



Novel fishway entrance modifications for Pacific lamprey

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ABSTRACT

Passage facilities at dams must accommodate a broad array of aquatic species to achieve full river connectivity. In an attempt to improve adult Pacific lamprey (*Entosphenus tridentatus*) passage, fishway entrance modifications were made at a large dam on the Columbia River in northwestern USA. The modifications consisted of a variable-width entrance weir and flow disrupters to create heterogeneity in water velocities near the bottom, without affecting attraction flows for adult salmonids (*Oncorhynchus* spp.) or alosids (*Alosa sapidissima*). Additionally, a lamprey passage structure (LPS) was installed to provide a lamprey-specific route from tailrace to forebay elevation (31 m). Passive integrated transponders and radio transmitters were used to monitor both Pacific lamprey and Chinook salmon (*O. tshawytscha*) movements. Fish use of the modified entrance was compared to that at a similar, but unmodified entrance before and after modifications. The entrance modifications resulted in increased velocity heterogeneity, but no measurable improvement in entrance efficiencies for lamprey or salmon. Lamprey successfully ascended the LPS, with annual counts ranging from 48 in 2010 to 3,851 in 2016 (0.2–8.9% of lamprey counted at the dam). Radiotelemetry indicated that tagged lamprey resumed upstream passage after LPS use and travelled at rates similar to those that used traditional fishway routes.

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Introduction

Passage facilities on impounded rivers must accommodate a diverse array of aquatic species if healthy riverine ecosystems are to be restored (Schwalme et al. 1985; Mallen-Cooper 1999; Baras and Lucas 2001; Nilsson et al. 2005; Pompeu et al. 2012). Traditional fishway designs typically accommodate passage for economically important species but are not generally effective for all species that require passage (Northcote 1998; Bunt 2001; Oldani et al. 2007; Vowles et al. 2017). In their review of fish passage literature from 1964 to 2011, Noonan et al. (2012) reported that targeted salmonids had higher mean passage efficiency than non-salmonids during both upstream (62 vs. 21%) and downstream (75 vs. 40%) migration at man-made barriers.

If it is not possible to remove a barrier, operational and/or structural modifications can be used to improve passage of multi-species complexes. Examples of operational change include opening tide gates to match fish passage timing (Piper et al. 2012; Wright et al. 2014) or altering discharge at dam spillways to promote juvenile salmonid survival (Johnson and Dauble 2006; Williams et al. 2012).

Similarly, fishway flows can be fine-tuned to attract and pass alosids during the day (Barry and Kynard 1986; Moser et al. 2000; Larinier and Travade 2002) and improve fishway entrance by Pacific lamprey (*Entosphenus tridentatus*) at night (Johnson et al. 2012). Structural modifications run the gamut from channels that mimic natural streams (Jungwirth 1998; Steffensen et al. 2013; Aronsuu et al. 2015) to engineered fishways that provide very specific hydraulic environments for target species such as salmon and shad (Monk et al. 1989; Clay 1995), eel (Verdon and Caumartin 2004; Vowles et al. 2017), and lamprey (Moser et al. 2011; Frick et al. 2017; Vowles et al. 2017).

Managers often use a combination of structural and operational methods to achieve passage goals for a multi-species complex (Monk et al. 1989; Mallen-Cooper 1999; Keefer et al. 2013a). These methods can be implemented simultaneously in response to logistic, funding, or political circumstances such as repair or maintenance, the sudden availability of funds or dam re-licensing decisions. Alternatively, passage solutions can evolve over long periods, either in piecemeal fashion or by using an adaptive management approach. Adaptive