Direct and Indirect Effects of Water Velocity on Foraging Success in a Stream-dwelling Fish Species
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Introduction
Perhaps the most conspicuous physical feature of stream ecosystems, water current can have profound effects on the ecology of stream-dwelling organisms. In this study, we set out to develop a mechanistic understanding of the link between water current and feeding (foraging) success in a stream fish species (see graph below).

This study was guided by the findings of an earlier experiment, in which we identified three discrete steps in the foraging process (see panel “The Foraging Process”).

Employing improvements in design and technology, our principal goal here was to see whether we could reproduce the findings of the first experiment. Accomplishing this, we then would use the experimental data to build a path model exploring the indirect and direct connections between water current and feeding.

The Foraging Process
Effects of Current
1. STEP 1: How much food is available to the predator. This is a function of food density, search volume, and water velocity.
2. STEP 2: How much of the available food is detected.
3. STEP 3: How much of the detected food is captured.

Because reaction time diminishes with water velocity, detection probability and feeding efficiency will likely decline with current speed.

Path Model
We combined results and constructed a path model to characterize the relative importance of water velocity and the three feeding phases on feeding success (consumption/time).

The resulting model revealed that feeding success was most strongly linked to detection probability and food availability (highest path coefficients in model) and that the effect of water velocity on feeding success was limited to an indirect effect on feeding efficiency.

Results – Effects of Water Velocity
Graphs show effects of water velocity on four attributes of foraging.
• The results of the two studies (2009, blue, 2015, red) were comparable.
• Search Volume, which affects how much food a fish will encounter (Food Availability), declined sharply with increasing water velocity, but, Food Availability (# of pellets traveling through the search volume/time) did not.
• Detection probability (probability of detecting a pellet in the search volume) did not change with velocity.
• Capture efficiency (successful strikes/attempted) declined with velocity.

Conclusions
Here we confirmed the findings of an earlier study and combined data from both to identify the mechanisms responsible for the relationship between feeding success and water velocity. Our main conclusions:
• There may be an adaptive component to the relationship between search volume and water velocity. Fish appear to adjust the size of their search volume so that the amount of food encountered and detected remains constant with changing velocity.
• The two components of the foraging process not correlated with water velocity explained most of the variability in feeding success. It would appear that the relationship between feeding success and water velocity is principally due to the effects of water velocity on how efficiently the fish handles and consumes its prey.

Methods
• Feeding experiments were conducted in a 70 liter recirculating flow chamber.
• Water velocity conditions in the chamber were manipulated, creating different experimental conditions.
• We employed a repeated measures design using adult Creek Chub, n = 10).
• All test fish were exposed to each of three water velocity conditions.
• Floating food pellets (n = 125) were introduced to the flow chamber at the onset of each trial.
• Feeding behavior was recorded via video (both side and top view).
• For each trial, we recorded 10 feeding events (both successful and unsuccessful feeding strikes).
• All videos were analyzed using the program Tracker to obtain the x, y, and z coordinates of the fish and food particle at the moment of food recognition. We used these data in combination with the food density data to calculate different feeding metrics.
• The earlier (2009) study used similar procedures, generated the same type of data, but was based on poorer quality video and less refined video analysis software than the present study.

Creek Chub (Semotilus atromaculatus)