REPORT OF ADVISORY PANEL ON IRON FERTILIZATION EXPERIMENT IN THE SUBARCTIC PACIFIC OCEAN

The meeting of the Advisory Panel on *Iron fertilization experiment in the subarctic Pacific Ocean* (IFEP-AP) was held from 17:00-19:30 hours on October 19 and 19:00-21:00 hours on October 20, 2004. The Panel Co-Chairman, Dr. Shigenobu Takeda, called the meeting to order and welcomed the participants (*IFEP-AP Endnote 1*). A new member, Dr. Hiroaki Saito, was introduced to the Advisory Panel. The draft agenda for the meeting was reviewed and adopted (*IFEP-AP Endnote 2*).

Activities in 2004 (Agenda Items 3 and 4)

In order to review the results and outstanding questions from iron enrichment experiments, and to discuss plans for the second longer-term experiment in the western subarctic Pacific (SEEDS-II), the PICES-IFEP workshop on "*In-situ* iron enrichment experiments in the eastern and western subarctic Pacific" was held February 11-13, 2004, in Victoria, Canada (workshop convenors: S. Takeda and C.S. Wong). 26 scientists from Canada, Japan and the United States of America attended the meeting. The workshop started with 4 synthesis talks on SEEDS-I, SERIES and SOFeX, followed by 14 shorter presentations on the physical behavior of the Fe-enriched patch, biological/physiological responses, food-web dynamics, chemistry of iron, carbon cycle, and model prediction. The results of the workshop have been reported in PICES Press (July 2004, Vol. 12, No. 2), and will be published as a PICES Scientific Report in 2004 or early 2005.

A joint Canadian SOLAS/PICES-IFEP session on "Response of the upper ocean to meso-scale iron enrichment" was convened on February 17-18, during the ASLO/TOS 2004 Ocean Research Conference held in Honolulu, Hawaii (session organizers: M. Levasseur, A. Tsuda, W. Miller, W. Cochlan and R. Rivkin). The call for papers was very well received, resulting in a session composed of 23 oral presentations and 17 posters. As expected, the session was a showcase for the most recent experiment: SERIES. But there was also significant contribution from SEEDS and SOFeX, and some presentations proposed thoughtful inter-comparisons between the various meso-scale experiments. This special session allowed the recognition of the similarities and differences in the responses obtained from various *in situ* experiments. The results of the session have been reported in PICES Press (July 2004, Vol. 12, No. 2).

Progress report of the SEEDS-I data synthesis and publication (Agenda Item 5)

In the summer of 2001, a joint Japan/Canada iron enrichment experiment (**S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamic **S**tudy – SEEDS-I) was performed in the western subarctic Pacific. A synthesis paper on the experiment was published in *Science* (Tsuda et *al*. "A meso-scale iron enrichment in the western subarctic Pacific induced a large centric diatom bloom", Vol. 300: 958-961, 2003). Twelve manuscripts were submitted to a special issue of *Progress in Oceanography*, and 8 papers have been accepted to date. The volume will be published in 2005.

Progress report of the SERIES data synthesis and publication (Agenda Item 6)

In the summer of 2002, a joint Canada/Japan iron enrichment experiment (**S**ubarctic **E**cosystem **R**esponse to **I**ron **E**nrichment **S**tudy – SERIES) was carried out in the eastern subarctic Pacific. A synthesis paper on the experiment was published in *Nature* (Boyd et *al*. "Evolution, decline and fate of an iron-induced subarctic phytoplankton bloom", Vol. 428: 549-553, 2004). In early April of 2004, a 3-day writing workshop was held at the Institute of

Ocean Sciences, Sidney, Canada, to encourage data discussion, synthesis, paper outlines and writing. The workshop was successful and worthwhile. To date, 8 papers have been submitted to a special issue of *Deep-Sea Research II* (Guest Editors: P.J Harrison, M. Levasseur, P. Boyd, R. Rivkin, A. Tsuda, and W. Miller), and about 8-10 papers are coming in October 2004. There are still 17 proposed papers to be submitted, so a second volume would be proposed for 2005.

Preliminary report of SEEDS-II in 2004 (Agenda Item 7)

The second *in situ* iron enrichment experiment (joint Japan/US effort) was conducted in the western subarctic gyre of the North Pacific (48°10'N, 166°E) from July 20 to August 20, 2004. The experiment consisted of two iron additions: (1) 1600 kg of $FeSO_4 \times 7H_2O$ with an inert tracer gas SF_6, over an 8 x 8 km patch with a mixed layer depth of 30 m on Day 0 and (2) 790 kg of $FeSO_4 \times 7H_2O$ on Day 6. After the iron release, significant increase in dissolved iron concentration (1.4 nM on Day 1 and 0.6 nM on Day 7) was observed. Chlorophyll-*a* concentration in the surface mixed layer increased from day 4 and reached >2.5 mg m^{-3} on Day 8, but these responses were relatively small compared with large increases observed during previous SEEDS-I experiment (about 20 mg m^{-3}). Size structure of phytoplankton was also different from SEEDS-I, and <10 µm size fraction accounted for 70-80% of the Chlorophyll-*a* biomass throughout the observation period. Diatoms did not dominate in the phytoplankton community and decreases in nitrate and silicate concentrations in the surface water were minimum. The observed differences between SEEDS-I and SEEDS-II suggest a need to develop new hypotheses to explain how plankton assemblage responds to iron supply in high-nutrient, low-chlorophyll waters in the subarctic North Pacific.

Expansion of the terms of references (Agenda Item 8)

Due to the unexpected outcomes of the three meso-scale iron enrichment experiments, the Advisory Panel felt that it is important to expand the existing terms of reference ((*IFEP-AP Endnote 3*) to include the following item:

- To synthesize, compare and contrast the results of SEEDS-I & II and SERIES, and to develop new experimental strategies and hypotheses to explain the different biogeochemical responses to iron enrichment.

IFEP-AP Workplan for 2005 (Agenda Item 9)

The following plans were outlined:

PICES XIV

- Conduct a ½-day IFEP/MODEL workshop on "Modeling and iron biogeochemistry: How far apart are we?" to enhance communication between experimentalists and modelers, and to establish a framework for organizing a 2-3 day workshop that will address problems on structuring iron biochemical models (*IFEP Endnote 4*).

Inter-sessional meeting

- Co-sponsor jointly with the Ocean Research Institute (University of Tokyo), a 2-day international symposium on SEEDS-II experiment, to be held in October 2005, in Tokyo, Japan. The goals of this symposium are: (1) to synthesize results from the second *in situ* iron enrichment experiments in the western subarctic North Pacific (SEEDS-II); and (2) to discuss differences in magnitude, biology and export between SEEDS-I and SEEDS-II.

Publications

- Selected papers from the SERIES iron enrichment experiment to be published as a special *Deep-Sea Research II* issue in 2005.
- A 5-year synthesis report of the Advisory Panel to be prepared for publication in the PICES Scientific Report Series. It will include circumstances of IFEP, summary of SEEDS-I & II and SERIES, terms of reference (initial and new), and future plans to understand why the three iron enrichment experiments in the subarctic North Pacific are different in magnitude, biology and export.

The Advisory Panel recognized the importance and needs for holding a special symposium or session on three successful meso-scale iron enrichment experiments in the subarctic North Pacific (SEEDS-I & II and SERIES). It is, however, not the right time yet to convene such a symposium/session because the sample analyses and data synthesis of SEEDS-II is still underway. The Advisory Panel decided to postpone the special symposium/session to 2006 or later.

Requests for travel (Agenda Item 10)

The IFEP-AP requests support for the following travel:

- 2 scientists to attend the joint IFEP/MODEL workshop "Modeling and iron biogeochemistry: How far apart are we?" at PICES XIV;
- 1 invited speaker for the symposium on SEEDS-II to be held in Tokyo, Japan, in October 2005.

IFEP-AP Endnote 1

Participation List

Members

William P. Cochlan (U.S.A.)
Hiroaki Saito (Japan)
Shigenobu Takeda (Japan, Co-Chairman)
Mark L. Wells (U.S.A.)

Observers

Fei Chai (U.S.A)
James Christian (Canada)
William R. Crawford (Canada)
Debby Ianson (Canada)
Jun Nishioka (Japan)
Angelica Peña (Canada)
Yasuhiro Yamanaka (Japan)

IFEP-AP Endnote 2

IFEP-AP Meeting Agenda

1. Round-table introduction of attendees
2. Adoption of agenda
3. Review of the IFEP activities in 2004
4. Report of the 2004 PICES-IFEP Workshop
5. Progress report of the SEEDS-I data synthesis and publication
6. Progress report of the SERIES data synthesis and publication
7. Preliminary report of SEEDS-II in 2004
8. Future perspective
9. Plans for 2005
10. Requests for travel supports
11. Other new business

IFEP-AP Endnote 3

Terms of Reference for Advisory Panel on
Iron fertilization experiment in the subarctic Pacific Ocean

1. To examine the reasoning for a subarctic iron enhancement experiment;
2. To examine the scale, disciplines, and resources (personnel and ships) required ensuring success of the experiment;
3. To design the experiment and its timing, particularly, the suite of chemical measurements and forms of iron, the biological parameters, the tracking of the spread of iron-induced bloom using SF_6 tracer;
4. To synthesize, compare and contrast the results of conducted experiments (SEEDS-I & II and SERIES), and to develop new experimental strategies and hypotheses to explain the different biogeochemical responses to iron enrichment (New).

IFEP-AP Endnote 4

Proposal for a ½-day IFEP/MODEL workshop at PICES XIV on "Modeling and iron biogeochemistry: How far apart are we?"

Synthesis of data from three successful meso-scale iron enrichment experiments in the subarctic North Pacific (SEEDS-I, SEEDS-II and SERIES) is underway. This workshop will enhance communication between experimentalists and modelers. For the most part, iron is not explicitly represented in current ecological models. The goal of this workshop will be to examine the structure of iron biochemical models with respect to what is known about iron biogeochemistry. The purpose will be to establish a framework for organizing a 2-3 day workshop that will address this problem in detail and compare ecological models that describe how plankton ecosystem respond to meso-scale iron enrichment in the high-nutrient, low-chlorophyll waters of the subarctic Pacific.

Recommended convenors: Fei Chai (U.S.A) and Shigenobu Takeda (Japan). MODEL has been approached to co-sponsor the workshop.

Travel support is requested for two scientists to attend the workshop, one expert on iron biogeochemistry and another on ecological modeling.