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Iron Fertilization

mp3 Russ George is a California businessman with a b
him some money and he will seed the ocean with iron, ca
phytoplankton to grow. The process is called Iron fertiliza
designed to take carbon out of the atmosphere to help yc
contribution to global warming. It is one of a number of b
that have grown out of the global demand for carbon trac
and it's becoming a big business. Russ George and his fo
Planktos is creating quite a stir: *Nature,* the BBC, and a h
newspapers have reported on his business venture.

For the past year, through a grant from the Fund for Inve
Journalism, journalist Wendy Williams has been investigat
warming mitigation stories. What she found behind all the
about Russ George was surprising: A man and his carbor
sorely lacking in scientific credentials. She spoke with Livi
recently, and wrote this piece for *Living on Earth Today.*

In late January, 2003, when Russ George walked up the
led from the dilapidated boat where he lived, he was clear
man. He tore at his fingernails as we spoke. He was disinc
in the eye. He was disarmingly open about his trepidation

"No one's ever actually come out here to see me before,"

This surprised me. George – along with his self-described
dubbed "Planktos" and his claim that putting dissolved iro
will help stop global warming – had recently been the sub
two-page feature in one of the world's most prestigious s
the London-based *Nature.* He'd been on the BBC, on a ma
City radio station and claimed to be speaking with staff at
news hour about a show. Newspapers all around the worl
him.

I felt like Dorothy, after she'd walked
Brick Road, entered the Gates of Oz,
back the curtain – only to find a very
who was, after all, no wizar

This spate of glorious publicity, of the kind that money ca
prompted such a steep spike in website hits that George'
has recently demanded more money for increased bandw
grant from the Fund for Investigative Journalism, I had b
global warming strategies for more than a year. Fascinate
I had come out to learn more about the science and to m
scientists he claimed were working with him. All I found w
clearly talented public relations man with no formal backg
oceanography, armed with a laptop, living on a boat.

I felt like Dorothy, after she'd walked the Yellow Brick Road, entered the Gates of Oz, and pulled back the curtain – only to find a very nice man who was, after all, no wizard. Indeed, with his disheveled hair, Hawaiian-style surfer's shirt and baggy pants, George looked more like a lost soul from the Age of Aquarius than like the smooth-talking entrepreneur who had just wangled himself some extremely valuable face space in *Nature.*

* * *

The scientific roots of George's claim are based in the globe's carbon cycle, the movement of atoms of carbon from the earth to the atmosphere to the oceans in an ever-flowing circle. Scientists divide these carbon flows into two general categories -- the long-term carbon cycle, which operates in terms of millions of years, and the short-term cycle, which can sometimes operate in terms of days, weeks and months.

In the short-term cycle, carbon in the atmosphere is turned into plant material by photosynthesis, then returned to the atmosphere by processes like animal digestion. In the long-term cycle, carbon from plants and animals is buried and decays gradually into compounds like oil and coal. Carbon stashed away under this long-term banking system may stay underground over the eons, until some extraordinary geophysical process – a volcanic eruption, maybe – brings it forth again.

We humans, however, are short-circuiting these accounts. When we burn fossil fuels, we withdraw carbon from the long-term banking account, then spew it out our smokestacks, depositing it in the short-term cycle, in the form of atmospheric CO2. This spending spree is one cause of global warming.

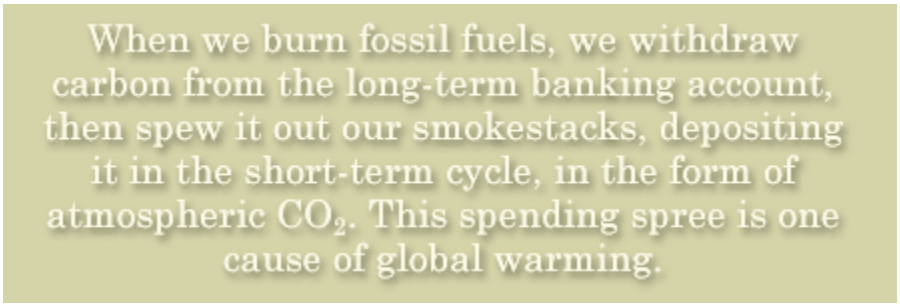
The first scientific paper on this problem was published in the late 19th century, but corroboration was a long time coming. Today, most scientists agree that too much carbon, deposited in the short term atmospheric account in the form of carbon dioxide, is throwing our world's climate out of kilter. As anyone who has ever managed household accounts knows, a little fudging between savings and checking probably won't do too much harm. But continue that strategy for too long and you're eventually going to have to pay the piper.

It appears we have been fudging nature's accounts for several hundred years now.

We've got to get the carbon out of the atmosphere.

Quickly.

We're in such a rush, in fact, that the world has recently devised a profit-driven financial market called "emissions trading." The intent of this brand-new market is ultimately to create carbon-dioxide-equivalent "certificates" that will circulate the world much the way the "legal tender" of American dollars do. The dollar bill "works" because it is backed by the American government, an institution which most people around the globe believe will continue to thrive. The hope is that CO2-equivalent certificates will work because they are backed by an international board that will, eventually, have the same kind of credibility.



Those supporting emissions trading – and there are many who don't, including a large number of climate scientists -- say the profit motive will inspire entrepreneurs to come up with ideas for capturing and banking carbon dioxide.

It turns out that lots of people have lots of ideas. And the promise of profits has inspired those people, including Russ George, to get right out into the marketplace with their products and see if they can build a business.

Says George: You can save the planet and make money too.

But will these ideas work?

Or, will they end up doing more harm than good?

"Iron fertilization is exactly the kind of project that points out how difficult it's going to be to create a trading system that really works," says Stanford University professor David Victor, author of "The Collapse of the Kyoto Protocol." "We're in the process of inventing money. Imagine how difficult it was back when the first monetary systems were invented. We're trying to figure out what is the currency, what's backing the currency and what is counterfeit script."

* * *

George and I sat down to a long and pleasant lunch.

He explained his thinking.

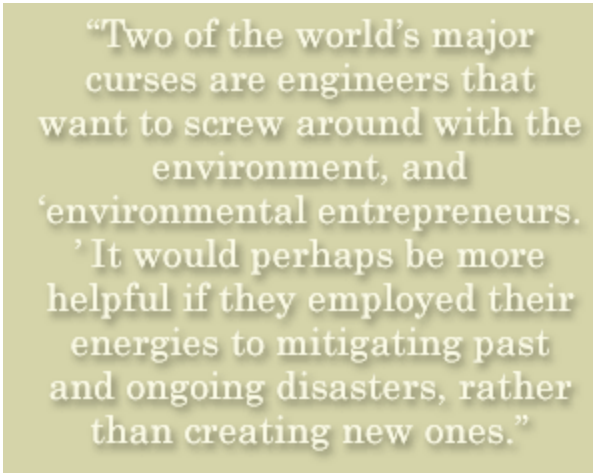
For a decade or so, scientists have been studying the ocean carbon cycles by scattering trace amounts of iron over small patches of open ocean. Oddly, they discovered that certain parts of the ocean are anemic. Some "less fertile" areas like the Southern Pacific have all the nutrients necessary for life to thrive – but iron. Scattering just a tiny hint of this missing element creates a phenomenon bordering on the miraculous. Where once, to the human eye, there was nothing – a bloom of single-celled plants suddenly appears. For the scientists who first discovered this, it must have been like waving a magic wand and making the desert bloom.

"When you add iron, everything changes," says oceanographer Richard Barber, one of the scientists involved in the first iron experiment. "All the groups of micro-organisms, all these taxonomic groups, have been shown to grow better in these ocean waters when iron is added. This is a total rewriting of what regulates growth in large portions of the ocean. As late as 1990, no textbook on biological oceanography would mention iron. Now every textbook which teaches high school oceanography has a big section

on the importance of iron.

"In one move, the view of how the ocean works has made a big leap….This is the single most significant piece of biological oceanographic research between 1950 and 2000."

As oceanographers researched this during 1990s, others thought about applying these findings to real-world problems. To grow, the ocean-surface plankton require a source of carbon, just as do land plants. That source is the atmosphere. Plants "inhale" carbon dioxide, photosynthesize the carbon into plant material, then exhale the oxygen.



Some scientists and engineers reasoned that this might be a good way to rid the atmosphere of extra carbon. If you could make the oceans bloom, they wondered, when the plant life died, wouldn't it sink to the bottom of the ocean, carrying away the extra carbon with it? Indeed, many scientists believe that oil and coal may derive from this process. And once the atmosphere was rid of its excess carbon (nearly twice what it was before the Industrial Revolution), wouldn't the world cool off?

Oceanographer John Martin first suggested this ultra-simple idea, perhaps somewhat playfully, almost as an advertising schtick, to help him get research money. "Give me half a tanker of iron," he boasted, "and I'll give you the next Ice Age." Whether he meant it seriously or not (no one knows, because he died soon after), the suggestion quickly found its way into the popular literature. Kim Stanley Robinson's wildly successful 1993 science fiction trilogy about geo-engineering and terraforming, Red Mars, Green Mars, Blue Mars, describes "the fertilization of the Antarctic Ocean with iron dust, which was to act as a dietary supplement to phytoplankton" as a cure for both global warming and dying coral reefs.

By the late 1990s, a number of entrepreneurs had made the inevitable connection between "iron fertilization" and the new profit-driven trading markets.

George told me at lunch that there's at least $180 billion a year out there available for carbon reduction technologies. He told me he wants some of that "money out there to mitigate global warming that's looking for a home." He told me that a forest of plankton is the same as a forest on land, that the vast majority of the ocean can act as a carbon sink, that much of the carbon in the plankton will actually sink to the bottom of the ocean and stay there – "a conservative number about what sinks is one-third" – and that the carbon banked in that long-term savings account "will not appear for at least a millennium. The ocean is a very secure place."

George also told me that he had been conducting his own research. During the summer of 2002, he said, his friend Neil Young had donated

his sailing schooner The Ragland which George and a team of researchers had used to test their hypothesis by actually putting iron into the ocean to see what happened. (A call to Young to find out about his interest went unanswered.)

As his source of iron, George bought bags of red ochre pigment from the Hoover Paint Company, which he trailed out behind The Ragland as it sailed along.

"It's a very simple experiment," he said. "It showed a bloom, which is what we wanted. We just wanted to see some effect."

"This trip," he also said, "removed the CO2 content from the atmosphere of about 3,000 households. This trip made the city of Half Moon Bay carbon-neutral for a year. We're still running on that bank account until next June."

"This year or early next year, we hope to run a project that will sequester about a million tons of carbon," he added, explaining that what he really wants to know is: "is this palatable in the carbon market place? And what price are they willing to pay?"

I asked to see his research papers. They weren't done yet.

"It's really more of a business experiment than a scientific experiment," he said.

* * *

To say that George has shocked and angered much of the scientific community is an understatement. Indeed I found many who were profoundly concerned by the increasingly popularized notion that scattering iron in the oceans could help solve global warming.

"This is madness. It's totally insane," says Canadian scientist Vaclav Smil, an expert in global nutrient cycling and author of "Enriching the Earth." "Why use something like that – when we can just drive a car that gets 45 miles per gallon. In science, you're looking for the elegant and simple solution. Well, that's it. I know that I cannot regret driving a car that gets twice as much per gallon." Smil, who has spent his life studying how humanity has changed natural cycles, says he's not surprised. "Hey, we're a dysfunctional society, so why shouldn't the nutrient cycles be dysfunctional, too."

Oceanographer Mark Lawrence, an American currently with the Max Plank Institute in Germany, explains: "phytoplankton produce gases which directly affect the climate and atmospheric chemistry. For instance, one gas known as dimethylsulfide ends up causing clouds to reflect more sunlight, which cools the oceans' surface, while other gases produced by phytoplankton can…affect other aspects of atmospheric chemistry."

Other scientists have completed work that points toward what is already obvious – if not iron, then some other nutrient will eventually be lacking. New Zealand researcher Tom Trull recently co-authored a paper that explained that, in the Southern Ocean, silicate may become a limiting factor. "In short," Trull wrote me in an e-mail, "it is not obvious that iron can stimulate carbon sequestration, and it is likely that it will lead to a different phytoplankton community than normally present (rather than just a faster growing normal community), the composition, properties and desirability of this new community is unknown." Sequestering carbon

in these parts of the global ocean via iron fertilization "would require significant ecosystem change," Trull's paper said.

MIT's Sallie "Penny" Chisholm, one of the world's top biological oceanographers, finds the idea of geo-engineering the earth's atmosphere through oceanic iron fertilization to be anathema. When two Mitsubishi scientists visited her lab in the summer of 2001 to discuss the idea, she delivered her "no-free-lunch" lecture. Iron fertilization just won't cut it, either scientifically or ecologically, she warned, adding that the best solution is simply to stop producing CO2.

Following that visit, Chisholm and colleagues Paul Falkowski of Rutgers and John Cullen of Canada's Dalhousie University, published a letter in the journal Science formally stating their scientific objections. Falkowski wrote a long article in Scientific American further explaining his caution. Chisholm's graduate students authored papers on the problem, available on the web.

Other scientists, watching from the sidelines, were equally put off by the idea. In one on-line discussion, Oklahoma State University botanist William Henley wrote that "large-scale ocean fertilization is a classic example of the traditionally favored 'end of the pipe' approach to environmental problems, as opposed to eliminating the source of the problem." University of Michigan algologist Eugene Stoermer was even more outspoken: "Two of the world's major curses," he wrote, "are engineers that want to screw around with the environment, and 'environmental entrepreneurs.' It would perhaps be more helpful if they employed their energies to mitigating past and ongoing disasters, rather than creating new ones."

A press release on the Planktos site, under the heading "New Era of Ocean Stewardship Unveiled by Planktos Foundation," touts "the work of the team of dedicated ocean scientists at The Planktos Foundation," but I didn't get to meet any scientists. I didn't see any evidence of on-going research, and I didn't receive any professional publications. I did get to see George pour some Hoover Paint pigment into Half Moon.

But perhaps the most significant statement comes from Duke University's Richard Barber. Barber had co-authored a paper with engineer Mike Markels in 2001 that proposed a 5,000 square mile "technology demonstration" in the equatorial Pacific. (Scientific studies using iron fertilization are generally small, about 50 square kilometers or so.) In that paper, Barber and Markels suggested that as much as 2 million tons of CO2 could be disappeared into the ocean depths in 20 days, perhaps at a cost of only $2 a ton.

At a time when some were claiming that carbon-control strategies could cost up to $300 a ton, this was truly Balm in Gilead to nervous corporate souls. Markels took out at least seven patents on iron fertilization strategies and set up a company now called GreenSea Ventures. Markels, whose company Versar founded in the 1960s is now fabulously successful

in both the field of environmental cleanup and the field of homeland defense, wanted to clean up atmospheric carbon, and, in a sort of two-for-the-price-of-one, feed fish with the extra phytoplankton to increase harvest numbers.

The 5,000-square-mile demo never did occur. Some say the Department of Energy feared the inevitable furor. So the GreenSea team turned to computer models. Dalhousie University oceanographer and computer modeler John Cullen finds that particularly frustrating. "We really don't have enough scientists to be working on all the problems. Is this how we want to be tying up four or five scientists who do this well?" he asks. "I don't feel that any of us, with confidence, can predict what's going to happen. It's the only ocean we have. Maybe the point is that we just shouldn't do it."

Damning with faint praise, Barber says today, after the latest research: "On the basis of the modeling that we have done, the model predictions suggest that this is not a method that will reduce atmospheric co2 very much, even if you did it on a massive scale."

A few scientists do say that, as we improve our understanding of marine ecosystems, iron fertilization may provide a small part of the total solution. Right now, says German expert Ulf Reibesell, we lack adequate knowledge of the ocean and "are therefore not able to reliably assess the risks possibly involved in iron fertilization. Nevertheless, in view of the serious risks we are presently taking with our global climate, I feel that considering iron fertilization as a possible means for purposeful co2 sequestration can not be entirely dismissed at this point."

* * *

Still, Russ George soldiers on. His website – www.planktos.com -- glitters with the kind of polish you would expect from a major multi-national. It tells the average visitor much more than he or she would ever want to know about the technical issues involved in climate change, and adds that by donating to the foundation, they can make their lives "carbon neutral." Flying to Australia? the website asks. "Buying Planktos Blue Green Tags at $4 a ton means you can tax yourself to save the planet $28 for your trip to Australia and fly guilt free."

Yet, despite the PR hoopla, the California Secretary of State does not have a registration on file for Planktos. Certification is "in process," says George.

A press release on the Planktos site, under the heading "New Era of Ocean Stewardship Unveiled by Planktos Foundation," touts "the work of the team of dedicated ocean scientists at The Planktos Foundation," but I didn't get to meet any scientists. I didn't see any evidence of on-going research, and I didn't receive any professional publications. I did get to see George pour some Hoover Paint pigment into Half Moon Bay.

In the overall scheme of things, how important is a hopeful entrepreneur like Russ George? As an individual, one can only hope that he eventually finds his way through this 21st century world. He's able to raise a lot of publicity, but whether he's able to raise actual money is another issue. He claims to be supported by "energy companies," but I didn't get specifics about that or any other financial backing.

But some people worry that George represents a trend. Jutta Kill of the World Rainforest Movement says that, all around the globe, the promise of quick money is inspiring a number of more-than-questionable business

ventures. In some cases, she says, the money is financing harmful projects. "Strong manipulation of an ecosystem is bound to bring about side-effects," she says. "The carbon-accounting framework…leaves so much room for creative book-keeping. If you liked Enron – you'll love Carbon Accounting."

GreenSea Venture, the company started by Markels, remains very focused on iron fertilization as a sequestration strategy. When it comes to money, GreenSea seems to have plenty. One member of the venture, Konrad "Chip" Kruger, was a financial high-flier during the 1990s, until his Connecticut-based company, Greenwich Capital, was bought by a UK bank in 1996.

GreenSea is funding a number of the nation's oceanic modelers to look more closely at the question, but they go to great pains to separate themselves from Russ George. "He's having fun," says Markels. "But what he's doing has nothing to do with the science and engineering of what we're trying to do."

GreenSea president Lee Rice says that the company continues to believe "in the long term that iron fertilization is going to be an extremely valuable technology for controlling atmospheric carbon." However, the company will, Rice promises, stick with modeling for the time being. "We're getting opposition from scientists, but we will argue that they don't have the data that really says that their position is sound either….But linking us with Russ George and saying we are out promoting this at this point in time is just fundamentally wrong. The idea has merit. If the science proves it has merit – then we would try to promote it. But we're not promoting something that is unproven scientifically."

Nevertheless, as Penny Chisholm moaned 15 months ago: This is an idea that just won't go away. The federal Department of Energy, recently provided with $90 million in carbon sequestration research, continues to seek proposals to study iron fertilization as a carbon dioxide amelioration strategy. Japan, a major emitter of carbon dioxide and a signer to the Kyoto Protocol, is desperate to find inexpensive ways to lessen their emission burden. Along with several other nations, Japan performed iron fertilization experiments in the Alaskan Gulf. While most nations now performing these experiments say their goal is pure research, Japan clearly states its hope for eventual application toward carbon mitigation. Click here to listen to this story.

Related Links

– UNESCO - Capturing Carbon?
– Southern Ocean Iron Fertilization Experiment (SOFeX)
– The basics of the most recent expedition
– Penny Chisholm's site, which lists many professional papers
– Paul Falkowski's article (PDF document)
– DOE article: *Climate Change Scenarios Compel Studies of Ocean Carbon Storage*
– Government site for carbon sequestration research
– An earlier piece Williams wrote on sequestration
– *Will Ocean Fertilization To Remove Carbon Dioxide from the Atmosphere Work?* (rerences to most recent science paper)

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