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Inter-observer Bias in Fish Classification and Enumeration Using Dual-frequency Identification Sonar (DIDSON): A Pacific Lamprey Case Study

Abstract

Dual-frequency Identification Sonar (DIDSON) is increasingly used as a fish monitoring and enumeration tool, but many studies do not evaluate potential observer biases. In this project, we assessed inter-observer differences in the identification and enumeration of adult Pacific lamprey (*Entosphenus tridentatus*) imaged with DIDSON passing a large dam fishway. Six trained viewers independently identified lamprey observation 'events' in the same ~ 12 h of DIDSON data collected at several fishway locations using two sonar orientations. Among-viewer variability in lamprey enumeration was high and viewer agreement on individual lamprey was often low. A total of 274 unique potential Pacific lamprey events was identified, but individual viewers scored only 89–173 events each (mean = 131, CV = 24%) or 32–63% of the total. Viewer identification rates (events/h) varied several-fold at some sites which we attributed primarily to event non-detection rather than species misclassification. Identification differences were related to viewer confidence, image duration, total fish density, and sonar orientation. Among-viewer agreement was highest in standard-orientation deployments lateral to the swimming lamprey, where images appeared as though acquired from overhead. Imagery in standard orientation had longer event duration and enhanced detection of anguilliform swimming, the most important characteristic for distinguishing Pacific lamprey from other species. Lamprey events observed in rolled orientation (sonar rotated 90°) tended to be short duration with foreshortened head- or tail-first images that reduced viewer confidence. Our results highlight the importance of quality control assessments in acoustic imaging studies, especially those targeting cryptic species and those conducted in hydraulically challenging, multi-species environments.

Keywords: *Entosphenus tridentatus*; imaging sonar; quality control; sensitivity analysis; species discrimination

Introduction

Dual-frequency Identification Sonar (DIDSON) is a multi-beam imaging system capable of acquiring near-video quality streaming imagery of fish and other targets of interest (Moursund et al. 2003). DIDSON operates at frequencies beyond the known hearing range of all fish species (Fay and Simmonds 1999) and is therefore useful as a non-invasive tool for enumeration and behavior studies. As with underwater optical video, DIDSON allows for direct visual observation without a need for fish handling. However, DIDSON also works at night and under turbid conditions and therefore can be more effective than optical video in some situations. Fisheries researchers have used DIDSON in a variety of studies, ranging from monitoring river herring (*Alosa* spp.) and Pacific salmon (*Oncorhynchus* spp.) migrations in small coastal streams (Pipal et al. 2010, Magowan et al. 2012) to enumeration of adult salmonids in larger rivers (Holmes et al. 2006, Maxwell and Gove 2007, Petreman et al. 2014). DIDSON has also been used in several regulated rivers to examine downstream dam passage by juvenile fish (Smith et al. 2010), spawning activity below dams (Tiffan

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