CRUISING THE SEAS ON THE WRECKAGE OF A NATURAL DISASTER

On 11 March 2011, a magnitude 9 earthquake off the east coast of Japan rocked the country's Tohoku region and generated tsunami waves with heights reaching 40 meters. In the ensuing days, buoys, fishing vessels, four large fisheries docks, and more were launched into the Pacific Ocean. The provenance of that detritus can be determined from explicit markings and other, more subtle forensic clues. And now a team led by James Carlton of Williams College has documented that the debris has carried at least 289 living species—including mollusks, crustaceans, and fish—from Japan to the Hawaiian Islands and the Pacific coast of North America; the photo shows one arrival, a barred knifejaw fish stowed in the stern well of a fishing vessel from the Iwate prefecture. Indeed, new species have continued to arrive at least up until February of this year, the most recent date considered by Carlton and company.

Organisms have long hitched rides across the seas in or on commercial vessels, but the research team emphasizes that a chunk of debris is a qualitatively different conveyance. Its slower speed enables a richer variety of species to more successfully cling to the surface. And organisms on a leisurely raft ride across the ocean can better acclimate to changing environmental conditions.

The tremendous trans-Pacific migration appears to be without precedent. Japan endured Tohoku-scale tsunamis in 1896 and 1933, but Carlton's team could find no reports of Japanese debris washing up on North American shores. The researchers note that in those days, port regions didn't use fiberglass, polystyrene foam, and other nonbiodegradable materials common today. Twenty-first-century rubbish rafts are better at surviving the harsh conditions of an ocean voyage without falling apart.

NANCY TRENEMAN

As far as is known, say the researchers, none of the seafaring organisms from Japan have proliferated enough to become invasive. But it is too early to sound the all clear; often years elapse before an invasion can be detected. (J. T. Carlton et al., *Science* **357**, 1402, 2017.)

—SKB

FLUID DYNAMICS EXPLAINS ANCIENT ORGANISM BEHAVIOR

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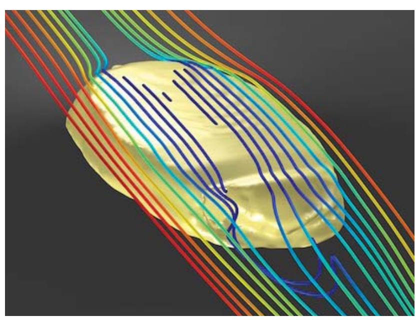

IMRAN RAHMAN

Fossil evidence tells only part of the story of an ancient organism. Take the roughly 550-million-year-old genus *Parvancorina*, a small, shield-shaped marine creature that doesn't resemble any modern animal (the left image is a reconstruction). Limited to fossil analysis, paleontologists have wondered whether the organism had the ability to move through the water. Now, after a simulation in which *Parvancorina* were exposed to currents through computational fluid dynamics (CFD), scientists are fairly certain that it did. The CFD technique is enabling researchers to better understand how *Parvancorina* and other ancient creatures moved and fed.

At a 23 October session of the Geological Society of America's 129th annual meeting, Oxford University paleobiologist Imran Rahman presented his work on three-dimensional digital models of *Parvancorina*. He developed the models based on fossils and then calculated how seawater would flow around the model organisms. Rahman found that turbulent currents flowing over the animal swept water toward specific areas of its body and that flow patterns differed depending on how the animal was oriented in the current. In the right image, the red lines represent where water flows fastest; the flow is slowest down the middle, near where the mouth (front right of the invertebrate) is located. The results suggest that not only was *Parvancorina* mobile, but it didn't just tumble helplessly along—it could adjust its orientation to maximize access to nutrients.

Rahman also used CFD to explain how 510-million-year-old primitive relatives of starfish and sea urchins ate. He found that flowing water could never reach the mouthlike groove of the flat-bodied *Protocinctus mansillaensis* without help. Rahman concluded that the animal likely filtered water by pushing it through gill-like organs. The simulations reveal that fatter species related to *Protocinctus* experienced the best flow to their mouths, which suggests that body shape was a trade-off between feeding advantages and stability in the current.

The importance of the CFD work goes beyond better understanding two ancient species. Based on Rahman's *Parvancorina* investigations, it's possible that other pre-Cambrian appendage-less organisms could have been mobile. And biologists can now study *Protocinctus* as a step in the evolution of active feeding. Rahman encourages paleontologists to apply CFD to other puzzles in fossil taxonomy, such as the evolution of swimming and flying.

—RB PT