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Hydrodynamics of ribbon fin-based swimming with application to highly maneuverable underwater vehicles. NEELESH PATANKAR, OSCAR CURET, MALCOLM MACIVER, Northwestern University — Gymnotiform fish swim by producing undulations of a long, ventral midline fin, also referred to as a ribbon fin. South American weakly electric gymnotiform fish are remarkably maneuverable fish – MacIver and co-workers have shown they achieve omnidirectional movement on short timescales. We investigated this system's mechanics with a view to gaining insight into sensory processing and neural control of movement, by using the immersed boundary method. The results suggest that this mode of propulsion may be an ideal underwater vehicle propulsion system for low speed applications where precise control of motion is needed. We show that in addition to the surge direction (forward/backward) traditionally associated with the ribbon fin, the ribbon fin can also achieve positive heave (up), pitch, and roll. Utilizing one traveling wave, we show how to control the thrust magnitude and direction over a limited range by varying amplitude and wave speed. By utilizing two traveling waves, our control space significantly expands to include pure heave motions, which have been informally observed both in gymnotiforms and in ammiform fish, where the midline fin is dorsally positioned. The non-dimensional thrust generated by the ribbon fin appears to be insensitive to Reynolds number over the relevant velocities.

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