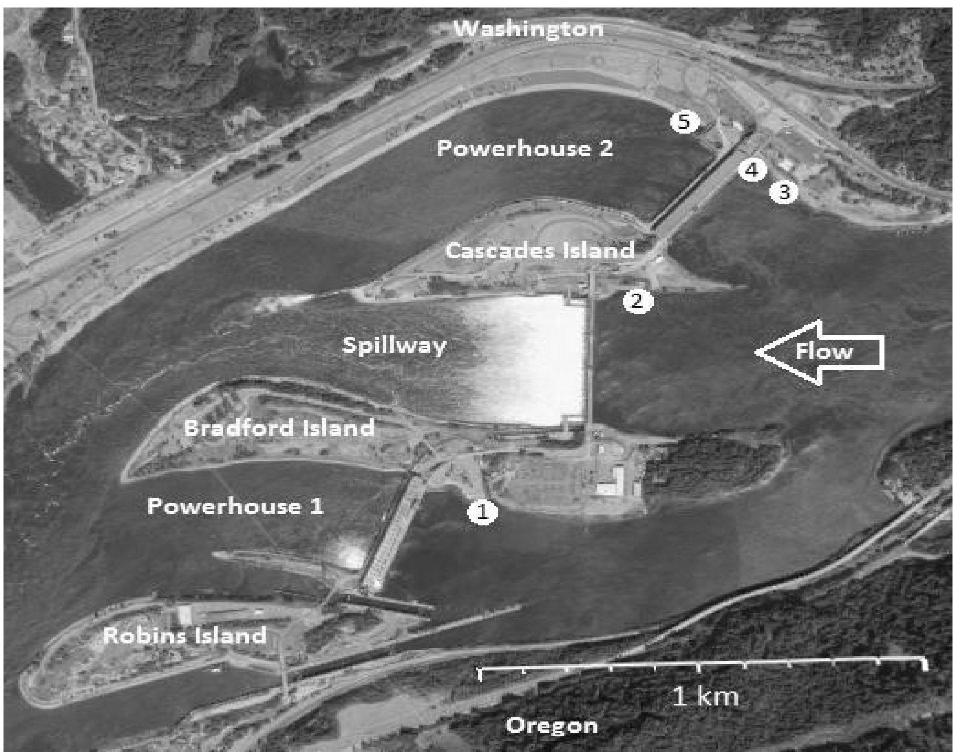

Figure 1. Image of Bonneville Dam depicting the locations of Lamprey Passage Structures (LPSs). (1) Bradford Island AWS LPS (2) Cascades Island ENT LPS (3) Washington shore AWS LPS (4) Washington shore UMTJ LPS (5) Washington shore Lamprey flume structure.

The mechanical counters used to count lamprey passing the LPSs have been inconsistent between years and locations. (Cates et al. 2020, Gallion et al. 2017 and Zorich et al. 2019). This inconsistency has necessitated an alternative counting method to improve LPS count accuracy. As such optical sensors were installed for testing at the WA-AWS LPS exit in 2020. Optical sensors have been used in applications as the standard for industrial counting in manufactured goods and offer an alternative solution for LPS count accuracy. Optical sensors tally counts when the passing lamprey breaks a beam of infrared light as opposed to each passing fish physically contacting a mechanical paddle. The benefits of optical sensors over mechanical paddles include the elimination of inaccurate counts due to mechanical malfunction and the potential injury or disease transfer to passing lampreys due to paddle contact.

Lamprey Passage Structure Operations

The three LPSs at Bonneville Dam operated between 196 - 197 days in 2022. The BI-AWS, CI-ENT, and WA-AWS pumps were started 18 April 2022. The BI-AWS LPS was dewatered at 08:00 on 01 June to 15:36 on 02 June for the installation of optic counters. No fish were found in the structure during the dewater. The WA-AWS LPS was dewatered from 08:30 to 11:48 on 02 June to remove the north entrance ramp for the season due to the structure separating from the wall. The WA-AWS LPS was then watered back up once the ramp removal was completed. All three LPSs were dewatered for the season on 1 November 2022, during which no lampreys were found in the structures. For a complete description of LPS locations, history, and methods please refer to Cates et al. (2020), Moser et al. (2011), and Zorich et al. (2019).

Count Validation and Estimates

Count validation was calculated using two different methods. At the BI-AWS and WA-AWS LPSs, 106 and 112 hours of video validation was performed, respectively. The correction factor was calculated using the method described in Gallion et al. 2017, we divided the number of lampreys that were observed passing in each video review period by the number of lampreys that were logged by the mechanical counter. Daily LPS counts were multiplied by the correction factors to achieve the corrected counts. At each location, the computer program logger shut down occasionally creating gaps in the data. Linear interpolation was used to fill these data gaps. At the CI-ENT LPS video was unavailable. We applied the average of correction factors calculated for CI-ENT LPS from the 2018 to 2020 passage seasons.

The Bonneville Dam LPS passage estimate during 2022 increased by 3,869 lampreys when corrected for mechanical counting error. Specific corrections indicate undercounting occurred at the BI-AWS LPS and the seasonal correction factor of 6% or 1,250 fish were added, thus we estimated a total of 22,091 lampreys passed using the BI-AWS LPS. Undercounting also occurred at WA-AWS and 2,863 fish or 16% were added, thus we estimated a total of 20,926 lampreys passed. Overcounting occurred at CI-ENT and 244 fish or -6% were removed from the count, thus we estimated 3,720 lampreys passed. After correction we estimate 46,738 lampreys passed using the Bonneville Dam LPSs in 2022.

The estimated total lamprey escapement for 2022 at Bonneville Dam was 114,291. This count includes 61,576 lampreys passing the fish count windows during the day (1 Jan – 31 Dec) and night (15 May - 30 Sep), 46,738 lampreys passing through the LPSs and 5,925 lampreys that were collected for the translocation program and released at various locations upstream of Bonneville Dam by the Columbia River Inter-Tribal Fish Commission. Bonneville Fisheries collected 52 lampreys from the Lamprey Flume Structure (Figure 1) and released at the Bradford Island Service Building Boat Ramp. Lamprey passage information from the fish count windows was queried from the Fish Passage Center. For historical lamprey LPS counts refer to appendix tables A1-A3.

Bradford Island Optical Sensor Installation

Three optical sensor counters were installed eighteen inches apart at the BI-AWS LPS exit slide on 01-02 June. The optical sensors sample at a rate of 3,500 Hz or 3,500 times each second. To prevent counting the same fish more than once, the optical sensors were all set to a 1.5 second time delay using one-shot timers. These optical sensors were wired to a laptop computer in the Washington shore ladder count station where data was recorded using the SyTech XL Reporter version 14.4. The count software program was developed throughout the season and optical sensor data collection started on 22 September. Technical issues throughout the first two weeks of data reporting caused gaps in the BI-AWS LPS data set.

Optical Sensor vs Mechanical Paddle

Two data recording systems were used at WA-AWS LPS. The data for the optical sensors at the WA-AWS LPS exit was downloaded using RTR-505 Wireless Data Recorders (T&D Corporation) and software until 22 September. Along with the optical sensors at the BI-AWS LPS exit, the optical sensors at the WA-AWS LPS exit were wired to the same laptop computer in the Washington shore ladder count station where the data was recorded using the XL Reporter. Data from the mechanical paddle counters at the BI-AWS, CI-ENT, and WA-AWS LPSs was tallied by a DATAQ Instruments DI-161 data logger and saved as a csv file until 22 September. Then, each of the three LPSs paddle counters were also transmitted to the same laptop computer located in the Washington shore count station via the XL Reporter.

For the 2022 lamprey passage season, we compared the three optical counters installed at the WA-AWS LPS exit with the mechanical paddles and video review. In Table 1 we compare the WA-AWS optical sensor, the WA-AWS mechanical paddle counter, and video review counts to access the efficiency of each optical sensors time delay setting at its specific location along the exit slide. Optical time delay settings of 1, 2, and 3 seconds, for the first, middle, and final optical counter respectively, remained the same as that of 2021.

Table 1. 2022 Comparison of the Washington shore AWS LPS exit mechanical paddle and optical sensor counts with video review counts at Bonneville Dam.

			Optical Sensor		
	Video	Paddle	1 Second Delay	2 Second Delay	3 Second Delay
Count	1,780	1,532	2,014	1,919	1,859
Difference		-248	234	139	79
% Difference		-13.9	13.1	7.8	4.4

A BI-AWS LPS video comparison of the optical sensors with the mechanical counter was not accomplished due to low passage numbers in September and October and gaps in optical sensor data collection during video review. The optical counters were online for 30 days during which 30 lampreys were counted passing the mechanical paddle counter and 29, 27, and 28 were counted passing the three optical sensors starting with the closest to the mechanical paddle.

Conclusion

The LPSs at Bonneville Dam are operated to encompass the seasonal run timing of adult Pacific Lamprey. Window counts indicated that 10% of the run passed Bonneville Dam by 28 June and the run was 90% complete by 20 August. The LPS operations in 2022 successfully covered these dates. We recommend continuing to operate the LPSs from 1 April to 31 October to provide additional routes of passage for early and late migrants.

Lamprey use of the BON LPSs was distributed similar to previous years. The BI-AWS passed 47.3% of lampreys using the LPSs, followed by WA-AWS (44.8%), and CI-ENT (8.0%). These LPS structures provide an alternate route of passage that has proven to be successful as 30-47% of the lampreys passing the dam typically use these structures (Cates et al. 2020, Gibbons and McClain 2021, Gibbons et al. 2022, and Zorich et al. 2019). Bonneville Dam LPSs continue to pass a substantial portion of the lamprey run. Overall, LPS passage for the 2022 monitoring season was 41% of the total lamprey escapement of 114,291.

Lamprey count estimates from optical sensors were typically superior to paddle count estimates. In 2022, each of the three time-delay settings of the optical sensors outperformed the paddle counter at WA-AWS LPS increasing in precision with each increase in time delay setting (Table 1). As in 2021, the accuracy of the optical sensors exceeded an 85% confidence interval. While the optical sensors were installed at BI-AWS LPS, count data was not collected until late in the season and we were unable to evaluate count accuracy. Lamprey passage season 2023 will be our first full year of comparing optical sensors at this location. The installation of optical counters for the CI-ENT LPS exit slide has begun for the 2023 season. Due to the placement of the optical sensors at the CI-ENT LPS, we plan to remove the paddle counter. These modifications will address overcounts due to lamprey attachment at this location. We will be validating counts using video at BI-AWS and CI-ENT LPSs in 2023. While the 3-second time delay setting proved to be the best performer in 2021 and 2022 at WA-AWS LPS, differences in exit configuration (slope of exit and shape) at BI-AWS and CI-ENT LPSs require further investigation to identify the optimal time delay setting at these locations.

Acknowledgements

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Appendix A. Annual lamprey passage tables for Bonneville Dam LPSs

Table A 1. Annual lamprey passage estimates at Washington Shore auxiliary water supply Lamprey Passage Structure during 2007-2014 (Corbett et al. 2015), 2015-2016 (Gallion et al. 2016), 2017-2018 (Zorich et al. 2019), 2019 (Cates et al. 2020), 2020 (Gibbons and McClain 2021), 2021 (Gibbons et al. 2022), and 2022.

Year	Dates Operated	# Days	Estimated Passage
2007	25 June – 22 October	119	2,517
2008	13 May - 28 October	168	1,985
2009	26 May – 2 November	160	1,199
2010	8 June – 25 October	139	2,961
2011	26 May – 9 November	167	6,345
2012	2 June – 11 November	162	5,686
2013	16 May – 16 October	153	18,329
2014	8 May – 29 October	174	29,756[1]
2015	30 March – 28 October	212	38,069[1]
2016	5 April – 27 October	202	40,880[1]
2017	1 May – 31 October	184	90,377[1]
2018	25 April – 31 October	189	31,432[1]
2019	11 April – 31 October	204	13,819[1]
2020	1 April – 2 November	215	11,116[1]
2021	11 May – 1 November	174	23,998[1]
2022	18 April – 1 November	197	20,926[1]

1: Corrected for mechanical count error,

Table A 2. Annual lamprey passage estimates at Bradford Island auxiliary water supply lamprey passage structure during 2007-2014 (Corbett et al. 2015), 2015-2016 (Gallion et al. 2016), 2017-2018 (Zorich et al. 2019), 2019 (Cates et al. 2020), 2020 (Gibbons and McClain 2021), 2021 (Gibbons et al. 2022), and 2022.

Year	Dates Operated	# Days	Estimated Passage
2004	Unknown	NA	7,490
2005	Unknown	NA	9,242
2006	Unknown	NA	14,975
2007	8 May – 22 October	167	7,387
2008	13 May – 28 October	168	6,441
2009	26 May – 2 November	160	3,302
2010	4 June – 25 October	143	1,933
2011	26 May – 9 November[1]	154	7,476
2012	2 June – 9 November[2]	144	4,392
2013	16 May – 16 October[3]	141	13,066
2014	8 May – 20 October	165	17,587[5]
2015	30 March – 28 October	212	13,986[5]
2016	5 April – 27 October[4]	205	12,115[5]
2017	5 April– 31 October	210	28,843[5]
2018	8 March – 31 October	237	28,105[5]
2019	18 April – 31 October	197	6,539[5]
2020	16 April – 2 November	200	9,467[5]
2021	6 April – 1 November	209	9,870[5]
2022	18 April – 1 November	196[6]	22,091[5]

1: 13 days of data gaps; 2: 16 days of data gaps; 3: 12 days of data gaps; 4: 2 days of data gaps; 5: Corrected for mechanical count error. In 2006 a second collection ramp was added to the east side of the AWS; 6: LPS was dewatered on 1-2 June to install optical counters.

Table A 3. Annual lamprey passage estimates at Cascades Island entrance lamprey passage structure during 2007-2014 (Corbett et al. 2015), 2015-2016 (Gallion et al. 2016), 2017-2018 (Zorich et al. 2019), 2019 (Cates et al. 2020), 2020 (Gibbons and McClain 2021), 2021 (Gibbons et al. 2022) and 2022.

Year	Dates Operated	# Days	Estimated Passage
2009	26 May – 3 September[1]	73	106
2010	31 May – 10 September[2]	75	48
2011	6 June – 15 September[3]	94	485
2012	23 May – 20 September[3]	113	2,472
2013	24 June – 4 October[3,4]	95	155
2014	14 May - 30 October[5]	167	2,832
2015	6 April – 30 September	177	72[6]
2016	8 April – 27 October	202	3,851[6]
2017	5 April– 31 October	210	3,027[6]
2018	25 April – 31 October	186	882[6]
2019	16 April – 31 October	199	775[6]
2020	1 April – 2 November	215	1,220[6]
2021	6 April – 1 November	209	928[6]
2022	18 April – 1 November	197	3,720[6]

1: Experimental flow testing was conducted; system was operated weekdays only; 5 days of data gaps; 2: LPS was operated weekdays only; 3: 7 days of data gaps; 4: CI LPS was extended to the forebay using mostly PVC pipe prior to 2013 operation; 5: two days of data gaps; 6: corrected for mechanical count error.