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Scaling the Performance of Hydrofoils with Combined Pitching and Heaving Motion in Underwater Swimming BENJAMIN FREEMAN, SUYASH VERMA, ARMAN HEMMATI, Department of Mechanical Engineering, University of Alberta — This study evaluates the scaling of the propulsive performance of an oscillating teardrop foil with combined heaving and pitching motions at a range of Reynolds numbers ($Re = 1000 - 8000$), reduced frequencies ($f^* = 0.16 - 0.64$), Strouhal numbers ($St = 0.1 - 0.8$), and phase angles ($\phi = 0^\circ - 270^\circ$). Over 150 simulations were completed using Overset Grid Assembly incorporated into Direct Numerical Simulations in OpenFOAM. The numerically verified results are validated against the experimental performance data of Van Buren et al. (2020). Using this large dataset, we developed new scaling relations that incorporate Re, f^*, St, and ϕ. This study extends the scaling laws originally developed for a solely pitching or heaving foil by Floryan et al. (2017) at a fixed Re, and then extended by Van Buren et al. (2020) to combined heaving and pitching motion for fixed Re and varying f^*. The preliminary scaling suggests that the performance data scales with $Re^{1/2}$, which is a laminar behaviour. Moreover, the effect of ϕ dominates the scaling at different f^* and St. These results also suggest that combining heaving and pitching motion alters the impact of effective oscillation amplitude, and thus the wake behaviour compared to a pure pitching motion.

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