Slow and fast, but not furious: Researchers trace how birds, fish go with the flow

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Like the collective motions of bird flocks, the patterns result from the concerted interactions of many individual particles without a central coordinator. Credit: Wikipedia.

Fish and birds, when moving in groups, could use two "gears"—one slow and another fast—in ways that conserve energy, a team of New York University researchers has concluded. Its findings offer new insights into the contours of air and water flows—knowledge that could be used to develop more energy-efficient modes of transportation.

"Some beautiful physics is at work in schools and flocks, with each individual creating a wave in the fluid while also 'surfing' on the wave left by its upstream neighbor," says Leif Ristroph, an assistant professor in NYU's Courant Institute of Mathematical Sciences who led the study.

The study, which appears in the journal *Nature Communications*, employs an innovative methodology—one that mimics infinitely large schools or flocks within the confines of a New York City laboratory.

The research team created a robotic 'school' in which the swimmers are 3D-printed plastic wings that flap and swim around a water tank. The trick, they note, was to have the wings swim in circular orbits, similar to the whirling blades of a fan or helicopter, so that each moves within the flow generated by all in their previous orbits. By moving in a circular motion, thus establishing and responding to its own wake, a small set of wings can mimic an infinitely long array.

In gauging the movements of this school, the researchers found that while a lone swimmer moves at a well-defined swimming speed, larger groups take one of two speeds. In "first gear," each swimmer traces out the same path through the fluid and goes with the flow created by its upstream neighbor, and the school as a whole swims slowly. "Second gear" is a fast mode in which each individual flaps counter to its neighbor and against the flow it encounters.

The researchers then conducted computer simulations in an attempt to understand more about these distinct speeds. Their results showed that the slower first mode saves on the energy required to swim—and therefore would be ideal for cruising or migrating—while the faster second gear burns more energy, but would be advantageous for fast escapes from predators.

The team sees its findings as applicable to the aerodynamics of bird flocks, with air replacing water as the flows to be navigated.

Moreover, they note the results yield a greater understanding of the principles of water and air flow—knowledge that could be harnessed by boats and planes to more efficiently capture energy from ocean waves or atmospheric turbulence.

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