Scientific Note

Comparing on site human and video counts at Igarapava fish ladder, Southeastern Brazil

Mark D. Bowen*, Simone Marques**, Luiz G. M. Silva**,
Volney Vono** and Hugo P. Godinho***

On site human observations and video images were collected and compared at the window of the Igarapava Dam fish ladder (IDFL), rio Grande , Southeastern Brazil, between March 1st and June 30th, 2004. We conducted four experiments with two humans (Observer 1 and Observer 2) observing fish passage in the IDFL window while a Sony 3CCD video camera (Observer 3) recorded fish passage at the same time. Experiments, each one hour in length, were distributed throughout the diel cycle using full spectrum lights. We identified fish species, the number of individuals for each species, and the real time that they passed. Counts from each human observer were compared to the video counts. The fish species most commonly observed in the window were - curimba (*Prochilodus lineatus*), mandi-amarelo (*Pimelodus maculatus*), piau-três-pintas (*Leporinus friderici*) and ferreirinha (*Leporinus octofasciatus*). The number of species and individuals were indistinguishable for the three observers. But, the number of species and individuals were significantly different among experiments. Thus, the three observers register the same number of species and count the same number of individuals even when these two response variables differ significantly among experiments. Based on these results, we concluded that the video count was an accurate method to assess fish passage at the IDFL.

Observações *in loco* e vídeo filmagens foram coletadas na janela da escada de peixes da UHE Igarapava (EPUG), rio Grande, sudeste do Brasil, entre 1º de março e 30 junho de 2004. Realizaram-se quatro experimentos com dois observadores humanos (Observador 1 e Observador 2) que observaram a passagem de peixes na janela da EPUG enquanto uma vídeo câmera Sony 3CCD (Observador 3) registrou simultaneamente a passagem de peixes. Os dois observadores humanos registraram *in situ* a passagem de peixes no visor da escada enquanto a câmera os filmava ao mesmo tempo. Os experimentos, cada um com uma hora de duração, foram realizados durante o ciclo diário, utilizando-se iluminação de espectro completo. Registraram-se as espécies, o número de indivíduos e o horário de passagem. Os registros de cada observador humano in situ foram comparados com os dos vídeos. Consideraram-se curimba (*Prochilodus lineatus*), mandi-amarelo (*Pimelodus maculatus*), piau-três-pintas (*Leporinus friderici*) e ferreirinha (*Leporinus octofasciatus*) como espécies alvo, tendo em vista sua alta freqüência de ocorrência na escada de peixes da UHE Igarapava. O número de espécies e o número de indivíduos não foram estatisticamente diferentes entre observadores. Por outro lado, o número de espécies e o número de indivíduos que passaram pelo visor foram estatisticamente diferentes entre experimentos. Assim, demonstrou-se que os três observadores registraram o mesmo número de espécies e contaram o mesmo número de indivíduos, mesmo quando as duas variáveis diferiram significativamente entre experimentos. Concluiu-se que o sistema de vídeo imagem constitui um método eficaz para avaliação da passagem de peixes na escada de peixes de Igarapava.

Key words: Fish ladder, On-site human counts, Video image counts.

*Science and Technology Program and Fisheries Applications Research Group, US Bureau of Reclamation; Denver, CO, USA; e-mail: mbowen@do.usbr.gov

**Centro de Transposição de Peixes, Instituto de Ciências Biológicas, UFMG; Brazil. e-mails: smarquess@terra.com.br, luictio@icb.ufmg.br, lagovono@dedalus.lcc.ufmg.br

***Programa de Pós-graduação em Zoologia de Vertebrados, Pontificia Universidade Católica de Minas Gerais, Prédio 41, Av.Dom José Gaspar, 500, 30535-610 Belo Horizonte, MG, Brazil; e-mail: hgodinho@pucminas.br

Brazilian reservoir fisheries management actions are in general not successful because of shortage of scientific information, limitations of financial and human resources, and absence of monitoring (Agostinho *et al.*, 2004). Monitoring fish passage in hydroelectric power plants is of paramount importance in evaluating the contribution of fish pass mechanisms in hydroelectric power plants for upstream reservoir fisheries.

The rio Grande, rio Paraná basin, is an important economic resource in Southeastern Brazil. In general, its fish stocks are low and some of its species are listed as threatened with extinction (Brazil, 2004). The 12 dams built along the 1,390 km of the river have undoubtedly contributed to its present poor fisheries status (Santos & Formagio, 2000). Igarapava Dam, located 501 km from the mouth, was completed in 1998, and is the 5th dam upstream from the confluence with the rio Paraná. To allow upstream fish passage around Igarapava Dam, a fish ladder began operation in 1999. A fish counting window near the top of the ladder allows visual counts of fish as they exit the ladder. Unpublished data on fish passage have been gathered using on-site visual counts and video-images counts.

Estimates of the number and species of fish in a fish ladder through direct counts are generally considered as absolute, as they only happen once and cannot be tested for accuracy, nor is independent confirmation of species identification possible. The degree of confidence that may be placed in such estimates is impossible to estimate both for the number of fish passing and for individual specimen identification (Hatch *et al.*, 1994, Hatch *et al.*, 1998)

Recent progress with video technology has allowed automation and reduced the need for visual counting carried out by observers *in situ* (Travade & Larinier, 2002). Time-lapse video systems have been used to record migration of adult Pacific salmon (Hatch *et al.*, 1994). This technique provides the opportunity to calculate variance and place confidence bounds on estimates. Video technology provides a permanent record of fish passage that can be reviewed multiple times by different readers to obtain accurate species and number of fish using the fish pass. Video fish counting can also reduce data gathering costs and increase the amount of data collected compared with on-site counting (Hatch *et al.*, 1998). In most situations, time-lapse recorded video tapes of fish passage contain only a small percentage of frames of actual fish images. However, a counter must review all tape frames, no matter how many fish are present (Hatch *et al.*,1994). Computerized image processing techniques have many potential applications for the analysis of fish passage (Travade & Larinier, 2002). Some authors believe that in the near future it may be possible for computers to count and identify fish with speed and accuracy at least as good as human counters. Eventually, computers may even be trained to recognize, classify and count fish (Nery, 2004).

This paper tested the feasibility of using video technology for estimating and evaluating fish passage at Igarapava Dam fish ladder (IDFL) on the rio Grande. The objectives of this study were to: i) document and count fish-ladder pas-
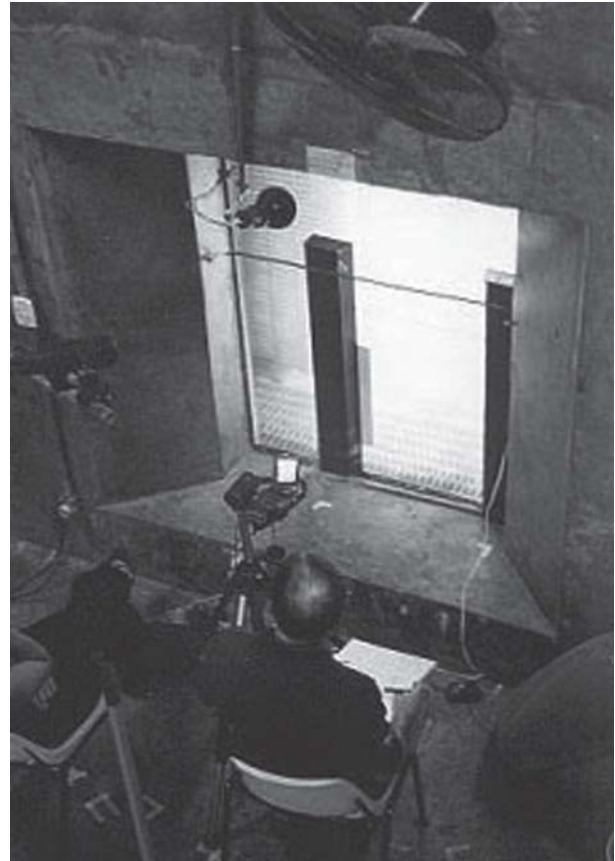

Fig. 1. Camera configuration with Sony Camera (DCR-TRV950) in frame center. The two vertically oriented full spectrum lights are adjacent to the window; above is the infrared light bulb.

sage using video technology; ii) compare fish counts generated from video recordings and on-site observers counts; iii) test species recognition between the two methods

The study was conducted using images acquired in the IDFL sub sampled window whose dimensions were 1.17 m in width x 0.50 m in height x 1.00 m in depth (Fig. 1). The images were obtained between March 1st and June 30th, 2004.

On-site counts and video camera. Four experiments were conducted at different times of the day, starting respectively at 15:45, 19:25, 12:17 and 19:58. Two human observers (Observer 1 and Observer 2) made on-site observations of fish passing through the window while a Sony 3CCD video camera recorded fish passage at the same time (Observer 3 identified fish recorded). The experiments conducted during the day employed full spectrum lamps (CORALIFE 10,000K VHO 95W, High-Intensity Purified Super Daylight Lamp) whereas the night experiments were performed under a General Electric lamp, model Chill Chaser Deluxe, infrared and heatlamp (Hiebert *et al*., 2000). This lamp provided infrared and some visible light. The water turbidity was not measured in our experiments since it was clear enough not to interfere with the counts (Fig. 2). For each experiment and for the three observers we recorded the number of species and the number of individu-
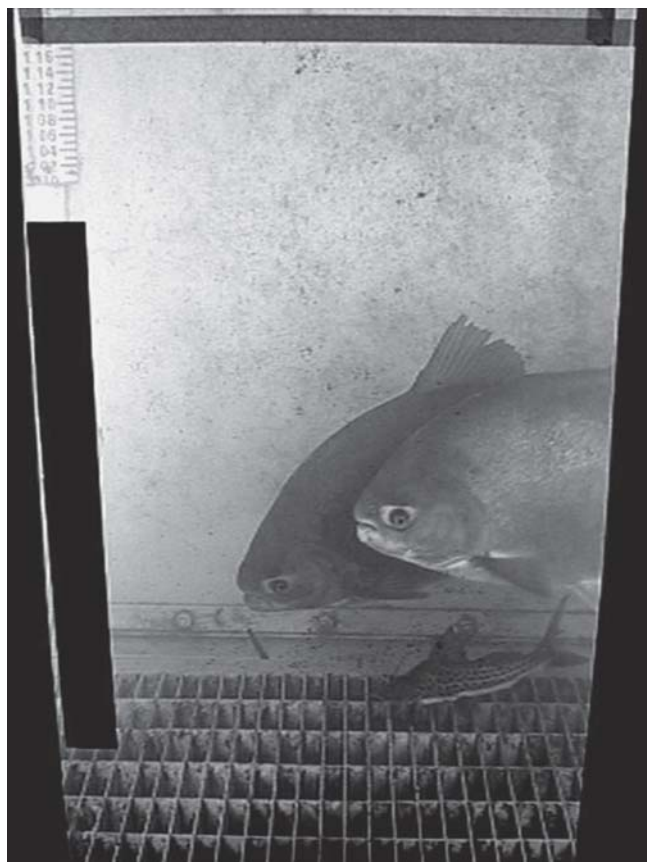
Fig. 2. Still image capture of two *Piaractus mesopotamicus* and one *Pimelodus maculatus,* upstream direction, registered by the video counter.

als passing by the IDFL window. During recording, the film record registered the time and date on each frame of video tape, providing a record of the exact time each fish passed through the counting slot. The species were identified by specialists that were the human observers.

All of the recorded films were watched by Observer 3 with the Ulead VideoStudio 6 SE Basic Program linked with the video camera.

Statistical analyses. We used a Mixed Model, 1-Way Analysis of Variance (ANOVA) (SAS, 1999) We executed an ANOVA for each of two independent variables: Observer and Experiment. We used a Mixed Model because the observers were selected from a large pool of fisheries professionals and cameras. But,

the experiments were fixed with respect to time and space.

Species identification and counts from observers and video camera: The following species were identified: *Pimelodus maculatus* (mandi-amarelo)*, Leporinus friederici* (piau-três-pintas), *Leporinus octofasciatus* (ferreirinha), *Piaractus mesopotamicus* (pacu-caranha), *Megalancistrus aculeatus* (cascudo-abacaxi), and *Cichla* sp. (tucunaré). The species and number of counts in each experiment are in Table 1.

Counts and comparisons. We found the number of species to be exactly the same (Table 1) (ANOVA: F = 0.00, p = 1.0000) and the number of individuals was statistically indistinguishable among observers (F = 0.04, p > 0.9569). But, the number of species was different among experiments (no statistical test is necessary because all observations for each observer were exactly the same within each experiment, *i.e.* variance = 0). The number of individuals counted was statistically significantly different among experiments (F = 81.80; p < 0.0001).

The results suggest the number of species passing may vary greatly but the human observers and the video camera register were not different from each other under these circumstances. Thus, the three observers registered the same number of species and counted the same number of individuals even though these two variables differ among experiments.

The technology of video cameras, computers and specialized software used in this study provide credible results compared with the human observers. It allowed monitoring the fish passage and the assurance of counts (Irvine *et al.*, 1991; Hatch *et al.*, 1994). The videotape system can make it easier, faster, and less expensive to count migratory fish passage (Irvine *et al.*, 1991). It is most useful at locations or during times when relatively few fish will be observed per day (Hatch *et al.*, 1998) as it avoids the need for full-time human observers.

Counts from video monitoring were found to be comparable to real-time counts in the fish ladder. The observer could also play the tape back an unlimited number of times and at varying speeds, and show the film to other fisheries professionals to confirm species identification (Hatch *et al.*, 1994; Travade & Larinier, 2002). This was not an option for the human observers in real time at the IDFL window.

The reliability of detection of fish in front of the window depends on various environmental factors including lights, water turbidity, water velocity and the characteristics of fish

Table 1. Species and number of individual observed in each experiment for two on site human observers (Obs.) and one video count (VC).

Species	Experiment 1			Experiment 2			Experiment 3			Experiment 4		
	Obs. 1	Obs. 2	VC	Obs. 1	Obs. 2	VC	Obs. 1	Obs. 2	VC	Obs. 1	Obs. 2	VC
P. maculatus	0	0	0	4	4	4	0	0	0	14	15	18
L. friderici	9	10	9	0	0	0	4	4	5	0	0	0
L. octofasciatus	2	2	2	0	0	0	0	0	0	1	1	1
P. mesopotamicus	0	0	0	0	0	0	0	0	0	2	2	2
M. aculeatus	0	0	0	0	0	0	3	2	3	0	0	0
Cichla sp.	0	0	0	0	0	0	1	1	1	0	0	0

species including size, color, speed and swimming behavior (Warren & Pardew, 1998; Travade & Larinier, 2002). In the case of our study, the lights and water turbidity were adequate to compare the observers and review the species of fishes that passed by the window.

This study has demonstrated that image acquisition hardware and a video editing software package could be used to automate essential fish-ladder observer functions. It also help to initiate the process for regulatory change that will allow for the deployment of video monitoring devices in lieu of human observers.

Literature Cited

Agostinho, A. A., L. C. Gomes & J. D. Latini. 2004. Fisheries management in Brazilian reservoirs: lessons from/for South America. Interciencia, 29(6):334-338.

BRAZIL. Normative instruction no. 5, May 21, 2004. National list of threatened and overexploited aquatic species. Ministry of Environment, Brazil. Official Diary, Federative Republic of Brazil 102:136-142 [in Portuguese]

Hatch, D. R., M. Schwartzberg & P. R. Mundy. 1994. Estimation of Pacific salmon escapement with a time-lapse video recording technique. North American Journal of Fisheries Management, 14:626-635.

Hatch, D. R., J. K. Fryer, M. Schwartzberg & D. R. Pederson. 1998. A computerized editing system for video monitoring of fish passage. North American Journal of Fisheries Management, 18:694-699.

Hiebert, S. , L. A. Helfrich, C. Liston & D. L. Weigmann. 2000. Anadromous salmonid passage and video image quality under infrared and visible light at Prosser Dam Fish Ladder, Yakama River, Washington. North American Journal of Fisheries Management, 20:827-832.

Irvine, J. R., B. R. Ward, P. A. Teti & N. B. F Cousens. 1991. Evaluation of a method to count and measure live salmonids in the field with a video camera and computer. North American Journal of Fisheries Management, 11:20-26.

Nery, M. S. 2004. Identificação de espécies de peixes utilizando visão computacional: estudo de caso da escada de peixes da Usina Hidrelétrica de Igarapava. Unpublished Master Thesis, Universidade Federal de Minas Gerais, Minas Gerais.109p.

Santos, G. B. & P. S. Formagio. 2000. Estrutura da ictiofauna dos reservatórios do rio Grande, com ênfase no estabelecimento de peixes piscívoros exóticos. Informe Agropecuário, Belo Horizonte, 11(203):98-106.

SAS Institute. 1999. SAS OnlineDoc, 8th version. Cary: SAS Institute.

Travade, F. & M. Larinier. 2002. Monitoring techniques for fishways. Bulletin Français de la Pêche et de la Pisciciculture, 364:166-180.

Warren, M. L. J. & M. G. Pardew. 1998. Road crossings as barriers to small-stream fish movement. Transactions of the American Fisheries Society, 127:637-644.