MORPHING FINS AND SHAPE-CHANGING BODIES IMPROVE UNDERWATER PROPULSION AND MANEUVERING

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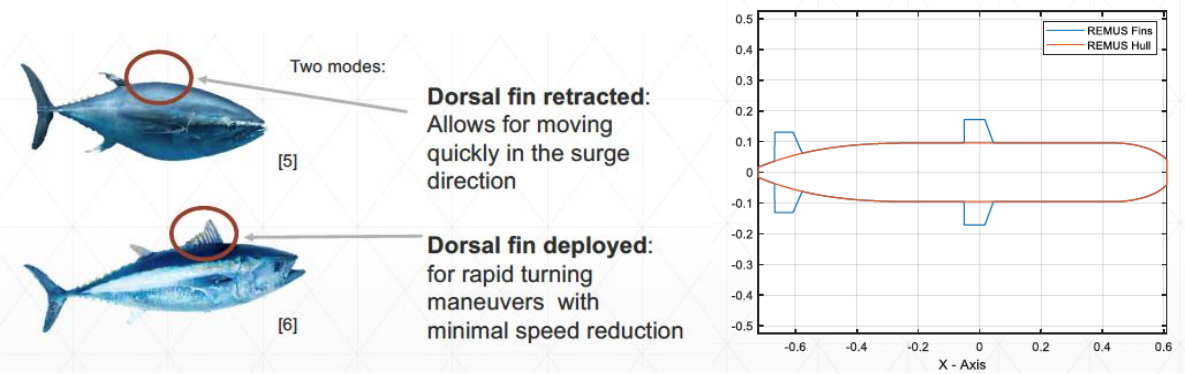
We demonstrate that shape-changing fins and bodies provide a new paradigm for improving the ability of vehicles to maneuver and move rapidly underwater. We provide two example applications.

In the first example we consider morphing fins. An ingenuous solution is employed by fish to accommodate both the need for stability of locomotion and the ability to perform tight maneuvers: Retractable fins alter their stability properties to suit their particular goals. Tunas are large fish that are fast swimmers and yet they need rapid turning agility to track smaller fish they pursue; they have perfected the use of their dorsal and ventral fins to ensure stability when retracted and rapid turning when erected.

Although fish employ unsteady propulsors rather than propellers, we show that engineering underwater vehicles can also exploit similar solutions. We explore the basic flow mechanisms and design considerations of employing morphing fins to alter the stability and maneuvering qualities of vehicles. We also show results from maneuvering simulations and experiments on a model of a REMUS underwater vehicle.



In the second example, we consider the ability of cephalopods such as the octopus, the squid, and the cuttlefish to fast-start rapidly through drastic body shape change. We explore the basic flow mechanisms that allow them impressive acceleration, added mass energy recovery and flow separation control. The principles are demonstrated through the use of a simple octopus-like robot consisting of a fuselage and a surrounding elastic membrane that is hyperinflated with water. When the orifice is released open and the pressurized fluid generates a propelling jet, rapid acceleration is achieved without flow separation, despite the original bluff-body shape. A non-dimensional quantity that allows the selection of suitable parameters to obtain this performance is presented.