Behaviour of adult Pacific lamprey in near-field flow and fishway design experiments

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Abstract An experimental fishway was used to examine adult Pacific lamprey, *Lampetra tridentata* (Gairdner), behaviour in a series of attraction and passage-performance tests. Among all experiments, lamprey oriented to the fishway floor and walls and were attracted to both ambient and concentrated flow. When confronted with high-velocity areas (vertical-slot and submerged-orifice weirs), many lamprey failed to pass upstream. However, lamprey were able to find and take advantage of low-velocity refuges when they were provided. Lamprey climbed shallow- and steep-angled ramps when attraction cues were sufficient and other passage routes were restricted. The combined results demonstrated the passage challenges that fishways designed and operated for salmonids present to non-salmonid species. They also highlight the importance of evaluating trade-offs between fishway attraction and passage efficiency. The experiments were integrated with tagging studies and development of lamprey-specific passage structures, a research combination that provided an effective template for fishway performance evaluations.

KEYWORDS: burst swimming, Columbia River, fishway performance, migration barrier, rheotaxis, velocity refuge.

Introduction

Understanding fish responses to environmental cues is critical to the development of effective fishways (Katopodis 2005; Castro-Santos et al. 2009; Roscoe & Hinch 2010). Although fish potentially orient to a host of environmental variables, current velocity and direction are dominant factors mediating fish movements. Consequently, a broad body of research has focused on the responses of fish to near-field (i.e. metres to 100s of metres) current vectors (Haro et al. 2004; Enders et al. 2009; Kemp et al. 2009, 2010). Such work has been critical to the development of effective devices to guide fish of various life stages past migration obstacles (e.g. Collins & Elling 1960; Kemp et al. 2008; Russon et al. 2010).

Unfortunately, not all species respond to environmental cues in the same way, nor do they all have equivalent swimming abilities. Most fishways in North America were designed to accommodate socially and economically important salmonids (*Oncorhynchus* spp. and *Salmo* spp.) or clupeids (*Clupea* spp. and *Alosa* spp.). Typical fishways for these strong-swimming taxa include baffled, serpentine weir and stepped weir-and-pool systems with submerged orifices, vertical slots or overflow sections (Clay 1995). Passage of non-target species through such systems is often problematic because of a mismatch between fish swimming abilities and behaviour and fishway design features or operational criteria (Stuart & Mallen-Cooper 1999; Agostinho et al. 2007; Mallen-Cooper & Brand 2007).