APPENDIX 4

IFEP-AP Annual Reports

1999 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Eighth Annual Meeting, October 8–17, 1999, Vladivostok, Russia)

The Advisory Panel on "An Iron Fertilization Experiment in the Subarctic Pacific Ocean" (IFEP) met on October 14. The IFEP Co-Chairman, Dr. Shigenobu Takeda, welcomed the members of the Panel and observers and called the meeting to order. The agenda was reviewed and accepted without changes.

Drs. Takeda and Paul J. Harrison introduced the IFEP objectives reflected in the terms of reference. Iron fertilization of HNLC (High Nutrients Low Chlorophyll) water is one possible approach to remove CO_2 from the atmosphere to combat global warming caused by GHGs. Natural iron fertilization has been hypothesized to control glacial/interglacial shift in atmospheric CO_2. Iron fertilization experiments were repeatedly done in the equatorial Pacific under the IronEx Programs I and II, and recently in the Southern Ocean. The Subarctic Pacific, with different biology and unique water structure (*e.g.*, strong pycnocline, fresher mixed layer) from the other two regions, is the only HNLC region without such an experiment to assess the CO_2 removal question related to iron. The Panel will (i) examine the reasoning for a subarctic iron experiment, the scale disciplines, and resources required to ensure success of the experiment, and (ii) design the experiment and its timing.

Drs. William Cochlan and Mark L. Wells gave a brief overview of IronEx I and IronEx II. In particular, Dr. Wells pointed out the importance of understanding the iron chemistry: What happens to the iron when it is added? Does it precipitate out?

Dr. Harrison presented physical, chemical and biological conditions at Station P, a potential site for the iron fertilization experiment in the eastern North Pacific. He also discussed eddies forming off the Queen Charlotte Islands in winter and whether whey could be used as an iron fertilization site. Dr. Josef Cherniawsky provided more details on the physics of the eddies. The IFEP members agreed that additional information is required to decide if these eddies would be a suitable fertilization site, an alternative to Station P.

Dr. Wells suggested that questions be formulated in order to test specific hypothesis and then decide on needs for the measurements and personnel. The following questions were drafted:

- What are the driving hypotheses for a fertilization experiment? Is it industry driven or science driven?
- What are the motivating questions and what are the best ways to answer these questions?
- How is a fertilization experiment going to improve our understanding of the iron response and what aspects of the response do you want to examine?
- What will a fertilization experiment tell you that the bottle enrichment experiments and mesocosm experiments have not?
- Why conduct an experiment at Ocean Station PAPA and the northwest subarctic Pacific?
- What will it tell you that SOIREE, SOFeX, Caruso and IronEx have not told you?

The Panel discussed the analytical resources needed to be brought to bear on the problem. A list was created in which all recommended measurements were arranged into two groups, primary and secondary importance. The IFEP members from each country were requested to announce the experiment to colleagues, distribute the list and ask who would be interested in participating and what they could measure/contribute. A list of suggested participants should be sent to IFEP Co-Chairmen October 2000.

The Panel reviewed a draft workplan developed during 1999 by correspondence. Presently the iron fertilization experiment is planned for August 2002 at Station P in the northeast subarctic Pacific and May or June 2003 at Station KNOT in the northwest subarctic Pacific. There is a chance for a preliminary experiment in spring 2001 in the northwest subarctic Pacific. The Panel recommends to convene a 2-day planning

workshop on “Designing the iron fertilization experiment in the Subarctic Pacific” (co-sponsored by PICES and CRIEPI), prior to the PICES Ninth Annual Meeting. Co-Convenors are Drs. Shigenobu Takeda (Japan) and C.S. Wong (Canada). The objective of the workshop is to initiate planning for experiment, including logistics and funding, *etc*. IFEP requests that PICES provide funds for three invited speakers to attend the workshop.

2000 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Ninth Annual Meeting, October 20–28, 2000, Hakodate, Japan)

The Advisory Panel on An Iron Fertilization Experiment in the Subarctic Pacific Ocean (IFEP) met in the evening of October 25. The Co-Chairman, Dr. Shigenobu Takeda, welcomed the members of the Panel and observers (*IFEP Endnote 1*) and called the meeting to order. The agenda was reviewed and accepted without changes.

A 2-day IFEP Planning Workshop on "Designing the iron fertilization experiment in the subarctic Pacific" was convened in Tsukuba, Japan, prior to the PICES Ninth Annual Meeting (October 19-20, 2000). A report of the Workshop appears as *IFEP Endnote 2*. The objective of the workshop was to initiate planning for the experiment, including logistics, ships, funding, *etc*. The workshop was very successful thanks to 19 excellent presentations and spirited discussion among 39 participants.

Dr. Takeda introduced the schematic diagram of subarctic plankton ecosystem that includes new biological and geochemical processes reported during the workshop. He also listed similarities and differences in physical, chemical and biological characteristics between the eastern and western subarctic Pacific. Such differences have a close relationship with the zonal gradients in atmospheric iron deposition.

From the results of the workshop, Dr. Paul J. Harrison proposed a central hypothesis for the iron enrichment experiments in the subarctic Pacific. The hypothesis was adopted by IFEP after modification according to the suggestions and comments from Drs. Kenneth Coale and Phillip W. Boyd, and other members (*IFEP Endnote 3*). The experiment should be driven by a scientific hypothesis and is to test the hypothesis on natural ecosystem and geochemical cycles, therefore the word "fertilization" would be replaced by "enrichment".

IFEP recognizes that it is very important to have a close linking between the Canadian and Japanese program. It is considered that scientists and ships from both Canada and Japan should perform the eastern and western experiments as a collaborative program to make the east-west comparison stronger by using the same methodology and team. The experiment needs the participation of American scientists and ships as well as scientists from other PICES countries to maintain the international activity achieved during the workshop. Due to the number of scientists that is needed to measure a wide variety of parameters, the experiment will require more than two ships. The R/V *J.P. Tully* (Fisheries and Ocean Canada) and R/V *Kaiyo-Maru* (Fisheries Agency, Japan) or T/S *Oshoro-Maru* (Hokkaido University, Japan) will be the base ships, both in the eastern subarctic experiment in July/Aug 2002 (Station P) and in the western subarctic experiment in August 2003 (45–50°N, 160–165°E). The R/V *Hakuho-Maru* (University of Tokyo, Japan) is also available to perform the survey for studying the long-term responses in October 2003. A preliminary experiment in the western subarctic in June–August 2001 is also planning to use the R/V *Kaiyo-Maru*.

The Panel discussed the timeline of proposals for research and ship time. The IFEP members from each country were asked to gather information such as what they could measure/contribute to prepare the proposals as an international program. The information will be distributed to colleagues who are interested in participating.

IFEP recommends using a web site on the PICES home page to improve communication between IFEP members and other scientists (group of American scientists) who are proposing to participate in the Canada-Japan experiments.

After the successful IFEP planning workshop, the IFEP felt strongly that the next step should be to convene a half-day mini-workshop or meeting at the PICES Tenth Annual Meeting in Victoria. This workshop would refine the details of the experimental design for 2002 and 2003 with information about a preliminary experiment in the western subarctic gyre in 2001 and Southern Ocean experiments in 2000–2001.

IFEP Endnote 1

Participation List

Members

Kenneth H. Coale (U.S.A.)
William P. Cochlan (U.S.A.)
Lev M. Gramm-Osipov (Russia)
Paul J. Harrison (Canada)
Isao Kudo (Japan)
Shigenobu Takeda (Japan)
Atsushi Tsuda (Japan)

Observers

Philip W. Boyd (UK)
Kenshi Kuma (Japan)
Maurice Levasseur (Canada)
Hiroaki Saito (Japan)
Sei-ichi Saitoh (Japan)
Mitsuo Uematsu (Japan)

IFEP Endnote 2

Report on IFEP Planning Workshop on Designing the Iron Fertilization Experiment in the Subarctic Pacific

Venue: Tsukuba, Japan, October 19–20, 2000
Conveners: C.S. Wong and Shigenobu Takeda
Co-Sponsors: PICES and the Japan Central Research Institute of Electric Power Industry (CRIEPI)

Objectives of the workshop

a. To establish the current knowledge about the role of iron in limiting phytoplankton production in the subarctic Pacific;
b. To identify the specific questions that should be answered by the *in situ* iron fertilization experiment in the subarctic Pacific; and
c. To initiate planning for the experiment, including logistics and funding, etc.

Scientific Sessions

1. *General overview of IronEx and SOIREE, iron chemistry and biology in seawater*
2. *Physics in the North Pacific and Fe addition techniques*
3. *Biology in the North Pacific and IronEx*
4. *Chemistry in the North Pacific and IronEx*

The workshop was very successful thanks to 19 excellent presentations and the spirited discussion from the 39 participants.

What do we know from IronEx I and IronEx II and SOIREE, *etc*.?

- Iron limitation is clearly present in populations of phytoplankton in HNLC regions.
- Iron enrichment de-couples larger phytoplankton from the meso-zooplankton community.
- Evidence for carbon export in SOIREE is not clear. There may have been export of carbon, yet retention of iron. Evidence for carbon export in IronEx is clearer.
- Response in SOIREE was much slower than the response in IronEx.
- There is now more interest in the effect of iron enrichment in different macro-nutrient-limited regimes, specifically in low NO_3 regimes where N-fixation dominates N-uptake.
- A ship-based study of light limitation of iron enrichment in the SOIREE region showed that light limitation is present at 100 m.
- There is some interest in long-term addition experiments of low levels of iron.
- The role of meso-scale eddies is intriguing at Station P. They may offer a way to track a patch of water for years, but the phytoplankton community in an eddy may be atypical of the Gulf of Alaska. Eddies also have no surface water expression and so their relevance to an iron enrichment experiment is not clear.

- The European community has just sent the *Polarstern* to the southern ocean (in the Atlantic sector) to do a SOIREE-type experiment over a longer time (CARUSO).

What do we still need to know?

- There is a need to study Station P and the NW Pacific, but other regions need to be studied as well.
- The fate of primary production (carbon): POC export flux, DOC, respiration and response of higher trophic levels (is there an increase in fish production?). The time scale is over a year, so the model approach is needed).
- What are the roles of ligands? What members of the community produce and take up ligands?
- Does zinc affect other enzyme processes?
- Need DMS/DMSP studies and other climate change biogases. Previous iron enrichment studies have measured DMS production. Should have both ships and aircraft for sampling. At Station P, ocean levels of DMS are very high and atmospheric levels are low.
- Need to know the factors that influence the carbon-to-nutrient and other trace metal export ratios.
- Iron might end up below the mixed layer during long-term commercial projects. It might become available the next summer after winter mixing.
- Would long-term iron enrichment drive a system toward another limitation (N, Si, Zn, Co, *etc*.)?
- What is the impact of long-term iron enrichment on fish? Governments may see the fish production as a secondary benefit of the iron enrichment, so this question will be asked. The public may see this as a problem, due to "wrong" species benefiting, such as pennate diatoms that produce domoic acid. (These are not questions that can be addressed with the current experiment.)
- What are the chemical processes associated with iron saturation and super-saturation of seawater?
- How does Fe(II) stay around so long in Fe enrichment patches?
- What are the major grazers on diatoms and how do they respond when diatom (pennate/centric) abundance increases?
- Understanding the dynamics of plankton ecosystem, export carbon flux and climate related gases to the iron enrichment is appropriate for the requests of Government and Industry who are seeking scientific information to asses the effect on future global atmospheric CO_2 and environmental impacts.

What do we hope to learn from an iron enrichment experiment at Station P and WSG?

What are the similarities and differences in the plankton ecosystem response to iron fertilization in the subarctic Pacific? There is a special interest in the east-west North Pacific comparison, which includes differences in dominant species (pennate/centric diatoms) and export flux (Org-C/Opal/$CaCO_3$).

Canadian program (extracted from the Canadian SOLAS proposal)

Canadian scientists are proposing to fertilize a 64 km^2 patch of ocean near Stn P in the NE subarctic Pacific during July/Aug 2002. Iron will be added 3 or 4 times during the three week experiment and a wide variety of physical, chemical and biological parameters will be measured. In particular, the expected increase in phytoplankton biomass and the subsequent carbon flux out of the photic zone, the drawdown in CO_2, and the production of other climate change gases such as DMS will be carefully documented.

There are several reasons why an iron enrichment experiment should be conducted at Stn P in the NE subarctic Pacific. Station P or Ocean Station Papa (50°N 145°W) has a 40-year time series of physical, chemical, and biological parameters and thus it has one of the longest open ocean time series in the world. Three large intensive sampling programs have provided detailed information, especially on biological rate process studies (SUPER, WOCE, and Canadian JGOFS). This large published data set/time series will provide an excellent background to assess the annual and interannual natural variability for evaluating the magnitude of the response to the

iron addition experiment. The subarctic North Pacific represents a latitudinal gradient between the polar (Southern Ocean) and equatorial regions and therefore an iron addition experiment at Station P will allow a comparison among the three large HNLC regions and between the eastern and western gyres in the subarctic Pacific.

The subarctic NE Pacific has different physical, chemical and biological properties than the other two HNLC regions (Southern Ocean and Equatorial Pacific). In particular, it has a very shallow summer mixed layer depth, a strong, shallow pycnocline and low currents which should help to keep the iron patch intact and ensure the success of the experiment. The biodiversity of the plankton is different from the equatorial Pacific and Southern Ocean and therefore the response to the iron addition and the flux of carbon out of the photic zone may be different.

Unlike the equatorial Pacific, Station P is in close proximity (3 days) to major research laboratories at the Institute of Ocean Sciences and the University of British Columbia and therefore it should be easier to document the longer term recovery from the iron addition. If the detailed documentation of the ecosystem response to a singe iron addition is successful, this will allow us to proceed to the next phase, repeated iron additions and the longer term monitoring that this will require.

Key questions that have not been entirely resolved by previous iron enrichment experiments, are:

1. How does the change in biodiversity and foodweb structure differ for markedly different ecosystems which have been perturbed by an iron addition?
2. What is the drawdown of CO_2 and especially the flux of carbon to the deep ocean?
3. How does the production of ligands influence the iron chemistry and the longevity of the phytoplankton bloom?
4. How does zooplankton grazing influence the formation of the bloom and the carbon flux (*e.g.*, fecal pellet production)?
5. What is the long-term response and recovery of the ecosystem following an iron addition?
6. What is the magnitude of production of other climate change gases such as DMS during the bloom and how is the production influenced by phytoplankton species, microbial processes and grazing?

Objectives

1. To measure the response of bacteria, phytoplankton and zooplankton in terms of species, standing stocks and rate processes to the iron addition.
2. To measure the drawdown of CO_2 and the flux of carbon to depth.
3. To study the relationship between ligand production and the associated changes in the iron chemistry and their influence on the longevity of the phytoplankton bloom.
4. To assess the influence of zooplankton grazing on the phytoplankton bloom formation and carbon flux.
5. To follow the long-term response and recovery of the phytoplankton bloom.
6. To quantify the production of various climate change gases during the iron enrichment experiment and assess the factors which influence the production of these biogases.

Biological oceanographic sampling

The upper 150 m will be sampled vertically (6–8 depths) each day using 12 acid-cleaned PVC samplers on a CTD/water sampler rosette system at the patch center (determined by SF_6 levels) and in the surrounding waters. Real-time vertical profiling of temperature, salinity, transmissivity, chlorophyll *a* fluorescence and underwater irradiance (PAR, 400–700 nm) will be carried out. Discrete water samples will be analysed for:

- chlorophyll *a* (size-fractionated, >20, 5–20, 2–5 and 0.2–2 µm)
- heterotrophic bacterial abundance
- microzooplankton abundance
- phytoplankton abundance (flow cytometry, epifluorescence and light microscopy).

Additional samples will be incubated on deck to measure rates of:

- primary production (14°C, 24 h incubation, simulated *in situ* and size-fractionated as for Chl-*a*)
- bacterial production
- microzooplankton grazing

Mesozooplankton abundance will be assessed from 150–0 m vertical hauls. The Th:U activity ratio of particles in the upper water column will

be collected using a submersible pumping system.

Geochemical measurements

Two types of sampling will be done: hydrocasts and underway sampling from the vessel's non-toxic seawater supply (intake 5 m subsurface) and analysed by fluorometry (calibrated with discrete chlorophyll *a* samples every two days, corrected for quenching during daylight hours), and using a bubble-segmented automated nutrient analysis system, respectively. Underway samples for dissolved iron will be conducted from a clean towed batfish sampling system, and samples for pCO_2 will be drawn from the vessel's non-toxic seawater system. Phytoplankton samples for the single-cell flavodoxin assay will be pre-concentrated onboard ship and later analysed shoreside. Sampling will be conducted by:

- Towed batfish: Continuous sampling will be made from a towed batfish with a clean pump and tubing for the following measurements (This is not a pumping undulating fish):
  - Conductivity/salinity sensor
  - SF_6
  - fCO_2, pH
  - nitrate
  - iron
  - chlorophyll *a* (fluorometer)

- Hydrocasts by rosette CTD/Niskin samplers:
  - T, S
  - O_2
  - Chlorophyll *a*
  - Macro-nutrients (N, P, Si) by auto-analyzer
  - Iron by chemiluminescence
  - Particulate iron size-fractions, total iron, dissolved iron
  - SF_6
  - DIC, TA, pH
  - DOC, DON, POC
  - DMS

- Free-drifting sediment traps (at 50 m intervals, 50–600 m) deployed and retrieved at 3 day intervals to obtain samples for detritus organic C, N, P, Si, PIC, Fe, Cd, Al, rare earth elements, Th/U ratios, coccolithophore counts, and planktonic species, and scanning electron microscope pictures.

- Deckboard perturbation experiments: Algal carbon, growth rates and C:Chl-*a* ratios, *etc*.

Drs. Wong and Harrison hope to have one or two strings of moored sediment traps, plus free floating traps. Moored traps would be at the control site. Floating traps would hopefully follow the patch. It will be difficult to keep the patch and traps together, but there is a real need for trap data to try to quantify and characterize export. Free-floating sediment traps may perform differently than moored traps. Therefore we should have free-floating traps in and out of the Fe patch.

There is a need to know more about micro-zooplankton and to know the effects of ligands and climate change biogases (including but not limited to DMS, CO_2, N_2O). SOIREE showed enhancement of nitrous oxide at the top of the thermocline. There will be aircraft-based sampling of gases and aerosols above the Fe patch. The experiment expects to have access to the R/V *J.P. Tully* for 4 weeks, but anticipates sampling over a longer time if back-to-back cruises using a second vessel can extend sampling over 6 weeks. Cruises could be separated by several weeks if the patch could be found on the second cruise. Iron limitation at Station P in July to August is severe, so the project will be conducted during this period. The project will be part of the Canadian SOLAS project.

Summary of Japanese programs

Japanese scientists are proposing to conduct a preliminary experiment of about 40 days duration in June–August 2001, using the R/V *Kaiyo-Maru* in the Western Subarctic Gyre. The next effort is anticipated for August to mid-September 2003 using either the R/V *Oshoro-Maru* or the R/V *Kaiyo-Maru* to initiate the SF_6/Fe patch and conduct the basic study. In October 2003, the R/V *Hakuho Maru w*ill be used for intensive sampling and measurements and assessing long-term responses. Sampling will occur in the Western Subarctic Gyre in the region 45–50°N, 160–165°E:

1. To measure the response of bacteria, phytoplankton and zooplankton in terms of species, standing stocks and rate processes to

the iron addition;

2. To measure the drawdown of CO_2 and the flux of carbon export;
3. To study the interaction between biogeochemical processes in the surface water during the phytoplankton bloom and the production of climate gases in the atmosphere;
4. To study the relationship between phytoplankton (diatom) production and the higher trophic level (salmon); and
5. To assess the influence of iron supply on the characteristics of the plankton ecosystem in the western subarctic Pacific.

The proposal would be funded by:

- The Science and Technology Agency (2001–2005);
- Ministry of Education, Science and Culture (2001 Basic Science, 2002–2004 Scientific project with high priority);
- NEDO grant.

Japan SOLAS is still in the preparation stage. A study of the influence of natural atmospheric iron supply on the characteristics of the plankton ecosystem in the western subarctic Pacific will be one of the important topics. (Long cruise staying at a station in the high dust season in spring.)

United States, SOFEX (by Kenneth Coale)

- Experiment will be along 170° west, near SO-JGOFS site.
- Experiment will use SeaSoar type of device that pumps water to ship.
- SO-JGOFS found a jump in silicate at Polar front near 62°S, with increase south of front. SOFEX will do experiments N and S of front, to see which type of species is enhanced in each region (*Phaeocystis* and diatoms).
- Big complement of scientists and studies. There are ten more scientists than berths on ship. Lack of ship bunks is a general problem in iron enrichment cruises. For example, samples will be frozen for later analysis by Edie Rue and will run the only ligand study.
- SOFEX will need to find the northern patch after a week or more, and plan to use Lagrangian drifters to keep track of the patch.

Methodology

- Need to standardize sampling methods to enable comparison among experiments in different HNLC regions. List of dominant species and their biomass is useful for the comparison. Export production is difficult to get quantitative samples?
- First step is the application of previous IronEx methodology ($FeSO_4$, initial concentration level, Fe infusion timing, *etc*.) and then we may go to new method such as the use of chelated iron (iron lignite), long-period and low-level iron supply, *etc*.
- Should add DMSP to list of samples.
- Micro-zooplankton are important grazers and dilution experiments are necessary to quantify coupling of primary production and grazing.
- Fe organic ligand study has technical problems.
- Analyses of biogases in the atmosphere are important, but how?
- Bag experiments have limitations. Small bags might not represent the ocean. Large bags are too difficult to manage. However, there should be some role for bag experiments.
- Use of organic chelated iron (iron lignite) may provide carbon source for hetero-trophic organisms.
- Stable isotope study will be done in SOFEX to see the proxy of paleo-oceanographic environment.
- After silicate in surface water will be used up, a re-infusion of Fe will give us some idea of the long-term change in dominant species.

Logistics issues

- The Station P project needs a second ship. Kenneth Coale recommended that a U.S. ship may be available if a group of American scientists were to propose to participate. The U.S. SOLAS program would be one way to generate support. It would help to have a Canadian–Japanese proposal ready. U.S. scientists must start to prepare proposals now for Station P 2002 cruise.
- A Canadian or U.S. airplane would be useful for tracking the Fe patch. An airplane with a hyperspectral sensor would be really useful.
- ADEOS-2 will be launched soon. It will be useful (similar to SEAWIFS).

IFEP Endnote 3

Proposed experimental summary

The North Pacific is characterized by relatively uniform distributions in temperature, salinity, macronutrients and light yet strong zonal gradients in atmospheric iron deposition exist between the eastern and western gyres.

We hypothesize that:

1. The difference in episodic iron deposition gives rise to distinct phytoplankton communities that characterize these biogeochemical provinces.
2. The biogeochemical response of any given province (air–sea flux of biogases, export flux of carbon) is driven by episodic events such as iron deposition.

To test these hypotheses (and offers as part of this program) an iron perturbation experiment, on the scale of the entire community is required such that the community response and resultant geochemical signal can be measured.

Scientific questions

- What is the fate/longevity of the bloom with an emphasis on ligand production and the response of the grazers (micro and mesozooplankton)?
- What is the magnitude and characteristics of particles (Carbon flux) sinking at the end of the bloom?
- What is the production of various climate change biogases (DMS, N_2O, methane, *etc*.) during and after the bloom?

2001 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Tenth Annual Meeting, October 5–13, 2001, Victoria, Canada)

The meeting was held from 08:30–17:30 hours on October 6, 2001. The Co-Chairman, Dr. C.S. Wong, called the meeting to order and welcomed the participants (*IFEP Endnote 1*). The Advisory Panel reviewed the draft agenda and it was adopted (*IFEP Endnote 2*). The meeting focused mainly on the results of the successful Japanese iron enrichment experiment in July 2001, and planning for the Canadian SOLAS iron enrichment experiment to take place at Station P in July 2002.

Summary of Japanese iron enrichment experiment in the western subarctic Pacific

A preliminary iron enrichment experiment was conducted during the FRV *Kaiyo-Maru* cruise in June–August 2001. The next larger scale experiment in the western gyre is planned for August–September 2003.

Five goals of the overall project were:

1. to measure the response of bacteria, phytoplankton, and zooplankton in terms of species, standing stocks and rate processes to the iron addition;
2. to measure the draw-down of CO_2 and the carbon export flux;
3. to study the interaction between biogeochemical processes in the surface water during the phytoplankton bloom and the production of climate gases in the atmosphere;
4. to study the relationship between phytoplankton (diatom) production and the higher trophic level (salmon); and
5. to assess the influence of atmospheric iron supply on the characteristics of the plankton ecosystem in the western subarctic Pacific.

This first iron enrichment experiment was rather rushed since funding was received in February 2001, the ship allocated in April, and the experiment conducted in June. It included only 16 scientists. The experiment provided the most dramatic phytoplankton response of any of the HNLC iron enrichment experiments done to date.

Overview of the Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study (SEEDS 2001)

Experiment

An *in situ* iron enrichment experiment was conducted in the western subarctic gyre of the North Pacific (48.5°N, 165°E) from July 18 to August 1, 2001. The experiment consisted of a single addition of 350 kg of iron as $FeSO_4$ with an inert tracer gas SF_6, over an 8 × 10 km patch with a mixed layer depth of 10 m. The iron release track was up and down along a north/south line generating a radiator pattern relative to the central buoy due to surface currents. The injection was completed on July 19, and followed by two weeks of observations. The patch moved ~ 100 km from the beginning to the end. Drogues were used to follow the patch for ~ 24–48 h, and were repositioned every two days.

Iron

Prior to release, dissolved iron concentrations in the ambient surface seawater were extremely low (<0.05 nM). At the first underway transect throughout the patch after the iron release, significant increase of dissolved iron (1.9 nM, mean value calculated using all measurements of first underway transect in the patch; maximum 6.0 nM) was observed, and most of dissolved iron was in the colloidal fraction in the mixed layer. Dissolved iron concentrations subsequently decreased rapidly, and the loss rate gradually decreased. High particulate iron concentrations (>1 nM) were observed throughout the experiment.

Biological responses

The first biological response to the iron enrichment was the increase in photochemical quantum efficiency (F_v/F_m) of phytoplankton on day-3 from the enrichment. Chlorophyll *a* increased from day-6 and reached 20 mg m^{-3} on day-10. The maximum differences between outside and inside the patch were 19.5 mg m^{-3} in chlorophyll *a*, and 11.7 μM in nitrate. Dominant phytoplankton species before the fertilization and

outside the patch was the pennate diatom *Pseudoniztschia pungens*. But in the patch, phytoplankton rapidly increased and large-sized (>10 μm) centric diatoms, mainly *Chaetoceros debilis*, were observed. Non-depletion in nitrate until the end of the observation, and shallower euphotic layer depth than the mixed layer observed on day-12, suggested that phytoplankton was light-stressed at the end of the experiment. Salmon and small squid abundance, collected by trawl sampling, were not changed between inside and outside of the patch, but northern mackerels were abundantly collected only in the patch.

pCO_2

The underway pCO_2 system with high measurement frequency (1-minute interval data logging) with real-time monitor facilitated tracing the enrichment patch with biological draw-down of pCO_2. The pre-experiment condition of the iron enriched area showed uniform pCO_2. The change of pCO_2 inside the patch was observed after 5 days of the iron enrichment. The draw down of pCO_2 expanded up to 146 μatm after 11 days of the enrichment.

Export flux

Export flux was measured using drifting sediment traps (Knauer type). The depths of the traps were 20, 40, 60, 100 and 200 m from the sea surface. The trap inside the patch was applied and recovered at about 2-day intervals. The reference trap outside the patch was applied and recovered at about 4-day intervals. The majority of the trapped material was fecal pellets of zooplankton. Increase of export flux was observed after 7 days of the enrichment. Wind-driven deviation of the inside-patch trap occasionally occurred, which made it difficult to estimate the export flux accurately, however, the increasing export flux inside the trap was apparent. Longer observation of the iron-enriched patch is needed to see the fate of accumulated organic carbon after the end of diatom blooming.

Bottle incubation experiments

Bottle incubation experiments on board were also conducted to elucidate the effects of iron concentration and temperature on the growth of phytoplankton and nutrient utilization. Subsurface seawater samples taken on day-2 were spiked with $FeCl_3$ ranging from 0 to 2 nM, and incubated at 5, 9, 13 and 18°C for 14 days. The bottle incubation revealed that the increase in chlorophyll *a* was almost the same between *in situ* and *in vitro*, but the draw-down of nutrients was much faster *in vitro* than *in situ*. The specific growth rate increased with the amount of spiked $FeCl_3$, and was also the function of incubation temperatures.

Planning session for Canadian SOLAS iron enrichment experiment in July 2002

Key issues to focus on in this experiment are:

1. What is the influence of Fe enrichment on the production of climate active gases? This is the central novelty of the Canadian SOLAS iron enrichment project.
2. What is the fate of carbon and carbon export? This question is also central to SOLAS because of CO_2 flux, and it is of general interest because of poorly restrained export in previous iron enrichment experiments.
3. What is the plankton community's (ecosystem) response to iron enrichment?
4. What happens with iron chemistry, ligand production, and fate of iron?

Discussions centered on technical preparations such as iron and SF_6 tanks, drogues, iron injection and following the patch.

Overview of NSF proposal

Scientists from the U.S.A. would like to take part in both the east and western gyre iron enrichment experiments. The highlights of the proposal submitted to NSF are as follows:

- Characterize the community and water chemistry within and adjacent to the iron-enriched patch over a time period of several weeks (20–50 days) after the initial enrichment;
- Test a series of sub-hypothesis using on-deck incubation studies;
- Assess the phenotypic differences of newly-isolated dominant subarctic Pacific diatoms in laboratory culture experiments; and
- Model the planktonic response to changes in iron concentrations and chemical speciation

in the iron-enriched patch over a time period of several weeks after the initial fertilization.

Should we establish a SOLAS component of PICES?

Discussions focused on a proposal for an iron working group since the iron work was underway, and would benefit from a North Pacific coordinated effort leading to conclusive results and inter-gyre comparisons in the next three years. The idea of an iron working group was presented to the CCCC Implementation Panel, but it was not put forward to the Science Board.

IFEP Endnote 1

Participation List

Members:

Robert Bidigare (U.S.A.)
William Cochlan (U.S.A.)
Paul J. Harrison (Canada)
Isao Kudo (Japan)
Vladimir Shulkin (Russia)
Atsushi Tsuda (Japan)
Shigenobu Takeda (Japan, Co-Chairman)
Mark Wells (U.S.A.)
C.S. Wong (Canada, Co-Chairman)

Observers:

Melissa Chierici (Canada)
John F. Dower (Canada)
Agneta Fransson (Canada)
Keith Johnson (Canada)
Andrew Leising (U.S.A.)
Maurice Levasseur (Canada)
Patricia Livingston (U.S.A., SB Chairman)
Adrian Marchetti (Canada)
Yukihiro Nojiri (Japan)
Wendy Richardson (Canada)
Hiroaki Saito (Japan)
Nelson D. Sherry (Canada)
Nes Sutherland (Canada)
Charles Trick (Canada)
Frank Whitney (Canada)
Emmy Wong (Canada)

IFEP Endnote 2

IFEP Meeting Agenda

1. Round-table introduction of attendees
2. Adoption of agenda
3. Adoption of first Panel Report of IFEP held in Tsukuba, Japan
4. Review of relevant background work, *e.g.*, eddy transport of iron
   - Where is HNLC water? ENSO factor
   - Iron distribution and possible transport to HNLC waters
   - CO_2 uptake/Fe enrichment in an eddy
5. Review of time-table of international Iron Enhancement Experiments in the subarctic Pacific
6. Review of July Canadian SOLAS iron enrichment planning meeting
7. Summary of Japanese Iron Enrichment Experiment results (SEEDS 2001)
8. SOLAS preparations at IOS
9. Overview of NSF proposal by Wells *et al*.
10. Should we establish a SOLAS component of PICES?
11. Planning session for the Canadian Fe enrichment in July 2002

2002 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Eleventh Annual Meeting, October 18–26, 2002, Qingdao, China)

The meeting was held from 08:30–17:30 hours on October 19, 2002. Co-Chairman Dr. Shigenobu Takeda called the meeting to order and welcomed the participants (*IFEP Endnote 1*). The Advisory Panel reviewed the draft agenda and it was adopted (*IFEP Endnote 2*). The meeting focused mainly on the preliminary results of the successful iron enrichment experiment in the eastern subarctic Pacific in July–August 2002.

Activities in 2002

Eastern subarctic Pacific

An *in situ* iron enrichment experiment in the eastern subarctic Pacific, SERIES (**S**ubarctic **E**cosystem **R**esponse to **I**ron **E**nrichment **S**tudy), was conducted in July–August 2002, as a part of the Canadian-SOLAS project.

SERIES scientific objectives

- Community response to iron addition (comparison with other HNLC regions such as Eq Pacific, S Ocean, NW Pacific);
- Natural longitudinal dust/Fe gradient from Western Subarctic Gyre to Alaska Gyre;
- Fe chemistry and complexing agents;
- Carbon export – needs > 30 days to see;
- Trace gas production *e.g.*, DMS and organic halides.

SERIES implementation - three ships

- CSS *John P. Tully* (Canada): pre-injection survey, patch mapping, buoy handling, underway sampling, nutrients, sediment traps;
- M/V *El Puma* (Mexico, chartered by Canada): atmospheric and ocean process studies (gas production, DMS, DMSP, grazing, BP, PP, Chl, zooplankton, *etc.*);
- M/V *Kaiyo Maru* (Japan): mapping, pCO_2, sediment traps, nutrients, BP, PP, Chl, foodwebs, taxonomy.

Experiment and preliminary results

An *in situ* iron enrichment experiment was conducted in the northeast subarctic Pacific near Station P26 – Ocean Station Papa (50ºN, 145ºW). Site selection was based on the location of waters with low density, uniform physical characteristics, the predominant direction of the drogued drifter buoys, and matching the HNLC condition. There was evidence of two eddy-like features, southwest and northeast of P26, that was taken into consideration.

The first iron release was performed from 01:05–18:45 hours on July 7, 2002. The SF_6 and iron solutions were mixed and pumped over the side at rate of 5 and 20 liters/min to a depth of about 7 m as maintained by attachment of the outlet to a Hi-Fin fish. The release track was an expanding square covering 4.75 × 4.74 n miles, with a distance between transects of 0.4 n miles. Some of the initial values for reactive and unfiltered iron were in the 4 nM range, while dissolved iron concentration was as high as 2.5 nM. Values declined very quickly over the first few days in the surface mixed layer of 10 m. Winds and rough seas mixed the iron down uniformly to about 30 m on July 13 to 14.

Re-infusion of iron was performed from 14:45 hours on July 16 to 08:00 hours on July 17, 2002. An expanding rectangle was used for the re-infusion with the SF_6 mapping system used to monitor the release. The second smaller injection brought levels up to 0.6–0.7 nM for dissolved Fe in the 3–10 m depth on July 17. By July 22, dissolved iron concentrations were very close to background.

Rapid and small initial responses were observed in phytoplankton. As the experiment progressed, the biological response, such as increases in F_v/F_m, primary productivity and Chl-*a* concentration and decreases in macronutrient concentrations, became apparent. This was also augmented by underway pCO_2.

The phytoplankton bloom peaked physiologically around July 21, primary production peaked on July 24, and Chl-*a* peaked on July 24–26 and reached 8 mg m^{-3}.

Concentration of Chl-*a* then decreased gradually to 1.5 mg m^{-3} on August 4. The most dominant phytoplankton at the Chl-*a* peak were centric diatoms, and many pennate diatoms were also observed. Exhaustion of iron and macronutrients seems to be one of the reasons for the termination of the bloom. Sinking particles gradually increased after July 31.

Western subarctic Pacific

The Panel reviewed the results of the Japanese iron enrichment experiment in the western subarctic Pacific – SEEDS 2001 (**S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamics **S**tudy). These results will be published as a special issue of *Progress in Oceanography*. The Panel discussed the plans for the second longer-term (>30 days) experiment in this area in July–August, 2004.

Scientific objectives for SEEDS 2004

- Observe the decline of the diatom bloom and elucidate the fate of fixed carbon;
- Measure additional parameters to see the overall biogeochemical responses to iron enrichment;
- Determine the influence of Fe on trace gas production and aerosol formation;
- Measure gas fluxes from ocean surface to atmosphere.

Scientists from the U.S.A. are planning to take part in the longer-term experiment in the western gyre, and the proposal submitted to NSF was presented.

Proposed activities in 2003

IFEP proposes a 3-day workshop on *In situ iron enrichment experiments in the eastern and western subarctic Pacific*, to be held December 4–6, 2003, at the Institute of Ocean Sciences in Sidney, British Columbia, Canada.

Specific objectives of the workshop are:

- Synthesize results from two *in situ* iron enrichment experiments performed in the eastern and western subarctic Pacific (SEEDS-2001 and SERIES);
- Discuss responses in lower and higher trophic levels, carbon cycles, trace-gas production and ocean–atmosphere flux, and models;
- Determine similarities and differences in biogeochemcal and ecosystem responses to iron addition between the eastern and western subarctic Pacific;
- Identify specific scientific questions for the longer-term experiment in the western subarctic Pacific (SEEDS-2004).

The results of the workshop will be published as a special issue of *Deep-Sea Research II*.

IFEP requests support for three invited speakers (two from New Zealand and one from Mexico) to attend the IFEP Workshop in December 2003 in Sidney, Canada.

It was suggested that IFEP needs to work more closely with MODEL Task Team for the improvement of NEMURO model by adding iron limitation to phytoplankton production using the data from two successful iron enrichment experiments performed in the eastern and western subarctic Pacific. Such a model would be useful to see the long-term ecosystem responses as well as the experimental design of SEEDS 2004.

IFEP Endnote 1

Participation List

Members

William Cochlan (U.S.A.)
Paul J. Harrison (Canada)
Isao Kudo (Japan)
Shigenobu Takeda (Japan, Co-Chairman)
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Yukihiro Nojiri (Japan)
Sachiko Oguma (Japan)
Kelvin Richards (U.S.A.)
Hiroaki Saito (Japan)
Daniela Turk (Canada)
Nelson D. Sherry (Canada)
Masahide Wakita (Japan)
Shuichi Watanabe (Japan)
Emmy Wong (Canada)

IFEP Endnote 2

IFEP Meeting Agenda

11. Round-table introduction of attendees
12. Adoption of agenda
13. Adoption of the report of the IFEP Panel meeting held at PICES X (Victoria, Canada)
14. Review of time-table of international iron enhancement experiments in the North Pacific
15. Progress report of the Japanese iron enhancement experiment (SEEDS-2001) activities in the western subarctic Pacific
16. Summary of the Canadian iron enhancement experiment (SERIES) in the eastern subarctic Pacific
    - 6.1 Introduction of SOLAS/SERIES
    - 6.2 Overview of logistics and biological responses
    - 6.3 CSS *J.P. Tully* measurements
      Cruise report, SF_6 mapping, iron, DMS, climate gases, pCO_2, carbon, nutrients, sediment trap, and physics
    - 6.4 M/V *El Puma* measurements
      Cruise report, primary production, Chl-*a*, incubation; DMS(P) biology, and aerosol/atmospheric studies
    - 6.5 M/V *Kaiyo-maru* measurements
      Cruise report, mapping, Chl-*a*, FRRF, iron, incubation experiments, pCO_2, nutrients, sediment trap
17. IFEP related activity in other areas
    - 7.1 Overview of SOFeX
    - 7.2 Modeling results of iron enrichment experiments (IronEx-II)
8. Future IFEP related activity plans in the North Pacific
    - 8.1 SERIES/SOLAS
    - 8.2 SEEDS
    - 8.3 US-NSF proposal for post-fertilization long-term study
9. Discuss plans for 2003
    - 9.1 Discuss need for special Symposium /Workshop(s) of SERIES and SEEDS
    - 9.2 Discuss need for PICES Scientific Report(s) of SERIES and SEEDS
    - 9.3 Requests for travel to future meetings
10. Other new business

2003 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Twelfth Annual Meeting, October 9–18, 2003, Seoul, Republic of Korea)

Activities in 2003

SERIES Workshop

A 4-day SERIES (**S**ubarctic **E**cosystem **R**esponse to **I**ron **E**nrichment **S**tudy) Workshop was held March 9–12, 2003, at the Institute of Ocean Sciences, Sidney, Canada. Observed results from the experiment conducted in July–August 2002, in the Eastern Subarctic Pacific by three research vessels, CSS *John P. Tully* (Canada), M/V *El Puma* (Mexico) and M/V *Kayio-Maru* (Japan) were synthesized. Data exchange, publications, timeline for the next 12 months, *etc*. were discussed.

SEEDS planning meeting

A planning meeting for the 2004 SEEDS (**S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamics **S**tudy) experiment in the Western Subarctic Pacific was held April 18, 2003, at the Ocean Research Institute, University of Tokyo, Japan. Objectives of the research projects were presented by both US and Japanese scientists. The ship schedule for US and Japanese research vessels and parameters that will be measured on each vessel were discussed.

Activities in 2004

PICES IFEP Workshop

A 3-day PICES IFEP Workshop on "*In situ* iron enrichment experiments in the Eastern and Western Subarctic Pacific" will be held February 11–13, 2004, at the Institute of Ocean Sciences in Sidney, British Columbia, Canada. (The schedule was changed from December 2003 to February 2004.)

Specific objectives of the workshop are:

- to synthesize results from two recent *in situ* iron enrichment experiments in the Subarctic Pacific (SEEDS-2001 and SERIES-2002);
- to discuss responses in lower and higher trophic levels, carbon cycles, trace-gas production and ocean-atmosphere flux, and models;
- to determine similarity and differences in biogeochemical and ecosystem responses to iron addition between Eastern and Western Subarctic Pacific; and
- to identify specific scientific questions for the longer-term experiment in the Western Subarctic Pacific (SEEDS-2004).

The results of this IFEP workshop will be published as a PICES Scientific Report in 2004.

Travel support from PICES is requested (and approved in 2003) for one scientist from New Zealand to attend the workshop.

Topic Session at ASLO/TOS Conference

A 1.5-day special session on "Response of the upper ocean to mesoscale iron enrichment" will be convened February 17–18, 2004, at the ASLO/TOS Ocean Research Conference in Honolulu, U.S.A. The Session represents a combined effort of the Canadian SOLAS and the PICES IFEP.

SEEDS-2004

The second *in situ* iron enrichment experiment in the Western Subarctic Pacific (SEEDS-2004) will take place in July–August 2004. A Japanese ship will release iron on July 17, 2004, stay at the iron-enriched patch for 10 days, and come back to the site from Day 23 to Day 34. A US research vessel will be at the site from Day 6 to Day 26, which allows us 4–5 days' overlapping at the beginning and the end of the experiment.

Publications

Selected papers from the SEEDS-2002 experiment as well as the experimental design of SEEDS-2004 will be published as a special issue of *Progress in Oceanography*.

2004 Report of the Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean*

(PICES Thirteenth Annual Meeting, October 14–24, 2004, Honolulu, U.S.A.)

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, and the PICES Secretariat 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 × 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 need 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 are 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.