VIMS Scientists Part of National Study in Antarctica

Ph.D. student Jill Peloquin in laboratory aboard the R/V *Roger Revelle.*

By David Malmquist

VIMS researchers have returned to Antarctica's frigid, stormy waters to further test one of oceanography's most controversial hypotheses—the idea that fertilizing the ocean with iron can help curb global warming by boosting the rate at which marine plants remove carbon dioxide from the atmosphere.

Supported by grants from the U.S. National Science Foundation and Department of Energy to VIMS researchers Walker Smith, Hugh Ducklow, and Jim Bauer, four VIMS graduate students and a technician are currently down under as part of SOFeX (the Southern Ocean Iron Experiment). This is a two-year collaborative effort that involves three ships, 45 tons of equipment and supplies, and 17 leading U.S. oceanographic institutions.

SOFeX is designed to test the "iron hypothesis," an idea first put forth by the late oceanographer John Martin. He argued that a shortage of iron—a minor yet crucial ingredient for phytoplankton growth—explained ocean "deserts." These are vast stretches of open ocean that support few phytoplankton despite ample stores of nitrogen and phosphorous, the two main nutrients that these tiny, floating plants require to grow.

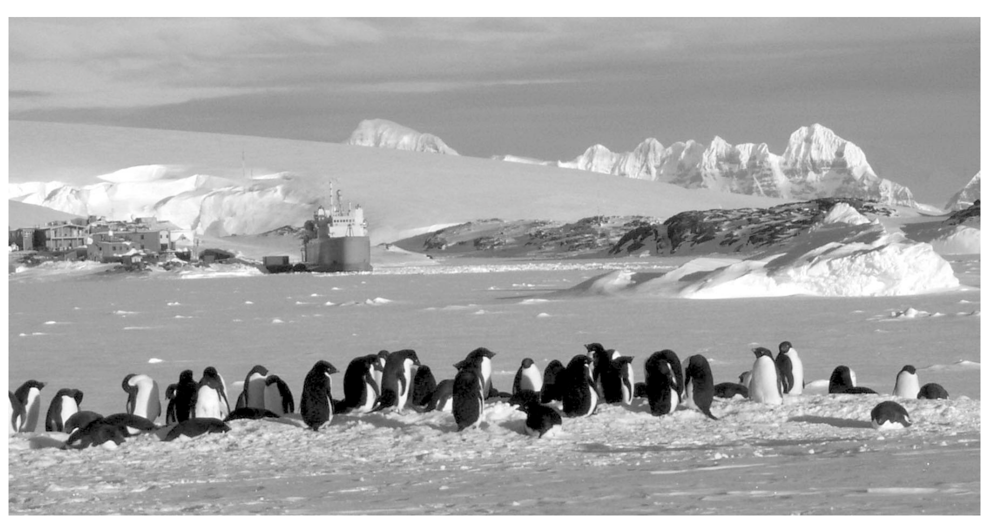
Add iron to these deserts, Martin argued, and you could make the ocean bloom. Early experiments proved him right—sprinkling just 1,000 pounds of iron across a patch of the equatorial Pacific produced a verdant bloom of phytoplankton whose biomass equaled that of 100 full-grown redwoods.

Although Martin posed his idea to help solve a long-standing scientific puzzle (the cause of ice ages), it quickly captured the attention of both policymakers and entrepreneurs. That's because phytoplankton take up carbon dioxide from seawater during photosynthesis, allowing the ocean surface to absorb more of this gas from the atmosphere. Because carbon dioxide is the main greenhouse gas, any reduction in its atmospheric concentration would help to curb global warming.

The seemingly intractable politics of global warming suddenly seemed to have a quick (and profitable) fix. Instead of spending $50-100 per ton to put scrubbers on power-plant smokestacks, a coal company could instead pay as little as $3 a ton to dump iron into the open ocean. A Virginia-based start-up, Ocean Farming Inc., already has plans to supply the iron and the boats. It argues that it could suck humanity's entire annual carbon dioxide output into the sea with 8 million tons of iron, a fleet of 200 ships, access to 10 percent of the world's ocean—and the help of countless phytoplankton.

Not so fast, say most scientists, including VIMS' Walker Smith. "The concept of [large-scale iron fertilization] is appealing, because it's so cheap," says Smith, "but most scientists think it's a bad idea."

Oceanographers are concerned because they have little knowledge of how the ocean food web might respond to a huge influx of iron. They're also unsure how much of the carbon captured by phytoplankton might sink to the deep ocean (where it would remain for hundreds of years), and how much might be cycled through the surface food web back into dissolved carbon dioxide gas (which would limit further uptake of carbon dioxide gas from the atmosphere).



A view of Palmer Antarctic Research Station.

Researchers are also uneasy because they know relatively little about the potential response of the Antarctica ecosystem to iron enrichment. Antarctica's Southern Ocean is the most likely site for any future large-scale iron-fertilization projects (it's the world's largest ocean desert and outside busy shipping lanes), but it might respond to added iron very differently than the equatorial waters where the early iron experiments were done.

SOFeX is designed to help answer these concerns, says Smith. The project began on January 5th, when the 274 ft. R/V *Revelle* left New Zealand to begin adding iron to two 80-square mile patches of the Southern Ocean near Antarctica, pumping 10 tons of iron sulfate from two 5,000 gallon on-deck tanks into the ship's wake. Researchers aboard the second SOFeX ship, the 278 ft. R/V *Melville*, which left New Zealand on January 19th, are examining the biological subtleties of the anticipated bloom.

Smith's graduate students Jill Peloquin and Liza Delizo are working to identify the particular kinds of phytoplankton that are most affected by iron fertilization, and to better understand the nature of their response. They suspect that diatoms—single-celled plants that construct a skeleton from silica—are likely to grow the fastest. Iron could boost diatoms' growth rates in a number of ways, says Smith. It might allow them to photosynthesize more efficiently, extend their peak photosynthetic efficiency over a wider range of light intensities, or achieve their greatest photosynthetic capacity at lower light levels.

Smith's team is also collaborating with other SOFeX researchers to study the role of silica—another substance that, like iron, limits phytoplankton growth in parts of the Southern Ocean. The researchers plan to study silica's role by creating their first iron patch in a silica-poor area north of Antarctica, and the second in a silica-rich area nearer the continent. Comparing the response of phytoplankton to iron enrichment in these two areas will help the scientists unravel the confounding effects of the two elements.

Hugh Ducklow's graduate student Jacques Oliver is studying the response of microbes (marine bacteria) to iron enrichment. A key question for this duo is whether bacteria respond to iron enrichment directly through their own metabolism, or indirectly, by consuming the carbon-rich organic matter produced by the iron-induced phytoplankton bloom. Microbes are a crucial component of the ocean food web and carbon cycle, both in the Southern Ocean and elsewhere, because they turn the carbon fixed by phytoplankton back into carbon dioxide in surface waters. By so doing, they help maintain high levels of this greenhouse gas in the atmosphere, and thus may negate any efforts to curb global warming via iron enrichment.

The third SOFeX vessel is the U.S. Coast Guard cutter *Polar Star*, which sailed from McMurdo Station, Antarctica on February 12th. Its goal is twofold: to help track the iron patches as winds and currents move them across the Southern Ocean, and to retrieve drifting sediment traps deployed earlier from the R/V *Revelle*.

Jim Bauer's technician Eva Bailey, along with current Ducklow graduate student Bob Daniels and former VIMS' student Chrissy van Hilst, are involved in these efforts. Their intent is to determine how much of the carbon captured by the phytoplankton bloom sinks to the ocean depths when the plankton die or are eaten, and how much remains at the ocean surface. Carbon in the deep ocean contributes nothing to global warming and can remain there for hundreds or thousands of years.

According to Smith, measurement of this "sinking flux" is crucial. Although early experiments clearly proved that iron enhances the uptake of carbon dioxide by phytoplankton, "no one has seen carbon disappear from the surface," says Smith. If marine animals and bacteria transform plankton-derived carbon back into carbon dioxide gas before it sinks to the depths, the promise of a quick-fix to global warming may prove nothing more than a tantalizing chimera.

To track the adventures of VIMS Antarctic researchers online, visit http://www.mbari.org/education/cruises/SOFeX2002/logbook.htm