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Curvature dependent modulation of fish fin stiffness KHOI NGUYEN, Okinawa Institute of Science and Technology, NING YU, Brown University, MAHESH BANDI, Okinawa Institute of Science and Technology, MADHUSUDHAN VENKADESAN, Yale University, SHREYAS MANDRE, Brown University — Propulsion and maneuvering ability of fishes depends on the stiffness of their fins. However, increasing stiffness by simply adding material to thicken the fin would incur a substantial energetic cost associated with flapping the fin. We propose that fishes increase stiffness of the fin not by building thicker fins, but by geometrically coupling out-of-plane bending of the fin's rays with in-plane stretching of a stiff membrane that connects the rays. We present a model of fin elasticity for ray-finned fish, where we decompose the fin into a series of elastic beams (rays) with springy interconnections (membrane). In one limit, where the membranes are infinitely extensible, the fin's stiffness is no more than the sum of the stiffness of individual rays. At the other limit of an inextensible membrane, fin stiffness reaches an asymptotic maximum. The asymptote value increases monotonically with curvature. We propose that musculature at the base of the fin controls fin curvature, and thereby modulates stiffness.

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