OIF System Design Considerations

There is no one strategy for Ocean Iron Fertilization, and there are numerous uncertainties surrounding to develop the necessary proof of concept design. However, it is useful to begin by listing general and specific constraints to create a framework within which potential designs can be assessed. What follows is intended to serve as a starting point for this framework that will be revised and expanded as design strategies are considered.

Required Design Constraints:

1. Any design must consider not only the efficacy of CDR but also to ascertain the negative or unintended consequences, so experiments will have to be conducted over long time scales.

2. Any design must be agile enough quickly “turn off” any proof of concept OIF at any early signs of negative ramifications.

3. Any design must allow open, predictable access to data and physical participation for interested parties wishing to evaluate the proof of concept investigation.

4. Any design must account for net carbon removal; i.e., include quantification of carbon export along with the fossil fuel use to implement the OIF strategy), along with predicted carbon sequestration time scales. This means that the design must generate a large enough both spatially and temporally, to capture all aspects of dissolved and particulate carbon transport, atmospheric exchange and diagenesis, both in the water column and at the sediment/water interface.

5. All designs must include an assessment of potential impacts on “sensitive” marine environments, or keystone ecological sites (e.g., animal breeding grounds).

6. All designs must be assessed in terms of “downstream” ecological and biogeochemical impacts; e.g., the removal surface nutrients to varying degrees.

7. Others required constraints?

Optimal Design Constraints — General:

1. Designs likely need to focus on oceanic HNLC regions; nearshore Fe-limited regions often have complex physical dynamics, different planktonic assemblages, and limited depths for carbon sequestration. Although carbon burial in shelf environments may increase carbon sequestration time scales, adequately quantifying this burial for verification is problematic.

2. Designs need to enable the integration of quantified C export across all stages of the bloom

3. Designs need to enable experimental replication (multiple times) under the same and different test conditions

4. Designs need to have a functional experimental control, where all conditions other than Fe addition can be replicated.

5. Designs need to of sufficiently long time scale to capture all of the biogeochemical and ecological consequences to enable responsible assessment of impacts relative to not developing effective CDR strategies.

6. Designs should include assess the likelihood for measurements via remote sensing, which likely will be a component of future verification methods.

7. The proof of concept investigations will need to consider a range of variables, so designs should reflect a multi-year “platform”. This strategy also will enable interested researchers to plan/submit proposals for associated studies to better assess OIF efficacy and impacts.

8. Other general design constraints?

Optimal Design Constraints — Logistical:

1. Consider locations that support fast potential rates of plankton response—hours vs. days (i.e., temperature and light conditions)

2. Consider locations having low dispersion rates of the Fe patch, or dispersion patterns that are predictable to enable quantification of net carbon sequestration.

3. Consider atmosphere/surface ocean CO_2 exchange dynamics; i.e., surface water residence time should be long enough to allow atmospheric CO_2 to re-equilibrate after OIF.

3. Consider locations that enable a near year-round investigation window (i.e., low seasonality that maximizes the possibility for experimental replications).

Key Manipulation Variables (to start)

One of the primary unknowns for study in the proof of concept stages of OIF is how to best “tune” OIF-induced blooms to maximize carbon sequestration (export mass and depth) while minimizing total Fe inputs (i.e., reducing the overall carbon footprint). Some of the key manipulation variables would include:

1. The amount of Fe addition (target concentration to maximize the efficiency of carbon sequestration)

2. The form of added Fe (e.g., natural or engineered substrates that maximize Fe availability over bloom time scales)

3. The dynamics of Fe addition. What are the relative effects of pulsed, continuous, or gradients, Fe input)