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6th April 2009

Dear Members of The Royal Society Working Group on Geoengineering,

I am writing on behalf of the ETC Group (Action Group on Erosion, Technology and Concentration). We are a non-profit international organization based in Canada that undertakes research and advocacy work. We monitor emerging technologies and corporate strategies relevant to the protection of biodiversity and the interests of marginalized groups. In January 2007 we published one of the first papers looking at geoengineering from a civil society perspective - entitled "Gambling with Gaia". We have since been monitoring developments in the field with increasing concern.¹

We are grateful that the Royal Society is willing to accept a submission at this late stage in its proceedings. We regard this submission as an urgent matter, for we are alarmed at the apparent emergence of an "official view", most recently articulated by the UK House of Commons Committee on Innovation, Universities, Science and Skills, which is prepared to sanction real-world geoengineering experiments despite complete absence of any global rules or regulations. We find that emerging view complacent, irresponsible and dangerous. This short note outlines six points on the question of geoengineering governance that no study concerned with policy-making in this critical area should ignore:

- 1) Governance of the sector must be universal, globally and unanimously agreed, accountable and inclusive.
- 2) Its scope must reach beyond the climate crisis.
- 3) It must remain consistent with the precautionary principle
- 4) Private sector interests will distort geoengineering governance
- 5) The line in the sand is real world experiments.
- 6) Ocean fertilization as a bellweather for precaution.

These points are expanded upon in the attached paper and we trust that the Working Group members will give these points careful attention. We thank you in advance for your consideration and please do not hesitate to contact us if you have any need for clarification or explanation.

Yours Sincerely,

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Jim Thomas
ETC Group

Six Points on Geoengineering Governance

Prepared by the ETC Group – April 2009

1) Governance Arrangements For Geoengineering Must be Universal, Globally and Unanimously Agreed, Accountable and Inclusive.

There is almost no exercise of power more overwhelming than claiming the technological means to restructure the entire planet. If such means appear even mildly feasible, governments will pay dearly for that power and wars will be waged to control the relevant technologies and research agendas. Many commentators have emphasized the imbalance between the global reach that geo-engineers aspire to for their technologies and the potential for individual actors, wealthy people, single states or a “coalition of the willing” to unilaterally deploy these measuresⁱⁱ. Just as the current distribution of political power in the global order reflects the ownership and development of nuclear weapons, so states and others claiming to own - or almost own and willing to countenance - geoengineering technologies, even if developed for "peaceful purposes", will deploy those claims as a pawn in geopolitical games. Even if they are never deployed or even proven to work, geoengineering technologies will have a profound impact on the security interests of all states and all peoples. Given the dual-use implications of geoengineering technologies, any decision-making must be unanimous, transparent, accountable and global.

If any of the technologies currently in the research stage was actually deployed at full scale, the direct impact on people would be widespread. This is true by definition, since the goal of geoengineering is to alter planetary-scale phenomena such as the carbon cycle and atmospheric dynamics. From our observations, most geoengineering proposals are inherently transboundary - sulphate aerosols spread across the globe on high winds, fertilized plankton blooms shift with the tides and clouds move and interact with other aspects of the weather system. In many cases, the technologies target the global commons of the oceans, the polar regions, the atmosphere, outer space or the genetic commons of plants and microbial species. Decisions over these commons must be taken with all interests at the table.

In the few cases where a geoengineering proposal at first appears “local” or “regional” the issue of scale will quickly elevate it to the global level. Some biochars, for example, may well prove harmless in small-scale applications. However, as soon as they are scaled up to a level that can sequester significant quantities of atmospheric CO₂, biochar production processes will inevitably use unsustainable amounts of biomassⁱⁱⁱ. This poses a global threat since ecological studies have documented that human appropriation of the biosphere has already exceeded the safe limits for the proper functioning of ecosystems.^{iv} Air-capture devices for sequestering carbon dioxide might appear static and local in impact. However, if enough CO₂ is subsequently sequestered in a geological formations to counteract warming, it poses a risk of badly undoing mitigation efforts should those gases ever escape^v. Seen this way, carbon capture and storage schemes present as great a risk as radioactive waste disposal and point therefore to the need for some legitimate

means of global oversight and agreement. New norms governing these issues are necessarily the product of international negotiations, by all nations, not simply those with geoengineering research and development capabilities. Recommendations from the working group should speak to this global governance dimension. A unilateral governance regime by the UK or US Governments, the European Union or the OECD is not an acceptable option.

ETC Group commends the Royal Society in having the courage to address the full suite of geoengineering proposals together. In so far as these technologies have a unity of purpose and vision we believe any governance proposals advanced should also point towards a unified framework for tackling this field as a whole. We have seen with the early political battles over ocean fertilization that even one geoengineering technique can challenge the mandates of several different international bodies, which in turn can be played against each other as protagonists claim legitimacy for the forum that best suits their interests. Shoe-horning the governance of individual technologies into different treaties and institutions not originally designed with geoengineering in mind will likely lead to very limited and inequitable outcomes – a patchwork of rules and regulations that will be easy to skirt around. For example the International Maritime Organization’s London Convention and Protocol on the Dumping of Hazardous Wastes at Sea has taken an interest in ocean fertilization^{vi}. It is, however, limited by its narrow mandate on environmental marine pollution and it cannot legally weigh the impact of the practice on livelihoods of fisherfolk, dual use implications, the modification of weather systems via DMS gas production or the implications of patenting and ownership of ocean fertilization techniques. Rather than allow geoengineering governance to fragment into many ill-fitting containers that cannot properly grapple with its complexity or depth, we encourage the working group to advocate for a single accessible and responsible international forum that can meet the challenge head on. The Working Group should recommend a process under the auspices of the United Nations to take this process forward, where a diversity of views and interests can be heard and whose rules can be universally – or almost universally – applied.

In one technological controversy after another, it has become clear that governance processes that privilege techno-scientific knowledge and perspectives above all other forms of knowledge often deliver inequitable, unsafe and poorly informed judgments.^{vii} Types of knowledge and perspectives typically excluded by such expert-driven processes (but highly relevant to geo-engineering) include indigenous knowledge of land and wildlife, the knowledge of weather, soils and vegetation held by farmers, the knowledge of oceans and weather developed by fisher-folk and so forth. Failure to solicit and incorporate these forms of knowledge in the past has led to conflict and poor decisions on nuclear waste, synthetic chemicals, hybrid seeds, genetically modified organisms, trawler fishing, biofuels and more. The Working Group will be well aware that, as a relatively closed expert-driven group convened by an elite science organization, it is incumbent not to replicate those limitations in any proposals put forward. Opening decision-making to more diverse actors representative of wider publics allows for more robust and nuanced governance outcomes.

2) The Scope of Geoengineering Governance Must Reach Beyond the Climate Crisis.

By extending the scope of governance beyond climate change we mean two things: (1) keeping in mind geoengineering technologies which have purposes other than climate change mitigation or adaptation and (2) not neglecting impacts on people and ecosystems which are not directly related to global warming.

ETC Group is acutely aware that conclusions reached by the Royal Society at a particular historical moment may shape governance arrangements for years or even decades to come. Often those governance arrangements reach beyond the technologies under consideration to further iterations or analogous technologies that may even be difficult to imagine today.^{viii} While this Working Group has limited its remit to “climate geo-engineering”, we draw your attention to the fact that actions emanating from Royal Society recommendations may shape governance for all geoengineering technologies - not just those related to climate change.

The present focus of geoengineering efforts to counteract global warming, can easily obscure the fact that, historically, geoengineering plans were primarily military^{ix}. We can see the emergence of geoengineering scale proposals that aspire to address the world water crisis, the global oversupply of reactive nitrogen and the acidification of the world’s oceans.^x We could further imagine geoengineering proposals to “fix” the ozone holes, guarantee the food supply and protect the planet and its population from asteroids and tsunamis. We therefore urge the Working Group to adopt a longer-term perspective when proposing governance actions and to acknowledge that any institutional arrangements developed now for climate geoengineering will likely be later extended or applied to encompass other geoengineering schemes .

Again, this points to the need to tailor the international governance architecture to examine the full social, economic and environmental impacts of the development of these new technologies in a broader context than just climate change. Various pieces of our existing international law are relevant and have a wider remit: the 1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD treaty)^{xi} ; the Convention on Biological Diversity; the UN Commission on Sustainable Development and the UN General Assembly to name a few. We recommend against handing oversight of geoengineering governance to bodies with a narrow climate and atmospheric focus since this may prove too limited down the road (eg UN Framework Convention on Climate Change or the Montreal Protocol).

The profile and interest generated by geoengineering is the result of a well-deserved sense of urgency around climate change. However, the climate crisis needs to be addressed in concert with other emergencies -- such as global hunger, species extinction, ecosystem destruction, over-appropriation of biomass and ocean acidification. These crises warrant careful attention in considering future harms and the efficacy of particular schemes to counteract anthropogenic global warming. An exclusive focus on climate

change as the one overriding consideration by which a particular scheme succeeds or fails is short-sighted and one-sided. Indeed, it is governance decisions driven by such a narrow vision that have propelled society to this point of desperation where geoengineering seems to many to be a viable option. From here on we should seek out governance structures and processes that are much more inclusive, open and long-term in their vision.

3) Geoengineering Governance Must Remain Consistent with the Precautionary Principle

Contemporary controversies over risk governance of emerging technologies frequently devolve to a routine stand-off between protagonists advocating the precautionary principle and technology enthusiasts offering some version of what has been called "the proactionary principle". This is already the case in the emerging debate over geoengineering where civil society groups have called for these technologies to be halted via moratoria (eg biochar and ocean fertilization^{xiii}) while geoengineering advocates have argued that a failure to develop these technologies will have catastrophic consequences. We urge the members of the Working Group to consider this values conflict carefully, to look beyond crude characterizations of these positions and to examine the origins of these formalized attitudes towards risk.

ETC Group strongly advocates that governance associated with geoengineering be founded on the precautionary principle. This is a well-established instrument in international environmental agreements usefully elaborated upon in the European Commission's Communication on the Precautionary Principle (2000). The precautionary principle is a simple but profound commitment affirming that when an activity raises threats of harm to human health or the environment, precautionary measures should be taken, even if causality has not been fully established scientifically. All definitions of the precautionary principle contain the following three core elements: (1) When there is reasonable threat of harm (2) and scientific uncertainty (3) we have a duty to act to prevent harm. At this point we can only identify only one common geoengineering proposal^{xiii} that doesn't readily meet these criteria .

The value of the precautionary principle has been extremely well-established in the field of climate change policy, and was invoked as an overriding rationale for global action on emissions reduction long before the IPCC had definitively established a causal link between human activities and global warming. Indeed the Maastricht Treaty of 1992 requires that all European Union environmental policy - thereby including climate change and future geoengineering policy - be "based on the precautionary principle". Precaution implies more than just "doing nothing". It means setting goals, monitoring effects, considering all the evidence and consequences, heeding early warnings of harm, engaging affected persons in democratic decision-making, choosing safer alternatives and more.^{xiv}

In contrast, the so-called "proactionary principle", largely developed by transhumanist libertarian Max More, posits that freedom to innovate is overwhelmingly critical to human survival^{xv}. It therefore establishes a high threshold of scientific certainty necessary

for opponents of an activity to prevent any innovation. In our experience, this ideological stance is most often employed by industrial interests defending a product or a new technology against controversy. . Supporters of geoengineering claim that society must allow geoengineering technologies to develop because we may have already passed significant tipping points which only radical innovation can amend ^{xvi}. Such a position, however, is itself contradictory. It both embraces the precautionary principle in demanding radical action on climate change (that we have passed the tipping points is not scientifically proven) and then rejects precaution in claiming that even the possibility of negative impacts should not forestall development of risky geoengineering technologies. ETC Group notes that the Royal Society has shown admirable support for the Precautionary Principle in previous enquiries and urges the Working Group to remain consistent with these precedents.^{xvii}

4) Private Sector Interests Will Distort Geoengineering Governance

ETC Group is alarmed that much of the current interest in geoengineering proposals and particularly the pressure for real-world experiments are being driven by commercial interests and the rise of new markets in carbon and environmental services. For example, in the past few years, we have seen several attempts to carry out ocean fertilization activities by private companies (GreenSea Ventures, Planktos Inc and Ocean Nourishment Corporation) each seeking to make profit by selling voluntary carbon offsets and win fishing rights. A fourth commercial ocean fertilization company, Climos Inc. of San Francisco, is currently investing a significant portion of its multimillion dollar capital in seeking to influence governance processes to its own advantage. It has stated it will also be channeling its funds towards academic scientists to carry out experimental research on its behalf^{xviii}. ETC Group views this as an attempt to “buy” scientific support.

Many in the oceanographic community, including supporters of ocean fertilization, have spoken out against the sale of carbon credits, pointing out that such offsets license emissions increases against unverifiable sequestration techniques. Writing in the journal *Science* in 2001, Sallie Chisholm, Paul Falkowski and John Cullen first called for ocean fertilization to become ineligible for carbon credits^{xix}, a position echoed in 2008 when 16 scientists wrote that it was premature to sell offsets from ocean fertilization experiments^{xx}. In May 2008 the Ninth Conference of Parties to the Convention on Biological Diversity agreed to a de facto moratorium on ocean fertilization that explicitly prohibited activities “for generating and selling carbon offsets or any other commercial purposes”^{xxi}. ETC Group believes that that the presence of private companies and their financial backers in this sphere will always skew scientific assessments and governance decisions in favour of outcomes that maximize profit rather than environmental safety, justice or climate protection.

What is true for ocean fertilization is becoming true across all fields of geo-engineering. The International Biochar Initiative^{xxii}, supported by carbon trading companies, agribusiness interests and commercial pyrolysis firms are pushing for inclusion of biochar-amended soils in the Clean Development Mechanism of the Kyoto Protocol and are developing standards for the sales of voluntary offsets long before biochar has been

proven as a viable carbon sequestration technology. A typical company operating commercially in this field is Mantria Industries which sells a char product, Eternagreen, produced from municipal waste, sewage sludge and old tires that has not been evaluated for long-term impact on soils.^{xxiii} Similar financial offset mechanisms are being proposed for radiative forcing projects. Alvia Gaskill of the Global Albedo Enhancement Project has proposed developing “thermal credits” for geoengineering schemes that reduce the atmosphere's radiative budget.^{xxiv}

Equally of concern is the impact of the private Virgin Earth Prize, announced by airline and spaceflight tycoon Richard Branson in 2007^{xxv}. This attempts to emulate the successful X-prize model by offering \$25 million (US), the world's largest science prize, for a team who can demonstrate a geoengineering technique enabling continuous net removal of CO₂ from the earth's atmosphere. Such privately run commercial prizes exist to spur investment and development of geoengineering technologies by “have-a-go” entrepreneurs. The prize also exists as a public relations exercise by an airline and spaceflight company looking to distract attention from its own significant climate change impacts. Neither motivation represents a careful, precautionary or responsible approach to research and development of this field. ETC Group urges the Working Group to look critically at the presence of commercial entities engaging in geoengineering activities, to condemn the use of commercial prizes in this sphere as irresponsible, and to recommend that no offsets, credits, fishing rights or other financial instruments be bought or sold from existing geoengineering technologies.

5) The Line in the Sand is Real World Experiments.

While the Working Group has many aspects of geoengineering to consider we believe your final report will be largely judged by how you handle one overriding question: Should real-world geoengineering experiments proceed at this time? We note with concern that some members of the Working Group^{xxvi} are already calling for research efforts to cross the controversial line from observing nature and modeling geoengineering scenarios in-silico to in-situ trials of geoengineering technologies (should we say “in-geo”?). How the Royal Society handles this matter in its report will signal whether the group has been able to take an impartial, considered and responsible view.

ETC Group opposes more real-world experiments in the current governance vacuum. We regard directly interfering with the soils, skies and seas of the planet for geoengineering purposes as unwise and unnecessary. Seen alongside the full set of possible responses to anthropogenic climate change, we regard geoengineering as a wrong and dangerous avenue, towards which further political will and resources will only be squandered. Our research shows that all geoengineering technologies, by virtue of being extremely large-scale, highly centralized and with latent military uses will always deliver unjust and authoritarian outcomes. We further believe that the illusion of a “technofix” just around the corner serves as an all too-convenient excuse for the powerful and comfortable to drag their heels and refrain from making the urgent changes (mostly societal changes) that are required to actually reverse the climate crisis. In a sane and sensible world, the

geoengineering option would not be on the table at all, and nobody in their right mind would be agitating for experiments.

Instead we note that such agitation is ramping up and that even seemingly respectable bodies, including the UK House of Commons Committee on Innovation, Universities, Science and Skills have proposed increases in research budgets for geoengineering in a manner that casually gives the nod to real-world experimentation.^{xxvii} We believe that crossing this line from in-silico to in-geo geoengineering is a grave and epochal step. To endorse such a step lightly, especially without appropriate governance in place, is reckless and irresponsible and we strongly urge the Working Group to refrain from adopting such a position.

Geoengineering cannot be conscientiously deployed without a global agreement governing these technologies. However there are those who appear to presume that geoengineering activities, when labeled as science, constitute something short of deployment and therefore can proceed in the absence of any legitimate international debate, let alone comprehensive governance arrangements. To observers of previous science controversies, this is an all too familiar proposition. Proponents of industrial whaling practice this form of “scientific exceptionalism” when they hunt protected whales in the Southern Oceans under the guise of “scientific whaling”. Proponents of genetically modified crops practice the same double standard when they carry out environmental releases of novel engineered crops, animals or microbes and then exempt them from regulatory review by labeling them as experiments. The closest analogy to what is now occurring with geoengineering is to be found in the history of nuclear weapons testing - a technology which enjoys the same dual-use status as geoengineering technologies. From 1945 until the Limited Test Ban Treaty was signed in 1963, hundreds of atmospheric and underwater nuclear tests, some for supposedly “peaceful purposes”, were carried out without a global treaty in place and despite massive protests. These dispersed isotopes of plutonium, cesium, strontium, iodine-131 and other deadly elements killing livestock, sickening civilians, causing leukemia, cancer, genetic deformities and heightening Cold War tensions. Estimates of human deaths, illnesses and casualties resulting from American, Soviet, British, French and Chinese nuclear tests run in the hundreds of thousands.^{xxviii}

In the realm of geoengineering there are proposals, such as dispersing nano-particulate matter in the stratosphere, whose geographic reach will exceed that of an atmospheric nuclear test since particles at that height can circulate the globe in a matter of months. There are proposals, such as altering the acidity of the world's oceans by adding silicates or other methods, which if they go the wrong way, could rival the ecological disruption of an undersea nuclear explosion. Such methods cannot be recalled once they are deployed. We believe it would be unconscionable for the Royal Society to make any statement suggesting such methods could move ahead to trials without strong governance.

There are proposals that may initially appear suitable to carry out in a relatively contained manner (eg. plots of biochar-amended soils, albedo enhancement of land and plants,

deposition of biomass at sea). However, because geoengineering is by definition large-scale, any small-scale tests will always be regarded as inadequate and pressure will come to bear to move swiftly to larger-scale (and therefore more problematic) interventions. This dynamic has been evident in the case of ocean fertilization where in the wake of 13 smaller, unpromising real-world tests, a small minority are now vocally arguing for the area of impact to be scaled up, claiming that small-scale tests are not scientifically useful to infer the real efficacy of this technique. Had the previous 13 tests delivered more positive results, there would still have been pressure for a scale-up. Hence the actual outcome of any set of geoengineering experiments is irrelevant to the trend to bigger and bigger scale. Diplomats at the the London Convention and the Convention on Biological Diversity are now struggling to choose an imaginary line where ocean fertilization experiments become “large scale”, thereby requiring oversight. This struggle could and should be simply resolved by formulating global rules that apply to all and any activities at any scale. Where the intent is to geo-engineer the planet whether now or in the future, any interference with the real world should demand oversight.

We understand that there have already been regrettable instances of real-world geoengineering experiments (most notably in the fields of ocean fertilization, weather modification and biochar). The Royal Society should look to take stock and re-set norms rather than feel obliged to legitimize past mistakes. ETC Group recommends a moratorium on real world geoengineering experiments at any scale, at least until just governance arrangements are established.

6) Ocean Fertilization as a Bellweather for Precaution.

In ETC Group’s view the Working Group's comments on ocean fertilization will be seen as a bellweather for how seriously the Working Group takes the precautionary principle. There have now been 13 real world experiments in ocean fertilization with dismal results. None have sequestered carbon at anything close to the efficiency of a natural plankton bloom. There is plenty of literature suggesting a reasonable threat of environmental harm - whether via deep ocean anoxia, promotion of harmful algal species (especially in the case of urea) and production of greenhouse and cloud-forming gases.^{xxix} There are clear statements from the Convention on Biological Diversity, the UN Commission on the Law of the Sea and the London Convention and Protocol urging “utmost caution”^{xxx} and far stronger calls for a complete halt to ocean fertilization activities arising from civil society including environmental NGOs and fisherfolk organizations.^{xxxi}

ETC Group believes that the Working Group should reflect on the wider meaning of the recent LOHAFEX debacle: Planned for 3 years by leading oceanographers, with the initial support of two national governments at a cost of several million dollars, untainted by commercial interests, LOHAFEX was not only one of the largest and best-planned experiments to date, it was a last ditch effort to show that ocean fertilization might have some lingering value. That it failed so spectacularly to actually sequester any carbon dioxide^{xxxii} is not merely “unlucky” but a sobering reflection on the viability of the technique as a whole. LOHAFEX may have contributed some interesting science on crustacean population dynamics but we echo the reported sentiment of Dr. Ken Caldeira

who explained that LOHAFEX represented “The last gasps of ocean iron fertilization as a carbon-storage strategy.”^{xxxiii} In the interests of precaution (and to paraphrase Monty Python) we believe the Working Group would do well to now pronounce this strategy fully dead: passed on.. no more.. ceased to be.. an ex-strategy.^{xxxiv}

ⁱ See Gambling with Gaia at http://www.etcgroup.org/en/materials/publications.html?pub_id=608. ETC Group since been active mainly on the question of ocean fertllization and has issued a number of press releases on related topics. See for example: The better world we seek is not Geo-engineered! A Civil Society Statement against Ocean Fertilization as well as press releases on specific ocean fertilization projects at <http://www.etcgroup.org/en/issues/geoengineering.html>. See also "Technofixes: Climate Solution or Corporate Scam: a Debate with Jim Thomas and Paul Fitzgerald" in the New Internationalist, August 2008 at <http://www.newint.org/features/special/2008/08/01/technofixes/>

ⁱⁱ David G. Victor (2008). "On the regulation of geoengineering". Oxford Review of Economic Policy (Oxford University Press) 24 (2): 322–336.

ⁱⁱⁱ For discussion of biomass requirements of Biochar as a geoengineering schemes see Section 5 of Almuth Ernsting and Deepak Rughani (2008) "Climate Geo-engineering with ‘Carbon Negative’ Bioenergy", Biofuelwatch UK - available online at <http://www.biofuelwatch.org.uk/docs/cnbe/cnbe.html>

^{iv} Loh J, Collen B, McRae L, Carranza TT, Pamplin FA, Amin R, & Baillie JEM (2008) Living Planet Index (ed Hails C). Living Planet Report 2008. WWF, Gland, Switzerland.

^v Emily Rochon (2008) "False Hope: Why carbon capture and storage won't save the climate, Greenpeace. available online at <http://www.greenpeace.org/international/press/reports/false-hope>

^{vi} IMO RESOLUTION LC-LP.1 (2008) ON THE REGULATION OF OCEAN FERTILIZATION (ADOPTED ON 31 OCTOBER 2008) available online at http://www.imo.org/includes/blastDataOnly.asp/data_id%3D24255/16.pdf

^{vii} see for example B Wynne, *May the sheep safely graze? A reflexive view of the expert-lay knowledge divide. Risk, Environment and Modernity: Towards a New Ecology*, 1996.

^{viii} See for example the discussion on how previous technologies controversies shape governance decisions on subsequent technologies in Kearns, M., Grove-White, R., Macnaghten, P., Wilsdon, J. & Wynne, B. *From Bio to Nano: Learning the Lessons, interrogating the Comparison. Science as Culture*. 2006;15:291-307.

^{ix} James Fleming, "The Climate Engineers," *Wilson Quarterly* (Spring 2007)

^x Large Dam schemes, re-routing rivers and large-scale desalination might all be considered geo-engineering reponses to the water crisis and deployment of crops or bacteria genetically engineered to improve notrogen fixation could be geoengineering responses to the nitrogen crisis. On ocean acidification see for example Jeremy Elton Jacquot, "Giving Geo-Engineering Another Go: Dumping Limestone into the Oceans to Fight Acidification" - <http://www.treehugger.com/files/2008/05/limestone-ocean-acidification.php>

^{xi} Susana Pimiento and Edward Hammond (2002), "A Political Primer on the Environmental Modification Convention (ENMOD)" - <http://www.sunshine-project.org/enmod/primer.html>

^{xii} See Calls by Civil Society against BioChar and ocean fertilization: "The better world we seek is not Geo-engineered! A Civil Society Statement against Ocean Fertilization" - March 2009 - available online at http://www.etcgroup.org/en/materials/publications.html?pub_id=727 and "Biochar, a New Big Threat to People, Land and Ecosystems" released April 2009 - available online at <http://www.regenwald.org/international/englisch/news.php?id=1226>

^{xiii} The one geo-engineering scheme that does not appear to offer any evidence of harm is the suggestion to paint roofs and pavements white - see Akbari, H. 2008, "Global Cooling: Increasing World-wide Urban Albedos to Offset CO2", Heat Island Group Ernest Orlando Lawrence Berkeley National Laboratory, presetaion to the Fifth Annual California Climate Change Conference, Sacramento, CA 9 September 2008

^{xiv} A good source for interpretive scholarship on the precautionary principle is The Science and Environmental Health Network (SEHN) - <http://www.sehn.org/precaution.html>

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- ^{xv} Max More (2005) "The Proactionary Principle" - available online at <http://www.maxmore.com/proactionary.html>
- ^{xvi} see for example John Nissen, Stephen Salter, John Latham et al (March 2009) "Open letter to Dr Rajendra K. Pachauri, IPCC chair" available online at <http://geo-engineering.blogspot.com/2009/03/open-letter-to-dr-pachauri.html>
- ^{xvii} see THE ROYAL SOCIETY AND THE ROYAL ACADEMY OF ENGINEERING, NANOSCIENCE AND NANOTECHNOLOGIES: OPPORTUNITIES AND UNCERTAINTIES p69 section 8.2 (5) (2004)
- ^{xviii} "Climos proposes to fund a team of scientists from the international academic/research community who are familiar with the science associated with OIF experiments." <http://www.climos.com/faq.php#10>
- ^{xix} Chisholm S, Falkowski P and Cullen J (2001) Oceans: Dis-crediting ocean fertilization. *Science*, 294, 309-310
- ^{xx} Buesseler, K.O., Doney, S.C., Karl, D.M., Boyd, P.W., Caldeira, K., Chai, F., Coale, K.H., de Baar, H.J.W., Falkowski, P.G., Johnson, K.S., Lampitt, R.S., Michaels, A.F., Naqvi, S.W.A., Smetacek, V., Takeda, S., Watson, A.J., 2008. Ocean iron fertilization--Moving forward in a sea of uncertainty. *Science* 319 (5860), 162. DOI: 10.1126/science.1154305
- ^{xxi} The decision of the Conference of the Parties to the CBD on ocean fertilization can be found here: <http://www.cbd.int/decisions/cop9/?m=COP-09&id=11659&lg=0>
- ^{xxii} see <http://www.biochar-international.org/>
- ^{xxiii} see <http://www.eternagreen.com/>
- ^{xxiv} Alvia Gaskill "Summary of Meeting with U.S. DOE to Discuss Geoengineering Options to Prevent Abrupt and Long-Term Climate Change" Juen 29th 2004. Available online at <http://www.see.ed.ac.uk/~shs/Climate%20change/Geo-politics/Gaskill%20DOE.pdf>
- ^{xxv} see <http://www.virginearth.com/>
- ^{xxvi} for example see Ken Caldeira "We should plan for the worst-case climate scenario" *Bulletin of Atomic Scientists* - 29 July 2008. <http://www.thebulletin.org/web-edition/roundtables/has-the-time-come-geoengineering#rt3845>
- ^{xxvii} UK House of Commons Select committee on Innovation, Universities, Science and Skills (2009) "Engineering: Turning ideas into reality" *Geoengineering Case Study*.
- ^{xxviii} Glenn Alan Cheney, *They Never Knew: The Victims of Nuclear Testing*. Impact Books , 1996.
- ^{xxix} for a critical technical overview of the failure of past ocean fertilization experiments see Allsopp, M., Santillo, D., Johnston, P. (2007), *A scientific critique of oceanic iron fertilization as a climate change mitigation strategy*,
- ^{xxx} see "OCEAN FERTILIZATION: A compilation of international statements, agreements and recommendations" - Prepared and submitted to London Convention by UNEP
- ^{xxxi} "The better world we seek is not Geo-engineered! A Civil Society Statement against Ocean Fertilization" - March 2009 - available online at http://www.etcgroup.org/en/materials/publications.html?pub_id=727
- ^{xxxii} National Institute of Oceanography (India) and Alfred Wegener Institute, "LOHAFEX provides surprising insights on plankton ecology that dampen hopes of using the Southern Ocean to sequester atmospheric CO2" 23 march 2009. Available online at http://www.nio.org/projects/narvekar/Lohafex_press_release_23_03_09.pdf
- ^{xxxiii} Catherine Brahic "Hungry shrimp eat climate change experiment" *New Scientist* 25 March 2009. Available online at <http://www.newscientist.com/article/dn16842-hungry-shrimp-eat-climate-change-experiment.html?DCMP=OTC-rss&nsref=online-news>
- ^{xxxiv} With Apologies to Monty Python's Dead Parrot Sketch - see http://en.wikipedia.org/wiki/Dead_Parrot