



NSF Press Release

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New Source of Natural Fertilizer Discovered in Oceans

New findings suggest that the deep ocean is teeming with organisms that produce essential natural fertilizers. A National Science Foundation (NSF)-funded research team led by Jonathan Zehr, a marine scientist at the University of California, Santa Cruz, has discovered a previously unknown type of photosynthetic bacteria that fixes nitrogen, converting nitrogen from the atmosphere into a form other organisms can use. The researchers reported their findings in the August 9 issue of the journal *Nature*. Zehr has also found evidence that many additional kinds of nitrogen-fixing bacteria live in the open ocean.

"This discovery points to how little we know about the organisms that drive ocean biogeochemical processes," says Phil Taylor, director of NSF's biological oceanography program. "It may have profound influences on our thinking about and modeling of the global ocean nitrogen and carbon cycles."

Although nitrogen accounts for nearly 80 percent of the Earth's atmosphere, most organisms can use it only when it is "fixed" to other elements, to make compounds such as ammonia or nitrate. As a component of proteins, nitrogen is essential to all known forms of life.

Zehr and his coworkers found the nitrogen-fixing bacteria, which they have grown in the laboratory, in water samples collected from the Pacific Ocean near Hawaii. The organisms appear to belong to the genus *Synechocystis*, a group of cyanobacteria (photosynthetic bacteria formerly known as blue-green algae) that includes both marine and freshwater species. The newly discovered nitrogen-fixers appear to be active at greater depths and over longer time periods than other marine cyanobacteria known to fix nitrogen in the open ocean.

On land, nitrogen-fixing bacteria are a known quantity, residing in the roots of legumes like peas and beans. While many nitrogen-fixing cyanobacteria have been found in coastal waters, very few are known to occur in the open ocean.

"It appears that there is much more nitrogen fixation than we know about," Zehr said. "In the open ocean, there are only one or two organisms known to fix nitrogen. They probably can't account for all the nitrogen getting fixed." The amount of nitrogen fixation in the open ocean has implications for global warming because nitrogen stimulates the growth of marine algae, which absorb carbon dioxide from the atmosphere.

Over the past 12 years, Zehr has uncovered evidence of dozens of nitrogen-fixing bacteria by looking not for the organisms themselves but for their DNA fingerprints -- specifically, for a gene encoding the protein responsible for nitrogen fixation.

The nitrogen-fixing marine *Synechocystis* is the first of these organisms Zehr's team has succeeded in cultivating in the laboratory. What emerged was a strain of nitrogen-fixing bacteria that are about 100 times as large as typical photosynthetic ocean bacteria. "They're like basketballs, compared to the pins of light we're used to looking at," Zehr said.

The relatively large size of these cyanobacteria and their abundance suggest that they make a significant contribution to nitrogen fixation in the ocean. "There's potentially as much biomass of these bacteria as of the other two known nitrogen-fixers in the open ocean combined," Zehr said.

The new bacteria are abundant as deep as 100 to 200 meters below the surface, compared to 50 meters for the most productive known nitrogen-fixer. And unlike the previously known nitrogen-fixers, which are only active in warm seasons, the new bacteria have shown activity in February.

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