Research finds water movements can shape fish evolution (w/ Video)

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Researchers from the University of Minnesota have found that the hydrodynamic environment of fish can shape their physical form and swimming style. The research, available on the *Journal of Experimental Biology* Web site, was sponsored by the National Science Foundation's National Center for Earth-surface Dynamics.

Catch a glimpse of a fish's body shape, and you can often guess how speedy it is. Tuna and mackerel look as if they should outpace frilly reef fish and eels. But how have all of these diverse body shapes evolved? Have fish bodies been shaped by the hydrodynamics of their environment or did they evolve for other reasons?

Turning to computational fish for answers, professor Fotis Sotiropoulos, along with postdoctoral researcher Iman Borazjani, from the university's St. Anthony Falls Laboratory decided to race hybrid and realistic fish in a massive parallel computer cluster to find out what influence the aquatic environment has had on fish shapes and swimming techniques.

But building the computational fish was far from straightforward. "We started this work over five years ago," says Sotiropoulos. "It was a challenge because we had never simulated anything living before."

Borazjani explains that the hydrodynamic forces exerted on swimmers vary enormously depending on their size and speed. Knowing that mackerel and eels swimming in water generate and thus experience different hydrodynamic environments, the duo simulated these different environments by varying tail beat frequencies and fluid viscosity (syrupiness).

Building two computational mackerels (one that beat its tail like a mackerel and a second that wriggled like an eel) and two eels (one that wriggled and another that beat its tail like a mackerel), the engineers set the fish racing from standing starts and noted how they performed.

The results showed clearly that all fish swam more efficiently if they had the body form or swimming style appropriate to the speeds at which they swam. For example, a lamprey that needed to swim faster could gain efficiency—which for a real fish would mean tiring less quickly—if it changed its shape or swimming style to mimic a mackerel. And a mackerel that had to move slowly would be more efficient if it could change shape or swimming style to mimic a lamprey. This is evidence that a fish's optimal range of swimming speeds generates hydrodynamic forces that influence the shape and swimming style it will evolve.

"From these experiments, we can deduce that real mackerel and eel's swimming styles are perfectly adapted to the hydrodynamic environments that they inhabit," says Sotiropoulos. The method could be adapted to study how a fluid environment molds the evolution of other organisms and to design robots that would swim at different speeds or in water of different viscosities, the researchers say.

More information: The full article can be found on the *Journal of Experimental Biology* Web site: bit.ly/b2ZqeY

Provided by University of Minnesota

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