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Gambling with Gaia

With hopes for Kyoto dimming, some governments may conclude that massive earth restructuring is the only feasible way out

Issue: Kyoto is fading and carbon trading is a farce. Recognizing this, OECD states can either "bite the bullet" and adopt socially-responsible policies to dramatically cut fossil fuel use and useless consumption or, they can hope for a "silver bullet" – some new techno-fix that might let them have their cake and eat it too. The silver bullet may be winning. At the UN's Intergovernmental Panel on Climate Change, the US government is lobbying for "geoengineering" activities such as deliberately polluting the stratosphere to deflect sunlight and lower temperatures.[1] At least 9 national governments and the European Union have supported experiments to spread iron filings on the ocean surface to nurture plankton and sequester carbon dioxide. At least a dozen additional countries are involved in stratospheric weather/climate modification. Commercial carbon traders are engaging in ocean fertilization as well. The scientific debate and the government/commercial experimentation is taking place, once again, in the absence of public discussion.

Impact: The "proof of principle" that we can indeed geoengineer the earth's climate is beyond dispute. That's why we have climate change. However, the notion that we can successfully correct our unintentional destructiveness with intentional geoengineering seems ludicrous. For the governments who caused the problem to experiment together on geoengineering solutions – outside the UN and without the participation of the South who bear the brunt of global warming and would likely bear the risks of geoengineering – is a grave miscalculation.

Fora: In 1978, at the request of the USA and USSR, the UN General Assembly adopted the Environmental Modification Convention (ENMOD) prohibiting governments from using weather or climate as a weapon against other states. The UN General assembly must reopen debate on its 1978 Treaty in the light of new technologies and new private and public initiatives underway around the world aimed at restructuring the stratosphere and/or the oceans to the advantage of some governments and the disadvantage of others. Other UN agencies dealing with the impact of climate change must also address this issue. This includes the Intergovernmental Panel on Climate Change (IPCC), UN Environment Programme (UNEP), UN Convention on Biological Diversity (CBD) and the UN Food and Agriculture Organization (FAO).

Policies: The United Nations must reaffirm (and, if necessary, expand) the Environmental Modification Treaty recognizing that any unilateral modification of weather or climate is a threat to neighboring countries and, very likely, the entire international community. Experimentation that could alter the structure of the oceans or the stratosphere should not proceed without public consent and UN authorization. The IPCC should revisit the concept and practice of carbon trading and replace this market-based "solution" with direct measurable standards for CO_2 emission reduction at source. OECD states must redouble their efforts to reduce their consumption of fossil fuels and to curtail other wasteful practices that contribute to global warming. The issue of geoengineering and its far-reaching social, ethical and political implications should be on the agenda of the UN Framework Convention on Climate Change, 3-14 December 2007 in Bali, and the World Meteorological Organization's 15th Congress in May 2007.

"Let's quit the debate about whether greenhouse gases are caused by mankind or by natural causes; let's just focus on technologies that deal with the issue." – US President George W. Bush, May 25, 2006[2]

In 1975, the US Central Intelligence Agency (CIA) and *Newsweek* magazine joined forces to warn of "the Cooling World"[3] – the same year that British scientists confirmed a hole over the ozone layer above Antarctica and, coincidentally, the year that the Soviet Union and the United States submitted identical draft treaties to the UN General Assembly prohibiting climate modification as a military weapon.[4]

What does geoengineering and climate change have to do with agricultural biodiversity and small-scale farmers in the South?

Everything. Some leading crop scientists fear that a sudden "tipping" in global temperatures could foment a crisis in which breeders would scavenge through the best-characterized gene banks searching for heat-tolerant genes to be engineered into the top commercial crops in the major growing zones. In the urgency, the precautionary principle would be abandoned and genetically-modified crops would proliferate. Claiming concern for contamination, companies will insist on using Terminator (sterile seed) technology. Global food security will depend on a handful of agribusinesses. The world's 1.4 billion people who depend on farmer-saved seed – most of whom farm on marginal lands – will be left to fend for themselves and will (ultimately) be driven off their land. Although these farmers are custodians of enormous crop genetic diversity, the scenario argues, that diversity is temperature sensitive and might prove useless if temperatures surge unexpectedly. We disagree. Genetic diversity and farmer seed exchanges – up and down the mountainside, across latitudes, and between ecosystems – is the answer – and community-based, farmer-led breeding programmes will be the front-line defense, as always, for insuring food sovereignty everywhere. ETC Group examines the issue in a forthcoming report.

Thirty years later, everybody – including the US president – was talking about Global Warming; scientists warned that the temperature rise on the Arctic ice cap and on Siberian permafrost could "tip" Planet Earth into an environmental tailspin; and, the US Congress agreed to study a bill that would establish a national weather modification research programme.

In 2006 George W. Bush proposed that a technological silver bullet will help us (or, the US) out of the current eco-quagmire. That silver bullet is most commonly known as geoengineering – the intentional and directed manipulation of the earth and its ecosystems. Geoengineering includes a wide range of schemes: blasting particles of sulfur into the stratosphere to shield us from the sun's rays; dumping iron particles in the oceans to nurture CO_2-absorbing plankton and blasting clouds with chemicals to nudge them into producing rain. University of Calgary physicist, David Keith, refers to geoengineering as "an expedient solution that uses additional technology to counteract unwanted effects without eliminating their root cause."[5]

Geoengineering – Intentional, large-scale manipulation of the environment by humans to bring about environmental change, particularly to counteract the undesired side effects of other human activities.[6]

There are, of course, human-made threats to the environment. We are, by no means, finished with the fallout from our first chemical adventure, for example. Despite the rekindled public concern that arose with the sudden failure of Sweden's Forsmark nuclear power plant in July, 2006,[7] nuclear power is making a comeback and at least some in the environmental movement are likely to accept nuclear energy as the only "politically-realistic" alternative to fossil fuels.

In this *Communiqué*, ETC Group surveys some of the geoengineering approaches gaining legitimacy among policymakers and scientists. With the impacts of climate change becoming more evident every day and the need for action more urgent, it's likely that rich, panicky governments will gamble on quick-fixes rather than risk inconveniencing their electorate and/or offending industry. As ludicrous as geoengineering may sound (and turn out to be), governments around the world are aware that some action must be taken quickly. They're also aware that carbon-trading schemes won't put a dent in climate change. Geoengineering warrants serious debate and preemptive action.

Proof of principle: Is geoengineering realistic? Unfortunately, humanity has already proven massive earth restructuring to be wonderfully operational. Fill enough wetlands and introduce crop monocultures in enough fields and the ecosystem changes. Cut down enough forests and the climate changes. Build up sufficient industrial pollution and the ozone disappears and the smog rolls in. Geoengineering's "proof of principle" is manifest!

Geoengineering – a brief history:

Stratospheric silver-linings: It has taken us some time to realize the influence we can wield over the planet. Back in 1930, Robert Millikan – physicist and Nobel laureate – insisted there was no danger that human activity could do lasting harm to anything as powerful as earth.[8] Even as he was speaking, chemists were inventing CFCs – chlorofluorocarbons – the chemical cocktail responsible for thinning stratospheric ozone at an alarming rate, whose use eventually led to intergovernmental action in the mid-1980s: the Vienna and Montréal Accords phased out the production of CFCs.

Likewise, the notion of a technological fix for global warming isn't new either. In the 1940s, Bernard Vonnegut (the novelist Kurt Vonnegut's brother) – a well-respected meteorologist – discovered that silver iodide smoke could cause clouds to give up their rain.[9] His discovery kick-started serious government efforts to manipulate the environment. Until then, cloud-seeding had been the preserve of crackpots and con artists, but by 1951, 10% of the US was under clouds that had been commercially seeded.[10]
Governments and industry have a sometimes ignoble history tampering with the weather, including the CIA's top secret "Project Popeye" rainmaking campaign that began in 1966 and ran for seven years and 2300 cloud seeding missions over the Ho Chi Minh Trail during the Vietnam War.[11] The goal was to make the trail impassible and, as a bonus, to drown out North Vietnam's rice crop. While rains did increase, the Air Force couldn't establish a clear link to its covert campaign.

Making rain has always been a tricky proposition. In 1952, flash flooding in Lynmouth in southwest Britain killed 34 people and was attributed (perhaps mistakenly) to clandestine Royal Air Force experiments at rainmaking.[12] As the UN Conference on the Human Environment was convening in Stockholm in 1972, a cloudburst drowned 238 people in Rapid City, South Dakota, USA on a day when seeding experiments were going on nearby.[13] Over time, the public has built up a healthy distrust of both public and private efforts to inject our clouds with artificial silver linings.

Recently, more convincing experiments have focused on "hygroscopic cloud seeding" – that is, warm-cloud seeding, as opposed to cold-cloud seeding (glaciogenic). Results from experiments at the South African National Precipitation and Rainfall Enhancement Programme earned researchers there the United Arab Emirates' 2005 Prize for Excellence in Advancing the Science and Practice of Weather Modification. Other warm-cloud seeding projects have taken place in the USA, Thailand, China, India, Australia, Israel, South Africa, Russia, United Arab Emirates and Mexico.[14] According to the UN's World Meteorological Organization (WMO), at least 26 governments were routinely conducting weather-altering experiments in 2000.[15] By 2003-2004, only 16 WMO member countries reported weather modification activities, although weather modification activities are known to have taken place in many additional countries (see map).

Many of the world's military powers remain fascinated with weather control. A US Air Force

report entitled *Weather as a Force Multiplier: Owning the weather in 2025* concluded that the weather "can provide battlespace dominance to a degree never before imagined," including the ability to thwart an enemy's operations by enhancing a storm or by inducing drought and making fresh water scarce.[16] In 2004, two Chinese cities in Henan province – Pingdingshan and Zhoukou – came close to fighting when they both tried to alter local weather patterns by blasting tiny silver iodide particles into the troposphere (the lowest portion of Earth's atmosphere).[17] The city downwind accused the city upwind of stealing its weather. This hasn't deterred the Chinese government from promising the International Olympic Committee that China will use weather modification to guarantee sunny days for the 2008 Beijing Olympics. If so, they'd better check with the King of Thailand, who – in 2006 – was granted two patents covering rainmaking processes.[18] It would be a shame if a patent dispute rained on the Olympic parade!

Geopolitical engineering (without Borders)

Lessons learned? The history of weather modification – both for economic and military purposes – is unquestionably spotty. Will governments do any better responding to climate change? Governments did act responsibly (though some would argue, belatedly) on ozone depletion and phased out CFCs under the Montréal Protocol of 1987.[19]

There was no real alternative because the hole in the ozone layer was directly traced to CFCs and the impact led directly to skin cancer on the beaches where rich people holiday. Confronted with the ozone hole, neither industry nor governments could come up with a quick alternative strategy to banning CFCs.

The causes and implications of climate change are much more complex and there are still many politicians and pundits seeking an up-side. In the years since the 1974 discovery of the ozone hole, voters in OECD countries, at least, have been "dumbed-down" and conditioned by corporations and politicians to believe that an effective response to climate change can be achieved painlessly. Today, industry and governments will not just confuse the issue, but point to a technological fix which, they hope, will safeguard the *status quo* of the wealthy.

The Guardian recently reported, for example, that the US is unhappy with the draft of a major 3-part report being prepared by the Intergovernmental Panel on Climate Change (IPCC).[20] The US doesn't care for the report's "focus on the negative effects" of climate change or its rejection of voluntary agreements and is pushing for techno-fix strategies to be given a prominent place in the final report's recommendations.[21]

Another strategy of the emissions-reduction deniers is to focus on improved efficiency. Clyde Prestowitz, for example, a much-published corporate cheerleader, enthuses that US motorists now get twice as much out of a barrel of oil than they did in 1975. Using the latest technologies, Prestowitz asserts, the US could double oil efficiency once more.[22] It takes 33% less energy to produce a unit of GDP in wealthy economies today than it did in the mid-70s.[23] The world wastes 2.3 billion gallons of gas yearly just in traffic jams.[24] We don't need to change our lifestyle – just improve our efficiency. No need to think about cutting consumption or conserving – we can always count on new technologies. Bring on the SUVs! Not to worry that humanity may have consumed more natural resources since World War II than in all the years before.[25] Nor that world energy demand – despite much-publicized potential improvements in efficiency – is forecast to jump 60%, from 2002 to 2030, and to require about $568 billion in new investments every year.[26]

So, if governments aren't prepared to ask their citizens to change their lifestyles, is geoengineering a real option? The concept is rapidly gaining ground.

TABLE 1: Proof of principle: Geoengineering past & present

Ten *old* ways to geoengineer the planet:

- ✓ Cut down most of the world's forests;
- ✓ Convert savannas and marginal land into monoculture cropland;
- ✓ Dam watersheds, divert rivers, dry-up wetlands and drain aquifers;
- ✓ Pump billions of tonnes of industrial pollutants, car exhaust and other toxic chemicals into the stratosphere and soil every year;
- ✓ Wipe out species and genetic diversity in livestock & crops;
- ✓ Overuse marginal lands leading to soil erosion and desertification;
- ✓ Erode the world's major ecosystems;
- ✓ Deplete – possibly beyond recall – most commercial marine species;
- ✓ Condemn half of the world's coral reefs to extinction;
- ✓ Pollute almost all of the world's fresh water reserve.

Ten *new* ways to geoengineer the planet:

- Create vast monoculture tree plantations for biofuels & CO_2 sequestration;
- Proliferate nuclear power plants;
- Contaminate Centres of Genetic Diversity with DNA from genetically engineered crops;
- **"Fertilize" the ocean with iron nanoparticles to increase phytoplankton blooms that sequester CO_2**;[27]
- Build 16 trillion space sunshades to deflect sunlight 1.5 million km from Earth;[28]
- Launch 5,000-30,000 ships with turbines to propel salt spray to whiten clouds to deflect sunlight.;[29]
- Store compressed CO_2 in abandoned mines and active oil wells;[30]
- **Biannually, blast sulfate-based aerosols into the stratosphere to deflect sunlight**;[31]
- Cover deserts with reflective film to repel sunlight.

Geoengineering – in real time:

Recent support for geoengineering has come from both scientific and political circles. The current debate over the possibility of engineering the stratosphere can be traced to a 1997 paper by the late Dr. Edward Teller – the Nobel laureate responsible for the hydrogen bomb, and one of the most politically influential US scientists in the latter half of the 20th century. Teller lent his support to geoengineering when he and two colleagues presented to the 22nd International Seminar on Planetary Emergencies in Erice, Sicily.[32] While the authors did not present their views as being endorsed by the US government, their work was conducted at the Lawrence Livermore National Laboratory, under contract with the US Department of Energy. In the late 1950s, Teller had attacked what he regarded as the unfounded public paranoia that prevented him from using nuclear devices on hydroelectric projects and mining schemes in the United States. Even so, the scientist's willingness to take on earth restructuring sent a shockwave through the climate change community.

Teller might have been dismissed as a scientist past his prime except that another Nobel laureate, Paul J. Crutzen – who won his Nobel prize for pioneering work on the ozone layer – amplified the scientific shockwave in 2002, when he offered grudging support for geoengineering in *Nature*: "Our future," the Dutch scientist wrote, "may well involve internationally accepted, large-scale geoengineering projects."[33]

Then, the following year Andrew Marshall, the long-time Pentagon insider who, along with Teller, helped develop and lobbied heavily for the "Star Wars" missile defense scheme, commissioned a former Royal Dutch/Shell planning chief and an Emeryville, CA scenario designer to design strategic government responses to a shift in the Gulf Stream running alongside the Sargasso Sea.[34] Among their seven recommendations: geoengineering to suppress climate change and to prevent the current's shift further offshore.[35] That same year, the US National Academy of Sciences released a report calling on Washington to launch a coordinated national research programme in weather modification.[36]

Paul Crutzen returned to the debate, stirring up a real tempest in a teapot in August 2006 when he wrote an "editorial essay" in *Climatic Change* magazine calling for active research into the use of "sub-micrometer"-sized sulfate-based aerosols to reflect sunlight in the stratosphere in order to cool the earth.[37] Crutzen, a professor at the Max-Planck-Institute for Chemistry in Mainz, Germany, opines that high-altitude balloons and artillery cannons could be used to blast sulfur dioxide into the stratosphere, in effect, simulating a volcanic eruption. The sulfur dioxide would convert to sulfate particles. The cost, he reckons, would run between $25 and $50 billion per year – a figure he argues is well below the trillion dollars spent annually by the world's governments on defense. Crutzen notes that the cost doesn't include the human cost of a half-million premature deaths from particulate pollution. Such tiny reflective particles could be resident in the air for two years. Crutzen willingly acknowledges that this is a risky proposition and insists that it should be undertaken only if all else fails. He goes on to add that the political will to do anything else seems to have failed already.

Crutzen's views have made him extremely controversial among scientists. However, an editorial in the same issue of *Climatic Change* by Ralph J. Cicerone, an atmospheric chemist and president of the US National Academy of Sciences, supports further research on Crutzen's geoengineering proposals. He told the *New York Times* in mid-2006: "We should treat these ideas like any other research and get into the mind-set of taking them seriously."[38]

Earlier in the year, Cicerone invited Roger P. Angel, a well-established astronomer at the University of Arizona, to speak to the Academy's annual meeting. Dr. Angel has a plan to put trillions of lenses – each about 2 feet wide but wafer thin – into orbit to deflect sunlight.[39]

Between Cicerone's backing and Paul Crutzen's essay, it has suddenly become politically-correct to talk about geoengineering as a legitimate response to climate change: a credibility shift that the *New York Times* called a "major reversal."[40]

Sky change – the downside: What goes up still (usually) comes down. Be it silver iodide, sulfur or salt spray, the tonnes of particles that would need to be regularly blasted into the stratosphere will find their way back to earth again. All the issues related to environmental health and safety associated with particulate pollution, including novel manufactured nanoparticles, remain relevant for these intentional polluting schemes. Climate change experts insist that we should distinguish between unintended pollution and climate modification schemes that pump particulate matter into the air we breathe, but our lungs won't know the difference.[41] According to the World Health Organization, more than 4.5 million people die each year from industrial and vehicle emissions and from burning fuels indoors.[42] Geoengineering the stratosphere makes it easier for industry to continue atmospheric pollution but compounds the potential problem by intentionally contributing massively to particle pollution.

Sea-change: From Sulfur Curtains to Iron Carpets

Seeding the seven seas: Not only are there serious proposals on the table to restructure the stratosphere, governments and industry are also contemplating major modifications to the ocean surface. Since 1993, there have been at least ten documented government and/or private experiments to "seed" sections of the ocean's surface to demonstrate the feasibility of iron fertilization for sequestering carbon and

countering global warming. Additional ocean fertilization experiments are on the drawing board for 2007.

In October 1993 – a year after the Rio Earth Summit – a US-led expedition (dubbed IRONEX I) carpeted a 64 sq. km patch of ocean with iron particles. The location was the eastern equatorial Pacific about 500 km south of Ecuador's Galapagos Islands.[43] The project was funded by the US Office of Naval Research and the US National Science Foundation and involved nine US research institutions as well as two British universities. The experiment resulted in a doubling of plant biomass, a tripling of chlorophyll and a quadrupling in plant production.[44] The researchers emphasized that their experiments "are not intended as preliminary steps to climate manipulation."[45]

IRONEX I's effect on the carbon cycle was unclear. Some researchers feared that the take-up of carbon dioxide would be temporary and the CO_2 will still eventually wind up in the atmosphere – just a little later. Additional tests were called for.

A second experiment (IRONEX II) took place about 1200 km southwest of the Galapagos during May-June 1995.[46] Funding came from three countries: Britain, Mexico and the United States with the majority of resources provided, again, by the US government – the National Science Foundation (NSF) and the US Office of Naval Research. Seven institutes, including Mexico's CICESE Oceanografia Fisica (Centro de Investigación Científica y Educación Superior de Ensenada), and the UK Natural Environment Research Council participated.[47] The effect on carbon sequestration was, again, inconclusive. The iron particle spray caused a massive phytoplankton bloom that absorbed carbon dioxide but researchers were still unconvinced that the absorption would sequester CO_2 or prevent CO_2 from being dumped back into the atmosphere after the research vessels went home.

Under the name SOIREE (Southern Ocean Iron Release Experiment Expedition), New Zealand, Australia, Canada, the UK, Germany and the Netherlands joined the USA in a February, 1999 expedition below New Zealand.[48] Additional funding came from the European Union's CARUSO (Carbon Dioxide Uptake Southern Ocean) project and two private companies (in the UK and Australia) also got into the act. Iron filings were distributed over a 50 sq. km region but, six weeks later, NASA satellites showed that a phytoplankton bloom had spread beyond the original seeding zone to cover over 1100 km of ocean. The amount of plankton inside the zone was 10 times that outside the zone. According to the report, there was no measurable removal of carbon from surface to deeper waters. The results of the SOIREE expedition do not support the use of ocean fertilization as a way of preventing climate change, but the experiment did conclude that "large-scale fertilization would be likely to cause substantial changes to the naturally occurring ecosystems of this pristine environment."[49]

Seeding the Seas – Why Iron Fertilization?

Oceans play a key role in regulating the world's climate. Despite their minute size, phytoplankton (microorganisms that dwell on the surface of the ocean) collectively account for half of the carbon dioxide absorbed annually from the Earth's atmosphere by plants.[50] Through the process of photosynthesis, plankton capture carbon and sunlight for growth, releasing oxygen into the atmosphere.

Phytoplankton productivity in the world's oceans is declining as a result of climate change and warmer temperatures. The amount of iron that is naturally deposited from atmospheric dust clouds into the global oceans (providing nutrients for phytoplankton) has also decreased dramatically in recent decades. According to NASA satellite data, as water temperatures increased from 1999 to 2004, the ocean's microscopic plant life dropped significantly. Oceans around the equator in the Pacific saw as much as a 50 percent drop in phytoplankton production.[51] Advocates of iron fertilization schemes believe that iron is the missing nutrient that will restore phytoplankton and sequester two to three billion extra tonnes of carbon dioxide every year – roughly one-third to one-half of global industry and automobile emissions.[52] Some regions of the ocean (especially near the Arctic and Antarctic circles) are nutrient-rich but anemic – they lack sufficient iron to stimulate plankton growth. With the addition of iron in these anemic but otherwise healthy zones – known as high-nitrate, low-chlorophyll (HNLC) zones – scientists hope to increase the plankton absorption of CO_2.

Despite the absence of carbon sequestration success, the experiments continued. In November 2000, another experiment (dubbed EisenEx) took place in the waters off Cape Town South Africa.[53] Funded primarily by the German Ministry of Research and Technology, along with the European Union, the Netherlands and the UK, scientists from 15 different countries joined the cruise. The experiment showed that the seeding of iron could produce a quadrupling of biomass within three weeks, but the team didn't assess what happens after the bloom was created.

Another experiment – this one, regarded by its financiers (but not all scientists) as successful – took place in July 2001 in the western Pacific, northeast of Japan.[54] The expedition (known as SEEDS – Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study) was mostly funded by Japan's Global Environmental Research Fund with some Canadian support. A second SEEDS iron fertilization experiment was held in the eastern subarctic North Pacific in summer 2004. Another Antarctic/Southern Ocean experiment (SOFeX – Southern Ocean Iron Experiment) was conducted during January-February 2002 involving a large number of US universities and institutes and bankrolled by the US NSF and Department of Energy.[55] The expedition dumped almost three tonnes of iron particles from the Scripps Institution of Oceanography research vessel.[56]

The results of this experiment worried many. Dr. Kenneth Coale, chief scientist on the expedition and director of the Moss Landing Marine Laboratories in California, told the science press at the time that iron fertilization could theoretically sterilize portions of the Pacific.[57] Researchers recalled the "optimistic" words of the late John Martin, former director at Moss Landing, who first articulated the "iron hypothesis" and in 1991, famously enthused that if he had a half-tanker of iron he could create a new Ice Age.[58]

A few months later, during July-August 2002, yet another iron fertilization expedition struck out for the Gulf of Alaska – SERIES (Subarctic Ecosystem Response to Iron Enrichment Study).[59] Among the countries involved: Canada (four universities), New Zealand, China and Japan.

With so many attempts and inconclusive results, one would expect governments to move on. Not this hardy band of mariners. In February-March 2004, Europeans sponsored another iron experiment in a patch of sea about 2200 kilometers southwest of Cape Town. EIFEX (European Iron Fertilisation Experiment) included 53 scientists from 14 institutions and three companies from seven European countries and South Africa. Over a nine-week period seven tonnes of iron sulfate were spewed over a 150 sq. km. patch. The Alfred Wegener Institute of Bremerhaven, Germany, which coordinated the exercise, couldn't determine how much phytoplankton actually sank to the deep ocean, but speculated that increased blooms might boost the food supply of the ocean's much-beleaguered whales.[60]

Carbon Traitors?

Ocean scientists contacted by ETC Group – even those who have participated in iron fertilization studies in the past – reject large-scale iron seeding as a means to combat climate change, and they are distancing themselves from commercial iron dumping ventures that aim to make money from the carbon market. If iron fertilization of the ocean can suck up carbon dioxide on a massive scale there will be money in it for carbon traders. Carbon trading allows companies or individuals to buy the rights to pollute (i.e., carbon credits) by investing in projects that are deemed by "experts" to reduce emissions of carbon dioxide.

GreenSea Ventures Inc. conducted two early experiments on iron fertilization in the Gulf of Mexico, first in January and again in May 1998.[61] On its website, the company indicates that the next step is to conduct a large-scale experiment: "In the test, a selected ocean area of about 5,000 square miles would be fertilized with iron and the results, principally the transport of carbon to the deep ocean, studied in detail."[62] GreenSea estimates that a 5,000 sq. mile application over one month would sequester 100,000-200,000 tonnes CO_2 equivalent – roughly equivalent to what a 1000-acre forest would sequester over a period of 40 years.[63] There is no indication when the company plans to conduct its large-scale experiment. Michael Markels, a board member of GreenSea Ventures, holds at least five

patents and patent applications related to iron fertilization for sequestering CO_2 (see patent table).

California-based **Planktos** is a self-described "ecorestoration firm," created to sell carbon credits to CO_2 polluters by sequestering greenhouse gases.[64] The company already sells voluntary carbon credits to individuals who want to shrink their carbon footprint by buying "ecosystem restoration credits." (See box: *Carbon Offsets: Forgiving the Sin of Emission*.) Planktos plans to conduct its first "commercial pilot" for iron fertilization in the Pacific (either near Hawaii or French Polynesia) beginning in March or April 2007.[65] The company aims to "bring home data that will verify permanent sequestration of CO_2 in the deep ocean."[66] Planktos claims that as a result of iron fertilization, CO_2 via phytoplankton is dragged down to the ocean floor where it remains "permanently" (they use quotation marks as a soft disclaimer), thus reducing greenhouse gases. Planktos also claims that it will use nano-scale particles of iron: "the particles are so small that the sink rate is measured in weeks and months as opposed to minutes."[67] This is alarming because scientists have warned that environmental release of nanoparticles should be prohibited until more is known about their health and environmental impacts.[68]

While the company claims that it "is supported by a renowned fellowship of international ocean science authorities and institutions,"[69] the company's scientific credentials have been previously called into question[70] and several scientists contacted by ETC Group denied collaboration with Planktos.

San Francisco-based, **Climos**, a new company that aims "to leverage natural processes to reduce greenhouse gasses," will reportedly work on ocean fertilization for controlling atmospheric carbon.[71] Climos is headed by Dan Whaley, a Silicon Valley entrepreneur who founded an Internet company that was sold in 2000 for $750 million. In December 2006 the company announced that Dr. Margaret Leinen will join Climos as Chief Science Officer. Leinen is former Assistant Director for Geosciences at the US National Science Foundation.

As The Corner House's Larry Lohmann describes in *Carbon Trading*,[72] sequestering can be a profitable game of soot and mirrors. Those involved in iron fertilization, for example, optimistically predict annual returns of €75 billion assuming a sequestration cost of about €5 euros per tonne and a carbon trading price of perhaps €25 per tonne.[73] But even if iron seeding induces blooms that transfer CO_2 from the atmosphere to the deep sea, there is no scientific basis for arguing that it will stay there permanently.[74] Some scientists assert that the CO_2 reservoirs will eventually be re-exposed.[75] But companies serving the carbon market need only keep CO_2 out of sight long enough to cash their cheques. If the CO_2 pops back up to the surface in a year or five, proving its source could be extremely difficult.

Critics of industrial-scale iron fertilization schemes point out that "the oceans' food webs and biogeochemical cycles would be altered in unintended ways."[76] Others note that iron may not be the ocean's only nutrient "deficiency" – researchers have identified silicate as a crucial component in carbon export, for example – but each "correction" to ocean water composition could have unintended effects. According to US and Canadian scientists writing in the journal *Science*, if carbon trading schemes make it profitable for companies to engage in ocean fertilization, "the cumulative effects of many such implementations would result in large-scale consequences – a classic 'tragedy of the commons.'"[77]

Mark Lawrence of Max-Planck-Institute (Germany) adds that large-scale iron fertilization could have unintended atmospheric and climatic impacts – including ozone depletion and intensified ultraviolet levels on the Earth's surface.[78]

> *"It's really more of a business experiment than a scientific experiment."* – Russ George, CEO, Planktos, Inc., describing his company's ocean fertilization activities to journalist Wendy Williams.[79]

Carbon Offsets: Forgiving the Sin of Emission
Indulgences for the 21st Century?

According to the *Catholic Encyclopedia*, an indulgence is "a remission of the temporal punishment due to sin." It goes like this: The sinner sins. God, exercising infinite wisdom and/or compassion, may choose to forgive the sinner, but even Divine forgiveness doesn't take away the need for the sin to be punished. "Good works" on the part of the sinner – including prayer, donating money to the Church or reading scriptures – however, can secure the sinner an *indulgence*, which takes away the consequences of the sin (i.e., the punishment that would have been meted out otherwise).

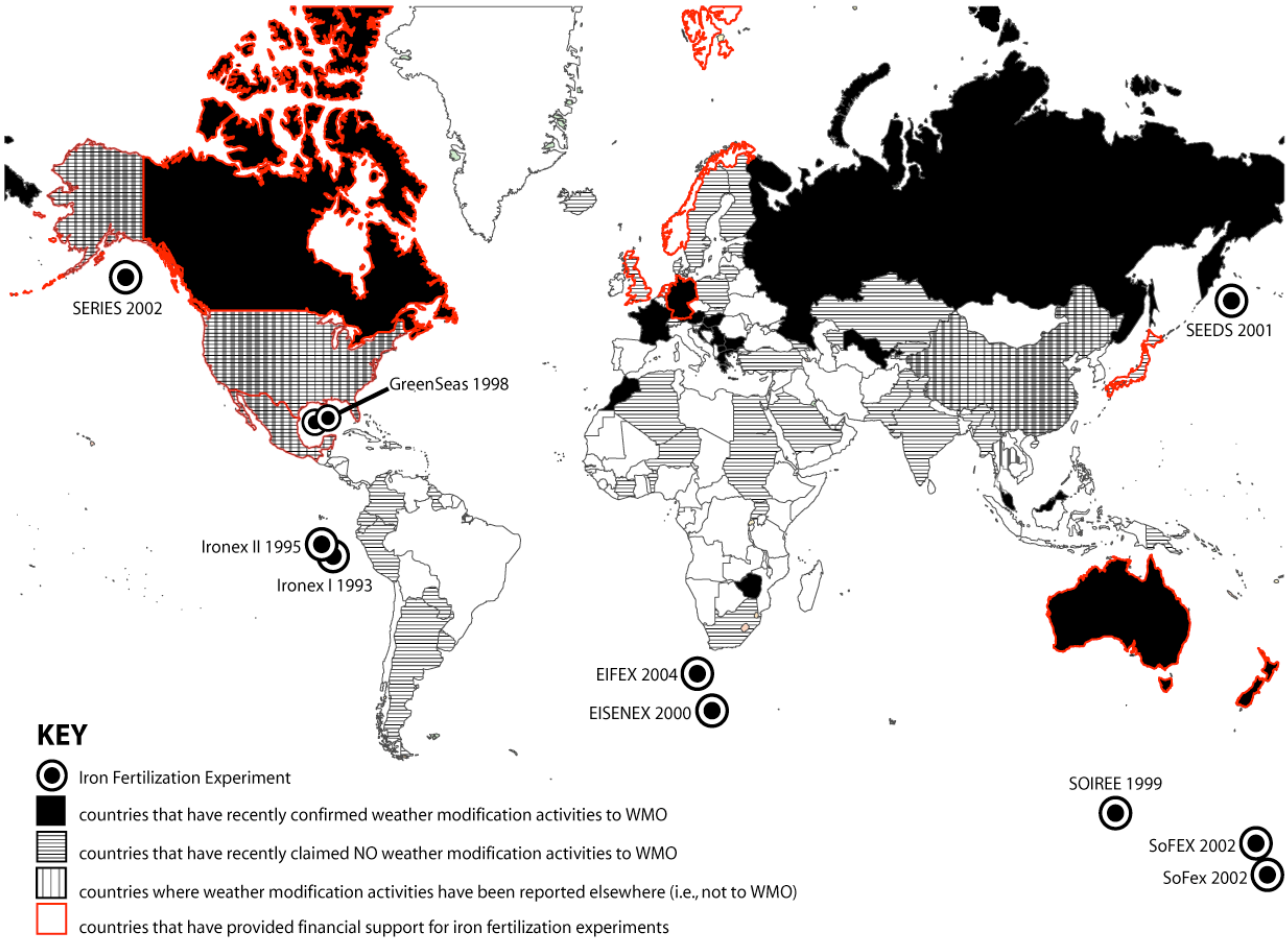
The carbon market – including the voluntary carbon marketplace, where there is no regulatory requirement to reduce emissions – offers a similar reprieve to businesses and individuals who've committed the sin of greenhouse gas emissions, provided, again, that "good works" are performed. Good works can take the form of writing checks to private companies that, in their infinite wisdom, have been graced with the power to "offset" the sin of emission. Planktos, headquartered in Forest City, CA, for example, claims it can zero out the emissions from a short commuter flight or a longer, international flight for $5 and $20, respectively. If your soul is troubled by the emissions from your gas-guzzling SUV, just give Planktos 50 bucks and they'll get Mother Nature to call it even. If you're already leading an environmentally pious life, you can pay Planktos to act as intercessor on behalf of friends and family: For a fee, Planktos will "carbon neutralize" your friends and family. (See the "Eco-Restoration Store" at http://www.planktos.com/content/view/90/67/lang,en/)

Planktos is one of several companies whose carbon-sequestering specialty is fertilizing the ocean with iron. As yet, there is no scientific consensus that iron fertilization is a long-term solution to CO_2-release, that it is safe for the environment or that the amount of permanently captured carbon can be accurately measured. Nonetheless, the details of every Planktos carbon-offset project is "carefully accounted for in a master ledger" so that the numbers can one day be verified through audit (will St. Peter serve as auditor?).[80] While the Church insists that it cannot forgive a sin (only God has that power), it can take away the punishment for a sin through indulgences. Carbon offset companies may find themselves in the opposite position: They claim the power to forgive sins of emission, but if temperatures continue to rise, the resulting hell-on-earth will punish both the pious and the polluters and expose the folly of praying (paying) to the Gods of Carbon-Offsets.

Patents Involving Fertilization of Ocean to Sequester CO_2

Patent or Application#	Inventor/Assignee	Title	Publication Date
US6056919	Michael Markels	Method of sequestering carbon dioxide	May 2, 2002
US6200530	Michael Markels	Sequestering carbon dioxide in open oceans to counter global warming	March 13, 2001
US6440367	Michael Markels / GreenSea Venture, Inc.	Method of sequestering carbon dioxide with a fertilizer comprising chelated iron	August 27, 2002
US5965117	DuPont	Water-bouyant particulate materials containing micronutrients for phytoplankton	Oct. 12, 1999
US5992089	Ian Jones, William Rodgers, Michael Gunaratnam, Helen Young, Elizabeth Woollahra (Australia)	Process for sequestering into the ocean the atmospheric greenhouse gas carbon dioxide by means of supplementing the ocean with ammonia or salts thereof	Nov. 30, 1999
US20030012691A1 (application)	Michael Markels	Method of sequestering carbon dioxide with a fertilizer comprising chelated iron	Jan. 16, 2003
WO0065902A1	Michael Markels	Sequestering carbon dioxide in open oceans to counter global warming	Nov. 9, 2000

Surf, Turf and Stratosphere:
Global Weather Modification Activities and Sites of Iron Fertilization Experiments



Countries that have recently confirmed weather modification activities to WMO:
Australia, Austria, Bulgaria, Canada, Croatia, France, Germany, Greece, Hungary, Malaysia, Macedonia (Republic of), Morocco, Russian Federation, Serbia And Montenegro, Uzbekistan, Zimbabwe

Countries that have recently claimed NO weather modification activities to WMO:
Algeria, Argentina, Bahrain, Barbados, Belize, Benin, (République du), Brunei Darussalam, Colombia,Costa Rica,Cote d'Ivoire, Cyprus,Denmark, Dominican Republic, Ecuador, Egypt, Estonia, Finland, Gambia, Georgia, Guyana, China, Iceland, India, Japan, Kazakhstan, (Republic of), Kyrgyz Republic, Liban, Lithuania, Maldives, Malta, Mauritius, Mexico, Myanmar, The Netherlands, New Zealand, Niger, Papua New Guinea, Pakistan, Paraguay, Peru, Poland, Qatar, Republica Dominica, El Salvador, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, St Lucia, Sudan, Sweden, Switzerland, Trinidad and Tobago, Turkey, Uganda (Republic of), United Kingdom, Uruguay, USA

Countries where weather modification activities have been reported elsewhere (i.e., not to WMO):
China, Mexico, Thailand, United Arab Emirates, USA

Countries that have provided financial support for iron fertilization experiments:
Australia, Canada, Germany, Japan, Mexico, Netherlands, New Zealand, United Kingdom, USA

This map includes colors which may not be visible when printed.

Source: ETC Group

Hurricane season – Future Techno-fixes

Sargasso Sea-change: This kind of geoengineering is not as "sci-fi" as we would wish. Many of the Western Hemisphere's most devastating hurricanes originate when temperatures rise in the mid-Atlantic – in the Sargasso Sea – the vast oval doldrums encased by the northward flow of a warm tropical current on its west and a chilly south-bound current from the Arctic on its east. Although the Sargasso Sea is known for the profusion of seaweed at its surface, biologists have always regarded the sea as relatively barren.

In 2004, with grants from the US Department of Energy, Craig Venter – the man who led the private sector mapping of the human genome – steered his 90-foot yacht, the Sorcerer II, into the Sargasso in search of marine microbes sporting novel genes to improve photosynthesis. Months later, Venter told a Washington news conference that he had found 1800 new microbial species and at least 1.2 million novel genes, including photosynthesis genes that could have a major impact on climate change.[81] With US Department of Energy funding, Craig Venter is committed to creating a new life form – a synthetic construct based upon simple microorganisms – that could be designed to clean up pollution, CO_2 or other greenhouse gases.

Given the dubious experience with iron fertilization, it could be tempting for desperate governments to try an alternative approach: the release of a living organism made from scratch designed to sequester carbon.

There are other – possibly related – developments. In 2005 a "Weather Modification" bill (S517) was introduced in the US Congress that would establish a committee to oversee a national research program on weather modification.[82] Sponsored by Republican Senator Kay Bailey Hutchison of George W. Bush's home state, Texas, the bill was originally expected to become law before the 2006 hurricane season, but never made it out of committee – and is dead in the water for now.[83] The bill unexpectedly ran into some opposition from the White House science adviser who was concerned that any technologies that might be introduced to modify the US climate would, inevitably, modify everybody else's climate.[84]

In April 2006, the US National Science Foundation held its third Hurricane Science and Engineering Task Force Workshop in Pensacola, Florida. Among the options under consideration according to the meeting's co-chair, Prof. Kelvin Droegemeier, a meteorologist at the University of Oklahoma, is creating a biological film over the ocean's surface to divert hurricanes.[85] Some researchers have lost enthusiasm for the idea of coating the ocean's surface with an oily film (to restrict evaporation and mitigate hurricanes) because the film breaks up in high-wind conditions.[86] Ross Hoffman of Atmospheric and Environmental Research (Lexington, Massachusetts, USA) is using computer modeling to study how to induce minor changes in weather conditions (e.g., air temperature or humidity) to weaken or divert hurricanes away from population centers. According to Hoffman, who received funding from NASA's Institute for Advanced Concepts, "the goal is not to change the climate, but to control the precise timing and paths of weather systems."[87] Hoffman speculates, for example, that earth-orbiting solar power stations could supply enough energy to heat the air around a hurricane and adjust the temperature. Hoffman writes that global weather control "might be implemented within a few decades" but will require further breakthroughs in nanotechnology, quantum devices and other areas.[88]

At the end of 2006, when the UN Convention on Climate Change convened in Nairobi, the Associated Press reported that geoengineering received a surprising amount of attention. What surprised government delegates and CSO observers most was that everybody was taking seriously Crutzen's proposal for stratospheric hazing or deliberate atmospheric polluting. Kyoto, according to the wisdom of the meeting, was on its deathbed, and geoengineering was looking more reasonable everyday. Even as the meeting was underway in Nairobi, the Associated Press added, on the US West Coast, NASA was holding a closed-door meeting to review a number of geoengineering possibilities including global hazing.[89] Is it coincidence that

in mid-2005, NASA – without consulting any of its employees – deleted the phrase, "to understand and protect our home planet" from its mission statement?[90]

Solomonic Summers? The political and ethical dimensions of climate modification are huge. In a 2005 interview in *The Boston Globe*, Harvard's Director of the Laboratory for Geochemical Oceanography, Daniel Schrag asked, "Suppose we could control hurricanes, but stopping one requires an incredibly hot day in Africa that would burn up all the crops."[91] Schrag goes on, "Let's say you have a mirror in space. Think of two summers ago when we were having this awful cold summer and Europe was having this awful heat wave. Who gets to adjust the mirror?"[92]

White night? In September 2001, officials with the President's Climate Change Technology Program invited about two dozen scientists to participate in a meeting titled "Response Options to Rapid or Severe Climate Change." Despite Bush's rejection of the Kyoto protocol six months earlier, the White House was quietly checking out its options. Among those invited were physicists from Lawrence Livermore National Laboratory (Edward Teller's *alma mater*, from where he developed the hydrogen bomb and launched his 1997 geoengineering proposal). The interest in geoengineering was intense. One of the organizers of the White House gathering was Dr. Michael MacCracken, a former senior scientist at the U.S. Global Change Research Program and, also, formerly with Lawrence Livermore. "We already are inadvertently changing the climate," MacCracken told one science journal, "so why not advertently try to counterbalance it?"[93]

This kind of thinking is not out of character. After World War II, the US Office of Naval Research and the Scripps Institution of Oceanography cooperated on studies that led to the atomic bomb testing in the Pacific being called *"a wonderful oceanographic tool."*[94] The director of the Scripps oceanographic programme at that time was Dr. Roger Revelle who complained that "ignorance and emotionalism" dominated the discourse about radioactive waste dumping at sea. The Scripps vessel used in at least one of the iron fertilization experiments, was *The Revelle*.

The bottom line is this: does anyone really think that the current US administration (or its counterparts in China or Russia, for that matter) would shy away from geoengineering the stratosphere or the ocean in order to save their oil industries or ward off their coastal cities?

> *"As remedies for the CO_2-climate problem, all proposed geoengineering schemes have serious flaws. Nevertheless, I judge it likely that this century will see serious debate about – and perhaps implementation of – deliberate planetary-scale engineering."* – David W. Keith, Dept. of Chemical Engineering and Dept. of Economics, University of Calgary[95]

Recommendations

ETC Group believes that geo-engineering is the wrong response to climate change. Experimentation that could alter the structure of the oceans or the stratosphere should not proceed without thorough and informed public debate on its consequences, and UN authorization. Geoengineering must not be undertaken unilaterally by any nation. The United Nations must reaffirm (and, if necessary, expand) the Environmental Modification Convention (ENMOD) recognizing that any unilateral modification of weather or climate is a threat to neighboring countries and, very likely, the entire international community. The Intergovernmental Panel on Climate Change should revisit the concept and practice of carbon trading and replace this market-based "solution" with direct, measurable standards for CO_2 emission reduction at source. OECD states must redouble their efforts to reduce their consumption of fossil fuels and to curtail other wasteful practices that contribute to global warming.

Table 2: Financial Sources Supporting Iron Fertilization Experiments Since 1993

Country	Name of Institute or Company	IRONEX1 1993	IRONEX2 1995	SOIREE 1999	EISENEX 2000	SEEDS 2001	SERIES 2002	SOFex 2002	EIFEX 2004	SEEDS II 2004	GreenSeas 1998	GreenSeas 1998	Planktos Pilot Projects 2007
AUS	BHP Billiton Group [Carbon Steel/Petrol./Alum./Energy Coal/Diamonds], CSIRO			■									
CDN	Nat'l Sci. & Engineering Research Council (NSERC)			■									
CDN	Canadian Foundation for Climate & Atmospheric Sciences (CFCAS)						■						
CDN	Fisheries & Oceans Canada; Panel for Energy Research & Dev. (PERD)						■						
CDN	Natural Sci. & Engin. Research Council; Canadian-Surface Ocean Lower Atmosphere Study (NSERC C-SOLAS)			■			■						
DEU	Ministry of Research & Technology (BMFT)				■								
EU/D	BMFT & European Union				■								
EU	Carbondioxide Uptake by the Southern Ocean (CARUSO)			■	■								
JPN	Central Research Inst of Electric Power Industry (CRIEPI)				■	■	■						
JPN	Fisheries Agency					■	■						
JPN	Global Environmental Research Fund, Ministry of Environment					■	■						
MEX	CICESE-Centro de Investigación Científica y Edu. Superior de Ensenada		■										
NL	Gov.of the Netherlands				■								
NZ	Public Good Service Fund (PGSF) for Antarctic Research			■			■						
UK	Natural Environment Research Council (NERC)		■	■									
UK	European Chemical Industry Council (CEFIC)			■									
USA	Univ.-Nat'l Oceanographic Lab. System (UNOLS) [62 academic institutions]												
USA	Nat'l. Science Foundation (NSF)	■	■	■	■			■					
USA	Cent. for Env. Bioinorganic Chemistry CEBIC), Princeton			■									
USA	Office of Naval Research (ONR)	■	■		■								
USA	Dept. of Energy (DOE)							■					
USA	Monterey Bay Aquarium Research Inst. (MBARI)		■										
USA	Nat'l. Science Foundation	■											

Country	Name of Institute or Company	IRONEX1 1993	IRONEX2 1995	SOIREE 1999	EISENEX 2000	SEEDS 2001	SERIES 2002	SOFex 2002	EIFEX 2004	SEEDS II 2004	GreenSeas 1998	GreenSeas 1998	Planktos Pilot Projects 2007
USA	Ocean Farming Inc. (OFI)/ GreenSea Venture Inc.												
USA	Planktos Inc.												

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linger so long in the surface waters that the iron is slowly made biologically available." http://www.planktos.com/educational/thedebate.htm (viewed February 1, 2007).

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ETC Group is an international civil society organization based in Canada. We are dedicated to the conservation and sustainable advancement of cultural and ecological diversity and human rights. ETC Group supports socially responsible development of technologies useful to the poor and marginalized and we address international governance issues affecting the international community. We also monitor the ownership and control of technologies and the consolidation of corporate power.

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