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Researchers Use Acoustic 3-D Imaging System to Unveil Swimming Behavior of Microscopic Plankton in the Ocean

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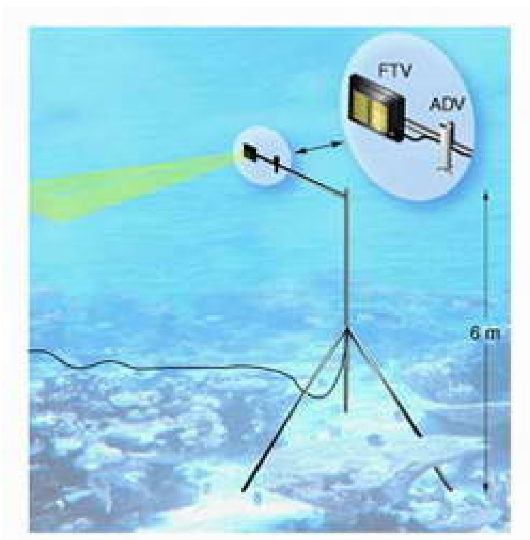

From the surface, the ocean appears to be vast and uniform. But beneath the surface, tiny animals called zooplankton are swept into clusters and patches by ocean currents. The very survival of many zooplankton predators-from invertebrates to whales-and the success of fishermen catches can depend on their success at finding those patches.

For almost a century ocean scientists have suspected that these patches form when the zooplankton swim against the ocean currents. In all those years, however, an understanding of zooplankton swimming response to ocean currents has remained elusive, mainly due to the lack of technology to track the motions of the miniscule animals in the sea.

Now, an international team of scientists from Israel, the United States and Germany led by Amatzia Genin of the Hebrew University of Jerusalem has provided, for the first time, evidence of the remarkable dynamics responsible for the formation of zooplankton aggregations. The new findings indicate that zooplankton are passively drifting with the current, as their name implies ("planktos" translates to "drifting" in Greek), but only in the horizontal direction, not in the vertical.

The recent development of a 3-dimensional acoustic imaging system by Jules Jaffe of Scripps Institution of Oceanography at the University of California, San Diego, has opened the door for a team of researchers to track several hundred thousand individual zooplankton at two coastal sites in the Red Sea. The team includes Genin and his student Ruth Reef from the Hebrew University; Jaffe and Peter Franks from Scripps Institution of Oceanography at the University of California, San Diego; and Claudio Richter from the Center for Tropical Marine Ecology in Bremen, Germany.

Their findings, reported in the May 6 issue of the journal Science, show that these small animals effectively keep their depth by "treadmilling" against upwelling and downwelling currents at speeds of up to several tens of body-lengths per second.

"Clumped distribution, termed 'patchiness,' is one of the most ubiquitous characteristics of oceanic zooplankton," said Genin, lead author of the Science paper. "Aggregations are found on all scales, from millimeters to hundreds of kilometers. Understanding the mechanisms that produce zooplankton patchiness is a central objective in biological oceanography."

Countless numbers of the minute, nearly transparent zooplankton are found under the surface of each square meter of the world's oceans. These animals play a key role in the marine food web as a crucial link between primary producers and predators.

The imaging system, Fish TV, uses multibeam sonar to uniquely measure animal movement. The system allowed the researchers to analyze the swimming behavior of more than 375,000 individual zooplankton swimming against vertical currents. Swimming against vertical currents allows the plankton to keep their depth, a behavior which was postulated long ago but had never been measured in the ocean until now.

The results were captured during three experiments lasting several weeks at two sites in the Red Sea's Gulf of Aqaba, near the coral reef of Eilat in Israel and at Ras Burka on the coast of Egypt's Sinai Peninsula. At the sites scuba divers attached Fish TV's sonar head ("transducer") on a large underwater tripod raised some 20 feet above the seafloor. The transducer was cabled to a control and data-acquisition unit consisting of a computer and other electronic hardware.

Fish TV's transmitters sent out 1.6 megahertz "pings" that bounced off the zooplankton and returned data to the instrument's receivers. It's a system not unlike those used in ultrasound procedures for biomedical applications.

"One of the most amazing aspects of this research is that we were able to see 375,000 of these animals, many as small as one millimeter in length," said Jaffe, a research oceanographer in the Marine Physical Laboratory at Scripps. "I find it fascinating and remarkable that we can capture the reflection of such tiny creatures in three dimensions from two meters away."

The divers frequented the underwater setup to sample the animals, reorient the transducer and measure the vertical currents using various methods, including releasing and tracking fluorescent dye and with state-of-the-art acoustic current meters.

Downward-flowing water in the ocean is always accompanied by horizontal flows, forming a convergence, or "downwelling" zone. When zooplankton swim upward against such a downward current, they form patches as more and more individuals are brought in with the horizontal currents and concentrated in the downwelling zone.

The scientists say the ecological implications of the zooplankton's depth-keeping behavior carry far-reaching consequences for predatory fishes, whales and humans.

Predators can dependably locate zooplankton aggregations by tracking well-defined cues, for example, sharp temperature gradients that occur across downwelling fronts where cold and warm waters meet. Vertical currents are common in many oceanic regions, including mid-ocean fronts, shelf breaks, submarine canyons and submerged banks.

"That small zooplankton are capable of remaining at a constant depth with a precision of centimeters, sometimes in the face of strong vertical currents, is incredible," said Genin. "It implies that these organisms have extremely sensitive depth sensors, the nature of which is yet unknown. That depth-keeping behavior has evolved in so many different species implies that this energetically demanding behavior provides significant, yet poorly understood benefits. Revealing those benefits and the nature of depth sensing will be a major and exciting challenge for future research in zooplankton ecology and evolution."

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Source: University of California - San Diego