Final Report
SOFeX, the Southern Ocean Iron Experiment
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The Southern Ocean Iron Experiment (SOFeX) was an experiment decades in the planning. It's implementation was among the most complex ship operations that SIO has been involved in. The SOFeX field expedition was successful in creating and tracking two experimentally enriched areas of the Southern Ocean, one characterized by low silicic acid, one characterized by high silicic acid. Both experimental sites were replete with abundant nitrate. About 100 scientists were involved overall. The major findings of this study were significant in several ways:

1) The productivity of the southern ocean is limited by iron avalibility.
2) Carbon uptake and flux is therefore controlled by iron availability
3) In spite of low silicic acid, iron promotes non-silicious phytoplankton growth and the uptake of carbon dioxide.
4) The transport of fixed carbon from the surface layers proceeds with a C:N ratio that would indicate differential remineralization of nitrogen at shallow depths.
5) These finding have major implications for modeling of carbon export based on nitrate utilization.
6) The general results of the experiment indicate that, beyond other southern ocean enrichment experiments, iron inputs have a much wider impact of productivity and carbon cycling than previously demonstrated.

Several major publications (see below) did receive widespread attention and the primary findings were prominently featured on the cover of Science Magazine together with two other papers from this expedition. To date, several other publications have emerged. Listed below are the ones with K. Coale as an author. These results continue to attract international attention and a special international symposium has been organized to address the results and future for additional studies of iron enrichment in the open ocean. This meeting will be held in Otago, New Zealand in October and November.

Scientific Presentations:

Coale, K., Johnson, K, Buesseler, K., 2002. The SOFeX Group. Eos. Trans. AGU 83 (47) OS11A-0199.

Coale, K., Johnson, K. Buesseler, K., 2002. SOFeX: Southern Ocean Iron Experiments. Overview and Experimental Design. Eos. Trans. AGU 83 (47) OS22D-01.

Buesseler, K., Andrews, J. Pike, S., Crossin, G., Herbold, C., Charlett, M., Coale, K., Johnson, K., 2002. Does Iron Fertilization Enhance Carbon Sequestration? Particle flux results from the Southern Ocean Iron Experiment. Eos. Trans. AGU 83 (47), OS22D-09.

Johnson, K. Chase, Z, Elrod, V. Fitzwater, S., Plant, J., Coale, K., Hunter, C., Gordon, R.,

Buesseler, K., 2002. Open Ocean Iron Fertilization Experiments From IronEx-I through SOFeX: What We Know and What We Still Need to Understand. Eos. Trans. AGU 83 (47), OS22D-12.

Coale, K. H., 2003. Carbon and Nutrient Cycling During the Southern Ocean Iron Enrichment Experiments. Seattle, WA. Geological Society of America.

Coale, K., 2003. Open Ocean Iron Enrichment Experiments: What they have told us, what they have not. American Society for Limnology and Oceanography and The Ocenography Society, Honolulu, February 2004.

Coale, K., 2004. Recent Research from the Southern Ocean Iron Experiment (SOFeX), in Taking the Heat: What is the Impact of Ocean Fertilization on Climate and Ocean Ecology? Science of Earth and Sky. AAAS, February 12-16, Seattle, WA.

Coale, Kenneth H., 2004. Open Ocean Iron Enrichment Experiments: What they have told us,what they have yet to tell. Gordon Research Conference in Environmental Bioinorganic Chemistry. Bates College, Maine. June 20-24, 2004.

Coale, Kenneth H., 2004. Iron and Climate: The Carbon Connection. Department of Environmental Studies, University of California at Santa Cruz, November, 2004

de Baar, H.J.W., Royal Netherlands Institute for Sea Research, debaar@nioz.nl, Boyd, P., NIWA, University of Otago, Dunedin, New Zealand, p.boyd@niwa.co.nz, Coale, K.H., Moss Landing Marine Laboratories, Moss Landing, USA, coale@mlml.calstate.edu Landry, M.R., Scripps Institution of Oceanography, LaJolla, USA, Mike.Landry@coast.ucsd.edu Tsuda, A., Hokkaido National Research Institute, Kushiro, Hokkaido, Japan, tsuda@ori.u-tokyo.ac.jp Bozec, Y., Royal Netherlands Institute for Sea Research, bozec@nioz.nl Rijkenberg, M., Royal Netherlands Institute for Sea Research, rijken@nioz.nl Synthesis of 8 Iron Fertilization Experiments: from the Iron Age in the Age of Enlightenment ASLO, Santiago, Spain, 2005.

Publications:

Kenneth H. Coale, Kenneth S. Johnson, Francisco P. Chavez, Ken O. Buesseler, Richard T.Barber, Mark A. Brzezinski, William P. Cochlan, Frank J. Millero, Paul G. Falkowski, James E. Bauer, Rik H. Wanninkhof, Raphael M. Kudela, Mark A. Altabet, Burke E. Hales, Taro Takahashi, Michael R. Landry , Robert R. Bidigare, Xiujun Wang, Zanna Chase[2], Pete G. Strutton, Gernot E. Friederich, Maxim Y. Gorbunov, Veronica P. Lance, Anna K. Hilting, Michael R. Hiscock, Mark Demarest, William T. Hiscock, Kevin F. Sullivan, Sara J. Tanner, R. Mike Gordon, Craig N. Hunter, Virginia A. Elrod, Steve E. Fitzwater, Janice L. Jones, Sasha Tozzi, Michal Koblizek, Alice E. Roberts, Julian Herndon, Jodi Brewster, Nicolas Ladizinsky, Geoffrey Smith, David Cooper, David Timothy, Susan L. Brown, Karen E. Selph, Cecelia C. Sheridan, Benjamin S. Twining and Zackary I.

Johnson , 2004. Southern Ocean Iron Enrichment Experiment: Carbon Cycling in High- and Low-Si Waters, Science April 16, 2000.

deBaar, H., P. Boyd, K. Coale and A. Tsuda (lead authors). 2004. Synthesis of eight in situ iron fertilizations in high nutrient, low chlorophyll waters confirms the control by wind mixed-layer depth of phytoplankton blooms. In. Synthesis 8, Iron Enrichments. The Oceans in a high CO2 World. Special Issue Deep-Sea Research. In Press.

Coale, K. H., R. M. Gordon and X. Wang. 2005. The distribution and behavior of the Dissolved and particulate iron and zinc in the Ross Sea and Antarctic Circumpolar Current along 70^{o} W. Deep-Sea Research I. V. 52, no. 2 pg 295-318.

Web info and outreach:

http://www.mlml.calstate.edu/news/newsdetail.php?id=34