Abstract Submitted
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**For free swimming the efficiency and economy optima are the same** HOSSEIN HAJ-HARIRI, University of Virginia — Most computational and experimental studies into the "optimality" of fins or wings are based on the placement of a model in a uniform stream and finding an optimum of either efficiency or economy. This approach is easy, but inherently inconsistent: any efficiency other than zero implies the presence of thrust, which is then incompatible with uniform speed. The proper way to reconcile the two is to assume the presence of sufficient parasitic drag to balance the thrust. But then different wings are implicitly attached to different bodies, and the optima are over a range of unrelated bodies. The consistent way to address optimization is in the context of free swimming. In this work a simple theoretical model based on a heaving and pitching plate is used to investigate the implications of free swimming. In particular, performance is optimized over the manifold of constant average thrust. Once constrained to this manifold, then the efficiency and economy optima are collocated. This simple model can predict the results of our prior computations for flexible wings. More importantly, the model details the interplay between the circulatory and non-circulatory lift/thrust, and can predict the motion of whale tails. The phase of pitch and heave work themselves out so as to keep the motion on the aforementioned manifold. These results have significance to swimming and to insect flapping in air where added mass has considerable effect.

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