Marine Carbon Dioxide Removal

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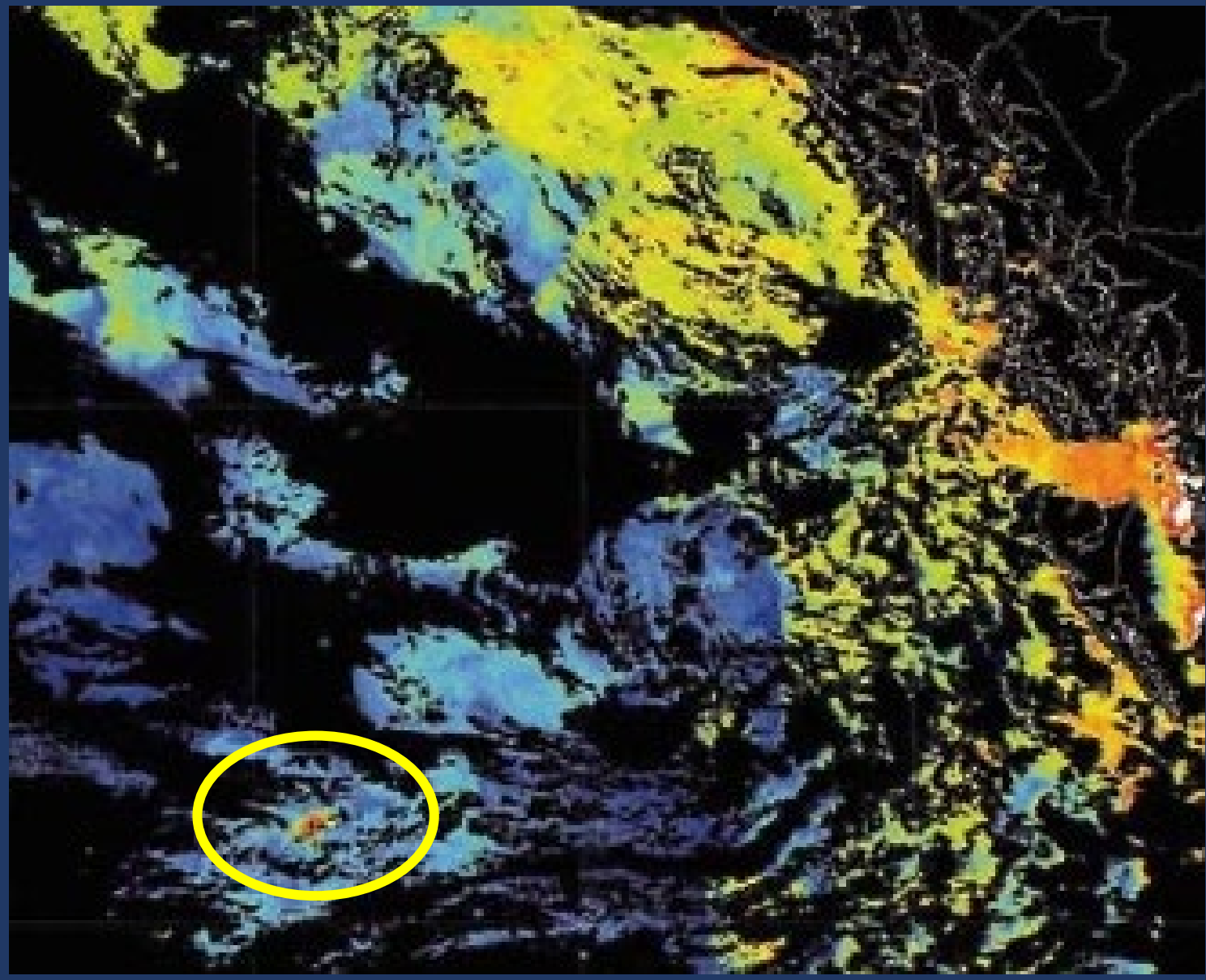
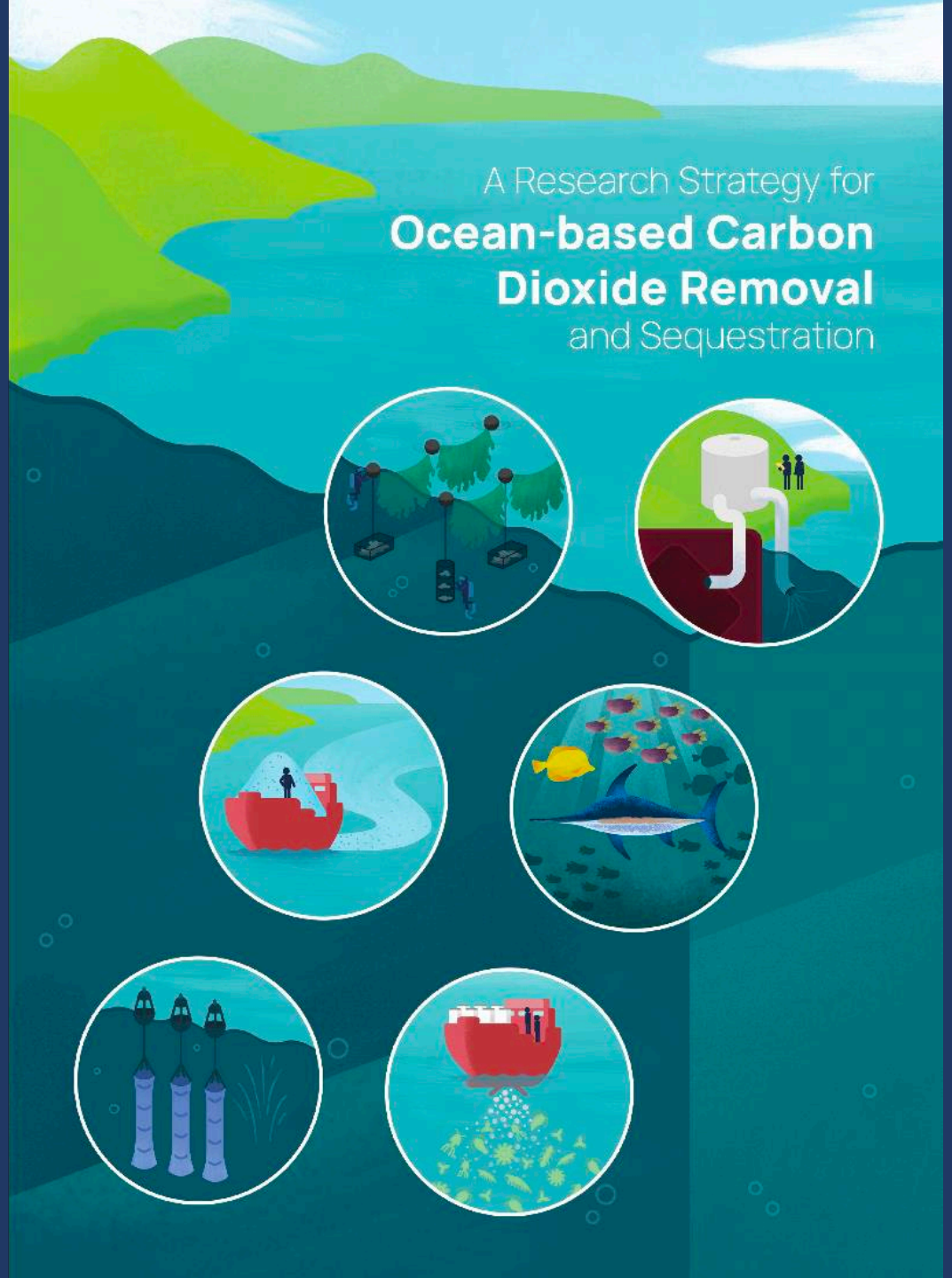


Subarctic Ecosystem Response to Iron Enrichment Study (SERIES)

Joint Global Ocean Flux Study 2002

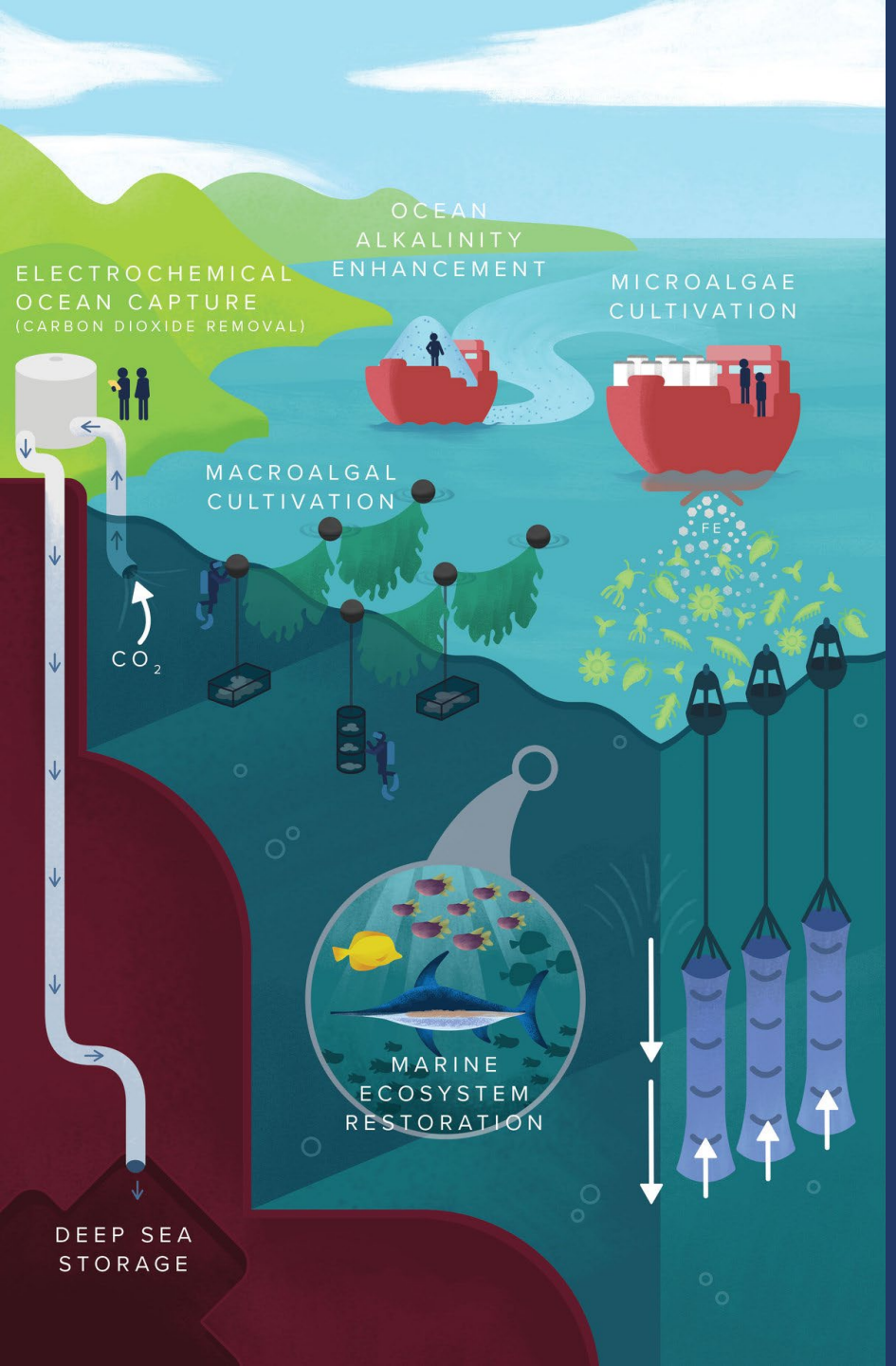


National Academies of Sciences, Engineering, and Medicine. 2022

A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration

Washington,DC:
The National Academies Press.
https://doi.org/10.17226/26278.

https://nap.nationalacademies.org/download/26278



Ocean-based Carbon Dioxide Removal and Sequestration

In-ocean techniques

- Techniques that add materials to the ocean
  - Ocean nutrient fertilization
  - Ocean alkalinization
- Techniques that enhance natural processes without addition of material
  - Artificial upwelling
- Growing algae for further use
  - sequestration
  - use in food/biofuel, etc.

Land-base techniques

- Electrochemical capture and deep-sea storage

“20 years from now what information will we wish we had gathered?” – Jim Haywood

- What we need to know about process
- What do we need to know about impacts

- What do we need to do/have in place to be able to study either
- What could NSF do to assist this process

Processes

- Arguably the 20 years of research by JGOFS (Joint Global Ocean Flux Study) and SOLAS (Surface Ocean-Lower Atmosphere Study) have established a firm foundation for processes responsible for stimulating phytoplankton growth by fertilization
- Processes related to carbon flux and sequestration were not the objective of fertilization experiments and need attention
- Alkalinization processes have been studied in some detail in the lab, but processes related to deployment in either open ocean or nearshore, as well as processes related to uptake of CO2 need attention

Processes, cont.

- Processes associated with artificial upwelling have been studied in very small deployments, but much work will be needed to understand how this activity would scale and the processes associated with it.
- Processes associated with growing kelp are informed by various kelp aquaculture activities. Processes associated with sequestration of kelp in the deep ocean have not been studied adequately.
- Processes associated with hydrolysis are well known from lab and industrial experience, but much work is needed to understand how this activity would scale and the processes associated with it

Impacts

- For all of the marine CDR techniques there is inadequate information about impacts of the techniques on the physics (e.g., in the case of artificial upwelling), chemistry (including nutrients), and especially for biology/ecosystems.
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What will we learn from the new companies…

Heimdal

SeaChange

- **06-03-21**
- **WORLD CHANGING IDEAS**

This carbon-capture tech removes CO2 from the ocean by making seashells

Seashells form naturally from carbon dioxide in the water. Now scientists are trying to mimic the process.

FAST COMPANY

Roles for NSF?

It is important for NSF to play a role if:

Their funding of research can set an ethical standard for doing research:

Abide by principles
Accept regulation it if can be developed
MRV included in the research
Assessment included in the research
Sequential scaling

Roles for NSF?

It is important for NSF to play a role if:

The research they would fund can set a scientific standard for the research itself

- Approach (efficacy, impacts)
- Completeness of field experiments
- MRV
- Nature of assessment (e.g., including social)

What should NSF be thinking about before funding ?

A vision/plan for what they are doing

- do they want to determine whether any of these ideas work and what their impacts are?
- or do they just want to fund pieces?
- many believe that the full impacts will only be apparent at the demonstration scale – is NSF prepared to fund demonstration scale?
- are they prepared to fund more than the geoscience experiments? e.g., Social science? Engineering? Biology

MRV Challenges

Atmospheric verification of emissions reductions on paths to deep decarbonization
Abdulla, et al., Env. Res. Lett., 2023

The most aggressive mitigation scenarios (i.e. 1.5 ◦C) require 11–16 years to detect a signal or demonstrable progress from the noise;
2 ◦C scenarios lengthen detection by at least a decade.

We need to measure how much is sequestered, but also what the net is after exchange with atmosphere

What do I think success would look like?

We have done the research to understand whether marine CDR makes sense at any level and can make science informed decisions – and we have done it in a transparent and ethical way

What do I think failure would look like?

Insufficient research results in the situation that profit motive, panic, or international politics of strategy are solely or mutually driving deployment