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# Plankton's Shifting Role in Deep Sea Carbon Storage Explored

ScienceDaily (Oct. 13, 2011) — The tiny phytoplankton *Emiliania huxleyi*, invisible to the naked eye, plays an outsized role in drawing carbon from the atmosphere and sequestering it deep in the seas. But this role may change as ocean water becomes warmer and more acidic, according to a San Francisco State University research team.

In a study published this week in the journal *Global Change Biology*, SF State Assistant Professor of Biology Jonathon Stillman and colleagues show how climate-driven changes in nitrogen sources and carbon dioxide levels in seawater could work together to make *Emiliania huxleyi* a less effective agent of carbon storage in the deep ocean, the world's largest carbon sink.

Changes to this massive carbon sink could have a critical effect on the planet's future climate, Stillman said, especially as atmospheric carbon dioxide levels continue to rise sharply as a result of fossil fuel burning and other human activities.

While floating free in the sunny top layers of the oceans, the phytoplankton develop elaborate plates of calcified armor called coccoliths. The coccoliths form a hard and heavy shell that eventually sinks to the ocean depths. "About 80 percent of inorganic carbon trapped down there is from coccoliths like these," said Stillman.

Stillman and his colleagues wanted to discover how ocean acidification and changes in the ocean's nitrogen cycle -- both hallmarks of climate warming -- might effect coccolith development. So they raised more than 200 generations of *Emiliania huxleyi* in the lab, adjusting carbon dioxide levels and the type of nitrogen in the phytoplankton's seawater bath.

They found that high levels of carbon dioxide -- which make the water more acidic -- along with a shift in the prevailing nitrogen type from nitrates to ammonium -- "had a synergistic effect" on the phytoplankton's biology and growth.

In particular, coccoliths formed under conditions of high carbon dioxide and high ammonium levels were incomplete or hollow, and contained less than the usual amount of inorganic carbon, the researchers noted.

"The ratio of inorganic to organic carbon is important," Stillman explained. "As inorganic carbon increases, it adds more ballast to the hard shell, which makes it sink and makes it more likely to be transported to the deep ocean. Without this, the carbon is more likely to be recycled into the Earth's atmosphere."

"Our results suggest in the future there will be overall lower amounts of calcification and overall lower amount of transport of carbon to the deep ocean," he added.

*Emiliania huxleyi* typically use nitrates to make proteins, but this form of nitrogen may be in shorter supply for the phytoplankton as the world's oceans grow warmer and more acidic, Stillman and colleagues suggest. In the open ocean, nitrates are upwelled from deep waters, but a thickening layer of warmer surface water could inhibit this upwelling. At the same time, the warmer temperatures favor bacteria that turn recycled nitrogen from surface waters and the atmosphere into ammonium, and acidification inhibits the bacteria that turn ammonium into nitrate.

"It is likely that in the future, the ocean surface will contain more ammonium," which the phytoplankton will assimilate instead of nitrates, Stillman suggested. "Metabolizing nitrogen as ammonium versus nitrates requires different biochemical constituents that impact how well the cells make their coccoliths. They will survive just fine, but their biology will be different as a result."

The study by Stillman and colleagues is the first to look at the intertwined effects of ocean acidification and changes in nitrogen on phytoplankton like *Emiliania huxleyi*. It's also one of the first studies to observe these effects continuously over a long time scale, "so the responses of the phytoplankton are likely what we'll see in the ocean itself," Stillman said.

Stephane Lefebrve, the SF State postdoctoral student who developed the experiments for the study, said he is now looking for phytoplankton genes that "will help us to build the genetic blueprint of their responses to elevated carbon dioxide and a nitrogen source."

Lefebvre, Ina Benner, Alexander Parker, Michelle Drake, Pascale Rossignol, Kristine Okimura, Tomoko Komada, and Edward Carpenter, all from SF State's Romberg Tiburon Center for Environmental Studies, were co-authors on the Global Change Biology study.



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**Story Source:**

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**Journal Reference**:

1. Stephane C. Lefebvre, Ina Benner, Jonathon H. Stillman, Alexander E. Parker, Michelle K. Drake, Pascale E. Rossignol, Kristine M. Okimura, Tomoko Komada, Edward J. Carpenter. **Nitrogen source and pCO2 synergistically affect carbon allocation, growth and morphology of the coccolithophore Emiliania huxleyi: potential implications of ocean acidification for the carbon cycle**. *Global Change Biology*,

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