ABILITY OF RIO GRANDE CUTTHROAT TROUT TO ASCEND VERTICAL BARRIERS

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EXTENDED ABSTRACT ONLY – DO NOT CITE

Introduction

We evaluated the ability of Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) to negotiate waterfall-type barriers as part of a larger study on barriers to salmonid upstream migration. Upstream movements of fishes are an important source of population re-colonization and recruitment (Horan et al., 2000). A valid criterion for identifying potential barriers to upstream migration is needed in order to assess the suitability of candidate watersheds. We intend to develop empirical models of cutthroat trout jumping ability as a function of size (total length, TL) and waterfall dimensions, barrier height (h_1) and plunge pool depth (h_2).

Materials and Methods

All experiments were conducted within a covered raceway at the Colorado Division of Wildlife Research Hatchery, Bellvue, CO. Our artificial waterfall is a flashboard design that used a series of tongue-and-groove stacked boards to create the vertical drop structure (Figure 1). We regulated waterfall height (h_1, 10 to 50 cm, in 10 cm increments)) by installing the appropriate number of 10 cm high flashboards. The lower end of the raceway served as the plunge pool. Plunge pool depth (h_2, 10 to 50 cm in 10 cm increments) was regulated by adding the appropriate number of 10 cm high flashboards at the downstream end of the raceway. Flows were set to 570 L/min; water temperatures at the hatchery are a constant 11± 1°C.

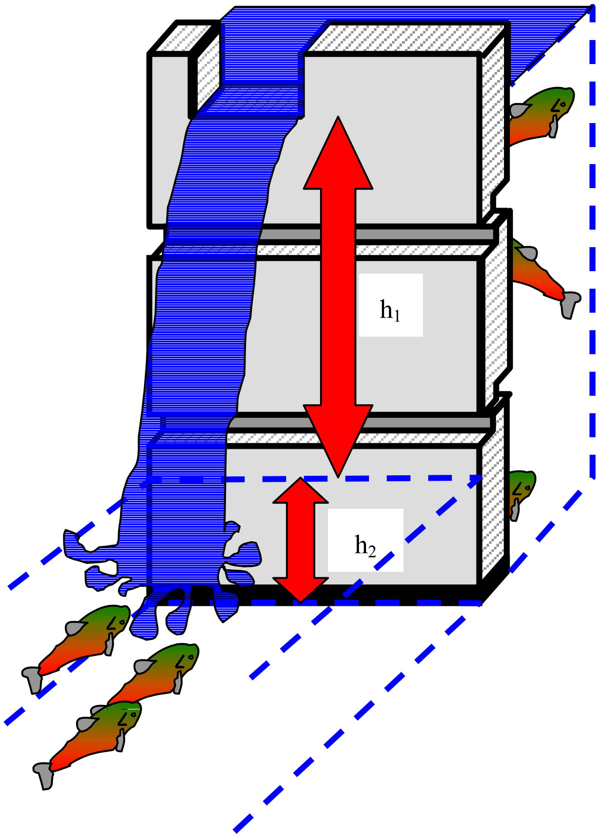

Figure 1. Schematic diagram showing flashboard-type artificial waterfall. Shown in red are h_1, barrier height and h_2, pool depth. Pool depth is manipulated by removing or adding tongue-and-groove boards to the spill at the end of the raceway.

Jumping experiments

The artificial waterfall was set to one of 25 possible combinations of waterfall height and plunge pool depth and flow started. A random sample of 15 cutthroat trout was netted from an adjacent raceway containing 1000 individuals. Fish were placed in the plunge pool. Once fish were added, the raceway was left undisturbed for 24 hours. At the end of the experiment, we recorded the following information: fish location (upstream or downstream), length (SL, FL, TL in mm), wet weight (g), body condition, and sex (when apparent).

Model Development

Pilot study data suggested the probability of a fish successfully negotiating a barrier largely depending upon the barrier height and plunge pool depth. We chose to use logistic regression framework to model "p", the probability that a fish could jump over a barrier, based on the fish's size, the barrier height, plunge pool depth, and interactions between the three factors. We used AIC_c model selection criteria to identify the terms that would best explain the observed variation in "p" (Anderson et al., 2001).

Results and Discussion

Cutthroat trout were able to jump over barriers up to 50 cm high as long as the plunge pool was at least 20 cm deep (Table 1). Our data showed that plunge pool depths of 10 cm or less effectively prevent cutthroat trout from jumping over barriers that were 30 cm or higher. We also noted a size effect, wherein smaller fish (ca. 22 cm TL) were better able to jump over barriers when faced with a shallow plunge pool than larger fish (ca. 27.6 cm TL).

The probability of a cutthroat trout jumping the barrier was best predicted by the logistic regression model (shown below) that included h_1 and the $h_1 \times h_2$ interaction (AIC_c value: 878.08 ; AIC_c weight: 0.276; ΔAIC_c: 0.00).

$$\text{logit}(P) = -0.16 - 1.53\,(h_1) + 0.91\,(h_1 * h_2)$$

Table 1. Effects of waterfall height and plunge pool depth on the proportion of Rio Grande cutthroat trout that jumped the barrier.

Depth (cm)	Height (cm)	Proportion successful (95% C.I.)	N
10	10	0.47 (0.32 – 0.61)	45
	20	0.14 (0.01 – 0.27)	29
	30	0.07 (-0.02 – 0.16)	30
	40	0.00 (0.00 – 0.00)	44
	50	0.00 (0.00 – 0.00)	63
20	10	0.80 (0.60 – 0.94)	29
	20	0.70 (0.54 – 0.86)	29
	30	0.60 (0.42 – 0.78)	30
	40	0.53 (0.44 – 0.62)	117
	50	0.03 (0.03 – 0.10)	30
30	10	0.79 (0.61 – 0.97)	29
	20	0.76 (0.61 – 0.91)	30
	30	0.68 (0.56 – 0.80)	73
	40	0.17 (0.03 – 0.30)	30
	50	0.17 (0.03 – 0.30)	30
40	10	0.77 (0.62 – 0.92)	30
	20	0.82 (0.71 – 0.93)	45
50	10	0.71 (0.58 – 0.84)	59

The two other competing models (i.e., within 3 ΔAIC_c of the best model) included h_1, the $h_1 \times h_2$ interaction and either the $h_1 \times h_2 \times$ fish size or $h_1 \times$ fish size interactions. We hope to refine our model after further cutthroat trout jumping data are collected, especially at higher waterfall heights and greater plunge pool depths.

Though preliminary in nature, our results may prove useful in identifying potential barriers to migration in streams that are being considered for cutthroat trout re-introductions. This would allow managers to assess the amount of habitat available to the fish as well as determine whether any existing barriers need modification or removal. Additionally, our data could be used to design culverts and flood control structures that are negotiable by Rio Grande cutthroat trout.

Cutthroat trout restoration attempts are often thwarted by the re-invasion of upstream areas by non-native brook trout—this re-invasion can only be prevented through the use of adequate barriers to migration (Thompson and Rahel, 1998). Development of models for harmful competitors to cutthroat trout, such as brook trout (Harig and Fausch, 2000), can be used as criteria for engineering more effective in stream barriers. We are currently using the techniques developed in this pilot study to collect data on brook trout (*Salvelinus fontinalis*) jumping performance.

References

Anderson, D. R., K. P. Burnham, and G. C. White. 2001. Kullback-Leibler information in resolving natural resource conflicts when definitive data exist. Wildlife Society Bulletin 29: 1260-1270.

Harig, A. L., K. D. Fausch, and M. K. Young. 2000. Factors influencing success of greenback cutthroat trout translocations. North American Journal of Fisheries Management 20: 994-1004.

Horan, D. L., J. L. Kershner, C. P. Hawkins, and T. A. Crowl. 2000. Effects of habitat area and complexity on Colorado River cutthroat trout density in Uinta mountain streams. Transactions of the American Fisheries Society 129: 1250-1263.

Thompson, P. D. and F. J. Rahel. 1998. Evaluation of artificial barriers in small Rocky Mountain streams for preventing the upstream movement of brook trout. North American Journal of Fisheries Management 18: 206-210.

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