

## **Should iron fertilization be used to mitigate global warming?**

*Instructor note: This activity is currently in development so this is a very rough outline of ideas that will shape the final activity. It is being designed to strengthen students' quantitative reasoning skills and to gauge their ethical reasoning skills)*

This activity is designed to address university and departmental objectives of problem solving and ethical reasoning. Part of the university objective for problem solving is that students “will analyze and interpret data as a means to evaluate arguments and make informed choices” and the ethical reasoning objective is that “students will recognize the ethical issue involved in human actions and be able to formulate a set of principles and virtues which can be brought to bear in personal and public decision making.” Students will be assessed on their proficiency in meeting these objectives.

### **Part I. Introduction to the iron fertilization hypothesis**

Students will learn about the iron fertilization hypothesis either through engaging with scientific literature (advanced course) or through class discussion (intro course). The main objective of this part of the activity is to have students explain the hypothesis that natural iron fertilization of certain regions of the ocean (e.g., Southern Ocean) during glacial periods leads to a drawdown of atmospheric CO<sub>2</sub> via enhanced marine productivity. For advanced students, a relevant article to read might be: Martínez-García et al., 2014. *Iron fertilization of the subantarctic ocean during the last Ice Age*. Science Vol. 343 no. 6177 pp. 1347-1350. For an intro course, we would discuss the hypothesis in class.

### **Part II. Does iron fertilization lead to carbon sequestration?**

Students will analyze graphs from several iron fertilization studies to evaluate how biological productivity changes with the addition of iron to the ocean. The main objective with this part of the activity is to have students use and strengthen their data analysis skills to answer the question, “should we use iron fertilization to mitigate global warming” from a *scientific* perspective. They would need to evaluate whether or not iron fertilization leads to enhanced productivity (which it generally seems to) and whether or not it leads to carbon sequestration (the data seems mixed on this aspect).

To complete this activity, students would work in groups to analyze data/graphs from several different iron fertilization experiments; this would likely be constructed as a jigsaw activity during which each group is analyzing a different set of data. (The studies will be referenced by the time this activity is in its final form.) For an advanced course, methodology would be discussed and students could be asked to read the paper from which their data is drawn. Limitations should also be considered, so they may be asked to read a scientific commentary on a published paper (e.g., Ken Buesseler, *The great iron dump*, Nature 487, 305-306 (2012) commenting on Smetacek et al's study in the same issue: Smetacek, V. et al. Nature 487, 313–319 (2012).

After examining and discussing data in groups, students would submit their written explanation of iron fertilization and whether or not it serves as a viable geoengineering strategy, using scientific evidence to support their argument. They would then be prompted to consider other issues (non-scientific) that come into play with such a strategy to prepare for part III.

### **Part III. Should we use iron fertilization to mitigate global warming?**

A class discussion/debate will be held during which students state their individual positions on iron fertilization as a geoengineering strategy. (An alternative model would ask students to debate the topic after being assigned to the ‘pro’ or ‘con’ side, regardless of their own stance.) During the discussion, we would consider the scientific considerations (does iron fertilization lead to carbon sequestration?), legal considerations (is dumping iron in the ocean legal?), and ethical considerations (who are the stakeholders? Who/what benefits? Who/what is at risk?) The final assignment would have students reflect on their own view regarding iron fertilization as a geoengineering strategy, again drawing from both the scientific and ethical perspectives.