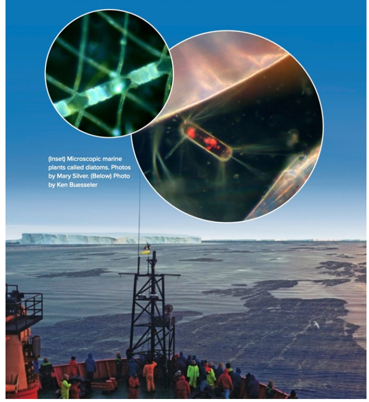
Exploring Ocean Iron as a Potential Climate Solution

EXOIS
EXPLORING OCEAN IRON SOLUTIONS

Ocean-based climate solutions

The ocean is home to a vast abundance and diversity of life. It provides a source of food and livelihoods that people and communities around the world depend upon. The continued warming of Earth is pushing many parts of the ocean into unknown, and often dangerous, territory. The next 5-10 years are critical if humanity hopes to avoid the worst consequences of continued change.

Leading scientific organizations agree that the only way to solve the climate crisis is to both cut emissions and pursue the widest possible range of science-based carbon dioxide removal (CDR) strategies. No single CDR approach is likely to provide the scale needed, therefore we must responsibly investigate all options while working to cut emissions.

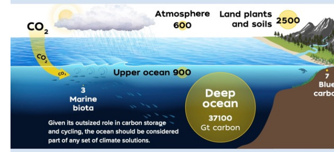


(Inset) Microscopic marine plants called diatoms. Photos by Mary Silver. (Below) Photo by Ken Buesseler

The case for ocean iron fertilization

Enhancing the growth of phytoplankton (marine plants) by adding relatively small amounts of iron to key parts of the ocean is one promising approach to carbon dioxide removal (CDR). This increases both the ocean's uptake of carbon dioxide from the atmosphere and the amount of carbon that is sequestered at depth, where it can no longer warm the planet.

Evidence suggests ocean iron fertilization (OIF) can potentially reach the billion-tonne (Gt) scale. If effective at removing atmospheric carbon dioxide, OIF should lead to less acidification of the ocean's surface, while also stimulating the base of the ocean food web. Moreover, the costs and consequences of acquiring and dispersing iron are minimal—new mining isn't required, even at scales relevant for climate mitigation.



What are the potential risks?

As with any form of marine CDR, there are potential concerns and risks. For example, as a consequence of stimulating plankton growth, sinking organic matter can reduce subsurface oxygen levels and may produce other greenhouse gases (N_2O, CH_4). Thirteen prior OIF studies, and observations of many naturally fertilized phytoplankton blooms, demonstrate that such effects can be measured, and are small relative to the potential large net positive impact of removing carbon dioxide with OIF.

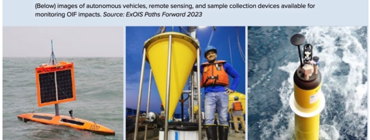
Also of concern is how well we can anticipate any unintended ecological shifts, such as harmful algal blooms or if increases in productivity in one part of the ocean reduces productivity in other regions. Because of these unknowns, field studies that measure potential negative impacts, and uncertainty around them, are urgently needed. Studies that include off-ramps if negative consequences do occur and that have rigorous and transparent oversight from experts in both their design and execution are also critical.

What is the role for social science and governance experts?

Future OIF research must be developed and conducted in collaboration with social science experts to ensure they include community outreach and engagement, and are conducted in an open and transparent manner with the appropriate social safeguards.

International regulations allow for the permitting of legitimate scientific research and include environmental impact assessments as part of the process.

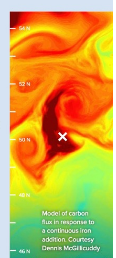
(Below) images of autonomous vehicles, remote sensing, and sample collection devices available for monitoring OIF impacts. *Source: ExOIS Paths Forward 2023*



What are the modeling challenges?

Models help us scale from local to regional and global impacts and predict outcomes of a future with and without marine carbon dioxide removal (mCDR). However, even the most complex models often oversimplify ocean dynamics and overlook key biological and chemical processes, such as plankton diversity, harmful algal blooms, and nitrous oxide (N_2O) emissions. In addition, carbon transport to the deep sea, which is key to predicting the long-term fate of carbon removed from the atmosphere, remains highly uncertain, and iron geochemistry in general is inconsistently represented across models.

To improve accuracy, we must refine model physics, while integrating data from targeted field studies to enhance how models reflect biological and chemical impacts on long-term storage.

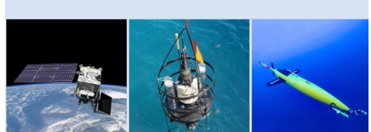


Model of carbon flux in response to a continuous iron addition. Courtesy Dennis McGillicuddy

Are monitoring tools ready for the next generation of field studies?

Advances in autonomous vehicles, remote sensing, models, and ocean sensors are ready for use in proposed pilot studies to help assess carbon dioxide removal from the atmosphere and evaluate the intended and unintended biological and environmental impacts.

We need to monitor, report and verify (MRV) not just on the fate of carbon, but also monitor ecological and environmental impacts (eMRV). MRV and eMRV are key to deciding when and how society might move to larger scale deployments of any marine CDR technique. While methodologies can be established with current tools and models, investments in improving MRV and eMRV models and technologies should continue in tandem.



What is ExOIS?

Exploring Ocean Iron Solutions is a group of international experts that fosters partnerships for scientific research. Our view is that global problems require global solutions and wide participation. We seek public and private partners for funding, as we strive to establish best practices and governance for OIF. ExOIS is not selling carbon credits and is not participating in the carbon market. We are ruled by a code of conduct that emphasizes stewardship of shared marine resources and we reach out to the public, the scientific community, and policy makers. We are hosted by the Woods Hole Oceanographic Institution, a 501(c) (3) non-profit.

oceaniron.org

EXOIS
EXPLORING OCEAN IRON SOLUTIONS