2006 PICES Workshop on "*Modeling iron biogeochemistry and ocean ecosystems*"

By Jun Nishioka and Fei Chai

The synthesis of data obtained from three successful meso-scale iron enrichment experiments in the western (SEEDS-I & II) and eastern (SERIES) subarctic North Pacific has been underway. The key findings of these experiments were presented at the Topic Session on "S*ynthesis of* in situ *iron enrichment experiments in the eastern and western subarctic Pacific*" held at PICES XV in Yokohama, Japan. To enhance communication between experimentalists and modelers who work on iron biogeochemistry and ecosystem responses, a workshop on "*Modeling iron biogeochemistry and ocean ecosystems*" was held on October 13, 2006, also at PICES XV. The workshop was developed by the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean* (IFEP) and the MODEL Task Team of PICES, and co-sponsored by SOLAS (**S**urface **O**cean-**L**ow **A**tmosphere **S**tudy). The convenors were Jun Nishioka (Japan) and Fei Chai (U.S.A.).

The workshop aimed to examine the role of the iron cycle and complexity in regulating the biological productivity and structure of ocean ecosystems (**Photo 1**). Twenty-seven scientists from Canada, Japan, United States of America, Hong Kong, France, and New Zealand attended the workshop. There were seven oral presentations, two focusing on iron biogeochemistry based upon observations, and five using numerical models to address the impact of iron on ecosystem dynamics.

Photo 1 Workshop in session.

An invited speaker, Dr. Marie Boye from France (**Photo 2**), reviewed recent advances in understanding the marine iron cycle, and the role of organic ligand chemistry in the ocean. Data on dust-iron solubility in the seawater were presented by Atsushi Ooki. Five of the talks examined several different approaches to treating the iron cycle in models. An ocean carbon cycle model indicated that it is important to have realistic iron distributions (Daisuke Tsumune). A couple of models tested iron fertilization and its impact on marine ecosystem structure (Masakiho Fujii and Fei Chai). One presentation compared simple with complex ocean ecosystem models, as well as models with an iron cycle against the models without an iron cycle (Albert Hermann). An iron cycle module has been incorporated in the NEMURO ecosystem model, and some preliminary results were presented (Naoki Yoshie).

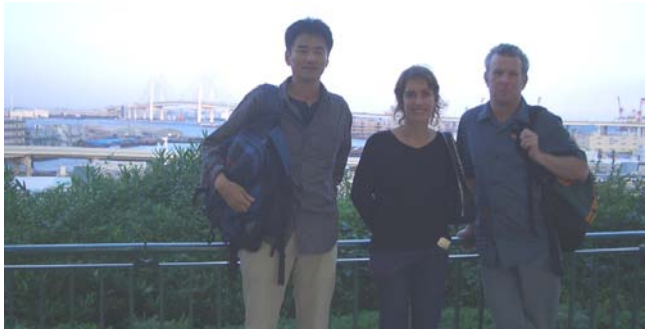


Photo 2 From left to right, Jun Nishioka (Japan), Marie Boye (France) and Philip Boyd (New Zealand) after the workshop in a park near the venue.

A dynamic discussion covered a number of topics and issues. The following are point-form summaries of the views of both experimentalists and modelers.

Suggestions from experimentalists:

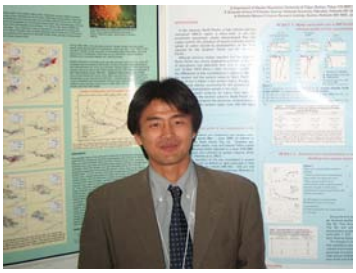
- Dust size, solubility, and its retention time are important factors for estimating bioavailable iron in the surface layer, and these should be incorporated into models;
- Modelers should consider the significant differences in the concentrations of organic ligands among the ocean basins;
- Experiments are required on the bioavailability of organic iron species;
- Modelers should use the data that are currently available for organic iron, with the parameterizations provided by biogeochemists, to develop and improve iron cycle models;
- Models should take into account species-specific bioavailability of organic iron;
- A conceptual model focusing solely on iron chemistry should be established, and it should include re-mineralization and photochemical processes;
- Changes in the chemical forms of iron occur during re-mineralization and the scavenging process; these transformations should be considered in the models;
- There is a need to establish observational systems to collect long-term time series data.

Suggestions from modelers:

- Information on stoichiometry of phytoplankton is needed to improve iron distribution in the models;

- Iron dust deposition affects iron distribution, but current data are too sparse to quantify these relationships;
- Initial conditions (phytoplankton species, chemical and physical variables) are important factors for determining ocean ecosystem responses to iron enrichment;
- After iron enrichment in the equatorial Pacific, the ocean ecosystem needs about 60 to 90 days to return to the original state;
- More information is required on interaction between phytoplankton and zooplankton functional groups, especially due to iron perturbation;
- Based upon comparative studies of different NPZ (Nutrient–Phytoplankton–Zooplankton) models, it appears that multiple classes of phyto-plankton models with an iron cycle are needed to reproduce the basic characteristics of HNLC regions;
- There is a need for more information on organic-ligand chemistry and associated biogeochemistry from field observations in order to incorporate these processes into models;
- Long-term time series data are required for improving biogeochemical and ecosystem models.

The workshop participants agreed to continue the dialogue. A new PICES Working Group, consisting of both experimentalists and modelers, will be proposed next year in order to examine the iron cycle and its role in regulating ocean productivity and marine ecosystem dynamics. We, the workshop convenors, thank all the participants for the excellent presentations and lively discussion.



Dr. Jun Nishioka (nishioka@lowtem.hokudai.ac.jp) is an Associate Professor at the Institute of Low Temperature Science, Hokkaido University. His research focuses on biogeochemical cycles of iron, iron speciation and biological interactions in the ocean. Within PICES, he is a member of the Advisory Panel on Iron Fertilization Experiment in the Subarctic Pacific Ocean.

Dr. Fei Chai (fchai@maine.edu) is an Associate Professor of Oceanography at the University of Maine. By developing and using physical-biological models, Dr. Chai studies how physical and biological processes contribute to the carbon cycle and marine ecosystems. He has been involved in several PICES-organized workshops.

Strolling through the NEMURO ecosystem model

A collaboration between EUROCEANS NoE (***Eur***opean Network of Excellence for ***OC***ean ***E***cosystem ***AN***alysi***S***, www.eur-oceans.eu**)** and PICES Modelling Task Team offers modellers, and process scientists alike, an on-line version of the recently published NEMURO pelagic ecosystem model (information on a special issue of *Ecological Modelling* can be found on pp. 27–29 in this PICES Press).

NEMURO model equations and parameters have been included in the Model Shopping Tool (MoST, www.eur-oceans.eu/models) developed within EUROCEANS NoE. MoST allows users to view concise model descriptions, search for specific biogeochemical processes or just walk through the equations of the virtual pelagic ecosystem they represent. Where relevant, the NEMURO process equations have also been compared to their equivalents in the carbon-based PISCES model (Aumont *et al*., 2006).

The aim of MoST is to provide a platform for an end-to-end approach on pelagic ecosystem process research and modelling by making major pelagic ecosystem models more accessible so model developers and process scientist can easily scrutinize the mathematical representation and parameterization of real biological processes. Where possible, the equations are also compared across modelling products. At present, MoST includes a searchable database for the process equations for the following model: PISCES (Monod, global biogeochemistry), PlankTOM (Monod, 10 Plankton Functional Types model based on PISCES), ERSEM-PELAGOS (Quota, global biogeochemistry), ECOSMO (Monod, North Sea biogeochemistry) and COHERENS (Quota, North Sea biogeochemistry).

In order to achieve the objective of providing 'platform for an end-to-end approach on pelagic ecosystem process research and modelling', modelling efforts focusing on upper trophic levels such as NEMURO.SAN and NEMORO.FISH are also planned to be included into the MoST database in the coming months.

For any queries and comments on model interfacing or to include your modelling effort into the database, please contact Ivo Grigorov (Project Officer for Model Interfacing within EUROCEANS NoE, ivo.grigorov@eur-oceans.eu)