Mimicking Nature’s Designs

For years, biologist (and morphologist) Frank Fish has studied humpback whales intrigued by how such large mammals could swim so smoothly in very tight circles. The answer, he discovered, lay in the bumps — or tubercles — along the leading edge of their flippers.

"The bumps help the water to flow evenly and keep the flippers from stalling," he says. A stall, in either air or water, happens when a flipper or wing banks at too high of an angle resulting in a loss of lift - a sometimes catastrophic event.

For example, one way an airplane pilot generates lift is by increasing the wing’s angle of attack. If the angle is increased too much, the air rushing over the top of the wing becomes turbulent causing the plane to drop from the sky.

Fish’s research led to the founding of WhalePower, a company which has designed practical applications from his work on whale flippers, including a wind turbine used in large ventilation fans in arenas and barns and, on a smaller scale, a sleeker surfboard fin. Other designs on the drawing board are for an airplane wing, a boat rudder, dive planes on submarines, and windmills.

Now, Fish and his team of undergraduate and graduate students have turned to the study of stingrays and, in particular, giant manta rays.

With funding by the U.S. Office of Naval Research, and in cooperation with the University of Virginia, Princeton University, and UCLA, the teams are hoping to define how the rays move with high speed and high efficiency.

Manta rays are not readily accessible to scientists. Because of their size few are in captivity and only four aquariums in the world exhibit them: Okinawa, South Africa; the Atlantis Casino and Resort Hotel in Nassau, and the Atlanta, Ga. Aquarium.

Fish and his team have traveled all over the world including Yap, part of Micronesia in the Western Pacific Ocean, a favorite destination for divers, and where the mantas range from 8 to 12 feet in length. “We videoed them underwater so we could get 3D images of their swimming capabilities,” says Fish.

For a hands on examination, Fish relies on the smaller stingray. Using CAT scans, he can observe their shape so the team can mimic how they look and how efficient they are. Their research findings will be passed along to engineers who would design and build a submarine manta robot.

“It would be an autonomous vehicle,” explains Fish. “We would program in what we wanted it to do and it would make its own decisions, operating on its own.”

Instead of huge ships collecting data on pollution sites and investigating changes in the coastlines, the robots could be as small as a foot wide from wing tip to wing tip and because they have no propellers they would be able to explore quietly and quickly in a new form of propulsion system. It would be of value to the military, oceanographers, marine biologists and environmentalists.

The eight students working with Fish in the lab are not all biology majors. Some are in a pre-medicine and pre-veterinarian programs as well as marine biology and some, he said, are just interested in animals.

Fish describes the manta rays as “charismatic megafauna,” and says that humans and animals have a lot to learn from each other. “They entertain us and offer an educational experience,” he says. “We’re responsible for them. They’re very trainable and if something goes wrong it’s usually our fault.

When asked if he ever worries that his underwater studies might be annoying to his subjects, he says, “If they didn’t like us to be near them, they would simply run away.”

A member of the biology faculty since 1980, Professor Fish received a B.A. in biology from SUNY Oswego in 1975 and completed a M.Sc. in 1977 and a Ph.D. in 1980 from the Zoology Department of Michigan State University.

His work has been published over 90 research articles, government reports, patents, and book chapters. He has served as chairperson of his department and was the chairperson of the Division of Vertebrate Morphology of the Society for Integrative and Comparative Biology. He is currently an associate editor for the journal Marine Mammal Science, and he is on the editorial board of the journal Bioinspiration and Biomimetics.