Quantifying iron fertilization with stable isotopes

Non-traditional Isotope Research on Various Advanced Novel Applications

ExOIS Forum

2022-08-15

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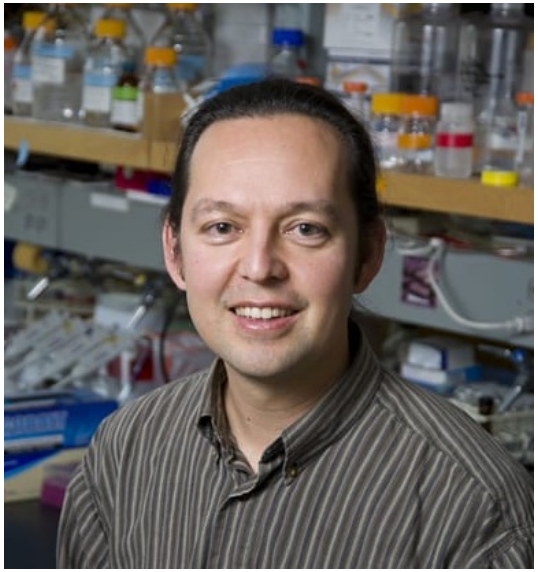
The team, supported by *OCIA*

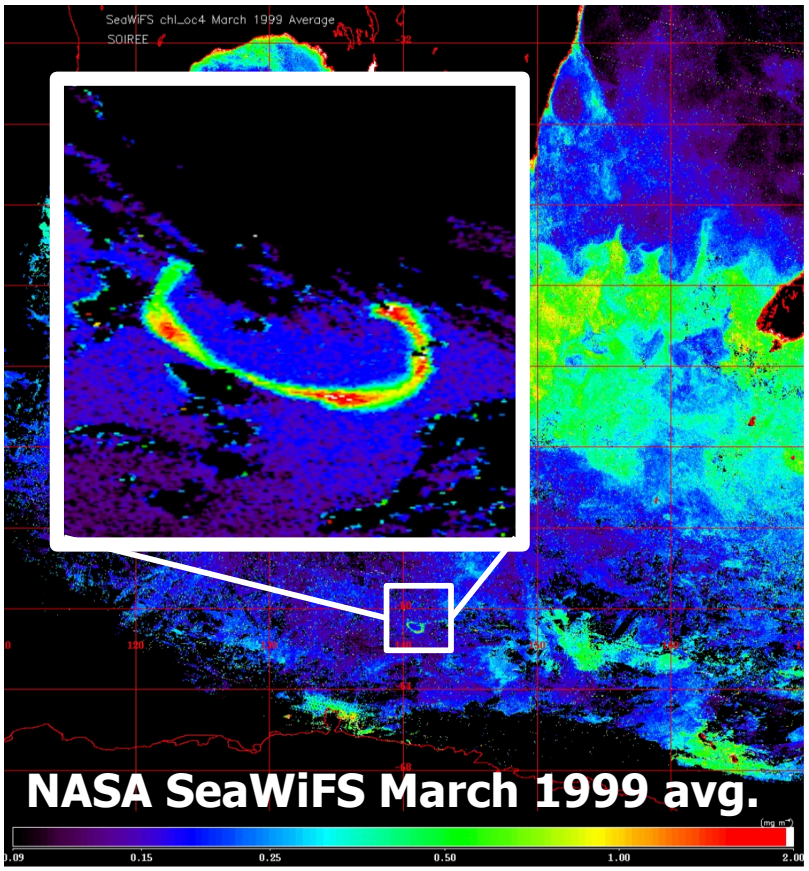
Tristan Horner
WHOI MC&G
(person talking now)



Mak Saito
WHOI MC&G

Ichiko Sugiyama
Weizmann Inst.
Soon: WHOI MC&G

The three uncertaintiE's of fertilization



Effect. Does fertilization stimulate carbon export?

Efficiency. What is the best way to add Fe?

Efficacy. Do plankton encounter a secondary nutrient limitation?

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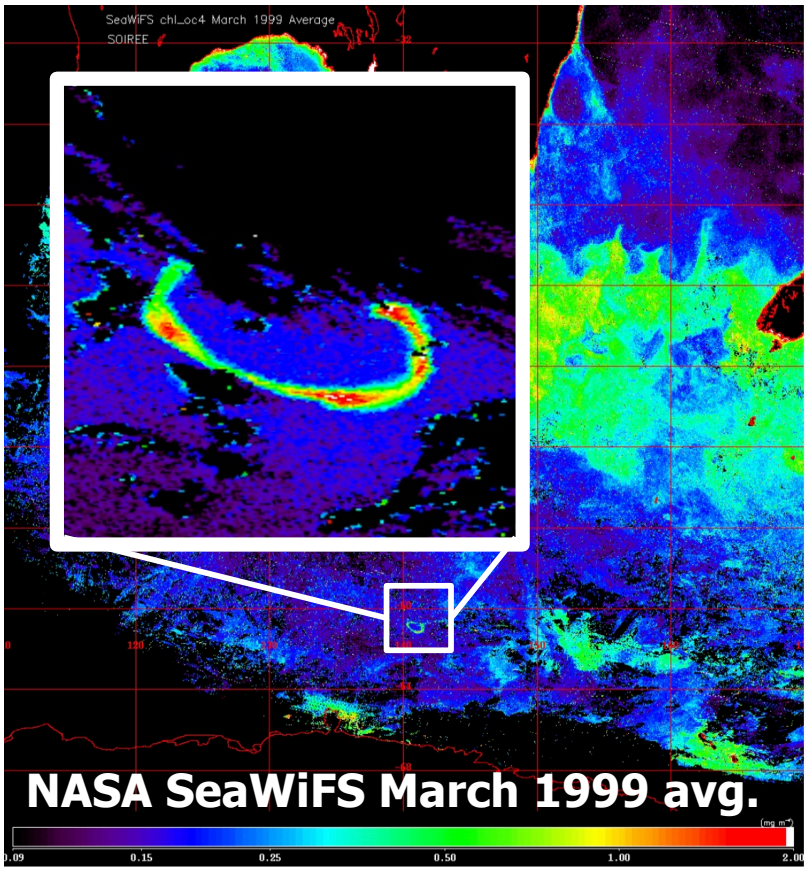

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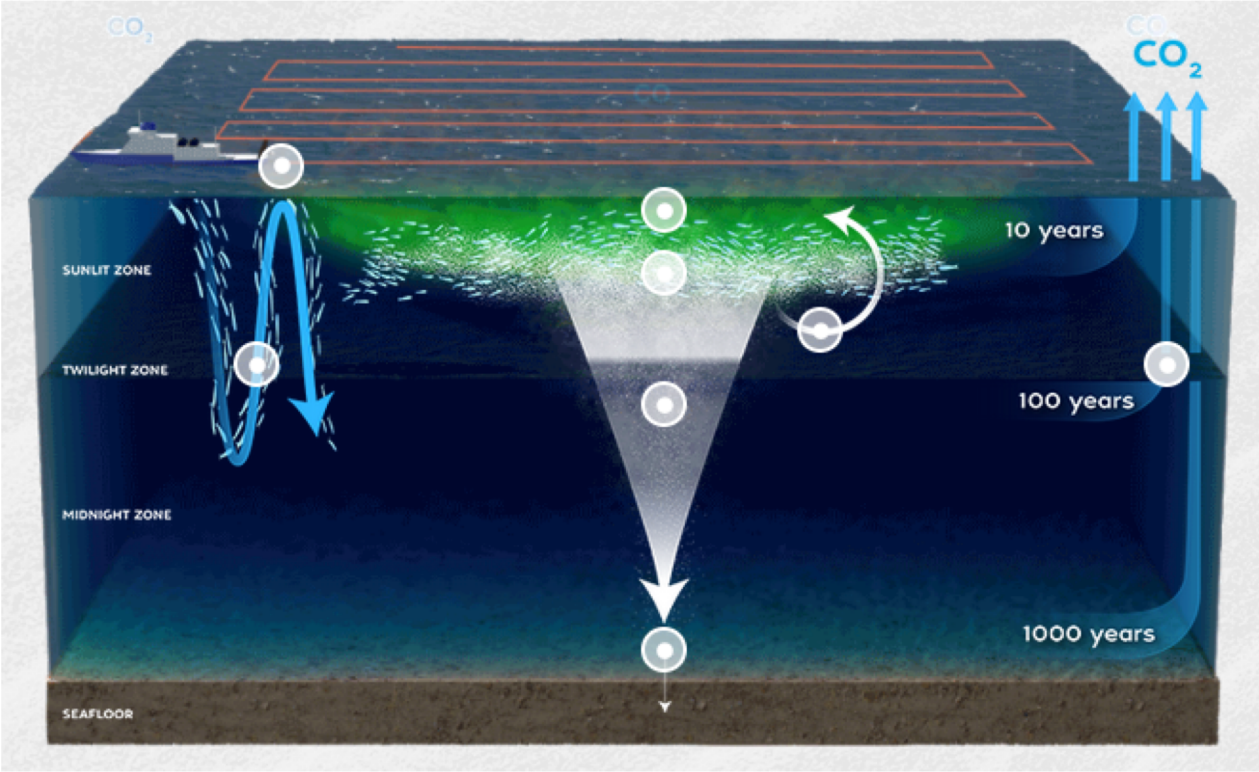
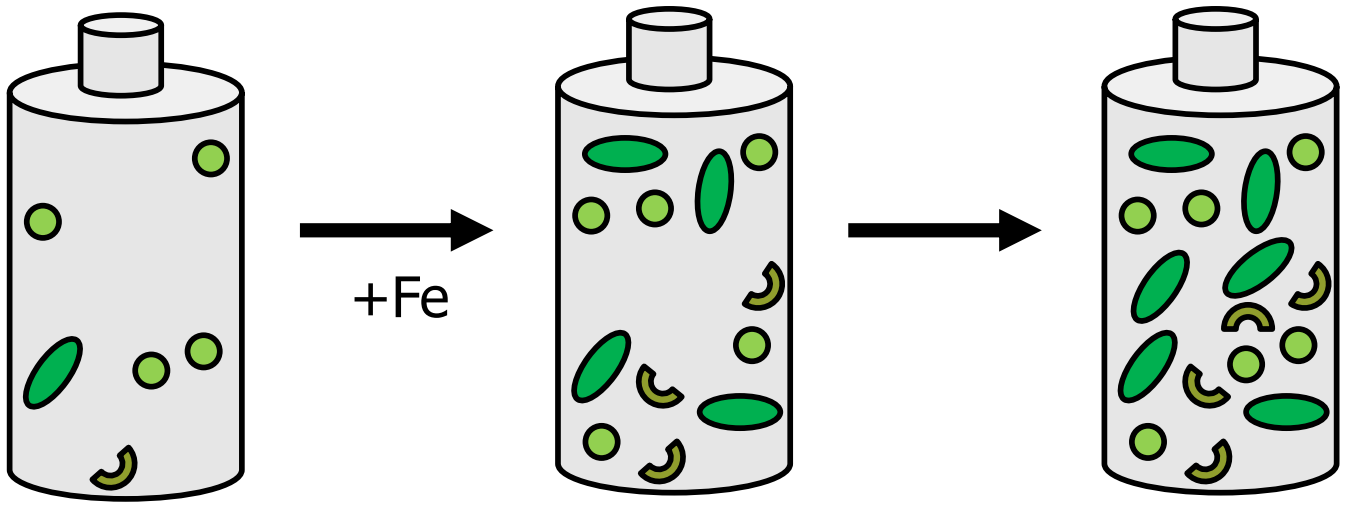
Trust, but verify

How can we **verify** that observed biomass was formed in response to fertilization?

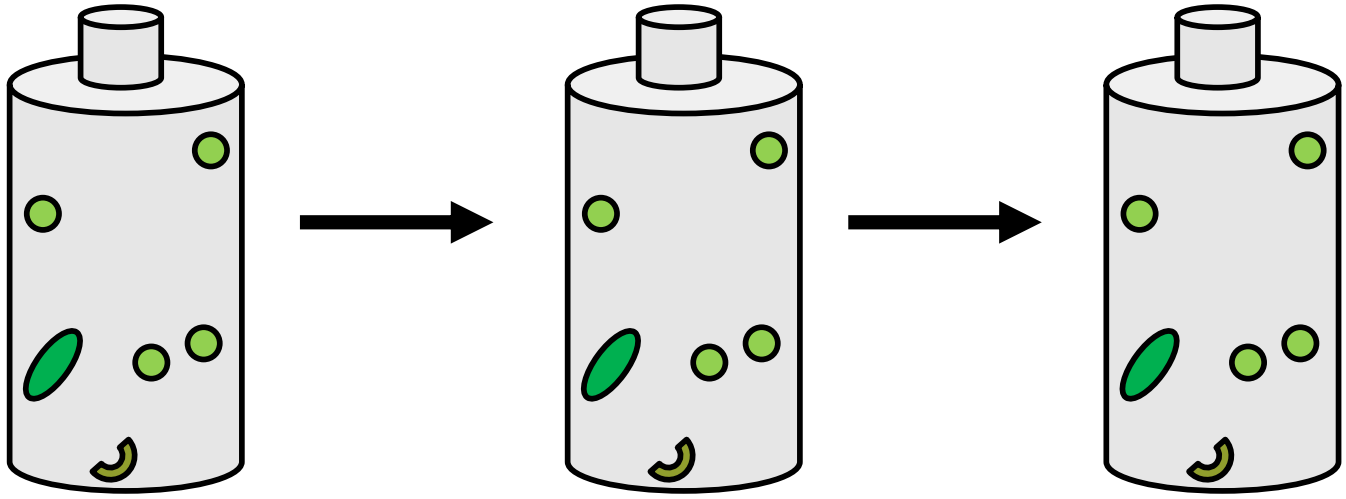


Verifying effects in enclosed experiments



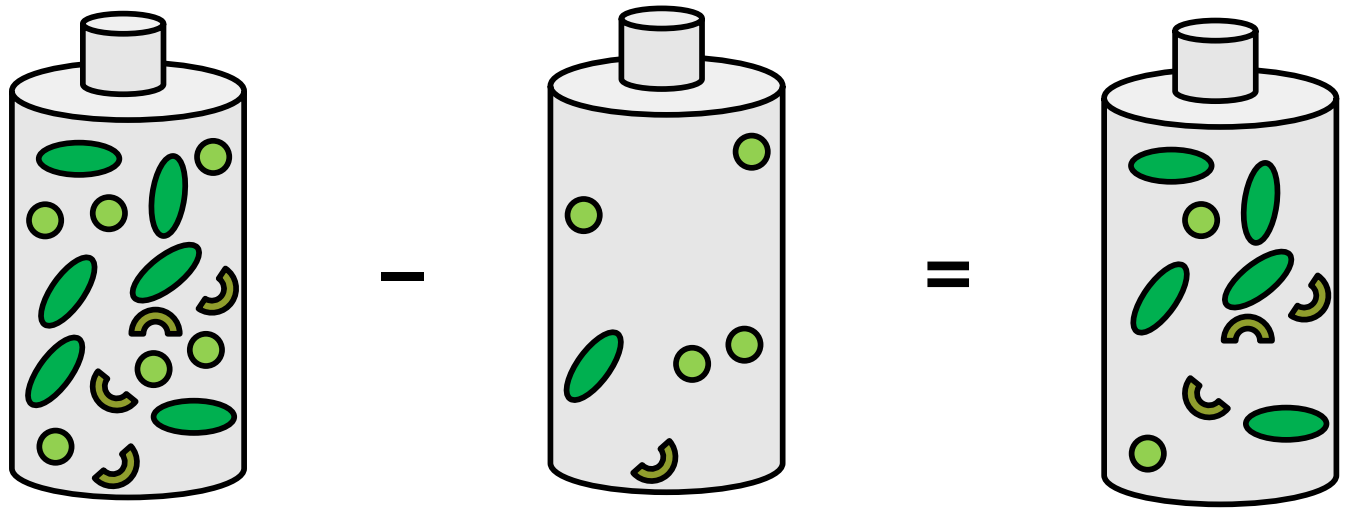
Amended

Verifying effects in enclosed experiments



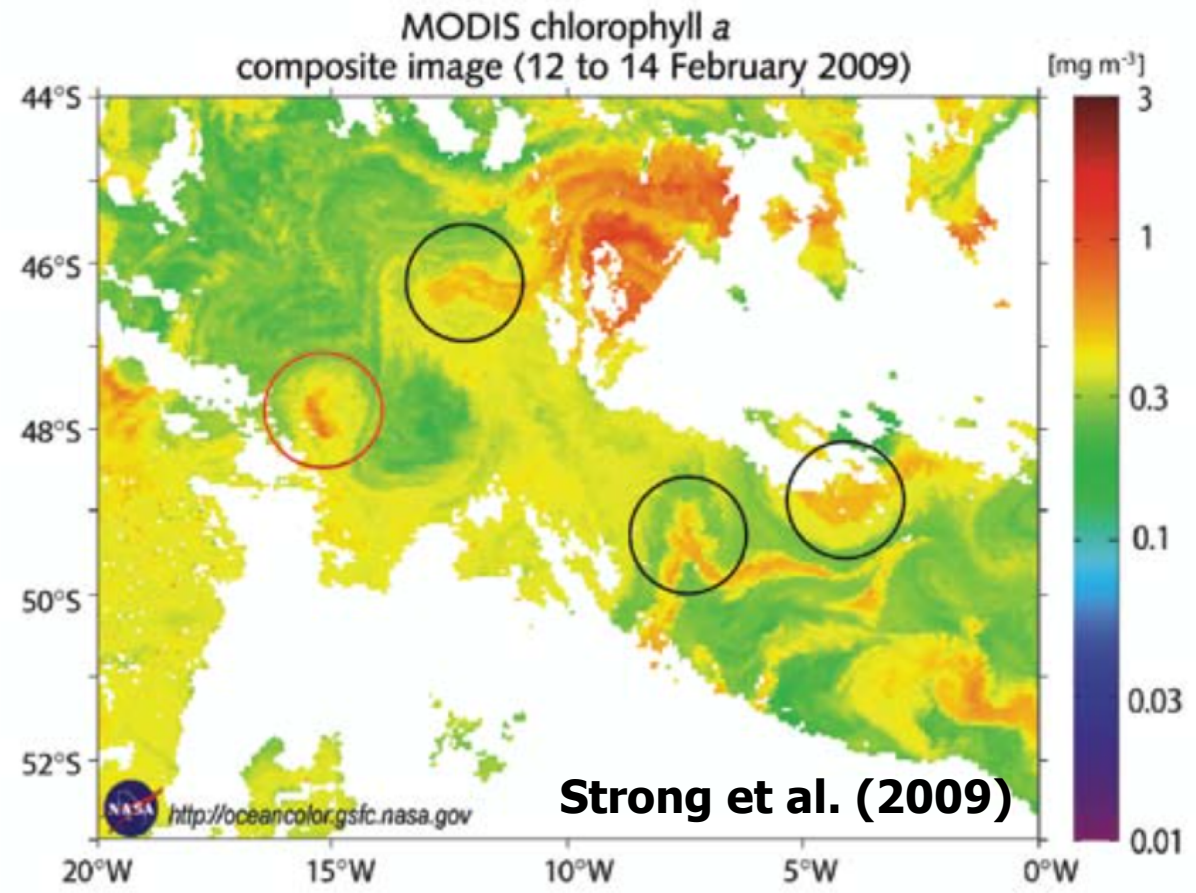
Unamended

Verifying effects in enclosed experiments



Amended – Unamended = Growth in response to fertilization

How do we put the ocean in a bottle?



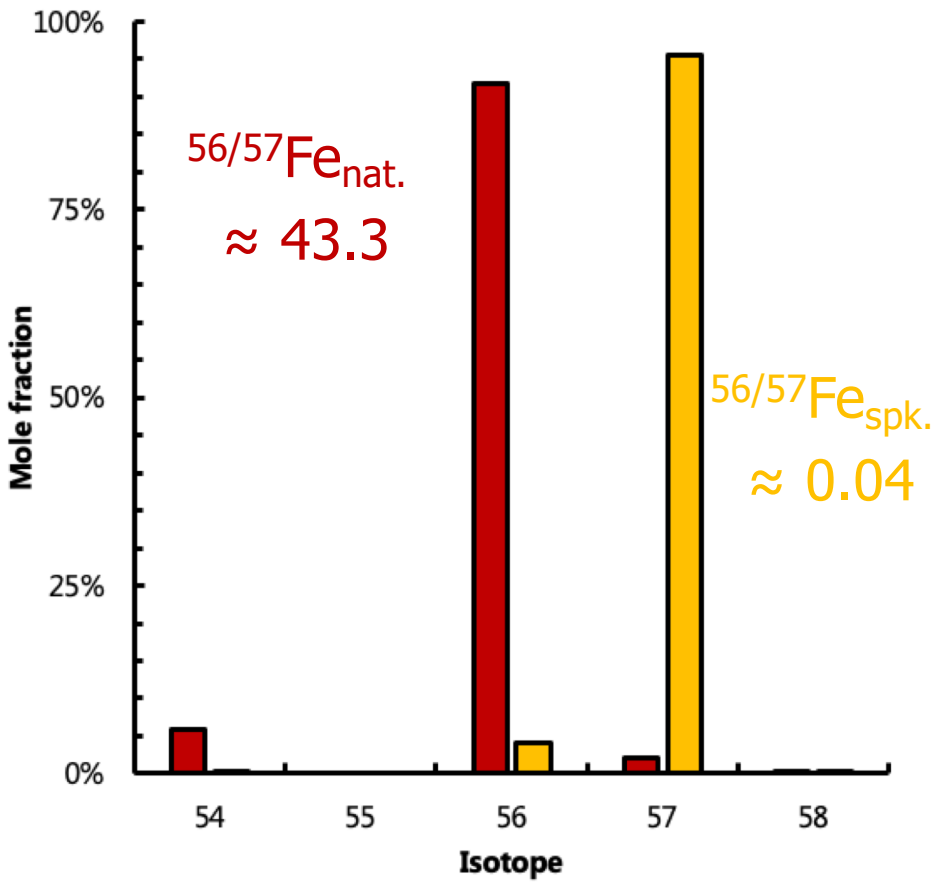
"ocean fertilization … would have to demonstrate that the iron-induced bloom would not have otherwise occurred"

The idea

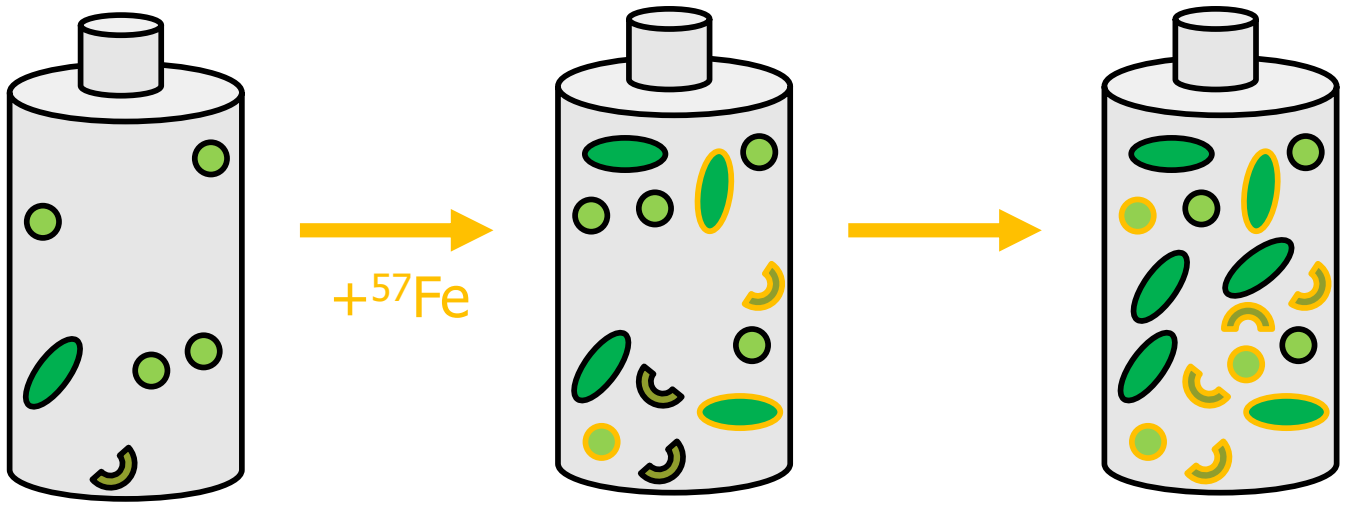
Can we use iron-57 to address the three E's?

Iron has four stable isotopes; most is iron-56

Can purchase enriched spikes of other isotopes



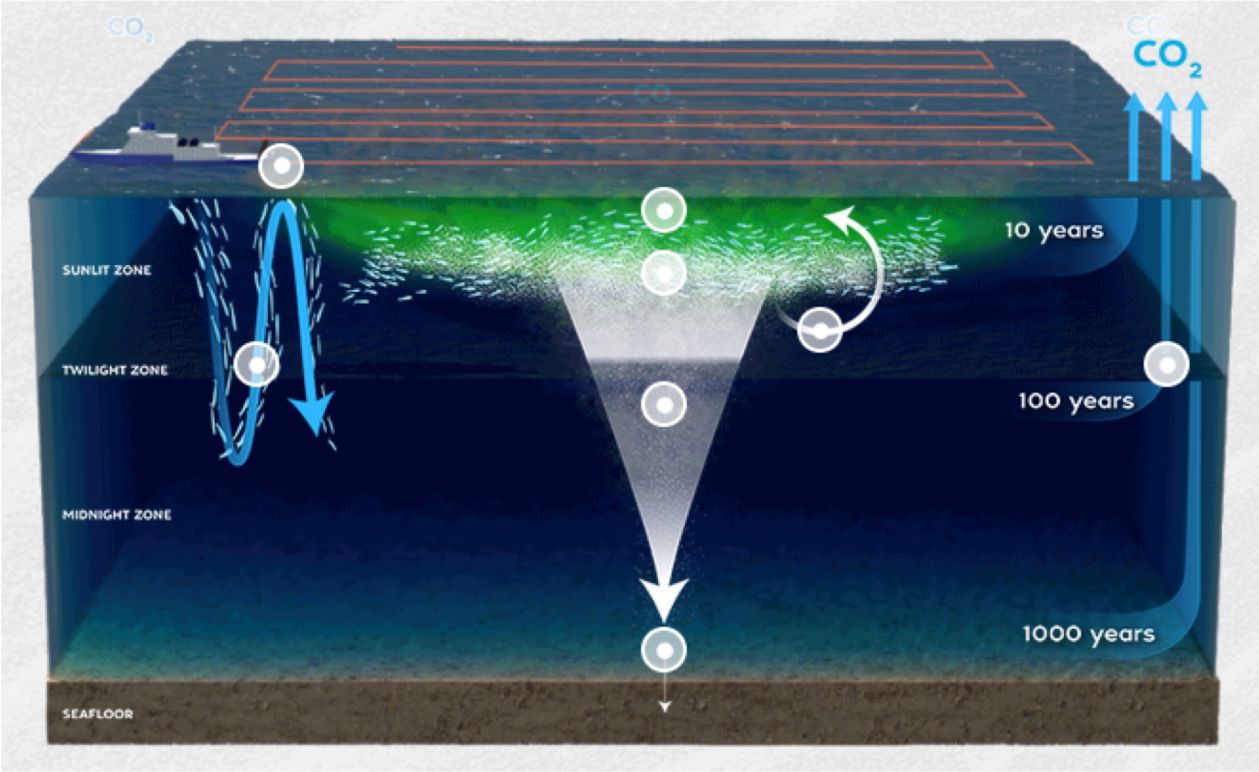
Verification using iron-57



^{56}Fe:^{57}Fe of biomass diagnostic of the iron source—fertilized or not

Verifying in unenclosed experiments

Iron isotope ratio of sinking particles will tell you if export from was Fe fertilization (low ^{56}Fe:^{57}Fe) or not (normal ^{56}Fe:^{57}Fe)



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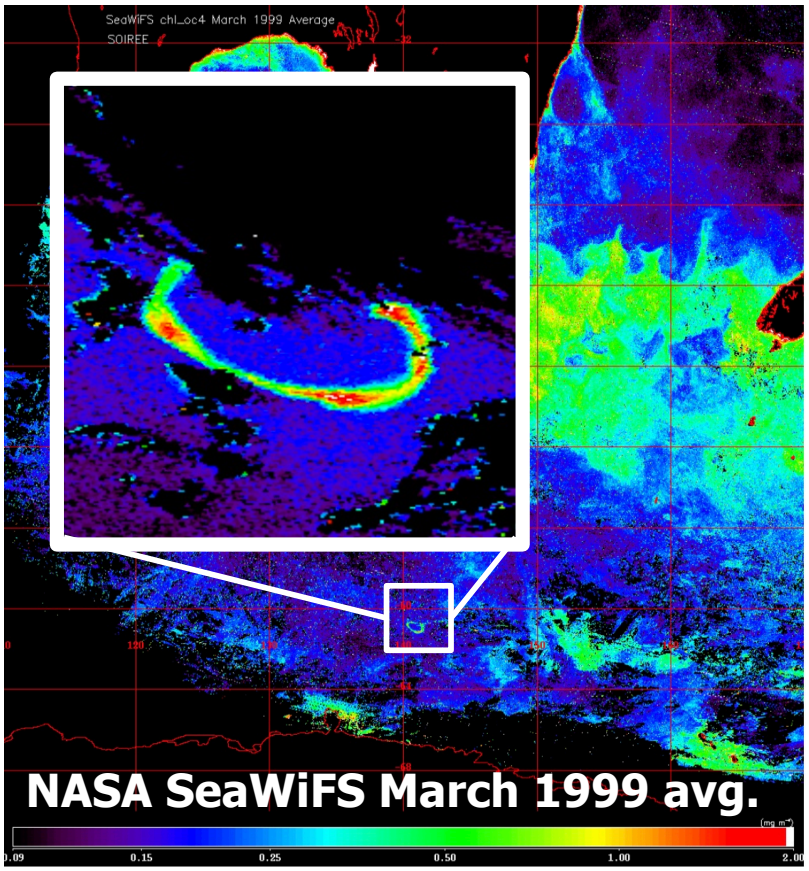

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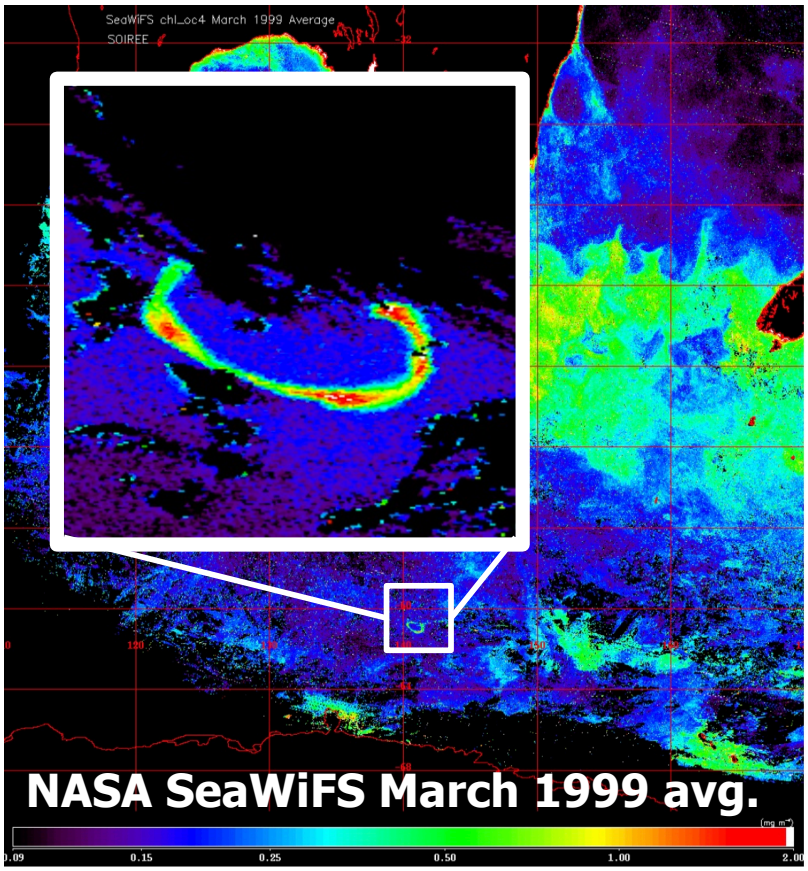

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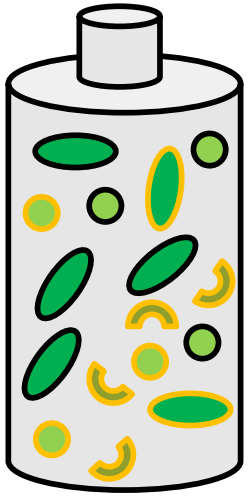
Fertilizing efficiently

How much Fe dissolves relative to how much Fe is added?

How much iron is taken up by cells relative to the bottle walls?



- Ligand
  - Sulfate
  - Chloride
  - …?
- Quantity
  - Amount over background
- Rate
  - All at once?
  - Every day?

Fertilizing efficiently

Cost of iron

- Normally ~$0.01 per g
- Iron-57 ~$5,000 per g
- Need to consider ways to bring cost down if scaling up

Areas for improvement

- Not all Fe need come from ^{57}Fe, just enough to measure
- Improve measurement precision (use MC-ICP-MS)
- Fertilize certain regions with ^{57}Fe, use ^{56}Fe elsewhere
- Lower iron-57 production costs (dedicated cyclotrons?)

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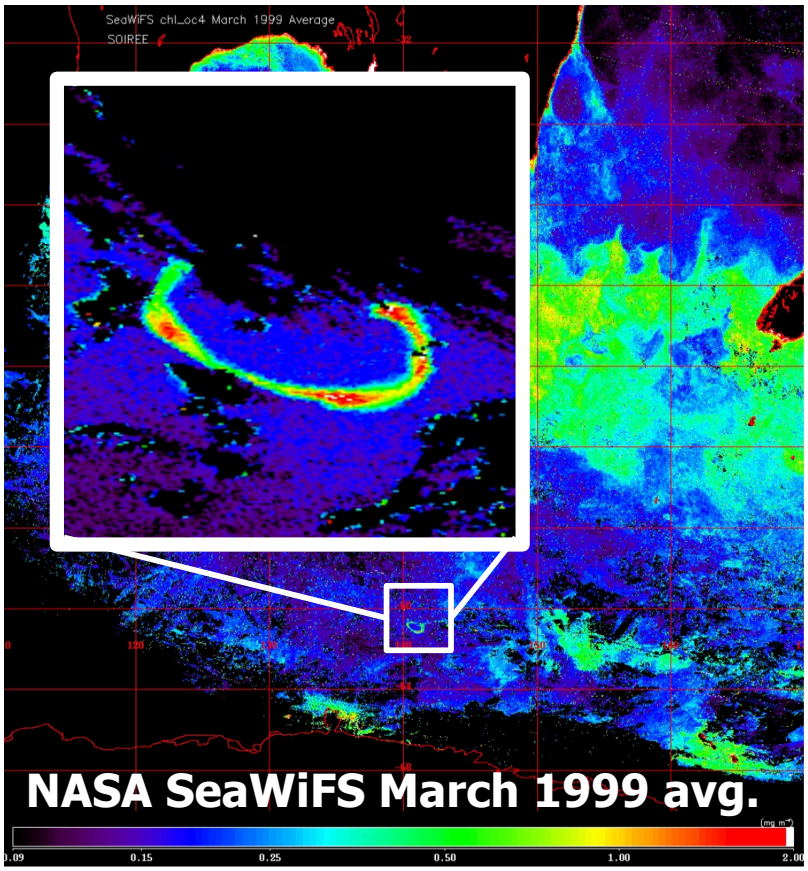

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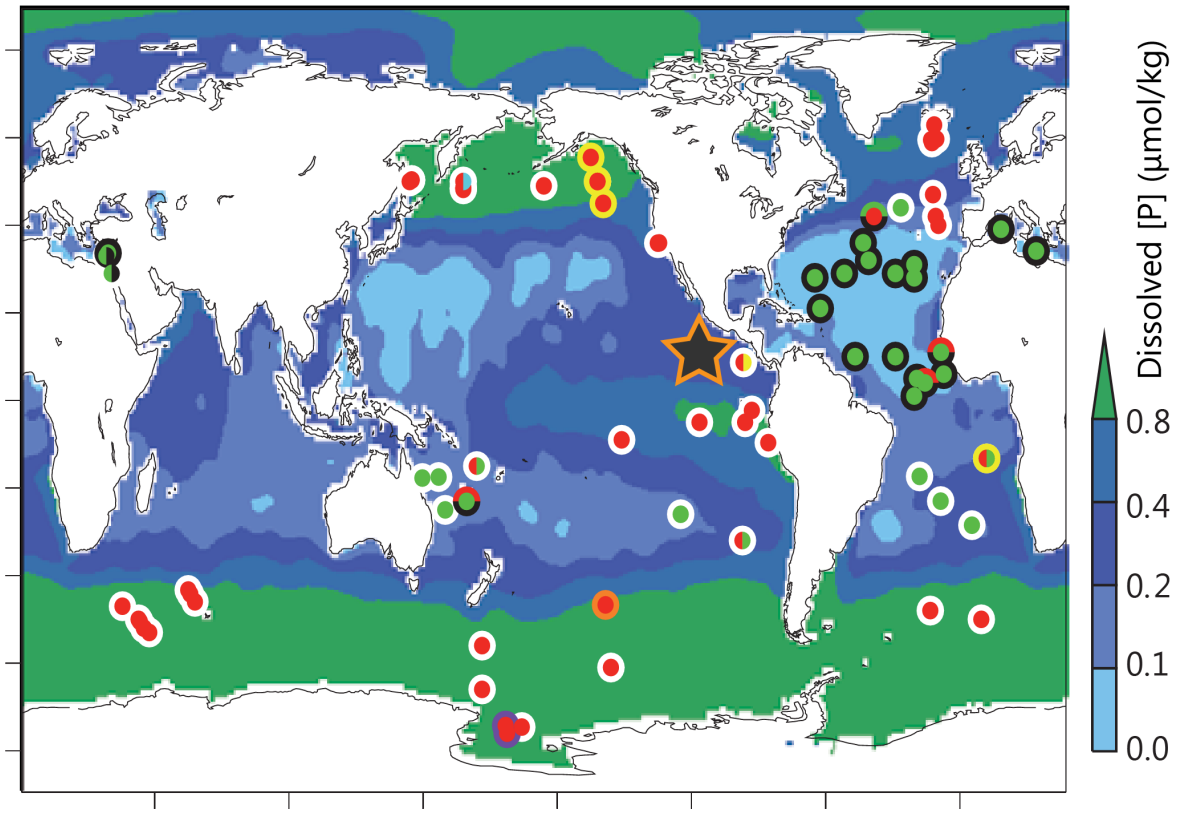
Maximizing efficacy



Moore et al. (2013)

Site-specific considerations:

- Do cells increase Fe quotas?
- Will ecology quickly respond?
- Are there secondary nutrient limitations?

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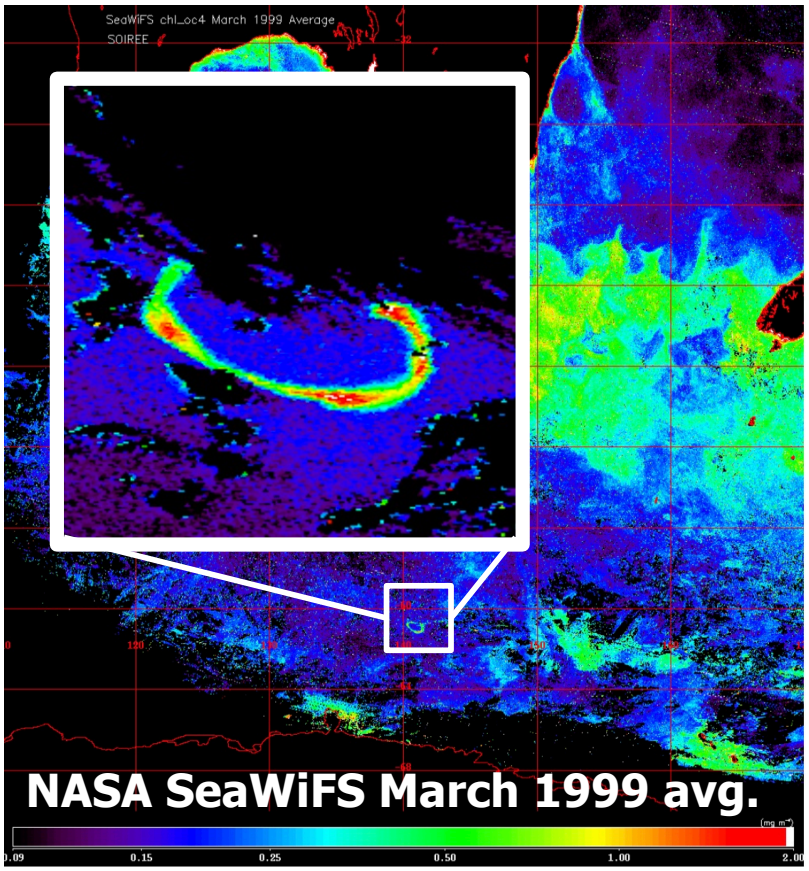

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