Scientists say ocean currents cause microbes to filter light

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(PhysOrg.com) -- Adding particles to liquids to make currents visible is a common practice in the study of fluid mechanics, one that was adopted and perfected by artist Paul Matisse in sculptures he calls Kalliroscopes. Matisse's glass-enclosed liquid sculptures contain an object whose movement through the liquid creates whorls that can be seen only because elongated particles trailing the object align with the direction of the current; light reflects off the particles, making the current visible to the viewer.

Researchers at MIT recently demonstrated that this same phenomenon is responsible for the swirling patterns scientists typically see when they agitate a flask containing microbes in water; many microbes are themselves elongated particles that make the whorls visible. More importantly, they say this phenomenon occurs in the ocean when elongated microbes caught in a current align horizontally with the ocean surface, affecting how much light goes into the ocean and how much bounces off as backscatter. Because many ocean microbes, like large phytoplankton, have either an elongated shape or live in communities of long chains, this orientation to ocean currents could have a substantial effect on ocean light — which in turn influences photosynthesis and phytoplankton growth rates — as well as on satellite readings of light backscatter used to inform climate models or assess algal blooms.

In a quiescent ocean, phytoplankton are randomly oriented and light filters through easily. This random arrangement is usually assumed in models of light propagation in the ocean and in satellite readings. But fluid flow can change things.

"Even small shear rates can increase backscattering from blooms of large phytoplankton by more than 30 percent," said Roman Stocker, Professor of Civil and Environmental Engineering at MIT and lead author on a paper about this work. "This implies that fluid flow, which is typically neglected in models of marine optics, may exert an important control on light propagation, influencing the rates of carbon fixation and how we estimate these rates via remote sensing."

Another consideration is microbial size. Very small microbes (less than 1 micrometer in diameter) don't align with the ocean current no matter what their shape. "These very small things don't align because they are too vigorously kicked around by water molecules in an effect called Brownian motion," said Stocker, who studies the biomechanics of the movements of ocean microbes, often in his own micro-version of a Kalliroscope called microfluidics. He recreates an ocean environment in microfluidic devices about the size of a stick of gum and uses videomicroscopy to trace and record the microbes' movements in response to food and current.

In this case, however, the research methodology was observation, followed by mathematical modeling (much of which was handled by graduate student Marcos, who created a model that coupled fluid mechanics with optics), and subsequent experimentation carried out by graduate students Mitul Luhar and William Durham using a tabletop-sized device.

But the impetus for the research was an observance of swirling microbes in a flask of water and a question posed by Justin Seymour, a former postdoctoral fellow at MIT. "Justin walked up to me with a flask of microbes in water, shook it, and asked me what the swirls were," said Stocker. "Now we know."

In addition to Seymour, who is now a research fellow at the University of Technology Sydney, other co-authors on the paper are Marcos, Luhar and Durham; Professor James Mitchell of Flinders University in Adelaide, Australia; and Professor Andreas Macke of the Leibniz Institute for Tropospheric Research in Germany.

The researchers plan to test this mechanism in the field in a local environment suitable for experimentation, most likely a nearby lake.

More information: "Microbial alignment in flow changes ocean light climate," by Marcos, Justin Seymour, Mitul Luhar, William Durham, James Mitchell, Andreas Macke and Roman Stocker, in *PNAS* Early Edition online Feb. 21, 2011. www.pnas.org/content/early/201 … /1014576108.abstract

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