

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

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The meeting of the Advisory Panel on *Iron fertilization experiment in the subarctic Pacific Ocean* (IFEP-AP) was held from 14:30-15:30 hours on October 2, 2005. Dr. Mark L. Wells called the meeting to order and welcomed the participants (*IFEP-AP Endnote 1*). A new member, Dr. Jun Nishioka (Japan), was introduced to the Advisory Panel. The proposed agenda was reviewed and adopted (*IFEP-AP Endnote 2*).

Report of the IFEP/MODEL Workshop at PICES XIV (Agenda Item 3)

To enhance communication between experimentalists and modelers concerning the structure of iron biochemical models, IFEP and MODEL convened a ½-day workshop on “*Modeling and iron biogeochemistry: How far apart are we?*” from 08:30-14:30 hours on October 2, 2005, at TINRO-Center, Vladivostok, Russia. Participation included 17 scientists from Russia, Canada, Japan, and the United States of America (*IFEP-AP Endnote 3*). The Panel started discussion on incorporating the iron cycle into the ecosystem models as a joint IFEP/MODEL activity, and intends to convene a workshop along these lines at PICES XV (*IFEP-AP Endnote 5*). The summary of the workshop is included elsewhere in this Annual Report.

SEEDS-II Workshop (Agenda Item 4)

A workshop on SEEDS-II (Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study II) was held from October 17-18, 2005, in Tokyo, Japan (*IFEP-AP Endnote 4*). The workshop was co-sponsored by the Ocean Research Institute (University of Tokyo), PICES and SOLAS-Japan. In attendance were almost 40 scientists from Canada, Japan, New Zealand and the United States of America. There were 7 keynote talks and 13 posters presented, followed

by working group discussions aimed at synthesizing these findings. The goals of the workshop were:

- to synthesize results from the second *in situ* iron enrichment experiments in the western subarctic North Pacific (SEEDS-II); and
- to discuss similarities and differences in responses of biological processes and export fluxes between SEEDS-I and SEEDS-II.

A summary of the workshop was published in PICES Press (Vol. 14, No. 1).

Future IFEP-AP activities (Agenda Item 5)

Governing Council agreed with Science Board’s recommendation to move the responsibility for the IFEP Advisory Panel from the CCCC Program to the BIO Committee.

IFEP/MODEL Workshop at PICES XV

To compare ecological models that describe how plankton ecosystems respond to mesoscale iron enrichment in the high-nutrient, low-chlorophyll waters of the subarctic Pacific, the Panel proposes to convene a 1-day IFEP/MODEL Workshop on “*Modeling iron biogeochemistry and ocean ecosystems*” at PICES XV (*IFEP-AP Endnote 5*).

IFEP Topic Session at PICES XV

IFEP-AP recognized the importance and need to compare and contrast all three successful meso-scale iron enrichment experiments in the subarctic North Pacific (SEEDS-I & II and SERIES). Therefore, the Panel proposes to convene a 1-day BIO Topic Session on “*Synthesis of in situ iron enrichment experiments in the eastern and western subarctic Pacific*” at PICES XV (*IFEP-AP Endnote 6*).

IFEP-AP-2005

Synthesis report of IFEP-AP activities

The final scientific report of IFEP-AP activities will be developed based on the extended abstracts of the Topic Session at PICES XV.

Future of IFEP-AP

It was suggested that IFEP-AP will conclude its activities in 2006 because three iron enrichment experiments have been successfully completed and will be synthesized at PICES XV. Nevertheless, the Panel recognized that iron plays an important role in biogeochemical cycles in the North Pacific, and considerable uncertainty still remains about iron chemistry and ecosystem responses to iron input. One option to continue such studies in PICES is to establish a new group under the BIO Committee or the CCCC Program (or its replacement).

Recent publications (Agenda Item 6)

SEEDS: Synthesis paper and special volume

Tsuda *et al.* published a synthesis paper entitled “A mesoscale iron enrichment in the western subarctic Pacific induced a large centric diatom bloom” in *Science* (Vol. 300: 958-961, 2003).

Thirteen papers were published in a special issue of *Progress in Oceanography* (Vol. 64, 2005) on “Results from the Subarctic Pacific Iron

Experiment for Ecosystem Dynamics Study (SEEDS)”

SERIES: Synthesis paper and special volume

Boyd *et al.* published a synthesis paper entitled “The decline and fate of an iron-induced subarctic phytoplankton bloom” in *Nature* (Vol. 428: 549-553, 2004).

More than 15 papers have been submitted to a special issue of *Deep Sea Research, Part. II* and are currently under review.

PICES Scientific Report Series

A report of the 2004 IFEP Workshop on “In situ iron enrichment experiments in the eastern and western subarctic Pacific” will be published in the PICES Scientific Report Series in 2005. It includes a summary of SEEDS and SERIES experiments, together with a report and abstracts of the 2000 IFEP Planning Workshop on “Designing the iron fertilization experiment in the subarctic Pacific” as appendices.

Request for travel support (Agenda Item 7)

The Panel requests support for 1 invited speaker each for the proposed IFEP/MODEL Workshop and BIO (IFEP) Topic Session at PICES XV (IFEP-AP Endnote 5-6).

IFEP-AP Endnote 1

Participation list

Members

William P. Cochlan (U.S.A.)
Jun Nishioka (Japan)
Mark L. Wells (U.S.A.)

Observers

Harold P. Batchelder (U.S.A.)
Angelica Peña (Canada)
Hiroaki Saito (Japan)

IFEP-AP Endnote 2

IFEP-AP meeting agenda

1. Welcome and introduction of new member
2. Adoption of agenda
3. Report of the IFEP/MODEL Workshop at PICES XIV

4. Program of the 2005 SEEDS-II Workshop
5. Future IFEP-AP activities
 - Topic Session on SEEDS/SERIES at PICES XV
 - IFEP/MODEL Workshop at PICES XV
6. Recent publications
7. Requests for travel support for 2006
8. Other business

IFEP-AP Endnote 3

Participants of the IFEP/MODEL Workshop at PICES XIV

Harold P. Batchelder (U.S.A.)
 Robin Brown (Canada)
 James Christian (Canada)
 William R. Crawford (Canada)
 Irina Ishmukova (Russia)
 Shin-ichi Ito (Japan)
 Michio Kishi (Japan)
 Yuri Nikonov (Russia)
 Jun Nishioka (Japan, Co-Convenor)

Angelica Peña (Canada)
 Hiroaki Saito (Japan)
 Kazuaki Tadokoro (Japan)
 Shuichi Watanabe (Japan)
 Mark L. Wells (U.S.A.)
 Francisco E. Werner (U.S.A.)
 Yasuhiro Yamanaka (Japan, Co-Convenor)
 Naoki Yoshie (Japan)

IFEP-AP Endnote 4

SEEDS II Workshop on “*Second iron enrichment experiment in the western subarctic Pacific*”

Date: October 17-18, 2005

Venue: Ocean Research Institute (University of Tokyo), Tokyo, Japan

Convenors: Atsushi Tsuda, Shigenobu Takeda, Mitsuo Uematsu (University of Tokyo) and Mark L. Wells (University of Maine)

Sponsors: Ocean Research Institute (University of Tokyo), North Pacific Marine Science Organization (PICES), and SOLAS-Japan

Main themes:

1. To synthesize the key biological findings of the SEEDS II
2. To elucidate the changes in iron biogeochemistry
3. To determine the effect of iron addition on the production of trace gases
4. To compare the biogeochemical changes associated with SEEDS I and SEEDS II

Oral presentations:

- Background and introduction of SEEDS II (A. Tsuda)
- Physical behavior of the iron-fertilized patch

by SF₆ tracer release (D. Tsumune, Y. Watanabe, A. Shimamoto)

- Iron and trace metal chemistry (J. Nishioka, H. Obata, S. Takeda, K. Johnson, M. Wells, S. Nakatsuka, Y. Kondo, S. Takada, Y. Sorin)
- Biological responses (H. Saito, K. Suzuki, H. Kiyosawa, A. Tsuda)
- Primary production, bacterial production and nitrogen assimilation dynamics during SEEDS II (I. Kudo, T. Aramaki, W. Cochlan, Y. Noiri, T. Ono, Y. Nojiri)
- Complexity of grow-out experiments: further iron stimulation of communities from an iron fertilized patch (W. Cochlan, M. Wells, C. Trick)
- DMS in the seawater and atmosphere measured during the iron fertilization experiment (SEEDS-II) in the sub-arctic North Pacific (I. Nagao, S. Hashimoto, M. Uematsu)
- The role of bacteria in modulating the impact of Fe on DMS production in HNLC waters (M. Levasseur, M. Lizotte, G. Caron)
- Distribution of marine biogases and their fates between surface seawater and marine atmospheric boundary layer during the

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SEEDS II cruise in the northern North Pacific (M. Uematsu, Y. Narita, Y. Iwamoto, M. Kondo, K. Yoshida, I. Nagao, S. Hashimoto, S. Toda, S. Kato, K. Kajii)

- The SAGE Experiment: Why was there no bloom? (J. Hall)
- Suggestions from modelers (M. Fujii, M. Wells, F. Chai, N. Yoshie)

Poster presentations:

- Meso- and microzooplankton dynamics in SEEDS II (A. Tsuda, H. Saito, R. Machida)
- Dynamics of mass flux and particulate matter flux during SEEDS II (T. Aramaki, Y. Nojiri, K. Imai)
- Release of organic iron-binding ligands during grazing on phytoplankton and its effect on phytoplankton community structure (M. Sato, S. Takeda, K. Furuya)
- Complexation of iron (III) by natural organic ligands during SEEDS II (Y. Kondo, S. Takeda, J. Nishioka, K. Furuya)
- Iron oxidation status during the SEEDS II mesoscale experiment and its potential biological implications (E. Roy, M. Wells, C. Trick, W. Cochlan)
- Trace gasses in the water (U. Tsunogai)
- Geochemistry of bioactive trace metals during an *in-situ* iron enrichment in the subarctic western North Pacific Gyre (SEEDS II) (S. Nakatsuka, J. Nishioka, M. Kinugasa, Y. Sorin)
- Ammonium inhibition of nitrate uptake during mesoscale iron-enrichment experiments: A comparison of the planktonic response during SOFEX and SEEDS II (W. Cochlan, J. Herndon, J. Betts, D. Costello, C. Trick, M. Wells)
- Behavior of rare earth elements and ^{210}Po - ^{210}Pb during the iron fertilization experiment (Y. Hara, H. Obata, T. Doi, Y. Hongo, T. Gamo)
- Behavior of thorium and particles obtained by the multiple-unit large-volume *in situ* filtration system in SEEDS II (T. Zono, T. Nakanishi, J. Zheng, M. Yamada, M. Kusakabe)
- Temporal variability of cosmogenic radionuclides ^{32}P , ^{33}P and ^7Be in SEEDS II (T. Nakanishi, T. Aono, M. Yamada, M. Kusakabe)

- Phosphorus dynamics during SEEDS II (T. Yoshimura)
- Effects of iron fertilization on the distribution of volatile organic compounds in seawater (S. Toda, Y. Narita, H. Oda, Y. Akatsuka, T. Nagai, M. Kurihara, M. Uematsu, S. Hashimoto)
- Six posters from the SAGE experiment.

List of participants

Tatsuo Aono (Japan)
Takafumi Aramaki (Japan)
William P. Cochlan (U.S.A.)*
Julie Hall (New Zealand)
Yasuko Hara (Japan)
Hidenori Iguchi (Japan)
Teruaki Ishii (Japan)
Y. Iwai (Japan)
Yoko Iwamoto (Japan)
W. Keith Johnson (Canada)
Syungo Kato (Japan)
Masaki Kondo (Japan)
Yoshiko Kondo (Japan)
Isao Kudo (Japan)*
Maurice Levasseur (Canada)
Ryuji Machida (Japan)
Ippei Nagao (Japan)
Takahiro Nakanishi (Japan)
Seiji Nakatsuka (Japan)
Noriko Nakayama (Japan)
Jun Nishioka (Japan)*
Hajime Obata (Japan)
Hiroshi Ogawa (Japan)
Tsuneo Ono (Japan)
Hiroaki Saito (Japan)*
Mitsuhide Sato (Japan)
Koji Suzuki (Japan)
Shigenobu Takeda (Japan, Co-Chairman)*
Syuji Toda (Japan)
Charles G. Trick (Canada)
Atsushi Tsuda (Japan)*
Daisuke Tsumune (Japan)
Makoto Tsutsumi (Japan)
Mitsuo Uematsu (Japan)
Hidetoshi Urakawa (Japan)
Mark L. Wells (U.S.A.)*
Kentaro Yoshida (Japan)
Naoki Yoshie (Japan)
Takeshi Yoshimura (Japan)

* IFEP-AP member

IFEP-AP Endnote 5**Proposal for a 1-day IFEP/MODEL Workshop on
“Modeling iron biogeochemistry and ocean ecosystems”**

Synthesis of data from three successful meso-scale iron enrichment experiments in the subarctic North Pacific (SEEDS-I & II and SERIES) has been underway, which helps development of ocean ecosystem models. This workshop will enhance communication between experimentalists and modelers working on iron biogeochemistry and modeling. The workshop will focus on a couple of key questions: 1) What have we learned regarding iron biogeochemistry in the ocean from natural observation and iron-enrichment experiment? and 2) How can ocean models be improved with detailed iron dynamics to better represent ocean

ecosystems? The workshop will provide an opportunity for experimentalists and modelers to share their latest results and understanding on iron biogeochemistry and ocean ecosystems, and make recommendations for future iron cycle observations and ocean ecosystem modeling in the subarctic Pacific.

Recommended Convenors: Fei Chai (U.S.A.) and Jun Nishioka (Japan).

Recommended invited speaker: Marie Boye (Institut Universitaire European de la Mer, France).

IFEP-AP Endnote 6**Proposal for a 1-day BIO (IFEP-AP) Topic Session at PICES XV on
“Synthesis of in situ iron enrichment experiments in the eastern and western subarctic Pacific”**

Three successful meso-scale iron enrichment experiments have been conducted in the subarctic North Pacific (SEEDS-I & II and SERIES) over the last four years. The proposed session will synthesize the key findings of these experiments and initiate the development of a common database. We invite contributions specifically comparing and contrasting these three experiments. In addition, the unpredicted response of recent mesoscale iron enrichment experiment (SEEDS-II) highlights our limited understanding of how iron affects biogeochemical cycles, and the complexity of ecosystems responses to iron in High Nutrient

Low Chlorophyll waters. We also encourage papers investigating how iron influences, and is influenced by, ocean-atmospheric exchanges, plankton activities and community structure, micronutrient chemistry, and other processes in the subarctic North Pacific.

Recommended Convenors: Maurice Levasseur (Canada), Shigenobu Takeda and Atushi Tsuda (Japan).

Recommended invited speaker: Philip Boyd (NIWA, New Zealand).

