Grating Size Needed to Protect Adult Pacific Lamprey in the Columbia River Basin

Mary L. Moser[1], Howard T. Pennington[2], and Jeremy M. Roos[2]
[1]NOAA Fisheries, Northwest Fisheries Science Center, Fish Ecology Division,
2725 Montlake Boulevard East, Seattle, WA 98112, mary.moser@noaa.gov
[2]Pacific States Marine Fisheries Commission,
45 SE 82nd Drive, Suite100, Gladstone, OR 97027-2522

Background

- Pacific lamprey *Lampetra tridentata* are an important cultural and ecological resource in the Pacific Northwest that must be protected.
- These lamprey are anadromous, participating in migrations to upriver spawning areas that can exceed 700 km.
- Protection of adults during their migration past Columbia River hydropower dams is a priority for restoration of Pacific lamprey.
- Picketed leads and diffuser grating at these dams exclude salmonids from dead-end channels, pumps, and other sources of mortality.
- Adult lamprey can pass through some of these structures, potentially resulting in delayed migration, injury, or death.

Objective: To determine the bar spacing needed to protect migrating adult Pacific lamprey.

Methods

Lamprey were captured in a trap that was deployed at night in a Bonneville Dam fishway (Columbia River rkm 235). Each morning experiments were conducted in the Adult Fish Facility at Bonneville Dam using lamprey collected during the previous night.

Vertical Gap Experiments

- A large flow-through tank was filled with ambient Columbia River water (Figure 1).
- The tank was divided into two unequal compartments by a piece of perforated aluminum plate (0.6-cm perforations).
- A vertical gap (2.5, 2.2, 1.9, 1.6, or 1.3 cm in height) was produced at the bottom of the divider by placing a spacer under the plate.
- Each day, lamprey trapped the previous night were placed in the smaller tank compartment and encouraged to pass under the plate.
- After approximately 15 min, the divider was lowered to the bottom to isolate lamprey that had successfully passed through.
- Individuals from both groups were anesthetized using 50 ppm eugenol, weighed (nearest g), and measured (nearest cm total length).
- Circumference (girth) at the origin of the first dorsal fin was also measured (nearest mm).
- Three replicates of each of the five vertical gap treatments were made at approximately 1-week intervals.
- Hierarchical analysis of variance was used to determine whether there were differences in lamprey size among dates and treatment groups.

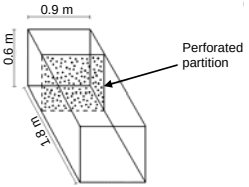

Figure 1. Experimental apparatus used to test lamprey ability to pass through a vertical gap. A vertical gap of 2.5, 2.2, 1.9, 1.6, or 1.3 cm was created by placing a spacer of the appropriate size under the perforated partition.

Figure 2. Photograph of traditional diffuser grating material with 2.5-cm bar spacing.

Horizontal Dewatering Simulation

- We tested traditional diffuser grating (2.5- × 9.2-cm openings, Figure 2) and a similar material that had 1.9- × 9.2-cm openings.
- The large (1.8 × 0.9 × 0.6 m), flow-through tank was filled with ambient Columbia River water.
- A horizontal grate was installed at a depth of 15 cm to completely separate the tank into upper and lower compartments.
- Ten lamprey were placed in the tank above the randomly-selected grate and allowed to acclimate for 5 min.
- Water in the tank was lowered 30 cm in 3 min so that lamprey were stranded on the grate and induced to pass through it (Figure 3).
- The experiment, using the same lamprey, was then repeated with the other grating size.
- Lamprey that passed down through the grate were scored, and all lamprey were anesthetized, measured, and released.
- A *t*-test was used to determine whether there were differences in size between lamprey that passed through and those that did not for each treatment

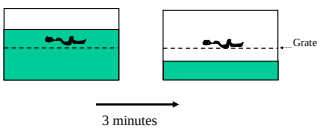

Figure 3. Cartoon of horizontal dewatering simulation as viewed from the side. A grate (either 2.5- or 1.9-cm bar spacing) was installed in a tank at a depth of 15 cm and lamprey were released above it. The water level was then dropped by 30 cm over the course of 3 min, so that the lamprey were stranded on the grate for 2 min and induced to pass vertically through it.

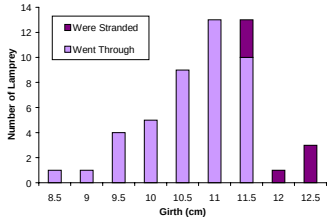

Figure 5. Frequency histogram of the lamprey girth (cm) recorded for fish that passed through the 2.5-cm bar spacing and those that were stranded on it during horizontal dewatering simulations.

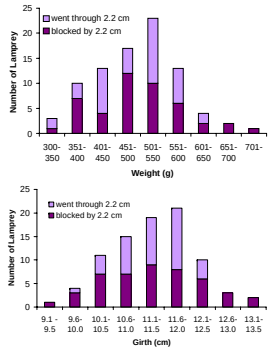

Figure 4. Size frequencies (weight in top panel and girth in bottom panel) of adult Pacific lamprey that were able to pass through a 2.2-cm vertical gap and those that were blocked by a 2.2-cm gap.

RESULTS

Vertical Gap Experiments

- There were no significant differences in fish length (F = 1.05, df = 15, P = 0.41), weight (F = 0.46, df = 15, P = 0.96), or girth (F = 0.42, df = 15, P = 0.97) among treatments or test dates.
- The mean length of lamprey tested was 67.5 cm (standard deviation = 4.2, range = 53.0 -79.0). Mean weight was 494 g (standard deviation = 85, range = 282-800) and mean girth was 11.3 cm (standard deviation = 0.8, range = 9.2-13.7).
- All lamprey were able to pass through the 2.5-cm gap, and none were able to pass through gap sizes of 1.9-cm or less (Table 1).
- For the 2.2-cm treatment group, there was no significant difference in length (t = 0.49, df = 85, P = 0.62), weight (t = 0.44, df = 85, P = 0.66), or girth (t = 0.52, df = 85, P = 0.60) of fish that passed through and those that did not (Figure 4).

Table 1. The mean and standard deviation in () of lamprey length, weight, and girth (cm) for each vertical gap treatment. The percentage of lamprey that were able to pass through is also given.

Treatment	N	Length (cm)	Weight (g)	Girth (cm)	Passage
2.5 cm	53	67.5 (4.3)	489.7 (76.5)	11.4 (0.8)	100%
2.2 cm	87	67.5 (4.1)	496.7 (87.7)	11.3 (0.8)	47%
1.9 cm	23	67.5 (3.8)	492.8 (83.7)	11.3 (0.8)	0%
1.6 cm	33	68.4 (4.8)	506.0 (97.4)	11.4 (0.8)	0%
1.3 cm	46	67.0 (4.0)	485.6 (80.4)	11.3 (0.8)	0%

Horizontal Dewatering Simulation

- Mean size of lamprey (n = 50): length = 67.5 cm (standard deviation = 4.7, range = 56.0-77.0), weight = 481 g (standard deviation = 88, range 284-684), and girth = 11.0 cm (standard deviation = 0.9, range = 8.9-12.9).
- None of these lamprey were able to pass down through the 1.9-cm grating, but 86% passed down through the 2.5-cm grating.
- Lamprey stranded on the 2.5-cm grating were significantly larger than those that passed through (Figure 5): length (t = 2.42, df = 48, P = 0.02), weight (t = 4.38, df = 48, P < 0.0001) or girth (t= 4.50, df = 48, P < 0.0001).

CONCLUSIONS

- A 1.9-cm bar spacing is needed to exclude most adult Pacific lamprey in the Columbia River drainage.
- In a field test, no lamprey were able to pass through when 2.5-cm grating was replaced with 1.9-cm grating in the winter of 2005 at Pool 16 of the John Day Dam south fishway (Columbia River Kilometer 347).
- The very smallest end of the Pacific lamprey size frequency distribution may have been missed in our testing because lamprey shrink during freshwater residence. The smallest lamprey in this study was 53 cm long, weighed 282 g and was 9.2 cm in girth.
- Lamprey movement through a gap did not seem to be affected by gap orientation.

ACKNOWLEDGMENTS

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