

# Order Parameter and Director Angle to Evaluate Electric Barriers

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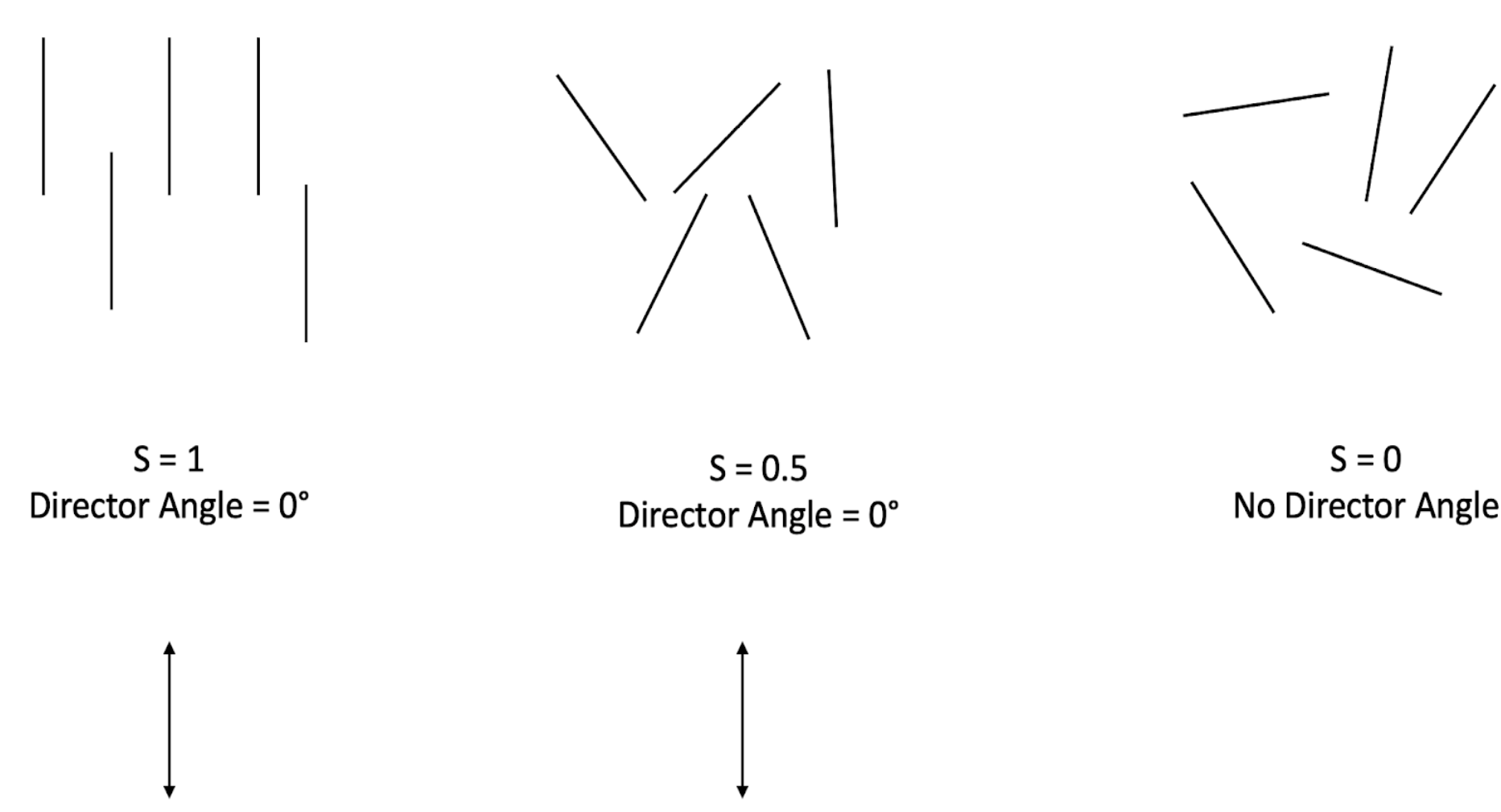


## Overview

Electric barriers are currently located in the Chicago Area Waterway System (CAWS) to prevent invasive Asian carp from entering Lake Michigan. However, Asian carp are not the only invasive species that may enter Lake Michigan through the CAWS. Smaller invasive invertebrates are also potentially very harmful to the lake's ecosystem. This research focuses on how the conditions of the electric barrier affect other invasive species present in the Mississippi River Basin near the CAWS.

## Order Parameter and Director Angle

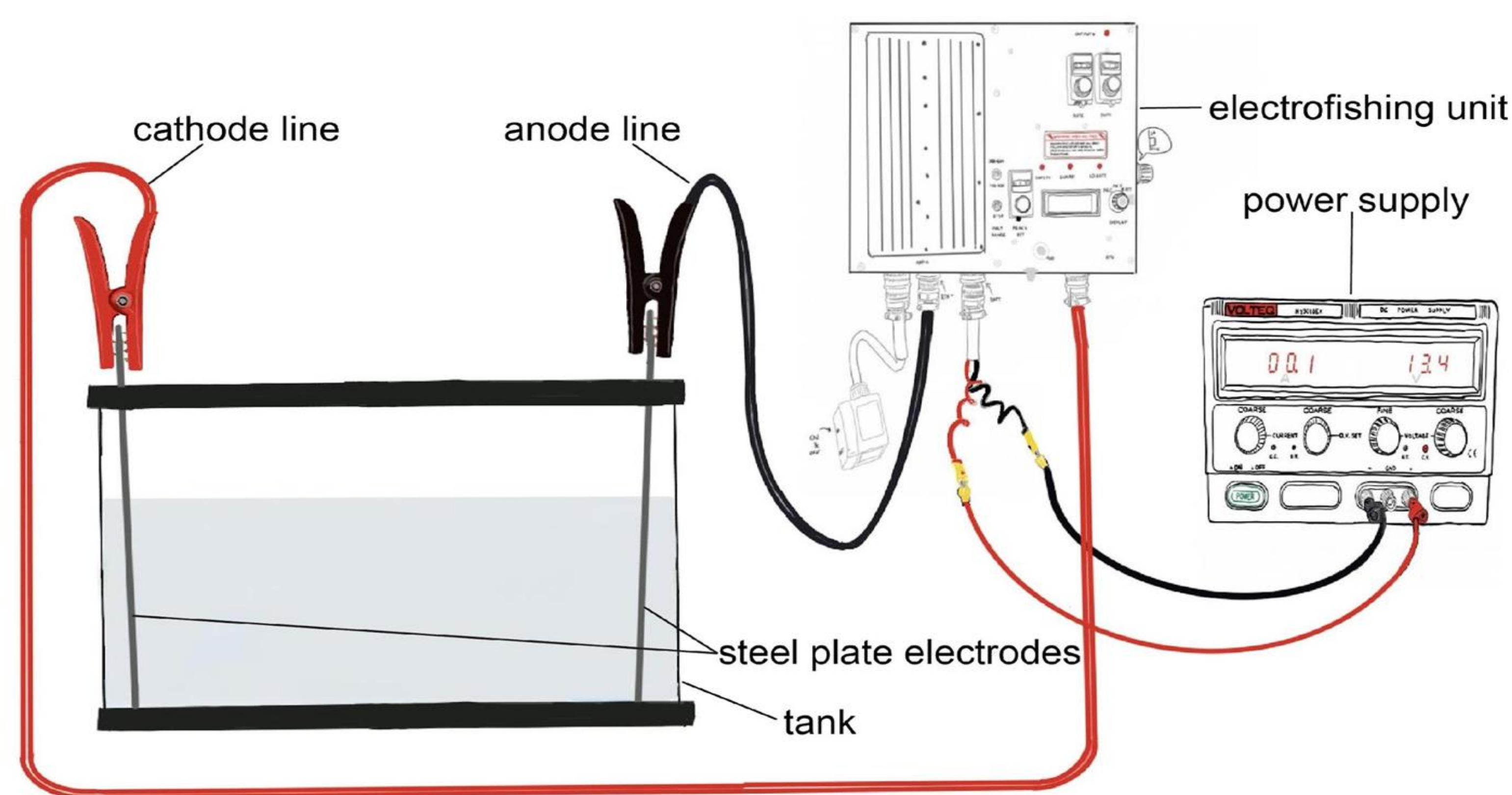
Research shows that crayfish and other rod-like species align perpendicular with the electric field to reduce the amount of shock they feel. Because species will try to orient themselves at 90 degrees with respect to the electric field, order parameter and director angles can be used to collect quantitative data from the trials. Order parameter depicts how well rods are aligned from values 0 to 1. A value of 1 shows complete alignment, a value of 0 represents complete randomness, and a value of 0.5 would show some alignment. The director angle is the average orientation, and it can be used to validate changes in order parameters.



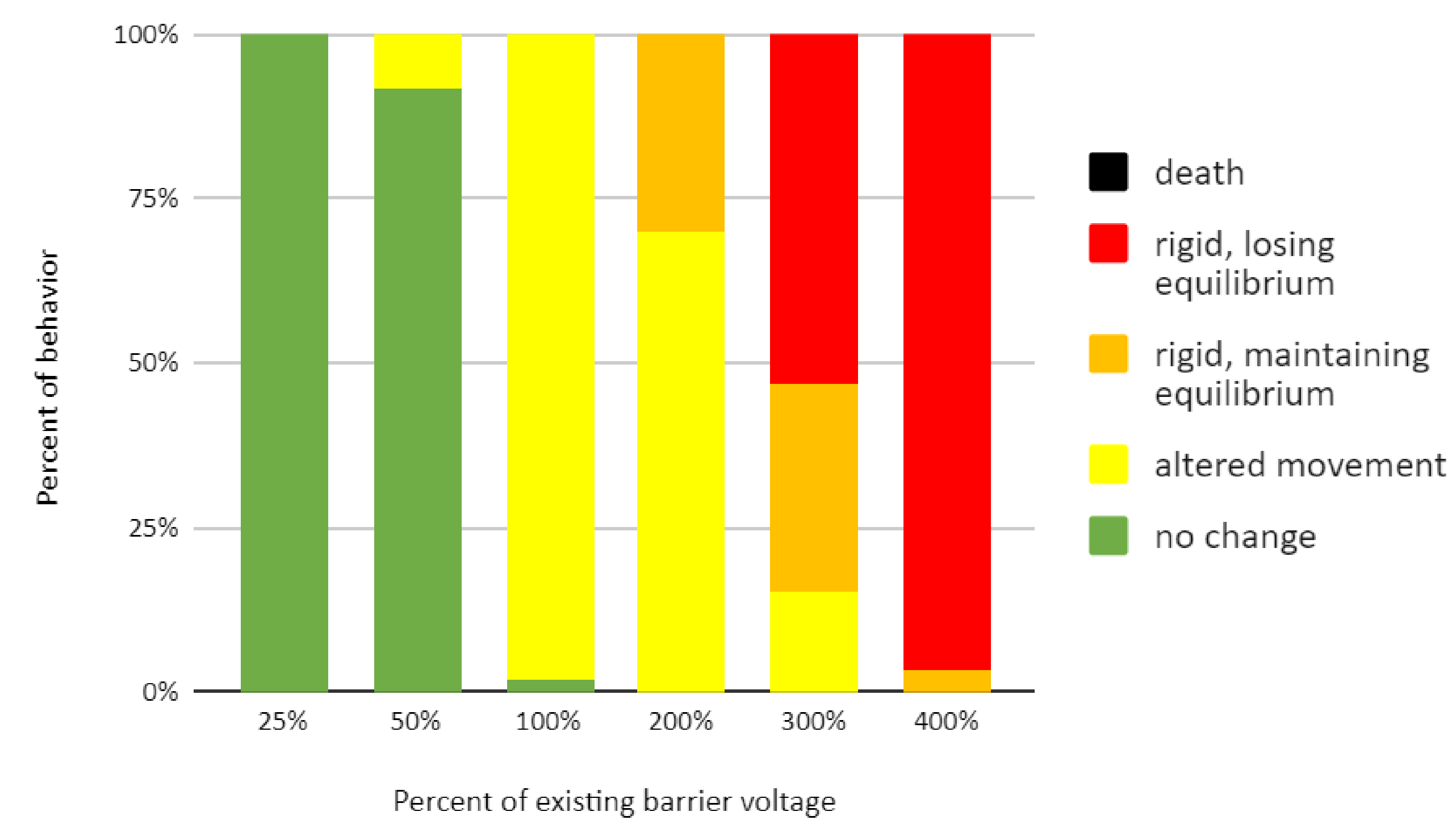
To measure the order parameter and director angles from the trials, the angles of the species were recorded with the use of SolidWorks. Angles were recorded at 30 second intervals while the electric barrier was on and were also recorded pre and post stimulus.

## Setup

A lab scale electric barrier was created to test various conditions of the electric barrier on desired species. The electric barrier was created by connecting an electric fishing backpack to steel plate electrodes in a freshwater tank. The electric field runs between the cathode and anode electrodes when the voltage is on.



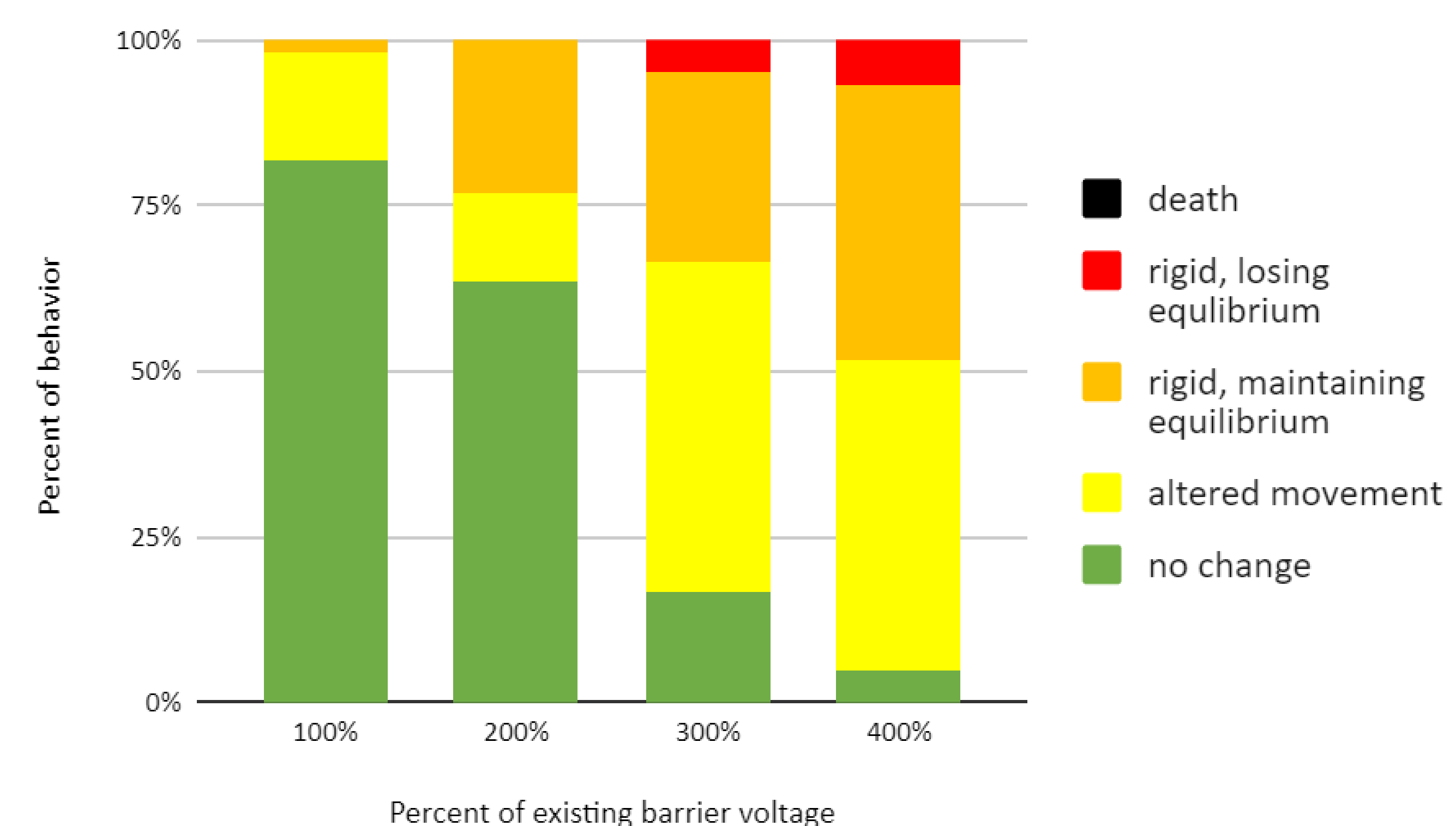
## Juvenile *Faxonius rusticus*



From 25% to 200% barrier conditions, the director angle of the *Faxonius rusticus* was close to 90 degrees. At 300% to 400%, the species lost equilibrium while the barrier was on so they were unable to align themselves perpendicular to the electric field.

Barrier Conditions	O.P. (OFF)	O.P. (ON)	Director Angle (ON)
25%	0.256	0.328	-76.0
25%	0.113	0.280	80.5
50%	0.132	0.472	68.6
50%	0.106	0.463	65.2
100%	0.041	0.644	82.9
100%	0.150	0.491	-89.4
200%	0.072	0.564	86.1
200%	0.070	0.552	-88.0
300%	0.045	0.288	22.8
300%	0.097	0.528	18.2
400%	0.139	0.203	-19.7
400%	0.235	0.478	-40.2

## *Apocorophium lacustre*



The order parameter and director angle shows that the *A. lacustre* felt the conditions of the electric barrier in each trial. In each trial, the director angle ranged from an absolute value of 78.8 to 88.6 degrees relative to the electric barrier.

Barrier Conditions	O.P. (OFF)	O.P. (ON)	Director Angle (ON)
100%	0.287	0.392	-86.2
100%	0.177	0.482	83.0
200%	0.313	0.326	-84.1
200%	0.177	0.482	83.0
300%	0.078	0.559	-84.7
300%	0.259	0.631	-81.9
400%	0.155	0.447	78.8
400%	0.170	0.591	88.6