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Labriform swimming of a ray-strengthened pectoral fin[1]
KOUROSH SHOELE, QIANG ZHU, UC San Diego — Labriform swimming is a common locomotion mode used by fish in low speed swimming, in which thrust generation is achieved through a combination of flapping and rowing motions of pectoral fins. Pectoral fins of bony fishes usually consist of a soft collagen membrane strengthened by embedded flexible rays. Morphologically, each ray is connected to a group of muscles so that the fish can control the rotational motion of each ray individually, enabling multi-degree of freedom control over the fin motion and deformation. We have developed a fluid-structure interaction model to simulate the kinematics and dynamic performance of a structurally idealized fin. This method includes a boundary-element model of the fluid motion and a fully-nonlinear Euler-Bernoulli beam model of the embedded rays. Using this model we studied thrust generation and propulsion efficiency of the fin at different combinations of parameters. Effects of kinematic as well as structural properties are examined. It has been illustrated that the fish's capacity to control the motion of each individual ray, as well as the anisotropic deformability of the fin determined by distribution of the rays, are essential to high propulsion performance. Specifically, it is found that a reinforced ray at the leading edge leads to performance enhancement.

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