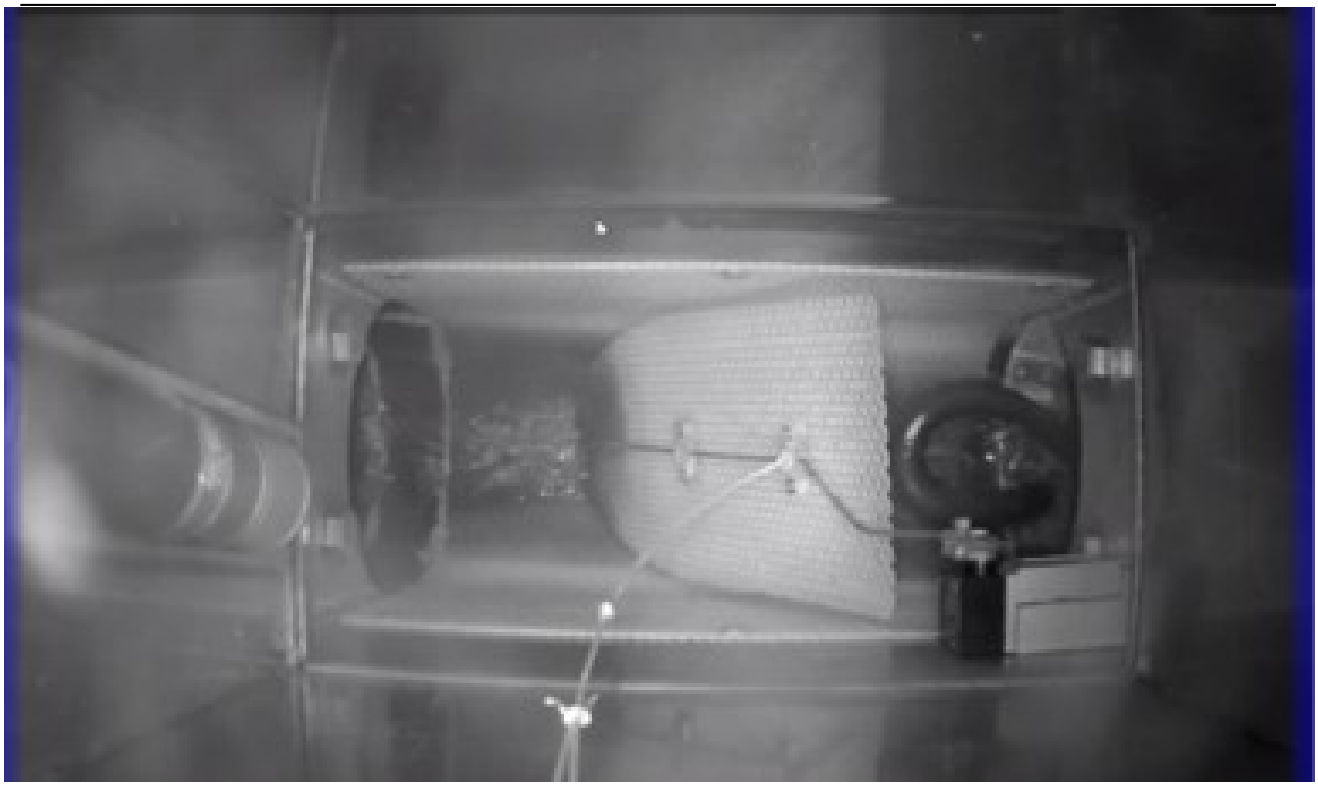
Use of Adult Pacific Lamprey Passage Structures at Bonneville Dam
2020 Letter Report



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On the cover: The Cascades Island LPS paddle and camera box. In the right side of the image, an adult lamprey (bent into a "C" shape) is descending the last section of the LPS before it reaches the spillway forebay at Bonneville Dam.

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Abstract

The Pacific Lamprey (*Entosphenus tridentatus*) is an anadromous fish species native to the Columbia River Basin, it is an important food and cultural resource for several Native American tribes, supplies marine derived nutrients to headwaters beyond salmon barriers by climbing them, and has declined in abundance. Traditional fishways at Bonneville Dam were designed for salmonid passage and are more difficult for lampreys to pass due to higher velocities, dead ends and serpentine weir sections that do not facilitate their swimming behavior. Lamprey Passage Structures (LPS) were designed for upstream passage where lampreys use their oral sucking discs and anguilliform swimming behavior to pass the dam effectively. The data collected from the LPSs are combined with Bonneville lamprey window counts to estimate the total Bonneville lamprey escapement. Overall, the total lamprey escapement at Bonneville Dam was estimated at 41,904 for calendar year 2020. Bonneville LPSs passed 21,804 lampreys or 52% of the total passage at Bonneville Dam from April through October. We reviewed 410 hours of video which was used to validate the accuracy of the LPS mechanical count systems. The overall count for all LPSs combined was adjusted down by 12% due to the mechanical systems over-counting lamprey passage events. The mechanical counters are imperfect, however, they have proven to be cost saving compared to live fish counting and they provide 24-hour monitoring throughout the season.

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Introduction

Low passage efficiencies of adult Pacific Lamprey (*Entosphenus tridentatus*) at Bonneville Dam have been implicated as one factor contributing to their basin-wide decline. To improve passage, lamprey specific fishways were built to help lampreys out of the auxiliary water supply and around areas of difficult passage thus increasing passage efficiencies. These fishways are called Lamprey Passage Structures (LPS) and they pass nearly half the lamprey crossing Bonneville Dam which indicates that these fishways are important routes of passage (Cates et. al. 2020).

Overall, the three LPSs at Bonneville Dam operated between 200 and 215 days in 2020 and passed a combined total of 21,804 lampreys. The Washington shore AWS LPS (WA-AWS) passed 11,116, the Bradford Island AWS LPS (BI-AWS) passed 9,467, and the Cascades Island Entrance LPS (CI-ENT) passed 1,220 lampreys when corrected for mechanical counting errors. The Washington shore Upstream Migrant Tunnel Junction LPS (WA-UMTJ) terminates at the WA-AWS rest box 3 and therefore the WA-UMTJ is not an additive count to the overall estimate.

In this report we define the objectives of the work, describe our approach, and provide the results of the 2020 passage season. Our efforts were focused on increasing lamprey passage and lamprey count accuracy. To this end, we implemented work to meet the following objectives: increase lamprey passage and count accuracy. We validated and corrected for mechanical counters used to monitor these structures, thus improving passage estimates. For a complete description of LPS locations, history, and methods please refer to Cates et al. (2020), Moser et al. (2010), and Zorich et al. (2019).

Results

Operation

The Bonneville LPSs operated between 200 and 215 days in 2020 (Table 1). The pumps for the BI-AWS were started on 16 April and the structure was dewatered on 2 November. The Cascades Island and Washington shore LPS pumps were started 1 April and dewatered 2 November.

Table 1. Operation dates of Lamprey Passage Structures at Bonneville Dam During the 2020 Season.

Location	Start Date	End Date	Days of Operation
Bradford Island-AWS	4/16/2020	11/2/2020	200
Cascades Island-ENT	4/1/2020	11/2/2020	215
Washington-AWS	4/1/2020	11/2/2020	215
Washington-UMTJ	4/1/2020	11/2/2020	215

LPSs were inspected by Bonneville project fisheries staff in 2020. Water supply volume to all four LPSs locations was sufficient for the entire passage season. However, the BI-AWS LPS was taken out of service 3 July 2020 at 10:30 am to repair a pump and it was returned to service 6 July at 8:30 am.

Some lampreys die due to the rigors of freshwater migration. In total, thirteen lamprey mortalities were found in the Bonneville LPS rest boxes in 2020 by Project Biologists. Six of these mortalities were in the Washington shore LPS (of 11,117 fish passed or 0.05%), five were in the Cascades Island LPS (of 1,220 fish passed or 0.4%), two were in the Bradford Island LPS (of 9,468 fish passed or 0.0002%). Additional lamprey mortalities were found in the fishways when inspected by Bonneville Project Biologists. These mortalities are not covered in this report, but can be found on the FPOM website: http://pweb.crohms.org/tmt/documents/FPOM/2010/

Passage Validation and Estimates

Count validation was performed by comparing 410 hours of video and 2,736 passage events to the associated mechanical counts and based on these comparisons, correction factors were determined. The difference between the mechanical and corrected counts was quantified using percent difference. To calculate the correction factor, 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 counts were multiplied by correction factors from the nearest biweekly review. To be compatible with early reports we followed the methods of Gallion et al. (2017) to calculate percent difference. The correction factors were calculated from 10 hours of video (one night) reviewed at each site every two weeks and ranged from 0.63 to 1.00 at WA-AWS, 0.64 to 1.00 at CI-ENT, and 0.74 to 1.03 at BI-AWS (Table 2). In 2020, the video feed for the WA-UMTJ camera was down. Fortunately, lampreys that use the WA-UMTJ LPS are counted and reviewed as they pass through the WA-AWS LPS. Video validation could not be performed for some weeks during May and June, due to equipment failures such as power outages or programming mistakes.

Table 2. Correction factors (CF) for Bonneville Dam LPS mechanical counters, video collected from 11 May to 30 September 2020. The mechanical column is the value reported by counter. The video column is the observed count during the same time period. Validations that could not be performed due to equipment failures are represented by 'NA'.

Observation Period	Bradford Island AWS			Cascades Island Entrance			Washington AWS		
	Mechanical	Video	CF	Mechanical	Video	CF	Mechanical	Video	CF
1	NA	NA	NA	0	0	1.00	65	65	1.00
2	2	2	1.00	1	1	1.00	81	69	0.85
3	12	12	1.00	5	4	0.80	86	72	0.84
4	43	32	0.74	28	18	0.64	320	202	0.63
5	213	208	0.98	122	102	0.84	181	121	0.67
6	187	189	1.01	113	103	0.91	95	60	0.63
7	227	221	0.97	4	4	1.00	188	178	0.95
8	195	200	1.03	3	2	0.67	221	208	0.94
9	60	60	1.00	6	5	0.83	119	113	0.95
10	38	38	1.00	11	10	0.91	89	88	0.99
11	162	162	1.00	0	0	1.00	158	150	0.95
12	4	4	1.00	4	4	1.00	23	22	0.96
13	10	10	1.00	0	0	1.00	4	3	0.75
14	8	8	1.00	0	0	1.00	4	4	1.00

Note: When reviewing the video, we account for each individual over and under-count that occurs. This is not seen in Table 2 because the table is adding the occurrences of both over and under-counts to get the observation period total.

The majority of LPS mechanical counter error was due to over-counting at each of the LPS locations. At the CI-ENT LPS, over-counting occurred about 17.9% during the total video review period. The most common over-count error is due to lampreys attaching above the paddle, hitting it with their tail, causing it to over-count (Table 2). The BI-AWS LPS accounted for 2.2% of over-counts during the total review period, occurring during observation period four (Table 2). Over-counting at the WA-AWS LPS occurred 20.6% during the total video review period. To correct over-counting at WA-AWS we adjusted the ferrous tab during observation period six, so that the arch covered the proximity detector, the correction factors remained low (Table 2).

Under-counts occurred when lamprey passage was observed in the video but not tallied by the mechanical counter, however, this occurred less frequently in 2020 compared to previous years. From the 2,736 passage events reviewed, incidents of under-counts were low; BI-AWS had the most occurrences (10), then CI-ENT (2), and WA-AWS (0).

Overall, the Bonneville LPS passage estimate during 2020 decreased from 24,869 to 21,804 when corrected for mechanical counting error. Percent difference was used to compare count accuracy at each location and at all sites over the season (Table 3). Correction factors were applied to the counts weekly or biweekly, depending on the video validation schedule. The most accurate counting location was the BI-AWS (-1%), followed by the CI-ENT (-15%), and the WA-AWS (-19%) required the most correction.

Table 3. Corrected estimates for lamprey passage at LPSs during 2020. Difference (%) = ((Corrected Estimate – Mechanical Count) / Mechanical Count) * 100 rounded to the nearest whole value.

LPS Location	Mechanical Count	Corrected Estimate	Difference (%)
Bradford Island-AWS	1,161	1,146	-1
Cascades Island-ENT	275	235	-15
Washington-AWS	1,681	1,355	-19
Total	3,117	2,736	-12

Corrected daily lamprey passage fluctuated greatly at each LPS, however the peak of the fish passage was in June and July (Figure 1, Figure 2, and Figure 3). LPS passage at Bonneville Dam during the 2020 season (April – October) was 21,804 fish or 52% of the estimated total lamprey escapement which was 41,904 by the end of the 2020 fish passage season. Of the lampreys that used LPSs, most favored the WA-AWS (51% of LPS passage), followed by BI-AWS (43%), and then the CI-ENT (6%). Generally, the highest daily LPS passage occurred during the end of June and early July and often exceeded the 24-hour count of the associated fish count window.

The first lamprey to pass the WA-AWS LPS, as well as the nearby counting window, was 11 May 2020 (Figure 1). In mid-July, passage was similar in magnitude to the window counts and then continued to surpass them. By early September, LPS passage dropped off dramatically for the season.

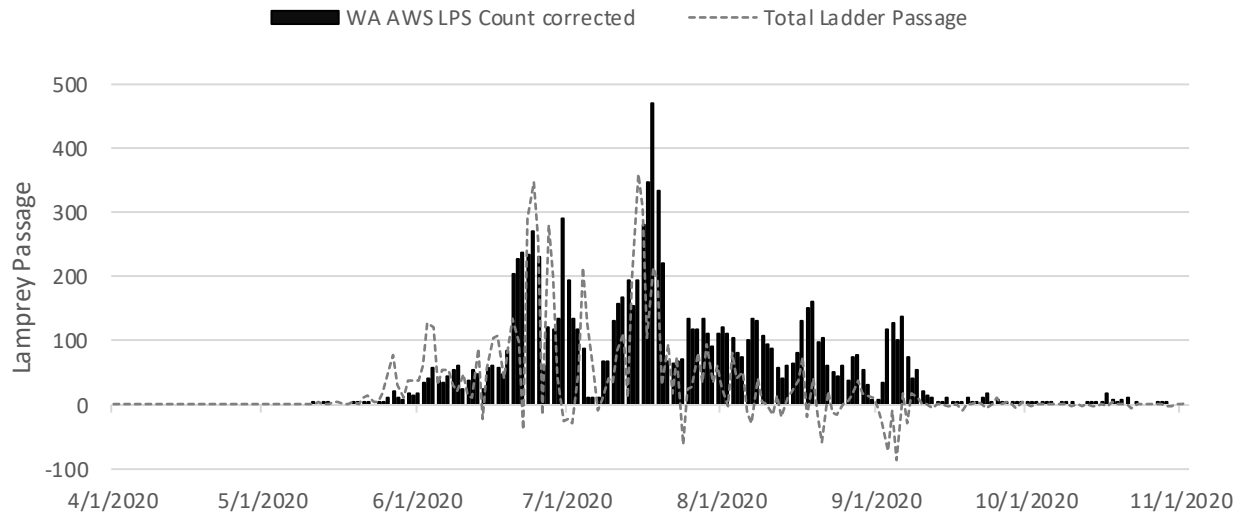

Figure 1. Washington shore auxiliary water supply (WA-AWS, black line) daily lamprey passage estimate (corrected). The dotted line represents daily 24-hour window counts at the Washington shore fish count window nearby.

Lampreys using the CI-ENT LPS found the structure earlier than the other LPSs but passage decreased dramatically after the beginning of July (Figure 2).

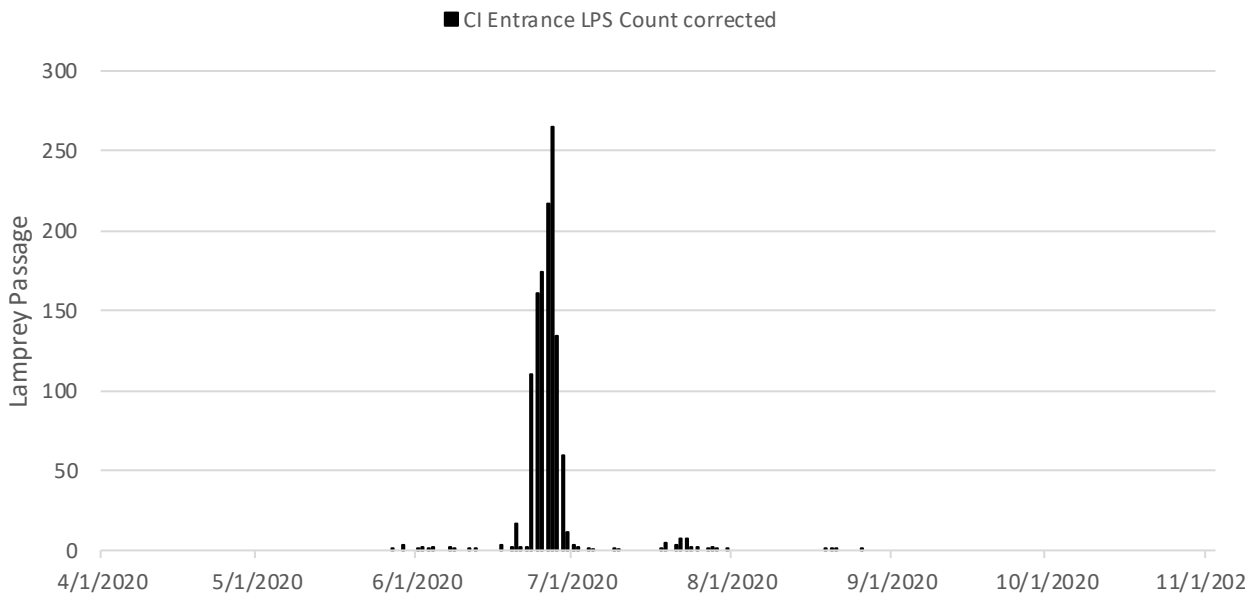

Figure 2. Cascades Island entrance LPS (CI-ENT LPS) daily lamprey passage estimates (corrected). There is no nearby window count for this time period.

Bradford Island AWS LPS passage started in June about one week after lampreys were seen in the nearby counting window. In late July, passage was similar in magnitude to the window counts, however LPS passage dropped off dramatically in August to October (Figure 3).

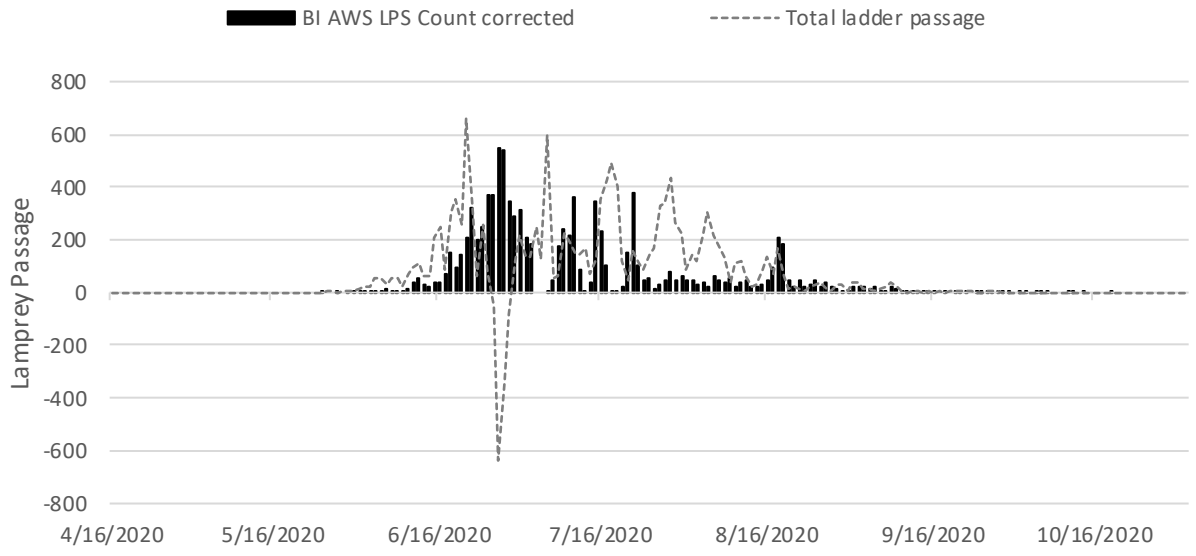

Figure 3. Bradford Island auxiliary water supply (BI-AWS LPS, black line) daily lamprey passage estimates (corrected). The dotted line represents daily 24-hour window counts from the Bradford Island window.

Diurnal passage through the LPSs is very similar for WA-AWS and BI-AWS with most passage occurring in the dark of night and decreasing at dawn (Figure 4). However, as in previous years, passage at CI-ENT was more protracted, showing a more gradual increase at sunset and gradual decrease after sunrise.

Figure 4. Diurnal distribution of lamprey passage by hour at Bonneville Dam 2020; BI-AWS LPS (top left), WA-AWS LPS (top right) and CI-ENT LPS (bottom left). Note varying y-axis.

Conclusion

The time frame for LPS operation and low mortality rates were adequate to provide safe passage for the 2020 lamprey run. The estimated total lamprey escapement at Bonneville was 41,904; this count includes 17,960 lampreys passing the window (day and night counts) and 2,140 lampreys were collected for the translocation program by the Columbia River Inter-Tribal Fish Commission (CRITFC). Window counts show that 10% of the run passed Bonneville Dam by 15 June and the run was 90% complete by 6 August. These dates were encompassed by LPS operations and we recommend continuing to operate LPSs surrounding this time frame to provide additional routes of passage for early and later migrants. With the successful completion of video validation of the mechanical counters, we were able to provide a more accurate estimate of lamprey passage at Bonneville Dam.

Acknowledgements

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