The Rationale for Commercial Participation in Ocean Iron Fertilization Experiments

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Introduction

Climos believes that there is a strong rationale for commercial participation in determining whether Ocean Iron Fertilization (OIF) is a potential mitigation technique for sequestering atmospheric carbon dioxide that contributes to global warming, ocean acidification, and other environmental change. Publicly funded basic research using OIF was designed to understand the role of iron in controlling the biological productivity of the oceans now and in the past. However, the emerging potential of OIF as an element of the portfolio of market-related approaches to reduce greenhouse gases in the atmosphere is of applied interest, not simply a basic research problem. The models for development of techniques for commercialization include both commercial funding and public/private partnerships in funding, but do not generally rely on public subsidy alone. We believe that either funding model can be successful in the case of OIF and that appropriate regulatory and market-based safeguards can be put in place for development. A phase of development research is essential because it will not only resolve issues related to the efficiency of OIF for carbon mitigation, but also provide information on environmental impact. Learning from this development phase will allow the evolution of safeguards for later deployment of OIF as a mitigation strategy if it proves successful and appropriate.

Background to commercial interest

Ocean Iron Fertilization (OIF) is one of a number of techniques that have been suggested as possible methods to mitigate the atmospheric carbon dioxide. OIF works by improving the efficiency of natural phytoplankton production in the open ocean, adding to the very large natural amount of carbon sequestration that takes place in the world's oceans every year. Publicly funded research scientists have investigated aspects of the science behind the technique in twelve experimental trials since 1993. Some of the more recent, relatively small scale experiments have shown promise, and now a number of scientists and private corporations are calling for larger scale demonstrations to better understand the efficacy and impact of this mechanism, specifically with the intention of assessing its possible use for climate mitigation (Buesseler, Doney et al. 2008).

In recent years, many developed countries have adopted a market-based "cap-and-trade" system for regulating greenhouse gas emissions. These systems provide economic incentives and penalties

aimed at achieving reduction of industrial gases over time. A "voluntary" market has also emerged in which both individuals and corporations can purchase Voluntary Emissions Reductions (VERs) from brokers, aggregators or retailers even though there is no regulatory or compliance-driven mandate to do so. In parallel to the carbon markets, other markets are evolving around the conservation of wetlands, water quality, biodiversity, and endangered species.

The ultimate purpose of these environmental markets is to protect or restore the environment by creating a financial incentive that will stimulate action and innovation within the private sector. Regulatory carbon markets provide a financial incentive by ensuring that a sufficiently aggressive 'cap' is in place, and maintain integrity by ensuring that traded credits represent an actual environmental benefit. Given the accelerating nature of the GHG emissions problem, and the considerable resources available from the private sector, it makes sense to provide a financial incentive to invest in developing creative and cost-efficient ways to reduce greenhouse gases. In this way, the private sector assumes the financial risk as well as receipt of financial benefits, but most importantly focuses its efforts on seeking ways to solve the climate change problem.

A few private corporations have been launched to explore OIF as a mitigation option. Long term, OIF will only develop as a commercial business if over the next several years it can also be demonstrated to the satisfaction of the scientific, regulatory and market communities that: 1) OIF sequesters carbon dioxide effectively and can be measured accurately, and 2) the benefit of OIF is greater than its environmental impact. All stakeholders have the joint responsibility to work together to ensure a thorough evaluation of these two primary metrics.

Concerns About OIF

The scientific issues that have been raised about OIF include:

- That the science does not indicate that OIF sequesters sufficient CO2 or that sequestration can be reliably measured;
- That there might be unwanted ecological side effects;

Specific concerns have been raised about the participation of the commercial sector in developing OIF:

- That the state of the science is too premature to warrant the move to commercialization;
- That private corporations cannot be trusted or adequately regulated in this context; and
- That the possibility of monetary reward distorts the scientific process.

Certain concerns are related to the role of project-based offset activities in the carbon market:

- That they have not been proven to be a credible source of real, quality project-based reductions;
- That they may not be effective at addressing the fundamental problem of climate change over time; or

- That many of the individuals and corporations involved seek monetary gain at the expense of the public interest, rather than in service of it.

Taken together, the questions fall into four categories: (1) efficacy of OIF, (2) potential impacts to the environment of OIF, (3) regulatory controls on commercial operation, and (4) credibility of commercial operators.

Efficacy

Does recent research support the efficacy of OIF?

Recent research on naturally occurring blooms and artificial OIF blooms has provided increasing support for the potential efficiency of OIF carbon sequestration. This scientific evidence comes from direct OIF experiments, other oceanographic experiments related to the role of iron in the biogeochemistry of the oceans, computer-based simulations, and paleographic evidence of enhanced carbon export. Several leading research scientists in this field have moved from disbelief about the potential of OIF to sequester carbon (e.g., [Charette and Buesseler, 2000]) to calls for better experiments to answer questions of efficiency (e.g. [Buesseler, et al., 2008]).

OIF Experiments. The twelve publicly funded experiments have conclusively demonstrated that phytoplankton in High-Nutrient, Low-Chlorophyll (HNLC) waters bloom in response to the addition of iron [Boyd, et al., 2007] . These experiments were not specifically designed to measure carbon export into the deep ocean, and thus suffered from design issues that greatly reduced the accuracy of export measurements. The last OIF experiment (EIFEX) was larger than prior experiments and was long enough to observe the carbon export phase of the bloom. Not surprisingly, EIFEX observed much high rates of sequestration than prior experiments(Smetacek, Strass et al. 2007).

Other Oceanographic Experiments. Recent measurements of carbon export from naturally-occurring seasonal phytoplankton blooms in the northwest Pacific and subtropical Pacific suggest that the biological pump is much more efficient than previous observations. The VERTIGO experiments used the latest equipment and techniques, including neutrally buoyant sediment traps to look at the fate of carbon below the mixed layer, and found that export to the deep ocean (below 500 m) was 2-5 times greater than previously thought (Buesseler, Lamborg et al. 2007). Similarly, observations of natural blooms stimulated by iron fertilization in the Southern Ocean showed extremely high rates of carbon export compared to prior observations (Blain, Queguiner et al. 2007).

Computer Simulations of OIF. In the last two years, new computer-based models explicitly simulated the ecological response to the natural iron cycle. When coupled to ocean circulation and climate models, these simulations provide much more realistic predictions than previous models. They have also shown that the potential concern of downstream nutrient depletion of decade-long large-scale OIF is only a concern in the equatorial Pacific (Jin, Gruber et al. 2008). The new models have also shown that a large scale 100-year deployment of OIF could produce enough carbon reductions to be

comparable with any other currently envisioned carbon reduction technique (Aumont and Bopp 2006; Jin, Gruber et al. 2008).

Paleographic Evidence. Observations of time series records that span multiple Glacial-Interglacial cycles show that iron delivery to the open ocean is higher during glacial times, and these records of dust flux are correlated with changes in ocean productivity (Jickells, An et al. 2005; Lambert, Delmonte et al. 2008; Winckler, Anderson et al. 2008). A recent synthesis of models and observations in the Southern Ocean suggests that increased iron supply resulted in enhanced efficiency of the biological pump, causing a 40ppm drawdown of CO2 during the last Glacial cycle (Cassar, Bender et al. 2007).

We feel that the directionality of previous research clearly supports larger scale projects, that these larger scale projects will sequester *at least some* carbon dioxide, and that *a lower bound* on the quantity and permanence of this sequestration can be able to be determined *within conservative limits*. A more comprehensive review of the recent scientific literature and support for OIF can be found in the Climos Response to the Canadian Review of OIF [2008] and the Climos Response to Concerns About Ocean Iron Fertilization (OIF) Raised by Greenpeace [2008].

What kind of further experimentation is needed?

Further experiments are needed in order to better understand the potential of this technology through more accurate measurements of carbon export and consideration of long-term ecological effects.. The funding for those experiments will need to be mobilized from private capital or research grants and public sources. Ideally, future experiments will be conducted under a public/private partnership approach, which would ensure both scientific and environmental integrity while also increasing the pace of research and development. As of May 2008, public research funding for OIF is extremely scarce, whereas private capital has already been engaged and is ready to conduct operations provided the necessary operational permits are obtained.

Environmental Impacts

Does the risk of unknown environmental impacts make commercial involvement premature?

Because environmental benefit is the objective of this activity, its environmental and ecological impact is of primary importance. Much has been learned from the 12 experiments to date concerning environmental impacts of OIF. However, the science community agrees that previous experiments and models are not sufficient to determine whether environmental impacts are significant. Climos has discussed the scientific information related to each of the following potential impacts of OIF in detail in other documents submitted to the Science Group of the LC (i.e. Climos Response to the Canadian Review of OIF [2008] and the Climos Response to Concerns About Ocean Iron Fertilization (OIF) Raised by Greenpeace [2008]), but agrees that further efforts are needed to more fully address the potential impact of OIF.

The scientific community has indicated that much can be learned about potential impacts from larger scale experiments, extending observation times, bringing more sophisticated instrumentation to bear and using the results to model the effect of larger scale deployment (e.g. [Buesseler et al. 2008]).

The framework for understanding potential environmental impacts must be detailed, robust, peer-reviewed and must include specific project design. Our Code of Conduct calls for and we are already developing an Environmental Impact Assessment (EIA) for the first demonstration cruise that we will propose. The EIA should clarify any possible long term effects of individual OIF demonstrations. Only with results from such experiments can the impact of longer term deployment of OIF be determined.

If OIF is determined to result in unacceptable adverse impacts on the ocean environment, it will not be commercially viable. These projects are expensive. The cost of bringing iron and instrumentation out to the ocean is in the millions of US dollars. If a benefit cannot be demonstrated—or if secondary effects prove unacceptable—then capital will not be available for further demonstrations.

Regulation of OIF

Is private sector funding appropriate for OIF experiments?

There are two primary reasons why it is appropriate for private sector involvement in OIF.

First, the notion of the application of OIF for carbon mitigation purposes, while interesting from a *pure* scientific perspective, is also *applied* science. Carbon sequestration is an active commercial field with a well developed market and numerous types of interrelated market participants. The precedence for private sector involvement in evolving fields involving the application of science to commercial scale problems is well known. Public funds should not have to bear the entire burden for the development of a commercial activity.

Second, the scale of the experiments required in order to explore this promising technology is large and presents a challenge for funding There is no reason future experiments could not take advantage of a public/private partnership approach (e.g. (Smith 2000)), ensuring both scientific and environmental integrity while also increasing the pace of research and development. Because the objective of these experiments is to determine whether OIF can be a viable carbon mitigation technique, at large scale, it is appropriate that private sector funds (as well as public funds) be used. There is an extensive history of this kind of developmental research being undertaken by the private sector. As of May 2008, public research funding for such larger cruise(s) is either not available or extremely difficult to secure, whereas private capital has already been engaged and is ready to conduct operations provided the necessary operational permits are obtained.

If private capital is willing to fund efforts to prove the effectiveness of OIF as a sequestration technique, in advance of the certainty of generating certified carbon credit sales, then the risk that the answer might be negative is being born by these investors. We see no inherent reason that the

source of capital is relevant to the quality of these experiments. What *is* critical is that the results of these early efforts can be trusted—that a commitment to a high standard of scientific integrity is demonstrated, that project performance data is published openly, and that independent scientists are performing these measurements with separate groups verifying the results.

Should there be a moratorium on commercial projects until environmental impact of OIF can be determined?]

A moratorium on commercial projects would result in shifting the burden for commercial development to the public sector. Even if governments were willing to undertake development of a technology for private sector deployment and profit, the pace of government funding would be substantially slower than that in the private sector and would needlessly delay understanding of whether OIF is an acceptable CO2 mitigation strategy.

All governments have the ability to regulate the activities of their registered vessels and activities in their ports, whether they are party to the London Convention/London Protocol (LC/LP) or not. In addition, governments that are party to the LC/LP also have mutually agreed guidelines that recognize the importance of the marine environment and ecosystem and that foster good governance for the oceans. The LC/LP and its subsidiary bodies are encouraged to provide additional guidance specific to OIF for assessment of project proposals and on-site measurement programs that would be required for such projects. This would allow effective regulation of experiments in the development stage. We assume that the LC/LP will actively follow such development experiments and their results. If development efforts identify either 1) methods that must be employed to avoid unacceptable environmental risks or 2) unacceptable environmental risks that cannot be managed, the LC/LP can take further steps to 1) agree to further guidelines for regulation or 2) consider a moratorium. We believe that this strategy is more likely to result in an appropriate pace of development balanced by responsible oversight.

The scientific community has emphasized that the risk of environmental impact from a few large scale experiments is small (e.g. [IOC 2008], [Buesseler, et al., 2008]). We believe that the risk from experiments during the development phase of OIF can also be minimized:

1) The risk from near term *permitted* projects prior to the development of more formal guidance pertaining to this activity can be minimized through application of the existing LC/Protocol Waste Assessment Guidance.

2) The scale of development phase projects can be guided by the scales that the scientific community has identified as appropriate (i.e., ~ 200 x 200 km).

3) The number of experiments will, we think, be limited during the development phase because of the cost of the substantial research necessary to assess environmental impacts.

4) Site monitoring during development phase experiments could also minimize risk.. Because they would go through a permitting process , there would also be an effective check on these parameters, particularly if further guidance to permitting authorities is provided by the LC.

We believe that an LC/LP moratorium might have the effect of encouraging less scrupulous actors to circumvent oversight by LC/LP parties altogether. Ironically, in the event that some organizations still decide to pursue operating out of non-signatory counties to avoid oversight, the LC/LP would not have control over this activity. It is still possible for developers to go outside the LC/LP and operate from countries that are not signatories in order to avoid regulation (Note: The mere operation from a country that is not a signatory does not imply that activities are irresponsible, but we recognize that the concern of the LC/LP parties is for operation out of non-signatory countries to avoid oversight.)

Under conditions in which developers went outside the LC/LP, it would be the self-imposed standards of the carbon market that would be the primary defense against inappropriate use of OIF. This is one of the reasons that Climos has suggested elements of a Code of Conduct for OIF activities to both the LC/LP and to the carbon markets themselves. We believe unpermitted projects would have a difficult time realizing any commercial potential for their efforts— if not permanently damaging any long term business potential. The major international carbon markets would very likely reject emissions reductions generated in this way, as would most nations' internal markets.

Climos has committed itself to seeking a permit from a signatory country. We have committed to a transparent and peer-reviewed process, open to scientific discussion and assessment. We have recently arranged to sponsor a workshop for the scientific community to participate in the planning of an initial development experiment. This workshop will be hosted at the US National Oceanographic and Atmospheric Administration Pacific Marine Environmental Laboratory. In addition, we have developed an agreement with two of the international global change programs interested in OIF, the Surface Ocean Lower Atmosphere Study (SOLAS) and the Integrated Marine Biogeoscience and Ecology Research (IMBER) programs to review our methodology once it is completed and to help us coordinate and international workshop to discuss results after the cruise.

We believe that permitting authorities will benefit significantly from being able to observe early commercial activity in progress. We plan to establish a high standard for commercial scientific performance and transparency in our operations and we think it is important that any LC/LP guidance established favor a stringent standard of excellence in project execution.

Credibility

Can commercial operators be trusted?

We believe they can. However, we also believe that steps must be taken up front to ensure that trust:

1) We think that permits should be issued only to other potential operators that agree to follow established basic criteria for: advance registration of project specifications, scientific credibility, environmental safeguards, methodological approach, transparency of operations and open availability of data. Climos has published a set of proposed elements for a Code of

Conduct (Climos 2007) that we pledge to uphold. We have encouraged other operators to endorse this code as well.

2) We believe that independent scientists must participate in and provide oversight to the development of OIF. We also believe that it is imperative that independent outside organizations audit both the direct process and integrity of all measurements and observations made, as well as verifiers from the carbon market (who would corroborate that the process undertaken matches a predefined and published methodology established in collaboration with the science community). We believe the carbon markets themselves will enforce these criteria.

3) Environmental markets, though imperfect, have proven quick to punish those that do not provide credits that meet quality standards. There has been a sharp and rapid focus on projects that do not meet an acceptable level of integrity (e.g., (Revkin 2007), (Kollmuss, Zink et al. 2008). OIF, perhaps because of the high level of environmental and scientific scrutiny that it has been subject to, will certainly not escape appropriate review of environmental impacts as well as carbon benefits, One OIF operator has already discontinued operations due to lack of funding, potentially exacerbated by a lack of attention to both efficacy and environmental concerns and the negative press which resulted.

Summary

The threat of global environmental change from anthropogenic CO2 is real and pressing. Scientific research continues to reveal alarming signs that the potential effects will be more immediate and more intense than even the most aggressive prior predictions of the Intergovernmental Panel on Climate Change (Canadell, Le Quere et al. 2007) [IPCC, 2007]. Given that the full effects of CO2 that we are introducing to the atmosphere now will not be felt for many tens of years [IPCC, 2007], any potential opportunities that we have to reduce atmospheric carbon safely and effectively should be encouraged, not discouraged. *Allowing well-designed early OIF projects with appropriate monitoring mechanisms in place is an approach to minimizing environmental risk and allowing for forward movement in addressing the larger GHG reduction issue.* If experiments are not effective at sequestering carbon, they will be halted for commercial reasons. If they are determined to pose a risk of significant adverse effects, they can be halted or modified to mitigate such effects. If they are safe and effective, then each year we are benefiting from them is a year earlier that we are seeing that benefit.

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