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PICES Press

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The future of PICES

The magical island of Jeju-do, Korea, was the location for the 2nd inter-sessional Science Board and Governing Council meeting, hosted by the Korean Ministry of Marine Affairs and Fisheries (MOMAF) and the Korean Ocean Research and Development Institute (KORDI) on May 6-8, 2004. This was only the second joint meeting of the two senior committees of PICES (in its 12 year history) and, like the first such meeting held last year in Victoria, it proved to be extremely valuable for assessing the progress of the many PICES Committees and Working Groups and for planning future directions for the Organization. Key items that were discussed included the PICES Strategic Plan, the North Pacific Ecosystem Status Report, the PICES web site, and the activities of PICES' Committees and Working Groups. Many of these activities will be featured during the Thirteenth Annual Meeting of PICES in Honolulu, Hawaii, October 14-24, 2004.

PICES Strategic Plan

Over the past year, all our Scientific and Technical Committees, and the Climate Change and Carrying Capacity (CCCC) Program have been discussing a draft Strategic Plan for PICES. This plan is designed to establish the broad goals and directions for the Organization, and to be used to guide future PICES activities. This Strategic Plan was developed by a Study Group which included members from Governing Council and Science Board, and was chaired by the PICES Chairman, Dr. Vera Alexander. The Strategic Plan highlights the PICES mission "To promote and coordinate marine scientific research in the North Pacific Ocean in order to advance scientific knowledge of the area concerned and of its living resources". The PICES Strategy for succeeding in this mission includes five central themes (each of these have detailed goals to support the theme):

- Advancing scientific knowledge;
- Applying scientific knowledge;
- Fostering partnerships;
- Ensuring a modern organization in support of PICES activities; and
- Distributing PICES scientific information.

Over the next months the scientists of PICES will be asked to consider how the activities of each Committee, Program and Working Group can support this plan, leading to the development of an Action Plan for PICES.

Dr. Ian Perry presents the agenda of the interim Science Board and Governing Council meeting.

North Pacific Ecosystem Status Report

A draft of the North Pacific Ecosystem Status Report was presented and discussed during the MONITOR Workshop and the Committee meetings at PICES XII in Seoul, Korea, in October 2003. Revisions to the report were completed over the past months. A second major step towards the future of PICES was achieved when Science Board approved the scientific content of the report at this inter-sessional meeting. It is hoped that the report can be made available soon on the PICES web site. PICES has also entered into discussions with the United States for a role in developing a Pacific Coast Observing System (PaCOS). PICES involvement could range from facilitating international collaboration among Canada, Mexico and the United States, to a "PaCOS desk" at the PICES Secretariat, which would have an important role in updating the California Current chapter of the next Ecosystem Status Report.

Symposia

Several symposia are being planned in collaboration with other international programs. These include: a symposium on "*Climate variability and sub-arctic marine ecosystems*" scheduled for May 16-20, 2005, in Victoria, Canada, and hosted jointly with GLOBEC; a joint NPAFC/PICES symposium tentatively titled "*Pacific salmon as indicators of the state of North Pacific marine ecosystems*" being planned for October 2005, in Seoul, Korea; a joint ICES/PICES symposium on "*Marine bioinvasions*" scheduled for April 2006, on the east coast of the United States; and a *4th International Zooplankton Symposium* jointly with ICES and GLOBEC planned for June 2007, in Hiroshima, Japan. In addition, PICES and ICES are discussing hosting a joint *Young Scientists Conference* to provide an international forum where young marine scientists from (P)ICES member countries can meet at an early stage of their career to experience international scientific cooperation, to begin to establish peer networks, and to provide an opportunity for young scientists to contribute to the international scientific work that forms the basis for managing the marine environment. Fund-raising for this conference has already begun.

Activities of Committees

PICES is becoming more successful at encouraging PICES activities to take place year-round, and not just at, and immediately before, the annual meetings. Most PICES groups are on-track, and Working Groups 14 (*Effective sampling of micronekton to estimate ecosystem carrying capacity*) and 16 (*Climate change, shifts in fish production, and fisheries management*) are expected to table near-final reports at PICES XIII in Honolulu. Planning for the micronekton sampling inter-calibration experiment by the MIE-Advisory Panel (under the BIO Committee) is well advanced, with a cruise onboard the new NOAA research vessel, the *Oscar Elton Sette*, scheduled just prior to PICES XIII, to compare various gears used to sample micronekton in the North Pacific; preliminary data analyses are expected to occur at PICES XIII. New groups that have been formed and are expected to have their first meetings at PICES XIII include: Working Group 18 on *Mariculture in the 21st century - The intersection between ecology, socio-economics and production* (co-chaired by Ik-Kyo Chung of Korea and Carolyn Friedman of U.S.A.), the *Harmful Algal Blooms* Section of the MEQ Committee (co-chaired by Hak-Gyoon Kim of Korea and Vera Trainer of U.S.A.), and Study Group on *Ecosystem-based management science and its application to the North Pacific* (co-chaired by Glen Jamieson of Canada and Chang-Ik Zhang of Korea).

What makes a successful Working Group?

During the 2nd inter-sessional Science Board and Governing Council meeting on Jeju Island, Korea, in May 2004, it was recognised that some Working Groups of PICES appear to be more successful at completing their activities than other groups. A lively discussion occurred as to what helps to make a successful Working Group. Key features include:

- strong chairmanship;
- members who are committed and enthusiastic about the topic;
- members who are capable and knowledgeable about the topic;
- having adequate resources available (especially of time and money);
- clear (and realistic) Terms of Reference, objectives, and deliverables;
- strong support and guidance from the parent committee.

PICES groups that propose Working Groups or subsidiary committees should keep these criteria in mind to help make these activities a pleasant and fruitful experience for everyone.

Group photo taken on the grounds of the Hyatt Regency Hotel after the completion of the interim meeting (Absent: Dr. Vera Alexander).

Climate Change and Carrying Capacity Program

The CCCC Program of PICES is heading towards the synthesis and conclusions of (at least) the present phase of the program. The Topic Session at PICES XIII titled "*The impacts of large-scale climate change on North Pacific marine ecosystems*" and the symposium on "*Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis*" (planned for April 19-21, 2006, in Honolulu, Hawaii) are major milestones towards this synthesis. In addition, the IGBP/SCOR/IOC GLOBEC Program (of which CCCC is a Regional Program) is also entering its synthesis phase, which is expected to last until the Program's completion in 2009. The PICES CCCC synthesis activities will therefore play a major role in helping GLOBEC to draw together their findings. To facilitate the CCCC synthesis activities, the structure of the CCCC Program is being modified. The BASS (*Basin Scale Studies*) and REX (*Regional Experiments*) Task Teams will be formally completed at PICES XIII, and their members thanked for their hard work. A new Task Team called CFAME (*Climate Forcing and Marine Ecosystem Response*) will be formed to focus these synthesis activities along with the MODEL Task Team. The Terms of Reference for this new Task Team are being finalised. In addition, the MONITOR Task Team is being moved outside of the CCCC Program to become a Technical Committee similar to TCODE (the Technical Committee on Data Exchange). This is being done to recognise the increasing importance of monitoring in the North Pacific and that monitoring should continue beyond the completion of the CCCC Program; the Terms of Reference for this Committee are also being finalised. It will add an additional member to Science Board.

PICES web site

The PICES Secretariat has worked very hard to develop a new PICES web site (http://www.pices.int), and the results are a great success. The site is now very pleasing to the eye and much easier to navigate. Electronic copies of past PICES reports and newsletters are being added to the site. What is needed now is material from each of the Scientific Committees, CCCC Program, and Working Groups to add to the site. A small "Web Publication Committee" under the guidance of Dr. Harold Batchelder has been established to facilitate adding new information and to provide some level of "quality control". In addition, PICES groups can easily have a private web page established for communications amongst their members, which should help improve the work of PICES.

PICES continues to be an exciting organisation with year-round activities. I invite you to visit and explore the new web site (http://www.pices.int) and to become involved – **PICES is there to help you with your science in the North Pacific.**

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Paris by day

Symposium on "Quantitative ecosystem indicators for fisheries management"

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Dr. Villy Christensen (top) is a fisheries scientist specializing in ecosystem approaches to fisheries management. He has been central to the development of the ECOPATH ecosystem modelling approach and software, which is used extensively throughout the world. He is part of the Sea Around Us project funded by the Pew Charitable Funds, and is an associate professor at the University of British Columbia, Vancouver, Canada.

Dr. Philippe Cury (bottom) is Director of the Centre de Recherche Halieutique Méditerranéenne et Tropicale. He is also a Senior Research Scientist and Director of Research, IRD. He has published several theories on linkages between climate and fisheries and on the functioning of marine ecosystems.

Spring in Paris helped to attract 250 participants from 43 countries to a symposium in early April this year. The symposium on "*Quantitative ecosystem indicators for fisheries management*" was hosted by the Intergovernmental Oceanographic Commission (IOC) at the UNESCO headquarters next to the Eiffel Tower. Years of preparation were over and the stage was set for a programme of 40 presentations and close to 150 posters.

The topic of the symposium reflects the growing understanding that exploited fish populations must be considered as integral components of ecosystem function instead of phenomena that operate independently of their environment. Internationally, there has been wide recognition of the need to move toward an ecosystem approach to fisheries, a development spearheaded by FAO (UN Food and Agriculture Organization) through the Code of Conduct for Responsible Fisheries, and supported by many regional and national institutions as well as academia, NGOs and the public-at-large. Intergovernmental organizations such as PICES, require meaningful indicators that adequately reflect the state of marine ecosystems.

As we move to embrace an ecosystem perspective, we need new measuring sticks. Ecosystem approaches to fisheries include consideration of the inter-dependent way we utilize ecosystems. At a minimum, these components include ecological, economical, social, technological, as well as governance aspects. When considering the ecosystem, we must include not only the target species, but also their effects on dependent, competitor, and non-target species, as well as on the habitats shared by these species. An important question thus arises, related to trade-offs. Management interventions directed at one target species may have consequences for many other species, including species that are targets of other fisheries. How do we evaluate the trade-offs involved, and how do we determine what direction we, as a society, should take?

To evaluate such questions, it is important to form our decisions based on well-founded science as well as on information about societal priorities. At the Paris Symposium, the focus was on the scientific aspects of ecosystem approaches to fisheries, with the intention to provide information and guidelines about how to develop, test and apply indicators, or frameworks of indicators.

Internationally, the first major initiative related to the use of ecosystem indicators for sustainable fisheries development was taken by the Government of Australia in cooperation with FAO, through a Consultation in Sydney in January 1999, involving 26 experts from 13 countries. The consultation resulted in Technical Guidelines No. 8 for the FAO Code of Conduct for Responsible Fisheries: Indicators for Sustainable Development of Marine Capture Fisheries. The Guidelines were produced to support the implementation of the Code of Conduct; they deal mainly with the development of frameworks, and they set the stage for using indicators in the decision-making process.

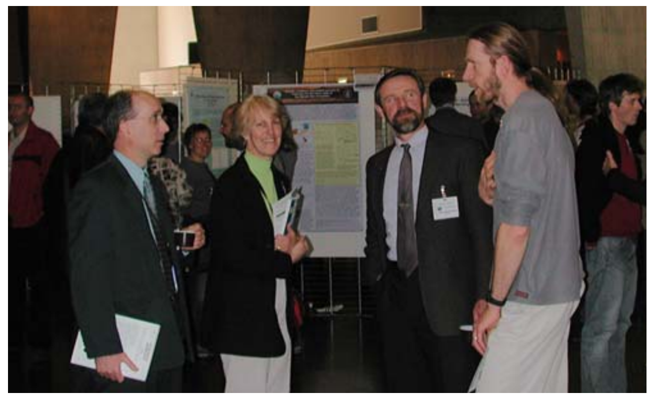
The Guidelines do not, however, discuss the properties of indicators, nor how they are used and tested in practice. Instead, this became the task of an international Working Group, formed jointly by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC). SCOR/IOC Working Group 119 on *Quantitative Ecosystem Indicators for Fisheries Management* was established in 2001, with 32 members drawn from a large number of countries. The Working Group was designed to support the scientific aspects of using indicators for an ecosystem approach to fisheries, to review existing knowledge in the field, to demonstrate the utility and perspectives for new indicators reflecting the exploitation and state of marine ecosystems, as well as to consider frameworks for their implementation.

The Working Group met first in October 2001, in Reykjavik (Iceland), to plan and report on progress; and then in December 2002, in Cape Town (South Africa), to organize its efforts with a series of task forces working in parallel on:

- Environmental indicators including habitat changes
- Species-based indicators
- Size-based indicators
- Trophodynamic indicators
- Integrated indicators
- Selection criteria
- Data sets and reviews, and
- Frameworks for implementing indicators.

As part of their work, the task forces reviewed the current status of using indicators for ecosystem approaches to fisheries, as well as seeking to develop new theory, applying it, and evaluating the performance of indicators. The major results of these endeavours formed the core of the presentations at the Paris Symposium. More than 200 abstracts were submitted for presentation at the Symposium. The Programme Committee of the Symposium thus faced a very difficult task in selecting oral and poster presentations when they met at the PICES Secretariat in November last year. This was, however, a wonderful problem when planning a symposium, and it clearly indicated that the timing was perfect for evaluating the role of indicators for an ecosystem approach to fisheries. This is also clear from the very generous and enthusiastic support the Symposium received from a number of organizations – the list includes SCOR, IOC, FAO, NOAA, Institut Français de la Biodiversité, the UBC Sea Around Us, South Africa's Department of Environmental Affairs and Tourism, ICES, IRD, IFREMER, GLOBEC and last, but not least, from PICES. Indeed, PICES supplied logistical support to get the Symposium organized by handling registrations, submission of abstracts, producing the book of abstracts, staffing the Symposium Office during the event, as well as supporting the participation by some colleagues from PICES member countries.

Press conference for the symposium: Philippe Cury, Serge Garcia, Ian Perry, Patrick Cayre and Daniel Pauly are on the host panel.



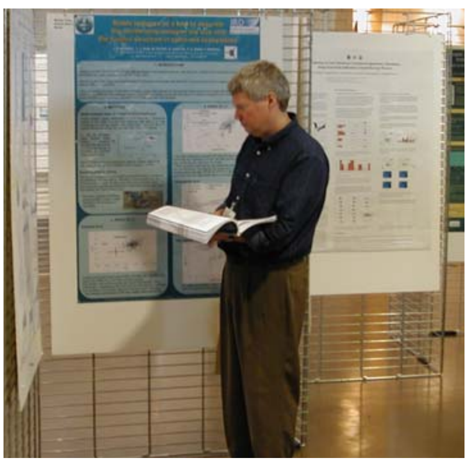
Villy Christensen, Pat Livingston, Skip McKinnell and Franz Mueter chat at the poster session.

Neils Daan, editor of the symposium proceedings, collects manuscripts from Julia Yazvenko of PICES.

Looking back at the Symposium, it is clear that we have moved a long way toward ecosystem approaches to fisheries within a relatively short time span. The presentations outlined a vast array of well-defined indicators for fisheries management, described their properties, and evaluated how they can be used at the ecosystem-level to describe the impact of fisheries, as well as to evaluate the relative contribution of environmental and fisheries impact. Given the number of available indicators that have been developed and applied, it is also clear that emphasis has to be directed toward methodologies for selecting indicators, and evaluating how capable indicators are of detecting trends in a noisy environment. While these topics were treated at the Symposium, it is yet too early to draw clear conclusions. It is noteworthy though, that by being dealt with explicitly as part of the Symposium, it is clear from the very onset of using indicators as part of ecosystem approaches to fisheries, that what we are aiming for is not to find the 'best' indicator, but rather a suite of indicators with known properties, and that this includes methodologies for selecting indicators as an integral part of the effort. Guidelines for how to test indicators and develop frameworks for their application is thus of essence.

The conclusion of the Symposium as expressed through a final panel discussion is clear: we have the science in place with regards to ecosystem indicators that is needed to make an ecosystem approach to fisheries operational. We anticipate that the special issue of the ICES *Journal of Marine Science*, due within a year, will present the major findings from the Symposium and will underline that the science is ready, and we are sure the special issue will become a reference publication for the scientific aspects of using ecosystem indicators as part of an ecosystem approach to fisheries. What is needed now are guidelines for how to implement ecosystem approaches for fisheries, and how to operationalize the role of ecosystem indicators.

Symposium organizers relax over lunch after the symposium (from left: J. Yazvenko, V. Christensen, I. Perry, P. Cury, J. Field, G. Hempel, D. Pauly, E. Gross, C. Chiu).



Bob O'Doyle working diligently at judging the posters for the Best Poster Awards.

After the hard work - Bob O'Doyle, Villy Christensen and Philippe Cury present Best Poster Awards to the winners at the Closing Session.

Closing Panel Discussion (from left: Daniel Pauly, Marie-Joelle Rochet, Poul Degnbol, Gottlief Hempel, Renato Quiñones, Jake Rice, Nico Willemse, Serge Garcia).

The Bering Sea: Current status and recent events

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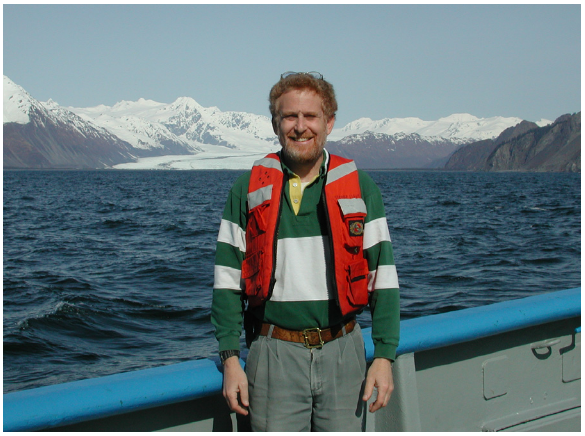

*Dr. Jeffrey (Jeff) Napp is a biological/fisheries oceanographer at the Alaska Fisheries Science Center of NOAA-Fisheries. He is Head of the Recruitment Processes Program at the Center and co-leader (with Dr. Phyllis Stabeno) of NOAA's Fisheries Oceanography Coordinated Investigations (FOCI). His own research is focused on physical and biological processes at lower trophic levels that affect recruitment variability in fish populations. He is active as Principal Investigator in both Bering Sea (NOAA's Bering Sea FOCI, Southeast Bering Sea Carrying Capacity) and Gulf of Alaska (FOCI, GLOBEC) Programs, and currently serves on a steering committee to organize a U.S. science initiative for the Bering Sea (BEST: **B**ering Sea **E**cosystem **ST**udy). Jeff participates in several PICES Working Groups and Technical Advisory Panels.*

This issue's report will be much briefer than the past issue. Most investigators have not been in the field since last summer or fall, and those initial late summer results were published in the previous issue. Scientists wishing to contribute observations, analyses or pure speculation are encouraged to contact the author at the above address.

Recent climate and upper ocean observations

The winter of 2003-04 brought weather typical of the recent past to the eastern Bering Sea. After a warm, early fall, the region experienced a series of moderate arctic air outbreaks interspersed with periods of mild, maritime conditions. The sea surface temperature (SST) over the shelf was on the order of 1.5°C warmer than normal going into the winter. This served to keep the air temperature over the shelf relatively warm for the entire winter, and to delay the seasonal advance of the sea ice. On the other hand, western Alaska, which was not as subject to the moderating influence of the shelf water, recorded near-normal air temperatures overall. There was an unusually pronounced cold snap at the end of March into April 2004; some of the coldest temperatures and the maximum ice extent (to about 57°N) occurred at this time (http://www.natice.noaa.gov). This was the third ice advance/retreat sequence of the winter. The cold snap was followed by a quick warm-up, and the ice sheet began retreating rapidly to the north, as has been typical of the last decade or two. At the time of this writing (late April), the ice edge was located at about 60°N, around Nunivak Island. From the ice distribution, I would predict an early spring phytoplankton bloom between 57° and 60°N, and a later spring phytoplankton bloom south of 57°N initiated by thermal stratification of the water column.

The overall atmospheric circulation anomalies for the winter (Nov.-Mar.) of 2003-04 included anomalously low sea-level pressure (SLP) over the Kamchatka Peninsula extending into northwest Alaska, and an anomalous high SLP center in the North Pacific near 45°N, 160°W. One of the consequences of this pattern was a tendency for cyclonic storms to track into the western portion of the Bering Sea more often than usual. El Niño-Southern Oscillation (ENSO) and the Arctic Oscillation (AO) represent important drivers of inter-annual climate variability on the hemispheric scale. The winter of 2003-04 was near-neutral with respect to ENSO, and moderately negative with respect to AO. For the North Pacific basin as a whole, it appears that the second leading mode of SST (Bond *et al. Geophys. Res. Lett.* , 2003, 30(23): 2183-2186) re-emerged in a moderately positive sense after a 1-year hiatus in 2002-03. That winter included an El Niño and a strongly positive state for the Pacific Decadal Oscillation (PDO); PDO has since been in a weak-moderate positive state.

New research projects

Late this summer there will be two new projects sampling the eastern Bering Sea. The first is a joint Russian-U.S. program to conduct a census of marine life in the northern Bering and Chukchi Seas aboard the R/V *Professor Khromov* (Fig. 1). The Russian-American Long-term Census of the Arctic (RUSALCA) project is sponsored by the Russian Academy of Sciences and NOAA (http://www.cifar.uaf.edu/rusalca_awards.html). Long-term trends in arctic sea ice cover and forecasts of loss of seasonal ice cover were the impetus for sponsoring the ecosystem exploration. Investigators from both sides of the Pacific represent a number of institutions and disciplines from physics, chemistry to adult fish. Dr. Terry Whitledge (University of Alaska, Fairbanks) will be the Chief Scientist.

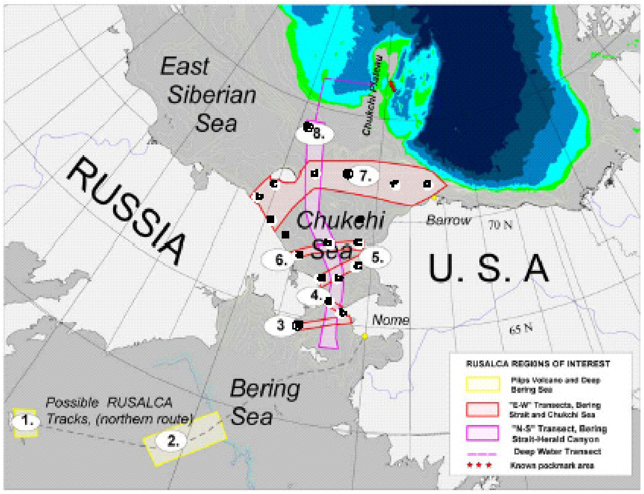

Fig. 1 *Proposed transects 3-8 for the Nome-to-Nome leg of the RUSALCA cruise. Letter designations on each transect are locations for proposed sampling of larval and juvenile fishes.*

The second project, sponsored by the U.S. National Science Foundation, is a test to determine if the transport of slope water onto the shelf and subsequent eutrophication of shelf waters around the Pribilof Islands can be tracked: physically, chemically, and through the food web. Seven physical oceanographic moorings were deployed in April 2004 around the Pribilof Islands (Fig. 2). Scientists will study hydrography, water chemistry, and biological productivity during a cruise in late July/early April aboard the R/V *Alpha Helix*. Dr. George Hunt (University of California, Irvine) will be the Chief Scientist.

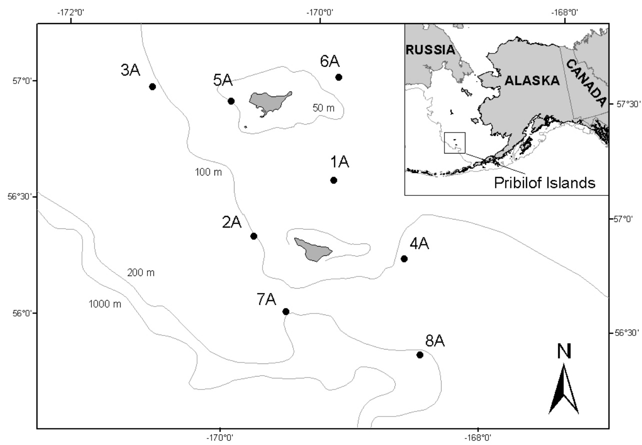

Fig. 2 *Mooring locations for the Pribilof Island study*

The Bering Sea Ecosystem Study (BEST) draft science plan (http://www.arcus.org/bering/science_plan.html) was presented to the science community at two recent meetings: SEARCH (Seattle, October 2003) and ASLO/TOS (Hawaii, February 2004). The deadline for comments was March 1. Those comments submitted are now being considered for incorporation into the plan. The next step will be to present the amended plan to the U.S. National Science Foundation. Once accepted it will be necessary to write an implementation plan.

Acknowledgement: Many thanks to Nicholas Bond for contributing to this report

The state of the western North Pacific in the second half of 2003

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Mr. Toshiyuki Sakurai is a scientific officer of the Office of Marine Prediction at the Japan Meteorological Agency (JMA). He is working as a member of a group in charge of oceanic information in the western North Pacific. Using a new "Ocean Comprehensive Analysis System" (in operation since January 2001), this group produces surface and subsurface temperature, salinity and current maps with 0.25×0.25 resolution in waters adjacent to Japan. Monthly averaged fields obtained from the system are included in the "Monthly Ocean Report" published by JMA. Mr. Sakurai is now involved in developing a new daily analysis system for sea surface temperature in the global ocean, using in situ *observations and data from several satellites with infrared and microwave sensors.*

Sea surface temperature

Figure 1 shows monthly mean sea surface temperature (SST) anomalies in the western North Pacific from July to December 2003, computed with respect to JMA's 1971-2000 climatology. Both NOAA/AVHRR and *in situ* data are used for the area between 20ºN and 50ºN from 120ºE to 160ºE, and only *in situ* observations are used in the other areas.

SSTs were generally below normal around Japan in July, and in the seas north of 35ºN around Japan in August and September. Negative SST anomalies exceeding -1°C were found in the southern part of the Japan Sea, east of Japan and west of the Korean Peninsula in July and August, and around the Kuril Islands in August. The negative anomalies around 37ºN, 145ºE persisted to December (region 4 of Fig. 2).

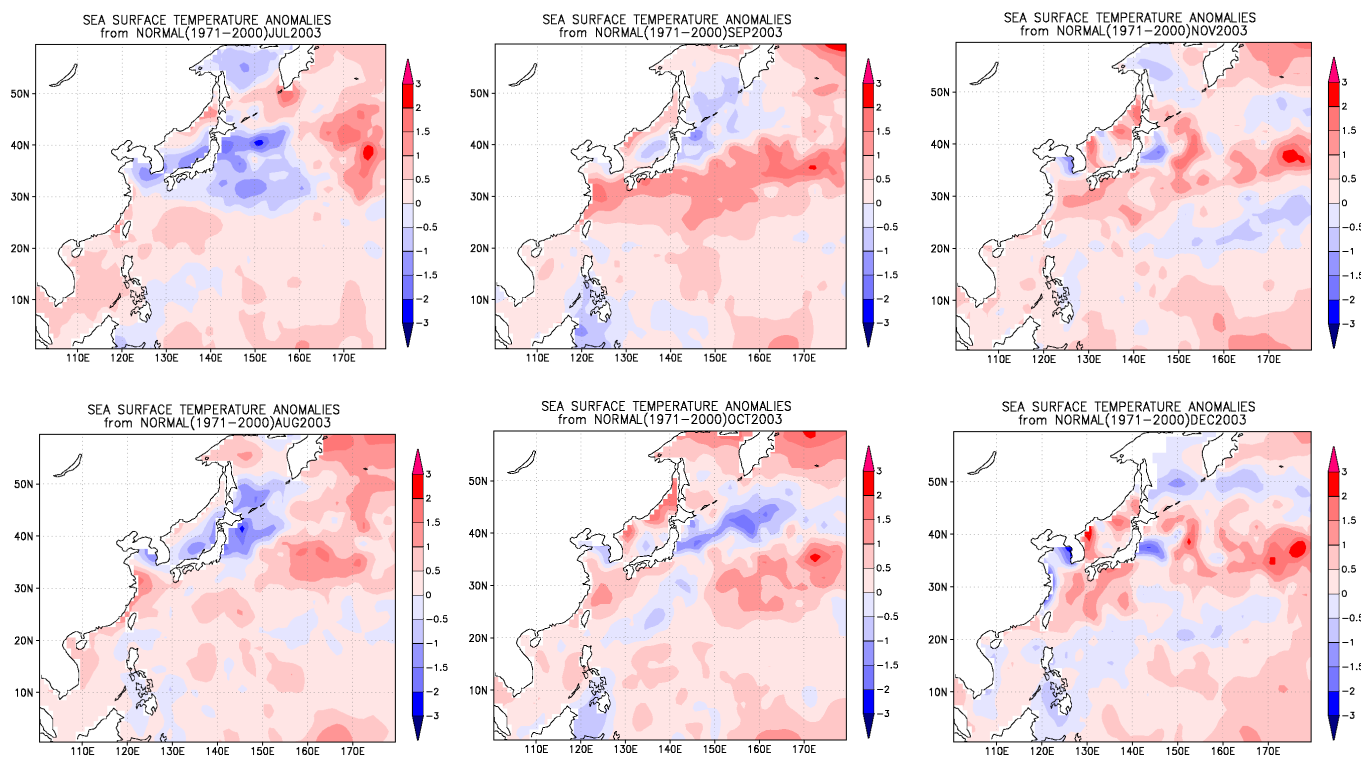

Fig. 1 Monthly mean sea surface temperature anomalies (ºC) in 2003: July, September and November (top row), and August, October and December (bottom row). Anomalies are departures from JMA's 1971-2000 climatology.

Positive SST anomalies exceeding +1°C were found around 40ºN, 170ºE in July, and in the seas between 150ºE and the date line along 35ºN from August to December. In addition, SSTs were more than 1°C above normal south of Japan in September, November and December, and in the northern part of the Japan Sea and east of the Korean Peninsula from October to December. The positive SST anomalies south of Japan (region 6, 9 of Fig. 2) have persisted for the last few years.

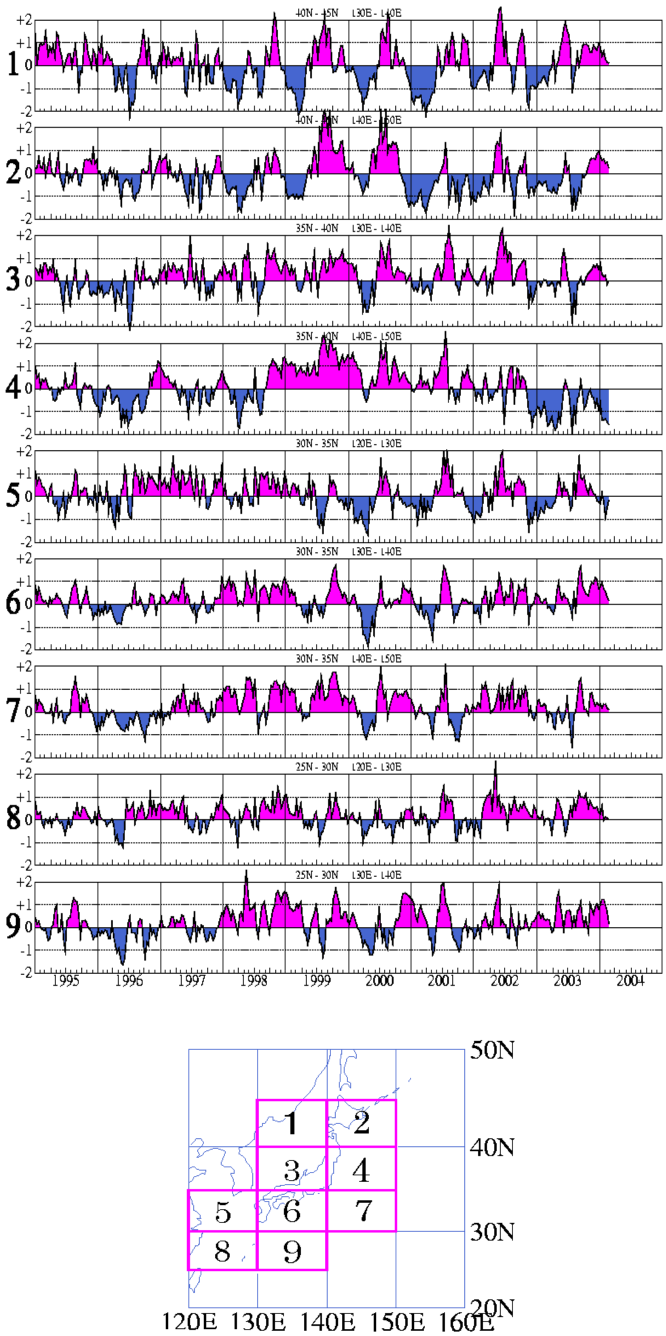

Fig. 2 Time series of the ten-day mean sea surface temperature anomalies (ºC), computed from JMA's 1971-2000 climatology (top panel) for the areas shown in the bottom panel.

Kuroshio

The Kuroshio took a non-large meandering path off Tokai from July to December. However, small perturbations propagated eastward off Tokai from late September to early October, and from late November to mid-December (Fig. 3).

After passing the Tokara Strait, the Kuroshio flowed along the southern coasts of Japan from July to early-November. A small meander of the Kuroshio was formed in the seas southeast of Kyushu from mid-November to December, and the Kuroshio flowed off-shore between 30ºN and 33ºN (Fig. 3).

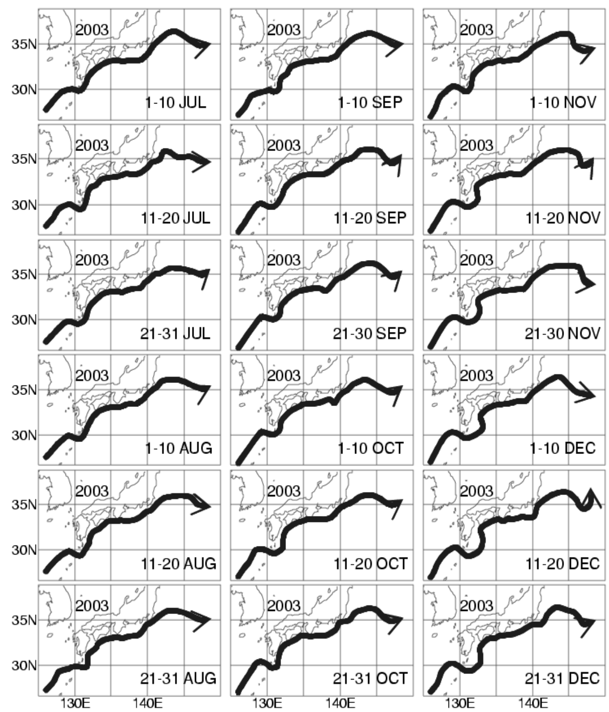

Fig. 3 Location of the Kuroshio axis from July to December 2003.

Carbon dioxide

JMA has been conducting observations for carbon dioxide (CO_2) in the surface seawater and overlying air in the western North Pacific, on board the R/V *Ryofu Maru* and R/V *Keifu Maru*.

Figure 4 illustrates the distribution of the difference in CO_2 partial pressure (pCO_2) between the surface seawater and overlying air, denoted as ΔpCO_2, observed in the western North Pacific in the four seasons of 2003. The ΔpCO_2 value represents the direction of CO_2 gas exchange across the air-sea interface, indicating the ocean to be a potential source (or sink) for atmospheric CO_2 in the case of positive (or negative) value of ΔpCO_2.

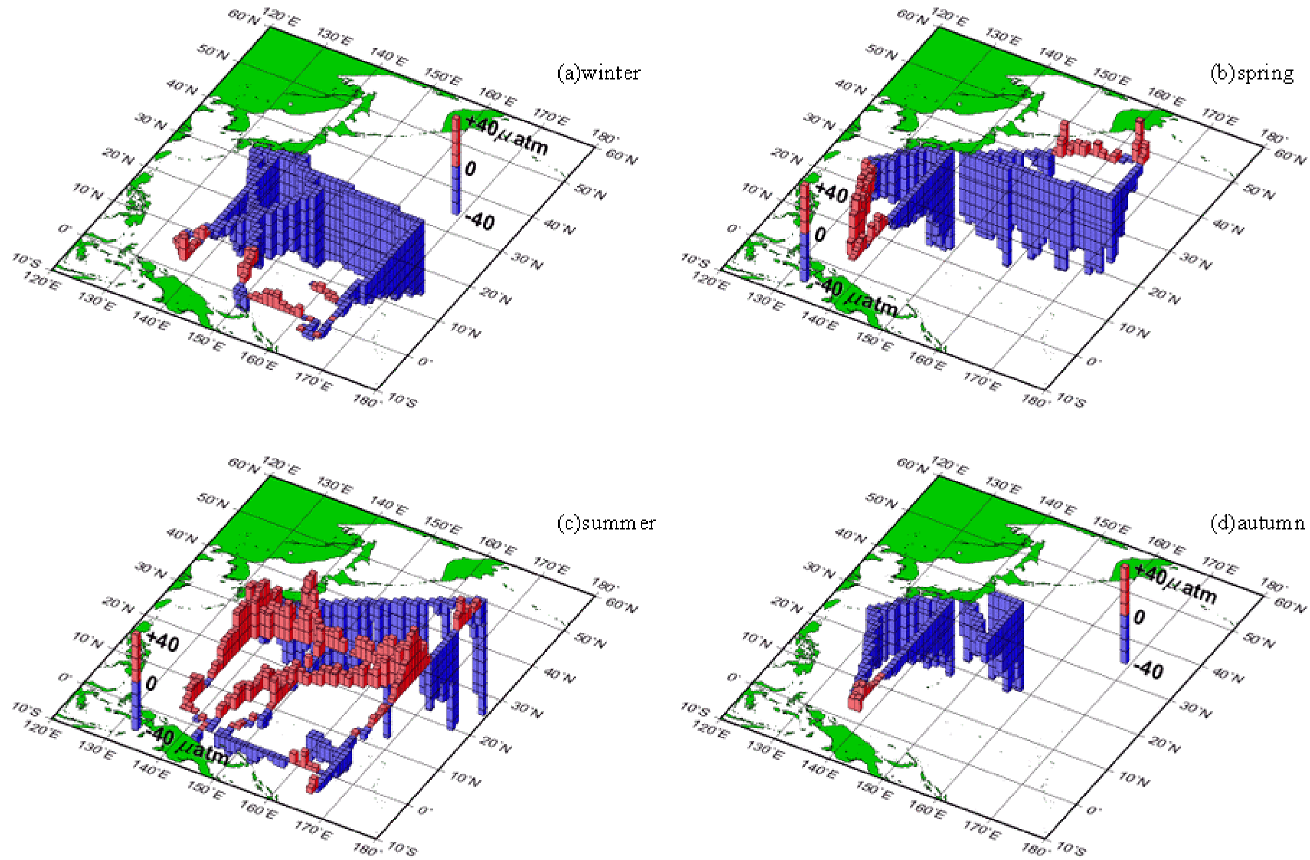

Fig. 4 Difference in the carbon dioxide partial pressure between ocean and atmosphere in the western North Pacific. Red/blue pillars show that oceanic pCO_2 is higher/lower than atmospheric pCO_2.

In the western subtropical Pacific, oceanic pCO_2 was lower than atmospheric pCO_2 in the winter, spring and autumn 2003, implying that the ocean acted as a sink for atmospheric CO_2; whereas this region changed to be a source in summer. In the western subarctic Pacific, a source area for atmospheric CO_2 was observed in the spring and summer, and was smaller than that in this region in 2002. In the equatorial Pacific, pCO_2 was also smaller than that in 2002. The average of oceanic pCO_2 in this region in 2003 was lower than those in 1998-2002, and was at about the same level as that in 1997 during the El Niño event.

The state of the eastern North Pacific entering spring 2004

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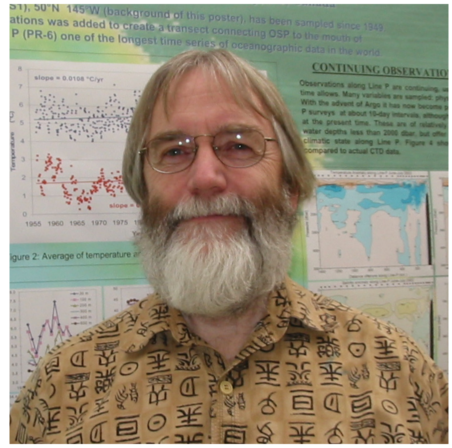

Frank A. Whitney has led the Line P program for the past 12 years, carrying out repeat oceanographic sections for WOCE (1991-97) and hosting the Canadian JGOFS program (1992-97) on these cruises. Through this time, his main research interest has been in understanding processes which control nutrient supply to the upper ocean. He has also surveyed meso-scale eddies several times in an attempt to estimate offshore transport of coastal waters in the Gulf of Alaska. Frank has been working in oceanography on the British Columbia coast since 1969.

Our most recent Line P survey in February 2004 shows that surface water in the Gulf of Alaska is warmer than our 1956-1991 climatology, and that a cool layer persists below it (Fig. 1). This figure also shows a warm body of water situated 270 km along Line P that is more saline than surrounding waters, suggesting that it is of a southern origin (rather than being a meso-scale eddy).

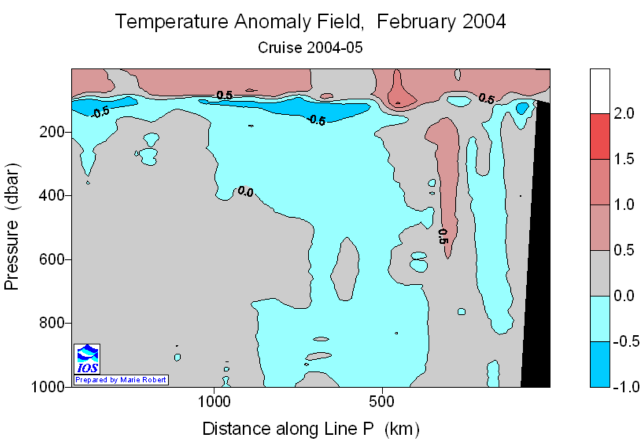

Fig. 1 Temperature anomaly along Line P from the coast of southern British Columbia to Ocean Station Papa (OSP - 50°N, 145°W).

The warm surface anomaly is a persistent feature of the mixed layer (ML) over most of the past decade, whereas the cool layer appeared in the past few years. The combination of these water masses has created stronger than normal stratification and a shallower winter mixed layer over the past couple of winters. In 2003, the 75 m-deep winter ML was the shallowest yet recorded at OSP, and in 2004, the mixed layer was again shallow (90 m) compared to an average of 112 m from 1977-2002.

The subsurface layer at OSP has shown huge variability over the past decade. Recent work (Whitney *et al.*, 1998. *Mar. Ecol. Progr. Ser.*, 170) described a 2˚C warming in waters between 125 and 200 m at OSP between 1988 and 1995. A feature of the warm water mass was low nutrient concentrations. As cool waters returned into the pycnocline, nutrient concentrations increased by ~50% (*e.g.* from 25 to 36 uM nitrate and from 40 to 67 uM silicate between 1995 and 1998, Fig. 2). High nutrient concentrations in these waters have persisted over the past few years.

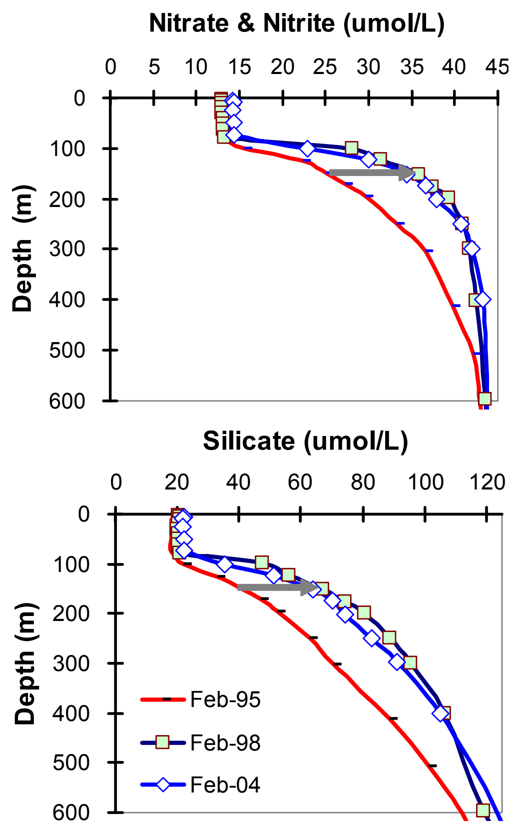

Fig. 2 Nutrient profiles at OSP during periods when subsurface waters were warm in 1995, and cool in 1998 and 2004.

By focusing on winter data, we are likely sampling pycnocline waters that have been produced during winter mixing, and advected from the south or north under the fresh surface layer of the subarctic Pacific. There is little open ocean evidence that shows us the speed or direction of subsurface currents in this region. However, the extreme upwelling event of summer 2002 is an example of subarctic waters being transported onto the continental shelf of Oregon from a great distance (Huyer, 2003. *Geophys. Res. Lett.*, 30).

At OSP, we can describe a "decadal" oscillation which sees the source of pycnocline waters switch from subarctic in 1989, to subtropical in 1995, and back to subarctic for the period from 1998 to 2004 (Fig. 3). Over the past several years, subsurface waters have cooled by ~2˚C to return to 1989 levels. The large changes in subsurface temperature observed at OSP suggest that there are processes in the subarctic ocean that are capable of exporting either warm or cold waters away from the atmosphere (winter ventilation or subduction) and storing it for several years. Known sources of pycnocline waters that are active in the NE Pacific include cold Alaska Gyre waters which are upwelled during winter, and California Undercurrent waters that are transported northward, especially during strong El Niño events. One large question in my mind is how the recent "decadal" (actually ~14 yr) oscillation seen at OSP is forced. I anticipate that the many Argo profilers currently deployed in the North Pacific are going to provide the data necessary to trace sources of pycnocline waters in the eastern subarctic Pacific, and will hopefully also be able to identify routes by which waters spread from open ocean to coast (subarctic), and from coastal margins into the ocean (subtropical).

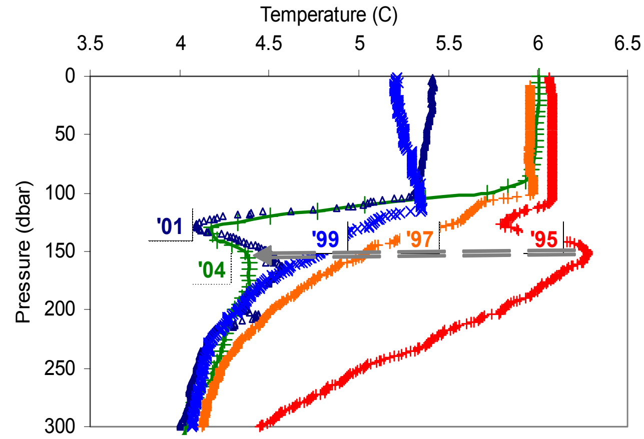

Fig. 3 Temperature in mixed layer and pycnocline waters at Ocean Station Papa.

PICES-IFEP Workshop on
"In-situ *iron enrichment experiments in the eastern and western subarctic Pacific*"

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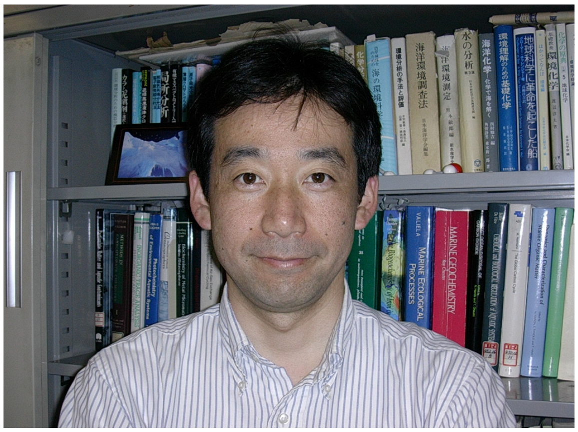

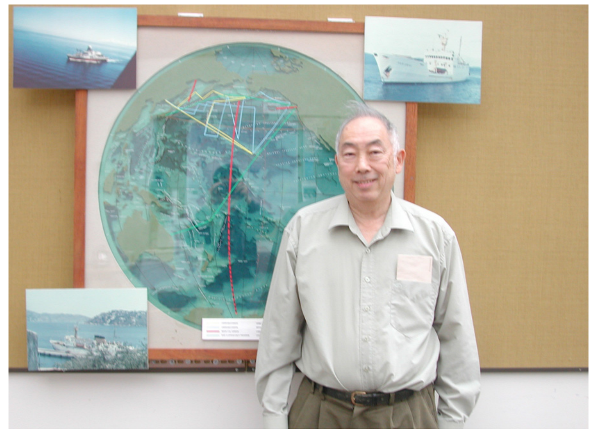

Dr. Shigenobu Takeda is an associate professor of Aquatic Biology and Environmental Science Laboratory, Graduate School of Agricultural and Life Sciences, University of Tokyo. His research interests include trace metals-phytoplankton interaction, biogeochemical cycles of iron, behaviour of silicon and other trace elements in the ocean, and eutrophication processes in coastal systems. Within PICES, Shigenobu is the Co-Chairman of the Advisory Panel on Iron Fertilization Experiment.

Dr. C.S. Wong is a senior research scientist and team leader of the Climate Chemistry Laboratory at the Institute of Ocean Sciences. His research focuses on the oceanic carbon cycle, halocarbon and isotopic tracers, iron fertilization and mitigation CO_2 *in the oceans. He co-chairs the PICES Advisory Panel on* Iron Fertilization Experiment, *and is also a member of the PICES Physical Oceanography and Climate Committee and WG 17 on* Biogeochemical data integration and synthesis.

Iron deficiency has been proposed as the reason for the existence of surface waters rich in macro-nutrients but low in phytoplankton biomass in the subarctic Pacific, the equatorial Pacific and the Southern Ocean. In summer of 2001, an iron enrichment experiment (**S**ubarctic Pacific Iron **E**xperiment for **E**cosystem **D**ynamics **S**tudy – SEEDS-I) was performed in the western subarctic Pacific; and in summer of 2002, another 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. These international collaborative projects between Canada and Japan were conceived at the first planning workshop of the PICES Advisory Panel on *Iron Fertilization Experiment* (IFEP), held in Tsukuba, Japan, in 2000, in conjunction with PICES IX.

In order to review the results and outstanding questions from these 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, at the Chateau Victoria Hotel, Victoria, British Columbia, Canada. 26 scientists from Canada, Japan, and the United States of America attended the workshop (Fig. 1).

The objectives of the workshop were to:

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

The workshop started with 4 synthesis talks on SEEDS-I, SERIES and SOFeX, followed by 14 shorter presentations

Fig. 1 Workshop participants at the entrance of the Chateau Victoria Hotel.

on the physical behavior of the Fe-enriched patch, biological/physiological responses, food-web dynamics, chemistry of iron, carbon cycle, and model prediction.

What have we learned from the enrichment experiments?

Both SEEDS-I and SERIES have demonstrated increased productivity and biomass of phytoplankton as a response to the iron enrichment. Bloom evolution and decline was captured in detail during SERIES. However, there are differences in the physical and chemical environments, the plankton ecosystem and dominant species, and zonal iron gradient between the Western Subarctic Gyre (WSG) and the Alaskan Gyre (AG). From SEEDS-I and SERIES, we can point out the following similarities and differences in biogeochemical and ecosystem responses to iron addition:

Similarities

- Diatom bloom occurred; floristic shift to large cells;
- Vertically-integrated Chl-*a* and primary production increased;
- Heterotrophic dinoflagellates grazed on diatoms after the development of the bloom, and led to significant loss of diatoms in the mixed layer;
- Copepods were not the primary grazers; SERIES was not well matched with the spring period of maximum diatom grazing (*Neocalanus plumchrus*);
- DOC (dissolved organic carbon) increased during the growth phase of bloom, was constant through the stationary phase, and decreased during the bloom decline; DOC production was about 10% of primary production;
- Increased dissolved-Fe was mainly in colloidal fraction;
- Dissolved-Fe concentration decreased rapidly by colloidal aggregation and biological uptake (less), and loss rate gradually decreased;
- Particulate-Fe concentrations remained high; bioavailability of remaining iron (mainly particulate) was low;
- Majority of macro-nutrients were consumed;
- Increase in Si/NO_3 drawdown ratio was observed after occurrence of physiological stress such as iron and light limitations.

Differences

- A larger and faster response (in terms of biomass) was observed in WSG;
- Initial diatom populations largely neritic for WSG and pelagic for AG; neritic species responded quickly to the iron enrichment and built up a large biomass, suggesting that the presence of coastal species as resting spores or cells is important in determining the magnitude of bloom evolution;
- The bloom was characterized by two ecological phases in SERIES. Phase I consisted of nano-phytoplankton (prymnesiophytes) and occurred before day 10 of the experiment, and phase II was mainly diatoms and began after day 10;
- Sediment traps collected large $CaCO_3$ fluxes after phase I, and high biogenic-Si and POC fluxes after phase II during SERIES, but not in SEEDS-I. SEEDS-I occupation may have been too short to observe export event;
- >50% of the mixed-layer POC (particulate organic carbon) deficit attributed to bacterial re-mineralization and meso-zooplankton grazing in AG; NH_4 in surface waters increased throughout the bloom;

- Characteristics of organic ligands changed rapidly upon Fe enrichment in WSG; ligands concentration tracked dissolved-Fe concentration in AG, rapidly disappearing together with dissolved-Fe concentration;
- The iron enrichment created a bloom of DMSP-rich nano-phytoplankton (*E. huxleyi*) which crashed after day 11 in SERIES, but no significant increase in DMS/DMSP was observed in WSG;
- The Fe-induced increase in DMSP had no clear effect on DMS concentrations in AG;
- The iron-induced deficit in DMS concentrations during the peak of the diatom bloom resulted from a decrease in biological DMS net production in AG.

Kenneth Coale was invited to give a synthesis talk on Southern Ocean Iron Experiment (SOFeX), which was performed in 2002, to investigate the effects of iron enrichment in regions with high and low concentrations of silicic acid. He identified the following questions to be resolved in future experiments.

- What are Fe:C:Si:N:P uptake and re-generation stoichiometries? How are these stoichiometries related to phytoplankton community structure?
- What is the steady-state condition? Is this a relevant question?
- What is the periodicity and magnitude of natural iron enrichment, both seasonally and inter-annually, and on glacial-interglacial time scales?
- What is the effect of iron enrichment on the geochemistry (low O_2 and de-nitrification) and ecology (nitrification) below and within the Fe patch?
- Do ecosystems respond in a natural manner to artificial Fe enrichments? What are the similarities and differences between natural and artificial Fe supply?

What are outstanding questions?

SEEDS-II is the second meso-scale iron enrichment experiment in WSG designed to investigate the longer-term effects of iron enrichment on plankton ecosystem, carbon export and trace gas production. SEEDS-II will involve about 50 researchers from universities and government institutions in Japan, the United States and Canada. The iron-enriched patch will be monitored by two ships, the R/V *Hakuho Maru* (Japan) and the R/V *Kilo Moana* (U.S.A.), for 34 days from July 21 to August 23, 2004. Through the integration and synthesis of the findings from SEEDS-I, SERIES and SOFeX, the workshop participants identified the following key themes and key scientific questions for the SEEDS-II experiment.

<u>Fate of carbon</u>

- What portions of organic carbon fixed by coastal centric diatoms in WSG will be exported from the surface mixed layer, and what portions will be regenerated?
- To what extent would heterotrophic dinoflagellates (*Gyrodinium*) respire Fe-induced carbon fixation?
- What is turnover time of produced DOC?
- What are community respiration rates?
- Is C:N:P:Si regeneration ratios in surface and subsurface layers crucial to our understanding of Fe-induced ecological response and nutrient dynamics?
- Is biological patchiness in species and export within the patch significant?
- How does physical dilution from outside affect the patch chemistry and biology? What is the effect of dilution on budget calculations?

<u>Ecosystem responses</u>

- Why did SEEDS-I and SERIES have opposite trends in dominant diatom composition?
- What is the role of cell lysis on changes in available nutrients, sources of DMSP, bacterial community structure and iron chemistry?
- What roles will sinking and grazing play in the decline of the bloom?
- What is the long-term effect of Fe availability on the ecosystem? How is the response to further iron addition affected?
- The ecological response to iron enrichment is largely determined by the seed population. What will the species variability and ecosystem differences be between iron-induced blooms in the same location?
- How predictable will the species response be to iron addition?
- Why does Fe addition to bottles result in N-limitation, but the large-scale Fe additions show Si-depletion?

<u>Seasonal timing</u>

- If natural events occur, should we try to emulate those that occur at other times of the year?
- What is the importance of the presence of endemic zooplankton at the time of iron enrichment?

<u>Fe biogeochemistry</u>

- What controls iron retention and loss after iron release?
- What is the main source of ligands production? How does it respond to iron enrichment?
- What is the role of iron ligands in Fe bioavailability and recycling?
- What is the role of Fe(II) in the phytoplankton bloom?
- What is the uptake of iron by different biota?
- What is the difference between single and multiple iron additions, and their effect on availability of iron?
- Comparison with natural iron supply: labile particulate iron was significantly higher in the surface mixed layer in WSG, but dissolved iron was at the same level as in the eastern region.
- Is bioavailability of iron (not total iron input) most important for ecosystem response?

Trace-gas production

- What is the fate of DMSP? Is it consumed by bacteria? Does it sink?
- What are the roles of physiological stress, Fe availability, light and macronutrients on DMSP cycling?
- What is the extent of emission to atmosphere?

Recommendations for SEEDS-II

- It was recommended to lengthen the experiment if possible; the decline will depend on patch physical dynamics, bloom dynamics, etc.
- Additional suite of measurements is required to study bloom evolution, including FRRF, Flavodoxin, sinking rates, TEPS, and supplement these with ^{15}N and ^{32}Si uptake rates;
- Additional methods are required to determine the role of the microbial community and zooplankton in the fate of POC and O_2 profiles of the upper ocean, community respiration, labelled particle decomposition experiments;
- Additional experiments are required for measuring export flux, such as trap calibration with thorium, large-volume pump thorium samples, more fluorometers for the upper trap moorings;
- Estimates of silica dissolution, bacterial production and respiration, and bacterial Fe-stress should occur;
- Measurements of micro- and meso-zooplankton grazing, and the prey (including particles are desirable.

Thanks to the excellent presentations and spirited discussion from all participants, the workshop was very successful. The results of the workshop will be published as a PICES Scientific Report in 2004.

Canadian SOLAS/PICES-IFEP session on "*Response of the upper ocean to meso-scale iron enrichment*"

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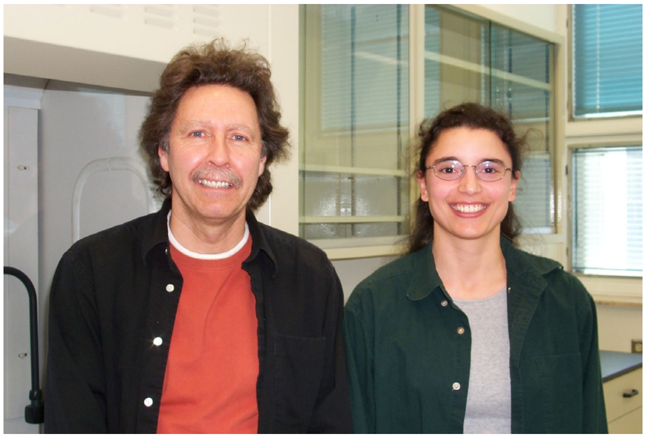


Dr. Maurice Levasseur is a professor in the Department of Biology at Université Lava, where he leads the Canadian Chair on Climate Variability and Plankton Ecosystems. He is also the Chairman of the Canadian SOLAS Network (csolas.dal.ca). His research focuses on the marine production of the climatically-active gases and the eco-physiology of harmful algal blooms. Within PICES, Maurice has been involved in activities of the Advisory Panel on Iron Fertilization Experiment *and the Working Group on* Ecology of the Harmful Algal Blooms in the North Pacific.

Anissa Merzouk graduated with a B.Sc. in Marine Biology from the Université du Québec à Rimouski. She is currently completing a Ph.D. in Oceanography at Université Laval under the supervision of Prof. Levasseur, working on understanding the controls of the biological production and consumption of DMSP and DMS in surface waters. Within the C-SOLAS program, she participated in the SERIES iron enrichment experiment in the NE Pacific to determine the influence of iron on the distribution and biological cycling of DMSP and DMS.

Background

The productivity of large portions of the global ocean is thought to be limited by the availability of iron, a micronutrient essential to phytoplankton growth. So far, eight meso-scale iron fertilization experiments have been conducted in order to test this hypothesis, and to provide insights on the potential effect of iron addition on algal blooms development and the biogeochemical cycle of major elements, with a special focus on climatically-active gases, such as CO_2 and dimethylsulfide (DMS). Two of these recent experiments conducted in the North Pacific were developed under the umbrella of PICES, through its Advisory Panel on *Iron Fertilisation Experiment*, co-chaired by Drs. Shigenobu Takeda and C.S. Wong. These experiments took place in 2001 in the Northwest Pacific (SEEDS), and in 2002 in the Northeast Pacific (SERIES). Both experiments were successful and generated important new findings (Tsuda *et al.* 2003. A mesoscale iron enrichment in the western subarctic Pacific induces large centric diatom bloom. Science, 300: 958-961; Boyd *et al.* 2004. Evolution, decline and fate of an iron-induced subarctic phytoplankton bloom. Nature, 428: 549-553).

Meso-scale experiments are costly, involve many scientists and generate huge volumes of data. It is our responsibility to maximize the diffusion of this information and to ensure a skilful utilization of these unique data sets. A group of research scientists involved in the planning and realization of these experiments thought that the timing was good to synthesize and compare the responses obtained so far during these experiments. To accomplish this task a joint C-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: Maurice Levasseur, Atsushi Tsuda, William Miller, William Cochlan and Richard 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 to recognize the similarities and differences in the responses obtained from these experiments.

Overview of presentations

The session started with a tutorial by Kenneth Coale who presented a synthesis of the knowledge gained from the seven mesoscale iron enrichments experiments conducted so far, pointing at similarities but also emphasizing that each experiment was unique in terms of location, season and initial conditions, and thus generated different responses to iron enrichment. The take home message was that although we know much more than 10 years ago, much remains to be understood in order to properly evaluate the global impact of iron on ocean biogeochemical cycles and climate.

The tutorial was followed by 4 talks on SOFeX, highlighting new outcomes from this expedition in the Southern Ocean. William Cochlan showed that there was a clear change in the relative utilization of new and re-generated nitrogen following the iron fertilization, with nitrate uptake increasing by 15-fold and 25-fold north and south of the Antarctic Polar Front Zone (APFZ), respectively. Stephen Baines reported on iron-induced changes in the elemental stoichiometries of individual diatoms and flagellates using a synchrotron x-ray fluorescence microprobe. His results indicate biochemical changes in the resident plankton, suggesting differences in the biogeochemistry of Fe-replete and Fe-deplete regions of the ocean. Mark Brzezinski showed that iron fertilization caused a shift from non-Redfield to Redfield nutrient uptake ratios in the Southern Ocean, shifts that will have strong implications for elemental cycling and climate during periods of enhanced Fe supply. Finally, Michael Hiscock demonstrated that iron addition resulted in an increase in the maximum quantum yield of photosynthesis, but that the intensity of the response varied within size fractions between the nitrate-rich and silicate-rich in the waters north and south of the APFZ. These presentations, along with the companion posters, highlighted important regional variability in the responses of the plankton community to iron fertilization in the Southern Ocean.

The next 2 talks, accompanied by 4 posters, reported more specifically on the SEEDS expedition conducted in the NW Pacific in 2001. Atsushi Tsuda gave an overview of SEEDS where the iron fertilization induced a large centric diatom bloom resulting in a marked consumption of macronutrients, a huge increase (factor ~ 20) in chlorophyll *a* concentrations and a marked drawdown in pCO_2. By day 13 of the experiment, the export of fixed carbon represented only 13% of the primary production in the iron-enriched patch, with most of POC (particular organic carbon) remaining in the surface mixed layer. The fate of the bloom remains unknown. Isao Kudo presented interesting results on the effect of water temperature on the response of the phytoplankton community to iron addition obtained in shipboard experiments performed during SEEDS and SERIES. The phytoplankton growth rate in the fraction of >10 μm was higher in the NW Pacific than in the NE Pacific for similar iron addition and temperature (12°C). Since surface temperature increased from 5 to 9°C in the weeks before the SEEDS experiment, he hypothesized that the growth rate dependence on temperature could explain the exceptionally large increase in chlorophyll *a* and primary production measured during SEEDS. Jun Nishioka presented a poster on the distribution of size-fractionated iron and showed that iron supply is higher in the NW Pacific than in the NE Pacific due to more frequent atmospheric inputs. During SEEDS, the added dissolved iron was rapidly transformed to labile particulate iron, reducing its bio-availability to phytoplankton, a process that probably also occurs for dissolved iron originating from atmospheric inputs. In his poster, Takeshi Yoshimura demonstrated that in the NW Pacific, 10 to 20% of the net organic carbon production was converted to DOC (dissolved organic carbon) during the growth and stationary phases of the bloom. In the NE Pacific, the net DOC production was higher during the decline phase of the bloom, suggesting the domination of decomposition processes. Hiroaki Saito's poster suggested that phytoplankton growth exceeded micro-zooplankton grazing at the beginning of the SEEDS experiment, but micro-zooplankton grazing rates and phytoplankton grazing mortality increased rapidly at the end of the experiment. These results highlighted the balance between phytoplankton growth and loss due to grazing, and how this equilibrium may be affected by iron. Naoki Yoshie presented a poster on the modeling of the SEEDS diatom bloom. The model successfully reproduced the vertical distributions of macronutrients and chlorophyll during the evolution of the bloom. The model predicts that the effect of iron on the ecosystem would last for 40 days, and that the export flux during the 13-day observation period represents 20 to 30% of the export predicted for 40 days.

The following 15 oral presentations (with 5 posters) reported on SERIES, the most recent meso-scale iron enrichment experiment at that time. This block of talks began with an overview of SERIES by Phillip Boyd, who presented the evolution, decline and fate of the SERIES bloom. His talk was completed by the presentation of David Timothy on the nutrient dynamics, uptake and export of carbon and biogenic silica. Their results showed that the termination of the diatom bloom was due to iron limitation followed by silicic acid limitation. More than half of the carbon fixed by the bloom was grazed or re-mineralized by bacteria and only a small portion of the bloom's particulate carbon (18%) and biogenic silica (34%) was exported from surface waters (>50 m). Jean-Eric Tremblay presented data on phytoplankton growth and nutrient uptake ratios during the evolution of the bloom. The nano-phytoplankton bloom was initiated by increased growth rates immediately after iron addition, and was halted by grazing losses. A presentation by Nelson Sherry and a poster by Paul Harrison described the shift in phytoplankton community composition from small nano-phytoplankton (flagellates) to large pennate diatoms. Chlorophyll *a* and primary production increased rapidly during the diatom bloom in parallel with a drawdown of macronutrients. Adrian Marchetti presented field and lab data on elemental composition ratios in a diatom, showing that iron-limitation resulted in an increase of the Si/N ratio due to a decrease in N-uptake. He concluded that diatoms were iron-stressed before the full depletion of silicic acid during SERIES.

Richard Rivkin presented an insightful synthesis of the influence of iron on bacterial stocks and processes during different meso-scale iron enrichments. Iron increased bacterial abundance and production during all fertilization experiments. The bacterial response during SERIES was markedly larger than in the Equatorial Pacific (IronEx II) and Southern Ocean (SOIREE), resulting in increased retention of carbon in the surface layer and reduced export to the deep ocean. Carol Adly and Michelle Hale presented posters on the bacterial response to iron enrichment. The first author reported a small but rapid increase in bacterial abundance and production immediately (few hours) after iron enrichment, suggesting that bacteria were initially iron-limited. Hale's results showed that the bacteria were generally DOM-limited during the first days of the experiment. Bacterial production and growth rates peaked 6 days prior to the increase in biomass, suggesting that bacteria were under strong grazing pressure during the first 13 days of the bloom.

Sonia Michaud and Michel Scarratt presented results on the influence of iron on the dimethylsulfoniopropionate (DMSP) and dimethylsulfide (DMS) distribution during SERIES, and Anissa Merzouk presented data on DMSP and DMS biological cycling. The bacterial utilization of DMSP shifted from high DMS production in the sulfur-rich nano-phytoplankton bloom to low DMS production during the sulfur-poor diatom bloom, resulting in an overall DMS deficit in the iron-enriched patch. It is the first time that a negative effect of iron fertilization on DMS is observed. William Miller and Rene-Christian Bouillon showed that iron fertilization decreased the DMS photo-oxidation rate coefficient. They proposed that nitrate-photolysis played a significant role in DMS photo-degradation. Yvonnick. Le Clainche used an inverse modeling approach to show that the regional increase in DMS concentrations during SERIES resulted from a combination of low ventilation and high DMS biological net production.

Robert Moore presented data on the production and fluxes of isoprene and methyl-iodide, two atmospherically-reactive gases. The net production of isoprene and its flux to the atmosphere increased during the course of the experiment, whereas methyl-iodide concentrations were lower in-patch than out-patch. These gases were of biogenic origin but their production mechanisms are poorly understood.

Kenneth Denman presented the modeling of the plankton community structure during the iron enrichment. The model reproduced well the development of the bloom but not the export of carbon fixed by the diatom bloom, suggesting that processes such as aggregation may have played a role in increasing the export flux at the end of the bloom.

Less usual for an ASLO meeting, the last two talks reported on the influence of iron fertilization on the atmospheric distribution of DMS, methane sulfonic acid (MSA) and aerosols. Moire Wadleigh presented the sea-to-air DMS fluxes and atmospheric DMS concentrations, while Lisa Phinney reported on aerosol processing over the region of the SERIES experiment. DMS fluxes were correlated with seawater DMS concentrations and wind speeds. Atmospheric DMS, MSA and sulfate concentrations were high in the study area compared to mean worldwide values. DMS and its degradation products were particularly elevated during a regional episode of high seawater DMS concentrations around days 6-9.

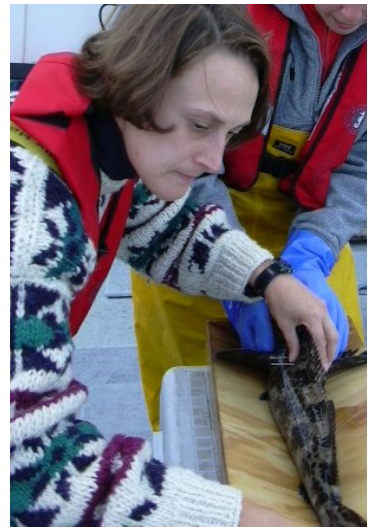
Conclusions

Papers presented during the session revealed important similarities and differences in the responses to iron fertilization observed in the different high nutrient low chlorophyll (HNLC) oceanic regions. One noteworthy similarity is that the growth of phytoplankton from all size classes seemed to be stimulated by iron addition, with small flagellated cells blooming first, followed by the diatoms.

Although a decrease in pCO_2 is generally measured in those experiments, results from SERIES indicate a low carbon sequestration efficiency. Whether such low efficiency can be extrapolated to the other HNLC regions is uncertain since bloom termination was generally not monitored during previous experiments. Carbon sequestration may vary depending on the structure of the phytoplankton assemblage, the limiting nutrient (Fe, nitrate, silicate), grazing, respiration, *etc*. Since these conditions vary from one site to another, the efficiency of carbon sequestration is expected to change as well. There is thus a need to determine the fate of the bloom in the major HNLC regions.

In addition to altering the carbon cycle, iron fertilization may also affect the production of other climatically-active biogenic gases such as DMS. During SERIES, the iron-induced diatom bloom coincided with a decrease in DMS concentrations. This was a clear departure from previous experiments where iron addition resulted in an increase in DMS. Again, these conflicting results call for further experiments. In order to properly evaluate the global impact of iron on sea-to-air exchange of climatically-active gases, we need a minimum, but statistically sound, understanding of the sensitivity of the different HNLC regions to iron. This can only be achieved through repeated, well planned, experiments. Given that up to 40% of the ocean surface is limited by iron, these experiments are essential steps in our quest to understand past, present, and future climate.

Fisheries and ecosystem responses to recent regime shifts



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Dr. Jacquelynne King is a research scientist in Groundfish Stock Assessment, at the Pacific Biological Station in Nanaimo, Canada. Her research focuses on the impacts of climatic and oceanographic variability on marine fish population dynamics and the implications for fisheries management. She has published research on a suite of disciplines including marine fish life history strategies, statistical methodology, climate impacts on ecosystems, aging methodology, stock assessment, fish population dynamics and behavioural ecology. Dr. King chairs the PICES Study Group on Fisheries and Ecosystem Responses to Recent Regime Shifts, *and is also a member of the PICES WG 16 on* Climate Change, Shifts in Fish Production, and Fisheries Management*.*

At last year's PICES Annual Meeting, Science Board formed a Study Group to address a formal request made by the United States government, asking for scientific advice on the implications of the 1998 regime shift for fisheries. This is the first such formal request for scientific advice made to PICES by a member nation. The request is a clear recognition of PICES' expertise and scientific leadership on the topic of ecosystem regime shifts, and represents an exciting new direction for the Organization.

Following the strong 1997-1998 El Niño, the North Pacific climate underwent a rapid and striking transition, the persistence of which suggests that a regime shift has occurred (Fig. 1, taken from Bond, J.A., J.E. Overland, M. Spillane and P. Stabeno. 2003. Recent shifts in the state of the North Pacific. *Geophys. Res. Lett.* 30(23): 2183-2186). Upwelling-favorable winds strengthened over the California Current (CC), and the Pacific Decadal Oscillation (PDO) reversed sign and remained negative through the summer of 2002. In the northern CC, the zooplankton biomass doubled and switched from a prevalence of warm-water species to cold-water species. Coho and chinook salmon stocks rebounded, and anchovy and osmeriid stocks increased. Previous regime shifts have had serious implications for ecosystems, and consequently for fish populations and the fishing industry. As such, the National Marine Fisheries Service has requested scientific advice from PICES that addresses six specific questions:

1. Has the North Pacific shifted to a different state or regime since the late 1980s?
2. What is the nature of the new state?
3. What are the ecosystem responses?
4. How long can the shift be expected to last?
5. Is it possible to predict when the regime will shift back and what indicators should be used to determine when it happens?
6. What are the implications for the management of marine resources?

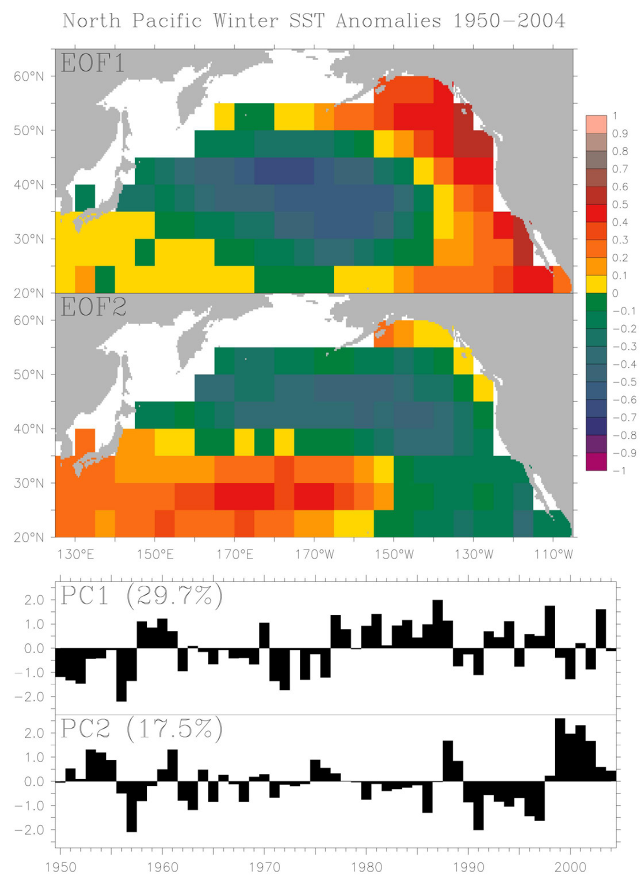

Fig. 1 Principal Component Analysis of North Pacific winter (November – March) SST fields north of 20°N. The first EOF corresponds to the Pacific Decadal Oscillation pattern, and its evolution over time is represented by PC1. The evolution of the second EOF pattern shows large magnitudes since the 1990s with a shift to large positive values in 1999-2002.

Fig. 2 Participants of the Study Group organizational meeting on February9-10, 2004, in Victoria, Canada (from left to right): Franklin Schwing, Suam Kim, William Crawford, Ian Perry, Akihiko Yatsu, Alec MacCall, Nathan Mantua, David Mackas, James Overland, Gordon McFarlane, Jacquelynne King, Jake Schweigert, Harold Batchelder and Jennifer Boldt.

In December 2003, a Study Group on *Fisheries and Ecosystem Responses to Recent Regime Shifts* (FERRRS) was formed. Jacquelynne King (Canada) was appointed to chair this group, and was joined by PICES scientists from Canada (William Crawford, David Mackas, Gordon McFarlane and Jake Schweigert), People's Republic of China (Qi-Sheng Tang and Jin-Ping Zhao), Japan (Akihiko Yatsu), Republic of Korea (Suam Kim), Russian Federation (Victor Lapko), the United States of America (Harold Batchelder, Jennifer Boldt, Anne Hollowed, Alec MacCall, Nathan Mantua, James Overland, Jeffrey Polovina and Franklin Schwing) along with PICES ex-officio members (Alexander Bychkov, Stewart (Skip) McKinnell and Ian Perry).

The Study Group held its first meeting on February 9-10, 2004, in Victoria, Canada. The meeting was well attended (14 of 18 official members and 3 ex-officio members), and the group was able to organize an approach to tackle the task. The Study Group will provide the PICES Science Board with a formal report, addressing the six questions posed by the United States government. The Study Group will rely on published literature and data, as well as any current, yet unpublished data, to formulate its advice. The anticipated completion of the report is August 2004, and a draft outline of the report, with general chapter topics, can presently be viewed through the PICES website.

The next meeting for FERRRS will be a 3-day workshop, to be held June 14-16, 2004, in Seattle, U.S.A. At this workshop, Study Group members will present the sections of the report that they are responsible for developing. The Study Group as a whole will review each section and provide feedback and guidance for revisions to all sections of the report. A major focus for the workshop will be the description of coherent regional responses to the 1998 regime shift, and the development of advice on resource management approaches. The workshop will provide the opportunity for the Study Group to formulate a collective response to the six questions of the US request for advice.

PICES Interns

PICES offers sincere thanks to Mr. Chuanlin Huo (National Marine Environmental Monitoring Center, State Oceanic Administration), the 2003-2004 PICES intern, who completed his term at the Secretariat at the end of May, and has returned to China. We are very grateful for his dedicated work during this past year.

We are pleased to welcome Mr. Gong-Gu Back (National Oceanographic Research Institute, Ministry of Maritime Affairs and Fisheries) Seoul, Korea, to the Secretariat as the Fifth PICES Intern. Mr. Back was behind the scenes helping us out at the Twelfth Annual Meeting in Seoul last year, and you will see him again at PICES XIII in Honolulu this year!

Mr. Gong-Gu Back and Mr. Chuanlin Huo together at PICES XII in Seoul, Korea, in October 2003.

Did a regime shift occur in 1998 around Japan? - Highlights from a symposium addressing this question

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Dr. Sei-ichi Saitoh (left) is a professor at Hokkaido University. He is currently interested in the application of satellite remote sensing and Marine-GIS to fisheries oceanography and marine ecosystem studies. He is also the Co-Chairman of the PICES MONITOR Task Team since 2002.

Dr. Sanae Chiba (second from left) is part of the Ecosystem Change Research Program of FRSGC, and has been a member of the GLOBEC Focus 2 Working Group since 2003. As a zooplankton biologist, her scientific career has focused on studying the link between physical/chemical environments and lower trophic level ecosystem variability.

Dr. Kaoru Nakata (third from left) is the head of the Marine Productivity Section at the National Research Institute of Fishery Science (NRIFS). Her current work focuses on changes in that occur at lower trophic levels in both coastal and oceanic waters in relation to climate change and global warming.

Dr. Akihiko Yatsu (right most) is the head of the Population Dynamics Section at NRIFS. His current work includes stock assessment of chub mackerel, and inter-annual and inter-decadal linkages of stock abundance and marine ecosystems in the Northwest Pacific. He is also the Co-Chairman of the PICES BASS Task Team and Working Group 16 on Climate change, shifts in fish production, and fisheries management*.*

The Japanese Society of Fisheries Oceanography held a symposium on March 31, 2004, at the Tokyo University of Marine Science and Technology (formerly Tokyo University of Fisheries), to examine changes that occurred in waters around Japan in 1998 and determine if these changes were indicative of a regime shift. A total of 106 scientists, including journalists and university students, attended the symposium, which was convened by Drs. Sei-ichi Saitoh, Akihiko Yatsu, Kaoru Nakata and Sanae Chiba. A total of 19 oral talks were presented.

Highlights of the symposium included talks addressing how to define a regime shift (time span required for detection, alternation of dominant commercial species, onset of drastic change in the productivity of fishery stocks, etc.), regional and taxonomic differences in response to regime shifts, and the relation of the 1998 changes to ENSO and inter-annual changes. In the physics session, four speakers discussed the effect of regime shifts at scales ranging from regional (northwest Pacific and Tsushima Current region) to global.

Minobe suggested that the variation of the East Pacific pattern, which is responsible for the 1998/99 change of sea-level pressure (SLP) as shown by Minobe (2002), is likely to be related to the North Pacific SST EOF2 (known as the Victoria Pattern) proposed by Bond *et al.* (2003). Sea Surface Temperature (SST) and upper water Heat Storage (HS) increased abruptly both in the Kuroshio/Oyashio Extension region and the central North Pacific due to Rossby wave (Minobe, 2002). At the same time, Sea-Level Displacements (SLD) rose from Japan to 160ºW, roughly along the Kuroshio Extension path with a tongue-like structure (Fig. 1; Minobe, 2002). This change has continued for only 4 years (1998 to mid-2002), so it is still early to decide that this phenomenon signals a regime shift.

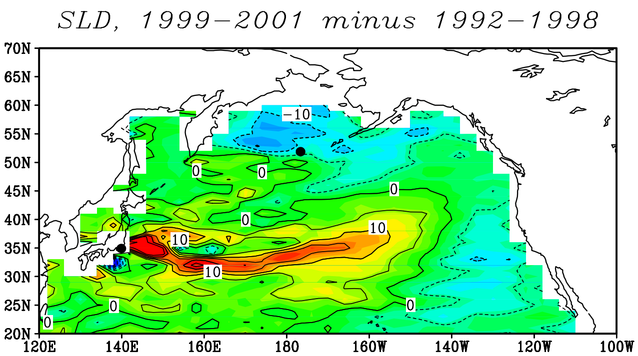

Fig. 1 Sea-Level Displacement (SLD) between 1999–2001 and 1992–1998. The contour interval is 5 cm, and the shaded areas indicate regions where SLD was larger than 10 cm (Minobe, 2002).

Yasunaka and Hanawa (2002) defined a regime shift as a "significant" and "systematic" change between the two quasi-steady states that continues for more than 5 years. They identified five regime shifts in 1925/26, 1945/46, 1957/58, 1976/77 and 1988/89. The 1998/99 change has similar characteristics to those of the previous ones, however, the Arctic Oscillation (AO) mode of the SST anomaly, which is one characteristics of a regime shift, has not continued since 1998, so we should continue analyses to determine if there was indeed a regime shift in 1998/99.

In the southern part of the Aleutian Islands in the western North Pacific, a cooling pattern of intermediate cold water was detected during 1998-2002. In the Tsushima Current region in the Japan Sea, there was no clear change in 1998/99, but a decadal change pattern was noticed. These results indicate that more data are needed to detect a signal of regime shift.

An analysis of correlations between the ENSO index and primary production estimated based on satellite images in the Pacific from 1998 to 2002, revealed that production was high during La Niña events in the equatorial eastern Pacific and off the California and Peruvian coasts, and during El Niño events in the equatorial western Pacific and the north and south subtropical gyres (Kameda, 2003). However, changes in the primary production in the western North Pacific are not related to the ENSO event and/or to the SST shift in 1998/99. On the other hand, the primary production has increased since the winter of 2000 in the Kuroshio, Kuroshio Extension and Oyashio (Kameda *et al*., Fig. 2). Primary production in the subarctic western North Pacific showed no consistent pattern, but was relatively high in 1999 and 2002 (Kameda *et al*.), and Yamada *et al*. reported that the primary production in the southern Japan Sea has also elevated since 2002.

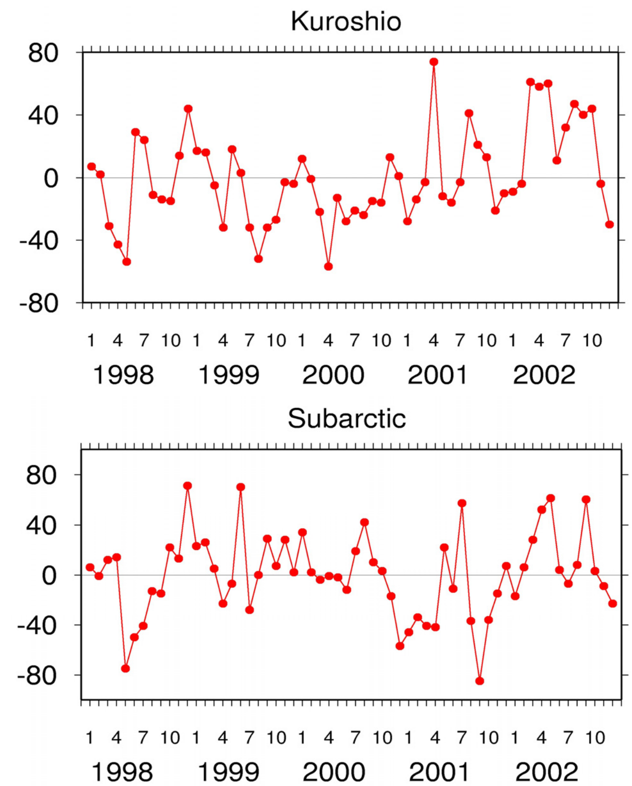

Fig. 2 Variations in primary production in the Kuroshio (upper panel) and subarctic western North Pacific (lower panel) from January 1998 to December 2002 (Kameda et al.*).*

Tadokoro *et al*. and Hidaka reported on changes that occurred in the meso-zooplankton biomass in the Oyashio and the inshore waters of the Kuroshio, respectively. In the Oyashio region, meso-zooplankton biomass in spring, which is dominated by *Neocalanus spp*., has decreased since the early 1970s, which seems to correspond to the decrease in the mixed layer depth and the net primary production estimated from a decline of PO_4-P in the surface mixed layer from winter to spring (Ono *et al*., 2002). In 1999, the net primary production increased to the level observed in the early 1970s (Tadokoro *et al*., Fig. 3), though there was no evidence of an increase in the meso-zooplankton biomass. In both of the Kuroshio and inshore water, the winter biomass of large copepods was also relatively high before the mid-1970s, but has tended to decrease since then (Nakata *et al*., 2001). In 1999, the biomass in the Kuroshio increased to the level observed in the early 1970s, and the increase was mainly due to the increase of *Calanus sinicus* (Nakata and Hidaka, 2003). Hidaka showed that the increase in the biomass in the late 1990s was limited to the Kuroshio region, and the abundance of *C. sinicus* in the slope water was stable through the second half of the 1990s. The Kuroshio flow axis showed a somewhat more meandering path in 1999 and 2000, than in 1998, so Hidaka inferred that the difference in the biomass trends between the Kuroshio and the inshore water was due to the difference in the meandering path which probably resulted in the entrainment of slope water into the Kuroshio.

Increase in water temperature may have had a severe impact on the distribution and composition of large algal communities. Kiriyama *et al.* reported that large brown algae decreased in biomass, and warm-water species increased in biomass, along the coast of the northwestern Kyushu Island when temperature increased, especially in the late 1990s. They also demonstrated that the feeding pressure of herbivorous fishes increased with increasing temperature.

Inter-annual and inter-decadal scale variations of stock size and recruitment success of commercial fish species in Japanese and adjacent waters were reported in nine presentations, five of which examined pelagic species and three studied benthic or coastal species.

Only a few clear regime-shift-related changes were recognized in both pelagic and benthic species in 1998. For example, the recruitment success (recruits-per-spawner, RPS) of blue-fin tuna increased (Fig. 4, Inagake *et al.*), while the catch-per-unit-effort (CPUE) and/or recruitment success for other pelagic species, markedly changed in 1998, most returned to pre-1998 levels after 1999: 1) the common squid stock decreased in 1998, but recovered to an average level, and then reached a maximum in 1998-2000 for the winter and autumn cohorts (Fig. 5, Kidokoro *et al.*); 2) the anchovy stock increased in 1998, and declined after a few years in the Tsushima Current region, East China Sea and Japan Sea (Oshimo); 3) RPS of sardine, mackerel and saury in the Kuroshio-Oyashio areas decreased in the late 1990s, and recovered in 2000, except for the Pacific saury, whose CPUE remained below average (Yatsu and Ueno). For benthic species, it was unclear if changes occurred in 1998. CPUE of several species gradually increased during the 1990s, and peaked in 1998-2000 along the Pacific coast of northern Honshu (willowy flounder, stone flounder, brown sole, shothole halibut, yellow goosefish; Nihira and Takahashi) and off east Hokkaido (Korean flounder, slime flounder, pointhead flounder, red halibut, octopuses; Nishimura *et al.*). This variation might have resulted from an increase in the carrying capacity after the collapse of the sardine stock in the 1990s.

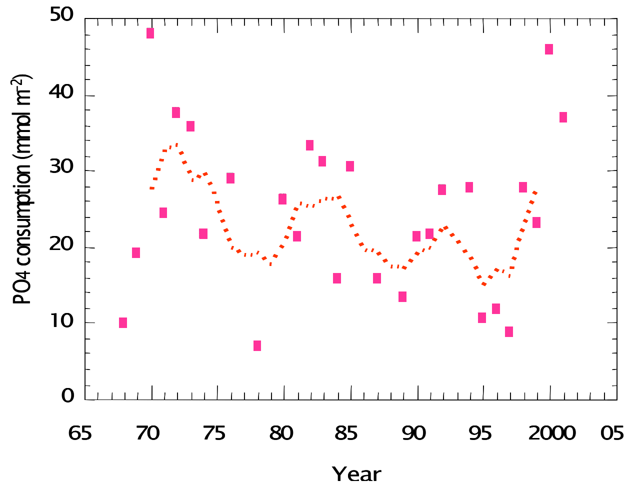

Fig. 3 Inter-annual variation of PO_4-P consumption in the Oyashio area during February-April (Tadokoro et al.*).*

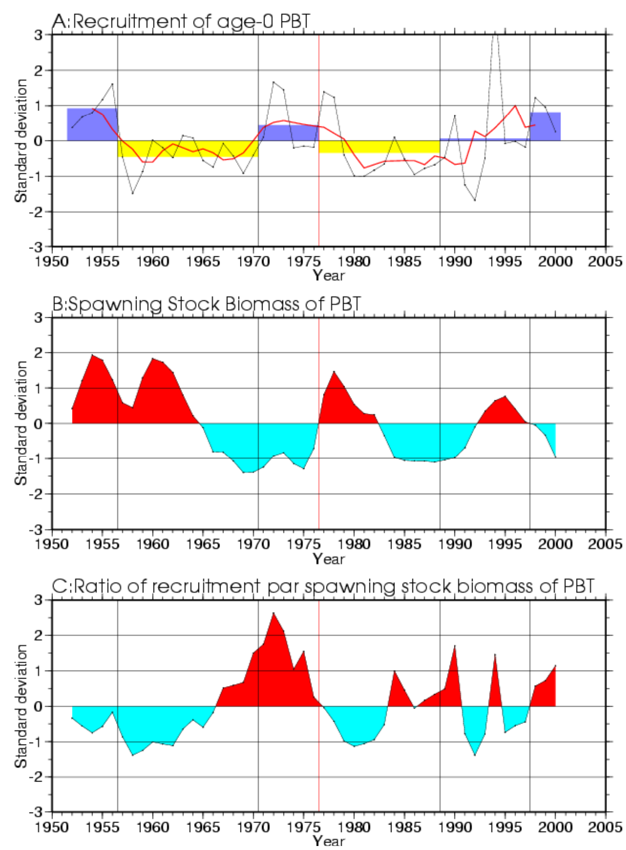

Fig. 4 Recruitment, spawning stock biomass and reproductive success (recruitment per spawner) of the Pacific stock of bluefin tuna (Inagake et al.*). Vertical lines: regime shifts found in SST data by Hanawa and Yasunaka.*

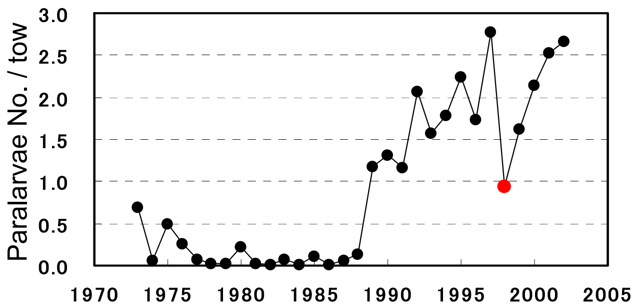

Fig. 5 CPUE of jig fishery of Japanese common squid, Todarodes pacificus *(Kidokoro* et al*.). Red mark represents the 1998 data.*

Some presentations examined the effects of the change in water temperature observed in 1998. In the western subarctic Pacific, the warming in 1998 resulted in a northward expansion in the distribution of the subtropical species, although overall fish abundance was constant (Yamaguchi *et al*.). On the other hand, the cooling after 1998 seemed to have negatively affected CPUE of willowy flounder in Mutsu Bay, northern Honshu. Inagake *et al*. reported that the RPS values of blue-fin tuna and albacore were related to the water temperature of their spawning grounds (and nursery ground for blue fine tuna), and found a regime-shift-related variation of RPS. However, the changes that occurred in 1998 were smaller than those that occurred during previous regime shifts.

Kidokoro *et al*. demonstrated that causes of the decline of common squid stock structurally differed between during the 1980s and after 1998, showing that the shift of the spawning ground that occurred in the 1980s did not occur in 1998 (Fig. 6).

The general consensus among symposium participants was that the changes that occurred in 1998 were much shorter than those that occurred during the 1976-77 regime shift. The reported changes in the higher trophic levels in 1998 might have been responses to the inter-annual or ENSO scale fluctuations in the physical and biological environments, rather than to decadal or multi-decadal scale climatic variation. The convenors concluded that more data should be collected to compare different areas in the North Pacific, and for global scale comparisons. To better compare regions and understand the links between climate and ecosystem variability, we may need to set a variety of working definitions of regime shifts using biological variables as well as physical/climatic variables.

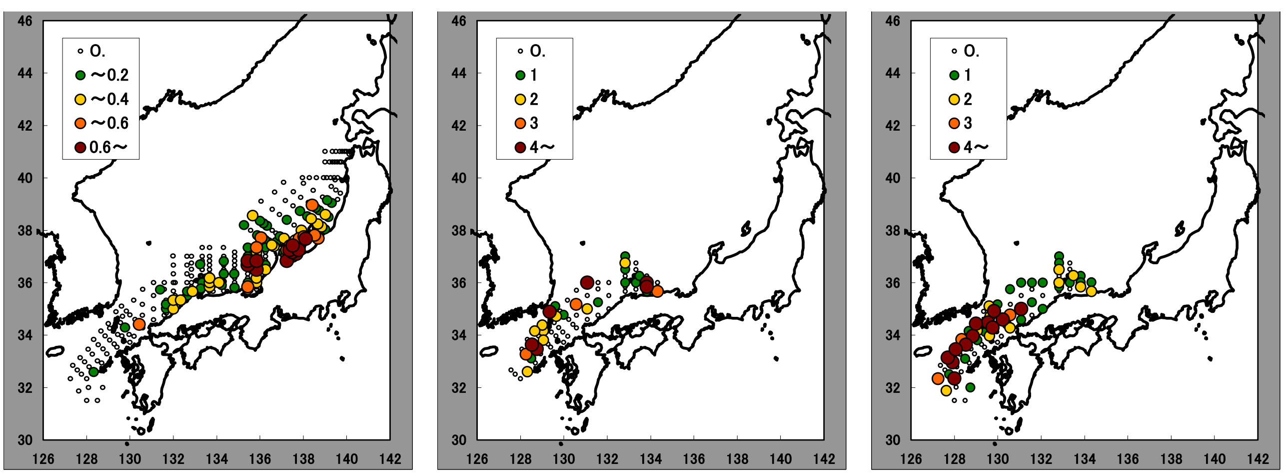

Fig. 6 Shift of spawning ground of Japanese common squid based on the larval distribution pattern (October - November) (Kidokoro et al*.). Left: low stock period (average of 1981-1986), middle: high stock period (1995) and right: 1998.*

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The Global Ocean Carbon Observing System – Connecting national programs and regional networks

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Dr. Maria Hood is a chemical oceanographer serving as a program specialist in the Ocean Sciences Section of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Her most recent research has focused on annual-to-interannual variability of surface ocean pCO_2 measured from autonomous drift buoys. At IOC, she serves as the technical officer for the SCOR-IOC Advisory Panel on Ocean CO_2 and its pilot project with the Global Carbon Project, the International Ocean Carbon Coordination Project.

Introduction

Human activities such as fossil fuel burning and deforestation have profoundly altered the Earth's global carbon cycle, and atmospheric concentrations of the greenhouse gas CO_2 are now higher than experienced on the planet for the past several million years. The ocean is the largest mobile reservoir of carbon on decadal-to-millennial time scales, and will ultimately absorb approximately 70-85% of the anthropogenic CO_2 released to the atmosphere. Observational and modelling estimates suggest that the ocean is presently taking up about 30-40% of fossil fuel CO_2 emissions, but the future behaviour of the oceanic sink is uncertain, depending upon possible carbon and climate feedbacks associated with changes in ocean chemistry, ocean circulation and marine biogeochemistry.

Ocean carbon scientists are faced with two different challenges in dealing with CO_2 in the ocean. One is how to understand, monitor, and predict the present and future ocean sink for CO_2. The other is how the CO_2 increase in the ocean will affect biogeochemistry and ecosystem functioning. The annual uptake of atmospheric CO_2 is much smaller than the spatial and seasonal variability of CO_2 in the ocean, and detecting the trend is a technical challenge. This "service" that the ocean provides of removing CO_2 from the radiative budget of the atmosphere, however, comes at a great cost. There is a strong possibility that by the middle of this century surface ocean pH changes resulting from increased dissolved CO_2 concentration (*e.g.*, acidification) may cause significant stress on calcifying plankton and coral reefs. While "dangerous anthropogenic interference with climate" has been widely discussed in the United Nations Framework Convention on Climate Change (UNFCCC), no scientific discussions have taken place to determine what oceanic CO_2 levels should be considered tolerable for marine life, or how proposed carbon management strategies might moderate or exacerbate effects on ocean chemistry and biology.

The vast scope of the ocean carbon problem can only be addressed through globally-coordinated research and observations. This issue has long been recognized at the highest levels of government, and numerous international conventions, such as the UNFCCC and the United Nations Conference on Environment and Development's "Agenda 21", have instructed IOC to develop the necessary coordination mechanisms to ensure that the combination of research and observations carried out by global and national research programs are coordinated, comprehensive and sustained. Over the last few years, the ocean carbon community has developed a collective vision for an ocean carbon observing system that would have significant scientific benefits. Along with this vision is the knowledge that implementing such a system will require international collaboration and coordination on an unprecedented scale. What we describe here are the first steps of our community to organize internationally to meet these challenges.

International Ocean Carbon Coordination Project

In response to these UN mandates, IOC, along with the International Council for Science's Scientific Committee on Oceanic Research (SCOR), established an Advisory Panel on Ocean CO_2 in 2000 to focus efforts on observation coordination. In 2003, the Panel initiated a pilot project with the Global Carbon Project (sponsored by the International Geosphere-Biosphere Program, the International Human Dimensions Program, and the World

Climate Research Program) called the International Ocean Carbon Coordination Project (IOCCP). IOCCP is working to develop a central information source of on-going and planned ocean carbon observations, and to establish international agreements on observation methods, best practices, data management, and data sharing that will lead to the joint development of global data products and synthesis activities documenting the ocean carbon cycle. IOCCP activities have been funded through grant OCE-0245278 from the U.S. National Science Foundation to SCOR, IOC, and the Japanese National Institute for Environmental Studies.

For several years, North Pacific research scientists have coordinated their efforts under the PICES framework and have begun Pacific CO_2 data integration. North Atlantic research scientists have also established a coordination mechanism to share ocean CO_2 observational data through the Carbon in the Atlantic (CARINA) activity of JGOFS. IOCCP is working to establish long-term relationships with PICES and other regional data synthesis groups to develop the collective capacity to produce data products such as annual basin- and global-scale air-sea CO_2 flux data sets and decadal basin- and global-scale data sets of carbon distributions in the water column.

The first workshop of the new IOCCP was held in January 2003, at the United Nations Educational, Scientific, and Cultural Organization (UNESCO) headquarters in Paris, and brought together 56 participants from 17 countries to discuss the current state of ocean carbon observation activities and the way forward for international coordination. The workshop produced compilations of on-going and planned ocean carbon measurements and outlined the scope for the project and working arrangements for the project office (to be managed through the CO_2 Panel Secretariat at IOC). These compilations are available at: http://ioc.unesco.org/ioccp. An observing system for ocean carbon builds on three basic elements: (1) repeat hydrographic sections, (2) time-series stations, and (3) underway measurements from research and volunteer observing ships. Each of these activities is at a different stage of development and is implemented with several partner programs.

Repeat sections – One of the key components of the initial ocean carbon observing system is the repeat hydrographic sections being conducted in collaboration with the Climate Variability and Predictability Program (CLIVAR). Observations of large-scale distributions of carbonate system variables provide important information on the patterns and rates of air-sea exchange, organic/inorganic matter export, subsurface re-mineralization, and anthropogenic carbon storage and transport. They also serve as key constraints on ocean biogeochemical numerical models. Transient tracer fields offer insight on physical mixing, circulation pathways and transport rates that have direct impact on the ocean's ability to absorb anthropogenic CO_2. The global survey lines of carbon and tracers carried out through the WOCE program are being re-occupied beginning in 2003. At present, there are 31 lines committed (funded) and another 6 awaiting funding approval (Fig. 1). In 2003, the CLIVAR Basin Panels included carbon and tracer experts as members of each of the Panels. The international community has been working together to determine the minimum set of core repeat sections required for a standard global survey of ocean carbon and tracers, and to establish international agreements on core and ancillary measurements for the survey. It is anticipated that an international strategy for the ocean carbon repeat hydrography program will be published by the end of 2004 as part of the IGBP - SCOR *Integrated Marine Biogeochemistry and Ecosystem Research* (IMBER) Program. IOCCP will be working with the international carbon and CLIVAR communities to develop this strategy into an implementation plan.

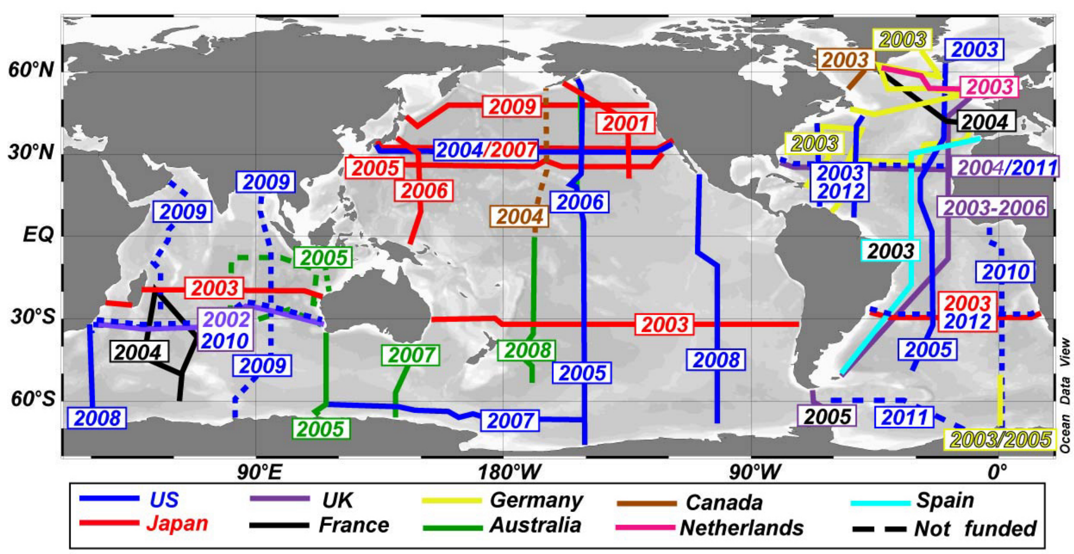

Fig. 1 Global repeat hydrography map.

Time series – Long-term time-series measurements are crucial for characterizing the natural variability and secular trends in the ocean carbon cycle, and for determining the physical and biological mechanisms controlling the system. In 2000, the Ocean Observations Panel for Climate (sponsored by the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the World Climate Research Program (WCRP)) joined with CLIVAR, and the Partnership for Observations of the Global Oceans (POGO) to develop an international science team to guide the development and implementation of a global network of time-series stations. IOCCP has been working with the carbon experts on this science team in the development of the design strategy for the network. A number of time-series stations measuring ocean carbon and related measurements will be developed as part of the global research programs such as SOLAS and IMBER. IOCCP and the SCOR-IOC Advisory Panel on Ocean CO_2 will be working closely with these groups to coordinate the research, observations, and data synthesis activities through regional groups including PICES.

Volunteer Observing Ship (VOS) surveys – One of the key products of a globally coordinated oceanic pCO_2 observation system is the development of global ΔpCO_2 maps. Taro Takahashi has already provided an initial global climatology for non-El Niño conditions (*Deep-Sea Res. II*, Vol. 49, pp. 1601-1622, 2002). His maps are the most significant product from the last several decades of ΔpCO_2 observations. This climatology plays a critical role in global carbon cycle model validation, and aids in improving the accuracy of climate change modelling. However, these climatological maps represent aggregated data for the last 40 years of observation projected to a single year: 1995. Surface ocean pCO_2 can be affected by short-term modes of climate variability (*e.g.*, El Niño events) and changes in biological productivity. Variability on time scales of 1 month or shorter can be significant for estimating annual air-sea CO_2 flux. It is clear that we must move beyond a pCO_2 climatology and develop time-resolved global pCO_2 maps in order to resolve temporal changes of the oceanic sinks and sources of CO_2. Such task truly requires extensive observation and data integration. At present, carbon VOS surveys (Fig. 2) are not coordinated through any global research activity, and the development of IOCCP has provided a forum for these scientists to address common issues and to develop joint plans. The two IOCCP-sponsored workshops in 2003 and 2004 have been focused on the VOS issues, and have been held in coordination with PICES scientists and programs.

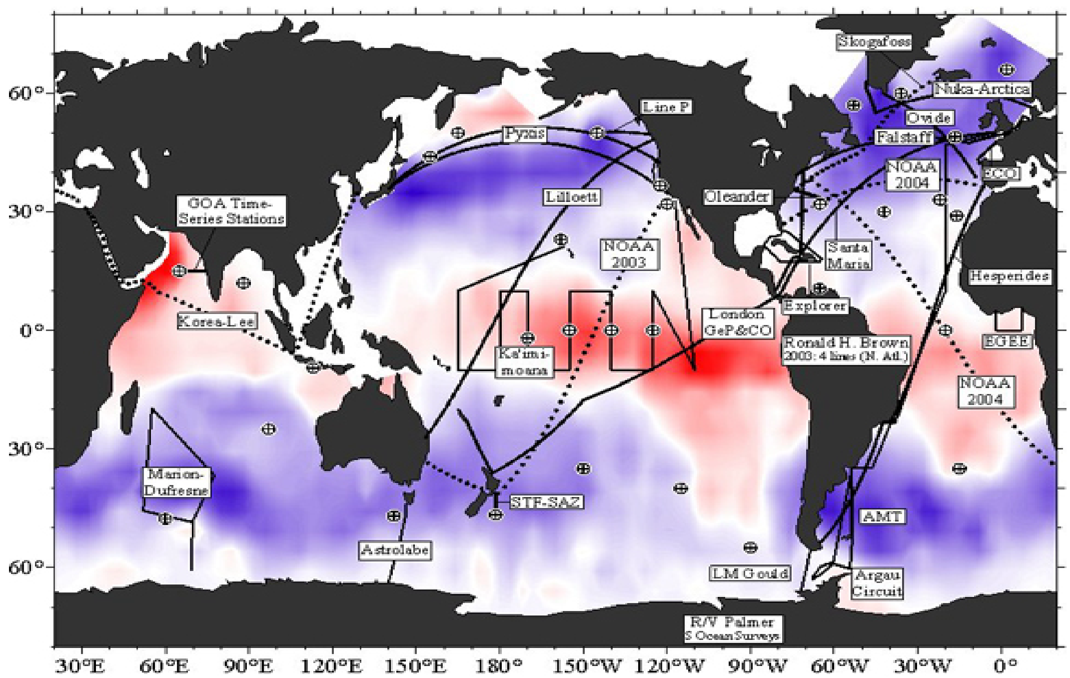

Fig. 2 Global underway pCO_2 map.

International pCO_2 system inter-comparison experiment

As one of the first contributions to this new coordination effort, Dr. Yukihiro Nojiri of the Japanese National Institute for Environmental Studies (NIES) organized an international pCO_2 inter-comparison experiment for underway pCO_2 systems in March 2003, with financial support from the Environmental Agency of Japan. Inter-comparison exercises are crucial to ensure the accuracy of pCO_2 observations. Previous pCO_2 inter-comparison experiments (in 1994 at the Scripps Institution of Oceanography, and in 1998 on board R/V *Meteor*) were useful, but the experimental set-up was not ideal in either case. The recent experiment, held March 10-14, 2003, at the National Research Institute of Fishery Engineering, Hazaki, Japan, used an indoor seawater pool under controlled laboratory conditions, which allowed very precise comparisons of the equilibrators and gas measurement systems. The pool contained 170,000 liters of coastal seawater adjusted to a salinity of 33 psu. Nine different underway systems, including 3 from Japan, 2 from the United States, 1 from the Republic of Korea, 1 from New Zealand, 1 from Germany and 1 from the United Kingdom, were plumbed in series into a water system that re-circulated saltwater from the pool at a rate of 300 L/min. In addition, three autonomous drifter-type systems (2 from the United States and 1 from France) were deployed in the pool. A series of experiments were run over five days to evaluate the response of the systems and potential biases over a range of temperatures and pCO_2 values observed in nature. A careful comparison of calibration approaches was also made by providing a common set of gas standards and a CO_2-free reference gas to all participants. The results of this experiment are currently being compiled, but the basic conclusion was that despite the wide variety of equilibrator and gas detection systems, the systems evaluated in this study agreed much more closely than observed in previous inter-comparison studies. However, a few sources of variability that could be attributed to specific design aspects were identified and will be discussed in the workshop report. In keeping with the goals of IOCCP, the workshop report will also include a set of "best practice" recommendations for those interested in making underway pCO_2 measurements.

Workshop on "Ocean surface pCO_2, data integration, and database development"

In January of 2004, IOCCP, NIES, and PICES co-sponsored a follow-up workshop to the inter-comparison experiment in Tsukuba, Japan, to address "Ocean surface pCO_2, data integration, and database development". This workshop, which brought together 44 participants from 12 countries, was carried out through three working groups focusing on:

- the results of the inter-comparison experiment for ocean pCO_2 systems,
- standardization of data and metadata formats, and
- data integration and networking.

Ocean pCO_2 systems – In order to combine the results of individual programs into a global observing network, it is first necessary to make measurements of known accuracy from a variety of different systems. It is unfortunately not practical to make liquid standards for pCO_2 measurements, and so we must have a detailed understanding of how different systems behave relative to each other under a variety of conditions, and compare with results from a laboratory-based system of known accuracy. At the workshop, Working Group 1 identified several key areas of errors and biases in the eight system designs, and outlined ways of resolving these discrepancies. In general, it was found that well-designed and operated systems agreed with each other to within ± 2 μatm, which is close to the estimated accuracy of the measurements from the at-sea systems. The goal is to be able to make an estimate of the annual mean uptake of ocean CO_2 with an uncertainty of about 10%, or ±0.2 Pg C yr^{-1}. Based on existing seasonal pCO_2 climatologies and wind speed distributions, basin average ΔpCO_2 must be resolved to 3-10 μatm. A full technical report of the experiment results will be published by the Carbon Dioxide Information and Analysis Center (CDIAC), following the outline and sensor designations used in the previous 1996 inter-comparison experiment (CDIAC Numerical Data Package 067). The goal is to have the first draft prepared by mid-April, with a final draft by June 2004 for a presentation at the PICES Thirteenth Annual Meeting in October 2004.

Standardization issues for data and metadata formats – Metadata and data file contents were developed by Working Group 2 and approved by the workshop. These are available on the IOCCP web site at: http://ioc.unesco.org/ioccp. These will be promoted as the IOCCP Recommended Format upon final revision. Alex Kozyr at CDIAC's Ocean CO_2 Project will create an easy-to-use web-based metadata reporting form to facilitate this uniform approach. Working Group 2 discussed the necessity of using a uniform approach to estimating overall uncertainty for CO_2 measurements, and recommended that a special working group be formed to develop and propose guidelines.

Data integration and data networking – While a mature observing system will have a network of operational data centers obtaining data in near-real time and producing regular data products, the first steps toward that goal involve making international agreements on data and metadata formats, and agreements on how to share these data among the existing data centers and data collectors. Because ocean CO_2 data are still very much in the research realm, where data collection is funded through research proposals and where the only "user" for the data products is the research community producing the data, it was felt that we still need to offer some "intellectual property" protection to those scientists who collect the data. This comes in two forms. One is in keeping with global research program policies, to allow scientists up to 2 years to make the data publicly available. The other is to pursue new innovations in electronic publishing, so that data sets housed at accredited data centers can be cited as peer-reviewed journal articles. Specific working arrangements discussed at the meeting are:

- <u>Data release / Data Center networking</u>
  Ocean CO_2 data sets (providing the IOCCP-recommended information) should be sent to the CDIAC World Data Center for Atmospheric Trace Gases (either directly or via other World, National or project Data Centers) no later than 2 years after the end of the cruise (current contact: Alex Kozyr, E-mail: kozyr@ornl.gov).

- Data citations and acknowledgements
  When data are submitted to a Data Center, the contributor should provide information on how the data set is to be cited or acknowledged in publications using the data. For data submitted <2 years before the end of a program, CDIAC can limit access to the data until the contributor has been contacted, if this is desired by the data contributor. As a courtesy to the original data contributors, it should become common practice for individuals who prepare scientific products based (even in part) on a particular dataset, to inform the contact person for that dataset of its use. IOCCP is investigating the American Geophysical Union protocol for citation of data sets in AGU journals and will encourage this practice where appropriate.

- Data integration and synthesis activities
  Surface pCO_2 data integration and synthesis activities (such as developing basin-scale and global data sets) undertaken in the next few years should be coordinated with activities of SOLAS Focus 3 (especially 3.1), with integration organized around regional (basin) groups. Integration should also cover coastal areas.

Workshop follow-up activities

The workshop reached a number of important agreements for the longer-term networking of data and synthesis activities, and produced the following action items for IOCCP for 2004:

- Development and publication of a CDIAC Technical Report on the ocean pCO_2 system inter-comparison experiment (first draft by mid-April 2004; final draft by June 2004);
- Development of the CDIAC Ocean CO_2 web-based metadata reporting form (first draft by mid-April 2004);
- Establishment of a small working group to develop and propose guidelines for a uniform approach to estimating overall uncertainty for CO_2 measurements;
- Final writing and publication of the "Guide of best practices for oceanic CO_2 measurements and data reporting", by Andrew Dickson, supported by PICES and the SCOR-IOC Advisory Panel on Ocean CO_2 (final draft by mid-2004 to incorporate international recommendations on data and metadata formats);
- The workshop participants also concluded that both individual scientists and national agencies need an internationally agreed upon implementation strategy, in order to evaluate national efforts in an international context, and to prioritize projects that contribute to the global network. We need both to sustain existing programs and to develop new programs based on the analysis of the spatial and temporal resolution of measurements needed to meet global data set goals. The workshop participants outlined the necessary elements for developing an implementation strategy of surface ocean CO_2 observations, and noted that many of the elements already exist, such as an inventory of on-going and planned activities, an initial analysis of the measurement resolution required, and a data management network. It was felt, however, that the initial sampling strategy analysis (see "Errors in the sea-air CO_2 flux due to time-space ocean sampling strategies for sea-air pCO_2 difference" by Takahashi and Sweeney, in "A large-scale CO_2 observing plan", Bender *et al.*, 2002.) should be re-evaluated considering issues like the time-space smoothing of the data sets. For 2004, IOCCP will seek funding support for the 2- to 3-month analysis project, and will prepare a first-draft of an implementation strategy by the end of the year, with the goal of having a full strategy ready for comments and publication by mid-2005.

Putting the pieces together

The coordination of national programs and regional networks is providing the foundation upon which we will build the ocean carbon observing system. While the calls for a coordinated system of observation come both from the highest levels of government as well as individual scientists, the resources for its development are almost entirely at the national level. This requires building the system from the ground up, where the international community of scientists must first develop joint implementation strategies (*e.g.*, for repeat sections, underway measurements from VOS, and time series stations), and then work closely with their national agencies to coordinate and implement their part of this network. At the international level, the ocean carbon observing system is connected to other global observing system elements through the GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC). IOCCP provides regular reports to OOPC, and contributes to the implementation strategy of the ocean observation system for climate being developed as part of the Global Climate Observing System for UNFCCC. While many national efforts in ocean carbon observation are well advanced, the international coordination of these efforts is at a very early stage, and our biggest challenges are still the basic building blocks of measurement technology, standardization, and data sharing. IOCCP will continue to rely on PICES for regional leadership in this global partnership.

The North Pacific Ecosystem Metadatabase

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Mr. Allen Macklin and Dr. Bernard Megrey co-direct the North Pacific Ecosystem Metadatabase and co-chair Data Management and Communications for the Alaska Ocean Observing System. Allen is a meteorologist with the Pacific Marine Environmental Laboratory. He is the coordinator for Fisheries-Oceanography Coordinated Investigations (FOCI), a NOAA research program to sustain fishery resources in the Gulf of Alaska and Bering Sea while maintaining healthy ecosystems. Allen has 25 years' experience studying Alaskan marine ecosystems and managing information. Bernard is a research fisheries biologist with NOAA's Alaska Fisheries Science Center where he has worked since 1982. As the lead investigator for recruitment modeling studies for FOCI, he has over 20 years' experience studying dynamics of exploited North Pacific fish populations, relationships of environment to recruitment variability, and application of computer technology to fisheries research and natural resource management. [This article is PMEL contribution 2703 and FOCI contribution 500.]

What is the North Pacific Ecosystem Metadatabase?

The North Pacific Ecosystem Metadatabase (NPEM, Fig. 1) is an Internet utility to aid the understanding, management, stewardship and utilization of North Pacific Ocean ecosystems. The utility is a browsable, and searchable, on-line inventory of data and other information. NPEM is dynamic, *i.e.*, it undergoes continuous development to keep its contents up to date, so that users can access current information from which to make decisions. Our goal is to provide free and open access to information that ordinarily would be unavailable to researchers. In this way, we hope to build collaborations between investigators, and to make the exchange and use of marine science data more efficient.

Metadata

Metadata, or data about data, describe the content, quality, condition, and other characteristics of data. For example, metadata for vertical profiles of ocean properties obtained from hydrographic casts might illustrate, minimally, the locations and times of the casts, the inclusive depths, the variables measured, the location of the data, and the name of the contact person to request access to the data. In general, metadata include thematic, semantic and syntactic descriptors of the data they reference.

- Thematic metadata describe the context of the study that produced the data. Such descriptors can include, *e.g.*, principal investigator, species association and study hypothesis.
- Semantic metadata provide contextual information about the data. Candidate descriptors are measurement type, measurement device, units of measurement, calibration information, etc.
- Syntactic descriptors define the way the data are packaged, *e.g.*, file size, file format, storage mechanism and location.

Metadata in NPEM are described in a common set of terminology and definitions using the Federal Geographic Data Committee (FGDC) metadata standard. The data themselves are not part of the metadatabase and continue to reside with their owner. Each metadata record provides a dynamic link to the data or to the contributor.

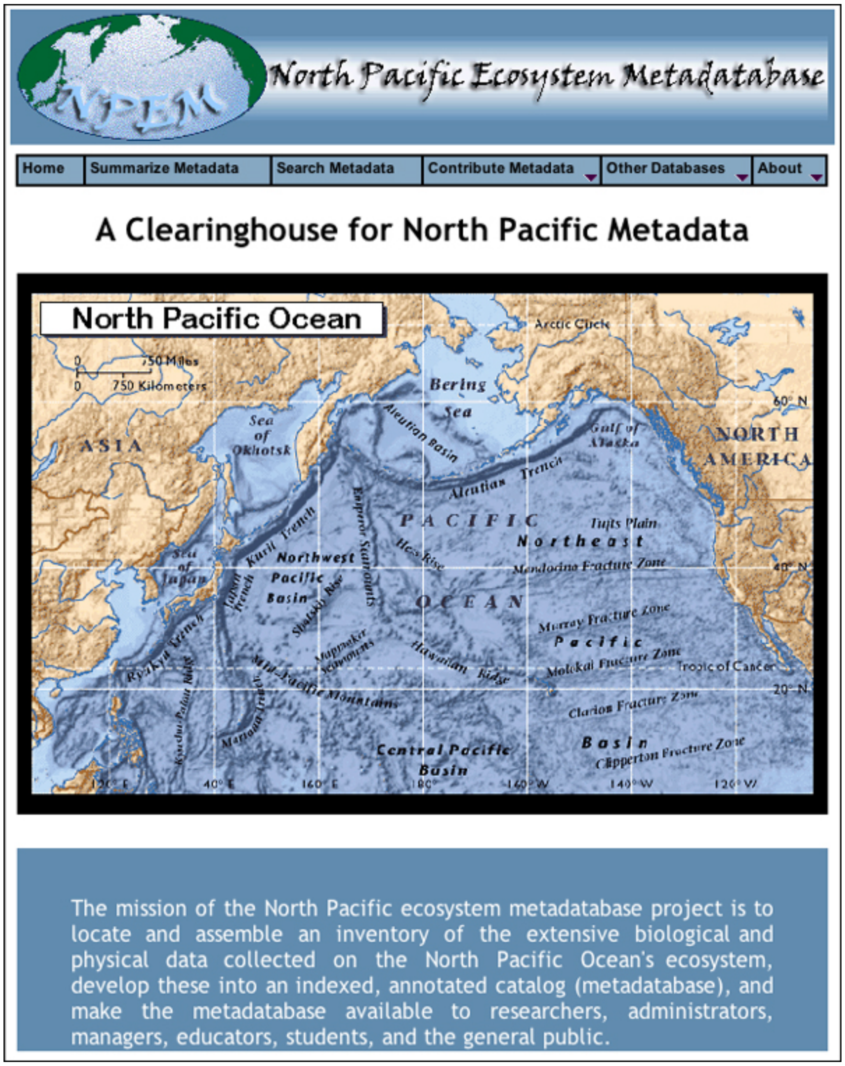

Fig. 1 Home page of the North Pacific Ecosystem Metadatabase.

History

NPEM began in 1996 as the Bering Sea Ecosystem Biophysical Metadatabase with a 3-year support from the National Oceanic and Atmospheric Administration (NOAA) Environmental Services Data Information Management (ESDIM). This earlier metadatabase is described in *PICES Press*, Vol. 6, No. 1 (January 1998). We established the metadatabase to address a deficiency identified in 1996 by the U.S. National Research Council. In its report on the Bering Sea ecosystem, the Council concluded that a directory of data and information sources relevant to the Bering Sea, cataloged in one place, was a critical need. Furthermore, the Council cited the lack of such a database as the one major impediment to studying the Bering Sea. It was clear that scientists had little appreciation of metadata or their importance.

We first developed a schema from the minimum set of FGDC descriptors, designed the database in Microsoft Access, and procured a Windows server as a public interface using Active Server Pages (ASP) scripts. In mid-1997, we published the first call for metadata. We solicited information from scientists, advertised in science newsletters, made national and international presentations, and, through PICES, developed contacts with Canadian, Chinese, Japanese, Korean and Russian marine science institutes. We educated the scientific community on the importance of metadata and indicated the benefits that would accrue to scientists and science as a result of proper metadata specification. We mailed thousands of metadata entry forms to scientists, requesting their metadata. From these efforts, the metadatabase grew to 70 records within a few months. By the end of the third year of funding, there were more than 1000 records populating the metadatabase. Also in those first years, the metadatabase earned support and endorsement from Fisheries-Oceanography Coordinated Investigations (FOCI), the North Pacific Marine Science Organization (PICES), the *Exxon Valdez* Oil Spill Trustee Council (EVOS) and the North Pacific Marine Research Program, for which the metadatabase was granted funds to be the official program metadata repository.

In March 2001, the metadatabase directors attended a PICES-sponsored, international workshop on "Impact of climate variability on observation and prediction of ecosystem and biodiversity changes in the North Pacific". Workshop participants from Canada, China, Japan, Korea, Russia, the United Kingdom, the United States, and 11 international science organizations nominated existing time series and predictions for determining status of North Pacific ecosystems. Attendees were amazed at the diversity and quantity of the many data series that were brought forward. Data from western Pacific nations has been particularly difficult to identify and obtain, as much of it is known only locally. The nominated time series from all around the North Pacific rim, basin and marginal seas, have sufficient historical length, accuracy, and likelihood of continuance to be important indicators of climate and climate response. Participants of the workshop recommended that the time series information and scientific contacts identified be recorded and updated in the North Pacific (*i.e.*, Bering Sea) Ecosystem Metadatabase. With this impetus, we again applied to ESDIM, successfully, to expand the Bering Sea Ecosystem Biophysical Metadatabase to NPEM, and that work began in late 2002. Search and display capabilities have been upgraded with this funding, and the metadatabase is now housed in mySQL and served from a Linux platform.

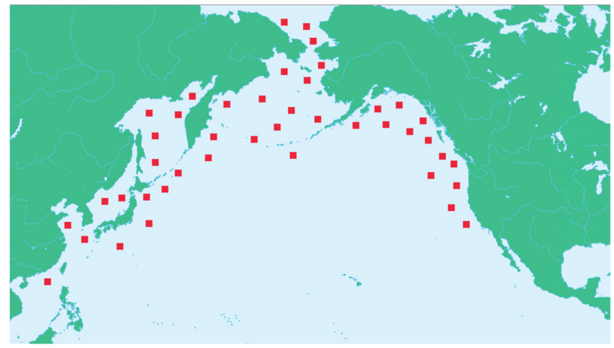

Fig. 2 Regional distribution of metadata records.

As of April 2004, NPEM contains 2746 records referencing physical and biological datasets, model outputs, museum samples, publications, reports, proposals, atlases, and audio and video programs. The regional distribution of these records is shown in Figure 2. Most records are from coastal areas. In terms of metadata density, most contributions pertain to the eastern North Pacific. We suspect that there has been a similar quantity of research performed in the western North Pacific, however results from this research are not as readily available to us. For example, although more than ten Asian institutes have contributed to the metadatabase, these records make up less than 11% of the holdings. Holdings span all biological and physical scientific disciplines, including historical and present information, ranging from atmosphere to open ocean to inter tidal areas. Figure 3 shows the distribution of metadata records by source country and keyword.

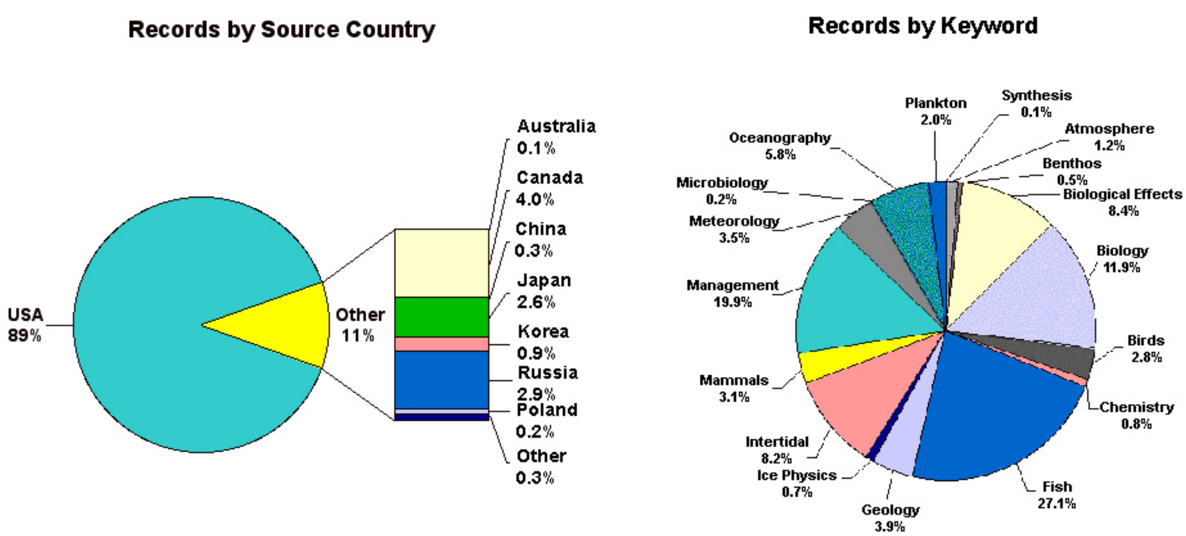

Fig. 3 Distribution of metadata records by source country and keyword.

Access

The North Pacific Ocean Theme Page (http://www.pmel.noaa.gov/np/) is the Internet gateway to the metadatabase. The Theme Page and the metadatabase offer a rich suite of environmental information to scientists, students, teachers, managers, and casual users. Since their inception, both the Theme Page and the metadatabase have increased in popularity as shown in Figure 4. Peaks in user activity correspond to important announcements of availability of research funds or other resources. Note the drop in summertime Theme Page usage when U.S. public school is not in session. On average, the metadatabase is exercised about 3500 times a month. This represents about 3% of all Theme Page use. A growth trend from 1997 to about 2002 seems to be leveling.

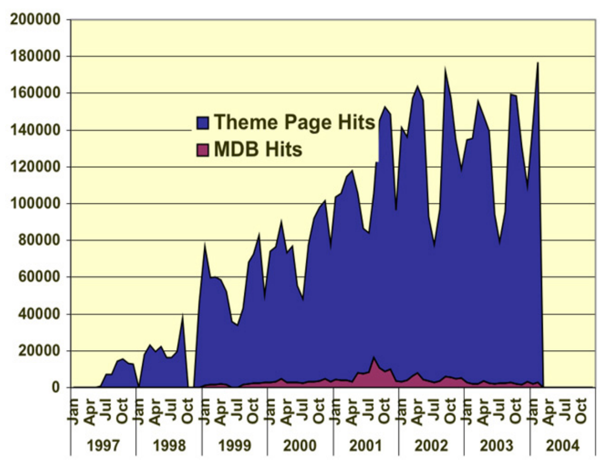

Fig. 4 Time history of Theme Page and metadatabase user activity.

The metadatabase is found through the Theme Page's DATA link or can be accessed directly at http://www.pmel.noaa.gov/np/mdb/. Once on-line, a user can learn about the metadatabase, contribute metadata, or search for metadata by time, location, keyword, country of origin, etc. Spatial searches are accomplished through an interactive map display or by direct specification of latitude and longitude. A user is able to build compound searches using any two or more search techniques.

Search results are returned according to user specification. Presently, the options are to return information as a list of metadata record titles or as dynamically linked icons on a regional map, such as in Figure 2. Clicking on a metadata title or clicking on an icon will display the complete metadata record selected.

Complete metadata records display to the user all FGDC descriptive elements captured within NPEM. These are contributor, citation, description, status, ecosystem components, keywords, spatial domain, time domain, source, and constraints.

Future directions

We continue to archive all metadata associated with the North Pacific Ocean. In particular, we want to increase holdings of Asian metadata to enrich our references to the western North Pacific and bordering regions. To gain recognition in NPEM, a contributor can complete an on-line form through the website. This information is e-mailed to the NPEM coordinator who enters it into the metadatabase.

Late in 2003, we launched plans to implement with other North Pacific marine data centers (*e.g.*, KODC, JODC) "federated searches" or queries that search all metadata sets in separate data locations in a manner that is completely transparent to the user. Using this technique, a user of any of the aforementioned data facilities or of NPEM will be able to search the collection of all subscribing data facilities in a single session. In conjunction with this effort, NPEM will become a clearinghouse node of the National Spatial Data Infrastructure.

During the coming year, NPEM will implement a drill-down keyword thesaurus that is a derivative of the Global Change Master Directory. Metadata contributors will be able to specify keywords for their metadata by scientific discipline using a pull-down menu. Keywords are specified by category, topic, term, variable (optional), and detailed variable (optional and user-provided), *e.g.*, EARTH SCIENCE > OCEANS > OCEAN CIRCULATION > EDDIES > CYCLONIC. Metadatabase users will be able to search for records using the same pull-down menu.

Finally, NPEM will cooperate with various efforts to establish North Pacific Ocean observing systems. NPEM will make metadata available, enter into discussions about metadata standards for description of various sorts of ocean information, and entertain proposals to federate.

International GLOBEC Symposium on
"Climate variability and Sub-Arctic marine ecosystems"

Background and objectives

Sub-Arctic seas support extraordinarily rich marine resources, which provide food and wealth to local communities. These seas include: the Okhotsk Sea, Oyashio shelf region, Bering Sea, Hudson Bay, Newfoundland/Labrador shelves, Gulf of St. Lawrence, Greenland shelves, Iceland regions, the Nordic Seas and the Barents Sea. These seas share several features in common: seasonal ice cover, freshwater from ice-melt and runoff, dramatic seasonality, reduced sunlight and low biodiversity. Recently, changes in species abundance or distribution have been observed within several Sub-Arctic marine ecosystems. A symposium on climate effects on the Sub-Arctic marine ecosystems is timely because these recent changes appear to correlate with fluctuations in the physical environment, and because of the growing concern about anthropogenically induced climate change. Also, several new national programs in Sub-Arctic seas have recently been initiated, *e.g.* Bering Ecosystem Study (BEST), Effects of North Atlantic Climate Variability on the Barents Sea Ecosystem (ECOBE), Ecosystem West Greenland (ECOGREEN), and the Oyashio-pollock project in Japan. Additionally, a new GLOBEC regional program, Ecosystem Studies of Sub-Arctic Seas (ESSAS), is in the planning stage (Fig. 1). This symposium offers the opportunity to influence the implementation plans of ESSAS and BEST.

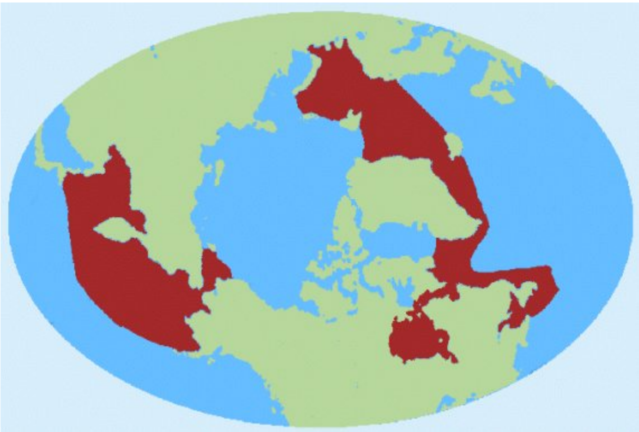

Fig. 1 The ESSAS regions.

Scientific program

The symposium's scientific objective is *to present current knowledge of the effects of seasonal to multi-decadal climate variability on the structure and function of Sub-Arctic marine ecosystems*. Papers, particularly inter-disciplinary or comparative ones, are invited on the following topics:

- large-scale climate forcing on the physical oceanography of Sub-Arctic seas;
- processes structuring Sub-Arctic ecosystems (sea ice, low temperatures, low species diversity, etc.);
- the transfer and fate of energy through subarctic food webs, from primary producers through zooplankton and benthic fauna to fish, seabirds, marine mammals and fisheries;
- recent changes in subarctic ecosystems, time scales of variation and possible causes;
- inter-comparisons between Sub-Arctic marine ecosystems.

Papers on related topics will also be considered. Scientists are invited to submit titles and abstracts (maximum of 250 words) for oral presentations or posters, through the GLOBEC website (http://www.globec.org). All abstracts will be reviewed for merit and relevance. **The deadline for abstract submission is December 1, 2004.**

Symposium structure

The symposium will have a combination of plenary sessions in the mornings, and parallel sessions in the afternoons. Keynote speakers will provide 40-minute introductions and challenges to selected topics. Contributed papers that are accepted will be 20 minutes in length. Posters will be displayed throughout the meeting, and sufficient time will be provided for discussion with authors. Workshops on BEST and ESSAS will be held on the first and last days of the symposium. The official language of the symposium will be English.

Publication

The symposium proceedings will be published in a refereed journal yet to be selected. Papers, including those based on poster presentations, will be considered for publication following peer review. Interested authors will be required to submit an electronic version of their manuscript in standard format at the time of the meeting.

Participation

The symposium is open to all scientists and students interested in Sub-Arctic marine ecosystems.

Registration fees

Those attending are invited to register by **December 1, 2004.** A registration fee of $250 US ($150 for students) will be charged to help cover the costs of the symposium. Late registration is $350 US ($250 for students). Limited support for student participation is expected to be available. Applications for student support must be made by **December 1, 2004**. Registration, abstract submission and student support application will be through the GLOBEC website.

Important dates

- December 1, 2004: Deadline for early registration and abstract submission and for application of Student Support Grants;
- February 1, 2005: Notification of abstract acceptance;
- April 1, 2005: Notification of Student Support Grants;
- May 17, 2005: Submission of electronic versions of papers.

Co-Convenors

George L. Hunt, Jr. (University of California, Irvine, U.S.A.)
Ken Drinkwater (Institute of Marine Research, Bergen, Norway)

Scientific Steering Committee

Olafur S. Astthorsson (Marine Research Institute, Reykjavik, Iceland)
Manuel Barange (GLOBEC IPO, Plymouth, UK)
Mickle Flint (Shirshov Institute of Oceanology, Moscow, Russia)
Jean-Claude Gascard (Universite Pierre et Marie Curie, Paris, France)
Jackie Grebmeier (University of Tennessee, Knoxville, U.S.A.)
Erica Head (Bedford Institute of Oceanography, Dartmouth, Canada)
Hans-Jurgen Hirche (Alfred Wegner Institute, Bremerhavn, Germany)
Eileen Hofmann (Old Dominion University, Norfolk, U.S.A.)
Anne Hollowed (Alaska Fisheries Science Center, Seattle, U.S.A.)
Michael Kingsley (Greenland Institute of Natural Resources, Nuuk, West Greenland)
Michio J. Kishi (Hokkaido University, Hakodate, Japan)
Harald Loeng (Institute of Marine Research, Bergen, Norway)
Bernard Megrey (Alaska Fisheries Science Center, Seattle, U.S.A.)
Ian Perry (Pacific Biological Station, Nanaimo, Canada)
Sei-ichi Saitoh (Hokkaido University, Hakodate, Japan)
Yasunori Sakurai (Hokkaido University, Hakodate, Japan)
Kurt Tande (University of Tromsø, Norway)
Terry Whitledge (University of Alaska, Fairbanks, U.S.A.)

PICES Calendar

- PICES-MODEL Workshop on "*Development of a model on coupled responses of lower and higher trophic levels for climate variability in the North Pacific*", August 20-23, 2004, Seattle, U.S.A.
- PICES Thirteenth Annual Meeting, October 14-24, 2004, Honolulu, U.S.A. (http://www.pices.int)
- APN/PICES Workshop on "*Climate interactions and marine ecosystems: Effects of climate on the structure and function of marine food webs and implications for marine fish production in the North Pacific Ocean and marginal seas*", October 10-13, 2004 (in conjunction with PICES XIII)
- PICES-CCCC Workshop on "*Seasonal cycles of plankton and nutrients around the North Pacific Rim*", October 14, 2004, (in conjunction with PICES XIII)
- PICES-MBMAP Workshop on "*Combining data sets on diets of marine birds and mammals - Phase II*", October 14, 2004 (in conjunction with PICES XIII)
- PICES/IOC Workshop on "*Developing a North Pacific HAB data resource*", October 15, 2004 (in conjunction with PICES XIII)
- PICES-CCCC Workshop on "*Linking open ocean and coastal ecosystems II*", October 15-16, 2004 (in conjunction with PICES XIII)
- PICES/CLIVAR Workshop on "*Scale interactions of climate and marine ecosystems*", October 23-24, 2004 (in conjunction with PICES XIII)
- GLOBEC/PICES Symposium on "*Climate variability and sub-Arctic marine ecosystem*", May 16-20, 2005, Victoria, Canada (see this issue, page 34)
- CREAMS/PICES/WESTPAC Workshop (with training component) on "*NEAR-GOOS Seas Circulation: What we know and how well can we forecast?*", summer 2005, near Vladivistok, Russia
- NPAFC/PICES Symposium on "*Pacific salmon as indicators of the state of North Pacific ecosystems*" (tentative title), November 2005, Seoul, Korea
- PICES Fourteenth Annual Meeting, September 30-October 8, 2005, Vladivostok, Russia
- ICES/PICES theme session on "*Fisheries, ecology and life history of small pelagic fish*" at the ICES Annual Science Conference, September 2005, Aberdeen, Scotland
- ICES/PICES symposium on "*Marine bioinvasions*", spring 2006, east coast of U.S.A.
- PICES/GLOBEC symposium on "*Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis*", April 19-21, 2006, Honolulu, U.S.A. (see this issue, page 36)
- PICES/ICES Young Scientist Conference, spring 2006 or 2007, venue TBD
- 4th International Zooplankton Production Symposium (co-sponsored by PICES, GLOBEC and ICES), spring 2007, Hiroshima, Japan

PICES/GLOBEC Symposium on *"Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis"*

Symposium description and science themes

Atmospheric forcing, ocean structure, and ecosystem structure and population dynamics vary on many spatial and temporal scales. Dominant temporal scales are diel, seasonal, interannual and longer. In the past ten to fifteen years, marine scientists have begun to document evidence that basin-wide or large-scale changes might be significant forcing for decadal to millennium-scale changes in marine ecosystems. In 1994, the PICES Climate Change and Carrying Capacity (CCCC) Program, a regional program of the IGBP/SCOR/IOC GLOBEC International, was developed to provide a framework for examining climate-ecosystem linkages, mostly on regional scales, but with plans for broader-scale, basin-wide synthesis, in the North Pacific. The primary scientific objective of this symposium is to present a synthesis of the effects of seasonal to multi-decadal variability on the structure and function of the North Pacific that goes beyond the analysis and understanding developed from studies of a single trophic level, process or region—a True Synthesis.

We invite papers that provide interdisciplinary or multi-regional comparisons on the specific science themes of the symposium:

- **Regime shifts**, especially, examination of the ocean and ecosystem responses to known strong, infrequent changes in the North Pacific, such as those that occurred in 1977, 1989, and 1998;
- **Ecosystem productivity and structural responses to physical forcing**, with an emphasis on shorter than inter-decadal time-scales—interannual (El Niño-La Niña), seasonal and event scales; and
- **Pan-Pacific comparisons**, with an emphasis on comparisons of similar species or processes from multiple coastal ecosystems and of open ocean-coastal linkages and climate connections.

Papers on related topics will also be considered.

Dates and venue

The symposium will be held April 19-21, 2006, at the Hawaii Imin International Conference Center (East-West Center) in Honolulu, U.S.A.

Symposium structure

The symposium will have a combination of plenary oral sessions and poster sessions each day. Keynote speakers will provide 40-minute overviews and challenges for each science theme. Contributed papers that are accepted will be 25 minutes in length. Number of posters displayed each day will be limited, and poster-only time will be provided for discussion with authors. The official language of the symposium will be English.

Publication

The symposium proceedings will be published in a refereed journal still to be determined. Papers, including those based on poster presentations, will be considered for publication following peer review. Interested authors will be required to submit one paper copy and an electronic version of their manuscript at the time of the meeting. Copies of the proceedings will be sent to all registered participants.

Registration and abstracts

Those wishing to attend are invited to register and submit abstracts (maximum of 300 words) through the PICES website (http://www.pices.int). **The deadline for early registration and abstract submission is November 4, 2005.** A registration fee of CDN$ 225 (CDN$ 150 for students) will be charged to help cover costs of the symposium. Late registration (after November 4) is CDN$ 325 (CDN$ 225 for students) and subject to availability of space. Because of venue arrangements and the intent for only plenary sessions and posters, we are limited to *ca*. 40 oral talks and 90 poster presentations during this symposium. In the event that response (abstract submission) exceeds this, the Steering Committee will consider abstract merit and relevance, and date of submission in determining abstract acceptance. Authors of accepted abstracts will be notified by January 4, 2006.

Co-Convenors

Harold (Hal) P. Batchelder (Oregon State University, Corvallis, Oregon, U.S.A.)
Suam Kim (Pukyong National University, Pusan, Korea)

NEW!!!!

PICES Report on Marine Ecosystems of the North Pacific

A pre-publication version is available on the PICES Website (http://www.pices.int/publications/default.aspx). Comments and inquiries about this report can be sent to mckinnell@pices.int. A printed version is anticipated in early 2005.

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