The Scientific and Policy Uncertainties Surrounding the Use of Ocean Fertilization to Transfer Atmospheric Carbon Dioxide to the Oceans

A summary statement drafted by participants in a workshop sponsored by the:

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Carbon dioxide (CO_2) is being emitted to the atmosphere in unprecedented amounts and the rate is accelerating. The control of this and other greenhouse gases must be made an international priority, and reducing anthropogenic emissions of CO_2 is of primary importance. Additional mitigation measures may also be required, however, including carbon sequestration strategies. One of the strategies being considered involves adding iron, a plant nutrient, directly to surface seawater in key ocean areas to stimulate phytoplankton growth and use the ocean's 'biological pump' to deliver carbon to the deep sea. This procedure may have the potential to sequester atmospheric CO_2 for centuries.

ASLO invited an international group of experts from academia, industry and government agencies to discuss the scientific and legal issues surrounding intentional fertilization of the ocean. These issues included the limits to our understanding of the ocean carbon cycle, the potential for stimulating ocean productivity, the environmental risks of ocean fertilization, and the appropriate intersection of science, government and industry in the pursuit of this possible CO_2 mitigation option. Although the group was not unanimous on all issues, the workshop generated the following findings and recommendations:

FINDING 1. Re: Carbon dioxide sequestration by ocean fertilization

On the basis of available scientific information, we cannot dismiss ocean fertilization with iron as a mitigation option. However, computer models predict that it would at the very best reduce the expected increase of atmospheric CO_2 by a small percentage[1]. Achieving this degree of sequestration would entail major alterations of the ecosystem — such as changes in food web structure and biogeochemical cycles — as has been demonstrated in several research experiments to date. These changes will have unknown consequences, some of which will be inherently unpredictable.

There is commercial interest in small-scale fertilization experiments to better understand the ocean carbon cycle and to take advantage of anticipated carbon credits. Given the present state of knowledge and technology, it is premature to justify carbon credits for ocean fertilization.

For example:

- There is no current capability to verify the amount and time scales of CO_2 sequestration resulting from ocean fertilization.
- It is difficult to assess biogeochemical and ecological consequences of fertilization in patches[2]. Far-field, long-term and cumulative effects of nutrient applications must be described. This will require computer models validated through observations and process studies.
- Fertilization will very likely result in increased marine emissions of atmospherically important substances, with unknown consequences. These emissions include the potent greenhouse gases nitrous oxide and methane, as well as dimethyl sulfide (which influences cloud formation) and halogenated compounds that are important for the oxidation (cleansing) capacity of the atmosphere.

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[1] These models assume complete utilization of all available nitrogen and phosphorus in the fertilized waters, thus this is a theoretical maximum based on many assumptions. .

[2] Patch fertilization involves the temporary creation of a patch of enriched water, which will dissipate through ocean mixing. Iron enrichment experiments to date have been patch fertilizations.

More fundamentally, there are profound deficiencies in our understanding of a broad range of ocean-atmosphere processes that must be addressed in order to assess the role of the oceans in climate regulation both through natural (via atmospheric mineral matter) and intentional iron enrichment.

Recommendation 1:

ASLO and other partners should initiate plans to convene an internationally sponsored symposium to address the role of marine primary productivity in climate change, including natural events and intentional fertilization of the ocean. The symposium should bring together appropriate scientific and policy experts to summarize the scientific and legal uncertainties behind ocean fertilization.

FINDING 2. Re: Guidelines for the relationship among scientists, industry and government

Recognizing that the global ocean common requires special governance, and that both private and public resources will be used for carrying out the necessary scientific and policy research, partnerships should be created among academic scientists, industry, and government.

Examples for partnerships may come from the biomedical field, as well as other agreements governing the use of the sea.

Recommendation 2:

In addition to accepted standards for any public-private partnership such as transparency, public access to data, and peer review, the partnerships must include:

- ***Shared commitment to advance the understanding of carbon cycle science***
- ***Governmental responsibility, for example an environmental assessment requirement and the notification of potentially affected citizens***
- ***Mechanisms for addressing liability for foreseen and unforeseen circumstances.***

FINDING 3. Re: Governance structure

No appropriate intergovernmental governance structure has been identified with specific authority for ocean fertilization, although many elements of existing treaties and conventions may be applicable to some portion of the ocean fertilization issue. International agreements on activities in the high seas have, for example, advanced the principles of a precautionary approach, the liability of polluters ("polluter pays"), transgenerational equity, and sharing knowledge and benefits.

Recommendation 3:

Review and oversight of intentional ocean fertilization should occur through an international mechanism. To initiate its development, the results of this workshop should be disseminated to the secretariats of the appropriate international, intergovernmental and government organizations for their consideration and action.

In the meantime, the international scientific community should start to develop a code of practice for guiding ocean fertilization research. ASLO should approach other scientific organizations (e.g., the Scientific Committee on Ocean Research, SCOR) and societies to initiate the formation of these guidelines.

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