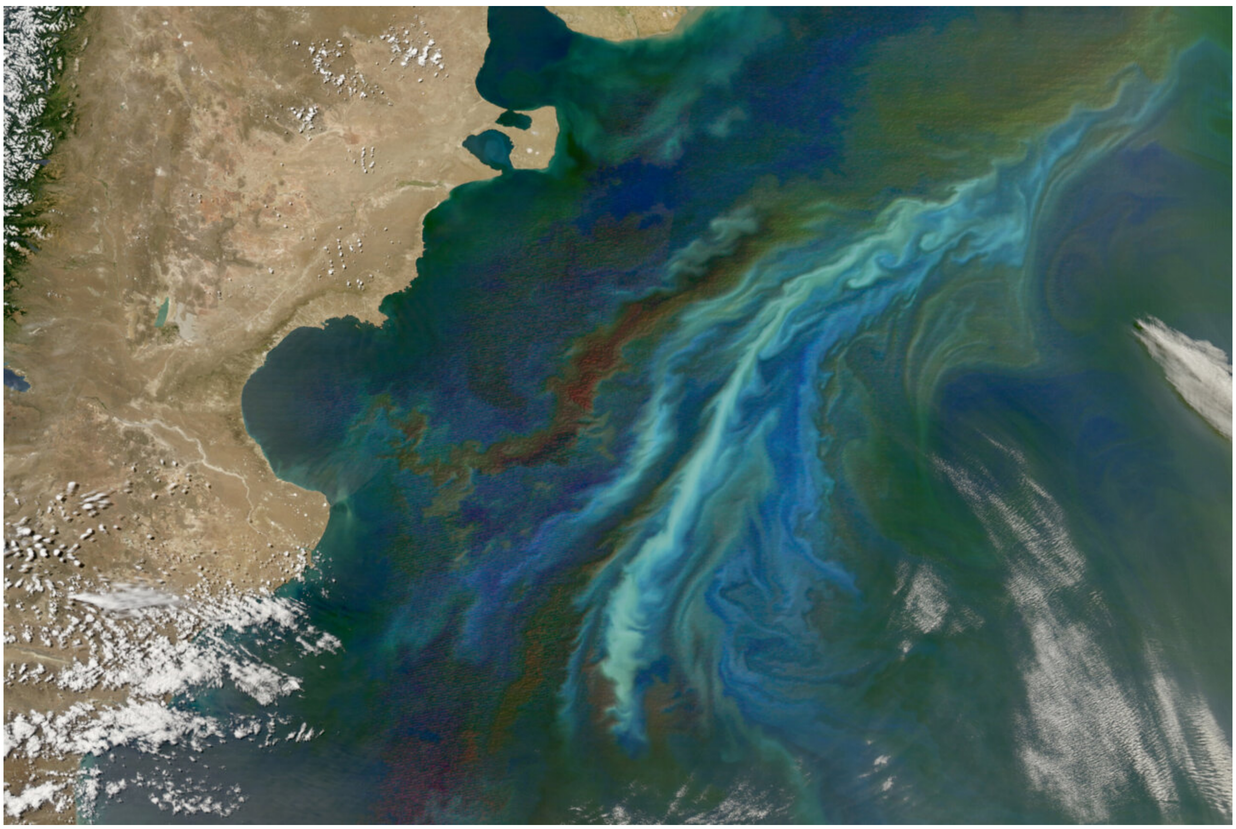
New research uncovers potential benefits, consequences of ocean iron fertilization

July 7 2023



Satellite image of a large phytoplankton bloom in 2010 off Patagonia, at the southern tip of South America, of the kind that could be triggered by ocean iron fertilization to help remove carbon dioxide from the atmosphere. Credit: NASA Earth Observatory

Removal of excess carbon dioxide in the atmosphere, in addition to major reductions in ongoing emissions, is required to stave off the most severe consequences of climate change. Large-scale ocean iron fertilization is one of several strategies that could help remove carbon dioxide, but new research published this week in *Global Change Biology* by a Bigelow Laboratory for Ocean Sciences researcher and colleagues shows that it might also negatively affect marine ecosystems in far corners of the ocean.

Using advanced models of ocean biogeochemistry and ecology, the team showed that iron fertilization in the Southern Ocean could exacerbate climate change-driven nutrient shortages and productivity losses in the tropics, potentially hurting the coastal fisheries on which many people rely. The findings illustrate both the interconnected nature of the ocean and the need for more objective research on the relative advantages and unintended consequences of marine carbon dioxide removal.

"These modeling experiments demonstrate the need to understand not only the implications of marine carbon dioxide removal strategies for carbon cycling, but also the ecological and 'downstream' implications, even those decades in the future or thousands of miles away," said Bigelow Laboratory Senior Research Scientist Ben Twining, one of the study's co-lead authors.

The ocean is the planet's largest sink for carbon emissions. Unsurprisingly, then, plans for carbon dioxide removal are increasingly focused on marine-based strategies like iron fertilization. The basic idea is that adding valuable micronutrients to certain areas of the ocean—like the iron-limited Southern Ocean—will stimulate primary productivity by allowing other nutrients to be more completely consumed, enhancing the amount of carbon dioxide that phytoplankton absorb at the surface and, ultimately, sink to the seafloor when they die.

Advocates for ocean iron fertilization have pointed out that the solution doesn't require land or freshwater and can be implemented more quickly than other strategies. And past modeling efforts have shown that iron fertilization does indeed reduce atmospheric carbon.

However, early research also showed that fertilization could exacerbate a process known as "nutrient robbing" by hampering the supply of critical nutrients from iron-limited areas to adjacent regions, in turn reducing the amount of marine life and productivity at the tropics.

On top of that, a 2021 report by the U.S. National Academies of Science argued that the current knowledge base around marine carbon dioxide removal approaches like fertilization was insufficient, especially when it came to scientists' understanding of how fertilization would interact with other climate-change driven changes to ocean processes.

To help fill some of those knowledge gaps, the authors of the current study expanded previous modeling work, incorporating recent research on how phytoplankton use micronutrients like iron and additional considerations for climate change and fisheries impacts.

"One of the new aspects of our work was to layer ocean iron fertilization on top of climate change," Twining said. "We also connected our results to a fisheries model, as a way to put the predicted changes in productivity into terms that are more meaningful to people."

Their results showed a five percent decline in the biomass of fish and marine species in the tropics, including economically important coastal areas, due to large-scale iron fertilization. This was on top of a 15 percent decline expected due to climate change as warming temperatures stratify the ocean, depriving the surface of critical nutrients.

"It's notable how the 'fingerprint' of ocean iron fertilization on the levels of nutrients was similar to that expected from climate change," said co-lead author of the study, Alessandro Tagliabue at the University of Liverpool. "This raises significant hurdles to the detection and monitoring of any negative impacts of fertilization."

The models did show that iron fertilization could remove up to 45 gigatonnes of carbon dioxide from the ocean surface between 2005 and 2100. But, while removing half a gigatonne a year is not insignificant, the authors stress it's very limited when compared to the current rate of carbon emissions—and the reductions required to meet climate targets.

"A lot of the conversation about carbon dioxide removal is just focused on the carbon," Twining added. "But clearly we need to evaluate, not just the carbon part of it, but the other ecosystem effects in an interconnected system."

The nuanced results of the study highlight the importance of objective and rigorous research of the relative merits—and potential harms—of ocean iron fertilization. It also shows the value of modeling efforts that can capture the large space and time scales concerned.

Scaling up those research efforts significantly in the coming years is essential, Twining said, in order to make informed decisions about these strategies while addressing the urgent threats of climate change. Future research should include continuing to improve existing models as scientists' understanding of how carbon, iron and other nutrients behave in the ocean evolve.

"We are at a critical moment in the planning and development of carbon dioxide removal approaches," Twining said. "Rigorous, peer-reviewed, purpose-designed research and experimentation will be central to evaluating all possible approaches."

More information: Alessandro Tagliabue et al, Ocean iron

fertilization may amplify climate change pressures on marine animal biomass for limited climate benefit, *Global Change Biology* (2023). DOI: 10.1111/gcb.16854

Provided by Bigelow Laboratory for Ocean Sciences