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Reducing atmospheric carbon dioxide: Oceans provide a huge opportunity for sequestration

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REDUCING ATMOSPHERIC CARBON DIOXIDE

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Introduction

The scientific community is fairly unified in their assessment of climatological change. It is happening primarily as the result of excess carbon dioxide (CO_2) in the atmosphere produced by unrelenting world industrialization. If it continues unabated it will cause major physical changes to the earth that will dramatically alter how mankind lives. And, the world has until the middle of this century to cap CO_2 levels short of where they will cause this irreversible change.

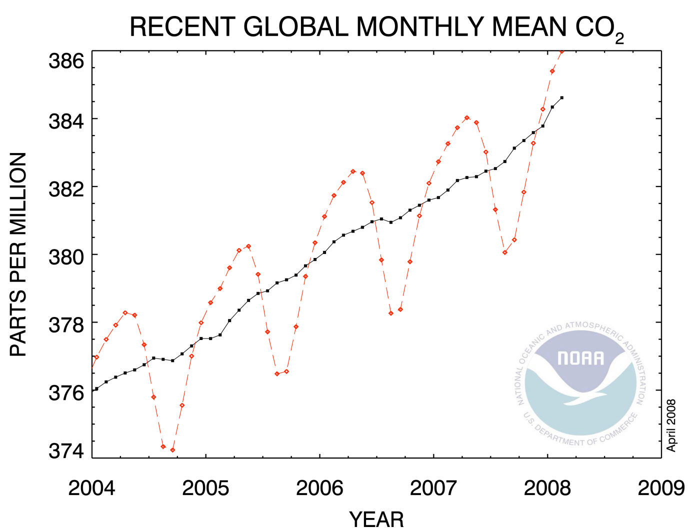
For many experts involved in this issue, actively reducing existing CO_2 levels is a necessary component for a total solution to the problem. This paper endeavors to outline potential technologies that promise to accomplish this.

Quantifying the Problem

For hundreds of thousands of years, the level of CO_2 in the earth's atmosphere has generally ranged from 200 to 300 parts per million by volume. Fluctuations have mainly been the result of ice age cycles. The industrial revolution, which was energized by carbon based fuels, has caused and continues to cause a dramatic rise in atmospheric carbon dioxide concentration.[1]

During the 19th Century, CO_2 concentration levels rose approximately 50 ppm. In the 20th Century the rise was much more pronounced when another 100 ppm were added to the atmosphere. As of 2007 the atmosphere contained 383 ppm - the highest concentration in the last 650,000 years.[2]

More frightening is the fact that the rate of increase keeps climbing. So while the world talks about reducing carbon emissions, progress has yet to be realized.[3]



National Oceanic and Atmospheric Administration

Carbon Battered Oceans

The largest natural areas that remain on earth are oceans and forests, both of which are carbon sinks - they take up carbon from the atmosphere. But these sinks are overworked carbon reducing engines. Deforestation has diminished the ability of land based plants to reduce CO_2 and the oceans have undergone significant change due to industrialization. After more than a century of absorbing CO_2 due to fossil fuel emissions, the oceans have become 30% more acidic and the phytoplankton population has decreased by 30%. The decrease in plankton has negatively impacted the ability of the world's oceans to process carbon.[4]

The oceans are perhaps the most important tool in fighting high CO_2 levels. They comprise 70% of the earth's surface and consume 25% of anthropogenic CO_2 emissions. It is clear then that their integrity must be restored and perhaps even enhanced to make them a counterweight to ongoing fossil fuel emissions. New and interesting solutions are emerging that need to be considered.

Making Oceans Hungry

Through the process of photosynthesis, plankton takes in carbon dioxide and gives off oxygen in much the same way that land-based plants do. Plankton live in large colonies throughout the oceans of the world and when they eventually die they sink to the bottom of the ocean taking carbon with them. This is about as simple and natural a carbon sequestration method that exists. However, not all the plankton makes it to the bottom. A certain percentage are consumed by other marine life before reaching the bottom and the carbon they contain is eventually reintroduced to the atmosphere.

The amount of plankton that actually makes it to the bottom of the ocean varies from as low as 20% to as high as 50%.[5] Scientists are just beginning to discover why such variations exist, but regardless, this is a key determinant in how much carbon is sequestered. The other key factor is the size and health of plankton colonies, the more and heartier the colonies, the greater the potential for carbon sequestration.

Like other living organisms, plankton health depends on the nutrients it ingests. The oceans however are not homogenous. Plankton does not occur everywhere and some locations have more nutrients than others. Thus there is a wide range of plankton concentration and fertility.

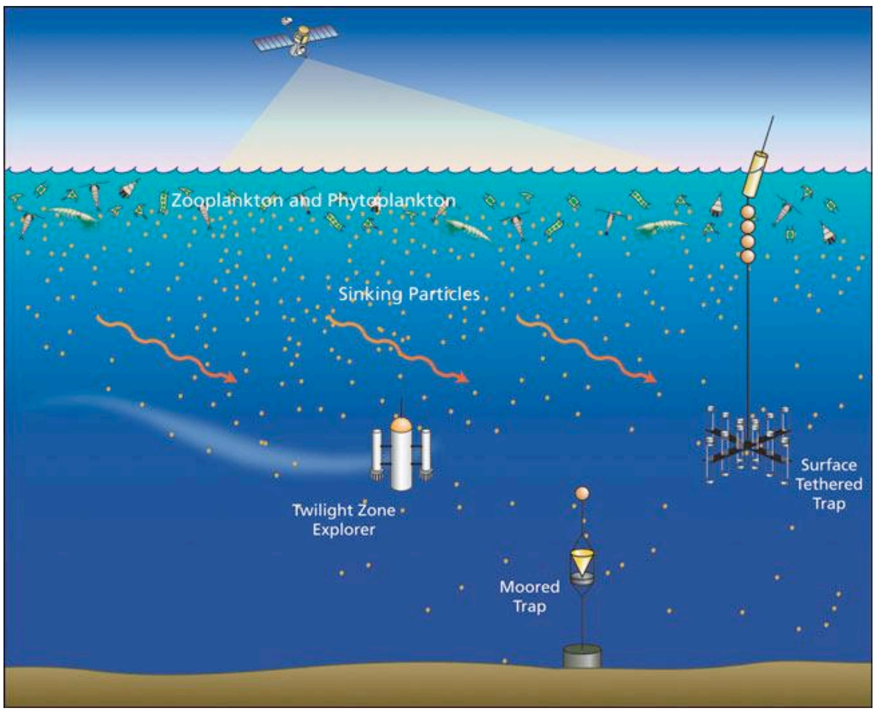
Most photosynthesis occurs from the surface of the ocean down to about 100 meters where sunlight penetration is greatest. If nutrients are plentiful and the water is cold, plankton flourish and carbon absorption is good. Most nutrients exist some 1,000 meters below the surface but rise to the surface by natural oceanic movements. Global warming has diminished this natural movement which accounts for the 30% reduction in plankton life. To return and even increase plankton populations, nutrients now need assistance to make their way to the surface.

In addition to supplying more nutrients to the surface for plankton to consume, scientists are also looking at ways to increase the amount of dead plankton that sink to the bottom of the ocean. The area of the ocean from 100 to 1,000 meters deep, known as the twilight zone, is the area where sinking plankton are consumed by other sea life. If scientists were able to assist dead plankton to make it through the twilight zone, even more gains would be made in carbon sequestration.

About a dozen research projects are currently underway that either attempt to fertilize the ocean to promote plankton development and/or to facilitate dead plankton's decent through the twilight zone to the ocean floor. Two in particular are discussed here to explore the potential of this approach to carbon sequestration.

A relatively simple project is being conducted by Professors David Karl, Ricardo Letelier, and Brian Von Herzen. They have designed a 1,000 foot long wave-powered tubular pump that promises to bring nutrients to the surface to create plankton blooms. The devices, which are predominantly polypropylene, cost a mere $150,000. And while the bloom spread from each device is yet to be determined, thousands or tens of thousands of them could be distributed to significantly increase plankton life.

A more robust project involves more than 40 scientists who are studying the sinking of dead plankton through the twilight zone in hopes of better understanding the dynamics. The rate of decent and the amount (percentage) vary greatly throughout the ocean. Maximizing both would be an obvious boost to the process.[6]



New Science Environment

This project utilizes various types of traps to capture and record the life cycle of plankton all monitored by satellite. Very little is know about the subtleties of the twilight zone as it pertains to plankton so this project may shed valuable light on facilitating their path all the way to the ocean floor.

To predict the impact of these types of projects is very difficult to ascertain given the infancy of the technology at this point. However, given the size of the oceans and how much they are already contributing to the absorption of CO_2 one would have to conclude that the impact has the potential of being very great. The same can be said for cost, although the relatively inexpensive tubular pumps seem well worth the investment even if they proved to be only moderately successful.

The biggest drawbacks for this approach to carbon management are the potential negative environmental impacts and the policies required for implementation. Ocean ecology is a very complex and fragile system unto itself. Can mankind really initiate such changes and expect no disruptions to other interrelated natural cycles? If such is the case, is there risk of creating more damage than that which is being fixed? These types of questions need to be kept in the forefront as this research continues.

Should these environmental concerns be relieved, and the technologies found to be effective, then what policies will be needed to make them become a reality? The biggest challenge has to do with the fact that the oceans predominantly belong to no single country. To implement a large scale project on international waters one would be hard pressed to determine what permissions would be needed and from whom they should be obtained. And of course the bottom line surfaces as to who should pay for these potential solutions?

Any endeavor that involves multiple nations would almost certainly mean slow progress and a complex process. How then might these barriers be overcome? The logical platform for this type of activity would be within the Kyoto Protocol and/or its successor(s). The basis for this agreement is for nations to meet reduced target emissions in the future. Since it is net emissions that are used, a county's sink resources become very important. If a country paid for an ocean sequestration project they would be the obvious beneficiary of its carbon credit.

Summary

The oceans of the earth cover some 70% of the surface area. While they are already a carbon sink, they have the potential of becoming even greater predominantly due to photosynthesis by phytoplankton. If the growth of plankton were stimulated and its ability to sink to the ocean floor enhanced, the resultant carbon sequestration could have significant impact on excess CO2 in the atmosphere.

While there are risks and policy issues to be overcome, in the short term, deep ocean carbon sequestration is an important element in an overall carbon reformation plan.

1. *Carbon Dioxide, Methane Rise Sharply in 2007*; National Oceanic and Atmospheric Administration; April 23, 2008
2. *Globalwarmingart.com*; Robert A. Rohde; 2008
3. *Carbon dioxide emissions even higher as China becomes world's No. 1 emitter*; Taipei Times; September 27, 2008
4. *The First State of the Carbon Cycle Report (SOCCR)*; A.W. King, et. al.; U.S. Climate Change Science Program; 2008
5. *Hungry Oceans Dummies Guide;* Discovery Project Earth; The Discovery Channel; http://dsc.discovery.com; 2008
6. *Ocean gobbles carbon at different rates*; Catherine Brahic; New Science Environment; April 2007