Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Scaling Laws for Three-Dimensional Combined Heaving and Pitching Propulsors[1] FATMA AYANCIK, KEITH MOORED, Lehigh University — The underlying physics of oscillatory swimming can be captured with simple models based on the scaling of the added mass and circulatory forces. Here, by considering both of these forces, we present new scaling relations for three-dimensional combined heaving and pitching propulsors with varying aspect ratios. Classic linear theory is augmented by additional nonlinearities and modified for three-dimensional effects by considering the added mass of a finite-span propulsor, the downwash/upwash effects from the trailing vortex system and the elliptical topology of shedding trailing-edge vortices. We verified the scaling relations by using experiments and self-propelled inviscid numerical simulations over a wide range of variables including the dimensionless amplitude, dimensionless heave-to-pitch ratio, Strouhal number, and aspect ratio. The developed relations are found to be in excellent agreement with the numerical and experimental data. These scaling laws are used to identify physical mechanisms that influence thrust and efficiency, and as a guide for improving performance.

[1]Supported by the Office of Naval Research under Program Director Dr. Bob Brizzola, MURI grant number N00014-14-1-0533.

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Date submitted: 05 Aug 2019 Electronic form version 1.4