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Breakthrough System for Understanding Ocean Plant Life Announced

Researchers at the University of California, Santa Barbara, NASA, and other institutions announced at a telephone press conference today the discovery of a method to determine from outer space the productivity of marine phytoplankton---a breakthrough that may provide a new understanding of life in the world's oceans.

The new approach is based on the premise that the "greenness" in phytoplankton, its level of pigmentation per cell, is a reflection of its growth rate, said David Siegel, professor of geography and director of the Institute for Computational Earth System Science at UCSB. The researchers have discovered a means, by satellite, to measure the biomass of phytoplankton from ocean light-scattering properties, and to infer growth rates from simultaneous measurements of the greenness of the individual phytoplankton cells.

Phytoplankton are the incredibly abundant microscopic plant forms that provide the basis for most of the marine food chain, half the oxygen in our atmosphere and ultimately much of the life on Earth. They have rapid growth rates and are constantly being produced and consumed in huge amounts -- but until now, it was impossible to determine their growth rate on a broad and useful scale for conducting Earth science.

The new findings, which were developed with funding from NASA and the National Science Foundation, have been published in Global Biogeochemical Cycles, a professional journal. Siegel, a co-author, has been working with NASA on satellite ocean color imagery for over a decade, along with collaborators at UCSB. He describes the breakthrough as similar to learning to play with the controls on a television set. "We analyze the color on the screen to look at plant greenness and brightness to determine the number of individual phytoplankton cells," he said. "This breakthrough will revolutionize the way NASA can assess carbon dynamics for the ocean."

"The new information on phytoplankton growth rates and biomass will greatly advance our understanding of the Earth's oceans," said Michael Behrenfeld, first author of the article and a research professor in the Department of Botany and Plant Pathology at Oregon State University.

"We don't have the satellite technology available yet to fully take advantage of this new approach," he said. "But ultimately this system should have a great potential to effectively monitor phytoplankton productivity and understand the physical and chemical forces that drive it."

Although too tiny to see, phytoplankton have a net annual production that's comparable to the total amount of terrestrial plant life on Earth, scientists say. They produce about 50-65 billion tons of organic matter each year, and in the process absorb carbon dioxide and pour oxygen into the atmosphere.

Their abundance dictates the location and health of most marine fisheries. They play a critical role in marine water quality issues, can help regulate climate, and their productivity is in turn affected by climate. The very basis of sustainable ecological systems is almost impossible to understand without a good grasp of phytoplankton productivity, and its implications for global climate change, according to the scientists.

Behrenfeld, an expert on phytoplankton, studies their molecular and metabolic pathways as well as their measurement from outer space. "It was only in the late 1800s that we even realized these tiny plants formed the base of the marine food web," Behrenfeld said. "By the 1950s, we had figured out how to accurately measure their production and use observations of chlorophyll to determine their biomass. But until now, we've never been able to measure their rate of production over large areas."

That production can be enormous, and highly variable. Phytoplankton biomass can double in as little as one day, and it's routine for the entire mass of phytoplankton in an area to either be consumed by other life forms or die and sink to the ocean bottom in less than a week.

"Obviously, there's a very tight coupling between phytoplankton production and its consumption or death," said Emmanuel Boss at the University of Maine, a co-author on the paper. "So it's almost impossible to really understand what's going on in the oceans without understanding that rate of production. Now we have a way to do that."

The researchers accomplished this by moving beyond the old standard for monitoring phytoplankton, the observation of chlorophyll.

"The growth rate of phytoplankton can change dramatically based on such factors as water temperature, nutrients and light," Behrenfeld said. "And it's the growth rate of phytoplankton we have to know, to really take the pulse of the oceans. That's the missing piece of the puzzle."

The mathematics behind this approach, the researchers say, is conceptually similar to technology that's used in a home supply or paint store when someone brings in a color chip and wants to "match" the paint color. A computer analysis is done that determines the final color of the paint, factors in the base colors used to produce it and then determines the original formula needed to reproduce the paint chip.

To fully use this approach, new satellite systems will be necessary that can more accurately determine both the color and brightness of marine waters, Behrenfeld said. He and colleagues are already working on a satellite instrument to do that called ORCA, or Ocean Radiometer for Carbon Assessment.

However, in studies already done, the scientists have demonstrated that carbon-based values are considerably higher in tropical oceans, show greater seasonality at middle and high latitudes, and illustrate important differences in the formation and demise of regional algal blooms. Researchers anticipate a fundamental change in how they can model and observe carbon cycling in the global oceans.

Related Links

NASA Web Site

NASA's 44-second video on the productivity of phytoplankton.

NASA's one-minute animation of SeaWiFS satellite.

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