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Sharkskin actually increases drag

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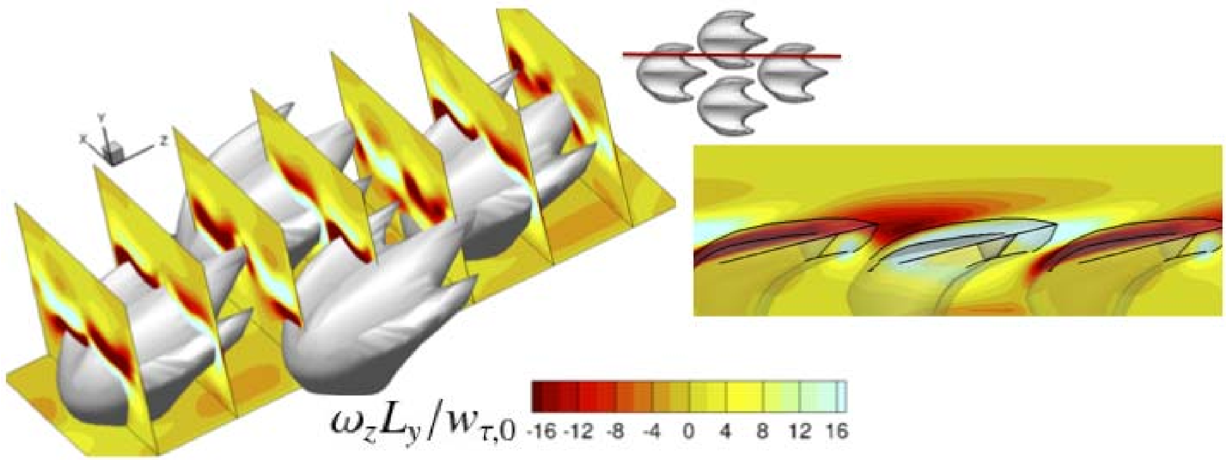

Computer simulations unveil flow around sharkskin. Credit: A. Boomsma & F. Sotiropoulos/UMN

On an intuitive level, you'd expect a shark's skin to reduce drag. After all, the purpose of sharkskin-inspired riblets—the micro-grooved structures found in aircraft wings, wind turbine blades and Olympic-class swimsuits—is to do just that. Sharkskin's ability to reduce hydrodynamic drag, however, has been academically contested for the past 30 years.

To clarify this phenomenon, researchers at Stony Brook University and the University of Minnesota recently conducted simulations on the ability of the small, tooth-like denticles that make up sharkskin to modify hydrodynamic flow with an unprecedented level of resolution. Far from easing the glide through the water, they found, the structures can actually increase drag by up to 50 percent.

Fotis Sotiropoulos—whose previous work focused on developing computational tools to study the evolutionary impact of hydrodynamic factors on fish body shapes and swimming styles—and his Ph.D. student Aaron Boomsma discuss their work exploring the hydrodynamics of sharkskin this week in *Physics of Fluids*, from AIP Publishing.

"The work on sharkskin was a natural progression, especially after observing the commonalities between sharkskin and riblet films," said Sotiropoulos, dean of the College of Engineering and Applied Sciences at Stony Brook University and primary investigator of the project. "Our interest was piqued by the thought that sharkskin was capable of providing a hydrodynamic advantage to sharks."

Sotiropoulos and his colleagues used experimental data about the three-dimensional geometry of shortfin mako shark denticles provided by George Lauder, a professor of organismic and evolutionary biology at Harvard University, to create computational beds of sharkskin denticles in aligned and staggered configurations. They then applied numerical simulations based on immersed boundary concepts to study the details of turbulent water flow through and over the stationary denticle beds.

"Our simulations show conclusively, that for the tested configurations, sharkskin actually increases drag—as high as fifty percent," Sotiropoulos said.

The researchers also simulated the same flow over riblets, finding that they reduced drag by 5 percent.

This disparity arises due to differences between the objects' geometries:

Riblets are able to confine viscous stress along their ridges because they're essentially two-dimensional, whereas the complex three-dimensional features of denticles generate turbulence and swirling flow patterns that complicate the confinement of viscous stress.

"This is a great example of how our attempts to get inspired by nature have led to something truly beneficial, even though the functionality of the original natural construct may not be as simple to explain or understand," said Sotiropoulos.

Future work for Sotiropoulos and his colleagues includes expanding their work to understand how sharkskin denticles perform under swimming conditions and its subsequent pressure forces. Sotiropoulos noted, however, that next-generation super computers are needed to gain a full understanding of this interplay.

More information: "Direct numerical simulation of sharkskin denticles in turbulent channel flow," by Aaron Boomsma and Fotis Sotiropoulos, *Physics of Fluids*, March 15, 2016 (DOI: 10.1063/1.4942474

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