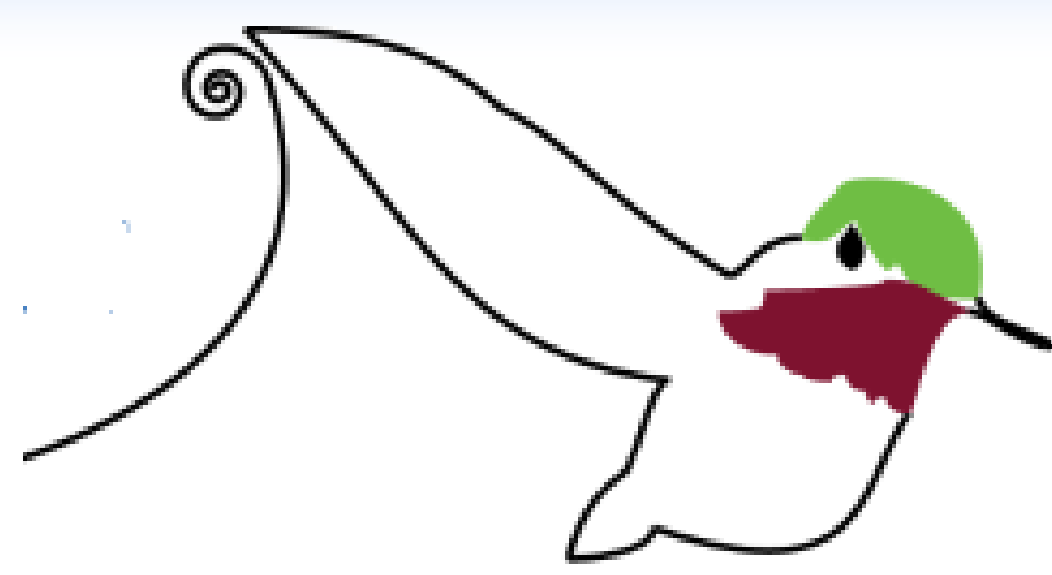# Magnetic, modular, undulatory robot: exploring fish-inspired swimming for advancing underwater locomotion and robotics

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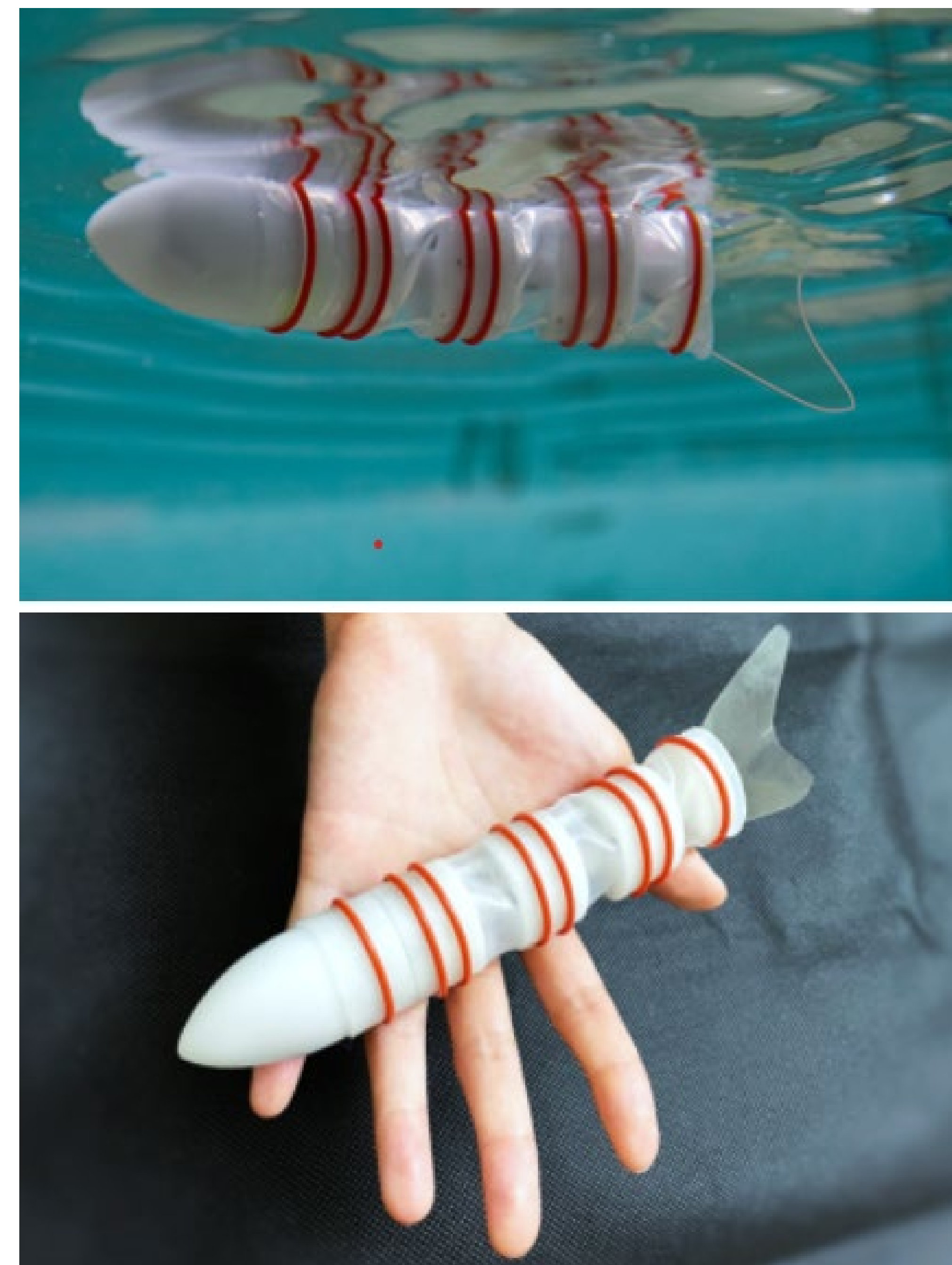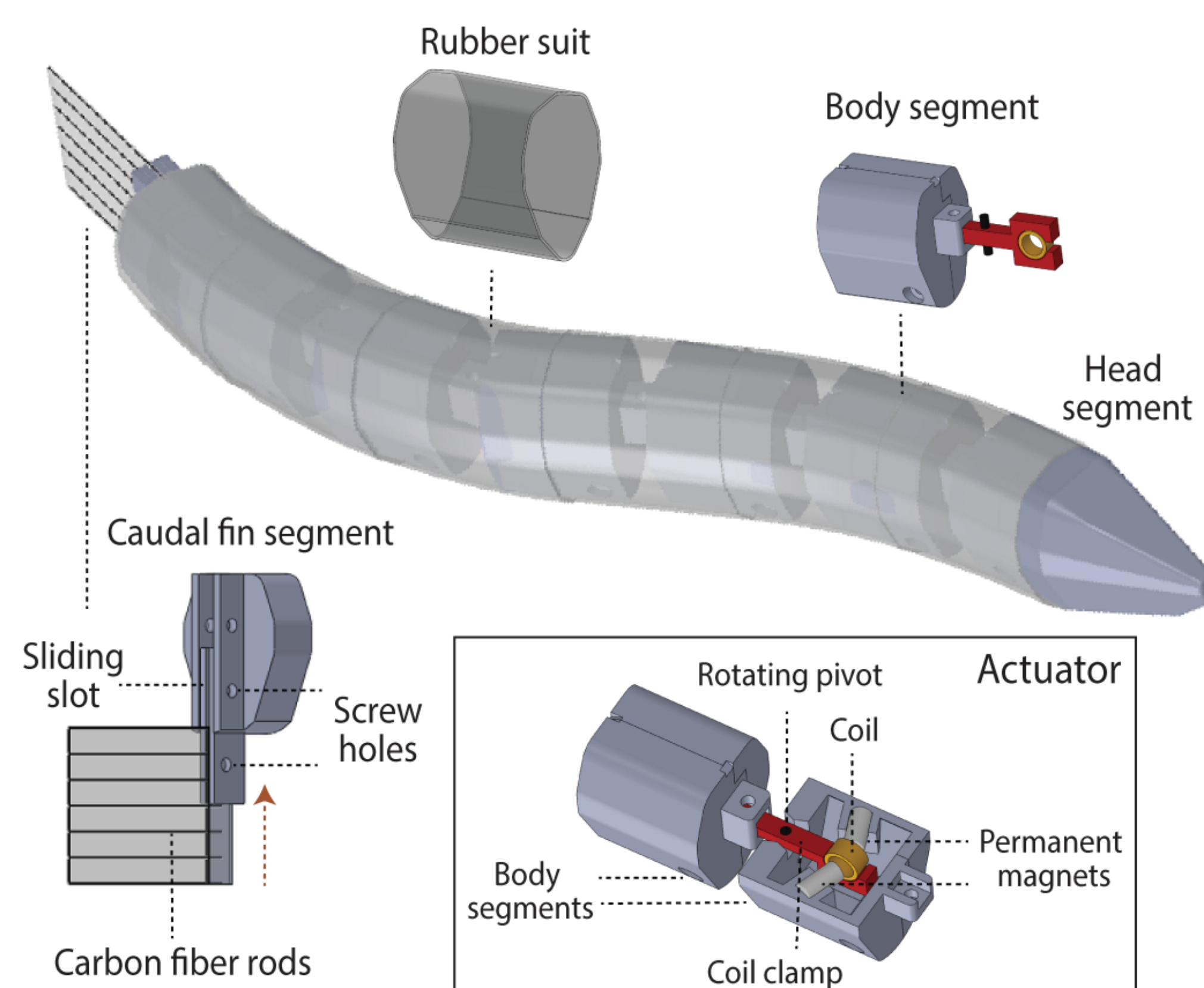
BioRob-InFL Lab

MOTIVATIONS

1. Understanding fish swimming: Fish swimming is a highly efficient and versatile form of underwater locomotion, and studying the relationship between their form, gait, and function can provide insights in understanding the physical principles and informing the design of underwater vehicles.

2. Developing innovative aquatic technologies: The development of advanced aquatic robotics has the potential to revolutionize underwater exploration, environmental monitoring, and search and rescue missions.
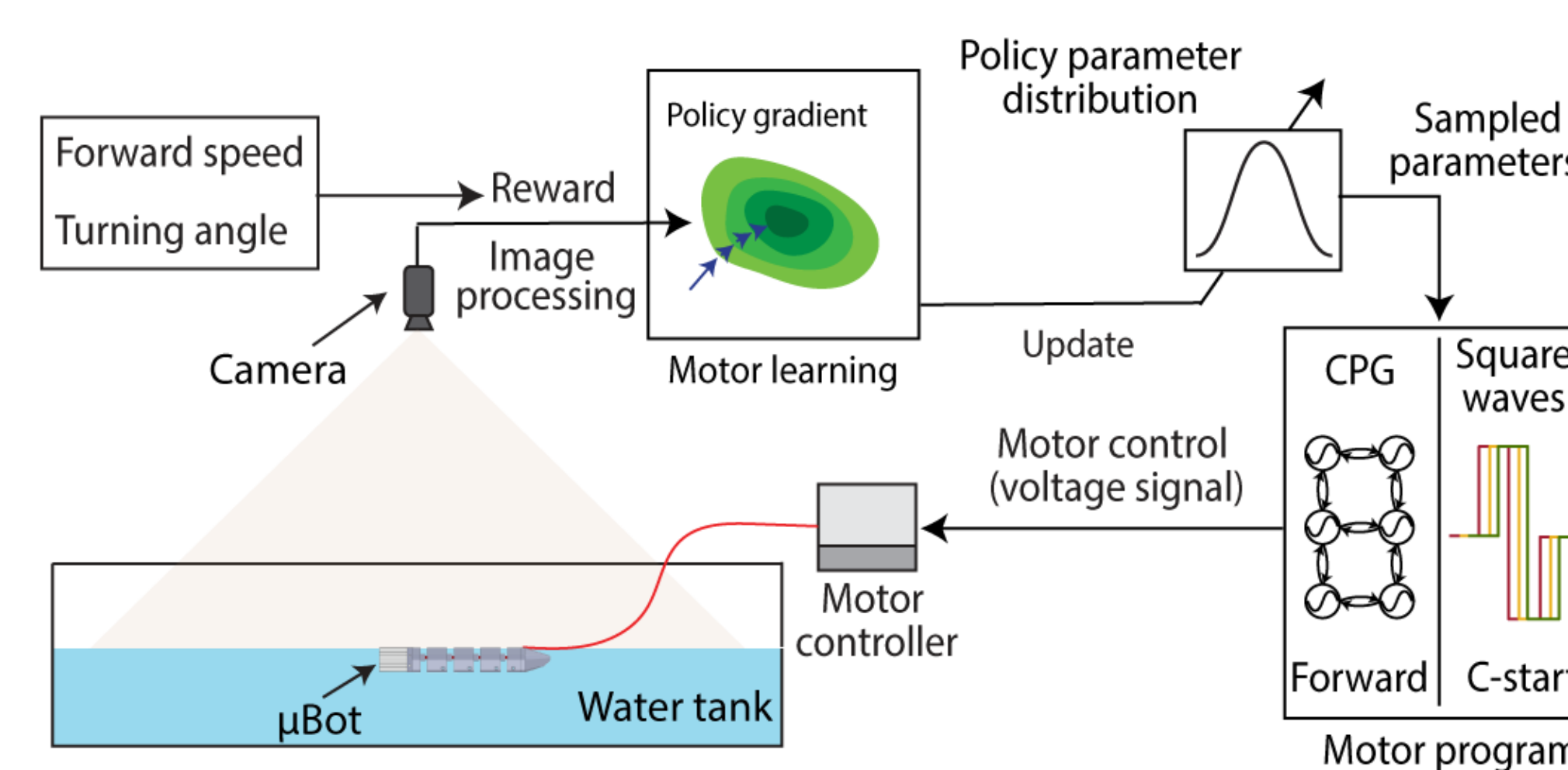
OBJECTIVES

1. Design a swimming robot that is easily modifiable in morphological design and compact in size.

2. Explore the relationship between form, gait, and function using robophysical model and experimental motor learning.

3. Investigate the disturbance rejection and path tracking capabilities of the robot for potential aquatic applications.
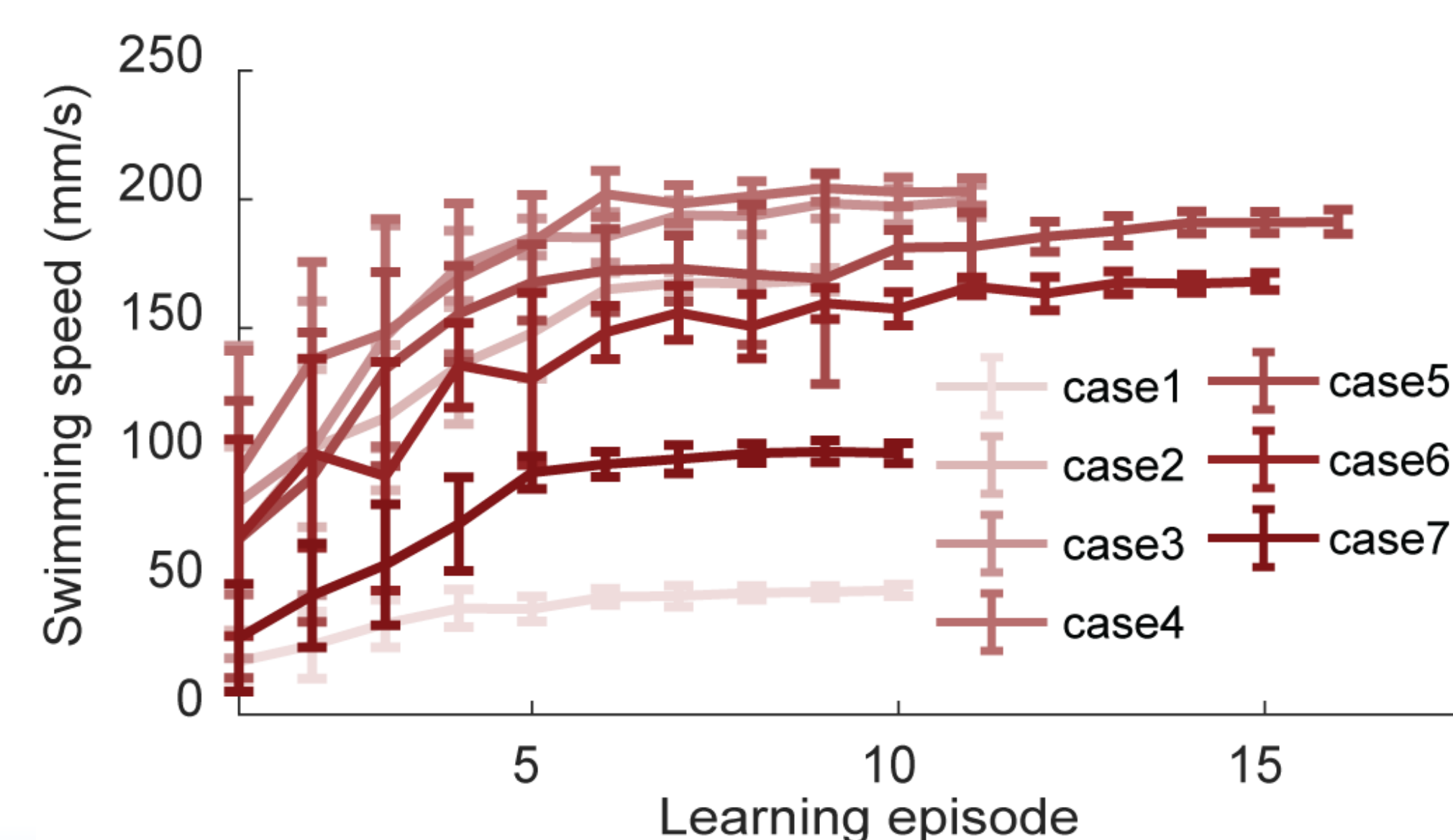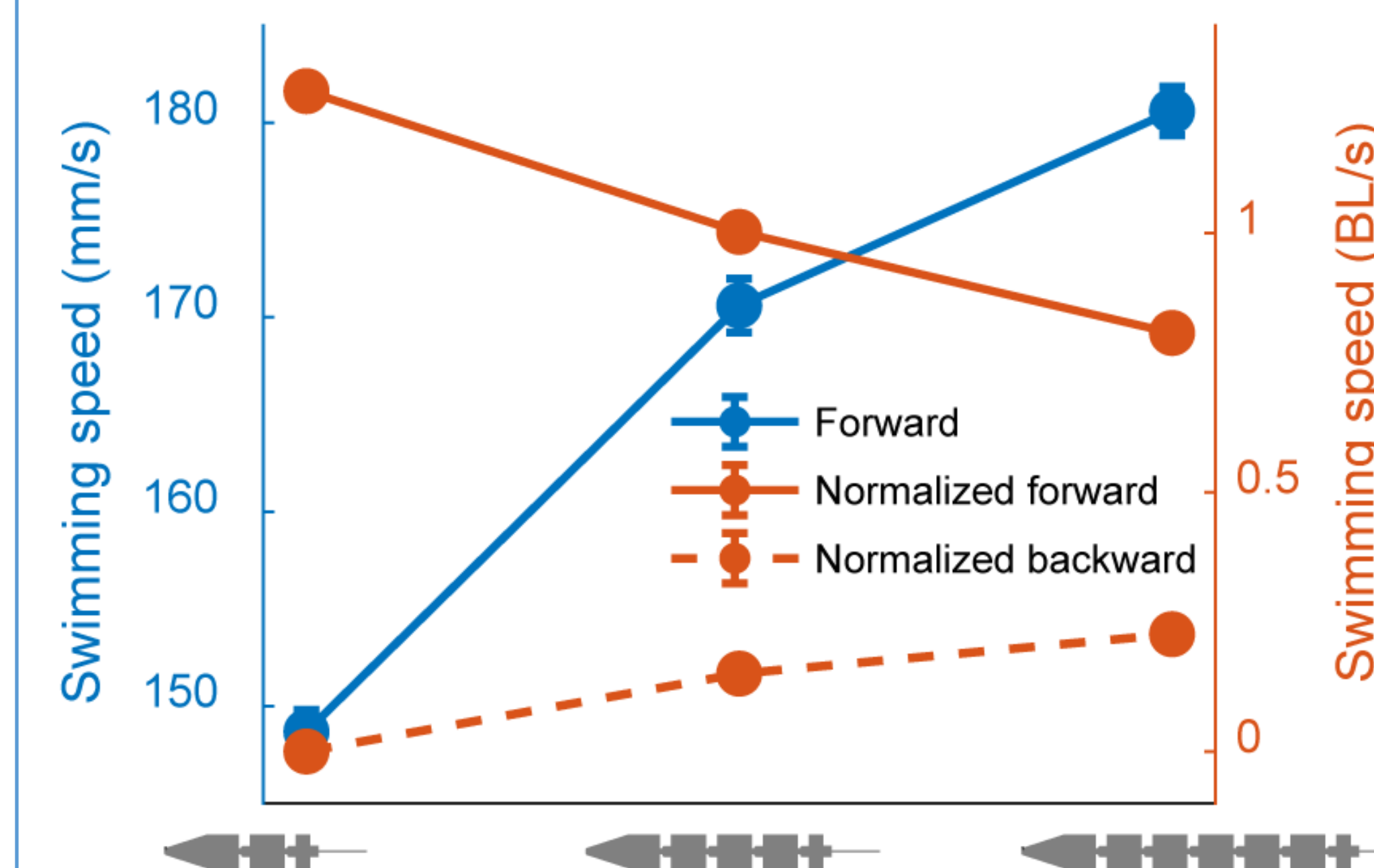
ROBOT DESIGN

Rubber suit

Body segment

Head segment

Caudal fin segment

Sliding slot

Screw holes

Carbon fiber rods

Rotating pivot

Coil

Actuator

Body segments

Permanent magnets

Coil clamp

EXPERIMENTAL MOTOR LEARNING

Forward speed

Turning angle

Reward

Image processing

Camera

Policy gradient

Motor learning

Policy parameter distribution

Sampled parameters

Update

Motor control (voltage signal)

CPG

Square waves

Forward

C-start

Motor controller

μBot

Water tank

Motor program

Examples of learning curves:

case1   case5
case2   case6
case3   case7
case4

RESULTS

Effects of body length on swimming speed:

Forward
Normalized forward
Normalized backward

Effects of tail stiffness on speed and turning angle:

No tail

Caudal fin stiffness (Pa*m⁴)
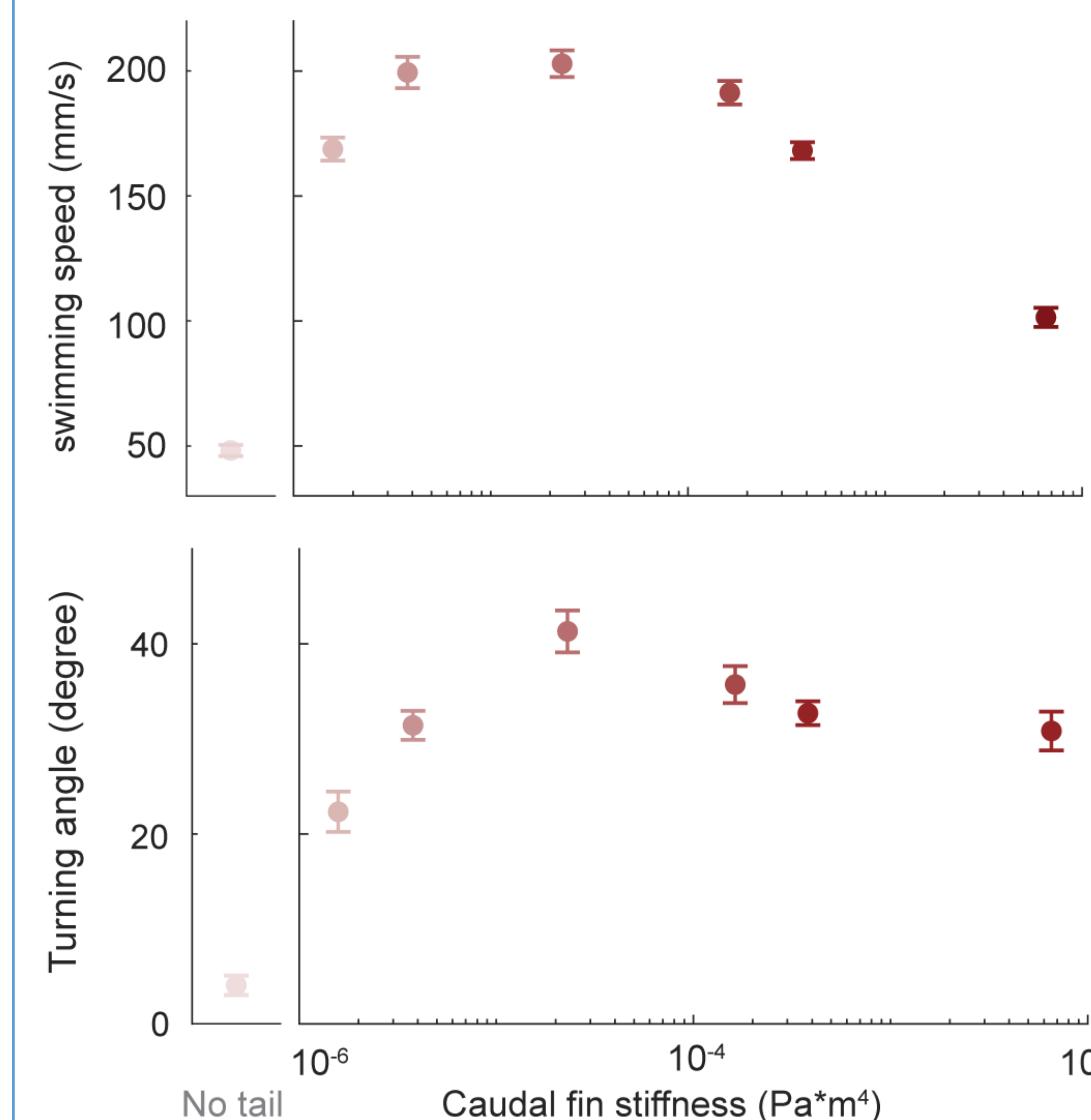
Heading disturbance rejection:
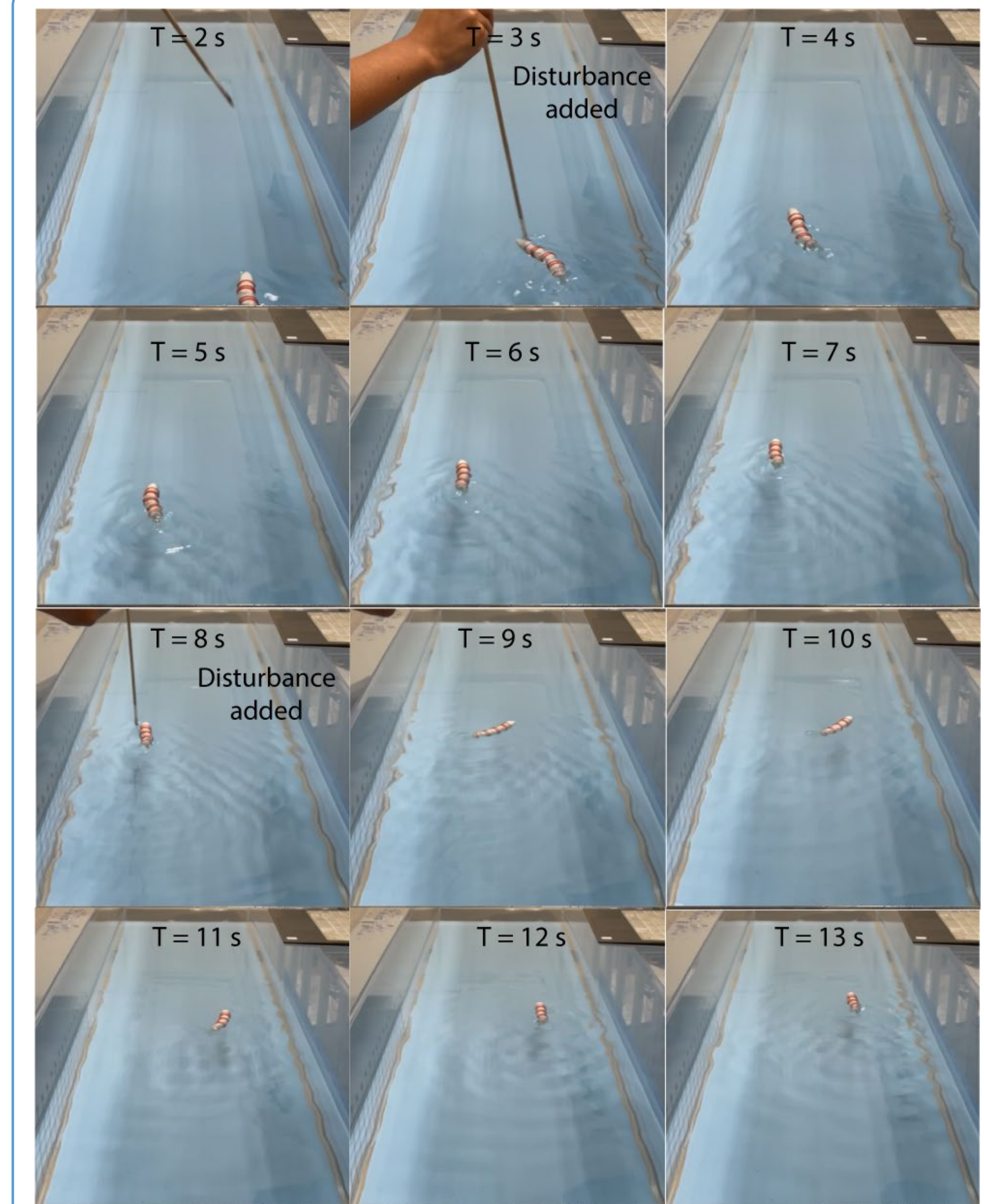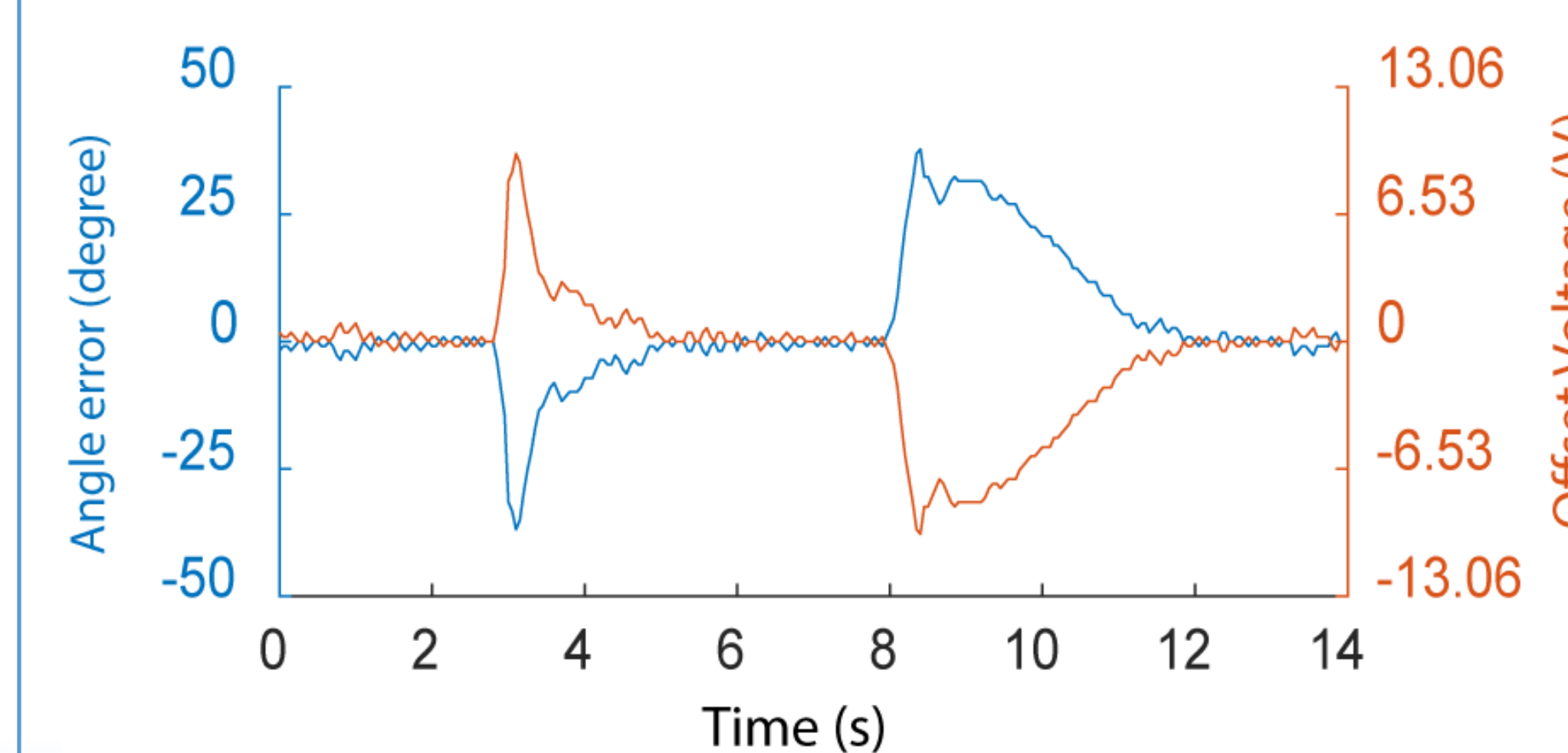
CONCLUSIONS

1. The use of a magnetic, modular, undulatory robot allowed for controlled experiments to be conducted in a lab setting, enabling the investigation of the influence of morphological factors on swimming performance.

2. The results revealed an optimal tail stiffness for both forward swimming and turning maneuver, and the importance of body length in determining swimming speed, which can provide insights in optimal design of future aquatic vehicles.

3. The robot's demonstrated ability for disturbance rejection and path tracking suggests its potential for use in various aquatic applications.

ACKNOWLEDGEMENTS