The Center for Fluid Mechanics

and

The Fluids, Thermal and Chemical Processes Group of
The Division of Engineering

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Propulsion through Wake Synchronization in Flapping Foils and Fish

Abstract:

The design of underwater vehicles operating in the surf zone or other high-energy environments is likely to have viable biomimetic solutions. The flapping fin is capable of producing high instantaneous forces, giving fish the ability to turn and accelerate rapidly. Additionally, the lateral line, an array of nerves running the length of the body, enables fish to sense the flow characteristics in their environment, aiding obstacle entrainment, schooling, rheotaxis, and prey detection. The ability to sense the changing flows in the environment and then use that information with high control authority would better enable an autonomous vehicle to survive and maneuver in dangerous currents. As an initial foray into the sensory and control methods that could be used by a biomimetic vehicle, we studied energy extraction through synchronization with an incoming cylinder wake with both live fish and mechanical flapping foils.

Rainbow trout voluntarily synchronize their motions to cylinder wakes in both frequency and phase. The oscillating flows in the wake create a beneficial angle-of-attack across the trout's tail, enabling the fish to passively hold position in the stream. These effects were studied with live and euthanized fish as well as with a mechanical flapping foil moving both passively and actively within the cylinder wake. These results are applicable for reducing energy expenditure in vehicles holding position in currents containing large-scale turbulence as well as for lightweight power generators in streams.

Tuesday – November 18, 2003
Barus & Holley, Room 190
4:00pm