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#### Flipped Robot Mimics Sea Creatures

By Tracy Staedter, *Discovery News*

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**May 18, 2006**— A new robot is shedding light on the locomotion of modern aquatic animals, and may also provide insight on how prehistoric giants such as the plesiosaur swam.

The biologically-inspired Madeleine robot, announced this month in the debut issue of *Bioinspiration & Biomimetics*, is an autonomous vehicle with four flippers designed to pitch up and down.

By experimenting with different combinations of flipper motion, biologist John Long of Vassar College and his team compared the efficiency two-flippered and four-flippered motion.

"What Madeleine has shown is that there are distinct differences and advantages to using just two. This has relevance to looking at the evolution of mammals themselves," said Frank Fish, professor of biology at West Chester University in Pennsylvania. Fish, an expert in the biomechanics of swimming animals, is not associated with the research.



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Modern aquatic animals such as sea turtles, sea lions and penguins have four flippers but use the front two only for propulsion and the back two for steering -- a gait known as sub-aqueous flight.

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The motion is distinctly different from the doggie-paddle style that four-limbed animals, or tetrapods, employ to stay afloat. This raises questions about why some tetrapods abandoned using four limbs for propulsion in favor of two.

"If you have four good legs, why not use them all?" Fish asks.

Also a mystery is how prehistoric tetrapods such as plesiosaurs and giant turtles, which dominated the seas between 251 and 65 million years ago, propelled themselves. Did they use all four flippers for fast acceleration and braking? Or only two for dynamic cruising?

Madeleine, named after the scallop-shaped pastry, could help answer those questions and more. At 24 kilograms (53 pounds), the robot matches the size, shape and weight of a modern sea turtle. Long designed the flipper motors to perform with about the same energy output as turtle muscle.

In swimming pool experiments, the researchers tested eight gaits -- some with two flippers, others with four.

Madeleine accelerated and braked faster with four flippers but needed more power to do so.

The robot maintained cruising speeds just as well with two flippers, which may explain why modern aquatic animals use only their front limbs for sub-aqueous flight. But using four consumed twice as much power, which raises questions about how ancient animals swam.

"If you're a plesiosaur and you're going to use four flippers to cruise, you're going to need twice the amount of food," said Long.

Although Madeleine cannot conclusively answer how plesiosaurs maneuvered through prehistoric seas, the robot could refine the possibilities.

"We might be able to shave off all of the irrelevant types of variables and combinations and finally get to more of a central point in which things look like they are plausible," said Fish.

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