A METHOD FOR ACCURATELY ESTIMATING FISH TRAFFIC THROUGH FISHWAYS WITH LESS EFFORT

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Introduction

Hydroelectric power dams block the upstream migration of riverine fishes (Agostinho *et al*., 2005; Antonio *et al.*, 2007; Pelicice *et al.*, 2015) and providing a fishway is one of the most common means for mitigating such impacts (Bizzotto *et al.*, 2009). Nevertheless, it is essential that fish traffic (i.e., the number of fish that bypass a dam via a fishway) be estimated correctly to evaluate the importance of the fishway to fisheries management and conservation. In fishway with water sufficiently clear, estimates of fish traffic can be accomplished by counting fish in video images (Haro & Kynard, 1997; Lira *et al.*, 2017). However, this technique is painstaking, time consuming (Travade & Larinier, 2002), and tedious.

The aim of this study was to propose a new method for estimating fish traffic from video images, reducing the amount of time spent counting fish recorded in video images by determining the smallest fraction of a given hour needed to accurately estimate the number of fish that pass through that hour.

Methods

We conducted our study at the Igarapava Fishway, located on the Grande River, which delineates the border of Minas Gerais and São Paulo, Brazil. A clear acrylic window placed at the end of the fishway permits recording of fish with a video image system. This allowed us to determine the number of each fish species passing by the acrylic window. All recordings were performed during 46 randomly chosen days between June 2003 and May 2004.

We used data collected on the seven most abundant fish species. From the counts of each of species, we determined a simple linear regression coefficient (*b*) from the equation $C_d = a + bT_x$, where C_d represents the daily census of fish on any given day (i.e., number of fishes that passed through the fishway on day *d*) and T_x is the estimate of the censused from the samples (i.e., the number of fish recorded in the first X minutes of each hour of day *d* multiplied by 60 X^{-1}, wherein X ranged from 5 to 60 min in 5-min increments). We then determined *b* for each value of X and analyzed for each species the relationship between *b* and X in a plot. When *b* = 1.00, the sample accurately estimates the actual census (C_d). The accuracy in the estimate of C_d declines as *b* becomes further from 1.00.

Results and Discussion

The seven most abundant species considering all video images were *Leporinus octofasciatus* (N = 4,756), *Pimelodus maculatus* (4,250), *Leporinus friderici* (1,238), *Prochilodus lineatus* (645), *Piabarchus stramineus* (615), *Schizodon nasutus* (241) and *Salminus hilarii* (87).

We found four types of relationships between *b* and X: (1) *b* varied erratically (e.g., *P. stramineus* and *S. hilarii*), (2) *b* was predominantly > 1.00 (e.g., *P. lineatus*), (3) *b* was relatively constant and close to 1.00 (e.g., *L. octofasciatus*), and (4) *b* tended to increase gradually until it reached 1.00 (e.g., *L. friderici*, *P. maculatus*, and *S. nasutus*). The erratic variation of *b* suggests non constant fish traffic during any given hour, which may be associated with passage of schools, whereas a relatively constant *b* indicates evenly distributed fish traffic throughout hour.

The first two types of the relationships between *b* and X do not allow an accurate estimation of C_d with data derived from a fraction of each hour. In contrast, the last two types of relationships allow one to estimate C_d accurately based on a fraction of an hour. Assuming that the error of the estimate for C_d from the equation is acceptable when 0.90 ? *b* ? 1.10, then C_d of *S. nasutus* can be estimated with 50 min of counts, *L. friderici* estimated with 45 min of counts and *L. octofasciatus* and *P. maculatus* each estimated with as few as 5 min of counts. On the other hand, if it is acceptable to estimate C_d only with 0.95 ? *b* ? 1.05, then accurate estimates can only be made for *L. octofasciatus* and *P. maculatus* with 5 min of counts and for *L. friderici* with 50 min of counts.

Conclusions

It is possible to reduce effort in estimating the number of fish moving past the Igarapava Fishway using the method we developed, but only for species that *b* is close to 1.00 and are relatively constant for any value of X or for species for which the *b* increases gradually until it reaches 1.00. For other species, all individuals must be counted to gain an accurate census. It is likely that the methodology we employed could be applied to other fishways to determine if sampling effort can be reduced for censusing fish traffic.

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