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Viewpoint

Ocean urea fertilization for carbon credits poses high ecological risks

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A B S T R A C T

The proposed plan for enrichment of the Sulu Sea, Philippines, a region of rich marine biodiversity, with thousands of tonnes of urea in order to stimulate algal blooms and sequester carbon is flawed for multiple reasons. Urea is preferentially used as a nitrogen source by some cyanobacteria and dinoflagellates, many of which are neutrally or positively buoyant. Biological pumps to the deep sea are classically leaky, and the inefficient burial of new biomass makes the estimation of a net loss of carbon from the atmosphere questionable at best. The potential for growth of toxic dinoflagellates is also high, as many grow well on urea and some even increase their toxicity when grown on urea. Many toxic dinoflagellates form cysts which can settle to the sediment and germinate in subsequent years, forming new blooms even without further fertilization. If large-scale blooms do occur, it is likely that they will contribute to hypoxia in the bottom waters upon decomposition. Lastly, urea production requires fossil fuel usage, further limiting the potential for net carbon sequestration. The environmental and economic impacts are potentially great and need to be rigorously assessed.

1. Introduction

Large-scale ocean enrichment experiments have been conducted over the past two decades to understand the response of the oceans to limiting nutrients. Most of these experiments have involved iron additions to the equatorial North Pacific, the subarctic Pacific, and the Southern Ocean, which are known as high-nutrient, low-chlorophyll (HNLC) areas where there is apparent ample macro-nutrient availability (nitrogen, phosphorus), but limited micro-nutrients (iron), and thus limited phytoplankton accumulation (de Baar et al., 2005; Boyd et al., 2007; Buesseler et al., 2008). Application of such research has led some to suggest that with such ocean enrichment, carbon sequestration can be enhanced, and this may serve as one approach to reduce the build-up of greenhouse gases in the atmosphere.

Iron experiments, now totaling more than a dozen (de Baar et al., 2005; Boyd et al., 2007; Buesseler et al., 2008), have shown that phytoplankton blooms can be successfully manufactured, and this has caught the attention of the business community as a means to promote engineered solutions to climate change. The carbon-offsets market is rapidly expanding, and new enterprises are seeking methods to sequester atmospheric carbon as part of cap-and-trade programs. If phytoplankton blooms can lock away carbon through sinking to the deep sea, the market for these carbon offsets could be very large, particularly if an international quota system for carbon trading is agreed upon. However, large-scale manipulation of iron in regions of the ocean where this element is limiting is economically challenging. Thus, entrepreneurs are turning to regions where the limiting nutrient is nitrogen, not iron, with the hopes of enriching waters with this element.

A current plan, as announced by the Ocean Nourishment Corporation of Sydney, Australia, calls for the dispersement of 1000 tonnes of urea in the Sulu Sea, off the coast of the Philippines beginning in 2008 (Young, 2007), although preliminary trials apparently have already begun (Aning, 2007). Broader oceanic applications are also projected beyond the Sulu Sea in the future (http://www.ocean-nourishment.com/technology.asp). The goal is not only to remove carbon from the atmosphere by increasing algal biomass production and sequestration through sinking, but also to enhance primary production that leads to enhanced local fish production.

The effects of nutrient enrichment on an ecosystem must be considered from multiple perspectives, including physical, biological, and socioeconomic (e.g., Nixon, 1995; Howarth et al., 2000; Cloern, 2001). Urea ($(NH_2)_2CO$) is a nitrogen fertilizer and feed additive, the global use of which has increased 100-fold in the past 4 decades (Glibert et al., 2006), and there is a large and growing body of literature on nitrogen cycling and urea metabolism by phytoplankton. These data permit us to propose several specific predictions about the Sulu Sea in particular and the fate of urea pumped into tropical or subtropical seas in general. Here we argue that this plan will likely not lead to enhanced fisheries or carbon sequestration. Instead, there is a real possibility that fisheries and the regional aquatic ecosystem could be significantly damaged for years to come, yielding environmental damage that could far outweigh the gains of carbon offsets.

2. The Sulu Sea

The Sulu Sea, a deep oceanic basin, is isolated from the surrounding ocean by a chain of islands, making it a region of restricted water exchange (Jones, 2002). It is connected to the South China Sea in the south through the Balabac Strait, and in the north via the Palawan shelf and Mindoro Strait (Jones, 2002; Campos and Villanoy, 2007). These connections are believed to

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