Office of Science
Notice 03-15

Ocean Carbon Sequestration Research Program

Department of Energy

Office of Science Financial Assistance Program Notice 03-15; Ocean Carbon Sequestration Research Program

AGENCY: U.S. Department of Energy

ACTION: Notice inviting grant applications.

SUMMARY: The Office of Biological and Environmental Research (OBER) of the Office of Science (SC), U.S. Department of Energy (DOE), hereby announces its interest in receiving applications for research on Carbon Sequestration in the Oceans.

DATES: Applicants are strongly encouraged to submit a brief preapplication for programmatic review by January 31, 2003, although later preapplications will still be accepted. The deadline for receipt of formal applications is 4:30 p.m., E.S.T., March 20, 2003, to be accepted for merit review and to permit timely consideration for award in Fiscal Year 2003 and early Fiscal Year 2004.

ADDRESSES: Preapplications should be sent e-mail to Dr. Anna Palmisano at anna.palmisano@science.doe.gov.

Formal applications in response to this solicitation are to be electronically submitted by an authorized institutional business official through DOE's Industry Interactive Procurement System (IIPS) at: http://e-center.doe.gov/. IIPS provides for the posting of solicitations and receipt of applications in a paperless environment via the Internet. In order to submit applications through IIPS your business official will need to register at the IIPS website. The Office of Science will include attachments as part of this notice that provide the appropriate forms in PDF fillable format that are to be submitted through IIPS. Color images should be submitted in IIPS as a separate file in PDF format and identified as such. These images should be kept to a minimum due to the limitations of reproducing them. They should be numbered and referred to in the body of the technical scientific application as Color image 1, Color image 2, etc. Questions regarding the operation of IIPS may be E-mailed to the IIPS Help Desk at: HelpDesk@pr.doe.gov or you may call the help desk at: (800) 683-0751. Further information on the use of IIPS by the Office of Science is available at: http://www.sc.doe.gov/production/grants/grants.html.

If you are unable to submit an application through IIPS please contact the Grants and Contracts Division, Office of Science at: (301) 903-5212 in order to gain assistance for submission through IIPS or to receive special approval and instructions on how to submit printed applications.

FOR FURTHER INFORMATION CONTACT: Dr. Anna Palmisano, SC-74, Office of Biological and Environmental Research, Germantown Building, U.S. Department of Energy, 1000 Independence Ave., SW, Washington, D.C. 20585-1290, telephone: (301) 903-9963, E-mail: anna.palmisano@science.doe.gov, fax: (301) 903-8519. The full text of Program Notice 03-15 is available via the Internet using the following web site address: http://www.sc.doe.gov/production/grants/grants.html.

SUPPLEMENTARY INFORMATION: Predictions of global energy use in the next century suggest a continued increase in carbon emissions and rising concentrations of carbon dioxide (CO_2) in the atmosphere unless major changes are made in the way we produce and use energy - in particular, how we manage carbon. One way to manage carbon is to use energy more efficiently to reduce our need for a major energy and carbon source - fossil fuel combustion. A second way is to increase our use of low- carbon and carbon-free fuels and technologies, such as nuclear power and renewable sources such as solar energy, wind power, and biomass fuels. The third way to manage carbon is by "carbon sequestration": The capture and long term storage of carbon either from the global energy system or directly from the atmosphere in oceanic or terrestrial ecosystems.

Any viable system for sequestering carbon must have several key characteristics. It must be effective and cost-competitive with alternative means, such as renewable energy. Unintended environmental consequences must be benign compared to alternative solutions, including no action. A carbon sequestration system must be able to be monitored quantitatively and verified, because contributions to carbon sequestration almost certainly need to be measured. Research sponsored by this program could contribute to any of these goals.

This solicitation invites applications for basic research projects on the purposeful enhancement of carbon sequestration in the oceans. Although many options exist to capture and sequester carbon dioxide, the focus of this solicitation is on fundamental research that would enable: a) the enhancement of the absorption and retention of atmospheric carbon dioxide by ocean biota; and b) scientifically-based analyses of the viability of using the deep ocean to store carbon dioxide that has been already separated, captured, and transported. The proposed research should be fundamental in nature, and address one or more of the technical areas of interest described below. Applications that test demonstrations of engineered technologies are not relevant to this solicitation.

Technical Areas of Interest

The ocean represents a large current sink for the sequestration of anthropogenic CO_2 emissions as well as a large potential for purposeful enhancement of the current sink. Two strategies for enhancing carbon sequestration in the ocean are the focus of the DOE Ocean Carbon Sequestration Research Program. One strategy is enhancement of the net oceanic uptake from the atmosphere by fertilization of phytoplankton with micronutrients, such as iron. A second strategy

is the direct injection of a relatively pure CO2 stream to ocean depths greater than 1000 m. Sources of CO2 for direct injection might include power plants or other industries. This solicitation seeks applications that specifically address the long term effectiveness and potential environmental consequences of ocean sequestration by these two strategies. The program currently funds projects in a wide range of scientific disciplines including marine biology and ecology; biological, physical, and chemical oceanography; computational science and modeling; and physical chemistry and engineering. Titles and abstracts of research projects currently being funded under the DOE Ocean Carbon Sequestration Research Program may be accessed at http://cdiac2.esd.ornl.gov/ocean.html.

Iron Fertilization

Much has been learned about the important role of iron in photosynthesis over the past 15 years through both laboratory and field experiments on iron enrichment. Iron deficiency has been shown to limit the efficiency of photosystem II in phytoplankton. Evidence from paleoceanographic samples also links iron supply with marine primary production and carbon flux. However, critical questions remain: How does iron enrichment accelerate carbon flux in high nutrient, low chlorophyll (HNLC), low nutrient, low chlorophyll (LNLC), sub-mixed layer and coastal ecosystems? What are the time scales of remineralization of the fixed carbon? What are the long term ecological and biogeochemical consequences of fertilization on surface and midwater processes? Basic research is needed on the coupling of iron and carbon cycles in the ocean. Our understanding of the biogeochemistry of iron (its concentrations, sources, sinks and ligands) in marine systems is also insufficient to assess the viability of using iron fertilization as a strategy for enhancing carbon sequestration.

The accurate measure of carbon flux following iron fertilization is critical to the objective evaluation of this strategy for carbon sequestration. We need to understand the regulation of carbon fluxes and the role of mineral ballast in export of organic carbon from the surface to the deep ocean. The potential impact of iron fertilization on the global carbon budget, as well as verification and duration of carbon sequestration are yet unknown. The complexity of marine ecosystems necessitates careful research on unintended environmental consequences of iron fertilization. These consequences may include the potential to impact key oceanic biogeochemical cycles as well as on populations of marine organisms and their trophodynamic interactions.

Research may focus on experimental/observational studies and/or predictive modeling. Integrative studies that couple experimental observations and numerical modeling approaches are encouraged. Such studies should develop, improve, and test models that can be used to simulate and predict quantities of carbon sequestered from iron fertilization. Relevant focus areas for enhancement of the biological pump through iron fertilization may include:

1. Improving the effectiveness of ocean fertilization as a strategy for long term (decades, centuries) carbon sequestration.

- Determining to what extent increased carbon fixation in surface waters would result in an increase in carbon sequestered in the deep ocean, and how long it would remain

sequestered. This includes quantifying the export of particulate organic carbon and particulate inorganic carbon to the deep sea, and mineralization or dissolution of all forms at depth.

- Understanding the role of micronutrients (such as iron) and macronutrients (such as nitrogen and phosphorus) in regulation of the biological pump. Research on coupling of iron and carbon cycles might include studies of photo-oxidation, complexation adsorption/desorption, export and mineralization.
- Developing numerical models (regional or global) for carbon sequestration, especially those that provide a measurable output that allows for model testing. Models might be used to predict the efficiency of sequestration as a function of mid and deep water transport of carbon and remineralization.

2. Determining environmental consequences of long term ocean fertilization.

- Examining changes in structure and functioning of marine ecosystems (composition of phytoplankton and zooplankton communities, ocean food webs and trophodynamics), resulting from ocean fertilization.
- Examining changes in natural oceanic biogeochemical cycles (carbon, nitrogen, phosphorus, and silicon) resulting from iron fertilization.
- Developing numerical models at an ecosystem level that predict downstream effects of fertilization on productivity and nutrient removal.

Research proposed on iron fertilization should also support the USGCRP Carbon Cycle Science Initiative (http://www.gcrio.org/OnLnDoc/pdf/carb_cycle_toc.html). In particular, the proposed research should provide the scientific foundation for assessing both the viability of using iron fertilization to enhance sequestration and storage of carbon dioxide and/or the potential for unintended effects of this carbon sequestration strategy.

Direct Injection

The overarching questions for this area of research are: Can direct CO2 injection effectively sequester CO2 in the ocean with minimal adverse environmental impacts? How and where might direct injection of CO2 be most effective as a carbon sequestration strategy? What are the plume dynamics and hydrate behavior at depth? Fundamental research is needed to: assess the efficiency and consequences of direct injection; calculate the maximum ability of the ocean to sequester a maximum tolerable level of CO2, while minimizing the impact on marine ecosystems. Current scientific literature on the physiology of deep sea animals suggests a high sensitivity of deep sea animals to acidosis and hypercapnia (CO2 stress), however, there are few data on impacts of specific levels of CO2 on animals from various marine habitats. Moreover, there are virtually no data on the potential effects of CO2 on microbially-mediated biogeochemical transformations of nutrients in the deep sea. Models are needed that provide information on the fate of injected CO2, particularly in the 100m to 100km range, from the point of injection. The ultimate goal is to be able to develop a coupled model that can predict the fate of injected CO2 and its chemical, physical and biological effects on marine ecosystems.

Research may focus on experimental/observational studies and/or predictive modeling. Integrative studies that couple both experimental and numerical modeling are encouraged, especially those incorporate feedback between experiments and models. Such projects should involve experimental studies to test and improve models, and modeling studies to help identify and design experiments needed to fill key gaps in our understanding. Examples of relevant research areas for direct injection of carbon dioxide into the deep ocean include:

1. Determining the environmental consequences of direct injection of CO2 into the ocean in midwater or deep sea habitats.

- Determining the effects of changes in pH and CO2 on the physiology and survival of organisms (including microbes) from midwater and deep sea habitats. These studies might include lethal or sublethal effects on organisms.
- Understanding the effects of sustained release of concentrated CO2 on biogeochemical processes, and on ecosystem structure and function. This might include investigations of biogeochemical interactions of seafloor sediments with a hydrated CO2 plume.
- Effects of secondary of contaminants on plume and/or hydrate physical/chemical properties, and related effects on indigenous fauna.

2. Improving the effectiveness of direct injection of CO2 for carbon sequestration.

- Understanding the longer-term fate of carbon that is added to the ocean including the carbonate chemistry of mid- and deep-ocean water.
- Investigation of physico-chemical behavior of a dense phase hydrate stream. Research might focus on such characteristics as determination of hydrate dissolution rates for a concentrated swarm, and calculation of plume dispersion and perturbation to state variables at depth.
- Addressing weaknesses in aspects of the Ocean General Circulation Models (OGCMs), specifically their ability to simulate accurately western boundary currents, ocean bottom currents, plume to eddy circulation; and testing models using natural or experimental tracers.
- Coupling near-field with far-field effects of CO2 injection, for example, coupling plume modeling at the basin and global scale with ocean circulation models.

Collaboration

Applicants are encouraged to collaborate with researchers in other institutions, such as: universities, industry, non-profit organizations, federal laboratories and Federally Funded Research and Development Centers (FFRDCs), including the DOE National Laboratories, where appropriate, and to include cost sharing and/or consortia wherever feasible. Additional information on collaboration is available in the Application Guide for the Office of Science Financial Assistance Program that is available via the Internet at: http://www.sc.doe.gov/production/grants/Colab.html.

Program Funding

It is anticipated that up to $1,500,000 (per year) will be available for awards in this area during Fiscal Year 2003, contingent upon availability of appropriated funds. An additional $1,000,000 will be available for competition by DOE National Laboratories under a separate solicitation (LAB 03-15). Projects involving single investigators or small groups of investigators may be funded at a level up to $300,000 per year for up to 3 years. Integrative studies, multi-investigator studies that combine experimental/observational approaches with numerical modeling may be funded at a level of up to $400,000 per year for 3 years. Applications for field experiments involving larger groups of investigators will be considered, but must be approved at a preapplication level. Multiple year funding of awards is expected, and is also contingent upon availability of funds, progress of the research, and continuing program need.

Preapplications

An informal preapplication may be submitted by E-mail. The preapplication should identify the institution, Principal Investigator name, address, telephone, fax and E-mail address, title of the project, and proposed collaborators. The preapplication should consist of a one to two page narrative describing the research project objectives and methods of accomplishment. These will be reviewed relative to the scope and research needs of the Ocean Carbon Sequestration Research Program. Preapplications are strongly encouraged prior to submission of a full application, especially for large, field-based collaborations. Notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Formal Applications

Applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d):

1. Scientific and/or Technical Merit of the Project;
2. Appropriateness of the Proposed Method or Approach;
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources;
4. Reasonableness and Appropriateness of the Proposed Budget.

For renewals, progress on previous DOE-funded research will be an important criterion for evaluation. The evaluation will include program policy factors such as the relevance of the proposed research to the terms of the announcement, the agency's programmatic needs, and the uniqueness of approach. Note, external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Both non-federal and federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Information about the development and submission of applications, eligibility, limitations, evaluation, selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Science Financial Assistance Program. Electronic access to the Guide and required forms is made available via the World Wide Web at:

http://www.sc.doe.gov/production/grants/grants.html. DOE is under no obligation to pay for any costs associated with the preparation or submission of applications if an award is not made.

The research project description must be 20 pages or less, exclusive of attachments and must contain an abstract or summary of the proposed research. Applicants who have had prior Ocean Carbon Sequestration Research Program support must include a Progress Section with a brief description of results and a list of publications derived from that funding. On the SC grant face page, form DOE F 4650.2, in block 15, also provide the PI's phone number, fax number and E-mail address. Attachments include curriculum vitae, a listing of all current and pending federal support, and letters of intent when collaborations are part of the proposed research. Curriculum vitae should be submitted in a form similar to that of NIH or NSF (two to three pages).

The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CFR Part 605.

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Associate Director of Science
for Resource Management

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