

# Don't be scared, just swim away: the C-start escape response in four species of surfperches (Embiotocidae) from central California



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## Introduction

Most fishes exhibit a C-start escape response to avoid disturbances, such as predators or powerful waves. This fast-start response consists of bending their body into a "C" shape, immediately followed by swinging their tail in the opposite direction to propel away from a stimulus. Surfperches, which primarily use their pectoral fins for locomotion (labriform swimming), also elicit this type of behavior. We hypothesized that four species of surfperches (barred, shiner, black, pile) will differ in their escape response based on variations in their fin morphology. Pectoral fins with a low aspect ratio (AR; length<sup>2</sup>/surface area) have a paddle-like form, thus allowing a fish to maneuver efficiently around an object; fishes with a higher AR fin tend to be better at achieving fast swimming speeds and less maneuverable. The angle of attachment of the pectoral fin, relative to the long axis of its body, indicates different modes of swimming. Fishes with pectoral fins attached at higher angles tend to be more efficient at maneuvering than fishes with lower fin angles. Barred surfperch, which have the lowest fin angle among the four species, were predicted to be the least maneuverable. Pile surfperch, at the opposite extreme in fin angle, were predicted to be the most maneuverable. Shiner and black surfperch were predicted to have intermediate escape responses due to their intermediate fin morphology.

## Methods

- four adult species selected based on different fin morphology (Table 1)

**Table 1. Morphological variables of the four species of surfperches selected for this study. Preserved specimens were analyzed from the Ichthyology Collections at the California Academy of Sciences.**

Species	n	TL (cm)	pectoral fin angle (°)	pectoral fin AR
barred	5	10.0 - 13.0	35.0 - 36.0	2.92 - 3.59
shiner	5	10.0 - 11.6	44.0 - 48.0	2.12 - 2.98
black	5	13.5 - 23.5	44.0 - 47.0	2.62 - 6.74
pile	5	17.8 - 39.0	51.0 - 52.0	3.75 - 4.93

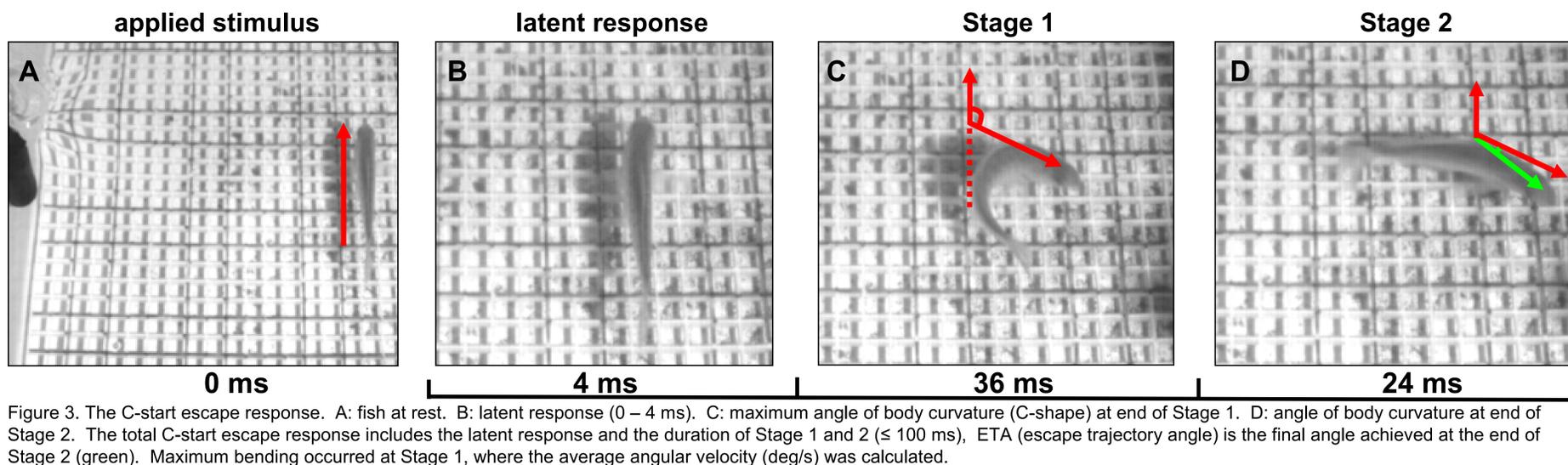
- captured fishes via beach seine (Figure 1)
- acclimated 1 to 2 fish in arena for 24 hrs
- dimensions: 53 cm x 55 cm x 30 cm
- fasted for 24 hrs to standardize metabolism
- experiments up to 4 hrs/day
- camera: 250 frames/sec via dorsal view
- recorded 4 videos per fish (Figure 2)
- analyzed videos using Image J software (Figure 3)
- T° recorded before & after experiments



Figure 1. Capturing shiner surfperch via a beach seine at Vierra's beach in Elkhorn Slough.



Figure 2. Videos were recorded with a digital camera via a dorsal view (mirror above tank at 45°) with a 650 watt light.



## Results

**Table 2. PCA (principal components analysis) was conducted to reduce the dimensionality of the dataset. Values in red loaded the most heavily.**

Principal components	1	2	3
Variation explained (%)	63.588	19.708	15.007
Stage 1 duration (s)	0.76	0.63	0.051
Stage 1 angle (°)	-0.768	0.635	0.072
Stage 2 duration (s)	0.955	0.236	0.006
Stage 2 angle (°)	0.165	-0.083	-0.983
C-start escape response (s)	0.931	0.35	0.019
escape trajectory angle (°)	-0.731	0.624	-0.273
angular velocity for Stage 1 (° s <sup>-1</sup> )	-0.971	0.076	0.046

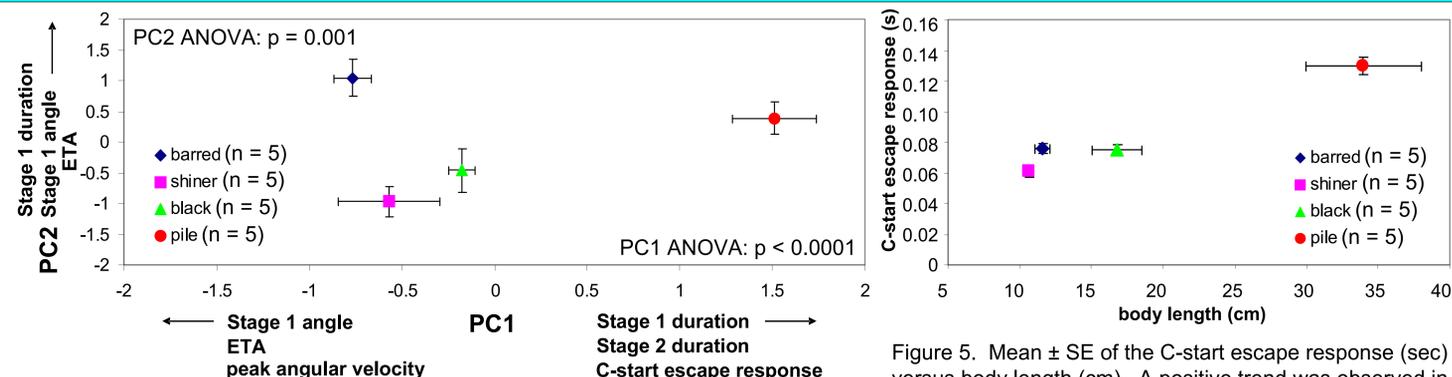


Figure 4. PC1: Values toward the right were slower (all time variables). Values toward the left on the x-axis had greater angles of curvature (all angular variables). PC2: all variables loaded positively. Barred surfperch had the greatest body curvature and fastest angular velocity for Stage 1. Shiner surfperch had the fastest escape response duration. Black surfperch were intermediates. Pile surfperch performed the slowest and turned the least.

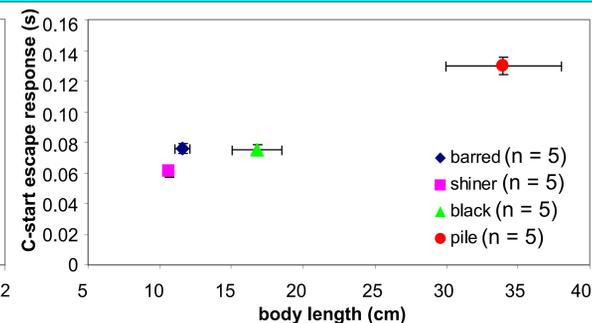


Figure 5. Mean  $\pm$  SE of the C-start escape response (sec) versus body length (cm). A positive trend was observed in the C-start escape response when dependent on body size. Escape responses were faster in the smaller species and slower in the surfperches with larger body sizes.

## Discussion

Surfperches exhibited a wide range in their escape responses, which may be due to their morphology and ecology. Barred surfperch had the greatest bending for Stage 1, the ETA, and the fastest angular velocity for Stage 1. They occupy the surf zone, which is a high energy habitat with waves constantly sloshing back and forth. This species must be able to maneuver efficiently to withstand the wave-swept conditions. Shiner surfperch had the fastest escape response and were also the smallest of the species. Black surfperch had reaction times and bending abilities that were intermediate of the four species, as expected with their intermediate differences in fin morphology. This is also a reflection of their habitat, which experiences moderate conditions. Pile surfperch were the slowest and had the least body bending, being the opposite of our prediction, especially because they occupy rocky structures where maneuvering is essential. Yet, they were much larger in size compared to the other species. Body size is a confounding factor here because there is no way to separate pile surfperch having the highest fin angle and largest body size, thus making it impossible to claim that fin morphology is the only variable responsible for the pattern we hypothesized.

## Acknowledgements

I would like to thank Dr. Lara Ferry-Graham for her amazing intellectual contributions to this research and to the many field volunteers who participated in the fish collections (SCP # 10140; IACUC # 918), including the Monterey Bay Aquarium and Aquarium of the Bay. Also to Lynn McMasters for her assistance with printing.