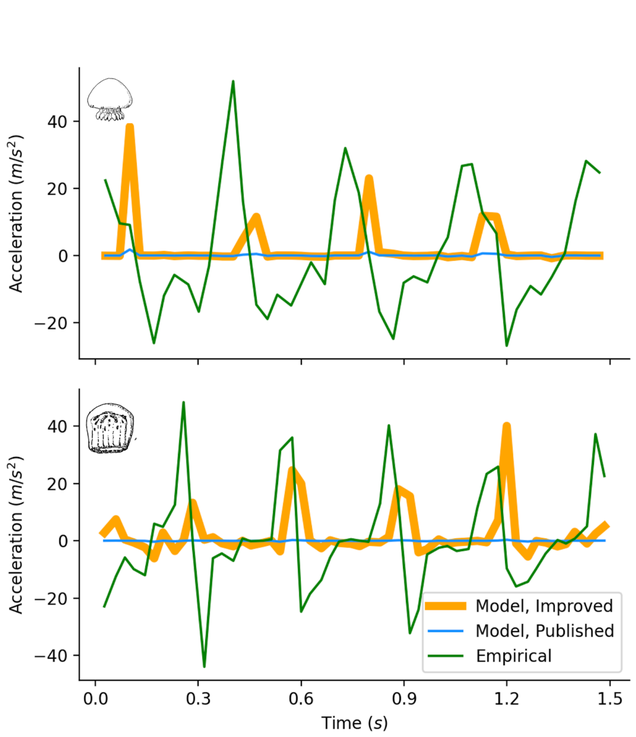
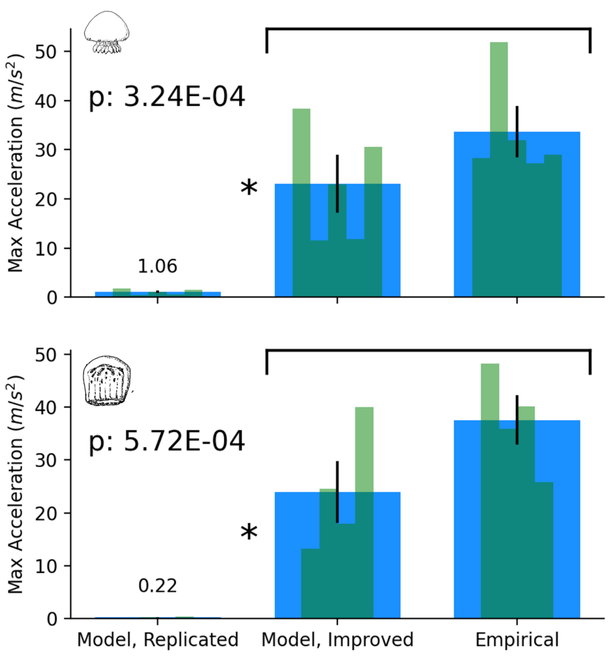
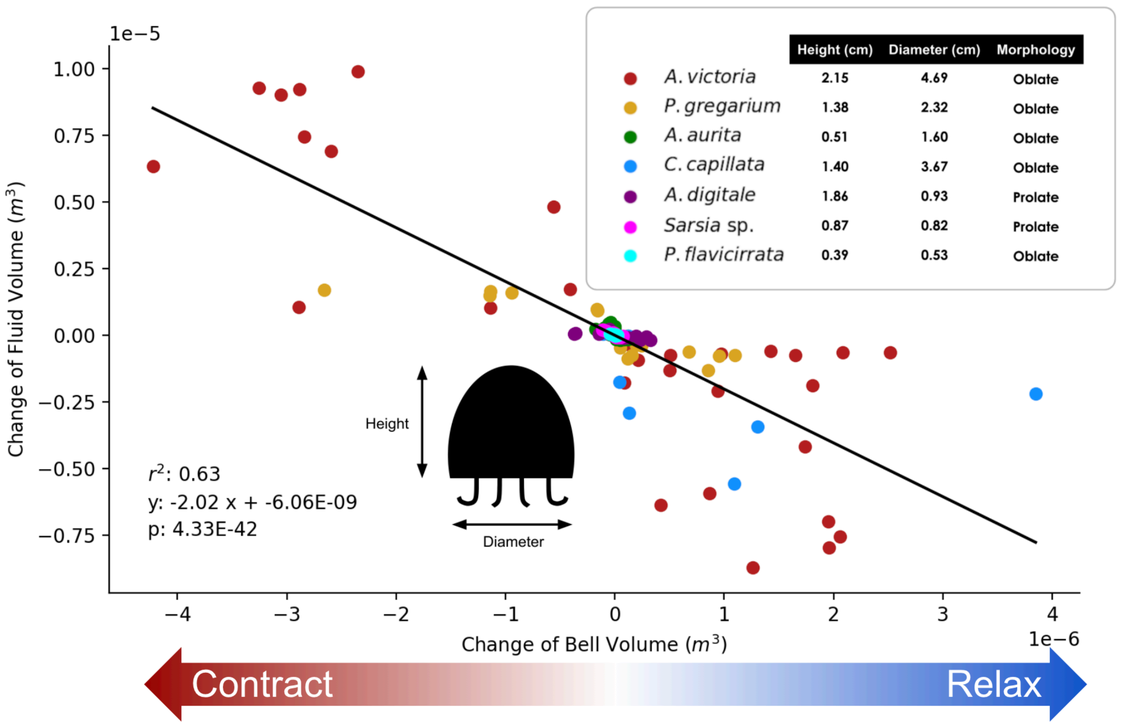
Jellyfish Propulsion: Modeling Fluid Flow and Medusae Morphology

Jo Hsuan Brian Lee '21, Professor Jodi Schwarz, and Professor John Long



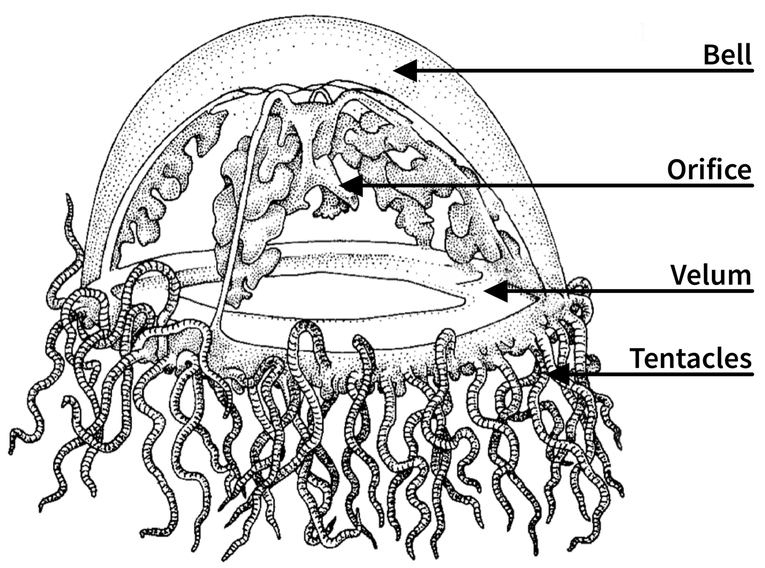




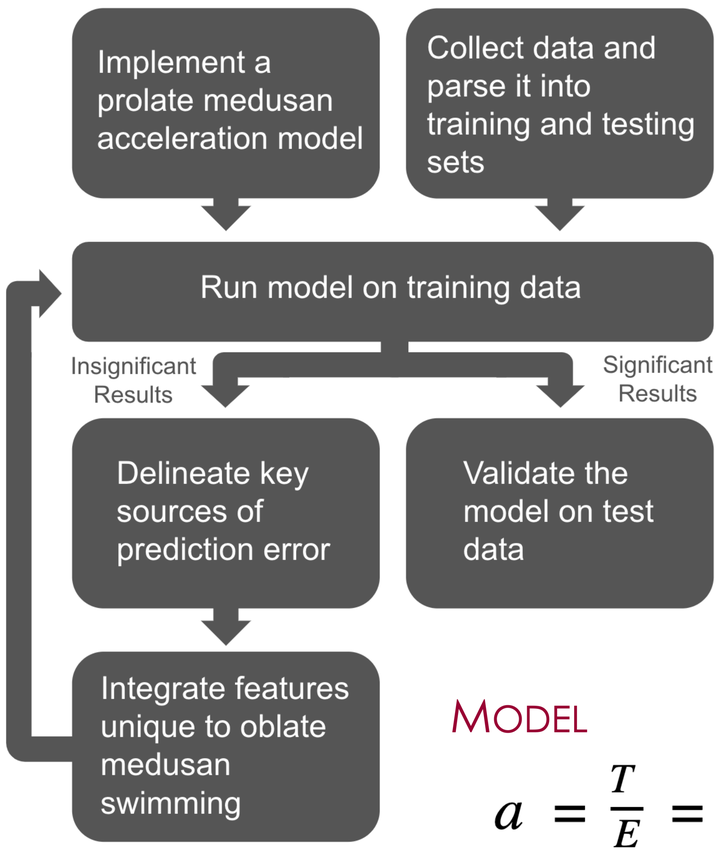
	Height (cm)	Diameter (cm)	Morphology
A. victoria	2.15	4.69	Oblate
P. gregarium	1.38	2.32	Oblate
A. aurita	0.51	1.60	Oblate
C. capillata	1.40	3.67	Oblate
A. digitale	1.86	0.93	Prolate
Sarsia sp.	0.87	0.82	Prolate
P. flavicirrata	0.39	0.53	Oblate

INTRODUCTION

Adult medusoids (Phylum Cnidaria) swim by cyclically pulsating their **bell,** the main portion of their body. Species with a **prolate** (bell height > bell diameter) morphology jet water out of their gastric cavity. Species with an **oblate** (bell diameter > bell height) morphology row, in addition to jetting, using the margins of their bell. Oblate jellyfish are cruise foragers and rely on fluid entrainment, generated by the bell, to capture prey. To understand how this thrust-generating mechanism allows for both propulsion and feeding, a fluid-mechanics model is developed.



METHODOLOGY



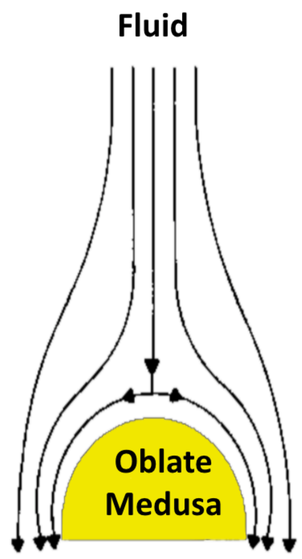
RESULTS

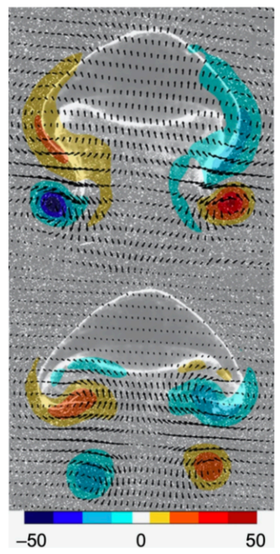
Two modifications of Colin & Costellos' original model (2002) increased the low acceleration in oblate medusans:

1. The changing **velar aperture area** over a pulsation cycle allows for larger ejected wake volume and greater acceleration on a slimmer body.

2. The **lateral vortex superstructure** in oblate medusan wake triples the effective thrust on cruising medusae in power strokes.

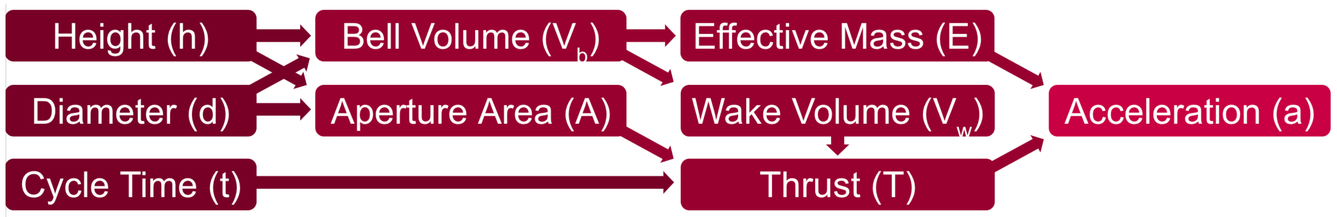
The model only made an accurate estimation of **maximum acceleration**, and both prolate and oblate medusae were incorporated in building the final model.





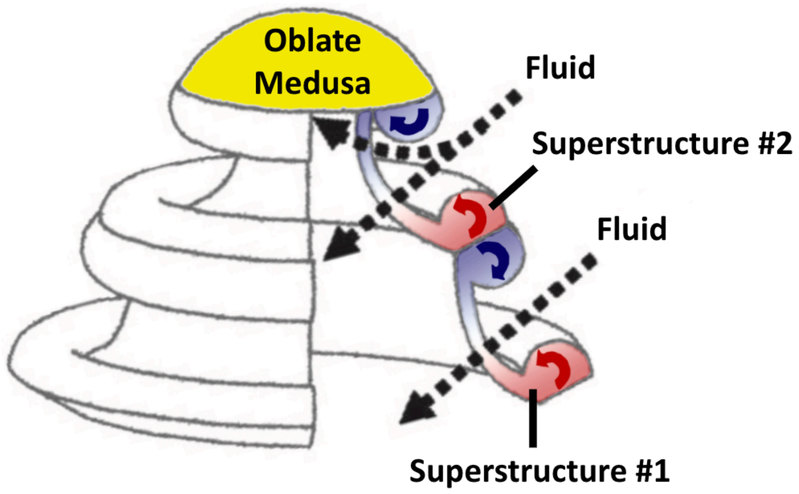
MODEL

$$a = \frac{T}{E} = \frac{dV_w^2}{AV_b(1+\frac{d}{2h}^{1.4})dt^2}$$



DISCUSSION

- The medusan acceleration could lead to analysis of the relative fluid velocity around the animal and the subsequent vorticity around the bell margin which carries in the prey.
- The kinetics of fluid entrainment should be considered alongside foraging features such as tentacles and oral arms.



SELECTED REFERENCES

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- Colin & Costello (2002). Morphology, swimming performance and propulsive mode of six co-occurring hydromedusae. *Journal of Experimental Biology*, 205: 427-437.
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