Is Iron Fertilization Good for the Sea?

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After a good day of fishing, chemical engineer Luis Marbles, his daughter Becky, and his marine biologist friends David and Kate Cheshire were enjoying a meal of grilled bass around a campfire.

"This is great! Nothing tastes better than fresh fish cooked just right," said David. "It's too bad we don't always get this lucky catching fish."

"Oh, but we will eventually. In fact, the fish will be so plentiful we'll be able to feed the world's hungry," replied Luis.

"What makes you think that, Dad?"

Luis put an arm around his daughter and replied, "I plan to capitalize on the 'Geritol effect' produced by seeding the oceans with iron."

Turning to David and Kate, Luis continued: "As you know, low iron concentrations in the equatorial Pacific and the Antarctic oceans limit the growth of surface algae.[1] I'm sure you remember the IronEx experiments led by the Moss Landing Marine Laboratory.[2, 3] Thirty-seven scientists from 13 different institutions of the U.S., Great Britain, and Mexico found that by slowly introducing iron into the ocean water they could encourage algae growth. In the IronEx I experiment, a single infusion of iron had little effect because the iron sank rapidly to the ocean bottom. But, in the IronEx II experiment, repeated iron infusions over time boosted the phytoplankton photosynthesis. The algae grew in number and used more carbon dioxide. Other studies conducted in the Southern Ocean gave comparable results.[4]"

"Scientists are pretty excited about finding a cheap way to decrease global warming,"[5] Luis added, turning back to his daughter.

"But what does this have to do with fishing?" asked Becky.

"Well, Becky, I figure that if the primary producers of the ocean increased in numbers, then the tiny critters like copepods will get more to eat. That means little fish will also get more to eat, in turn feeding the big fish."

"What's your plan, Luis?" Kate asked, a bit tentatively.

"I've established a company called MOFI, for Maximizing Ocean Farming Inc. My company has made a deal with the Marshall Islands for commercial rights to the 800,000 square miles of ocean around the archipelago. We'll not only fix global warming, we will get rich as well!"

"How will you do that?" asked Becky.

"We plan to put a mixture of iron, phosphorous, and key trace elements into floating time-release minicapsules that will keep my special Geritol mixes afloat longer and seed the ocean more slowly.[6] In this way, we will mimic the enrichment provided by upwellings in the ocean off Peru and have the same kind of rich fishing. Why, by continuous seeding of just 100,000 square miles of ocean, we can probably cut down by one-quarter to one-third the carbon

dioxide emissions from the United States! Since there is talk about greenhouse gas emission taxes for each country, we can get rich while helping to decrease CO_2 emissions without having to cut down on too much fossil fuel and land use in the U.S."

Looking rather askance, Kate exclaimed, "Luis, that is an oversimplification! We don't know enough to predict what kind of algal species will bloom by your enrichment methods. Surface blooms may cut off the oxygen for life forms beneath the surface.[7] How do you know that the blooms won't kill the coral reefs? If surface growth becomes too thick, you will also cut off the light. This could kill the coral reefs!"

With a puzzled frown, Becky asked, "Why would the lack of light kill corals? Aren't they animals?"

"Because the corals are dependent on their live-in friends, tiny algae that photosynthesize and help feed the coral and promote its growth. When El Niño warmed the water, many coral reefs suffered losses that we can see as bleaching.[8] Bleached corals are dead coral," Kate responded.

Becky added, "Dad, I remember reading somewhere that corals are the oases in an ocean desert and that they grow very slowly."

"Yes," interjected Kate, "their growth is measured in just millimeters each year."[9]

"How long will it take coral reefs to recover?" asked Becky. "It would be horrible if we see dead corals instead of the breathtaking colorful reefs we've seen when we scuba dive. Where will the octopus and the beautiful fish live? What will they eat? Won't they die, too?"

David chimed in: "And not all algal blooms are good algal blooms. We don't need 100,000 square miles of toxin-producing harmful algal blooms.[10] Instead of growing fish, you'll be killing them, not to mention hurting people who might eat contaminated shellfish."

"Hang on a minute," said Luis. "Harmful algal booms occur only in coastal areas, not out in the open ocean. Besides, if a coral reef dies but we manage to feed more hungry people, well, I for one could accept the trade-off."

Kate shook her head and said, "Blooms occur on coastal areas because that's where nutrient enrichments occur. If you enrich the nutrients in the open ocean, you will have blooms there, too. And even if the blooms are not due to toxic species, not all species of algae favor copepod reproduction. My research shows that iron fertilization results in diatom bloom. Copepods feeding on diatoms have lower counts of eggs. And diatoms can clog the gills of marine animals."[11]

Luis answered, "I guess we'll find out. If we don't try, we'll never know. We've conducted experiments in the Gulf of Mexico to find the best Geritol mixes and the best delivery system. The next step is to try this out around the Marshall Islands. With enough funding, we can start the 100,000-square-mile experiment in the year 2002. If scientists don't think this will work, why are they proposing an IronExIII?[12] The recent *New York Times* report regarding the melting of the North Pole ice cap would support any measures to prevent global warming."[13]

Questions

1. What limits the primary productivity of the ocean?
2. What are greenhouse gases and how are they affecting global temperatures?
3. How does the proposed MOFI venture differ from other ocean fertilization experiments?
4. What are the potential ramifications of the MOFI venture?
5. Discuss the scientific merits and ethical implications of Luis Marbles' proposed commercial venture. What would you do if you were in Luis Marble's place?

Footnotes

[1] *Iron as a limiting factor for phytoplankton productivity*

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[4] *Southern Ocean Iron Release Experiment*
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[5] *Greenhouse gases and global warming*
- Global Warming Frequently Asked Questions (NOAA)
  http://www.ncdc.noaa.gov/ol/climate/globalwarming.html
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  http://www.epa.gov/climatechange/index.html
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[6] *Ocean Farming, Inc. Venture*
- Testing the Waters (Schueller, G. *New Scientist*, Oct. 2, 1999)
  http://www.newscientist.com/article/mg16422064.800-testing-the-waters.html
- Fertilizing the Sea (Nadis, S. *Scientific American*, Apr. 1988)

[7] *Effects of surface blooms*
- Testing the Waters (Schueller, G. *New Scientist*, Oct. 2, 1999)
  http://www.newscientist.com/article/mg16422064.800-testing-the-waters.html

[8] *Zooxanthellae, corals, and temperatures*
- El Niño Causing Coral Bleaching in Galapagos, NOAA Announces. January 20, 1998 press release. *National Oceanic and Atmospheric Administration*
  http://www.publicaffairs.noaa.gov/pr98/jan98/noaa98-004.html
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[9] *Growth of corals*
- Birkeland, C. (ed.) 1997. *Life and Death of Coral Reefs*. Chapman & Hall.
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[10] *Harmful algal blooms*
- State of the Coastal Environment: Harmful Algal Blooms (NOAA)
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- Harmful Algae Page (Woods Hole Oceanographic Institution)
  http://www.whoi.edu/redtide/

[11] *Detrimental effects of diatoms*

- Testing the Waters (Schueller, G. *New Scientist*, Oct. 2, 1999) http://www.newscientist.com/article/mg16422064.800-testing-the-waters.html

[12] *IronEx III*

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