Propulsion Performance Evaluation of a Lego-Based Carangiform Mechanism for a Prototype Robotic Fish Unmanned Underwater Vehicle (UUV)

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The Philippines' 7,100-island archipelago is recognized for its diverse marine ecosystems, requiring extensive surveillance both for security purposes and further study. One way to conduct underwater observation is through Unmanned Underwater Vehicles (UUVs) which usually run on a propeller-based propulsion system. However, the system can kill marine organisms as a result of propeller strikes, and disturb shallow water ecosystems through cavitation and noise pollution. This study aims to develop and test a nature-inspired, marine environment-friendly Carangiform-simulated propulsion system for an unmanned underwater vehicle. A 3D modeling program called SketchUp was used to design a UUV chassis with a fish-like caudal-fin, and fabricated it by CR-10 3D printer with PLA filament. A Lego EV3 robotic kit brick and motor were programmed to power and control the prototype. The prototype UUV was sealed and tested in an artificial water pond with no water flow and tested at flapping frequencies ranging from 0.25 Hz – 0.5 Hz at 0.05 Hz intervals. At flapping frequencies of 0.25-0.3 Hz, the mechanism exhibited a Strouhal number range of 0.6-1.4, was unable to dominate viscous forces, and unable to produce large amounts of thrust (0.02-0.04 N). At flapping frequencies of 0.35 Hz and beyond, the mechanism increased propulsion, and achieved the Strouhal number ranges optimal for living fishes (0.2-0.4), providing thrust without cavitation. Hence, the propulsion system has effectively mimicked nature's propulsion strategy, and with appropriate fish-like morphology, it can be utilized in efficiently propelling environment-friendly UUVs the way swimming animals do.