Triangles Go Underwater and Supersonic

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Paul Weber and Laurens Howle with some of their model flippers.

(PhysOrg.com) -- The seemingly effortless way dolphins and porpoises slice through the water and the unique capabilities of the supersonic Concorde airplane have more in common than one might think.

The first study to systematically compare the hydrodynamic properties of the flippers of several kinds of dolphins, porpoises and whales has concluded that the swept back, triangular flippers help the animal move efficiently through the water in much the same way that the jet's delta wings provide lift in the air.

The study was carried out by Duke University engineers and researchers from the U.S. Naval Academy and West Chester University.

By creating models based on real flippers and testing them in water tunnels, the researchers were able to calculate the characteristics of flippers from seven different animals - Amazon River dolphin, striped dolphin, harbor porpoise, Atlantic white-sided dolphin, bottlenose dolphin, common dolphin and pygmy sperm whale.

“We found that flippers of similar shape had similar hydrodynamic performance properties,” said Paul Weber, a graduate student in mechanical engineering and materials science at Duke’s Pratt School of Engineering. He, and senior researcher Laurens Howle, Duke associate professor of mechanical engineering and materials science, reported the results of their experiments in the June 26 issue of the *Journal of Experimental Biology*.

The researchers focused on two important forces experienced by flippers during movement - lift and drag. Lift is the upward force exerted on the flipper, while drag is the rearward force.

For their experiments, the researchers collected flippers from dead, stranded animals and performed complete computed tomography (CT) scans on them. Using computer software developed at Duke, the researchers turned the CT data into 3-D renderings, which became the basis for the creation of scale-model flippers.

“The CT scans allowed us to recreate as closely as possible the shape, structure and surface of the each of the flippers,” Weber said.

After categorizing each flipper as either triangular, swept-pointed, or swept-rounded, the scale models were put through their paces in water tunnels at the Naval Academy in Annapolis, Md. The researchers measured the hydrodynamic forces as the flippers’ orientation and water speeds were changed.

When the researchers plotted the results of their experiments in graph form, they found that the lift and drag curves exhibited by the flippers were quite similar to those of hydrofoil surfaces designed by engineers.

“Unexpectedly, we also found a unique lift curve for animals with swept-wing-like flippers,” Weber said. “The same phenomenon occurs in aircraft with delta wings.”

A delta wing is basically a large triangle, named after the uppercase Greek letter “delta,” which in the case of the Concorde generates sufficient lift at low speeds and is highly efficient at high speeds.

Animals such as the Amazon River dolphin have larger flippers, since maneuverability -- not speed -- is essential in its world of rivers and flooded forests. On the other hand, the bottlenose dolphin has smaller, swept flippers for speed in the open ocean.

“Our work represents a first step toward the understanding of the association between the three-dimensional form of the flippers and each animal’s ability to exist in its environment to get food, escape from predators or mate,” Howle said. “While some studies have focused on flippers of individual species, there hasn’t to date been any comparative study.

“Many factors, including ecology, body shape and performance requirements, have influenced the evolution of cetacean flippers, and these factors are all linked to hydrodynamic characteristics of the flippers we see today,” Howle said. “As we continue to evaluate more animals, we will be better able to link these factors together.”

Provided by Duke University (news : web)