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A Flounder's Disappearing Act Explained by Physics

The disappearing act used by flounders to escape predators inspired a team of researchers in France to explore whether the oscillation process involved can provide an efficient new approach to the resuspension of granular material within a fluid

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WASHINGTON, D.C., November 24, 2015 -- Simply oscillating its fins is all a flounder, a flat fish, needs to do to resuspend sand and quickly disappear beneath it to hide. By discovering the physics at play, researchers in France are hoping to provide a new flounder-inspired solution to a common technological challenge: the resuspension of granular material within a fluid.

While scuba diving in the Mediterranean Sea, a flounder that suddenly appeared within view and disappeared just as stealthily startled Alban Sauret, a research scientist for the French National Centre for Scientific Research (CNRS) at SVI Laboratory. At the time, he was already exploring the coupling of granular material and fluids in the laboratory.

So the flounder's disappearing act inspired Sauret and his colleagues from the FAST Laboratory (CNRS/Paris-Sud University) to run some experiments delving into the physics involved, and during the American Physical Society's 68th Annual Meeting of the Division of Fluid Dynamics, Nov. 22-24, 2015, in Boston, Mass., they'll present their findings.

The team's experiments involve an oscillating circular or rectangular foil whose motion -- including the amplitude and speed of the oscillation and the position above the granular bed -- are controlled by the researchers.

"We measure the velocity of the fluid around the oscillating foil via a 'particle image velicometry' method because it allows us to track and quantify the vortices generated by the oscillation of the foil," said Sauret.

They also visualize the behavior and the topography of the eroded granular bed, and then compare these experimental results with theoretical predictions of the onset of the erosion process. "Indeed, when a fluid flows over a granular bed at large enough velocity, erosion occurs and sand is entrained into the fluid flow," explained Sauret. "So we can predict the amplitude and frequency of the oscillations necessary to erode a granular bed."

While previous studies by others were devoted to erosion and resuspension processes -- including in rivers and deserts -- most focused on the effects of a steady fluid flow on a granular bed. Here, the situation is more complex because it involves the coupling between the oscillation of a rigid plate and the erosion of the bed through the motion of the surrounding fluid. "The fluid flow isn't trivial: vortices are periodically shed by the oscillating foil," he said. "This complex interplay between the foil, the fluid, and the granular bed needs to be understood."

Understanding how a fluid flow can modify a granular bed and how oscillating flows or vortices can resuspend a granular bed are of interest for numerous applications. "Some technological processes require digging in a granular bed or resuspending particles, for example in a fluidized granular bed," noted Sauret.

In other situations, the resuspension of particles can cause catastrophic events. When a helicopter lands in sandy and dusty environments, its blades trigger air recirculation, which can cause resuspension of particles. The limited visibility in the generated sand cloud causes serious safety issues, so understanding how and when this resuspension is generated could help to avoid the cloud formation.

"Our experiments revealed that the initial position of the foil and the direction of the very first oscillation -- upward or downward -- strongly affect the generated vortices and the efficiency of the erosion process," said Sauret. "This was very surprising and shows there's likely a combination of motions that leads to easier resuspension of the granular bed. I wonder if the flounders have figured this out and are minimizing their efforts."

Now that Sauret and colleagues have discovered when and how oscillations of the foil trigger granular bed erosion, the next step is to more quantitatively characterize the amount of sand resuspended by the oscillating foil.

"This requires the use of a visualization method that allows tracking of both the fluid motion and the particle trajectories," said Sauret. "Then we'll be able to compare the efficiency of our foil with that of the flounders. We're just beginning to understand a process that nature has optimized so that flounders can escape their predators."

The team has also begun exploring the effects of swimming fish and motion nearby a granular bed. "Some fish, for example, create beautiful underwater structures simply by swimming -- eroding the granular bed and resuspending some sand," he added. "Both for this particular aspect and for transportation within dusty environments, it's worth studying the resuspension of a granular bed within the wake of a 'translating object' in the form of a fish or a vehicle."

Presentation #M12.10, "How do fish hide in the sand: erosion by an oscillating foil," is authored by Alban Sauret, Cyprien Morize, Guillaume Quibeuf and Philippe Gondret. It will be at 9:57 a.m. ET on Tuesday, Nov. 24, 2015 in Room 200 of the Hynes Convention Center in Boston, Mass.
ABSTRACT: http://meetings.aps.org/Meeting/DFD15/Session/M12.10

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MEETING INFORMATION

The 68th Annual Division of Fluid Dynamics Meeting will be held at Hynes Convention Center in Boston, Mass. from Nov. 22-24, 2015. More meeting information: https://apsdfd2015.mit.edu

REGISTERING AS PRESS

Any journalist, full-time or freelance, may attend the conference free of charge. Please email: <jbardi@aip.org> and <dfdmedia@aps.org> and include "DFD Press Registration" in the subject line.

ONSITE AND ONLINE PRESS ROOMS

Workspace will be provided on-site during the meeting. The week before the meeting, news, videos and graphics will be made available on the Virtual Press Room: http://www.aps.org/units/dfd/pressroom

LIVE MEDIA EVENT

A press briefing featuring a selection of newsworthy research talks will be streamed live from the conference at 1:00 p.m. ET on Monday, Nov. 23. For more information, email jbardi@aip.org

ABOUT THE APS DIVISION OF FLUID DYNAMICS

The Division of Fluid Dynamics (DFD) of the American Physical Society (APS) exists for the advancement and diffusion of knowledge of the physics of fluids with special emphasis on the dynamical theories of the liquid, plastic and gaseous states of matter under all conditions of temperature and pressure. DFD Website: http://www.aps.org/units/dfd/index.cfm

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Image captions:

1. Flow patterns near a flounder-mimicking oscillation foil.

2. Liquid vortices shed near a granular bed resuspend the sand.