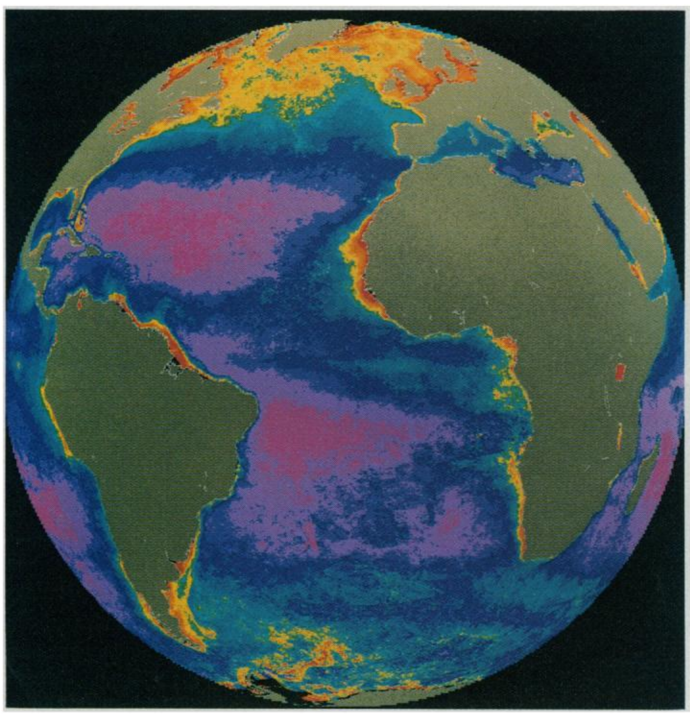
Report Nixes "Geritol" Fix for Global Warming

Oceanographers reject adding iron to the oceans as a greenhouse fix but support a smaller test of the iron hypothesis

SEVERAL YEARS AGO JOHN MARTIN OF THE Moss Landing Marine Laboratory in California suggested—tongue in cheek, he now says—a quick fix to the greenhouse problem: dump iron into the Southern Ocean near Antarctica. That, he said, would trigger a massive bloom of the ocean's microscopic plants, which in turn would suck carbon dioxide out of the atmosphere and help reduce global warming. His idea ignited a firestorm of controversy that rages on today. While the idea quickly won supporters—including some prominent members of the National Academy of Sciences—much of the oceanographic community was incensed, arguing that you don't tinker with a perfectly healthy ecosystem to clean up humanity's mess. As even Martin concedes, "People were madder than hell at me."

Now the American Society of Limnology and Oceanography (ASLO) has weighed in with a report that represents the views of much of the oceanographic community, and there's a surprise in store. In the report, released in late summer, ASLO trounces the idea of fertilizing the oceans with iron as a greenhouse fix, as expected. But in an unexpected twist, the society endorses a small-scale experiment in which iron would be added to the open ocean. The idea isn't to engineer the oceans, the report stresses, but to test a hypothesis that might answer one of the long-standing puzzles in biological oceanography: Why do the phytoplankton of the Southern Ocean, as well as those in parts of the subarctic and equatorial Pacific, grow so poorly, even though the waters are rich in nutrients such as phosphorus and nitrogen? The answer could shed light not only on how the food web operates, says Sallie Chisholm, a biological oceanographer at the Massachusetts Institute of Technology, but on the global carbon cycle as well.

Blooming oceans. *Phytoplankon grows like a weed in the regions shown in yellow and red, but not in the Southern Ocean.*



NASA

The oceans play a key but still elusive role in the carbon cycle. Through a set of complex processes known as the "biological pump," they remove carbon dioxide from the atmosphere and sequester it in the deep ocean. And in the Southern Ocean and other areas where huge quantities of nutrients are unused, the pump seems to be working inefficiently. If it were working at full tilt, then the Southern Ocean would absorb considerably more atmospheric carbon dioxide. Indeed, Jorge Sarmiento and Robbie Toggweiler of Princeton suspect that is what happened 18,000 years ago, when, as ancient ice cores reveal, atmospheric carbon dioxide levels dropped from 280 to 200 parts per million. The only problem is that no one knows what, exactly, controls the speed of the pump.

Enter Martin, who suggested several years ago that the missing ingredient in these ocean regions is iron. First, he says, trace amounts of iron are essential for all life. And what's more, all of the nutrient-rich/productivity-poor ocean regions share one common feature: They receive very little atmospheric dust, the major source of iron input to open oceans. Martin was not the first to suggest that iron played a regulatory role—indeed, the idea goes back to the 1930s. But he and his colleagues Michael Gordon and Steve Fitzwater are credited with being the first to measure accurately the vanishingly small amounts of iron in the ocean—not a trivial achievement, considering the horrendous problems with iron contamination.

The researchers found that iron concentrations are exceedingly low in unproductive waters—just as Martin had predicted. What's more, when they added minute quantities of iron to the sample bottles, phytoplankton productivity soared. It didn't take long for Martin to calculate that with just 300,000 tons of iron, in still unspecified form, he could fertilize the entire Southern Ocean and remove about 2 billion tons of carbon dioxide from the atmosphere. "Give me a half a tanker of iron and I'll give you an ice age," he quipped at a meeting in Woods Hole in 1988. His life has not been the same since.

Martin's plan instantly won its champions, like Adam Heller, a chemist at the University of Texas, Austin, who was swayed by its undeniable economic appeal. A member of the National Academy of Engineering, Heller was the impetus behind two small workshops on the topic held at the National Academy of Sciences. Although the academy's estimate has since been contested, that group put the price tag for fertilizing the Southern Ocean at less than $1 billion a year—a cheap fix if it could remove 1 billion or 2 billion tons of carbon, especially when curbing greenhouse gas emissions might cost up to hundreds of billions of dollars a year. Participants at the workshop also concluded that as speculative as the idea was, it was worth trying in a $50- to $150- million experiment in the Southern Ocean.

But many oceanographers were horrified when they learned of the idea. Not content to leave matters to the small group invited to the academy workshops, ASLO decided to hold its own "grass-roots" meeting last February, which brought together 150 scientists working in the field, says Chisholm, who co-chaired the meeting.

Not only is it unclear whether iron would stimulate phytoplankton productivity in the ocean as it does in a bottle, but it is even less clear how much carbon dioxide would be absorbed, the oceanographers say in their report, which grew out of that February meeting. The most optimistic models predict that, if the nutrient-rich oceans were fertilized for 100 years—and if the fertilization worked—the buildup of carbon dioxide would be reduced by 17% to 25%. But other models put the reduction at about 5%.

Such a small change

might not be worth it, especially considering the enormous environmental risks, the ASLO participants say. Iron enrichment could dramatically alter the composition of phytoplankton species, with effects propagating up the food chain. And it might render the deep ocean oxygen deficient and lead to an increase in nitrous oxide and methane, two greenhouse gases more powerful than carbon dioxide. In sum, the participants urge governments to abandon any notion of a quick fix and concentrate instead on curbing emissions.

But once the policy fix is divorced from the underlying science—Martin's iron hypothesis—the oceanographers become visibly excited. Notes Chisholm: "The hypothesis is gathering momentum while the geochemical engineering option is losing momentum." While the hypothesis still has vehement detractors, new evidence from several groups seems to support it, says Chisholm. Richard Barber of Duke University Marine Laboratory, for instance, has just analyzed phytoplankton growth rates and nutrient and iron concentrations at stations across the Pacific. "My equatorial data suggest Martin is absolutely correct," he asserts.

The only way to find out for sure is to test the hypothesis—and in this case, at least, it should be feasible. For years, limnologists have been able to manipulate lake ecosystems, adding nutrients and studying the effects on the food web. But such experiments have been impossible in the ocean, says Chisholm, given its vast expanse and the huge quantity of nutrients required. But if Martin is right—if tiny amounts of iron are a limiting factor in phytoplankton growth—then oceanographers have a shot at a successful experiment.

Indeed, Martin and Chisholm are already planning an experiment—one that might cost half a million dollars rather than $50 million or $150 million. They are thinking of fertilizing a 100- to 400-square-kilometer patch in the equatorial Pacific. Chisholm, Martin, and others will meet in Monterey in October to firm up plans for the experiment, which, if funded, will be done as part of the international Joint Global Ocean Flux Study.

Does that mean the Geritol solution to greenhouse warming, as it has been dubbed, is dead? Not necessarily. Though Martin is more circumspect now and talks only of testing the basic hypothesis, he still waxes rhapsodic about iron. "Iron is a common element. Plants love it—dump some on your lawn and see what happens." And, he adds, "if we find it could remove carbon dioxide without damaging the food chain, and if the greenhouse scare becomes true," then people just might change their minds about seeding the oceans. ■ LESLIE ROBERTS

Space May Be Bad for Your Health

The 2000 jellyfish lofted into space aboard the space shuttle in June swam around placidly, much as they do on Earth, but not so the seven humans and 29 rats on board. In fact, the mammals produced some surprising data, according to scientists who at a briefing last week described preliminary findings from the first major life sciences project flown by the National Aeronautics and Space Administration since 1974. Concluded Laurence Young, director of the man-vehicle lab at the Massachusetts Institute of Technology, unless better "countermeasures" are developed, astronauts on long trips—such as a flight to Mars—will need "artificial gravity." And that would be enormously expensive, requiring that living quarters be spun continuously.

It was Arnauld Nicogossian, NASA's life sciences chief, who explained the biggest surprise from the mission. Physiological changes induced by weightlessness, he said, seem to occur very quickly. The shuttle crew members, elaborately wired and catheterized, showed the classic effects of space travel almost from the moment of liftoff. These included a shift of blood volume from the legs to the upper torso, an increase in heart rate, a reduction of liquid and food consumption, weight loss, a decrease in total plasma volume, and motion sickness. The rapidity with which these occurred is not currently reflected in computer models, Nicogossian said, and so the models must be "refined."

Researchers also were surprised to learn that something they had taken for granted about the lungs proved to be wrong. On Earth, the blood is concentrated more heavily in the lower part of the lungs while air collects in the top, and researchers assumed that this imbalance would disappear in the absence of gravity. It did not—a discovery that will compel a review of lung function theory.

Another striking discovery, said Young, is that the mammalian brain may be able to adapt on long flights to the confusing signals it receives when the body is set adrift in zero gravity, much as sailors adapt to the roll of the ocean by developing "sea legs." This news could be encouraging, for Young points out that two-thirds of the people who go into space now suffer from motion sickness. For example, all but one of the astronauts on this trip had motion sickness. Young cites the "sensory conflict" theory to explain the phenomenon: Messages from the visual and tactile sensors tell the brain the body is stable, while messages from the inner ear, freed from gravity's reference frame, signal that the body is tilting. The brain's inability to resolve this conflict may induce sickness.

A study of rats, directed by Muriel Ross and her colleagues at NASA's Ames research center, suggests that the brain may be able to resolve the conflict, given enough time. A microscopic examination of the astro-rat tissues has revealed first, that the small calcium crystals called otoliths that move around in the inner ear were not affected by the loss of gravity. (Some feared they would de-mineralize like other bones.) However, the preliminary data do hint at changes in the otolith receptor organ, the vestibular macula. Ross says that the first indications are that the number of receptor synapses seems to increase when the animal is in zero gravity. This may be an attempt to overcome sensory conflict by boosting the signal. Says Ross: The mammalian inner ear seems to be "beautifully adaptive" to space flight.

While this physiological response may be good for space travelers, other responses may not. For example, the shift in blood from the lower limbs to the chest seems to suppress lymphocyte and red cell production, which in turn could impair the immune system. The long bones grow less rapidly while—according to preliminary data—the head mass may increase. The leg muscles that serve as the main counterforce to gravity atrophy quickly in space, even more rapidly that they recover once back on the ground. Finally, the kidney changes in space, increasing its filtration rate while the plasma flow decreases. This raises a special concern about kidney stones, said Carolyn Leach-Huntoon of NASA's Johnson Space Center.

It will be about a year before these scientists are prepared to release their research in final form, but already they are crowing, as MIT's Young says, that the project is churning out valuable data "like gangbusters." Considering the price tag for the shuttle mission—upwards of $400 million—that's just as well. Then again, NASA's critics may conclude that the agency's budget remains just as immune to gravity as the jellyfish it lofted. ■ ELIOT MARSHALL