

A New Generation of Iron Enrichment mCDR Field Studies coupled with Social Science and Governance Activities

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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.

GUIDING PRINCIPLES

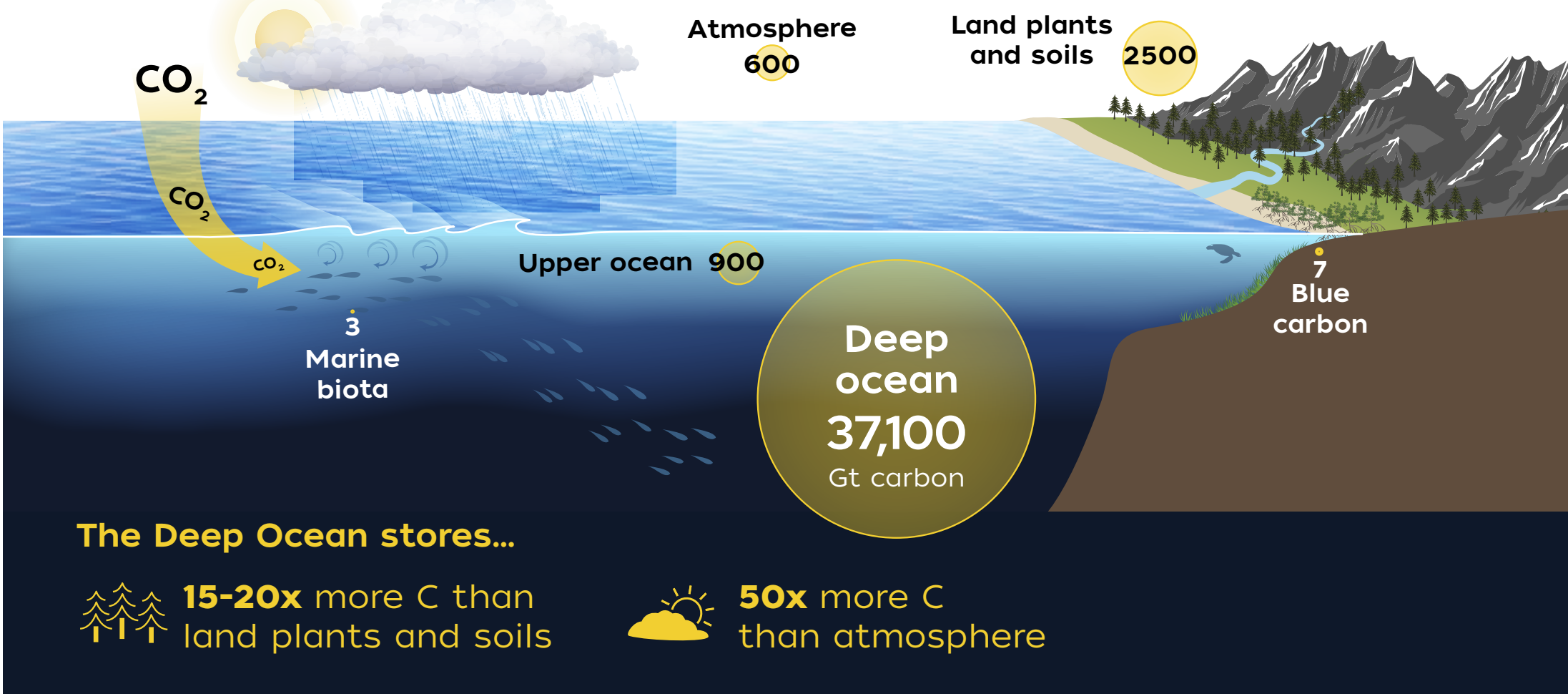
For ocean carbon dioxide removal studies

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).

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).



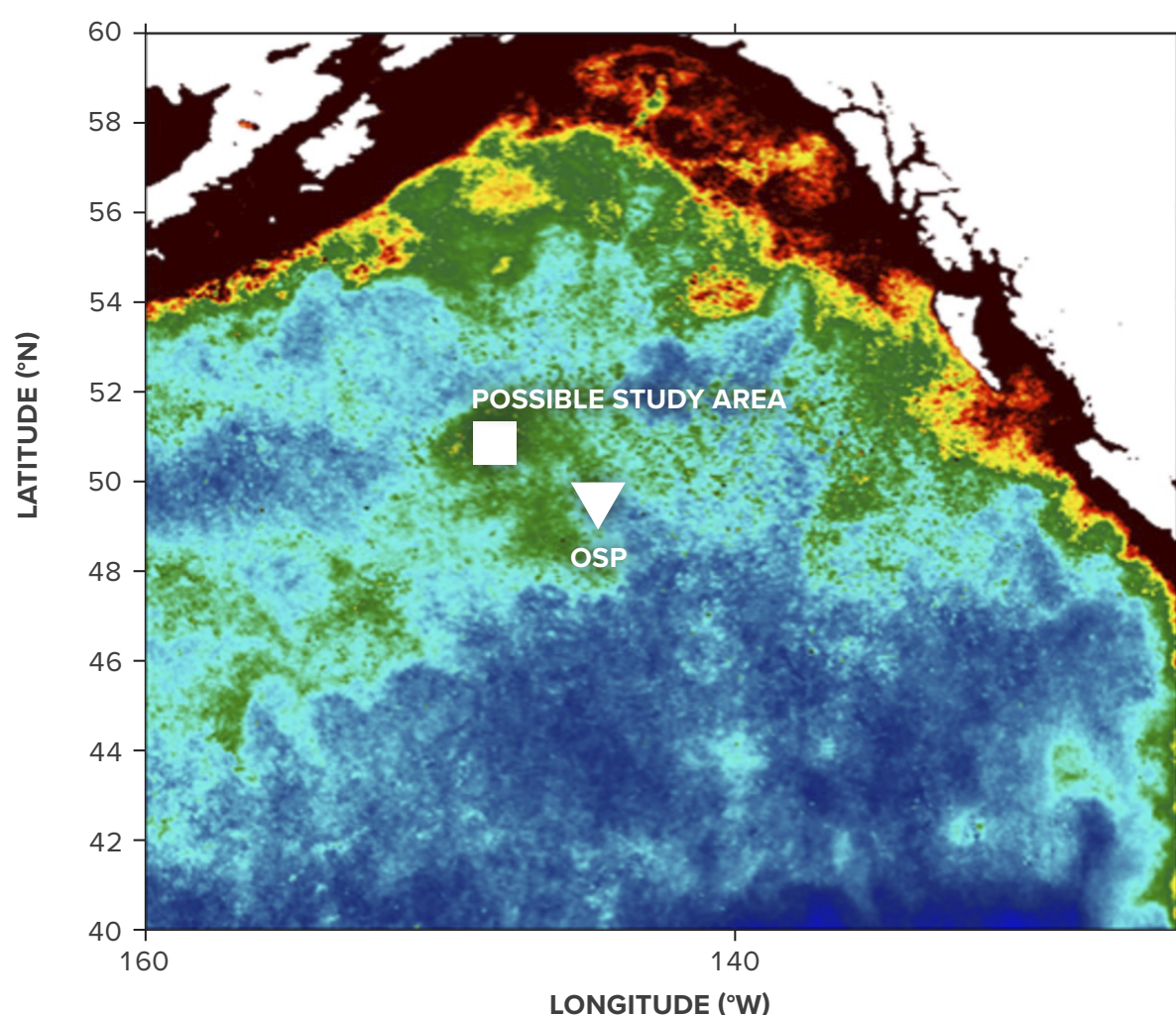
The Ocean’s Outsized Role

- The ocean plays an outsized role in the carbon cycle with a capacity for carbon storage more than 50 times larger than the atmosphere and 15-20 times larger than all land-based plants and soils
- 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

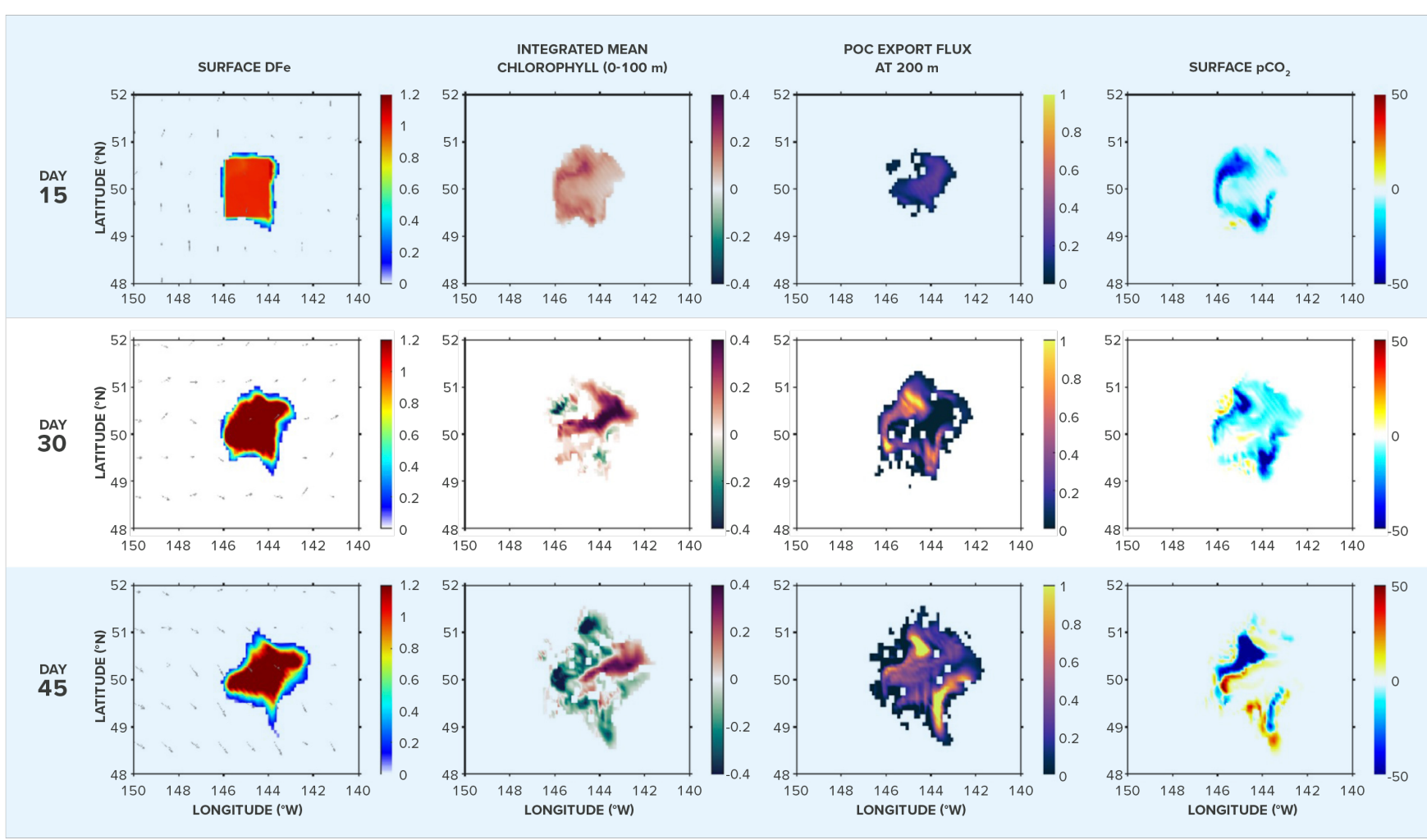
RESEARCH ACTIVITIES

ExOIS has 5 core research paths

- 1. Next generation field studies**
Studies of long-term (durable) carbon storage will need to be longer (year or more) and larger (>1000-10,000 km²) than past experiments
- 2. Regional, global and field study modeling**
Incorporation of new observations and model intercomparisons are essential to accurately represent how iron cycling processes regulate OIF effects on marine ecosystems and carbon sequestration
- 3. New forms of iron and delivery mechanisms**
Rigorous testing and comparison of new forms of iron and their potential delivery mechanisms
- 4. Monitoring, reporting, and verification**
Advances in observational technologies and platforms are needed to support the development, validation, and maintenance of models required for MRV
- 5. Governance, and stakeholder engagement**
Attention to social dimensions, governance, and stakeholder perceptions will be essential from the start



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



Model of biogeochemical response to OIF addition in NE Pacific for 15, 30, and 45 days after iron addition to a 200 x 200 km patch. Left to right: surface dissolved iron; integrated chlorophyll; particulate organic carbon flux at 200 m; and surface pCO₂. (F. Chai et al. pers. comm.).



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

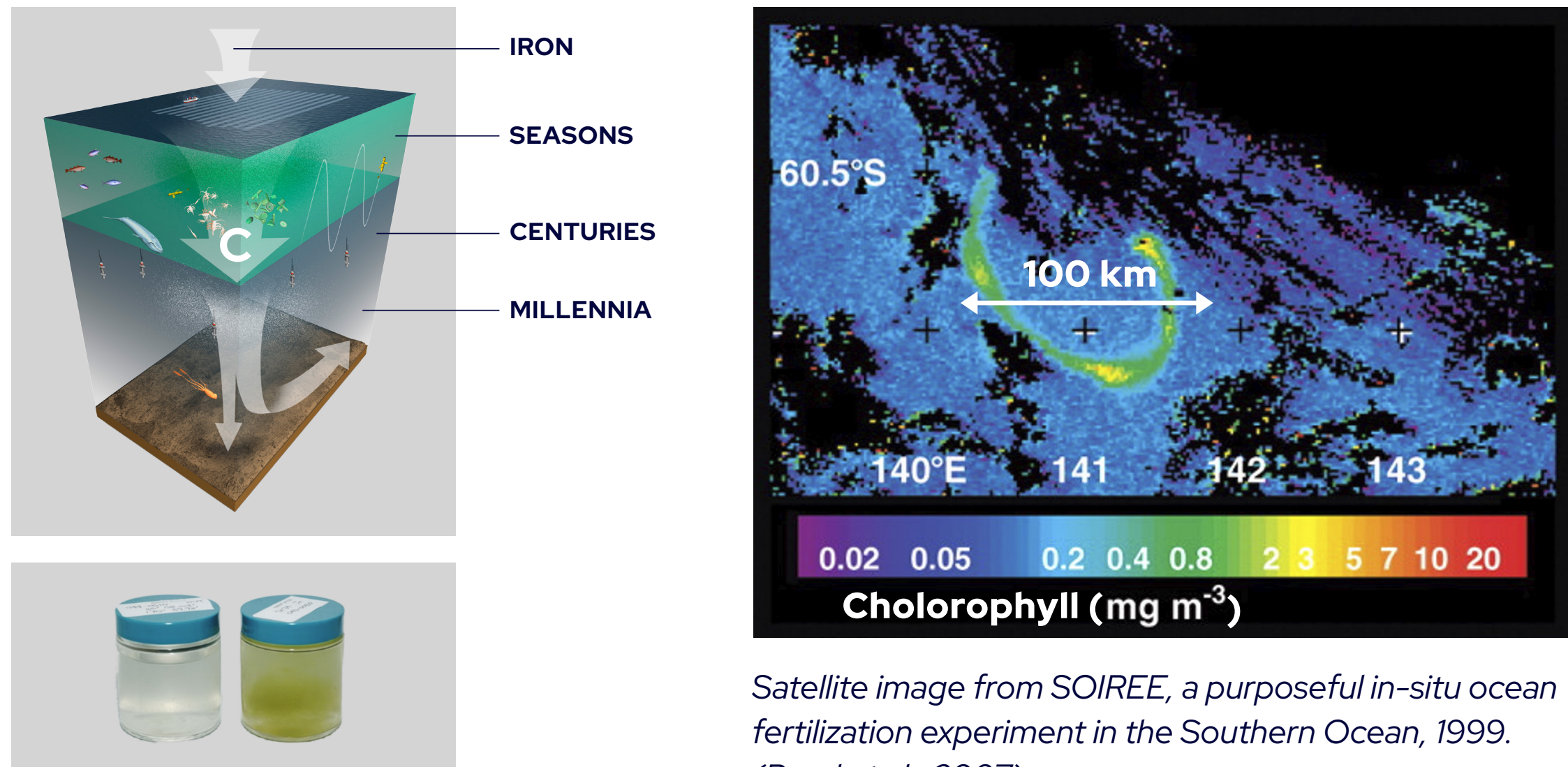
WHY OCEAN IRON FERTILIZATION

Why is OIF a promising climate solution?

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

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, as shown in the seawater samples below: left not iron enriched, right iron enriched.

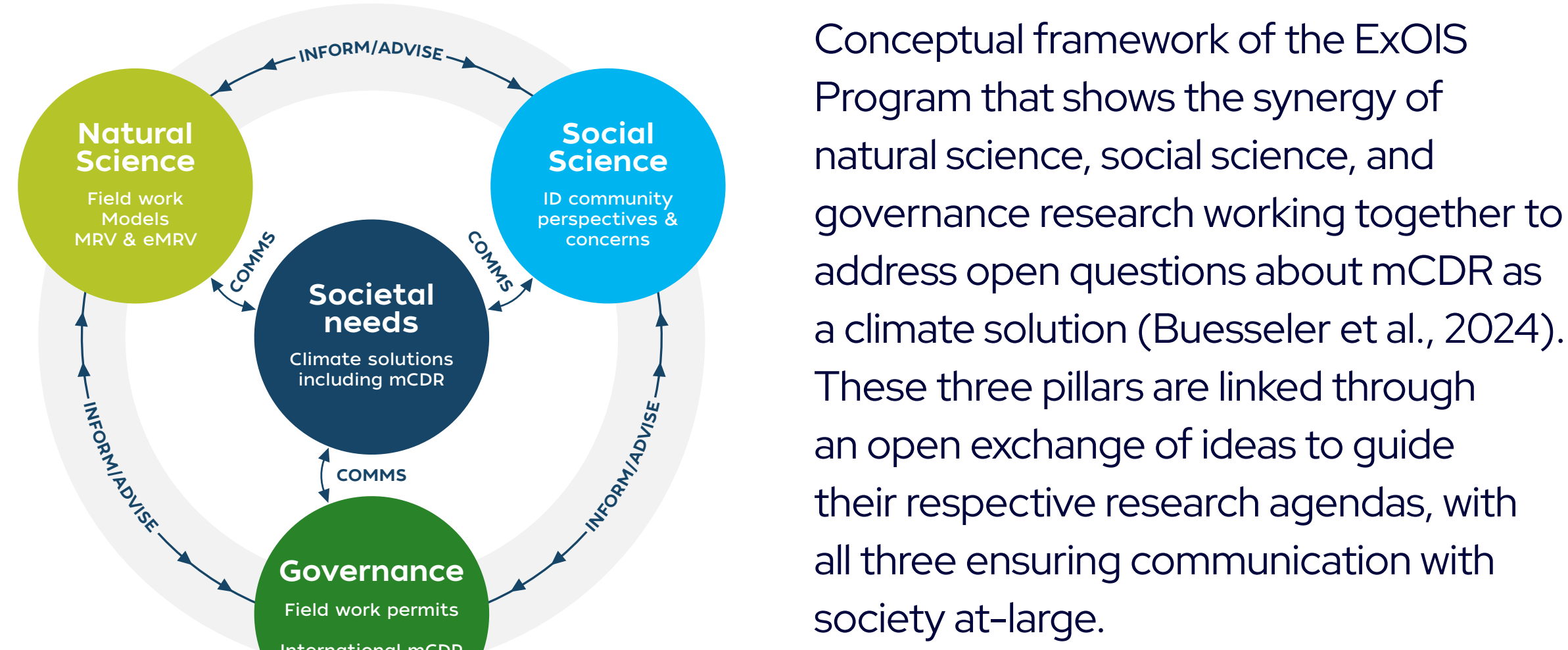
The magnitude and durability of carbon export following OIF needs further research following the conclusion of the 2002 SOFeX experiment that showed that an addition of 1.3 tonnes of iron removed about 2,000 tonnes of carbon (Buesseler et al., 2004).



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

THE ExOIS PROGRAM

ExOIS has published a plan to implement its research



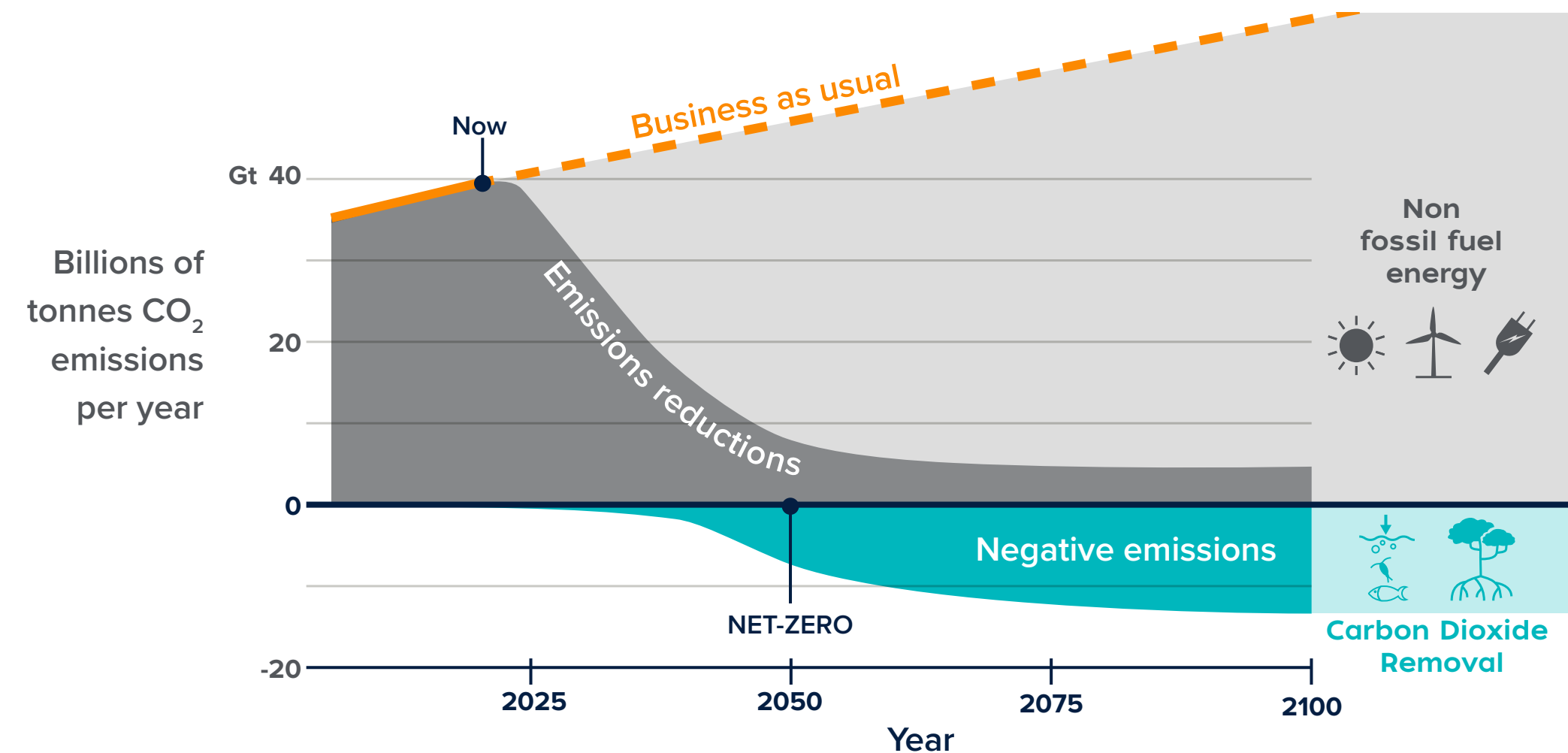
Conceptual framework of the ExOIS Program that shows the synergy of natural science, social science, and governance research working together to address open questions about mCDR as a climate solution (Buesseler et al., 2024). These three pillars are linked through an open exchange of ideas to guide their respective research agendas, with all three ensuring communication with society at-large.

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



JOIN ExOIS

We have a path forward – the time is now



We are always growing and welcome new members to ExOIS. If you would like to learn more please see our website and sign up to join monthly forum meetings and receive updates. [Oceaniron.org](https://oceaniron.org).

- International consortium of experts dedicated to studying ocean iron fertilization for carbon dioxide removal (CDR)
 - 60 members
 - 37 institutions
 - 9 countries
- Independent program housed at the not-for-profit Woods Hole Oceanographic Institution
- ExOIS fosters partnerships for scientific research and outreach

References: Boyd, et al. (2007) *Science*, 315, 612-617; Buesseler, et al. (2004) *Science*, 304, 414-417; Buesseler, et al. (2022) *Nature*, 606, 864; Buesseler et al. (2024) *Frontiers in Climate*, 6, 1430957
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