Foreword

Over twenty years ago, John Martin, Director of the Moss Landing Marine Laboratory, California State University, began putting evidence together from studies in the 1930s to propose that phytoplankton were limited by the availability of iron in some areas of the ocean. These regions were termed high-nutrient low-chlorophyll (HNLC) regions. Today, we know that the subarctic Pacific, equatorial Pacific, and the Southern Ocean are the three major HNLC regions of the world. Since Martin put forth his hypothesis, iron fertilization of HNLC water has been thought to be one possible approach to remove CO_2 from the atmosphere to combat global warming caused by greenhouse gases. Natural iron fertilization has also been hypothesized to control the glacial/interglacial shift in atmospheric CO_2.

The subarctic Pacific is characterized by a shallow (100–200 m) permanent pycnocline during winter, permitting relatively high numbers of phytoplankton and micro-grazers to subsist over winter. This, in turn, strongly influences the pelagic community structure. Two gyres, the Alaska Gyre (also called the Eastern Subarctic Gyre; both names used interchangeably in this report) and the Western Subarctic Gyre, dominate the subarctic Pacific. In the Alaska Gyre, Ocean Station Papa has produced a 50-year time series of physical, chemical and biological parameters, and has been the focus of three intensive sampling programs, the **SU**barctic **P**acific **E**cosystem **R**esearch Project (SUPER), the **W**orld **O**cean **C**irculation **E**xperiment (WOCE) and **C**anadian **J**oint **G**lobal **O**cean **F**lux **S**tudy (CJGOFS). In the Western Subarctic Gyre, the establishment of the time series station KNOT in 1998 has produced much data collected for understanding the seasonality of various parameters in this area.

In these two gyres, we now know that iron limits the utilization of nitrate and hence, the primary productivity of large cells, such as diatoms, except in the winter when iron and light may be co-limiting. In the Western Subarctic Gyre, which is in closer proximity to the Asia than the Alaska Gyre, the degree of iron limitation changes in parallel with the dust season in Asia. In fact, measured iron concentrations in the surface and deep waters seem to be higher in the Western Subarctic Gyre compared to the Alaska Gyre. Bottle incubation experiments have demonstrated that iron addition results in the increase in pennate diatoms in the Alaska Gyre and the increase in centric diatoms in the Western Subarctic Gyre. Such differences between these two gyres may also have an influence on the pelagic community structure and export production.

To test the iron limitation hypothesis of phytoplankton production in nutrient-rich areas of the open sea, iron fertilization experiments were first conducted in the equatorial Pacific under the programs IronEx I and II in the early and mid 1990s. These mesoscale enrichments experiments offered the chance to test the whole ecosystem response, and the results showed that iron supply controls phytoplankton processes, leading to enhanced phytoplankton stocks and associated macronutrient uptake and CO_2 drawdown. Another iron fertilization experiment soon followed in the Southern Ocean (SOIREE, **S**outhern **O**cean **I**ron **RE**lease **E**xperiment) during the summer season of 1999 and again demonstrated that iron supply controls phytoplankton growth and community composition, but the fate of produced organic carbon remains unknown.

The subarctic Pacific, with a unique water structure and biology, was the only HNLC region without an iron fertilization experiment to assess the iron hypothesis. Key questions that were not entirely resolved by the previous iron enrichment experiments, were:

1. How does the change in biodiversity and food-web structure differ for markedly different HNLC 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 dimethyl sulphide (DMS) during the bloom, and how is the production influenced by phytoplankton species, microbial processes and grazing?

The proposal to establish an Advisory Panel on *Iron Fertilization Experiment in the subarctic Pacific Ocean* (IFEP-AP), under the BASS (BASin Studies) Task Team of the PICES Climate Change and Carrying Capacity (CCCC) Program, was approved at PICES VII in 1998, in Fairbanks, U.S.A. Working by correspondence, the Advisory Panel developed a workplan to tackle the following tasks: (1) to draw on the results of IronEx I, II and SOIREE to design a subarctic experiment and to come up with an hypothesis not answered in previous works; (2) to campaign for resources, particularly ship time required for successful experiments; and (3) to create an infra-structure for interaction, data distribution and publication, and scheduling for the participants.

A first IFEP-AP meeting was held at PICES VIII in October 1999, in Vladivostok, Russia. Here, the Advisory Panel (i) examined the reasoning for a subarctic iron experiment, the scale disciplines, and resources required to ensure success of the experiment, and (ii) produced a preliminary design of the experiment and its timing. The Panel provided an important co-ordination mechanism for international planning of meso-scale iron fertilization experiments conducted for the first time in the HNLC waters in the subarctic Pacific Ocean.

Japan organized the first of a series of experiments in the northwestern Pacific, SEEDS-I (**S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamics **S**tudy), in the summer of 2001, followed by the Canadian SERIES (**S**ubarctic **E**cosystem **R**esponse of **I**ron **E**nrichment **S**tudy) in the summer of 2002, in the northeastern Pacific, and the Japanese SEEDS-II in the summer of 2004, again, in the northwestern Pacific. The Panel also convened a series of international workshops (in October 2000 in Tsukuba, Japan, and in February 2004, in Victoria, Canada) so that international scientists engaging in iron fertilization experiments (*e.g.*, IronEx I, IronEx II in the equatorial Pacific, SOIREE in the subantarctic Pacific, and SOFeX in the Antarctic waters) could gather to share their experiences and exciting new findings, which came out as PICES literature as well as in publications in *Nature*, *Science*, and other professional journals. The Panel has served as a roadmap for the science of iron fertilization as a new tool for process research, and will point the way to future achievements.

This scientific report contains 13 extended abstracts by 25 participants from 3 countries involved in a PICES-sponsored workshop on "*In situ* iron enrichment experiments in the eastern and western subarctic Pacific", held February 11–13, 2004, in Victoria, Canada, which compares iron fertilization experiment results between the western and eastern subarctic Pacific. We have also provided background information that will enable the reader to refer to items and events related to this workshop. Appendix 1 includes the proceedings of the initial planning workshop on "Designing the iron fertilization experiment in the subarctic Pacific", held October 19–20, 2000, in Tsukuba, Japan, and co-sponsored by PICES and the Japan Central Research Institute of Electric Power Industry (CRIEPI). This workshop resulted in a spirited discussion among 39 participants from 5 countries and the submission of the extended abstracts from the 19 presentations. Appendix 2 is an historical list of all members of the Advisory Panel from 1999 to the present. Appendix 3 contains the IFEP-AP terms of reference, approved in 1999, and amended in 2004 to include a fourth term in response to the unexpected outcomes of the three iron enrichment experiments (SEEDS-I, 2001; SERIES, 2002, and SEEDS-II, 2004). Appendix 4 is comprised of the IFEP-AP Annual Reports, from its inception to 2004. The last Appendix contains featured articles on the iron enrichment experiments in the subarctic Pacific Ocean taken from the 2002 and 2004 issues of the PICES Press newsletter.

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