Chapter 9

Sequestration of Carbon Dioxide by Ocean Fertilization

Michael Markels, Jr. and Richard T. Barber
GreenSea Venture, Inc.: Duke University, Nicholas School of the Environment, USA

Abstract: Sequestration of carbon dioxide to the deep ocean by the fertilization of high nutrient, low chlorophyll (HNLC) ocean waters can be an answer to the concerns arising from the increasing carbon dioxide content of the atmosphere. This approach has the potential to sequester about 400,000,000 tons of carbon dioxide by repeated episodic fertilizations of the Pacific equatorial current for a cost of about $2.00/ton of carbon dioxide and for 1000 to 2000 years. A technology demonstration is planned to fertilize an area of 5,000 square miles of the equatorial Pacific that is expected to sequester between 600,000 and 2,000,000 tons of carbon dioxide in a period of 20 days. The ecological changes expected consist of the increase in diatoms, which double or triple each day until the limiting fertilizing element is used up. No adverse changes are expected, since this is exactly what happens naturally when episodic fertilization occurs in the open ocean. The concept is that fertilization of HNLC waters with chelated iron will cause a bloom of phytoplankton that sink below the thermocline into deep water due to their high density after they die. The experiment, while large by land comparisons, is small in terms of ocean area, about one square degree at the equator. The demonstration protocol will include measurements of the amount of carbon dioxide that is removed from the surface layer and the amount of organic carbon that is produced and exported to the ocean depths as well as other effects in the water column over a period of 20 days. After this time no further effects of iron fertilization are expected to take place because macronutrient elements (N, P and Si) are depleted to limiting concentrations. Since the iron enrichment is transient, no steady-state modification of the food web will occur. The experiment will be carried out outside the EEZ of any nation, as were the previous five experimental voyages, so, like them, no permits will be required. The five recent ocean experiments observed iron stimulation of phytoplankton growth, but the effects were difficult to quantify in the 9 to 28 square mile experiments since eddy diffusion along the edges of the patch diluted the bloom. This problem will be minimized in the planned technology demonstration because its larger area restricts the diffusion from the center of the patch to less than 2% of the concentration over the 20 day period of the test.

Key words: Ocean fertilization, iron fertilization, CO_2 sequestration, ocean sequestration

Environmental Challenges and Greenhouse Gas Control for Fossil Fuel Utilization in the 21st Century, Edited by Maroto-Valer *et al.*, Kluwer Academic/Plenum Publishers, New York, 2002

1. INTRODUCTION

The CO_2 content of the atmosphere has increased from about 280 ppm to about 365 ppm during the last 60 years[1]. During the 1980's the rate of increase of CO_2 in the atmosphere, in terms of carbon metric tons, was about 3.3 gigatons of carbon per year (GtC/yr). Fossil fuel emissions were about 5.5 GtC/yr (20 Gt CO_2/yr)* and terrestrial emissions were about 1.1 GtC/yr during that period, so about 3.3 GtC/yr, 60% of fossil fuel emissions, were sequestered naturally. Of this, about 2.0 GtC/yr was absorbed by the oceans and 1.3 GtC/yr by the land.[2] The remaining 40%, 2.2 GtC (8.1 $GtCO_2$)/yr, contributed to the increasing atmospheric CO_2 concentration. This increase in the CO_2 content of the atmosphere has led to concerns that this increase will result in global climate change, which, over time, can have adverse effects on weather, sea level and human survival. This concern has led to the 1992 Rio Treaty, the IPCC Working Group** and the Kyoto Protocol of 1997, which call for a reduction of emissions of 34% by 2050 and a reduction of 70% from the then-expected emissions by 2100[3]. These reductions, if put into effect, would not materially reduce the CO_2 content of the atmosphere since they only include the industrialized nations. The fast growing nations of India, China and the African continent are not included and would overwhelm the planned reductions by 2050 and 2100. However, these reductions would have serious adverse effects on the economy of the United States, causing loss of jobs, decrease in our standard of living and a reduction in the life span of our citizens. These required reductions would not address the concerns that demand an approach to permit the reversal of atmospheric CO_2 increase, should this become necessary.

2. THE PROBLEM

The problem is how to address peoples' concerns. A proven technology is required that has the capacity to reverse the increase in the CO_2 content of the atmosphere without relying on changes in peoples' habits, numbers or standard of living. It must be affordable, reliable and environmentally benign. It must include provisions to monitor the effects of the CO_2 content of the atmosphere and predict the future global results so that the introduction of the technology can be initiated in time to do this. Continued experiments in the oceans must be undertaken to validate the models so that people and scientists can rely on the modelling results. The key concern is that we could be moving to an instability point in the environment that could

* 1GtC = 3.67 Gt CO_2.

** IPCC (Intergovernmental Panel on Climate Change) 1996.