Tuna-inspired morphing fins are shown to dynamically alter the stability and maneuvering properties of the self-propelled underwater vehicle *Morpheus*.

by

Michael Triantafyllou
Henry L. and Grace Doherty Professor of Ocean Science and Engineering
Director of MIT Sea Grant, Massachusetts Institute of Technology

Tunas are massive fish praying on smaller and much more maneuverable fish, by continuously controlling their retractable fins. By adopting such bioinspired retractable/morphing fins, we provide the theory, principles, and engineering practice to achieve good directional stability, exceptional maneuverability, and minimal adverse response to turbulent flow. These are properties that are highly desirable for a rigid hull autonomous underwater vehicle (AUV), but are impossible to achieve without morphing fins, because they impose contradictory requirements on the vehicle design. We show how morphing fins allow a vehicle to switch between operating with increased stability that ensures a steady course in the presence of disturbances, hence requiring low control action, to a state of high maneuverability that allows to execute very rapid course and depth changes, but also ensuring at all times that angular responses to external turbulence are minimized. We built and tested a 1-meter long AUV, named *Morpheus*, capable of dynamically changing its stability –maneuverability qualities through morphing fins, which can be deployed, deflected and retracted, as needed. Using the theory of morphing fins and employing a series of free-swimming experiments and maneuvering simulations, *Morpheus* was shown to exhibit either a stable locomotion, or exceptional maneuverability, depending on the fin configuration.