# The Role of Mouth Shape on the Fluid Dynamics of Suction Feeding

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## Abstract

This research involves analyzing the feeding habits of an Amia fish, also commonly known as a Bowfin fish. The Amia fish catches prey through suction feeding which is the rapid expansion of the oral cavity, drawing prey into the mouth. Overtime, through Darwin's theory of natural selection, the Amia fish's mouth has evolved into a circular shaped mouth compared to its previous wedge shaped mouth. The key event in the evolution of fishes that allowed for this is the Maxilla decoupling form skull which is the cause of a circular mouth rather than wedge shaped during suction feeding. To create a wedge shaped mouth, minor surgery is conducted on the fish to manipulate the maxilla. Amia fish are used because they are easily accessible in this region and recover from surgery quickly. The hypothesis is that the circular shaped mouth has allowed for a greater flow rate which is more efficient for suction feeding. The goal is to understand this mouth shape evolution by analyzing experimental data and developing computational models.

*Figure 1: Photo of a side profile of the Amia fish*

## Introduction

The goal of this work is to manipulate the mouth shape in Amia fish and investigate the fluid dynamics of the feeding event. The experimental data for the study was collected at a biology lab at Hofstra University using a 2D Particle Image Velocimetry (PIV). PIV is a laser optical measurement technique which can be applied for a wide range of flow problems. The fluid is seeded with tracer particles that are illuminated using the laser. The change in position of these particles can than be used to find the speed and direction. This technique provides a means of measuring the velocity seeded particles in the flow of interest, in and around the oral cavity of the fish. Data from those experiments is being post processed using MATLAB. A post-processing tool is programmed to analyze the data from the PIV to find the flow rate through the mouth of the fish for each individual feeding trial. Other metrics are also being developed in order to determine which mouth shape is most efficient. As for the computational model, a mouth geometry is designed in Solidworks and the fluid dynamics is modeled using Fluent. Fluent is used to study the incompressible, steady flow through the mouth. Various post-processing tools in Fluent provide additional metrics for determining feeding efficiency.

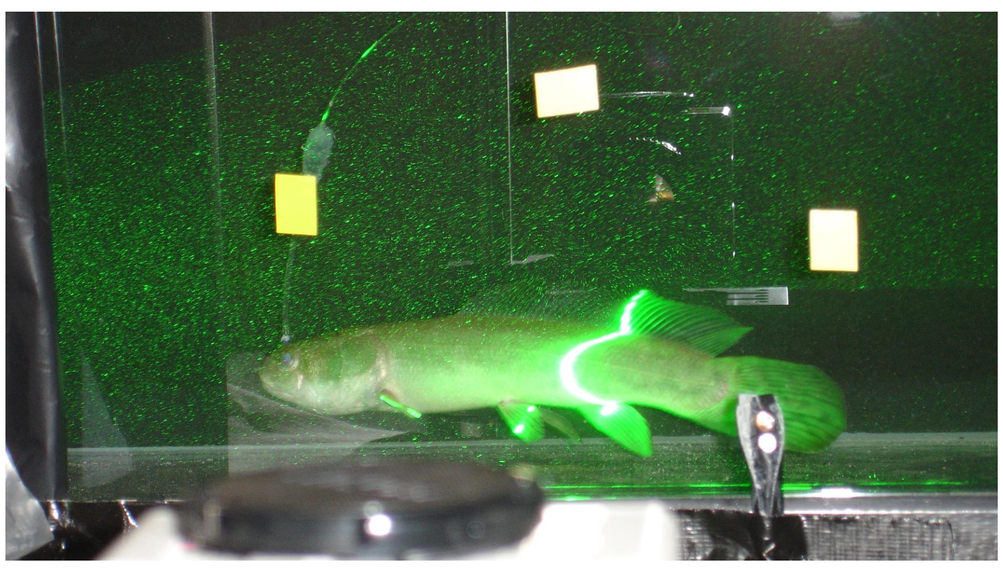

*Figure 2: Photo of PIV being used during the feeding of the Amia fish*

## Methods

### Post Processing of Experimental Data Using MATLAB

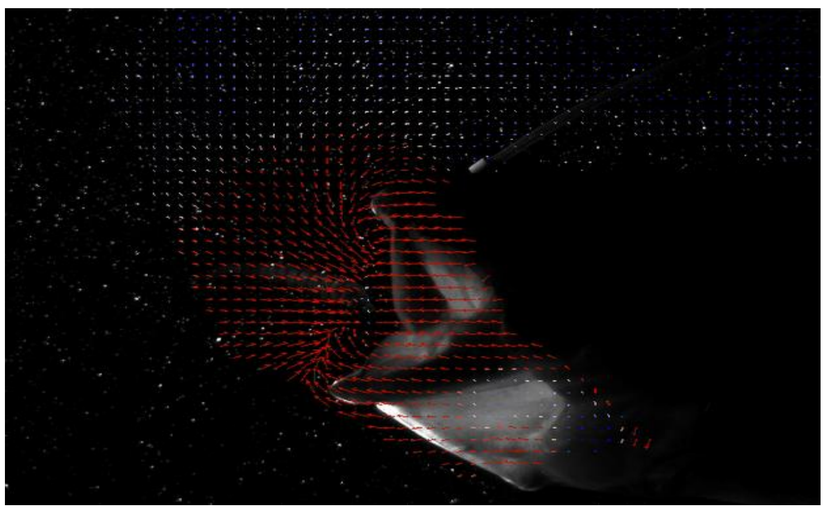

*Figure 3: Image from 2D PIV*

### Bubble Calculated

Data from the 2D PIV machine is read into a program created in MATLAB to post process the data.

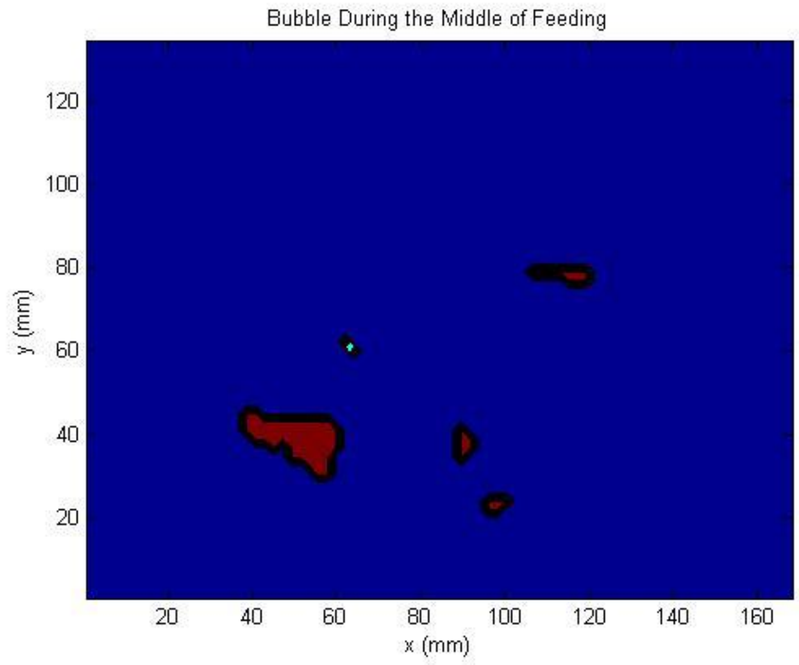


*Figure 4: Image from MATLAB of the velocity bubble in the middle of feeding trial*

## CFD Modeling Using Fluent

### Mouth Geometry Designed in SolidWorks

Computational models were analyzed using SolidWorks in which two designs of the Amia fish's mouth were created. These designs include the circular shaped cylinder and wedge shaped cylinder. The circular shaped cylinder was designed to replicate the evolved oval cavity of the Amia fish and the wedge shape cylinder represents the oral cavity of the Amia fish but with a notch cut out on both sides. Created these designs allows one to further analyze with shape of mouth is more efficient for suction feeding and thus finding the flow rate into the cavity.

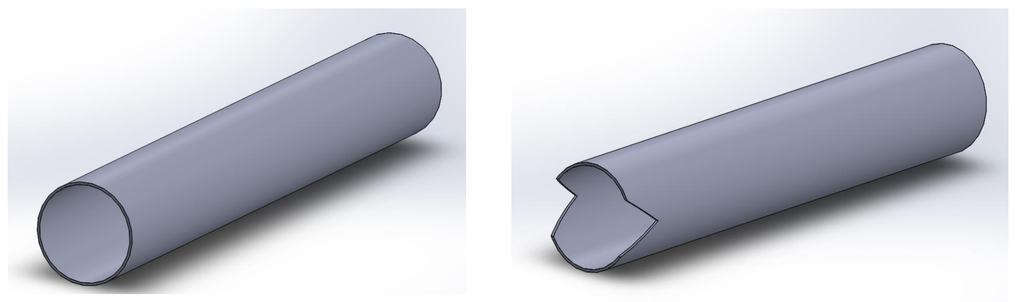

Figure 5& 6: Image of Planar and Wedged shaped mouth geometries.

### Mesh Generated in Fluent

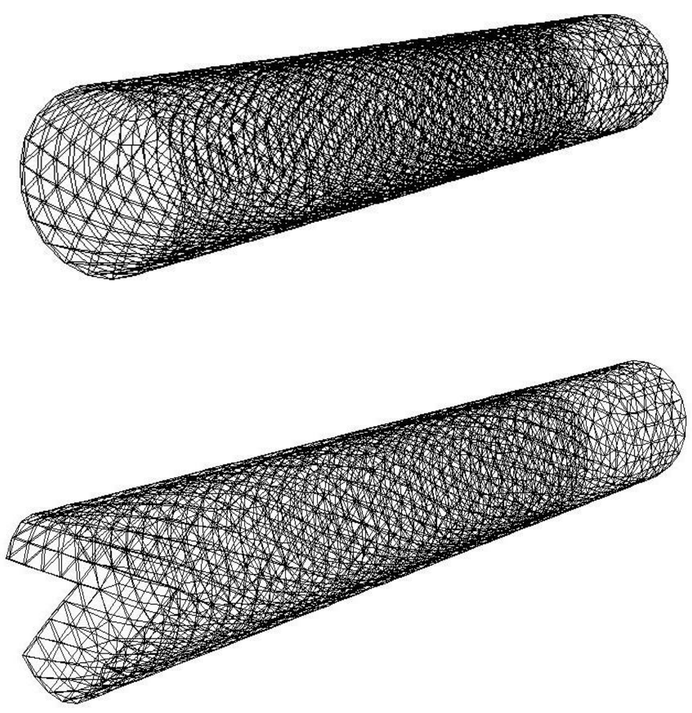


Figure 7 & 8: Image of generated mesh for planar and wedge shaped mouth in Fluent

### CFD Analysis

Computational models are also analyzed using Fluent where a mesh is taken in this program through the geometries created in SolidWorks. This then allows for the analysis of flow rate entering the Amia fish's mouth using these model.

## Future Work

Future enhancements to this project include:

- Calculate the Flow rate from the 2D PIV data from multiply feeding trials
- Create a similar program in MATLAB to read data from the 3D PIV
- Use these meshes created in Fluent to find the flow rate of the two mouth shapes and compare the results to the experimental results