

The next generation of mCDR ocean iron fertilization research studies

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WHO WE ARE

Exploring Ocean Iron Solutions (ExOIS) is a not-for-profit non-commercial consortium of experts that strives to foster partnerships for scientific research, as well as with public and private partners for funding. ExOIS strives to establish best practices and governance for the study of ocean iron fertilization (OIF) as one of many steps that will be needed to remove atmospheric carbon dioxide (CO₂) over the coming decades. Global problems require global solutions and wide collaboration.

Guiding principles for ocean carbon dioxide removal studies

1. Prioritize collective benefit for humans and the environment
2. Establish clear lines of responsibility to oversee studies
3. Commit to open and cooperative research, including risk assessments
4. Perform evaluation and assessment in an iterative and independent manner
5. Engage the public in consideration of climate intervention options

ExOIS is organized around a responsible and ethical code of conduct that prioritizes activities for the collective benefit of our planet, while engaging in open and transparent studies that include public engagement (Buesseler et al., 2022).

ExOIS is an independent program housed at the not-for-profit Woods Hole Oceanographic Institution, USA.

60 members (and growing)
37 Institutions
9 countries

OceanIron.org

THE EXOIS PROGRAM

ExOIS has published a plan to implement its research

Future OIF research programs 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 appropriate social safeguards. International regulations allow for the permitting of legitimate scientific research and include environmental impact assessments as part of the process.

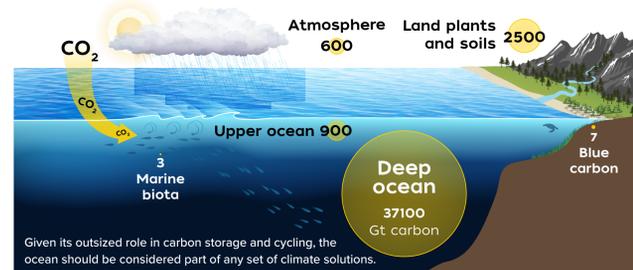
Access [Frontiers in Climate](#) article - Next steps for assessing OIF:



THE NEED FOR OIF RESEARCH

There is concern that commercialization of marine carbon dioxide removal (mCDR) is moving ahead faster than the science needed to assess carbon sequestration efficiencies and ecological impacts. ExOIS is seeking to establish open-source protocols for OIF for mCDR that can be assessed with appropriate monitoring, reporting and verification (MRV) for carbon accounting. ExOIS will also expand MRV to assess environmental, ecological, and other non-carbon related effects (eMRV).

The Ocean's Outsized Role



- Urgent and immediate action is needed to develop mitigation strategies to the climate crisis
- Enhancing the ocean's natural ability to store CO₂ needs to be considered
- Field studies are a necessity to advance our understanding of OIF and its potential for mCDR
- Ocean iron fertilization has been shown to stimulate biological productivity following natural and deliberate iron inputs to the ocean

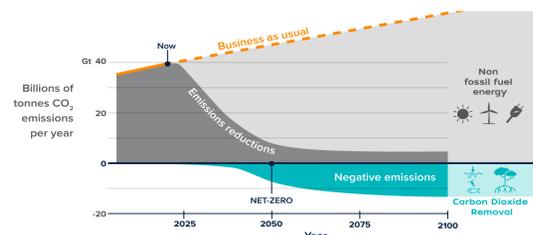
A promising climate solution

- Scalable - up to 1 Gt C per year in HNLC regions
- A little iron goes a long way
- Low cost - has the potential to be less than \$50 per tonne CO₂
- Experience - 13 prior field experiments provide a wealth of existing data

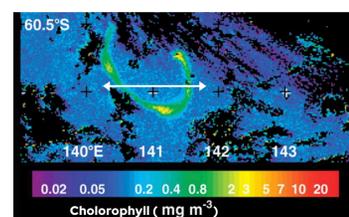
Potential risks

- Robust field studies will enable the evaluation of potential concerns and risks, and the uncertainty around them, such as:
- Sinking organic matter can reduce subsurface oxygen levels and may produce other greenhouse gasses (N₂O, CH₄)
 - How well can we anticipate unintended ecological shifts (i.e. harmful algal blooms or shifts in productivity from one region to another)
 - Impacts on fisheries and higher trophic levels (food web restructuring, benthic communities)

We have a path forward - the time is now



Numerous purposeful iron enrichment studies have been conducted, mostly in the iron-limited subpolar and equatorial regions. Iron additions have been shown to stimulate phytoplankton growth, with diatoms dominating in HNLC waters.

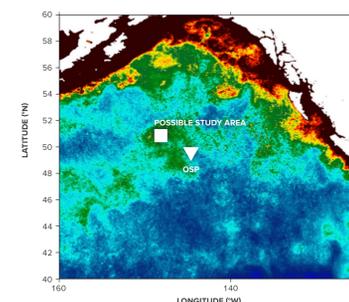


Satellite image from SOIREE, a purposeful in-situ ocean fertilization experiment in the Southern Ocean, 1999. (Boyd et al., 2007).

RESEARCH ACTIVITIES

ExOIS has 5 core research paths

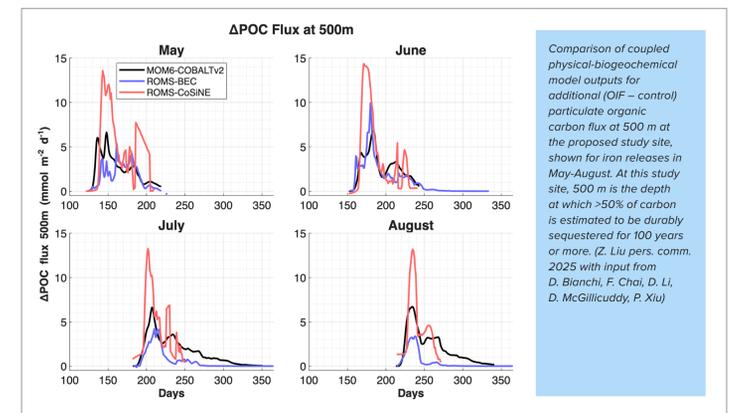
- Next generation field studies**
Studies of durable carbon storage will need to be longer (>3–6 months) and larger (ca. 1000 km²) than past experiments
- Regional, global and field study modeling**
New observations and model intercomparisons to better represent how iron regulates OIF effects on marine ecosystems and carbon storage
- New forms of iron and delivery mechanisms**
Testing and comparison for the most efficient, cost-effective, and scalable iron delivery
- Monitoring, reporting, and verification**
Advances in observational technologies and platforms to support the development, validation, and maintenance of models
- Governance and stakeholder engagement**
Attention to social dimensions, governance, and community education and engagement



Map of the nominal location of the next generation field studies site in the NE Pacific. Also showing Ocean Station Papa (OSP), a long term time-series monitoring site. Background color is chlorophyll concentration.



Examples of potential autonomous platforms that could be used for monitoring OIF field studies. These include autonomous surface and underwater drones, floats and gliders, in situ samplers, and remote sensing.



Study site selection considerations?

For HNLC ocean regions, the Southern Ocean has the largest potential for CO₂ removal; however, it presents significant challenges for new field studies that make it far riskier for a first large scale experiment. These challenges include: international governance structures, logistical hurdles (remote and challenging sea states), strong surface advection that would lead to faster patch dispersion, and higher costs.

Access [Dialogues on Climate Change](#) article - The case for ocean iron fertilization field trials:



The NE Pacific site maximizes field trial success, and will provide insights that can be applied to other systems. Key considerations are:

- Low iron conditions
- Decades of research and ongoing time-series at Ocean Station Papa
- Evidence of natural iron-driven blooms in the past
- Favorable physical characteristics for reducing patch dispersal
- Relatively shallow 100 y sequestration depth of 500 m

Visit poster [CM14B-0779](#) for more on permitting and governance.

References: Boyd, P.W. et al. (2007) *Science*, 315, 612-617; Buesseler, K.O. et al. (2022) *Nature*, 606, 864.