oceanironfertilization

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# Ocean Fertilization: Ironing Out Uncertainties in Climate Engineering


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*Carbon Sequestration in the Deep Sea: Navigating the Knowns and Unknowns*

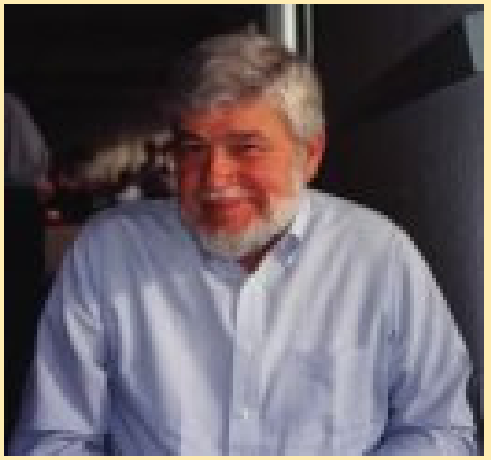
*Nov. 12, 2007*

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

## The Iron Hypothesis-

"Give me half a tanker of iron and I'll give you the next ice age"

-John Martin, 1988



## The science behind ocean iron fertilization

- Connections between iron and ocean carbon cycle

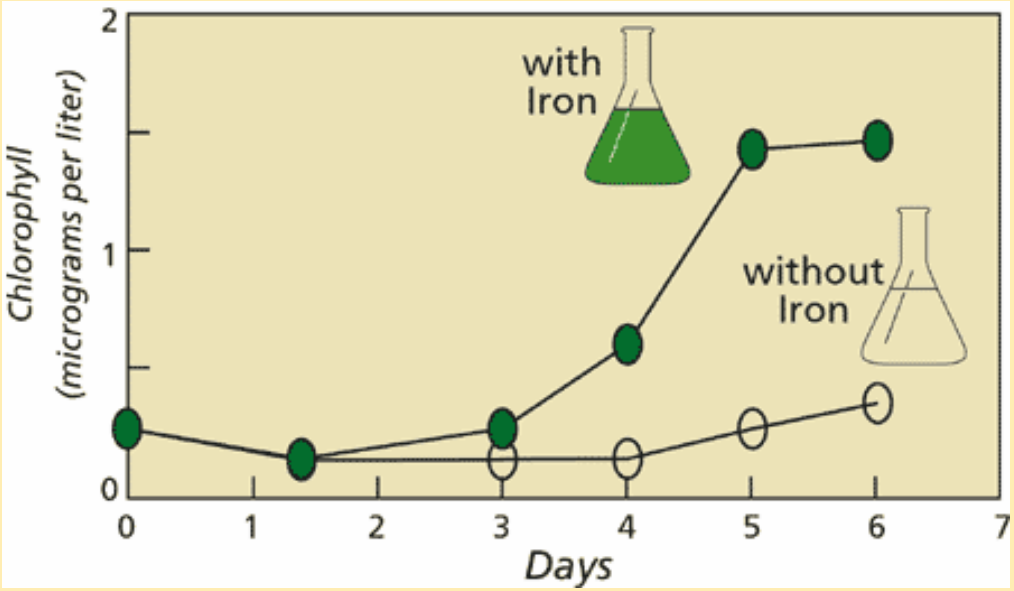
## Can iron fertilization be used to reduce $CO_2$?

- Impacts and efficacy

## New ocean carbon offset markets

# What is ocean iron fertilization?

1. Adding iron can stimulate phytoplankton growth



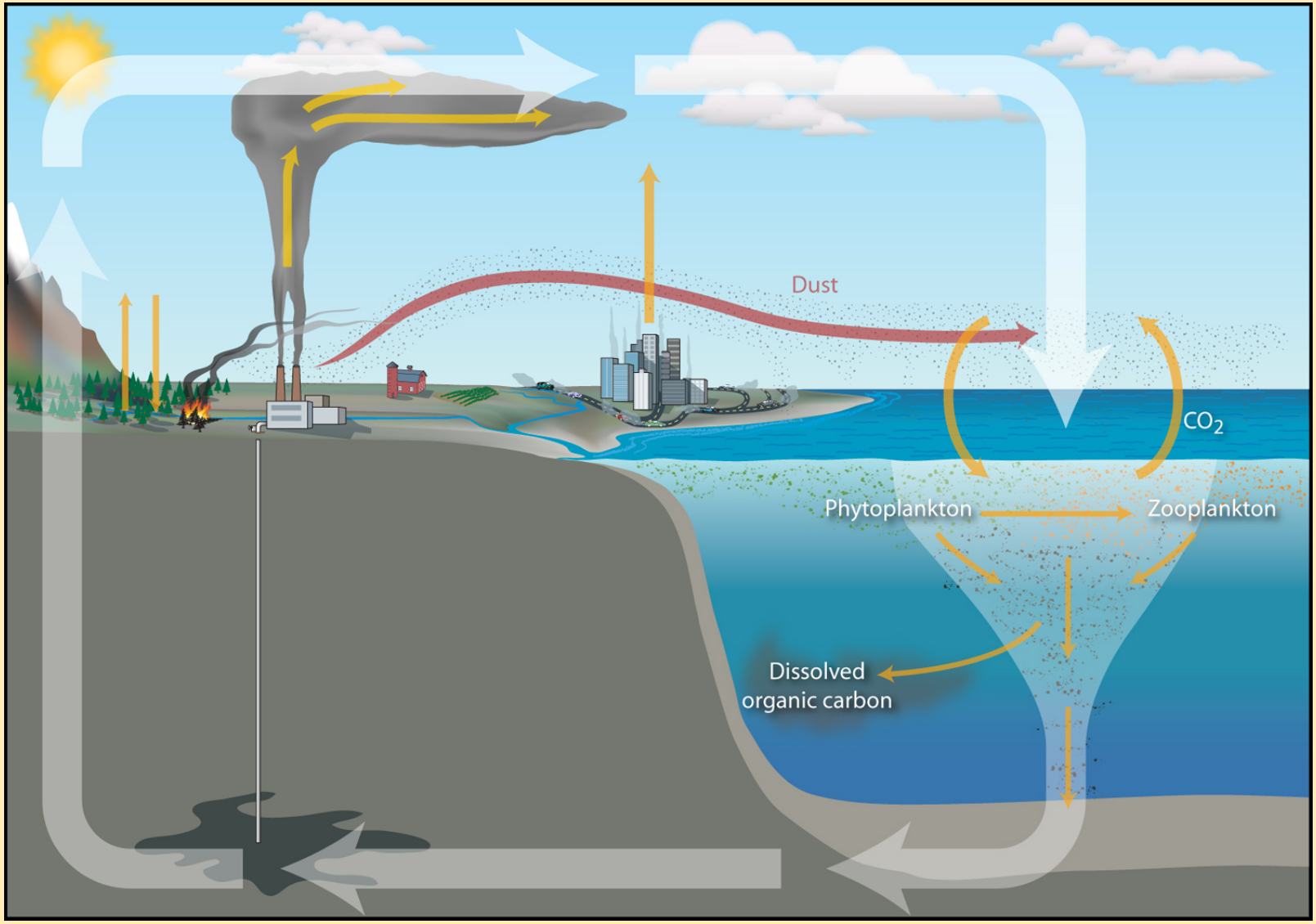

*2. A little iron goes a long way!*

3. How does this work in nature?
4. Can we enhance nature?

# The natural iron cycle

Dust is a major source of iron to the ocean

# Dust can enhance phytoplankton growth and $CO_2$ uptake




Significant carbon is "sequestered" in deep ocean

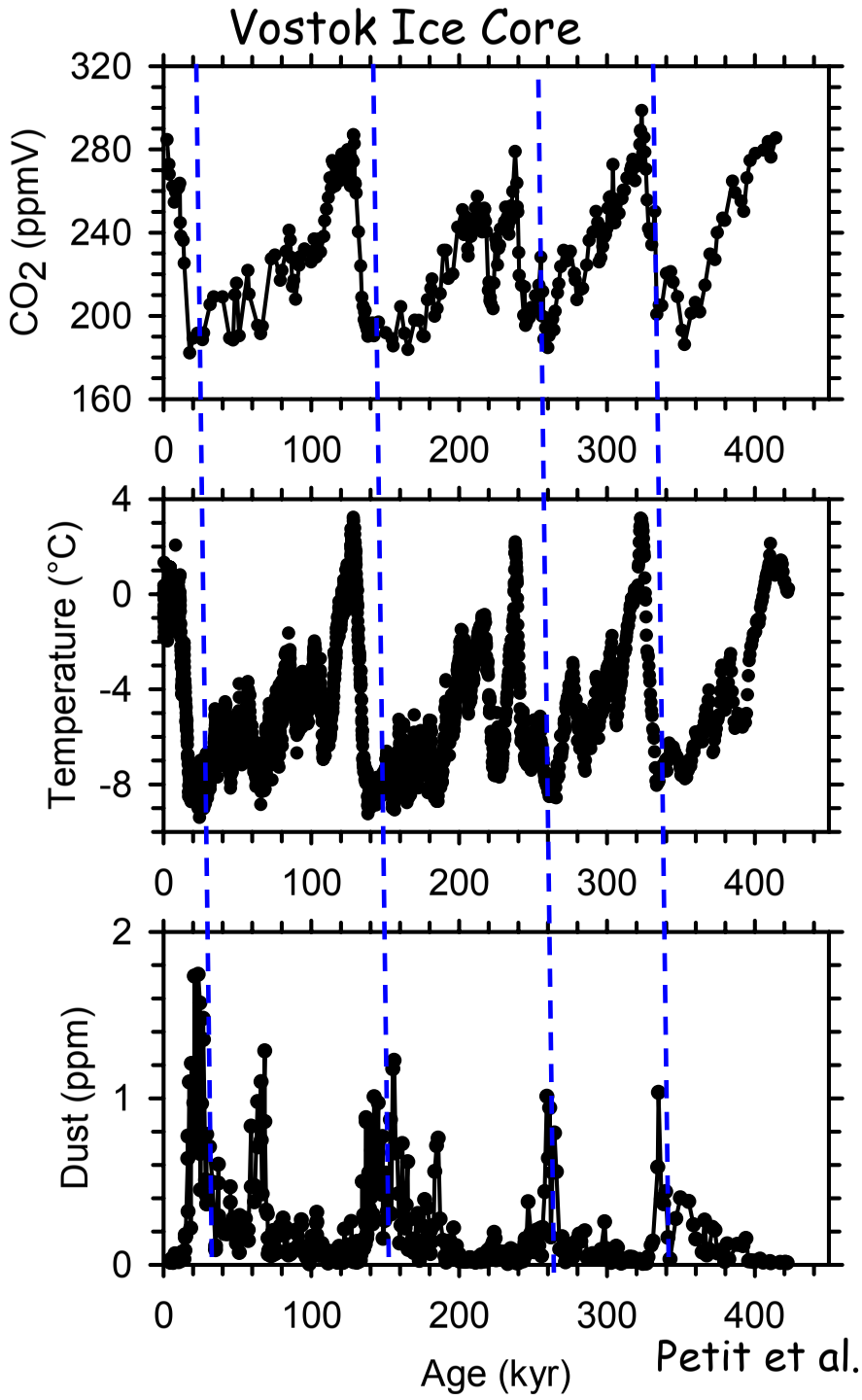
## Dust and past climate cycles

-evidence of global change

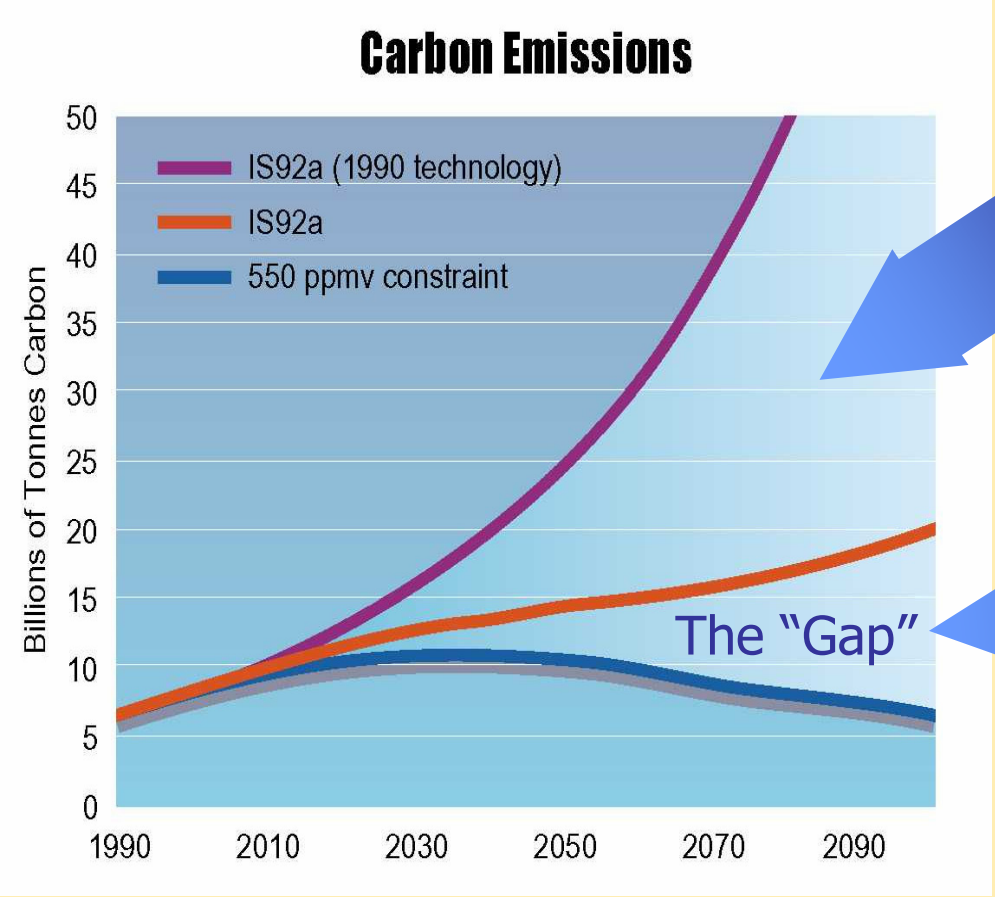
High dust (high Fe)

low temperatures

and low $CO_2$



# Can we stabilize rising $CO_2$?



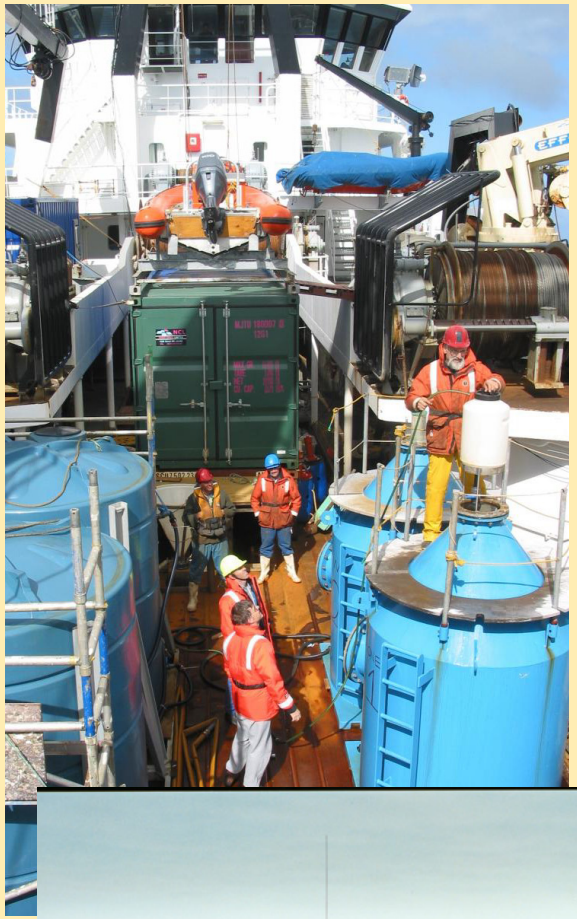

**Reducing $CO_2$ sources**

- Higher efficiency
- Renewables
- Nuclear

**Enhancing $CO_2$ sinks**

- Carbon capture & disposal
- Land/ocean carbon sequestration

- Can ocean C sequestration help fill the "gap"?



**How would we geoengineer the ocean to become a larger C sink by adding iron "dust"?**

Two processes are needed to impact atmospheric $CO_2$ via iron additions:

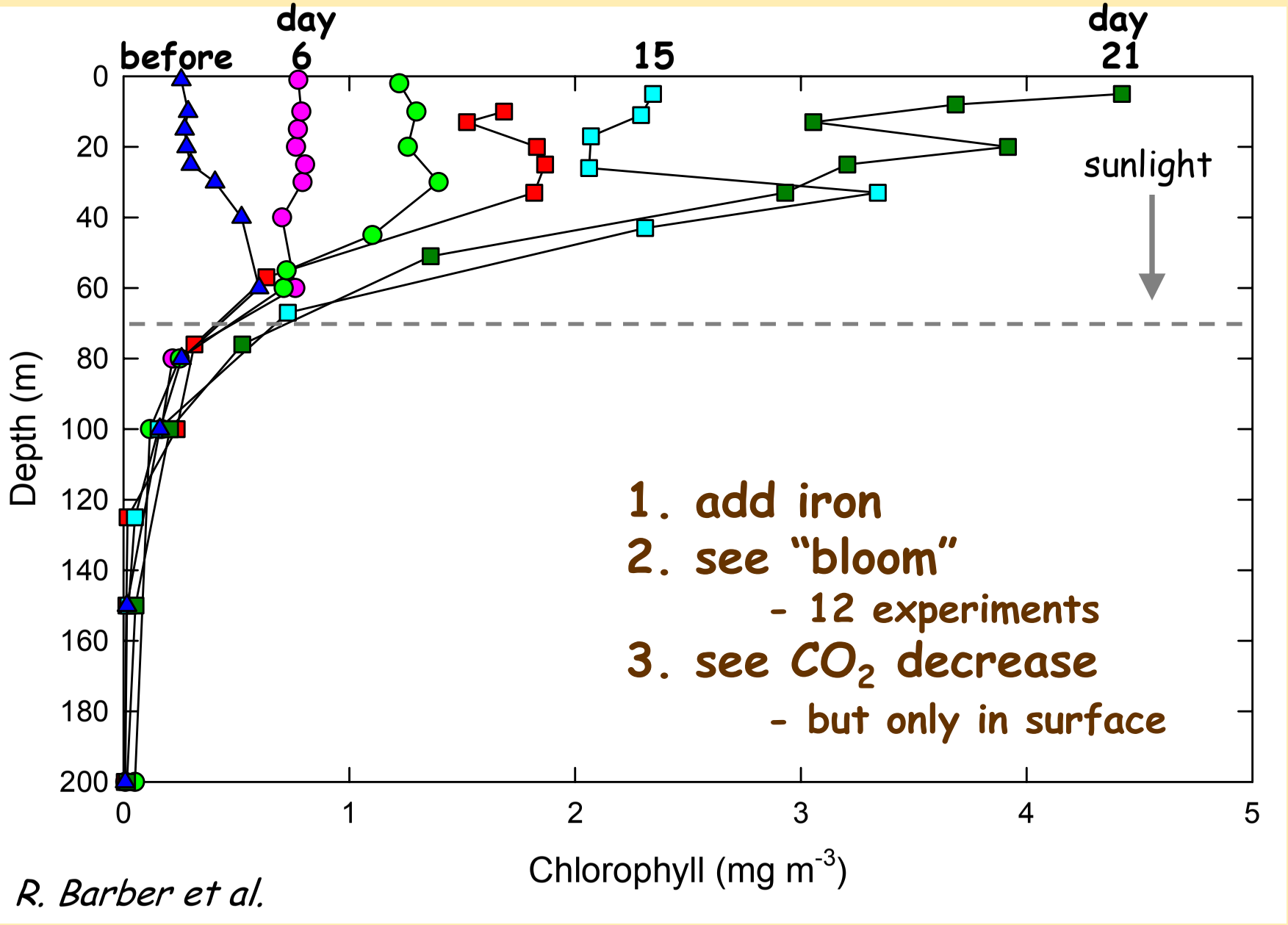
**1. Stimulate phytoplankton growth**

- relatively well known

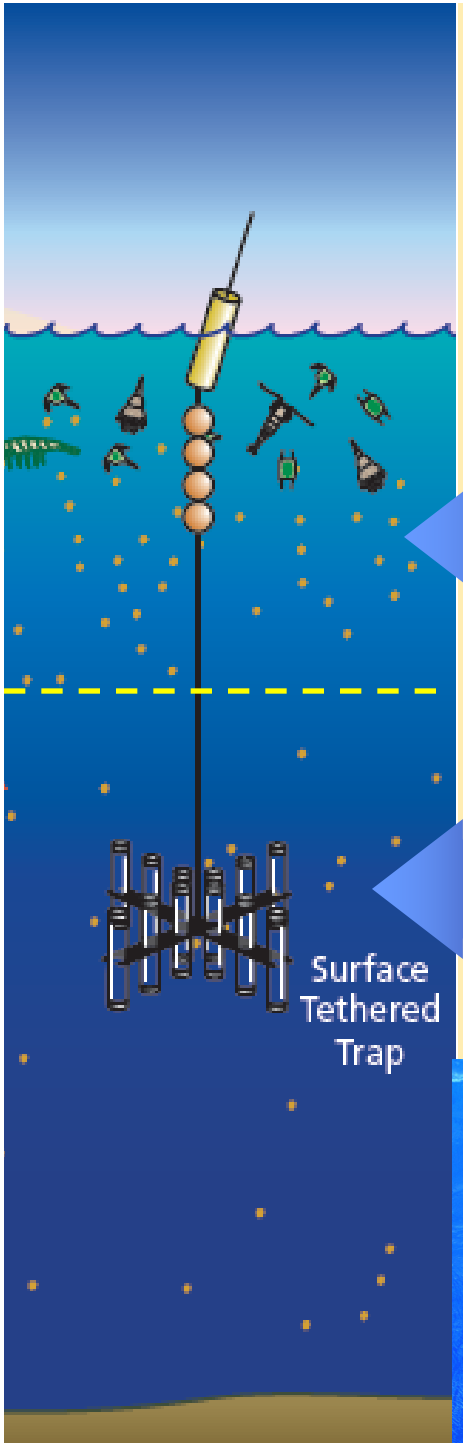
**2. Enhance carbon transport to the deep-sea**

- little known,
hard to measure,
but key to C credits

# Increase in phytoplankton seen after iron addition

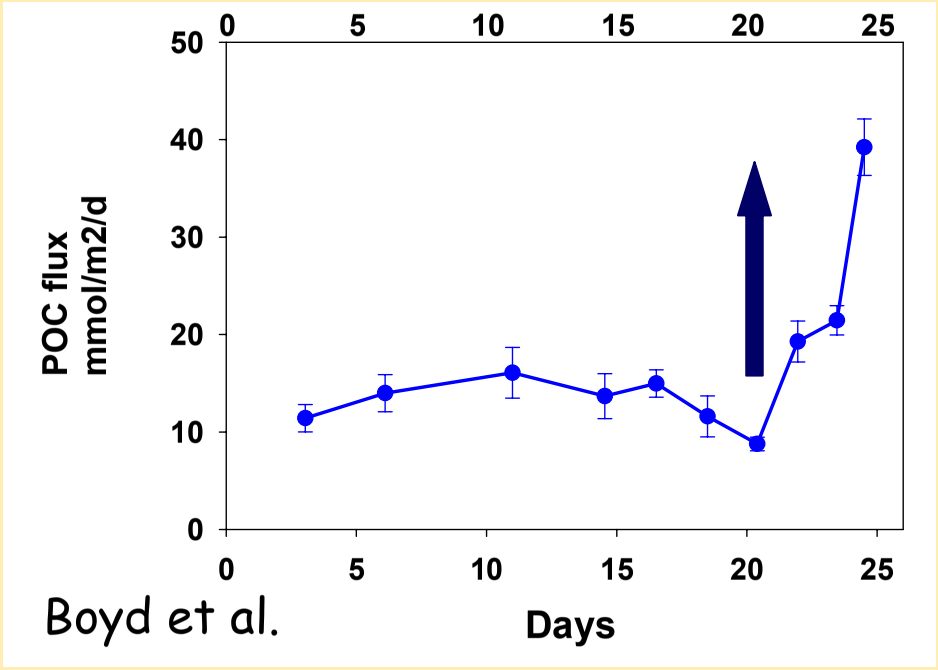


# What happens below the surface?



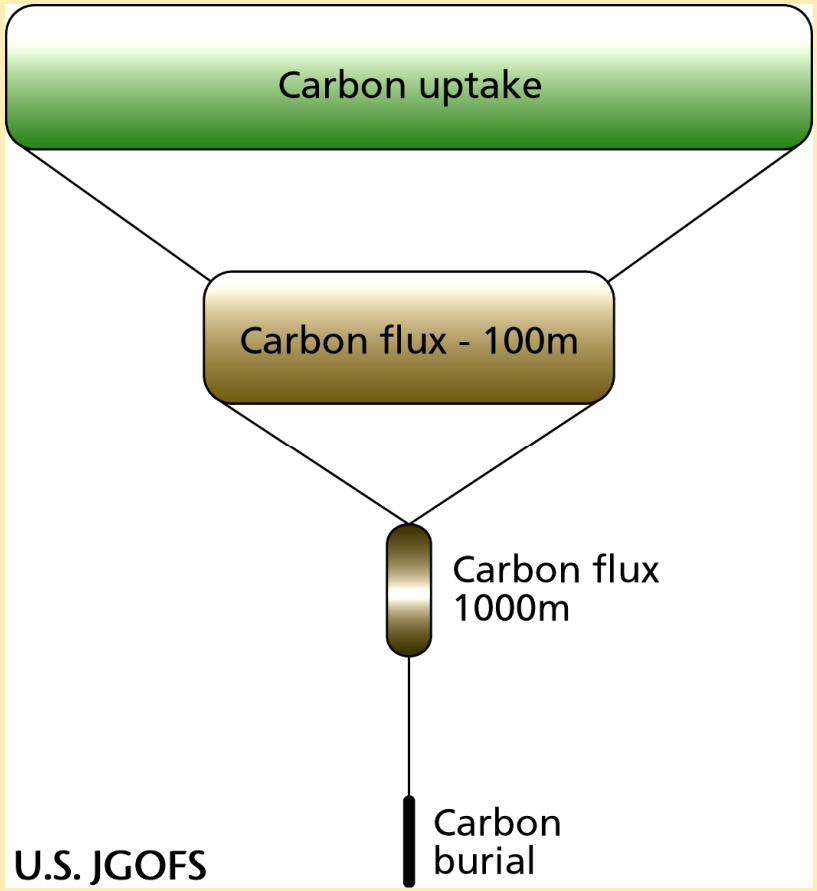

Add iron here

Collect C on sinking particles here




- *not so easy to measure*
- *highly variable response*

# Does iron enhance carbon sequestration?




$CO_2$ uptake

Carbon transport

to 100m
*<2 to >50% (decades)*

to 1000m
*~1-10% (centuries)*

to sediments
*~0.1% (millennia)*

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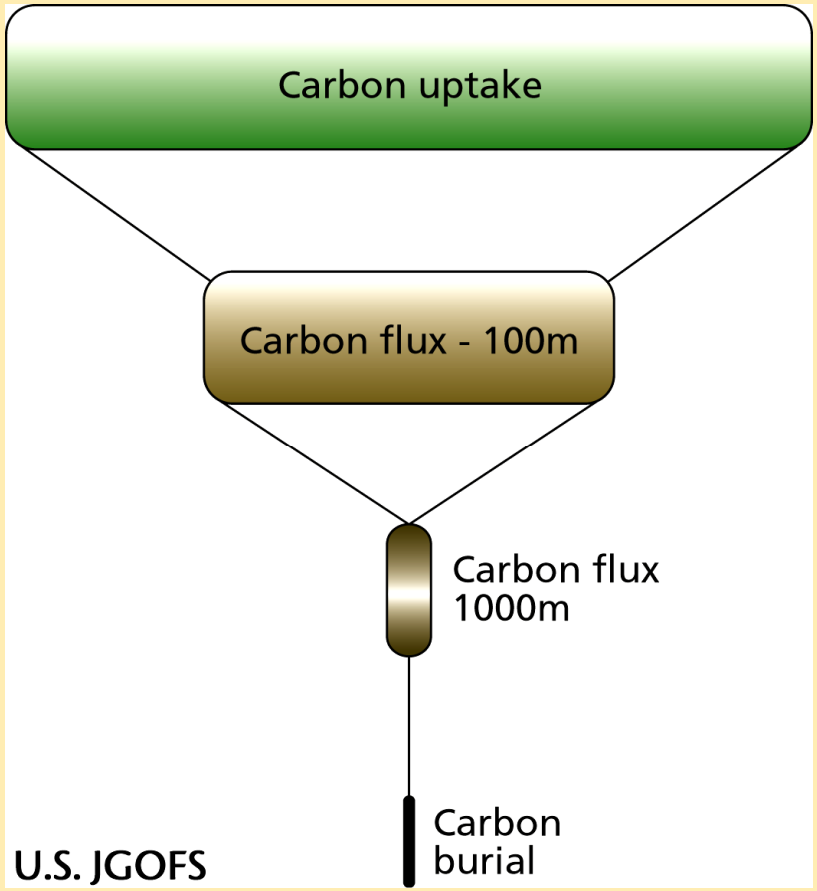


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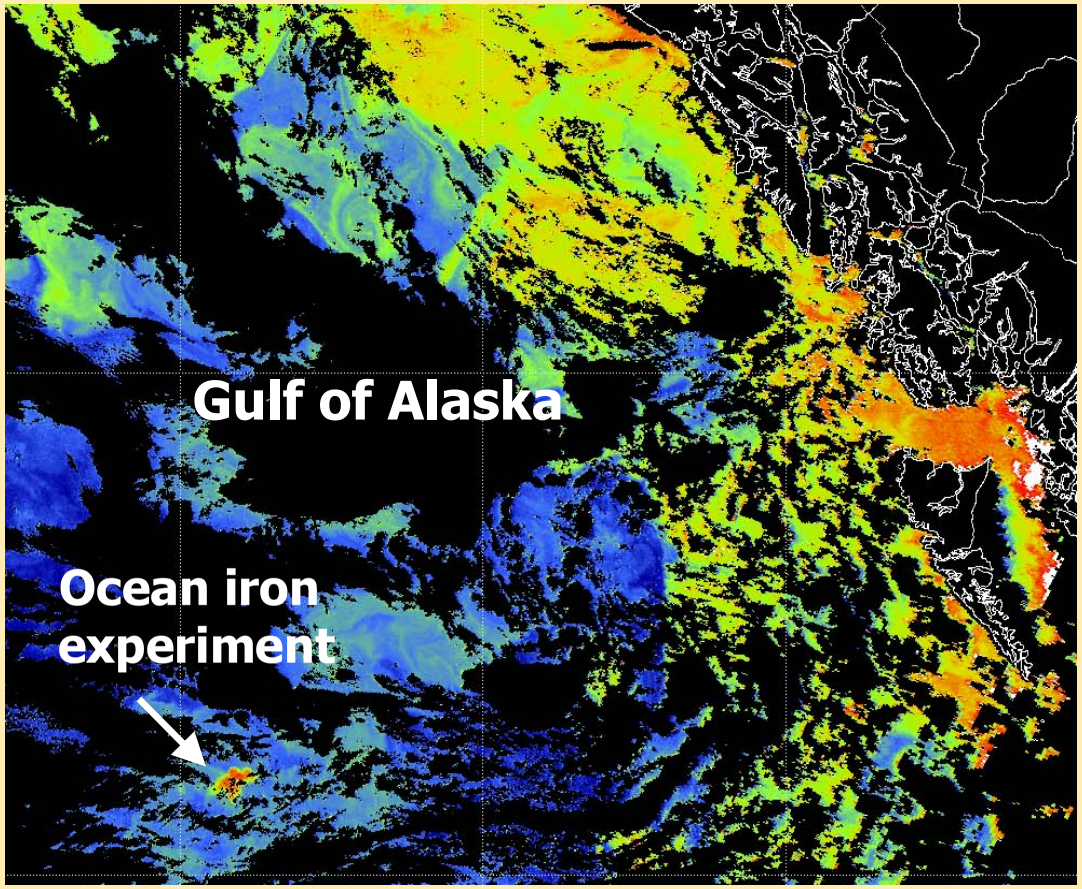
Most carbon does not reach the deep sea (<10%?)

# What controls the ocean response to iron?

## Location, location, location…

*[Phil Boyd- U. Dunedin, NZ]*



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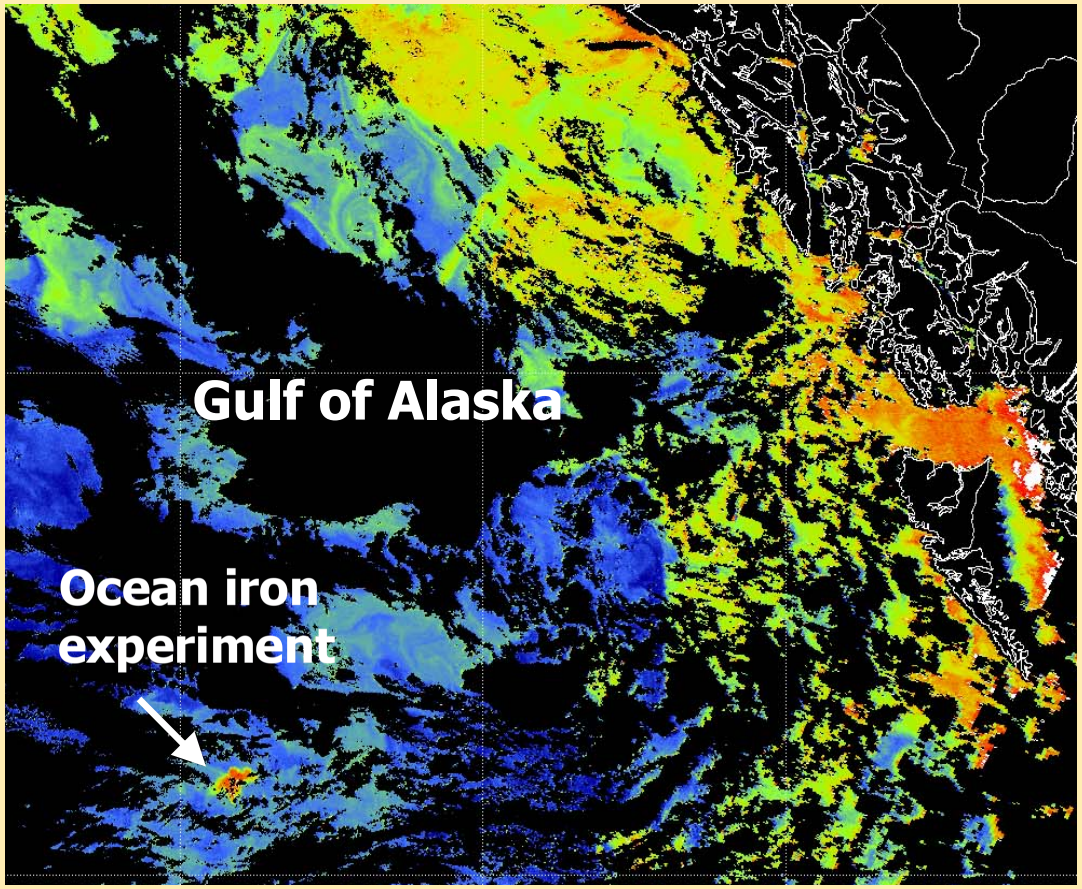



initial conditions matter both for C uptake and C sequestration

- light
- temperature
- season
- winds
- biota
- currents etc.

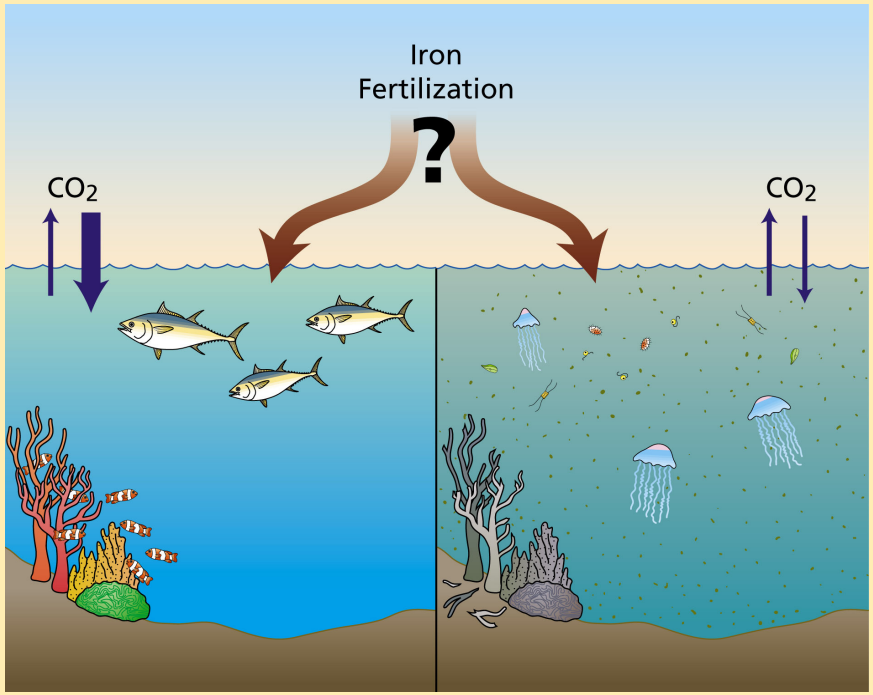
# Ocean fertilization changes ecology

## but many questions remain

- scaling is key

- possible unintended consequences
  - oxygen depletion?
  - other greenhouse gases (DMS, $CH_4$, $N_2O$)
  - ecological shifts to harmful algae?

- watch out for bold claims!
  - \+ enhanced fisheries
  - \+ support whales
  - \- harmful algal blooms
  - \- dead fish



# Commercialization of Ocean Iron Fertilization

## - here already

PLANKTOS

BLUE GREEN TAG

*"option to own one ton $CO_2$ equivalent = $4*
*(15 tons per US household to offset typical contributions)"*

**Anyone can sell voluntary C offsets**

**Planktos- "ecorestoration" planned off of the Galapagos**

**Climos- "code of conduct", academic partners, 3rd party verification**

**Potential value of ocean iron fertilization may be $100b**

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# Exploring Ocean Iron Fertilization:
## the scientific, economic, legal and political basis

*Woods Hole, MA September 26-27, 2007*

**Will it work?**

**What are the environmental consequences?**

**Can carbon offsets be verified?**

**What is legal, policy, economic framework?**

**What comes next?**

**http://www.whoi.edu/conference/OceanIronFertilization**

***-video, slides, resources, links, press, articles***

# Ocean Iron Fertilization

## Science is *clear* regarding-

1. iron can stimulate plankton blooms

## Science is *unclear* regarding-

1. will it work?
   - to sequester atmospheric C into mid-waters
2. what are the ecological consequences?
   - intended & unintended
3. what is variability/predictability?
   - especially at larger & longer scales

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* New *experiments* could answer some of these questions