Study and Application of a Biomimetic Fish Propulsion System Mimicking the Body Structure and Stroke of Black Marlin for Energy-Efficient Propulsion With Respect to the Added Mass Effect

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To provide a sustainable solution for marine vehicle efficiency, a biomimetic propulsion mechanism can offer an energy-efficient and high-speed locomotion system. Such marine vehicles can be used for ocean environmental monitoring and unmanned autonomous vehicles. The grand goal of my research is to develop a biomimetic locomotion mechanism that advances the current propulsion system in terms of velocity and power efficiency. My research presents a black marlin-based locomotion system by mimicking the variable amplitude stroke and the body structure based on a novel added mass-effect. The composite made of elastomer and biomimetic bone structures is used for power-efficient underwater actuation. The main hypothesis is that the black marlin's movement of variable amplitude stroke can increase the speed in a power-efficient way. By mimicking the one large stroke and then three small strokes of black marlin, we will study how the energy can be saved with the enhancement of the velocity. To test the hypothesis, a mathematical model of a biomimetic fish is constructed with the force equilibrium equation. Based on the mathematical model, the propulsion efficiency of a biomimetic fish with different types of strokes is analyzed by experiments. The fish mimicking black marlin's bone structure is integrated into a boat for experimental validation. Variable amplitude actuation is tested and analyzed in terms of power efficiency and velocity. Field testing in a water fountain and lake are accompanied to try the actual use. The studied propulsion mechanisms can be applied for autonomous marine vehicles requiring high energy efficiency.

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