Stimulating the Ocean Biological Carbon Pump by Iron Fertilization

Background

The subarctic Pacific is known to have surface waters with high nutrient and low chlorophyll (HNLC) as the equatorial Pacific and the Southern Ocean. In recent years, the micro-nutrient iron has been shown to play a key role in limiting phytoplankton growth, nutrient utilization and carbon uptake in the HNLC regions. Therefore, the carbon transfer efficiency to deep water by the ocean biological pump might be controlled by iron availability. Additionally, an idea that fertilizing the ocean by adding small amounts of iron to stimulate the biological pump and remove large amounts of CO_2 from the atmosphere has been proposed.

Objectives

Objective of this study is develop the iron release and observation method for iron fertilization experiment and investigate the responses in chemical and biological parameters in phytoplankton ecosystem after iron release.

Principal Results

1. Approximately 350 kg of iron and 0.48 mol of the tracer sulphur hexafluoride were released to a surface mixed layer over an area of 80 km^2 (Fig-1). Ship was navigated along the grid spiral pattern centered on the buoy with a lagrangian coordination system to conducted iron enriched-patch (Fig-2) and we tracked the patch by onboard sulphur hexafluoride measurement during the experiment.
2. During the experiment, a large increase in the phytoplankton standing stock, with drawdown of macro-nutrients and carbon dioxide, caused in the iron enriched-patch (Fig-3). Dominant phytoplankton species shifted from small size pennate diatoms to a large size centric diatom in the patch. The findings of the experiment clearly demonstrate that iron availability fundamentally controls the phytoplankton growth thereby regulating the biogeochemical carbon transport process in the ocean.
3. After iron release, enriched iron in the dissolved fraction was rapidly transformed to suspended labile particulate iron and the labile particulate iron remained in the surface mixed layer. This iron transformation process reduces dissolved iron concentration and iron bioavailability (Fig-4). Therefore, the transformation process is important to understanding how phytoplankton become iron limited and the biogeochemical iron cycle in the western subarctic North Pacific.

Future Developments

Long term experiment is required in different ocean waters to evaluate the fate of fixed organic carbon and influence on surrounding environment after induced phytoplankton bloom.

Main Researcher: Jun Nishioka,
Research Scientist, Biology Dept., Abiko Research Labolatory

Reference

Nishioka, J et al.: Size fractionated iron distribution and iron-limitation processes in the Western Subarctic North Pacific, Geophysical Research Letters (2003)
Tsuda et al.: A Mesoscale iron enrichment experiment in the western subarctic Pacific induce a large centric diatom bloom, Science (2003)

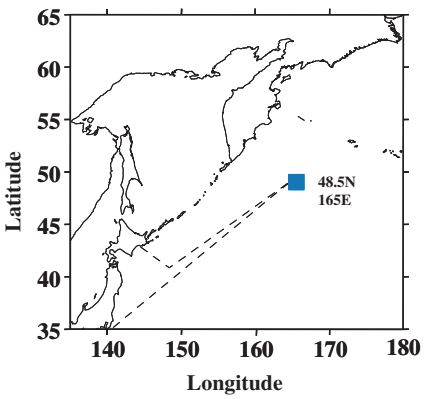
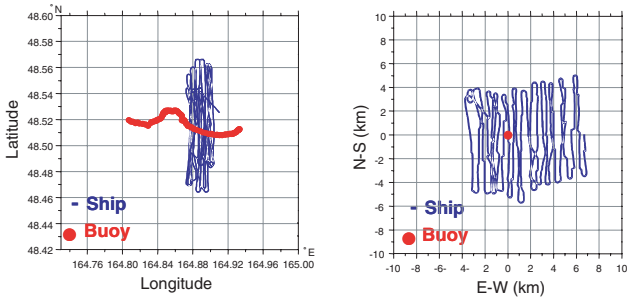


Fig.1 Location of the in situ iron enrichment experiment



Ship's and bouy's track during iron release

Express the ship's track by lagrangian coordination system

Fig.2 Ship's position trajectory during Fe and SF_6 infusion. Ship was navigated along the grid spiral pattern centered on the buoy with a lagrangian coordination system.

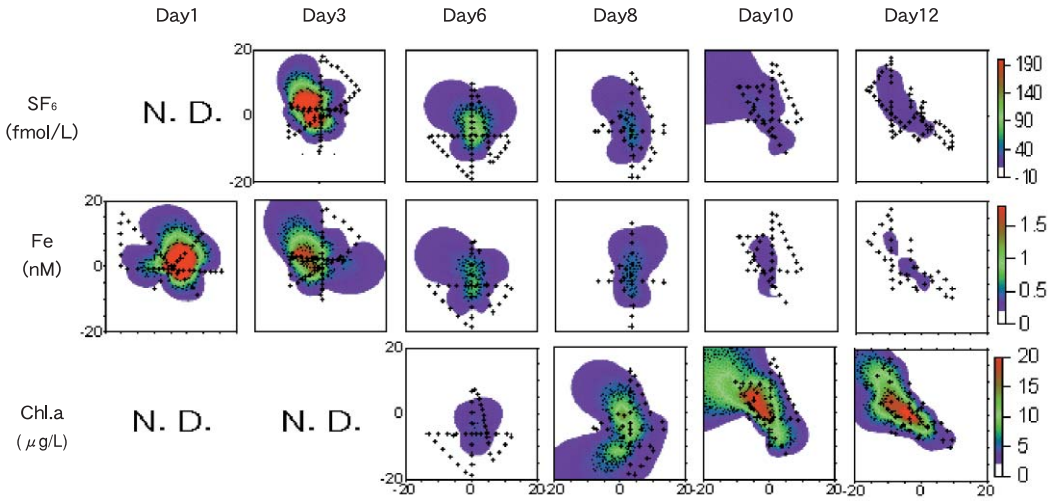


Fig.3 The contour maps of SF_6, dissolved iron and Chl.a concentration during the experiment. Change of chemical and biological parameter was observed during the experiment.

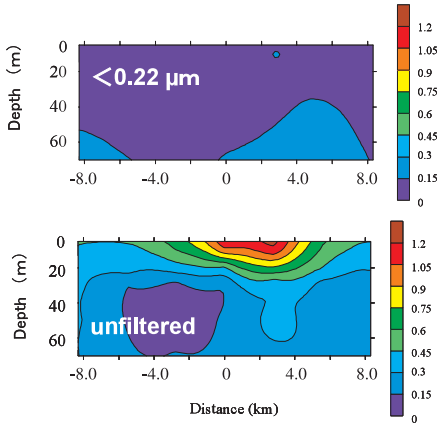


Fig.4 Vertical section profiling of dissolved Fe (< 0.22 μm) 12 days after iron release

Rapid iron transformation process occurs in ambient seawater after iron supply and labile particulate iron remains in the surface mixed layer at the end of experiment (Day 12).