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PICES Press

Newsletter of the North Pacific Marine Science Organization (Published semi-annually)

PICES science in 2007

Sixteenth Annual Meeting

PICES XVI was held from October 26–November 5, 2007, at the Victoria Conference Centre in Victoria, Canada. It was hosted by Fisheries and Oceans Canada, and coordinated by the PICES Secretariat. A total of 484 participants from 18 countries attended the 15 sessions, 6 workshops, and 23 business meetings. The Science Board Symposium on "*The changing North Pacific: Previous patterns, future projections, and ecosystem impacts*" opened with a keynote lecture on "*The North Pacific, human activity, and climate change*" by Dr. Kenneth Denman (Fisheries and Oceans Canada and Canadian Centre for Climate Modelling and Analysis). Dr. Denman reviewed some of the human effects on the oceans that change the climate through the burning of fossil fuels, by overfishing, and by physical and chemical alternation of the coastal zone. He urged the development of "end-to-end" foodweb and biogeochemical models and embedding them in comprehensive climate models, and the need for sustained sampling and focused scientific studies in both the coastal and open oceans. The keynote lecture was followed by six invited papers presented by Richard Feely (U.S.A.), Gregory Flato (Canada), Yasunori Sakurai (Japan), Steven Murawski (U.S.A.), Chang-Ik Zhang (Korea) and Gregory Ruiz (U.S.A.), and 7 contributed papers and 9 posters.

PICES XVI will be remembered for a long time for several reasons. Dr. Denman was the first person in PICES history to receive the Wooster Award (see pp. 4–5 in this issue) and to give the keynote lecture. On top of these honours, Ken was also awarded a share of the 2007 Nobel Peace Prize in October 2007, for playing a significant role in the Intergovernmental Panel on Climate Change. It was also the first time at an Annual Meeting that 4 parallel sessions were held in 1 day due to an overwhelming number of contributed papers. PICES XVI lasted longer than usual to allow time for a workshop on the next PICES science program, FUTURE (see pp. 6–7).

Congratulations are in order to winners of the Best Presentation Awards at PICES XVI. These awards are given by the Science Board, Committees or the CCCC Program to scientists who gave the best presentation at a Topic or Paper Session. Recipients for best oral presentations are: Muyin Wang (Science Board), Takumi Nonomura (BIO), Naoki Tojo (FIS), Xuelei Zhang (MEQ), Hiroaki Tatebe (MONITOR), Hitoshi Kaneko (POC), Hanna Na (TCODE), and Tadanori Fujino and Motoko R. Kimura (CCCC). Recipients for best posters are: Goh Onitsuka (BIO), Dongwha Sohn (FIS), Chunjiang Guan (MEQ), Gitai Yahel (MONITOR), Chun-Ok Jo (POC) and Shusaku Kobayashi (CCCC) (see details at www.pices.int/meetings/annual/PICES16/Best_2007/Best_2007.aspx).

Three conferences in 2007

Since the last Annual Meeting in Yokohama, PICES has had a very busy year. A total of 14 meetings were co-sponsored by PICES and convened at various locations around the North Pacific and the world at large. Not only was it a busy year, but it was also an unusual one because PICES was involved in co-sponsoring three major inter-sessional symposia during the spring and summer of 2007.

In May, PICES and ICES worked with the U.S. National Sea Grant College Program and MIT Sea Grant College Program to organize the 5th International Conference on "*Marine Bioinvasions*" in Cambridge, U.S.A. Immediately following this conference, the first ever meeting of the PICES WG on *Non-indigenous aquatic species*, the ICES Working Group on *Introductions and transfers of marine organisms* and the ICES/IOC/IMO WG on *Ballast waters and other ship vectors* was held.

Later that month, the 4th International Zooplankton Production Symposium on "*Human and climate forcing of zooplankton populations*", co-sponsored by PICES, ICES and GLOBEC, was convened in Hiroshima, Japan, after a period of long and meticulous planning. This was the first time this symposium had been held outside of Europe, and its location allowed for greater participation by Pacific Rim countries. Three hundred and thirty-four participants from 46 countries attended this symposium, and presented 141 papers and 250 posters. The symposium was as big as our Annual Meetings and was a great success. Two special publications in the *ICES Journal of Marine Science* and *Deep-Sea Research II* are expected from this symposium.

In June 2007, ICES and PICES joined forces to sponsor a conference for early career scientists on the topic of "*New Frontiers in Marine Science*" in Baltimore, U.S.A. It was conceived at PICES XII (2003, Seoul, Korea) when representatives of the ICES Secretariat proposed the idea for a joint activity to PICES. The conference differed from any that have occurred in PICES' history as it was designed to encourage scientists to meet, share knowledge, and build networks across disciplines and international borders at the early stages in their careers, in the hope that they will last for decades. It was unique in that many of the costs were paid, either in part or in full, by ICES and PICES, and as a result, an "invitation only" model was adopted with the selection of each participant made according to the relevance of their abstracts to the conference theme. Nearly 100 early career scientists from 20 nations attended this conference which featured six theme sessions, each with a keynote speaker, for a total of 65 oral and 33 poster presentations. The conference was a resounding success, accomplishing its goals and more (see PICES Press Vol. 15(2), pp. 11–13). Let us applaud the success of this conference and express our thanks to the Scientific Steering Committee (also early career scientists): Franz Mueter, Sukkyung Kang and Julie Keister (PICES), Elizabeth North, Angel Lopez-Urrutia and Jens Floeter (ICES), and to the coordinators of this conference, Drs. Skip McKinnell from PICES and Adi Kellermann from ICES. And finally, our thanks to NOAA/Fisheries, the North Pacific Research Board, EUR-OCEANS, and the Korean Oceanographic Research and Development Institute for their financial contributions which really helped to make the conference a success. A selection of papers presented at the conference will be published as a section of a regular issue of the *ICES Journal of Marine Science*, with Franz Mueter and Elizabeth North as the Guest Editors.

Excellence in publication

This year has been most remarkable and, indeed, a milestone was reached in the publication of a special issue of *Ecological Modelling* on NEMURO, which stands for "North Pacific Ecosystem Model for Understanding Regional Oceanography", and NEMURO.FISH which is "NEMURO For Including Saury and Herring". This was the culmination of international teamwork and energy over a period of 7 years and 10 international workshops. Drs. Michio Kishi, Bernard Megrey, Shin-ichi Ito and Francisco Werner edited this 17-paper issue. This publication might be the best example to demonstrate why PICES exists and what PICES can do. The editors and contributors dedicated

Zooplanktologists advected into the Hiroshima, Japan, convergence zone in May, 2007 for the 4th World Zooplankton Conference.

this special issue to Dr. Daniel Ware, who was their colleague, mentor, and friend. Dan was the first Chairman of the PICES Science Board who helped guide the establishment of PICES' first science program on Climate Change and Carrying Capacity and later became a key member of its MODEL Task Team within this program.

Two more major publications have just been released: selected papers from the 2006 Symposium to mark the 50th anniversary of Line-P was published in *Progress in Oceanography* (Vol. 75, No. 2) as a special issue entitled "*Time Series of the Northeast Pacific Ocean*" (Guest Editors: Angelica Peña, Steven Bogard and Alexander Bychkov), and a major compendium of papers presented at the 2005 GLOBEC/ESSAS Symposium on "*Climate Variability on Sub-Arctic Marine Ecosystems*" appeared as a special issue of *Deep-Sea Research II* (Guest Editors: George Hunt, Kenneth Drinkwater, Skip McKinnell and David Mackas).

PICES continues to release new volumes in its Scientific Report series. Number 33 is the proceedings of the 2006 PICES/NPRB workshop on "*Integration of Ecological Indicators of the North Pacific with Emphasis on the Bering Sea*". In 2007, PICES also introduced its new electronic Technical Report Series. Technical Report No. 1 entitled "*Metadata Federation of PICES Member Countries*" describes the history of the PICES Metadata Federation Project that PICES initiated with the objectives of creating standardized metadata descriptions of national, institutional and agency databases, and serving those descriptions in a World-Wide-Web-based, one-stop environment with search and delivery capabilities. This is a living document and the goal is to keep it current.

The much anticipated "*Guide to Best Practices for Ocean CO_2 Measurements*" is being published as *PICES Special Publication No. 3*, and is edited by Andrew Dickson, Christopher Sabine and James Christian. This Guide will allow scientists from different countries to use the same standardized methods for their surveys and will allow a Pacific-wide ocean CO_2 synthesis based on these surveys.

Forthcoming in 2008 and beyond

Next year, in addition to the publications from the 4th International Zooplankton Production Symposium, the 5th International "*Marine Bioinvasions*" Conference and the ICES/PICES Early Career Scientists Conference, we expect to see several special issues of primary journals. For example, selected papers from the PICES XV Topic Session on "*The human dimensions of jellyfish blooms*" will be published in *Plankton and Benthos Research*; papers from the SEEDS-II experiment will appear in *Deep-Sea Research II*; a set of papers from the 2006 PICES/GLOBEC Symposium on "*Climate variability and ecosystem impacts on the North Pacific: A basin-scale synthesis*" will be published in *Progress in Oceanography*; and selected papers from the CREAMS/PICES Workshop on "*Model-data inter-comparison for the Japan/East Sea*" in the *Journal of Marine Systems*.

Several international symposia of interest to PICES are awaiting your participation. In May 2008, an International Symposium on "*Effects of climate change on the world's oceans*" will be held in Spain, co-sponsored by ICES, PICES and IOC, with support from other organizations. This meeting will be followed by an International Symposium on "*Coping with global change in marine social-ecological systems*" to be held in Rome in July 2008. In August 2008, an International Symposium on "*Herring: Linking biology, ecology and status of populations in the context of changing environments*" will be held in Galway, Ireland, co-sponsored by ICES, PICES and GLOBEC.

The new Science Program, FUTURE, will be launched at PICES XVII to be held in October 2008, in Dalian, China, with a meeting theme of "*Beyond observations to achieving understanding and forecasting in a changing North Pacific: Forward to the FUTURE*". Science Board has approved many exciting sessions and workshops for PICES XVII, and has also begun preparing for PICES XVIII (Busan, Korea, 2009). Bring your ideas to Dalian so they can be built into the plans.

Dr. Kuh Kim receives a hand-carved maple vase from Dr. Tokio Wada, PICES Chairman, in appreciation for his service as Chairman of Science Board (November 2004–November 2007).

I would like to conclude the 2007 report with my personal note. What is PICES? When I first attended PICES Annual Meeting about 10 years ago, I did not know what PICES stood for. I thought it should be NPMSO (North Pacific Marine Science Organization). After serving three years as the Science Board Chairman, I have learned that **P** means *Partnership*, **I** is for *Interdisciplinary*, **C** means *Collaboration*, **E** is for *Exploration*, and **S** is, of course, for *Science*. At the same time **S** in PICES means, I believe, *Service*. PICES should serve the people around the North Pacific Ocean and PICES should also serve the North Pacific itself for the generations to come.

Kuh Kim
PICES Science Board Chairman
E-mail: kuhkim@snu.ac.kr

2007 Wooster Award

Prof. Warren S. Wooster, the principal founder and the first Chairman of PICES.

In 2000, PICES established an award for scientists who have made significant contributions to North Pacific marine science, who have achieved sustained excellence in research, teaching, or administration, who have worked to integrate the various disciplines of the marine sciences, and preferably, all of these in association with PICES. The award was named in honour of Prof. Warren S. Wooster, the principal founder and the first Chairman of PICES, a world-renowned researcher of climate variability and fisheries production, and an ambassador of international scientific cooperation.

This year's Wooster Award presentation ceremony took place on October 29, 2007, during the Opening Session of the PICES Sixteenth Annual Meeting in Victoria, Canada. Drs. Tokio Wada, PICES Chairman, and Kuh Kim, Science Board Chairman, conducted the ceremony. Dr. Kim announced that **Dr. Kenneth L. Denman** (Fisheries and Oceans Canada and Canadian Centre for Climate Modelling and Analysis) was the recipient of the 2007 Wooster Award and presented the following Science Board citation (reading of the citation was accompanied by a special slide show dedicated to Dr. Denman).

The list of previous Wooster Award recipients places this year's winner among a distinguished company of scientists. Previous recipients include Prof. Michael Mullin (2001), Prof. Yutaka Nagata (2002), Prof. William Pearcy (2003), Prof. Paul LeBlond (2004), Dr. Daniel Ware (2005) and Dr. Makoto Kashiwai (2006). It gives me great pleasure to announce that the Wooster Award for 2007 is being given to Dr. Kenneth L. Denman, a world-renowned inter-disciplinary ocean scientist.

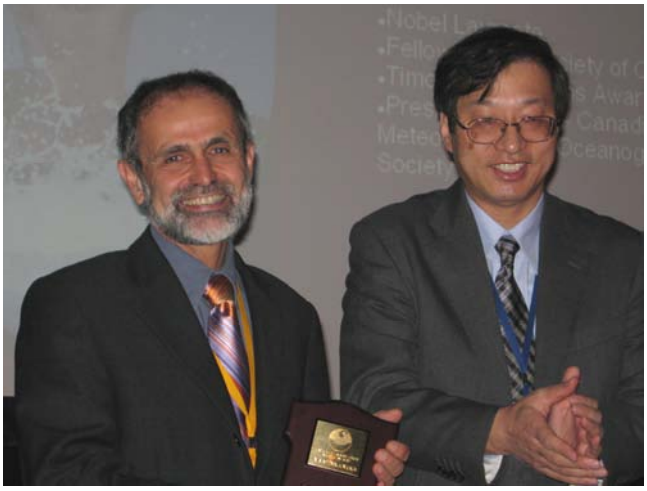
Ken has authored more than 75 primary journal articles, book chapters or review papers on air–sea interaction, lower trophic-level biological production, and the role of the ocean in the global climate system. He was born and raised in the city of Calgary, Alberta. For those of you unfamiliar with Canadian geography, Calgary is located in the transition zone between the foothills of the Rocky Mountains and the vast Canadian prairie. Calgary is a long, long way from any ocean. As you will see in the accompanying photos, Ken never lost his affinity for mountains.

After completing a Bachelor of Science degree at the University of Calgary, Ken began graduate studies in physical oceanography at the Institute of Oceanography at the University of British Columbia, under the direction of Prof. Mike Miyake. The Institute was best known at that time for its advanced work on air–sea interaction, but the influence of Prof. Tim Parsons and others at the Institute stimulated what were, at the time, novel interdisciplinary collaborations. This was to have a significant effect on Ken's career.

With his shiny new Ph.D. in hand, Ken took a position as junior scientist at the Bedford Institute of Oceanography where he worked closely with Trevor Platt. They applied approaches used in meteorology and physical oceanography to the study of plankton. This was an important contribution to biological oceanography as the field was then dominated by descriptive science. The application of advanced analytical techniques to field data, satellite observations and numerical models is a hallmark of Ken's career.

In 1977, he returned to the Pacific coast as a research scientist in the Ocean Ecology Laboratory at the newly constructed Institute of Ocean Sciences (IOS). He continued to apply advanced techniques to practical problems in biological oceanography. In recognition of his skill, energy and leadership, Ken was promoted to senior positions in science and management in the Department, where Ken eventually discovered his deep dislike for matters of bureaucracy and administration, and returned to being a senior research scientist at IOS.

Having bridged the fields of physical and biological oceanography, Ken turned his attention to chemistry, to the ocean carbon cycle, and to its importance in the global climate system. He played a leading role in many aspects of both the international and Canadian JGOFS, GLOBEC and SOLAS programs. These interests ultimately led him to work on the Intergovernmental Panel on Climate Change (IPCC) as a convenor and lead author in the 1995 Assessment, and as coordinating lead author for the Fourth Assessment Report that was completed last spring. He shares with his IPCC colleagues the reward of a Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change."



Dr. Kenneth Denman receiving congratulations from PICES Chairman, Dr. Tokio Wada.

Dr. Kenneth Denman at the IPCC (Intergovernmental Panel for Climate Change) meeting in Paris 2007.

Ken was very active in the earlier history of PICES. He was a Canadian member of the BIO Committee from its very first meetings until 2000, a member of Working Group 6 on the Subarctic Gyre, *and Working Group 7 on* Modeling Ocean Circulation. *He worked to integrate the JGOFS North Pacific Task Team into PICES activities. In addition to his personal contributions to science, he also mentored, encouraged and entrained younger scientists into PICES activities. Many of these individuals are in the room today – you know who you are!*

Ken has been an adjunct professor at both the University of Victoria and the University of British Columbia, and for the last several years, he has been spending most of his time working at the Canadian Centre for Climate Modelling and Analysis, a branch of Environment Canada located on the campus of the University of Victoria. There, he is engaged in an interdepartmental effort to develop a global atmosphere, land and ocean climate model, complete with an ocean carbon cycle.

Please join me in congratulating Dr. Kenneth Denman as the 2007 Wooster Award winner.

Prof. Wooster was unable to join this ceremony, but sent the following accolade that was read by Dr. Wada:

It is a privilege to endorse the selection of Ken Denman for the Wooster Award, not only for his many services to PICES but also for his cross-disciplinary scientific approach that epitomizes the aspirations of PICES from its inception. When I read his list of research interests and resulting publications, I see them all as significant contributions to the unifying question that has motivated the organization from the beginning – "What is the nature of the subarctic Pacific ecosystem and how is it affected over periods of months to centuries by changes in the physical environment, by interactions among components of the ecosystem, and by human activities?" *In particular, he has brought his insight as a physicist to an assessment of the physical and biological mechanisms whereby these ecosystem changes are effected. It is through the efforts of Ken Denman and his colleagues, and the support of organizations such as PICES, that we can hope one day to establish a more sustainable relationship with the North Pacific and its flora and fauna.*

Dr. Wada presented a commemorative plaque to Dr. Denman (a permanent plaque identifying Wooster Award winners resides at the PICES Secretariat), who accepted the award with the following remarks:

It is a great honour and privilege to be selected as the recipient of the 2007 Wooster Award. The citation is very flattering, and I would like to thank the people who nominated me for the award. I first went to Ocean Station Papa in May 1972, early in the 51 years of oceanographic sampling there, although at the time I thought that it was already a very long time series. Since then, except for five years when I worked at the Bedford Institute of Oceanography in Halifax on Canada's Atlantic coast, I have worked towards understanding first the physics, then the planktonic ecology, and more recently the biogeochemistry of the subarctic Northeast Pacific Ocean. Two Canadian scientists from the Department of Fisheries and Oceans influenced my scientific path early on. First, Sus Tabata had published two fascinating papers on the time series measurements at Ocean Station Papa that guided my Ph.D. thesis research on the dynamics of the upper mixed layer of the ocean. Second, Tim Parsons, as I was finishing my thesis, encouraged me to look beyond physics and apply my expertise in physics to the planktonic ecosystem and related biogeochemical cycles. I followed his advice and as a result have had a wonderful and fascinating career studying the interactions between physical, biological and chemical processes in the North Pacific. So, I thank you all for this great honour, and I thank Warren Wooster for his vision and perseverance in getting PICES started.

FUTURE – A milestone reached but our task is not done

by John Stein

At this year's Annual Meeting, PICEanS took a major step forward when Governing Council approved the FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) science plan. Congratulations to all because it was a collective effort that got us to this important milestone. To be more precise, Governing Council gave approval-in-principle to our next integrative science plan, with final approval to come once the final draft is completed: now a top priority. So there is more to do: we have to finish the science plan and then immediately start developing an implementation plan for FUTURE.

The need for a new scientific program in PICES was identified by Science Board at the Thirteenth Annual Meeting in October 2004, in Honolulu, U.S.A. FUTURE was then one of six candidate programs discussed at the Fourteenth Annual Meeting in 2005, in Vladivostok, Russia. It emerged as the preferred option during the course of various meetings in 2006, including the Fifteenth Annual Meeting Open Forum, and culminating in a second Open Forum and a Workshop at the Sixteenth Annual Meeting in 2007, in Victoria, Canada.

Many colleagues have to be acknowledged for their commitment to developing this new, 10-year integrative science plan; however, listing each is not practical. So let me start by thanking everyone in PICES who contributed oral or written comments at Committee meetings or at the Open Fora. Special thanks go to the Writing Team of our Study Group on Future Integrative Scientific Program(s) (SG-FISP): their very active participation led to our new Science Plan. Although it took many months to reach consensus, it was very important to ensure that everyone had an opportunity to express their views in order to produce a plan that most scientists in PICES could support. While some had, and may still have, concerns on various aspects of the objectives or approaches described in FUTURE – that is the nature of science. Finally, my thanks to Science Board and Governing Council for their sustained interest, support and participation at key times as we worked (and occasionally struggled) to arrive at a plan that resonates with PICES goals, is scientifically relevant, and is compelling to the constituents who support our scientific activities. I think we have accomplished these objectives with this science plan.

What is the FUTURE?

FUTURE is a science program to be undertaken by PICES member countries to *understand* the responses of marine ecosystems in the North Pacific to climate change and human activities at basin-wide and regional scales, to *provide forecasts* of what might be expected based on current understanding, and to *communicate* this information effectively to their members and to society in general.

Why is PICES taking this direction?

FUTURE was motivated by a growing societal concern for the future of marine ecosystems, given an increasing awareness of the potential threats to the diverse benefits that are derived from them. The threats include:

- Diminished resiliency and productivity of marine ecosystems and their components;
- Irreparable damage to non-renewable resources;
- Loss (or change) of socioeconomic opportunities;
- Increasing risks and uncertainty.

The combined pressures of climate change and a growing human population, with the associated human activities in and around the oceans, are a major impetus for the central scientific issues. These pressures affect the composition, structure, and function of North Pacific ecosystems in ways that are not completely understood. The rapidity of recent changes is unprecedented in the human experience.

To increase our understanding there is a need to examine closely the mechanisms for an ecological response to change. To be policy-relevant it is a necessary to develop forecasting capabilities of known reliability to quantify both the risks and uncertainties of the consequences of the major pressures. Finally, a strategy is required to communicate those forecasts effectively for their implications to be known and useful in a policy context.

What are the challenges?

FUTURE addresses a large and complex set of problems, to which our member countries must respond. While the trajectory of some of the major effects is known generally, there is great uncertainty about the magnitude of the changes and the consequences of interactions among them. This uncertainty is caused by an inadequate understanding of the mechanisms by which the pressures affect ecosystem composition, structure and function, and the linkages among oceanic, coastal and terrestrial ecosystems. These uncertainties hamper the ability of science to provide reliable estimates of known precision of the future status of the ecosystems of a region. Hence, the goals of FUTURE are to improve these abilities and to communicate expectations effectively. By so doing, science will be more policy-relevant by providing a better appreciation of the consequences of change and variability in the North Pacific.

What are the major questions?

> *"Given current and expected pressures, what is the future of the North Pacific?"*

This overarching question will guide FUTURE's activities for the next decade. Three themes will organize the research to address this question:

1. What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing?
2. How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future?
3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

Expected outcomes

- Better understanding of the processes that link climate, physics, chemistry, biology, and humans to provide a better understanding of how anthropogenic and climate pressures have and will affect ecosystems;
- Better quantitative and qualitative forecasts of ecosystem change, with uncertainty measures;
- Improved scientific basis for managing coastal ecosystems to sustain ecosystem services and to mitigate environmental problems;
- Quantification of the benefits and risks associated with different management strategies;
- IPCC-like reports (*e.g.*, IPCC Part 2) on marine ecosystem responses to climate change;
- Regional assessments of emerging topics (*e.g.*, HABs, eutrophication, ocean acidification);
- Coordinated monitoring and nowcasts of the current state of ecosystems;
- Increased data sharing, access and dissemination, with a focus on coordination and metadata;
- Increased capabilities in PICES member countries.

> *"The challenge is not only to improve our understanding of the North Pacific Ocean, including its climate, biological processes and human activities, but to communicate this information effectively to governments and society at large so they can establish policies and directions that anticipate change."*

With FUTURE, PICES is setting goals that are challenging but can be achieved if we are effective in communicating the value and benefits of FUTURE to agencies and organizations in our member countries. I am convinced that we will be successful if we address the challenges described below. A key ingredient of scientific success is an improved, effective communication of the program's value and benefits to society.

Where do we go from here?

Our first job is to finalize the science plan for final approval by Governing Council. Thereafter, an inter-sessional Science Board meeting and workshop will be held April 23–25, 2008, to begin the implementation phase of FUTURE. A key task is appointing the Implementation Plan Writing Team. The agenda of the workshop will include: discussing the organizational structure for FUTURE, developing a detailed outline for the Implementation Plan, determining the composition of the Writing Team and establishing the timeline.

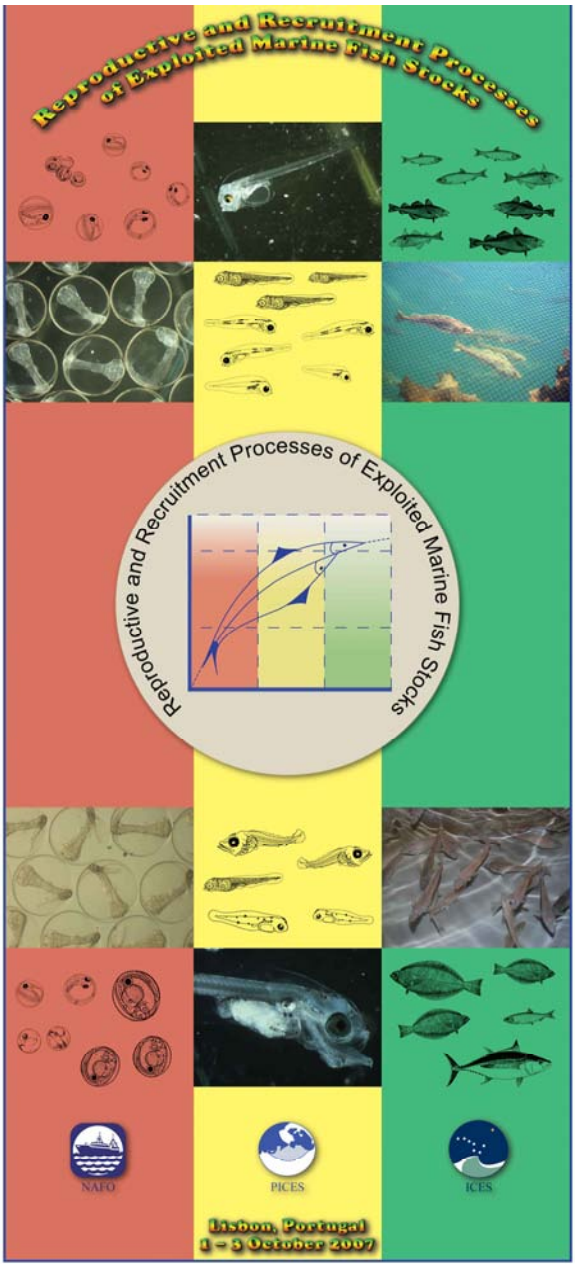
Once the Implementation Plan Writing Team is in place, PICES will establish dates shortly after the inter-sessional Science Board meeting, with the initial objective of developing a first draft. This approach worked well to develop the implementation plan for the CCCC Program, so I recommend the same approach be used to develop the implementation plan for FUTURE. I expect that a full draft of this plan would be available by September 2008, for review by Science Board, Governing Council and the PICES community. The draft plan could be presented at an Open Forum during the Seventeenth Annual Meeting in Dalian, China, with the intent to seek approval-in-principle from Governing Council at this meeting. If we can meet this timeline, FUTURE would likely begin in early 2009.

In closing, we took a significant step at the last Annual Meeting towards making the next integrative science plan of PICES a reality. While that accomplishment is worth celebrating, there is much to be done in implementing the plan so that it is effective in answering the questions posed in FUTURE. To be effective we must have a structure that builds on the "lessons learned" in the CCCC Program and that can be sustained by the Organization. Finally, the latest IPCC reports have highlighted the value and continued need for multi-national science programs that address key societal questions at multiple scales and devote focused effort on how to communicate the science so that it has clear and tangible benefits to difficult decisions that confront societies. Improved forecasts and understanding of ecosystem responses to human activities and environmental variability will be essential to meet societal needs for establishing sound policies and directions that anticipate change and either adapt to the change or mitigate the impacts where possible. Through FUTURE, PICES can do its part in meeting this challenge, and now it is up to us to deliver, as I know we can.

International symposium on *"Reproductive and Recruitment Processes of Exploited Marine Fish Stocks"*

by Richard D. Brodeur and Suam Kim

The North Pacific Marine Science Organization (PICES), the Northwest Atlantic Fisheries Organization (NAFO) and the International Council for the Exploration of the Sea (ICES), sponsored an international symposium on "*Reproductive and Recruitment Processes of Exploited Marine Fish Stocks*" held on October 1–3, 2007, in Lisbon, the historic capital of Portugal. The symposium was organized by the NAFO Secretariat and convened by Drs. Edward A. Trippel (representing NAFO), Richard D. Brodeur (PICES) and Mark Dickey-Collas (ICES), with support from a Scientific Steering Committee that included Drs. Suam Kim (Korea) and Jie Zheng (U.S.A.) from the PICES community.



It has been almost a decade since the topic of fish reproduction and recruitment has been addressed at a symposium, and it was felt that this area of research was ripe for an attempt at integration and synthesis. The participation by the scientific community reflected this as 151 scientists and managers from 23 countries and 6 continents attended this 3-day symposium and presented 52 talks and 70 posters.

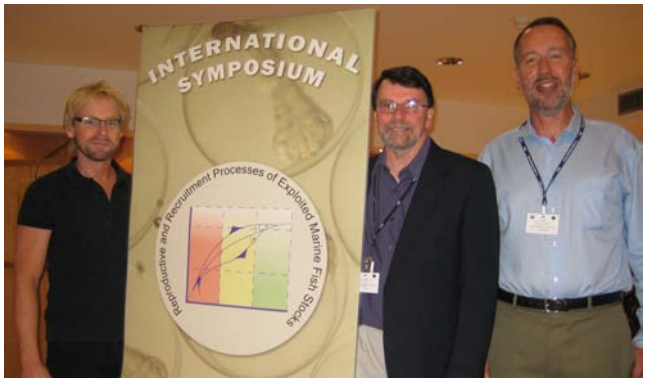
The symposium was led off with a stimulating keynote talk by Dr. Ed Houde of the University of Maryland entitled "*Emerging from Hjort's shadow*", which outlined the history of recruitment research starting with the famed Norwegian scientist Johan Hjort (1869–1948), who introduced the "critical period" hypothesis that framed much of the early research on recruitment. Dr. Houde brought us up to date on the current thinking on the physical and trophodynamic factors that affect fish survival and, ultimately, recruitment. He also challenged us to examine paradigms currently directing research on fish reproduction and recruitment, and highlighted some of the recent advances made by many interdisciplinary programs initiated in the last couple of decades on these topics. Dr. Houde emphasized that all life stages of fishes are important in generating variability, and thus are potentially critical in generating year-class fluctuations. He concluded by stating that: "*Solving the recruitment problem is no longer the holy grail of fishery science. Appreciating recruitment variability, explaining probable causes, considering implications for management, and understanding it in the context of broader variability in marine ecosystems are worthy goals.*"

The overall meeting was structured along four main themes, each with two invited presentations and a number of contributed talks. The first theme dealt with "*Age and size at sexual maturation*", with invited talks from Drs. Tara Marshall (UK) and Mikko Heino (Norway). The second was "*Fecundity and spawning success*", with keynote addresses by Drs. Yvan Lambert (Canada) and David Armstrong (U.S.A.). Then the emphasis shifted to "*Survival of eggs and larvae*", with invited presentations by Drs. Brian McKenzie (Denmark) and Yoshiro Watanabe (Japan). The final theme integrated among the previous topics with a slant toward "*Stock assessment and management implications*", with a diverse spectrum of presentations and with invited talks by Drs. Joanne Morgan (Canada) and Louis Botsford (U.S.A.). Ending up on a

positive but cautionary tone, Dr. Keith Brander (ICES) summed up the presentations and gave his take on the progress in the field and suggested that the future will not be like the past, and we need to take a precautionary approach in managing fluctuating populations. He left us with the challenge "*How can we use all our new knowledge to guide sustainable management of marine ecosystems?*"

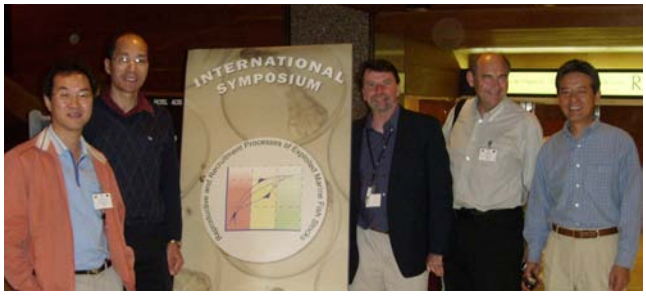
Similarly, the poster session held on the first evening had representation from a broad spectrum of topics and species of interest, with a strong representation of management applications. Although the majority of talks and posters examined finfish in marine waters, there were also several presentations on commercially important shellfish which have their own unique reproductive and life history patterns (sperm storage, multiple paternity). There was even a talk on freshwater fish reproduction and recruitment, and how these processes differed from those in the marine environment.

Altogether, the symposium was declared to be a successful integration of current thinking on these processes which may regulate production of most fish species. Several talks pointed out that due to the substantial variation in maturity rates, sex ratios, fecundity, spawning frequency, and viability of eggs, we can no longer use spawning stock biomass as an indication of reproductive output. The integration of management principles along with the science is a critical element, considering the present depressed state of many fish stocks and the potential for unknown trajectories in the presence of climate and anthropogenic changes that are occurring in most marine ecosystems. It is planned that suitable manuscripts from the meeting will be published in a special volume of the *Journal of Northwest Atlantic Fishery Science* in 2009. We feel that the PICES community can learn much, particularly in the area of maturation and egg production, from our Atlantic colleagues, who are perhaps a bit more cognizant of maternal as well as fishing effects on reproduction and ultimately fishery management and stock rebuilding policy, than we are in the Pacific Ocean.



Symposium convenors (left to right): Drs. Mark Dickey-Collas (ICES), Richard Brodeur (PICES) and Edward Trippel (NAFO).

Dr. Ed Houde (University of Maryland, U.S.A.) delivers the keynote address at the symposium.



PICES representatives at the symposium (left to right): Drs. Suam Kim (Korea), Jie Zheng (U.S.A.), Richard Brodeur (U.S.A.), Douglas Hay (Canada) and Yoshiro Watanabe (Japan).

Dr. Richard Brodeur (Rick.Brodeur@noaa.gov) is a Research Fisheries Oceanographer working at the Northwest Fisheries Science Center, NOAA Fisheries, and is based in Newport, OR. Ric received his B.S. in Fishery Science from the University of Massachusetts, his M.S. in Oceanography from Oregon State University, and his Ph.D. in Fisheries from the University of Washington. His dissertation research examined the feeding ecology of juvenile salmon and its relationship to ocean carrying capacity. Following a postdoctoral position at the Pacific Biological Station in Nanaimo, B.C. Canada, he began his career working on early life history and recruitment dynamics of walleye pollock in the Gulf of Alaska and Bering Sea for the Alaska Fisheries Science Center. He returned to Oregon to work again on habitat preferences and trophic ecology of juvenile salmon and other pelagic fishes as well as recruitment processes in marine fishes. Ric has been heavily involved with PICES, serving on several committees and working groups and organizing a number of special sessions at past meetings. He has published on a variety of topics ranging from satellite oceanography to fish bioenergetics to fisheries acoustics, but has focused much of his research on feeding and food web interactions centering on nekton.

Dr. Suam Kim (suamkim@pknu.ac.kr) received his B.Sc. (1976) and M.Sc. (1979) in Oceanography from the Seoul National University and his Ph.D. in Fisheries Oceanography from the University of Washington in 1987. Currently he is a professor of the Pukyong National University, in Busan, Korea. He served as the Director of the Polar Research Center of the Korea Ocean Research and Development Institute (KORDI) and Chairman of Korea GLOBEC. His areas of interest include fisheries ecology, especially recruitment variability focusing on early life histories of fish in relation to oceanic/climate changes. Suam represented Korea on several international organizations/programs such as PICES (Co-Chairman of the CCCC Program), GLOBEC (SSC member), CCAMLR (Vice-Chairman of the Scientific Committee), IPCC (Expert reviewer for the Fourth IPCC Report), IGBP and SCAR.

Recent results of the micronekton sampling inter-calibration experiment

by Orio Yamamura

Micronekton (osteichthyes, cephalopods and crustaceans) are ubiquitous in oceanic and neritic areas and are an important component of marine ecosystems. In terms of body size and swimming ability, they are intermediate between mesozooplankton and nekton, so they have an important role in transporting organic materials from the productive euphotic zones to the less productive mesopelagic layers through diurnal vertical migration. Furthermore, in subarctic ecosystems micronekton have indispensable roles in smoothing the seasonal variation of prey availability during the less productive autumn and winter seasons.

MIE-1 cruise

The PICES Working Group (WG 14) on *Effective sampling of micronekton* was established in 1997, under the direction of the Biological Oceanography Committee, to tabulate information on micronekton in the North Pacific, including taxonomic composition, biomass, sampling methods and trophic relationships. At the recommendations of WG 14, PICES formed an Advisory Panel on *Micronekton sampling inter-calibration experiment* (MIE-AP) in 2002, to conduct a field study to compare micronekton sampling gears and other quantifying technologies such as acoustics and visual sampling methods. The initial field survey, MIE-1, was carried out aboard the NOAA R/V *Oscar Elton Sette* in October 2004, off Oahu, Hawaii. Three sampling gears were compared: a 140-m pelagic Cobb trawl, a 4-m Hokkaido University Rectangular Frame Trawl (HUFT), and a 1.8-m Isaacs-Kidd Mid-water Trawl (IKMT). For detailed description and results of that survey, please refer to Brodeur *et al*. in PICES Press Vol. 13(1), pp. 7–11.

MIE-2 cruise

In September–October 2005, AP-MIE conducted its second cruise aboard the R/V *Hokko-maru* (902 t) of the Hokkaido National Fisheries Research Institute (HNFRI), Japan. *Hokko-maru*, launched in 2004, is a state-of-the-art 65-m stern trawler with a MOCNESS-10 and has capabilities to deploy other mid-water sampling gears, including stern trawls equipped with a MULTI-SAMPLER (an opening-closing multiple cod-end system, Simrad Inc.). Other gears compared during the cruise were the Matsuda–Oozeki–Hu Trawl (MOHT; Oozeki *et al*., 2004) and HUFT (**Fig. 1**). The former gear is a 5-m^2 rectangular mid-water trawl with a newly developed depressor, which enables the net to be towed at a desired depth at higher speed (5 knots) with a near perpendicular and stable angle of 8°. For the latter gear, two nets with different mesh sizes (3 mm and 9 mm) were used separately. In addition to the sampling gears, backscattering from the scattering layers was recorded using a Simrad EK-60 echosounder with 38, 70, 120 and 200 kHz transducers. The scientists onboard were: Orio Yamamura (HNFRI), Hiroya Sugisaki (Tohoku NFRI), Kazuhiro Sadayasu, Shinsuke Abe and Ryuichi Matsukura (all Hokkaido University). Since the cruise overlapped the dates of PICES XIV in Vladivostok, Russia, members of AP-MIE from countries other than Japan were not able to participate in the cruise.

Basically, every fishing gear was towed at 4 stations which were all located at the outer shelf of the Doto area, off southeastern Hokkaido Island (bottom depth 380–480 m), during the daytime and nighttime, with an exception of MT (rope trawl with multi-sampler), which was towed at

Fig. 1 Comparison of sampling gears during the MIE-2 cruise: MOHT (left top), MOCNESS-10 (right top), rope trawl with multi-sampler (left bottom), and HUFT (right bottom).

2 stations only during the daytime. Every gear sampled the 0–300 m layer. In total, the myctophid *Diaphus theta* was dominant in both numbers (>80%) and weight (>70%). A brief comparison of catch efficiency of different gears for *D. theta* revealed that MOHT was evidently the most effective gear for the sampling of micronekton (**Fig. 2**).

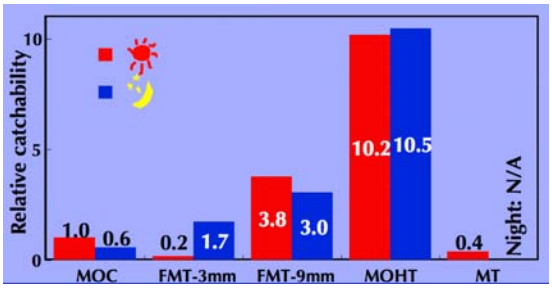


Fig. 2 Comparison of catchability (number of Diaphus theta *(in >40 mm SL) per volume of seawater filtered) for different sampling gears during MIE-2: MOCNESS-10 (MOC), Hokkaido University Frame Trawl (FMT), Matsuda–Oozeki–Hu Trawl (MOHT), and rope trawl with multi-sampler (MT). Numbers are standardized so that MOCNESS-10 during daytime = 1.0.*

MIE-3 cruise

After the MIE-2 cruise, AP members were keen to find ship time for some unfinished business. A direct comparison between IKMT and MOHT was essential because there are so much historical data collected with an IKMT. After two years, the third experiment was carried out onboard the R/V *Oscar Dyson* in the eastern Bering Sea, from September 18–27, 2007. Despite the vessel being engaged in an NPAFC/BASIS salmon survey, Dr. Jim Murphy of the Auke Bay Laboratory (NOAA/NMFS) kindly donated ship time for our experiment. The scientists participating in the experiment were: Orio Yamamura (HNFRI), Hiroki Yasuma (HU) and Andrey Suntsov (NWFSC, NOAA). Although 48–72 hours of ship time were expected for the experiment, the actual duration was only 24 hours due to the extraordinarily rough weather in the Bering Sea during autumn. The gears compared during this cruise were a 1.8-m IKMT and a MOHT. A Cantrawl 300/262 rope trawl was also included in the arsenal, but the limited time window excluded this gear from the comparison. To reduce the time required for each deployment, a site adjacent to St. Paul Island, with a bottom depth of *ca*. 60 m, was chosen for the experiment where age-0 walleye pollock were densely distributed. The sampling was in a day/night sequential design, in which different gears were towed sequentially at each location, with triplicate samples collected during daylight and night at the same ship speed (3 knots). Aside from the sampling gears, backscattering from the scattering layer was recorded using a Simrad EK-60 echosounder with 15, 38, 70, 120 and 200 kHz transducers. The catch was dominated by age-0 walleye pollock (>99%), offering a good opportunity for gear comparison (**Fig. 3**). The catchabilities of the nets were compared by relative number of pollock per volume of seawater filtered by the nets. The nets showed similar catchability during the daytime (1.1 times larger for MOHT in density estimate), but MOHT showed significantly higher catchability in night sampling (2.8 times higher). The fact that the catch efficiencies during the daytime were similar for both gears indicates that visual avoidance by age-0 pollock was virtually identical between these gears. The 2.8 times difference for nighttime tows may represent the difference in the stability of net angle and net mouth opening during hauls.

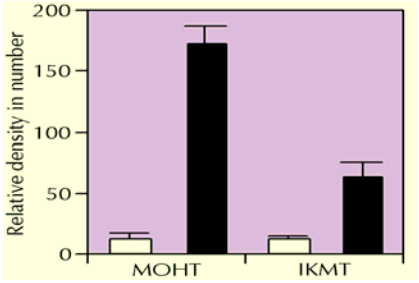


Fig. 3 Comparison of catchability (number of walleye pollock per volume of seawater filtered) between MOHT and IKMT during MIE-3; open bars: daytime, solid bars: nighttime.

How do we proceed?

We have undertaken 3 inter-calibration experiments, providing data for direct and indirect comparison of 8 different micronekton sampling gears. The results suggest that MOHT is the most reliable sampling gear for micronekton. Nevertheless, a brief comparison between acoustic and net sampling suggests that MOHT still underestimates the standing stock by >50%. Fortunately, some data sets are available for direct comparison between results of acoustic and net sampling. We are planning to include a comparison in the final AP-MIE report to be submitted to BIO next fall at PICES XVII in Dalian, China.

Dr. Orio Yamamura (orioy@affrc.go.jp) is a Fisheries Biologist working for Ecosystem Studies in Hokkaido National Fisheries Research Institute (HNFRI), Kushiro, Japan. He received his M.S. and Ph.D. in Marine Ecology from Hokkaido University and then began his career at HNFRI. Orio's research focuses on topics ranging from trophodynamic processes of walleye pollock in the coastal area to carrying capacity for salmonids in the Bering Sea. Since 2005, he has supervised the Steller sea lion research program in Hokkaido Island. Orio co-chairs the PICES Advisory Panel on Micronekton sampling inter-calibration experiment.

2007 PICES workshop on "*Measuring and monitoring primary productivity in the North Pacific*"

by Paul J. Harrison and Sei-ichi Saitoh

Marine net primary productivity is a key metric of ecosystem health and carbon cycling, and is commonly a function of plant biomass, incident solar flux, and a scaling parameter that accounts for variations in algal physiology. Net primary productivity is defined as the amount of photosynthetically fixed carbon available to the first heterotrophic level, and is the relevant metric for addressing environmental questions ranging from trophic energy transfer to the influence of biological processes of carbon cycling. Long-term monitoring of primary productivity is a high priority for PICES member countries, because it is one of the essential parameters needed for the understanding of marine ecosystems and biogeochemistry. Recently, measurement technology of primary production has become extremely advanced through the application of fast repetition rate fluorometers, satellites, buoys, *etc*. However, inconsistencies between *in situ* measurements and satellites still exist, and there are some differences between the values obtained with ^{13}C and ^{14}C isotopic methodology. The workshop on "*Measuring and monitoring primary productivity in the North Pacific*" was developed by the BIO (Biological Oceanography) and MONITOR Committees and was held on October 27, 2007, at the PICES Sixteenth Annual Meeting in Victoria, Canada. The convenors were Drs. Paul J. Harrison (Hong Kong University of Science and Technology, Hong Kong) and Sei-ichi Saitoh (Hokkaido University, Japan).

Workshop convenors: Drs. Sei-ichi Saitoh (Japan) and Paul J. Harrison (Hong Kong).

The workshop aimed to discuss the state-of-the-art of primary productivity measurement technology and its application to understanding primary productivity in the North Pacific. There were 2 invited and 4 contributed talks and 1 poster. Presentations addressed techniques for measuring primary productivity, compared *in situ* and satellite measurements of primary productivity, demonstrated the utility of long time series measurements in understanding ecosystem variability, and described the application of primary productivity studies to marine ecosystems and biogeochemistry.

Our first invited speaker, Dr. Michael Behrenfeld (Oregon State University, U.S.A.), gave an excellent overview of the differing seasonal cycles in North Pacific phytoplankton discerned through changes in chlorophyll (Chl) and carbon (C) biomass, and discussed the implications of these two different viewpoints on uncertainties in net primary productivity estimates. Discrepancies between Chl and C biomass reflect physiological acclimations to light, nutrient and temperature variability. Light variability plays an important role in Chl:C changes throughout the North Pacific, but in the eastern subarctic, iron stress also has a major effect. He raised a number of questions for future studies which are highlighted in the recommendations.

In another invited talk, Dr. Toshiro Saino (Nagoya University, Japan) explained his new *in situ* ocean primary productivity profiling system that was developed to measure ocean primary productivity for real time validation of satellite-derived primary productivity estimations. The system uses a fast repetition rate flourometer (FRRF) installed on a profiling buoy tethered to an underwater winch. These FRRF measurements of gross primary productivity were compared with the oxygen-17 anomaly in dissolved oxygen, which measures gross primary productivity over time scales of a week to 10 days. It was also suggested that if the oxygen-17 anomaly method is combined with the oxygen/argon (or nitrogen) ratio, it can provide, in addition to gross primary production, net community production and total (algal + heterotrophic) respiration, which are parameters that are central in carbon cycle studies. The FRRF measurement could *objectively* be validated with that method, and hence the FRRF measurements could be a standard method of primary productivity measurement in place of ^{14}C incubations. The use of FRRF measurements for validation of satellite-based estimates of gross primary productivity was recommended.

Dr. Sinjae Yoo (Korean Ocean Research and Development Institute, Korea) reported on the challenges of measuring Chl and primary productivity in the very turbid Yellow Sea. He divided the Yellow Sea into different zones and different seasons. In the center of the Yellow Sea, estimates were more accurate in summer than in winter, because the Yellow Sea is very turbid in winter due to wind mixing which produces a large overestimate of chlorophyll.

Workshop invited speakers: Drs. Toshiro Saino (Japan) and Michael Behrenfeld (U.S.A.).

Dr. Sei-ichi Saitoh showed that primary productivity is increased several weeks after the passage of the typhoons, with slow passage of the typhoon and strongest winds giving the highest primary productivity. The number of typhoons has increased in the last 15 years and average primary productivity has increased also; these increases may be related to the warming of the sea surface. Typhoons appear to be more frequent in warmer El Niño years.

Drs. Akihiro Shiomoto (Tokyo University of Agriculture, Japan) and Paul Harrison discussed primary productivity in the North Pacific. Dr. Shiomoto reported that primary productivity in winter is 2 to 3 times lower at Station KNOT (NW Pacific) due to lower light, compared to Station P (NE Pacific). Also at Station P, the photic zone is deeper (80 m *vs*. 55 m at Station KNOT). Primary productivity saturates at about 3 Ein m^{-2} d^{-1} at Station P and around 18 Ein m^{-2} d^{-1} at Station KNOT. In summer, Station P has about 1.6 times greater primary productivity than Station KNOT.

Dr. Harrison reviewed the variability in chlorophyll and primary productivity in the NE Pacific. While Chl appears to be relatively constant at about 0.4 μg/L over the annual cycle, small blooms greater than 1 μg/L have been observed in June and August/September, and some of the blooms are sub-surface. Blooms of coccolithophores also occur and cause problems for remote sensing estimates of Chl. Although the NE Pacific appears to have a relatively constant Chl and only a factor of 2 or 3 seasonal increase in primary productivity, episodic larger variations could be caused by eddies moving offshore and injections of iron from dust deposition and some vertical mixing.

Discussion led to the following recommendations:

- The SeaWiFS operational lifespan is uncertain. MODIS could take over from SeaWiFS if it fails, but beyond MODIS there are no other satellites planned with capabilities similar to SeaWiFS and MODIS. Continuation of the ocean color climate–quality data record is of paramount importance for future advances in our understanding of ocean ecosystems and their link to climate. Given the long lead time from funding to launch, there is a serious immediate need to establish a new ocean color sensor as a priority for satellite earth observing systems. This new sensor should not simply reproduce the measurement suite of SeaWiFS and MODIS, but should reflect in its design scientific developments since these heritage sensors, including an expansion of the wavelength range (near UV to short-wave infrared) and resolution (5 nm from UV through visible). These expanded capabilities will ensure inter-comparison with heritage satellite data, support the more effective implementation of advanced spectral matching algorithms, and enable the application of future algorithms that address many of the scientific questions listed below.
- Chlorophyll alone can be a very poor proxy for net primary productivity. This conversion requires estimation of the light-saturated chlorophyll-specific carbon fixation efficiency (*i.e*., the "assimilation efficiency"), which is not readily retrieved from remote sensing. Sea surface temperature should not be used as a proxy for physiological variability in natural phytoplankton populations.
- The new "carbon-based approach" provides an avenue for addressing physiological variability from space. However, additional field studies are needed to further resolve the relationship between backscattering coefficients and phytoplankton carbon biomass, regional variations in this relationship, and the derivation of growth rates from Chl:C ratios.
- How much variability is occurring under the clouds and during the long periods when there are no images?
- Remotely sensed information of species/functional groups and their influence on the particle size spectrum is required to have a better understanding of phytoplankton carbon standing stocks and ecosystem functioning.
- We need to re-evaluate the use of FRRF measurements as a proxy for primary productivity measurements.
- We have to continue time series measurements on both the western and eastern sides of the Pacific since these data can provide valuable ground-truthing for satellites and observations of episodic events that may occur during cloud cover. There is a very strong need to develop techniques for routinely and accurately determining phytoplankton carbon standing stocks and growth rates (*i.e*., beyond microscopic analyses and dilution experiments).

2007 Harmful Algal Bloom Section annual workshop events

by Charles G. Trick

Background

The workshop was the third of an annual series of workshops organized by the PICES Section on *Ecology of harmful algal blooms in the North Pacific* to document the existing knowledge on the eco-physiology of harmful algal bloom species (HABs) that impact all, or most, countries in the North Pacific. The series began in 2005 at PICES XIV (Vladivostok, Russia) with *Pseudo-nitzschia* and *Alexandrium*, and then continued in 2006 at PICES XV (Yokohama, Japan) with *Dinophysis* and *Cochlodinium*. In 2007 at PICES XVI (Victoria, Canada), we reviewed the abundance, distribution and harmful ecological affects of *Heterosigma*, *Chattonella* and other raphidophytes. *Heterosigma* is the representative species of marine flagellates that are associated with extensive fin-fish losses after local or regional blooms. This genus is cosmopolitan and represents a problem in many of the PICES countries, and its occurrence results in a significant loss to coastal aquaculture facilities. Topics included detection methods for each species and toxic activities, ecosystem comparisons, and new advancements in physiology and ecology from each of the PICES member countries. In particular, we stressed those factors that need additional study in order to develop a predictive capacity for these HABs. The workshop was held at the Victoria Conference Centre and included a half-day laboratory demonstration on classical and automated methods of detection (October 26), and a one-day scientific session (October 27).

Laboratory demonstration

The demonstration was organized by Drs. Charles Trick (University of Western Ontario, Canada) and Vera Trainer (Northwest Fisheries Science Center, U.S.A.), and was well attended by 28 participants from Canada, China, Denmark, Japan, Korea, Philippines, Russia, Spain, and U.S.A.

The first demonstration, "*Using DNA probes to determine raphidophyte taxonomy*", was conducted by Roman Marin (Monterey Bay Aquarium Research Institute, U.S.A.). He illustrated the importance of this sandwich hydridization technique in the quantification of raphidophyte species in natural waters, and provided both detailed theory and a precise and complete demonstration of the methodology. We challenged his procedures with two unknown samples from Spain, which were confirmed to be *Heterosigma*.

In the second demonstration, "*Microscopic observations and detailed analysis of raphidophyte taxonomy*", Dr. Carmelo Tomas (University of North Carolina–Wilmington, U.S.A.) presented the audience with a detailed and effective microscopic survey of all the raphidophytes. He educated each of us on the fine details of taxonomic differentiation and provided a theoretical analysis of the taxonomic position of the raphidophytes within the Kingdom Protist. We were given practical assistance through Louise Tieman of Saigene Corporation (Gig Harbor, WA, U.S.A.) and excellent microscopes through Dennis Tanji of Tanji Consultants (Sammamish, WA, U.S.A.).

Dr. Carmelo Tomas preparing materials for the practical laboratory demonstration on harmful raphidophytes.

The two demonstrations illustrated that there is a balanced need between the automated sandwich hybridization techniques and the experienced microscopy. It is very easy to misidentify the different species and genera within the raphidophytes given that some of the characters that we commonly rely on, such as number of chloroplasts, are variable within a species and certainly among genera. Misidentification at the early stages of a study may result in molecular probes being created that are not clearly associated with the desired HAB species.

Scientific session

The scientific session was convened by Drs. Charles Trick and Ichiro Imai (Kyoto University, Japan). There were more than 30 scientists in attendance from 9 nations (Canada, China, Denmark, Japan, Korea, Philippines, Russia, Spain, and U.S.A.). Three experts were invited: Drs. Ichiro Imai, Tatsuya Oda (Nagasaki University, Japan) and Carmelo Tomas (U.S.A.). Traveling expenses for these invited speakers were provided by PICES and the Fisheries Research Agency of Japan.

Dr. Tomas gave an in depth and detailed presentation, "*The Raphidophyceae: Enigmas in taxonomy, identification and morphology*", that outlined the taxonomic position of both *Chattonella* and *Heterosigma* with regard to the general group of raphidophytes and illustrated the complex position these genera have among other, presumably unrelated,

Some participants of the 2007 HAB annual workshop at PICES XVI (Victoria, Canada, October 2007).

protist taxa. One conclusion is that while raphidophytes have common physical, photosynthetic and toxicological characteristics, which we exploit in our microscope observations, they do not comprise a monophyletic group and thus, have nucleic acid sequences more similar to other marine phytoplankton. This knowledge has little impact on our monitoring programs but does influence strategies for the creation of molecular probes. It also implies that the toxicological attributes aligned to these raphidophytes may be expressed in non-raphidophytes as well.

In his talk on "*Life cycle strategies and occurrences of red tides of* Heterosigma akashiwo *and* Chattonella *spp. in temperate coastal sea*", Dr. Ichiro Imai carefully outlined the maintenance and inter-annual variation of established populations of *Heterosigma* and *Chattonella* in coastal waters of Japan. His presentation indicated the importance of the different life stages of these raphidophyte species. Cysts and resting cells are essential components of maintaining a bloom in a region, and indicate that once blooms occur locally, the sediment phase cells of the life cycle may ensure a long-term repetition of these blooms.

In his presentation entitled "*Generation of ROS (reactive oxygen species) by* Chattonella marina *as a possible factor responsible for the fish-killing mechanism*", Dr. Tatsuya Oda gave a greatly detailed analysis of the environmental factors that influence reactive oxygen species production in *Chattonella*. Through the use of published and recent research, he made a strong case concerning the important role that ROS has on the toxicological attributes of the fish-killing raphidophytes (*Heterosigma* and *Chattonella*). He provided some brilliant experiments to illustrate the important role that the extracellular matrix (glycocalyx) plays on the expression of toxicity.

The invited presentations generated considerable discussion focused on two major themes: (1) What are the common factors that limit the distribution and toxicity of these two genera in PICES countries? and (2) What is the actual mechanism of fish kill?

The invited lectures were complemented by a series of presentations concerning these genera in individual PICES countries. Dr. Jack Rensel (U.S.A.) reviewed the local dynamics of *Heterosigma* in Puget Sound and associated waters. His perspective was unique and valuable since he has a close working association with local aquaculture industries that are directly influenced by *Heterosigma*. Bloom dynamics in PICES countries with distinct historical *Heterosigma* populations were reviewed by Dr. Hakgyoon Kim (Korea), Dr. Takashi Kamiyama (Japan), Dr. Jinhui Wang (China) and Julian Herndon and Roman Marin (U.S.A.). These talks illustrated the common features of a bloom. Dr. Charles Trick, Desmond Johns (U.S.A.) and William Bjornsson (Canada) reviewed their work on laboratory-based studies on toxicity and other unique metabolites that may provide an ecological advantage for the producing species.

The next workshop of this series will be held in October 2008 at PICES XVII in Dalian, China, and will focus on *Karenia* and *Prorocentrum*. The workshop will be co-convened by Drs. Ming-Yuan Zhu (China) and Vera Trainer (U.S.A.), and will have the same format as the previous workshops.

Dr. Charles G. Trick (trick@uwo.ca) is the Beryl Ivey Chair for Ecosystem Health at the Schulich School of Medicine and Dentistry at the University of Western Ontario, Canada. Dr. Trick researches issues of human health and environmental conditions, with a strong emphasis on harmful algal blooms. He is a member of the PICES Section on Harmful Algal Blooms.

A global approach for recovery and sustainability of marine resources in Large Marine Ecosystems

by Kenneth Sherman and Alfred M. Duda

Large Marine Ecosystems

Large Marine Ecosystems (LMEs) are natural regions of ocean space encompassing coastal waters from river basins and estuaries to the seaward boundary of continental shelves and the outer margins of coastal currents. They are relatively large regions of 200,000 km^2 or greater, the natural boundaries of which are based on four ecological criteria: bathymetry, hydrography, productivity, and trophically-related populations (Sherman, 1994; Sherman and Duda, 2005). The LMEs are areas of the world oceans most stressed from habitat degradation, pollution, and over-exploitation of marine resources. Ninety percent of the usable annual global biomass yield of marine fish and other living marine resources is produced in 64 LMEs (**Fig. 1**) identified within, and in some cases extending beyond, the boundaries of the exclusive economic zones of coastal nations located around the margins of the ocean basins (Sherman, 1994; Garibaldi and Limongelli, 2003).

Levels of primary production are persistently higher around the margins of the ocean basins, within the boundaries of the LMEs, than in the open-ocean pelagic areas (**Fig. 2**). Urban centers with high population density characterize many of these coastal ocean areas, and contribute to nutrient over-enrichment that has its greatest impact on natural productivity cycles through eutrophication, anoxic conditions, and dead zones from high levels of nitrogen and phosphorus effluent from estuaries (Kroeze and Seitzinger, 1998). Toxins in poorly treated sewage discharge, harmful algal blooms, and loss of wetland nursery areas to coastal development are ecosystem-level problems that also need to be addressed (GESAMP, 1990).

Since 1995, the Global Environment Facility (GEF) has provided substantial funding to support country-driven projects for introducing multi-sectoral ecosystem-based assessment and management practices for LMEs located around the margins of the oceans. At present, 116 developing countries and countries in economic transition are engaged in the preparation and implementation of GEF-LME projects, totaling US$650 million in start-up funding. A total of 16 projects including 85 countries have been approved by the GEF Council, and another 9 GEF international waters projects involving an additional 31 countries are under preparation (www.iwlearn.net).

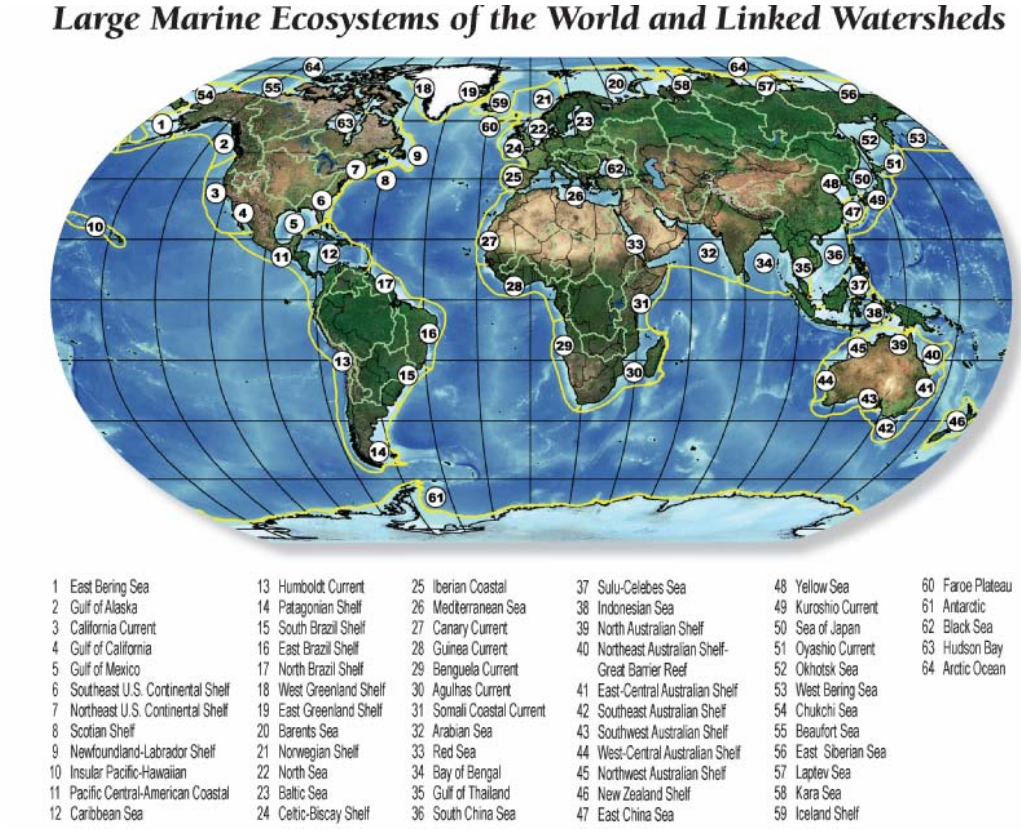


Fig. 1 Global map showing 64 LMEs and linked watersheds.

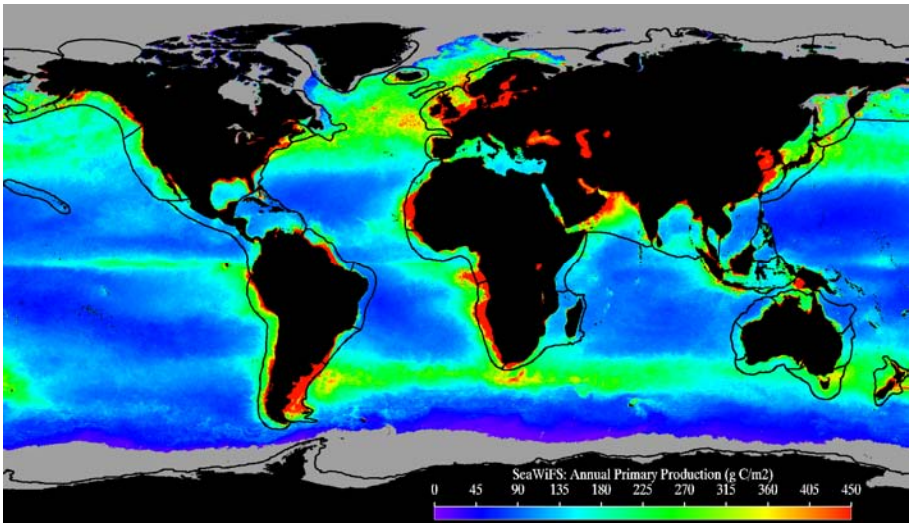


*Fig. 2 Global map showing 64 Large Marine Ecosystems (LMEs) and their estimated average annual productivity. Estimates are based on SeaWiFS satellite data collected between September 1998 and August 1999, and the model developed by M. Behrenfeld and P.G. Falkowski (*Limnol. Oceangr. *1997, 42(1): 1–20). The color-enhanced image (provided courtesy of Rutgers University) depicts a shaded gradient of primary productivity from a high of 450 gCm^2yr^{-1} in red to less than 45 gCm^2yr^{-1} in purple.*

A five-module indicator approach to assessment and management of LMEs has proven useful in ecosystem-based projects in the United States, and GEF-supported projects elsewhere (**Fig. 3**). The modules are adapted to LME conditions through a transboundary diagnostic analysis process to identify key issues and a strategic action program development process for the groups of nations or states sharing an LME to remediate the issues (Wang, 2004). These processes are critical for integrating science into management in a practical way, and for establishing appropriate governance regimes. In a number of these projects, science advisory bodies are utilized to continue providing a science base for management decision-making.

The GEF-LME projects presently funded or in the pipeline for funding in Africa, Asia, Latin America, and Eastern Europe represent a growing network of marine scientists, marine managers, and ministerial leaders who are pursuing ecosystem and fishery recovery goals. The annual fisheries biomass yields from the ecosystems in the network are significant, at 44.8% of the global total, and are a firm basis for movement by the participating countries toward the 2002 World Summit on Sustainable Development (WSSD) targets for introducing ecosystem-based assessment and management by 2010, and for recovering depleted stocks and achieving fishing at maximum sustainable yield (MSY) levels by 2015 (Sherman, 2006). The Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fishery Practice (FAO, 2002) is supported by most coastal nations, and has immediate applicability to reaching the WSSD fishery goals. The Code argues for moving forward with a precautionary approach to fisheries sustainability, using available information more conservatively to err on the side of lower total allowable catch levels than has been the general practice in past decades (Freestone and Hey, 1996).

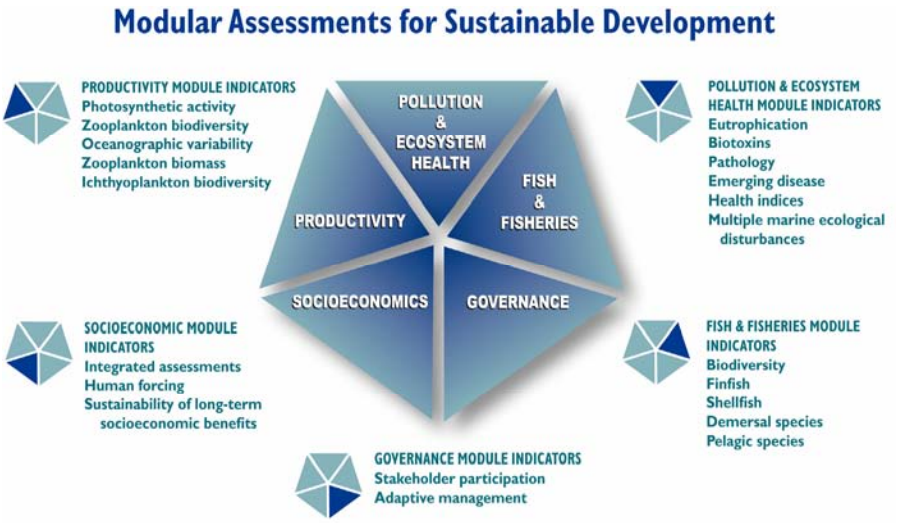


Fig. 3 LME modules as suites of condition indicators for inputs to integrated ecosystem assessments.

2007–2010 GEF support for fisheries recovery and biodiversity conservation

The recent study by Worm *et al*. (2006) reached the conclusion that cumulative catches within the world's LMEs have declined 13% (10.6 million metric tons) since passing a cumulative maximum in 1994. They argue that species average catches in non-collapsed fisheries were higher in species-rich systems and that species robustness to over-exploitation was enhanced in LMEs with high fish species diversity. They further argue that sustainable fisheries management, pollution control, maintenance of essential habitats, and the creation of marine reserves will prove to be good investments in the productivity and value of goods and services that the ocean provides humanity, while business as usual will threaten water quality and ecosystem stability. The US$60 billion in international trade in marine fisheries products is at risk from this depletion. In an effort to assist developing countries in moving forward to recover and sustain marine fisheries, water quality and habitats, the draft GEF strategy for its International Waters (IW) focal area for the period 2007 to 2010 places a priority on recovering depleted marine fish stocks and implementing selective and less destructive fishing practices than those that are now threatening coastal economies and the communities depending on them, as well as causing adverse impacts on biological diversity. The draft strategy is available on www.iwlearn.net.

The impact of declining fish stocks and destructive fishing practices has serious implications for loss of species and biomass, and of ecosystem structure, integrity, and stability. Consequently, the GEF IW focal area is joining forces with the GEF Biodiversity focal area during the period of 2007 to 2010 to catalyze cost-effective solutions. Already, 116 different states have requested GEF help to work with their neighbors in GEF IW foundational capacity-building projects for 16 of the planet's LMEs that are shared by developing countries, in recognition of these social and economic concerns. GEF-recommended processes are underway toward development of ministerially-agreed collective programs of action that should benefit from use of marine protected areas (MPAs).

During the period 2007 to 2010, the GEF IW focal area plans to support developing countries bordering LMEs in Africa, Asia, Latin America, and Eastern Europe to introduce an ecosystem-based approach for moving toward the recovery and sustainability of depleted fish stocks, the control of over-enriched coastal waters, the restoration of habitats, the protection of biodiversity, and adaptation to climate change. Participating countries may also be eligible to request GEF funding for addressing land-based sources of marine pollution and habitat conservation, including support for (1) barrier removal in improving wastewater treatment and using low cost constructed wetlands for sewage treatment, (2) wetlands restoration, (3) integrated coastal management and community-based fisheries, and (4) transitional support to fishers for alternative livelihood activities for near-coastal fisheries that are overcapitalized, over-fished, and under stock rebuilding management regimes.

LME approach to World Summit targets

Since 1993, the U.S. NOAA Fisheries Service has been cooperating with GEF, the World Conservation Union (IUCN), Intergovernmental Oceanographic Commission (IOC) of UNESCO, and several other United Nations (UN) agencies, including the UN Industrial Development Organization, UN Development Program, UN Environment Program, and FAO, to assist developing countries in planning and implementing ecosystem-based management focused on LMEs as the principal assessment and management unit for near-coastal ocean resources. NOAA contributes scientific and technical assistance and expertise to aid developing countries in reaching the targets of the 2002 WSSD (Duda and Sherman, 2002). The targets, agreed on by officials of more than 100 countries, call for the achievement of "substantial" reductions in land-based sources of pollution, introduction of the ecosystems approach to marine resource assessment and management by 2010, designation of a network of marine protected areas by 2012, and the maintenance and restoration of fish stocks to MSY levels by 2015. The GEF-LME strategy supports the WSSD targets for addressing coastal and marine issues by jointly analyzing scientific information on transboundary problems and their root causes, and setting priorities for action on these problems.

Reforms are taking place among the participating countries in operationalizing this ecosystem-based approach to managing human activities in the different economic sectors that contribute to place-specific degradation of the LMEs and adjacent waters. The WSSD target for introducing ecosystem-based assessment and management practices by 2010 can still be met by many of the countries constituting the existing LME network. It is unlikely that the WSSD target for maintaining and restoring fishery resources to MSY levels by 2015 will be met. However, progress is being made in the recovery of depleted fish stocks through mandated reductions in fishing effort (Sherman *et al*., 2002). With regard to the target for control and reduction of land-based sources of pollution, considerable additional effort will be required to achieve "substantial reductions", whereas good progress has been made in designating MPAs within the GEF-LME project network. The U.S. Ocean Action Plan, published on December 17, 2004, by the Office of the President in response to the U.S. Commission on Ocean Policy's final Report (USCOP, 2004), supports the LME concept and strategy for ecosystem-based management within the UN regional seas programs and by international fisheries bodies (EOPUS, 2004):

> *The United States will promote, within the Environment Program's regional seas programs and*

by international fisheries bodies, the use of the Large Marine Ecosystems (LME) concept as a tool for enabling ecosystem-based management to provide a collaborative approach to management of resources within ecologically bounded transnational areas. This will be done in an international context and consistent with customary international law as reflected in the 1982 Convention on the Law of the Sea.

Additional information on NOAA's contributions to the global LME movement toward ecosystem-based management and resource sustainability is available from the LME Program Office, Northeast Fisheries Science Center, Narragansett Laboratory, Narragansett, Rhode Island, and from the LME website: www.lme.noaa.gov. Additional information on the GEF International Waters focal area is found at www.iwlearn.net.

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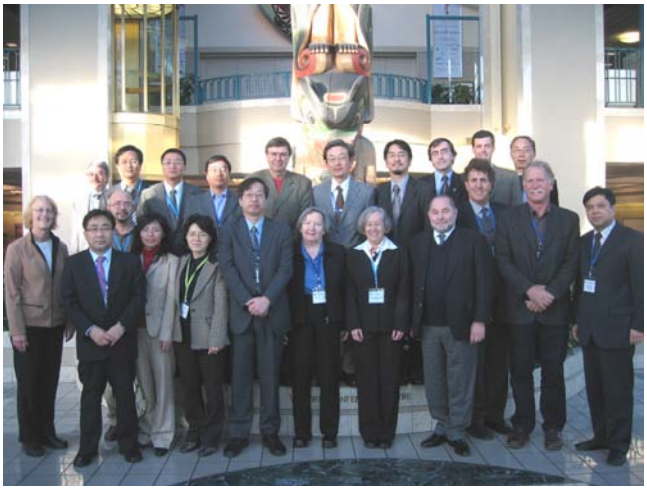
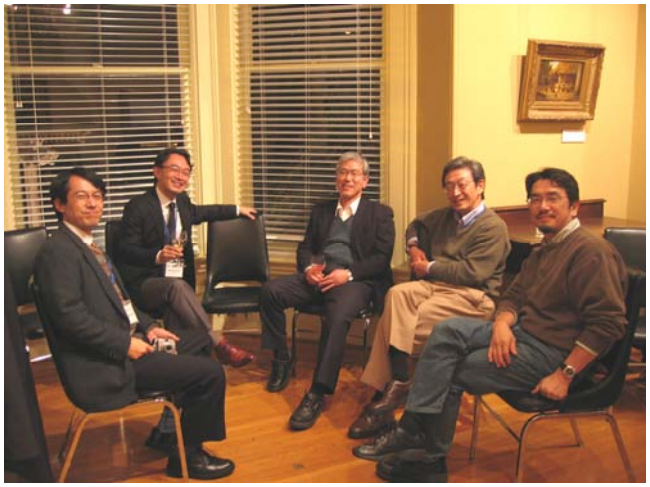
Dr. Kenneth Sherman (Kenneth.Sherman@noaa.gov) is Director of the Narragansett Laboratory and the Office of Marine Ecosystem Studies, Northeast Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration (NOAA). He is also an Adjunct Professor of Oceanography at the University of Rhode Island Graduate School of Oceanography, and an Adjunct Professor at the School of Marine Science and Technology, University of Massachusetts, Dartmouth. He has served as Chairman of the Biological Oceanography Committee of the International Council for the Exploration of the Sea, and as U.S. representative to the Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources. Dr. Sherman has conducted research on ocean plankton productivity from NOAA research vessels in the Central Pacific, across the Atlantic, and throughout waters of the U.S. Northeast Shelf LME from the Gulf of Maine to Cape Hatteras. His work on LMEs has examined the impacts of natural and human interventions on ecosystem productivity and biomass yields. He serves as a senior editor for the Marine Ecology Progress Series *journal, is author of over 200 published reports on marine plankton, fisheries, and ecosystems, and is the series editor or co-editor of 11 volumes of LME studies published by Elsevier Science.*

Dr. Alfred M. Duda serves as Senior Advisor, International Waters, for the Global Environment Facility (GEF) Secretariat in Washington, DC. He has been posted for the last 13 years in a number of management positions at the GEF following his appointment to the World Bank Group in 1991. Following completion of his doctoral work at Duke University, Dr. Duda worked in a series of supervisory positions in the water quality regulatory agency of the State of North Carolina and then at the corporate environment staff of the Tennessee Valley Authority. In 1987, he was named by the U.S. Department of State as Director and Chief of Diplomatic Mission of the Great Lakes Office of the International Joint Commission (Canada and U.S.) in Windsor, Ontario. The Commission has responsibilities to resolve, and avoid where possible, water disputes along the border under the Boundary Waters Treaty of 1909. Dr. Duda's work at the World Bank and GEF continues to address relations among sovereign nations in sharing benefits from transboundary water systems such as LMEs and shared surface or groundwater systems. The GEF is a multi-billion dollar financial mechanism that unites 178 member governments in addressing global environment issues while supporting sustainable development. The GEF has provided over $1 billion in grants in its International Waters Focal Area to 135 developing countries for projects related to LMEs and shared freshwater basins.



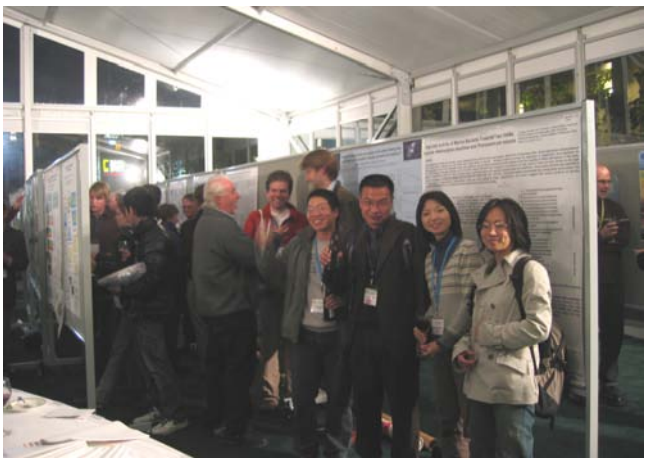
Governing Council members and advisors at the Victoria Conference Centre



Shoshiro Minobe, Hiroaki Saito, Yukimasa Ishida, Yuji Uozumi and Hideki Nakano share a relaxing moment at the Chairman's Reception.

Science Board 2007: (Front) Fang Li Qiao, Sinjae Yoo, Jeffrey Napp, John Stein, Michael Dagg, Gordon Kruse, Skip McKinnell; (Back) Michio Kishi, Michael Foreman, Kuh Kim, Harold Batchelder, Glen Jamieson, Igor Shevchenko.

John Stein, Michael Dagg, Samuel Pooley, Marcia Hamilton, Thomas Royer form part of the U.S. delegation to the Extravaganza Dinner at the Paprika Bistro.



Everyone enjoying the socializing, food and drinks, and posters of course, at the Poster Session Reception.

Enthusiastic discussion at the well-attended the FISP Workshop.

Dr. Tokio Wada addresses his first Opening Session as PICES Chairman.

Early career marine scientists from Korea.

Oleg Katugin, Gerd Hubold and Serge Labonté mingle at the Chairman's Reception.

Keynote Lecture by Kenneth Denman fills the auditorium.

Three sweepers discussing curling strategy.

Michio Kishi, Christina Chiu, Hal Batchelder and Tracy Shaw show their real identities on Halloween's Day.

Ocean acidification of the North Pacific Ocean

by Richard A. Feely, Victoria J. Fabry and John M. Guinotte

Abstract

The addition of fossil fuel carbon dioxide to the atmosphere is rapidly changing seawater chemistry and the calcium carbonate saturation state of the world's oceans as a result of the acidifying effects of CO_2 on seawater. This acidification makes it more difficult for many marine organisms (*e.g.*, corals, plankton, calcareous algae, and mollusks) to build skeletons, tests, and shells of calcium carbonate. Impacts on these calcifying organisms could lead to substantial changes in marine ecosystems. Repeat hydrographic and time-series data for the North Pacific show direct evidence for ocean acidification. These dramatic changes can be attributed, in most part, to anthropogenic CO_2 uptake by the ocean over the past several decades.

Introduction

Over the past two centuries the release of carbon dioxide (CO_2) from humankind's collective industrial and agricultural activities has resulted in atmospheric CO_2 concentrations that have risen from pre-industrial levels of about 280 ppmv (parts per million) to nearly 383 ppmv (Solomon *et al.*, 2007). The atmospheric concentration of CO_2 is now higher than experienced on Earth for at least the last 800,000 years, and is expected to continue to rise, leading to significant temperature increases in the atmosphere and oceans by the end of this century. The rate of current and projected increases in atmospheric CO_2 is more than 100 times faster than has occurred over the last 650,000 years (Raven *et al.*, 2005; Kleypas *et al.*, 2006; Hoegh-Guldberg *et al.*, 2007). To date, the oceans have absorbed approximately 525 billion tons of carbon dioxide from the atmosphere, or about one third of the anthropogenic carbon emissions released during this period (Sabine and Feely, 2007). This natural process of absorption has benefited humankind by significantly reducing greenhouse gas levels in the atmosphere, thus minimizing some impacts of global warming. However, the ocean's daily uptake of 22 million tons of carbon dioxide is beginning to have a significant impact on the chemistry and biology of the oceans. For more than 25 years, an international group of PICES scientists has been conducting repeat hydrographic and chemical surveys of the North Pacific Ocean, documenting its response to increasing amounts of carbon dioxide being emitted to the atmosphere by human activities. These surveys, as well as the time-series data from Ocean Stations Aloha and Papa, have confirmed that the oceans are absorbing increasing amounts of carbon dioxide (**Fig. 1**). Both the hydrographic surveys and time-series data reveal that the chemical changes in seawater resulting from the absorption of carbon dioxide are lowering seawater pH (Caldeira and Wickett, 2003; 2005; Feely *et al.*, 2004; in press; Orr *et al.*, 2005; Solomon *et al.*, 2007). For example, the time-series data at Ocean Station Aloha shows an average pH decrease of approximately 0.02 units per decade in the Northeast Pacific (**Fig. 1**). It is now well established that the pH of our ocean surface waters has already fallen by about

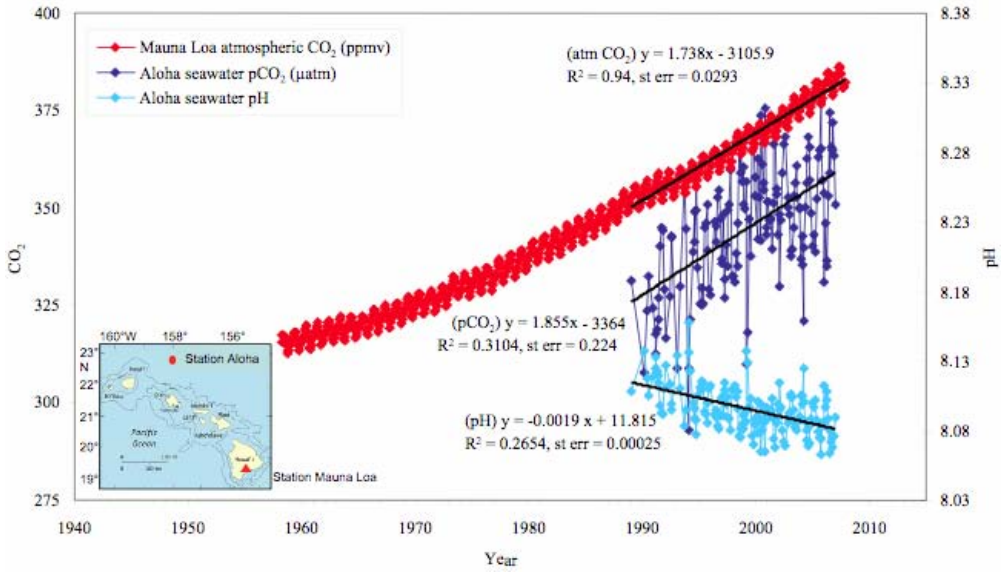


Fig. 1 Time series of atmospheric CO_2 at Mauna Loa (ppmv) and surface ocean pH and pCO_2 (µatm) at Ocean Station Aloha in the subtropical North Pacific Ocean. Note that the increase in oceanic CO_2 over the last 17 years is consistent with the atmospheric increase within the statistical limits of the measurements. Mauna Loa data: Dr. Pieter Tans, NOAA/ESRL (http://www.esrl.noaa.gov/gmd/ccgg/trends); HOTS/Aloha data: Dr. David Karl, University of Hawaii (http://hahana.soest.hawaii.edu).

0.1 units from an average of about 8.21 to 8.10 since the beginning of the industrial revolution. Estimates of future atmospheric and oceanic carbon dioxide concentrations, based on the Intergovernmental Panel on Climate Change (IPCC) CO_2 emission scenarios and general circulation models, indicate that by the middle of this century, atmospheric carbon dioxide levels could reach more than 500 ppmv, and near the end of the century, they could be over 800 ppmv. This would result in a further surface water pH decrease of 0.2–0.3 pH, and the carbonate ion concentration would decrease almost 50 percent by the end of the century (Orr *et al.*, 2005). To put this in historical perspective, this surface ocean pH decrease would result in a pH that is lower than it has been for more than 20 million years (Feely *et al*., 2004).

When carbon dioxide exchanges across the air–sea interface, the concentrations of carbon species in seawater are changed *via* a series of chemical reactions:

$$CO_{2(atmos)} \rightleftharpoons CO_{2(aq)} \quad (1)$$

$$CO_{2(aq)} + H_2O \rightleftharpoons H_2CO_3 \quad (2)$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \quad (3)$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-} \quad (4)$$

where the air–sea CO_2 exchange reaction (1) leads to an initial increase in dissolved CO_2. This dissolved CO_2 reacts with H_2O to form carbonic acid (2). Some of the carbonic acid quickly dissociates into a hydrogen ion and a bicarbonate ion (3). A fraction of the bicarbonate ions can then dissociate further into a hydrogen ion and a carbonate ion (4). These reactions are rapid and reversible, and the basic thermodynamics of these reactions in seawater are well known (Millero *et al*., 2002) such that, at a pH of ~8.1, approximately 90% of the carbon is in the form of bicarbonate ion, 9% in the form of carbonate ion, and only about 1% of the carbon is in the form of dissolved CO_2.

The ocean's ability to absorb more CO_2 from the atmosphere also depends on the extent of interactions of marine carbonates with CO_2 *via* the dissolution reaction:

$$CO_2 + CaCO_3 + H_2O \rightleftharpoons 2HCO_3^- + Ca^{2+} \quad (5)$$

The primary contributors to this reaction are the carbonate shells that are produced in the euphotic zone. Upon death, the carbonate shells fall through the water column and are either dissolved or deposited in shallow or deep-sea sediments. As the oceans become enriched in anthropogenic CO_2, the locations and extent of dissolution will increase as a function of the decrease in the $CaCO_3$ saturation state. The *in situ* degree of saturation of seawater with respect to calcite and aragonite is the ion product of the concentrations of calcium and carbonate ions, at the *in situ* temperature, salinity, and pressure, divided by the apparent stoichiometric solubility product (K^*_{sp}) for those conditions:

$$\Omega_{arg} = [Ca^{2+}]\,[CO_3^{2-}] / K^*_{sp_{arg}} \quad (6)$$

$$\Omega_{cal} = [Ca^{2+}]\,[CO_3^{2-}] / K^*_{sp_{cal}} \quad (7)$$

in which the calcium concentration is estimated from the salinity, and the carbonate ion concentration is calculated from the dissolved inorganic carbon (DIC) and total alkalinity (TA) data. Since the calcium to salinity ratio in seawater does not vary by more than a few percent, variations in the ratio of $[CO_3^{2-}]$ to the stoichiometric solubility product govern the degree of saturation of seawater with respect to aragonite and calcite. The interaction between CO_2 and seawater reduces the availability of carbonate ions which play an important role in shell formation for a number of $CaCO_3$ shell-forming organisms, including marine plankton, shellfish and cold-water corals. This phenomenon of decreasing pH and carbonate ion concentration, which is called "ocean acidification", could affect the oceans' most fundamental biological and geochemical processes in the coming decades. This rapidly emerging scientific issue has created serious concern across the scientific and fisheries resource management communities.

Saturation state changes in the North Pacific Ocean

Shell and skeleton formation is favored in regions of the North Pacific where the calcium carbonate saturation state is >1.0. Saturation state <1.0 indicates that waters are corrosive to $CaCO_3$, and dissolution will occur if the shells and skeletons are not protected. Saturation states are generally highest in the tropics and lowest in the high latitude regions because the solubility of $CaCO_3$ increases with decreasing temperature and increasing pressure. Therefore, there is significant shoaling of aragonite saturation horizons in the North Pacific north of 40°N, near the equator, and especially near the eastern boundary of the basin. High DIC levels occur in this region because enhanced upwelling brings deeper waters rich in DIC and nutrients to the upper ocean. In the waters off the Alaskan coast (north of 50°N) the aragonite saturation depth shoals to depths ranging from 90–150 m (**Fig. 2**).

Feely *et al.* (in press) provide maps of projected aragonite saturation states for the surface oceans for years 1765,

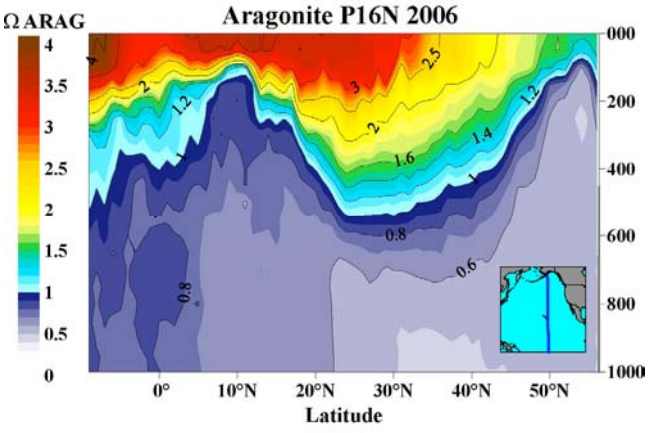


Fig. 2 Distribution of aragonite saturation along the March 2006 P16N transect along 152°W in the North Pacific (after Fabry et al.*, in press).*

1995, 2040 and 2100, which are based on the modeling work of Orr *et al.* (2005). The model results show that by the time atmospheric CO_2 reaches 780 ppmv, near the end of this century, the entire water column (from the ocean floor to the surface) will become undersaturated with respect to aragonite in some regions of the subarctic North Pacific. At this point, the average surface ocean carbonate ion concentration will have decreased by nearly 50%. The warm waters of the tropics and subtropics will remain supersaturated with respect to aragonite and calcite over the range of IPCC-projected atmospheric CO_2 concentrations. However, some upwelling areas in the low latitude regions are experiencing low aragonite saturation state conditions, and these waters are within depth ranges of several critically important pelagic species (Feely *et al.*, 2004). Priority areas for ocean acidification research are high latitude regions that are projected to experience the highest relative changes in carbonate chemistry within the century. Given the importance of coastal areas to fisheries and other marine resources and services, coastal ecosystems constitute another important target region where research is critically needed.

Effects of ocean acidification on marine ecosystems

Ongoing research suggests that elevated CO_2 levels may have deleterious impacts on commercially important fish. Silver seabream larvae exhibit very high mortality rates in CO_2-enriched waters (Ishimatsu *et al.*, 2004). Some experiments indicate that additional physiological stresses are also observed (Kleypas *et al.*, 2006; Fabry *et al.*, in press). Exposure of fish to lower pH levels can cause decreased respiration rates, changes in blood chemistry, and changes in enzymatic activity. The calcification rates of the edible mussel (*Mytilus edulis*) and Pacific oyster (*Crassostrea gigas*) decline linearly with increasing CO_2 levels (Gazeau *et al.*, 2007). Squid are especially sensitive to ocean acidification because it directly impacts their blood oxygen transport and respiration (Pörtner *et al.*, 2005). Sea urchins raised in lower-pH waters show evidence for inhibited growth due to their inability to maintain internal acid–base balance (Kurihara and Shirayama, 2004). Scientists have also seen a reduced ability of marine algae and animals to produce protective carbonate shells (Gattuso *et al.*, 1998; Langdon *et al.*, 2000; Riebesell *et al.*, 2000; Feely *et al.*, 2004; Orr *et al.*, 2005; Fabry *et al.*, in press). These organisms are important food sources for many marine species. One such example is a pteropod, a free-swimming mollusc that is eaten by organisms ranging in size from tiny zooplankton to whales. In particular, pteropods are an important food source for North Pacific juvenile salmon. Mackerel, pollock, herring and cod are also known to feed on pteropods. Many species of other marine calcifiers, such as coccolithophores (microscopic algae), foraminifera (microscopic protozoans), coralline algae (benthic algae), echinoderms (sea urchins and starfish), and mollusks (snails, clams, and squid) also exhibit a general decline in their ability to produce shells with decreasing pH (Kleypas *et al.*, 2006; Fabry *et al.*, in press).

Since ocean acidification research is still in its infancy, it is impossible to predict exactly how individual species responses will transfer through marine food webs and impact the overall structure of marine ecosystems. It is clear, however, from the existing data and from the geologic record that some coral and shellfish species will be reduced in a high-CO_2 ocean. The rapid disappearance of many calcifying species in past extinction events has been attributed, in large part, to ocean acidification events (Zachos *et al.*, 2005). Over the next century, if CO_2 emissions are allowed to increase as predicted by the IPCC CO_2 emissions scenarios, humans may be responsible for increasing oceanic CO_2 to levels that are more corrosive to calcifying organisms than anytime since the last major extinction, over 65 million years ago. Thus, the decisions we make about our use of fossil-fuels for energy over the next several decades will have a profound influence on the future composition of marine ecosystems for centuries to millennia.

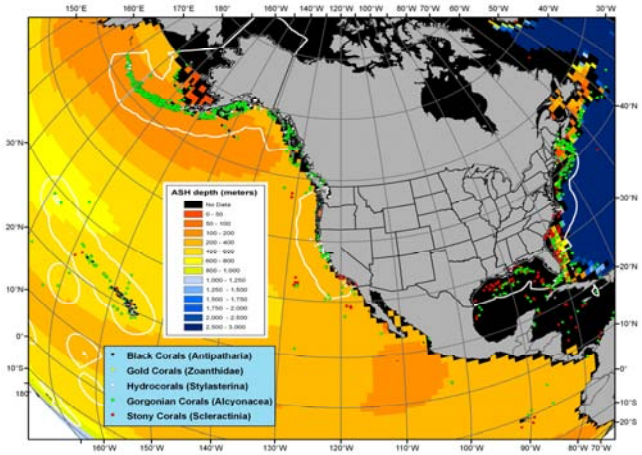


Fig. 3 Distribution of selected cold-water corals in U.S. coastal waters and the depth of aragonite saturation horizon for year 1995 (CO_2 = 365 ppmv). Note: very little model results exist for the coastal zone where the majority of cold water corals and commercial fisheries are located. Aragonite saturation data from Orr et al. *(2005; modified from Guinotte* et al.*, 2006 and Morgan* et al.*, 2007).*

The impact of ocean acidification on fisheries and coral reef ecosystems could significantly impact the U.S. and global economies. The U.S. is the third largest seafood consumer in the world, with total consumer spending for fish and shellfish around $60 billion per year. Coastal and offshore commercial fishing generates upwards of $30 billion per year and employs approximately 70,000 people. Nearly half of the U.S. fish catch is taken from the coastal waters surrounding Alaska. Increased ocean acidification may directly and/or indirectly influence fish populations because of large-scale changes in local ecosystem dynamics. It may also have detrimental impacts on the newly discovered cold-water corals in the Alaskan Aleutian Island region (**Fig. 3**, Guinotte *et al.*, 2006). The Aleutian

Islands have the highest abundance and diversity of cold-water corals found to date and 85% of commercially important fish species observed on submersible transects in this region were associated with corals (Heifetz *et al.*, 2005; Stone, 2006; Guinotte and Fabry, in press). Direct and/or indirect effects of ocean acidification on the cold-water coral ecosystems of the North Pacific will probably have significant impacts on associated species that depend on these organisms for food and shelter, including commercially important species (Guinotte and Fabry, in press).

Conclusions

Ocean acidification may be one of the most significant and far-reaching consequences of the buildup of anthropogenic carbon dioxide in the atmosphere. Results from laboratory, field and modeling studies, as well as evidence from the geological record, clearly indicate that marine ecosystems are highly susceptible to increases in oceanic CO_2 and corresponding decreases in pH. Corals and many other calcifying organisms will be increasingly affected by a decreased capability to produce their shells and skeletons. Other species of fish and shellfish will also be negatively impacted in their physiological responses due to a decrease in pH levels of their cellular fluids. Because of the very clear potential for ocean-wide impacts of ocean acidification at all levels of the marine ecosystem, from the tiniest phytoplankton to zooplankton to fish and shellfish, we can expect to see significant impacts that are of immense importance to humankind. Ocean acidification is an emerging scientific issue, and much research is needed before the ecosystem responses are well understood. Even though ecosystem responses are not well known, the potential risk for negative environmental, economic and societal impacts is high and warrants serious and immediate attention. For these reasons, the national and international scientific communities have recommended a coordinated scientific research program with four major themes: (1) carbon system monitoring coupled with high-quality measurements tracking the vertical and latitudinal distributions and abundances of calcifying organisms; (2) calcification and physiological response studies under laboratory and field conditions; (3) environmental and ecosystem modeling studies; and (4) socio-economic risk assessments. This research will provide resource managers with the basic information they need to develop strategies for protection of critical species, habitats and ecosystems.

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Dr. Richard A. Feely's (Richard.A.Feely@noaa.gov) major research areas are carbon cycling in the oceans and ocean acidification processes. He received a B.A. in Chemistry from the University of St. Thomas, in St. Paul, Minnesota, in 1969. He then went to the Texas A&M University, where he received an M.S. degree in 1971 and a Ph.D. degree in 1974. Both of his post-graduate degrees were in Chemical Oceanography. He is a member of the Science Steering Committees for the U.S. Carbon Cycle Science Program, the U.S. Ocean Carbon and Climate Change Program, and the U.S. Ocean Carbon and Biochemistry Program. Dr. Feely has authored more than 160 refereed research publications. In PICES, he co-chaired WG 13 on CO_2 in the North Pacific, *was a member of WG 17 on* Biogeochemical data integration and synthesis, *and now serves as a member of the Section on* Carbon and climate.

Dr. Victoria J. Fabry (fabry@csusm.edu), Professor of Biological Sciences at California State University San Marcos, is a Biological Oceanographer whose research interests encompass the role of marine organisms in geochemical cycles. The response of calcifying organisms to ocean acidification and the dissolution kinetics of biogenic calcium carbonate in the upper ocean are two areas of her current work. She earned a Ph.D. in Biology at the University of California Santa Barbara, conducted post-doctoral work in marine chemistry at the Woods Hole Oceanographic Institution, and worked as a biogeochemist at the International Atomic Energy Agency's Marine Environmental Laboratory in Monaco. She is a member of numerous national and international committees concerned with ocean acidification research.

Dr. John M. Guinotte (john@mcbi.org) is a Marine Biogeographer at the Marine Conservation Biology Institute (MCBI) in Bellevue, WA. He received his Ph.D. from James Cook University (Townsville, Australia). His Ph.D. work focused on predicting coral reef habitat in the Coral and Timor Seas, climate change related threats to coral ecosystems, and modeling marine environmental gradients in the waters of Papua New Guinea. Prior to joining MCBI, John worked for the University of Kansas (Kansas Geological Survey) on the NSF-funded Biogeoinformatics of the Hexacorallia project. John spent two years as a postgraduate researcher at the Australian Institute of Marine Science investigating the effects of climate change on the corals of the Great Barrier Reef, and has been a consultant for The Nature Conservancy, the U.S. Environmental Protection Agency, and the U.S. Fish and Wildlife Service.

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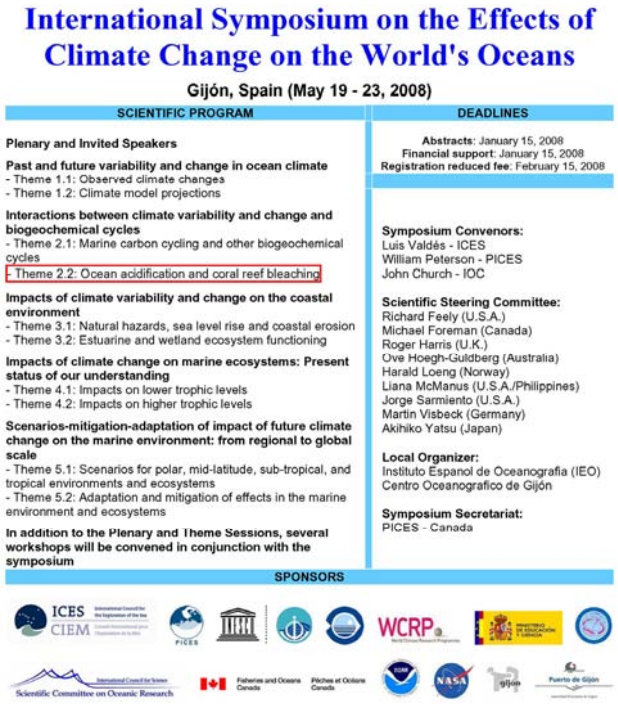
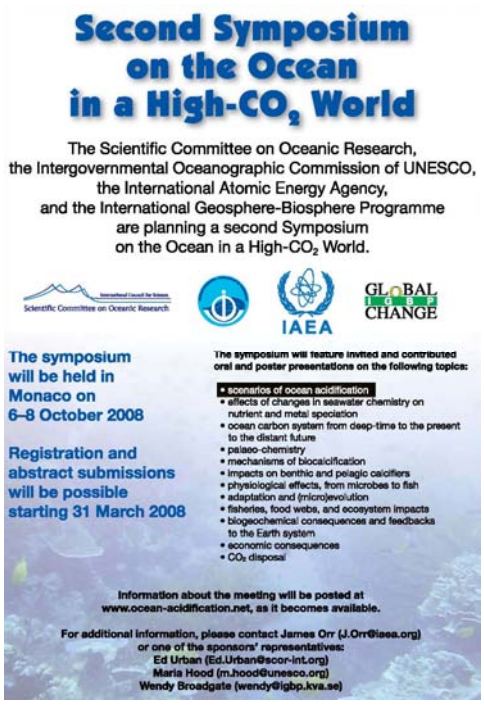
Ocean acidification will be discussed in further detail at two PICES-supported international symposia.





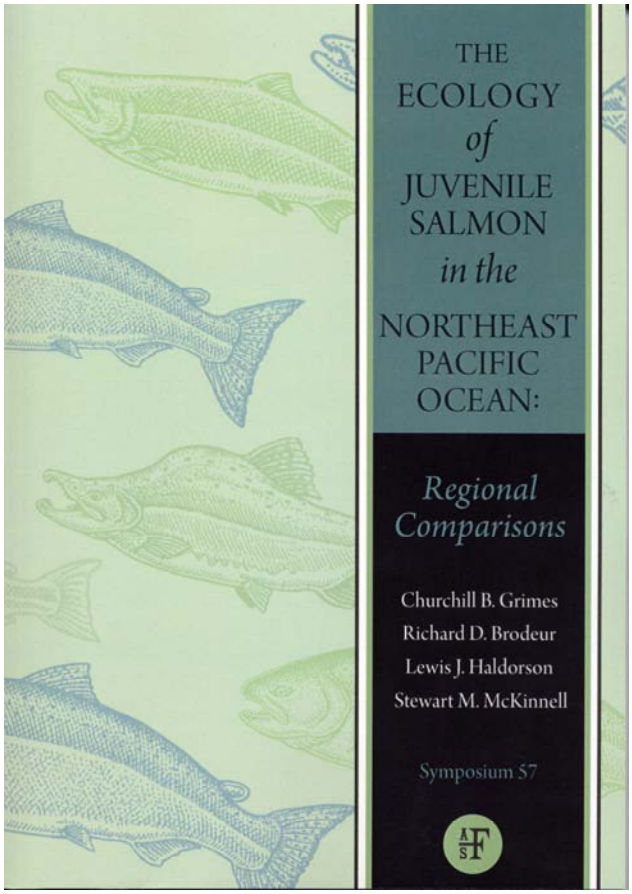
Workshop on NE Pacific Coastal Ecosystems (2008 Call for Salmon Survival Forecasts)

by Marc Trudel and Skip McKinnell

Coastal ocean ecosystem sampling programs in the Northeast Pacific are providing new insights into the dynamics of the region's marine resources. Each year since 1999, a dedicated cadre of scientists has been gathering at one of the coastal laboratories for a couple of days to compare recent observations of the coastal ocean ecosystem, to put these new observations within the context of what has happened in the past, to offer interpretations of changes in pattern or abundance, should they appear, and just recently, to formulate ideas about the likely consequences of what has occurred.

The changes from year to year have not been subtle. The period from late 1988 to the 1998 El Niño is characterized as one of the warmest in historical record of temperature measurements. Declines in abundance of many subarctic species from plankton to seabirds were coincident with this persistent anomaly. Following the 1998 El Niño, coastal ocean temperatures dropped abruptly for several years and subarctic species increased in abundance. Descriptions of these changes, as they occurred, have appeared in previous PICES Press articles (Peterson and McKinnell, 2000; McKinnell, 2001; McKinnell, 2002; Emmett, 2003). The brief period of enhanced subarctic influence along the Oregon, Washington and southern British Columbia coasts ended with the 2002/03 El Niño. Then a 2-year period of extreme surface warmth in the Gulf of Alaska followed. These changes were of special interest to salmon biologists who saw marine survival reach its lowest recorded values for many populations that went to sea during the summer of 2005.

Beginning in 2007, extra time was allocated at our annual workshops to allow the participants an opportunity to provide their expectations of the future consequences for salmon of the current ocean state. While not yet as sophisticated as the ENSO (**E**l **N**iño **S**outhern **O**scillation) forecasting forum, multiple qualitative forecasts of anticipated marine survival were recorded, and the performance of these forecasts will be reviewed in 2008. The advantages of producing multiple forecasts generated independently are similar to the arguments used by the Intergovernmental Panel on Climate Change (IPCC) to garner support for their climate models; greater confidence is placed in the forecasts if a majority of the models indicate the same future. The advantage with a salmon forecasting forum is that these models of nature can be tested annually. In 2005, the group organized a symposium to focus on regional comparisons of Pacific salmon ecology in the Northeast Pacific at the annual meeting of the American Fisheries Society (AFS) in Anchorage, Alaska. Authors from California to Alaska pooled their data, analysis, interpretation, and wisdom. The resulting collection of papers has just been published as Volume 57 of the AFS Symposium Series, "*The ecology of juvenile salmon in the Northeast Pacific Ocean*".



New book on regional comparisons of salmon ecology in the sea.

The workshop in 2008 will take place at the Coast Bastion Hotel in Nanaimo, Canada, from April 28–29. While these dates are somewhat later than normal, it will allow the workshop participants an opportunity to attend an Open House at the Pacific Biological Station (PBS) on the preceding Saturday or Sunday. PBS is celebrating its centennial anniversary in 2008.

The state of the western North Pacific in the first half of 2007

by Shiro Ishizaki

Sea surface temperature

Figure 1 shows the monthly mean sea surface temperature (SST) anomalies in the western North Pacific from January to June 2007, computed with respect to JMA's (Japan Meteorological Agency) 1971–2000 climatology. Monthly mean SSTs are calculated from JMA's MGDSST (**M**erged satellite and *in-situ* data **G**lobal **D**aily **SST**), which is based on NOAA/AVHRR data, microwave sensor (AQUA/ AMSR-E) data and *in-situ* observations. Time series of 10-day mean SST anomalies are presented in **Figure 2** for 9 regions indicated in the bottom panel.

In January and February, SSTs were above normal, except southeast of the Kamchatka Peninsula. In particular, positive SST anomalies exceeding +2°C were found southeast of Japan. In April, SST anomalies south and east of Japan turned to negative values. In June, negative SST anomalies exceeding –2°C appeared southeast of Japan and around 35°N, 155°E. Positive SST anomalies found in April along 20°N east of 150°E spread westward and intensified, and positive anomalies exceeding +2°C appeared east of 160°E in June.

Kuroshio and Oyashio

Figure 3 shows the Kuroshio path for the first half of 2007, at intervals of 10 days. In January, it took a slight meander east of Kyushu Island (30°N, 132°E). From the middle of February to June, the Kuroshio took a meandering path off Tokai (135–140°E). This meander moved eastward, and the current returned to a straight path off Tokai in late June.

Figure 4 shows the subsurface temperatures at a depth of 100 m east of Japan for March 2007. This chart is based on the numerical ocean data assimilation system (JMA's Ocean Comprehensive Analysis System).

The Oyashio cold water (defined as temperatures less than 5°C in **Fig. 4**) is known to extend southward in spring and return northward from summer until autumn (indicated by the green line in **Fig. 5**). The coastal branch of the Oyashio cold water extended almost to its normal location in March 2007, and returned significantly northward after May (**Fig. 5**). The southernmost point in March was 39.0°N, 143.0°E, which is 50 km north of the normal location.

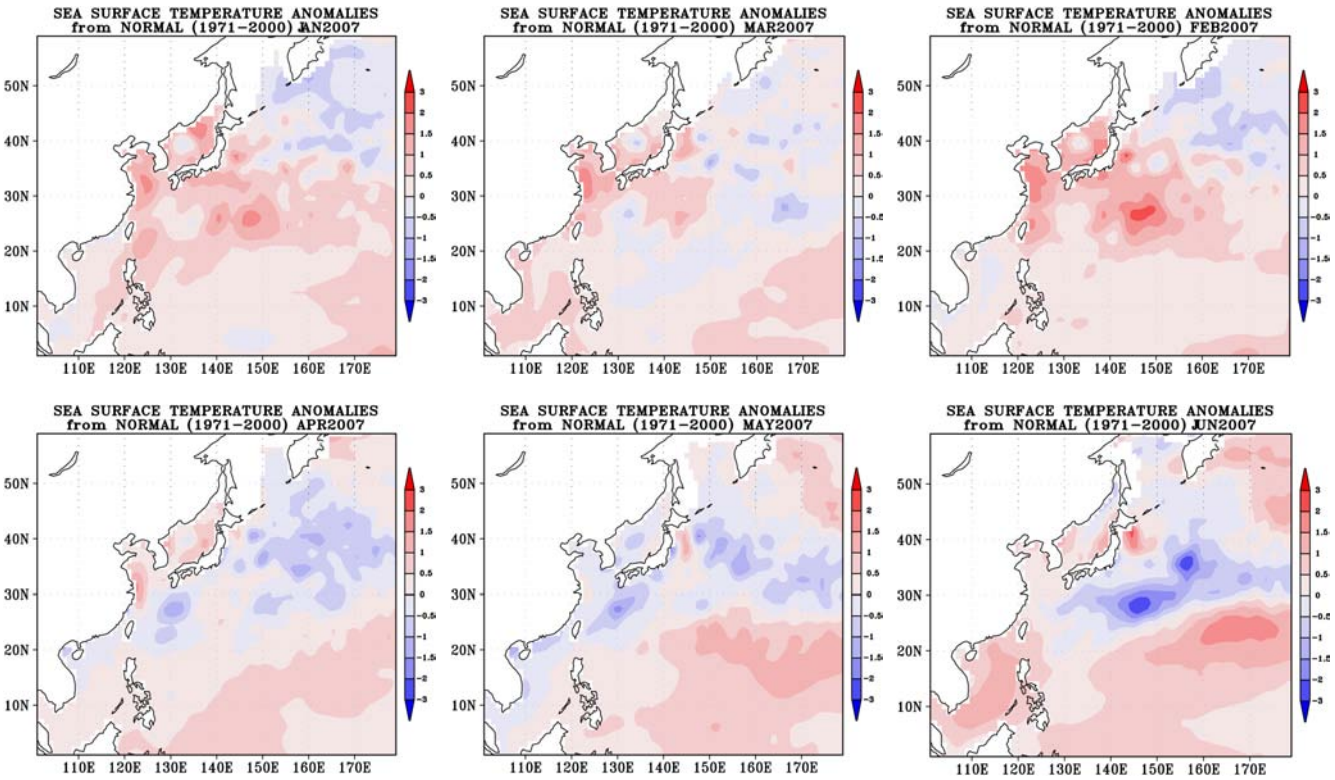


Fig. 1 Monthly mean sea surface temperature anomalies (°C) from January to June 2007. Anomalies are deviations from JMA's 1971–2000 climatology.

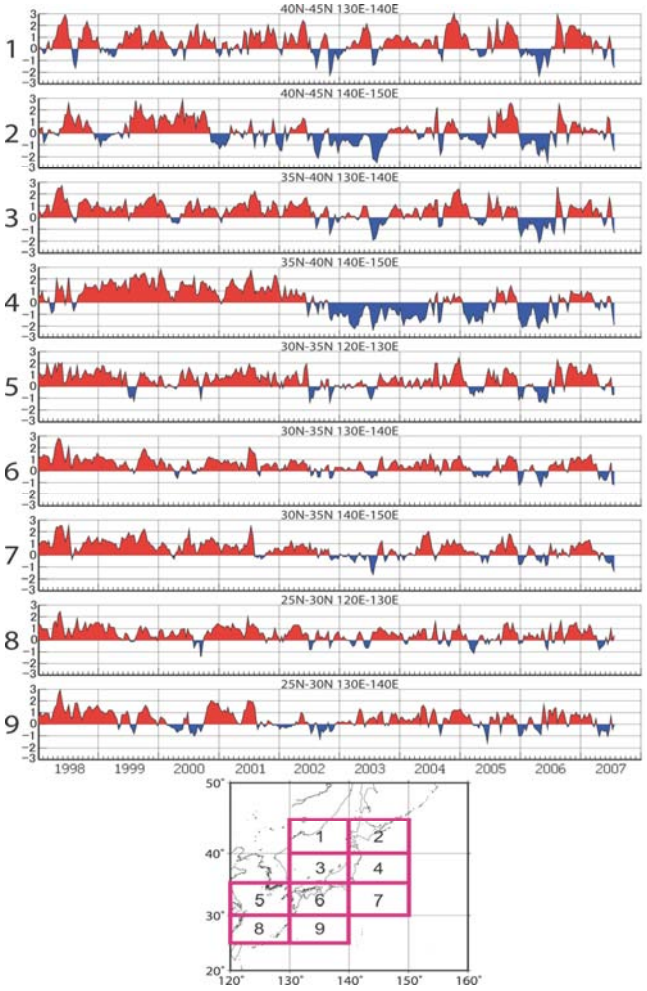


Fig. 2 Time series of 10-day mean SST anomalies (°C) averaged for the sub-areas shown in the bottom panel. Anomalies are deviations from JMA's 1971–2000 climatology.

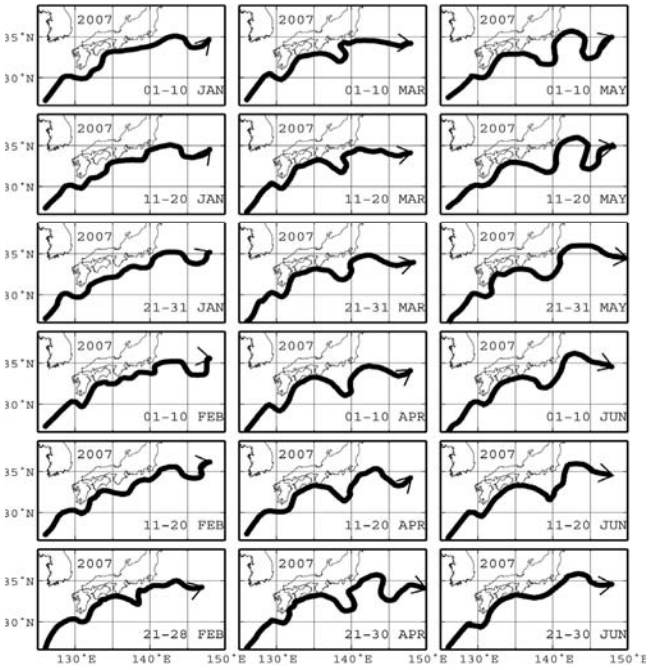


Fig. 3 Location of the Kuroshio path from January to June 2007.

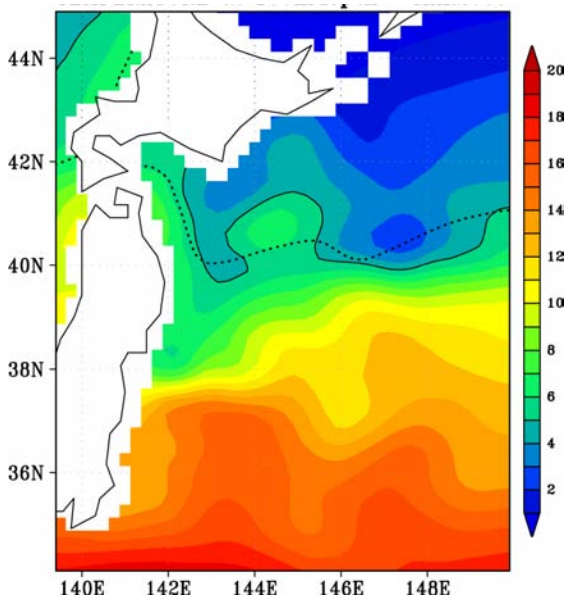


Fig. 4 Subsurface temperatures (°C) at 100 m depth east of Japan for March 2007. The solid line denotes the 5°C isotherm and the dotted line is its climatology (averaged values from 1971 to 2000).

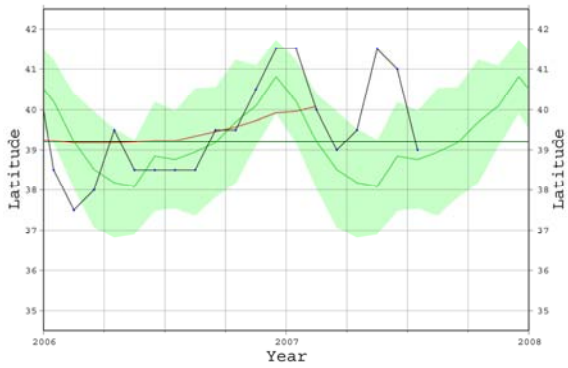


Fig. 5 The southernmost position of the coastal branch of the Oyashio cold water from January 2006 to July 2007 (black line), and the 30-year averaged values (green line), with the range of one standard deviation (green area) from 1971 to 2000.

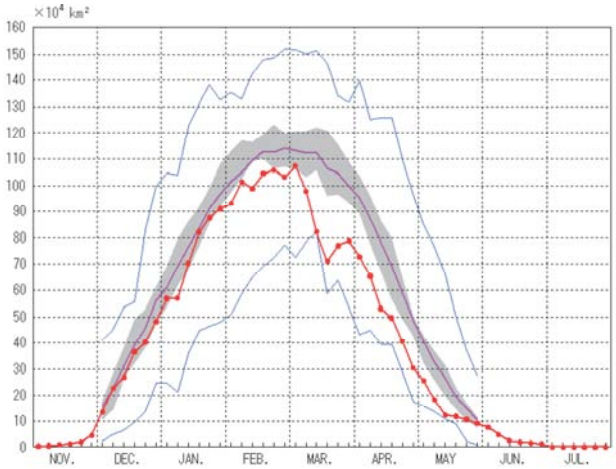
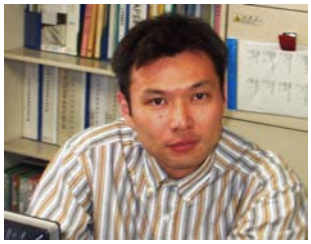


Fig. 6 Time series of sea ice extent in the Sea of Okhotsk from November 2006 to July 2007 (red line: 2006–2007 analysis; pink line: JMA's 1971–2000 climatology; blue lines: maximum/minimum sea ice extent since 1971; gray area: normal range).

Sea ice in the Sea of Okhotsk

The extent of sea ice in the Sea of Okhotsk was below normal (30-year averaged values from 1971 to 2000) throughout the period from December 2006 to May 2007 (**Fig. 6**). After reaching its seasonal maximum of 107.3×10^4 km^2 on March 5 (the normal value is 122.8×10^4 km^2), the sea ice area rapidly decreased to a near-record minimum. Sea ice conditions for March 2007 show a rapid retreat of the sea ice edge over the northern and eastern Sea of Okhotsk. The accumulated sea ice extent, defined as the sum of the 5-day sea ice areas from December to May, was 2153.4×10^4 km^2 (the normal value is 2574.3×10^4 km^2).



Shiro Ishizaki (s_ishizaki@met.kishou.go.jp) is a Scientific Officer of the Office of Marine Prediction at the Japan Meteorological Agency (JMA). He works as a member of a group in charge of oceanic information in the western North Pacific. Using the data assimilation system named "Ocean Comprehensive Analysis System", this group provides an operational surface current prognosis (for the upcoming month) as well as seawater temperature and an analysis of currents with a 0.25 × 0.25 degree resolution for waters adjacent to Japan. Shiro is now involved in developing a new analysis system for temperature, salinity and currents, that will be altered with the Ocean Comprehensive Analysis System.

PICES Calendar

- Inter-sessional meeting of PICES Working Group on *Ecosystem-based management science and its application to the North Pacific* (WG 19), February 21–22, 2008, Seattle, U.S.A.
- Inter-sessional meeting of PICES Working Group on *Non-indigenous aquatic species* (WG 21) to evaluate the protocols and reach final agreement on standards, data elements and data entry templates for the MIS (Marine/Estuarine Invasive Species) Database for the project on "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*", March 3–5, 2008, Busan, Korea.
- ICES/PICES meeting on "*Environmental interactions of mariculture*", April 14–18, 2008, Victoria, Canada.
- Workshop of PICES *Climate Forcing and Marine Ecosystem Response* (CFAME) Task Team on "*Linking and visualizing climate forcing and marine ecosystem changes: A comparative approach*", April 15–17, 2008, Honolulu, U.S.A.
- Inter-sessional Science Board meeting and Workshop to develop an Implementation Plan for the new PICES integrative scientific program, FUTURE, April 23–25, 2008, Seattle, U.S.A.
- International Symposium on "*Effects of climate change on the world's oceans*" (primary sponsors: ICES, PICES and IOC; co-sponsoring organizations: GLOBEC, SCOR, WCRP, DFO, NOAA, NASA, KORDI, The City of Gijón, Port Authority of Gijón, Spanish Science Foundation), May 19–23, 2008, Gijón, Spain.
- International Symposium on "*Coping with global change in marine social–ecological systems*" (primary sponsors: GLOBEC, EUR-OCEANS and FAO; co-sponsoring organizations: IRD, IFREMER PICES, SCOR, IMBER, ICES), July 8–11, 2008, Rome, Italy.
- Second PICES Summer School on "*Biomass-based management*", August 22–25, 2008, Hakodate, Japan.
- International Symposium on "*Herring: Linking biology, ecology and status of populations in the context of changing environments*" (primary sponsors: ICES, PICES and GLOBEC), August 26–29, 2008, Galway, Ireland.
- Fourth PICES Workshop on "*The Okhotsk Sea and adjacent areas*", August 27–29, 2008, Abashiri, Japan.
- ESSAS/PICES Workshops at the ESSAS Annual Meeting, September 15–19, 2008, Halifax, Canada.
- ICES/PICES Theme Sessions on "*Coupled physical and biological models*", "*Marine spatial planning in support of integrated management – tools, methods, and approaches*" and "*New methodology for tracking fish, mammals and seabird migrations and behaviour*" at the ICES Annual Science Conference, September 22–26, 2008, Halifax, Canada.
- PICES/ICES Theme Session on "*The effects of ocean acidification on fisheries and ecosystems*" at the International Symposium on "*The Ocean in a High CO_2 World – II*" (primary sponsors: SCOR, IOC, IAEA and IGBP), October 6–8, 2008, Monaco.
- PICES Seventeenth Annual Meeting, October 23–November 2, 2008, Dalian, China.
- Sixth International Conference on "*Marine bioinvasions*" (primary sponsors: PICES, ICES and the U.S. National Sea Grant College Program), summer of 2009, Portland, U.S.A.
- Third PICES Summer School on "*Recent methods of investigating red-tide organisms and controlling red tides*", August 2009, Busan, Korea.
- ICES/PICES Symposium on "*Rebuilding depleted fish stocks: Biology, ecology, social science and management strategies*", September 2009, Hamburg, Germany.
- PICES Eighteenth Annual Meeting, October 23–November 2, 2009, Busan, Korea.

The Bering Sea: Current status and recent events

by Jeffrey M. Napp

Current status of the Bering Sea ecosystem

The winter of 2006/07 in the eastern Bering Sea was colder with more ice farther south than in the previous 6 years. Winter temperatures at NOAA's Mooring Site M2 reached freezing, and the maximum summer integrated water temperatures were cool (~ 4ºC; **Fig. 1**). In contrast, ice cover in the Arctic Ocean was 40% less than the long-term average, and half of this loss occurred in the last year. Speakers at the 2007 Science Board Symposium on "*The changing North Pacific: Previous patterns, future projections and ecosystem impacts*" (PICES XVI, Victoria, Canada) noted that the loss of arctic sea ice may be occurring at a rate faster than predicted by IPCC models.

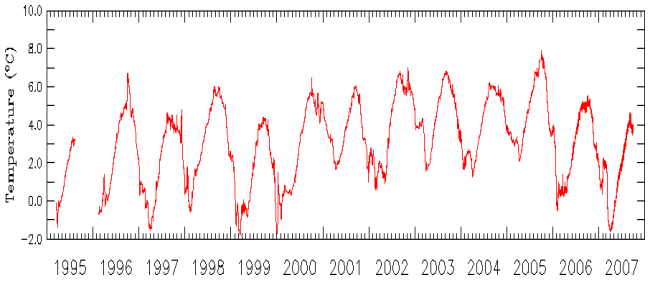


Fig. 1 Average water column temperature in the southeastern Bering Sea (1995–2007), measured at NOAA's Mooring Site M2. Source: P.J. Stabeno, NOAA – PMEL.

During the summer of 2007, the cold pool (bottom water with temperature <2°C on the eastern Bering Sea shelf remaining from the southern ice extent) was clearly evident in bottom trawl surveys conducted by NOAA–Fisheries Alaska Fisheries Science Center (**Fig. 2**). The cold pool extended south to the Alaskan Peninsula.

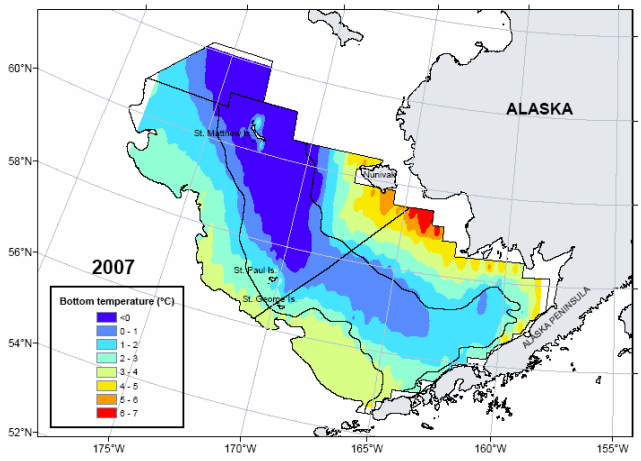


Fig. 2 Bottom water temperatures measured from the head rope of a trawl during the annual NOAA–Fisheries Alaska Fisheries Science Center summer bottom trawl survey. Figure courtesy of R. Lauth, NOAA, AFSC, RACE Division.

A late summer/early fall bloom of coccolithophores was observed from ~57ºN to 60ºN and ~169º to 172ºW (south of St. Lawrence Island and east of the Pribilof Islands) by the U.S. component of the Bering Aleutian Island Salmon International Survey (BASIS, **Fig. 3**). Hokkaido University's Satellite Remote Sensing Group detected the bloom as late as October using MODIS/Aqua.

Fig. 3 Aquamarine waters in the eastern Bering Sea during BASIS. Source: L. Eisner, NOAA – AFSC.

Climate models predict that the effects of global warming on ice cover will be largest in the fall. Unlike previous years, the ice growth in the Arctic and the Chukchi Sea was slow in the fall of 2007. In mid-December 2007, open water persisted in the Chukchi Sea with up to +10ºC anomalies in air temperature over most of the western Arctic and Chukchi Sea. BASIS researchers also noted in their surveys of the northern Bering and Chukchi Seas that the Chukchi Sea was warmer than the Bering Sea. At the time of this writing (December 2007), Chukchi Sea ice growth appears to be delayed by about 2 months, potentially diminishing the atmosphere's ability to generate conditions (cold northerly winds) that favor production of large amounts of ice in the eastern Bering Sea.

However, November 2007 sea surface temperatures (SSTs) from the Bering Sea are among the coldest since 1982, and are similar to the most recent cold year, 1999 (**Fig. 4, top**). The dominant pattern of SST covariation (55%) in November features a region of positive loadings throughout most of the Bering Sea centered over the deep basin, which is contrasted with a region of lesser negative loadings in Norton Sound in the northeastern Bering Sea (**Fig 4, bottom**). Positive loadings are associated with warmer SSTs.

The eastern Bering Sea did not experience much heating during the previous summer, so present water temperatures are cool (see above), requiring less heat flux to form ice. Scientists are divided in their opinions of whether or not 2007/08 will be a cold winter and spring for the eastern Bering Sea. Some point to the absence of Arctic sea ice that conditions the northerly winds responsible for Bering

Sea ice formation, and say that we can expect less ice this year; others point to the already cold water temperatures (and the moderate to strong La Niña on the equator) and say that we could have extensive sea ice coverage.

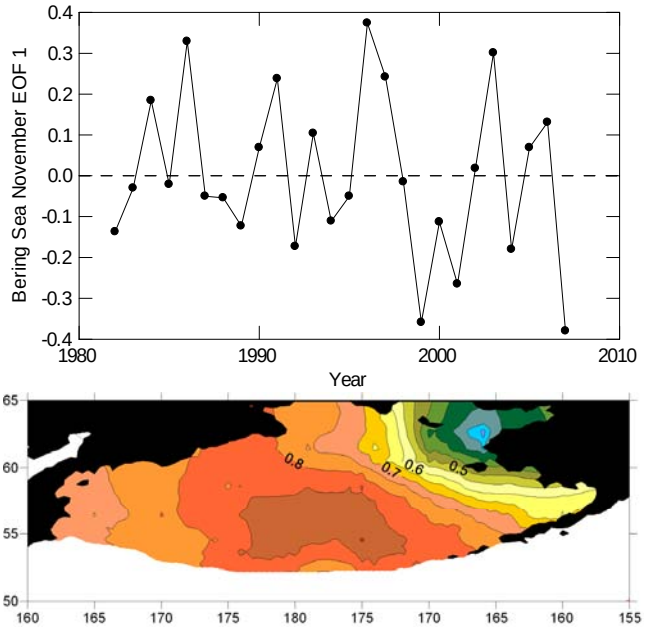


Fig. 4 (Top) Time series (1982–2007) of EOF 1 from Bering Sea November sea surface temperature (SST) data. (Bottom) Spatial pattern of EOF1 loadings from November SST data. Figures courtesy of S. McKinnell, PICES Secretariat.

The disappearance of sea ice can be expected to affect the management of ice-dependent wildlife such as polar bears, ice seals, and walrus. At last year's Alaska Marine Science Symposium there were several reports of impacts on polar bears, specifically on their increased mortality. The higher mortality rates were the result of starvation. Instances of cannibalism and decreased food availability due to loss of sea ice were reported. Recently, there have been reports from Russia of increased mortality of walrus due to reduced availability of sea ice as habitat. Densities of animals within walrus colonies were much greater last summer due to the lower availability of ice. Disturbances of the animals by bears, humans, *etc*., result in stampedes of walrus off the ice, and during these stampedes many animals are mortally injured or killed (http://seattlepi.nwsource.com/national/1501ap_sea_ice_walruses.html).

Recent data on fish populations in the eastern Bering Sea show continued decline in the biomass of both Pacific cod and walleye pollock, and increases in the biomass of flatfishes, including arrowtooth flounder. Pollock biomass is only 87% of the long-term mean, though the 2006 year class appears to be well above average at this time (http://www.fakr.noaa.gov/npfmc/newsletters/NEWS1207.pdf).

2007/08 activities in the eastern Bering and Chukchi Seas

2008 will be an active year for research in the Bering and Chukchi Seas. Scheduled programs include: 1) the Japan–U.S. IPY cruise, (http://www.nipr.ac.jp/~ipy/sympo/proc-files/ 34-Saitoh.pdf); 2) a partnership between the U.S. National Science Foundation's Bering Sea Ecosystem Study (BEST), and the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program (BSIERP, http://bsierp.nprb.org); and 3) the joint Russian–American Long-Term Census of the Arctic (RUSALCA). These investigations are in addition to annual cruises and surveys planned by the U.S. NOAA–Fisheries and the State of Alaska.

For example, last year, Hokkaido University's T/S *Oshoro-maru* extended their "usual" area of operations in the southeastern Bering Sea to include stations south of St. Lawrence Island, Norton Sound, and the eastern Chukchi Sea (**Fig. 5**). They will occupy nearly the same stations in 2008, and one of the objectives will be to compare the distribution of Arctic cod (*Boreogadus saida*) in the last two years with trawls taken in the early 1990s. Similarly, BEST will conduct a series of cruises aboard the USCG Icebreaker *Healy* beginning in approximately mid-March through mid-July in the eastern Bering Sea from the Aleutian Islands to St. Lawrence Island.

The Understanding Ecosystem Processes of the Bering Sea website sponsored by BEST and BSIERP (see above) has a page dedicated to information about research cruises (note

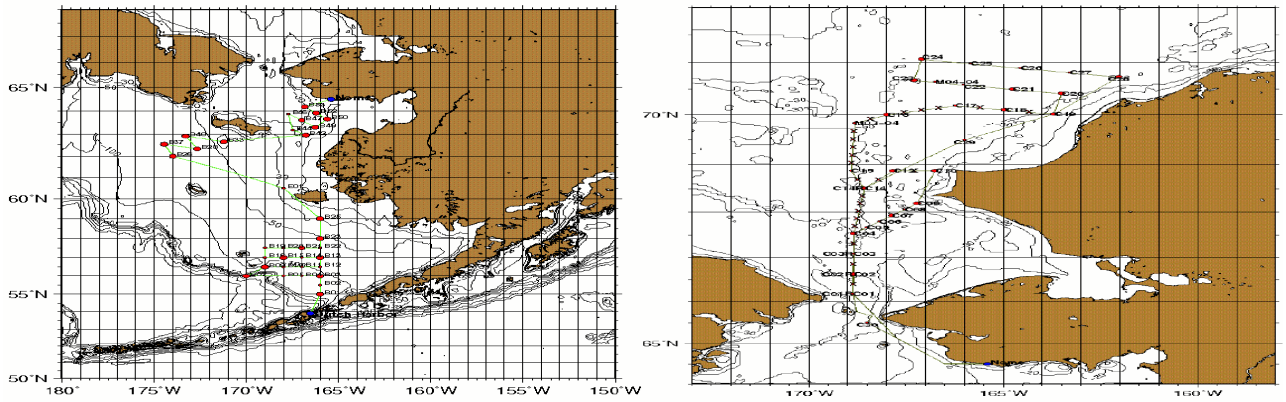


Fig. 5 *T/S* Oshoro-maru *stations and cruise tracks from Legs 2 and 3, summer 2007. Figure courtesy of S. Saitoh* (http://odyssey.fish.hokudai.ac.jp/IPY/).

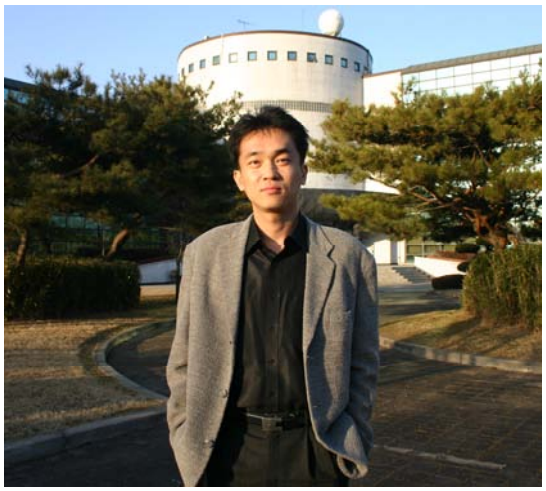
that there is also an IPY arctic ship coordination website at http://www.asci-ipy.de/). The author would like to encourage all who are working in these geographic regions to submit descriptions of their field programs (including land-based studies on birds, seals, and humans) to the website. Metadata can also be submitted to the North Pacific MetaDatabase that is maintained by PICES (http://www.pices.int/projects/npem/default.aspx). A little effort to make your programs known to others working in these areas will foster increased collaboration and interdisciplinary research in these regions.

Last, but not least, there will be a full day workshop at the PICES Seventeenth Annual Meeting (PICES XVII) in Dalian, China (October 23–November 2, 2008), for the presentation and discussion of results from IPY field projects. We hope to see you there!

Acknowledgements: Many thanks to the following PICEanS who helped create this report: Drs. Lisa Eisner, George Hunt, Skip McKinnell, James Overland, Sei-ichi Saitoh, and Phyllis Stabeno.

Dr. Jeffrey (Jeff) Napp (jeff.napp@noaa.gov) 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 Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI). His research is focused on physical and biological processes at lower trophic levels that affect recruitment variability in fish populations. Jeff was active as a Principal Investigator in past Bering Sea research programs (NOAA's Bering Sea FOCI, Southeast Bering Sea Carrying Capacity) and is currently a Principal Investigator on an NPRB-sponsored Bering Sea Integrated Ecosystem Research Plan (BSIERP) project. He formerly served on the BEST (Bering Ecosystem Study) Science and Implementation Plan Steering Committee. Jeff is also a member of the PICES MONITOR Technical Committee.

PICES Interns



PICES offers sincere thanks to **Mr. Xuewu Guo** (Yellow Sea Fisheries Research Institute of the Chinese Academy of Fishery Sciences, Qingdao, China), the 2007 PICES intern, who will complete his term at the Secretariat at the end of January, and return to China. Many of you had an opportunity to meet him at the ICES/PICES Conference for Early Career Scientists on "*New frontiers in marine science*" in Baltimore (U.S.A.), at the PICES Sixteenth Annual Meeting in Victoria (Canada), or at the PICES Secretariat office. It was very enjoyable working with him, and we appreciate his dedicated efforts and excellent performance during this past year. We wish him great success in his career.

We are pleased to announce that **Mr. Key-Seok Choi** from the Korean Ocean Research and Development Institute (Ansan, Korea) will join the Secretariat in early February as the 2008 PICES Intern. He has a unique combination of a Bachelor's Degree in Oceanography and a Master's Degree in Library Science, and we look forward to his involvement in PICES activities.

Recent trends in waters of the subarctic NE Pacific

by William Crawford and William Peterson

The winter of 2006/07 was characterized by a drop in temperatures in the eastern Gulf of Alaska accompanied by unusually large snowfalls on the inland mountains. We attribute these conditions to the persistent anomalies that were observed in the atmosphere. The Aleutian Low was located far to the east of its normal winter position, as indicated by the location of the anomalous low pressure region labelled **L** in **Figure 1a**. The resulting winter winds blew more strongly from the west, bringing cooler surface waters to the eastern Gulf, as shown in **Figure 2a**. These conditions share many features with the winters of 1999 to 2002 when the Victoria pattern was strongly positive. From April to September 2007, the North Pacific High (labelled by **H** in **Fig. 1b**) was located far to the south, and a region of anomalously low pressure occupied the Gulf of Alaska creating anomalous winds from the south (**Fig. 1b**) and warmer coastal waters (**Fig. 2b**). Lower sea surface temperature anomalies developed closer to the center of the low pressure anomaly (**Fig. 2b**).

Based on local sea levels, the spring transition arrived early off central Oregon (March 12), although it featured weakly upwelling winds that prevailed through the summer. The date of the biological spring transition (the first date when the copepod community had changed from a winter (warm-water) downwelling community to a spring upwelling (cold-water) community) was March 21.

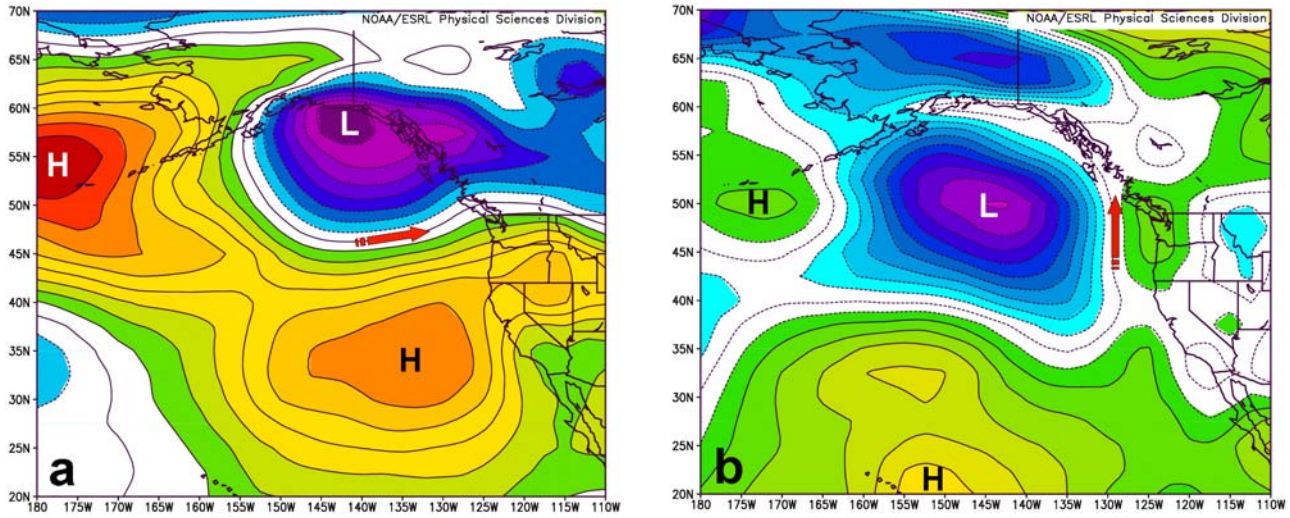


Fig. 1 Contours of sea level pressure anomalies from the average for each period for the years 1968 to 1996. Red arrows indicate the direction of anomalous winds. (a) November 2006 to March 2007, contour interval is 0.25 millibars; (b) April to September 2007, contour interval is 0.5 millibars. (Source: NOAA Earth System Laboratory, Physical Sciences Division.)

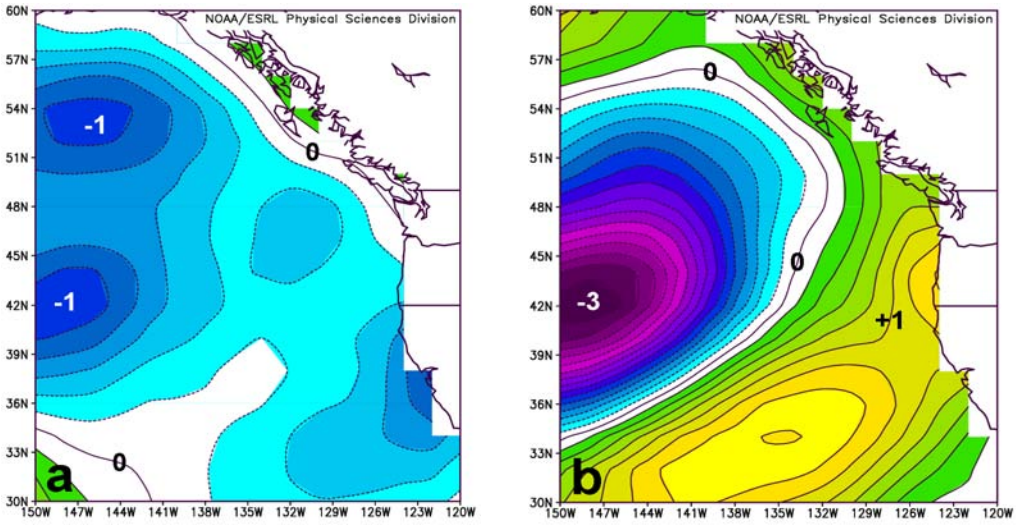


Fig. 2 SST anomalies in (a) January 2007 and (b) July 2007. (Source: NOAA Earth System Laboratory, Physical Sciences Division.)

Despite warmer surface temperatures (**Fig. 3, bottom**) due to weaker upwelling winds of Oregon, the shelf bottom waters that could have upwelled (*i.e.*, the source waters) were very cold, as cold as the well-described *sub-Arctic intrusion* of the summer of 2002, and equally as cold as what was observed during the 1999 La Niña (**Fig. 4**). This past summer, however, the water was much saltier than all summers observed since recent measurements began in 1997. We attribute the presence of cold sub-surface water (which has Gulf of Alaska origins) on the shelf to the cool temperatures generated in the Gulf of Alaska during the winter of 2006/07. The warm surface waters in summer are likely due to the dominance of southwesterly winds in summer (**Fig. 1b**). Thus, the Oregon upwelling zone in 2006/07 had the best sub-arctic conditions in the deeper water but the worst of times at the surface in the summer.

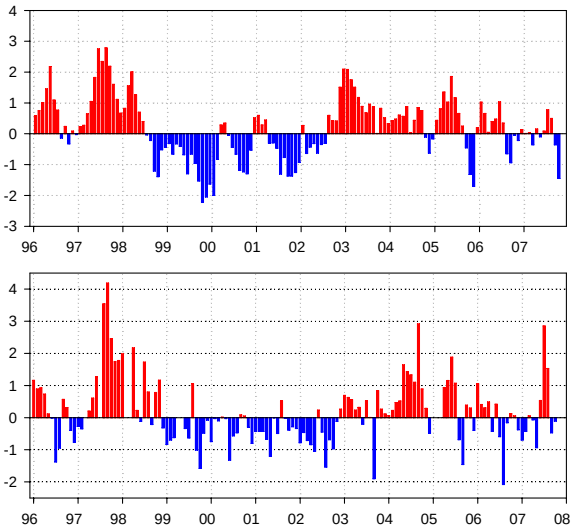


Fig. 3 (Top) Time series of the monthly PDO index since 1996. Note that the PDO was very weak from fall 2006 through summer 2007. The Victoria pattern appears to have dominated through this winter. The PDO turned negative in September 2007 and strongly negative in October 2007. (Bottom) SST anomalies (from 1992–2005 mean) at the NOAA buoy off Newport, OR The months of June through August 2007 were warmer than average, with a difference of nearly 3°C in July.

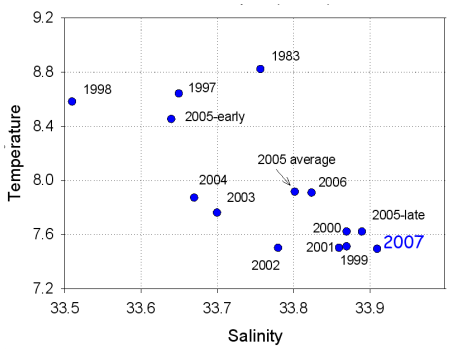


Fig. 4 Temperature and salinity averaged over the months of May through September at a baseline station located 5 miles off Newport (NH05). Water depth at this station is 62 m. In 2007, the deeper water was the saltiest observed since measurements began in 1997; temperatures were similar to those seen from 1999–2002. For each year the number of visits to NH05 varied from 12 to 20.

As for the zooplankton, copepod species richness anomalies were negative or neutral during all months of 2007, indicating that the community composition was chiefly northern cold water species. This shift to northern copepods is plotted in **Figure 5**.

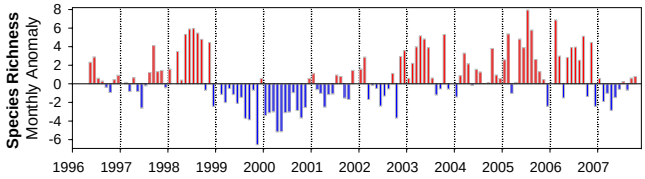
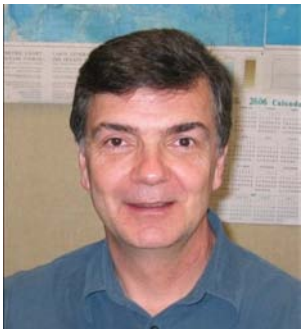


Fig. 5 Copepod species richness anomalies were negative throughout 2007 indicating a cold water community. This matches with the cold water that was off the coast during the winter and the cold, salty deep water during summer 2007.

The question is, of course, will the "cold water" conditions prevail into next year? So far, all indications are that this will be the case, especially since the PDO is strongly negative. However, note in **Figure 3** that the PDO has turned negative during late autumn in each of the past four years (2004-2007), but then returned to the positive phase by late winter or spring.



Dr. William (Bill) Crawford (left, crawfordb@pac.dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. He conducts research into the movement of water masses in the Gulf of Alaska and their impacts on marine biota. Bill co-chairs the Fisheries and Oceanography Working Group that prepares the annual "State of the Ocean" report for Canada's Pacific Region and neighbouring waters. Bill is the senior Canadian delegate to the International Association of Physical Sciences of the Ocean. He also serves as the Canadian member of the Pacific Panel of CLIVAR and the PICES CFAME Task Team.

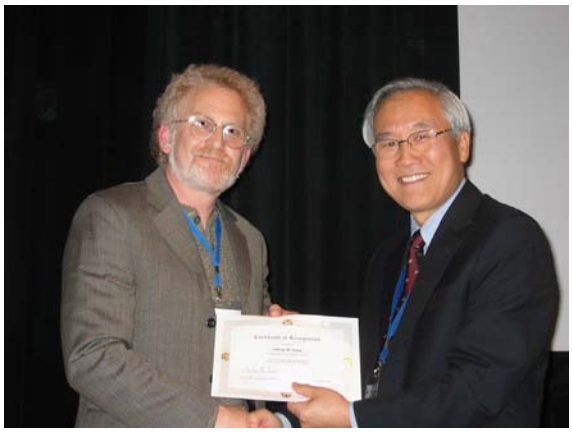
Dr. William (Bill) Peterson (right, bill.peterson@noaa.gov) is a Research Scientist with the U.S. National Marine Fisheries Service at the Newport facility in Oregon, and is also an Adjunct Professor of oceanography at the College of Oceanographic and Atmospheric Sciences at Oregon State University. Bill's main research interest is the effects of climate variability and change on zooplankton and pelagic fish populations (particularly juvenile salmonids) in the Northern California Current region. In PICES, he is a member of the Biological Oceanography Committee and Co-Chairman of the newly formed Working Group on Comparative ecology of krill in coastal and oceanic waters around the Pacific Rim.

Election results at PICES

PICES thanks Drs. Kuh Kim (Science Board Chairman, October 2004 to November 2007), Igor I. Shevchenko (TCODE Chairman, October 2001 to November 2007) and Jeffrey M. Napp (MONITOR Chairman, April 2005 to November 2007) for their dedicated service and leadership over the years. We hope that PICES will continue to benefit from their expertise and contributions.

Elected at PICES XVI are, for Science Board: Drs. John Stein (Chairman) and Sinjae Yoo (Vice-Chairman); for TCODE: Drs. Bernard Megrey (Chairman) and Kyu-Kui Jung (Vice-Chairman); for MONITOR: Hiroya Sugisaki, (Chairman) and Phillip Mundy (Vice-Chairman), whom are introduced in this article.

Dr. Kuh Kim making sweeping changes at the PICES XVI curling event.



Drs. Igor Shevchenko, outgoing TCODE Chairman, and Jeffrey Napp, outgoing MONITOR Chairman, receiving a Certificate of Recognition from Dr. Kuh Kim, Science Board Chairman, at the PICES XVI Closing Session.

Science Board

John Stein began his association with PICES in 1993, when he was appointed a member of Working Groups formed under the Marine Environmental Quality Committee (MEQ). Later, he assumed chairmanship of MEQ and led the Committee for six years. Before becoming Science Board Chairman, John also served as Vice-Chairman of the Science Board for two years. Some of the noteworthy highlights of John's time in PICES were being part of the group that organized and held PICES' first practical workshop where scientists from all member countries conducted field surveys and laboratory studies on the status of the environmental quality of the Vancouver Harbour, Canada; serving as Chairman of MEQ during the establishment of the Section on *Ecology of harmful algal blooms in the North Pacific*, which has been very successful, and was the MEQ Committee's first step in broadening its focus from strictly chemical contaminants; being part of the effort to develop the first North Pacific Ecosystem Status report; and most recently, leading the Study Group and Writing Team to develop the next integrative science program of PICES, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems). During his tenure as **Science Board Chairman**, John is looking forward to seeing FUTURE become truly integrative of all committees in PICES, and to begin to develop and deliver scientific products sought and used by the member countries.

John, a native of Washington State, was born and raised in Mount Vernon, a farming community north of Seattle, well known for their tulip festivals. He attended Central Washington University and received a B.S. in Chemistry in 1974. In 1980, he received his Ph.D. in Organic Chemistry from the University of Washington. Later that year, John accepted a

position in the Environmental Conservation (EC) Division at the Northwest Fisheries Science Center (NWFSC) as a research chemist. His early research involved investigations on the uptake and metabolism of polycyclic aromatic hydrocarbons (PAH) in marine biota. John expanded his scientific expertise to include the development and application of biological markers of chemical contaminant effects and the application of these techniques in delineating relationships between chemical contaminant exposure and effects in fishes and marine mammals. During this time he became a program manager for the biochemistry unit of the EC Division, and was principal investigator for several national NOAA programs, including marine mammal investigations through the Marine Mammal Health and Stranding Response Program, and development of environmental biomarkers under NOAA's Coastal Ocean Program. John has also served on numerous environmental task forces and committees in the Pacific Northwest and nationally, as well as a Research Associate Professor for the Department of Chemistry at Seattle University, and most recently as Affiliate Professor in the Department of Environmental and Occupational Health Sciences of the University of Washington.

From 1994–2005, John served as Director of the EC Division investigating the impacts of anthropogenic and natural perturbations (*e.g.*, chemical contaminants and harmful algal blooms) on fishery resources, protected species, and the quality of marine habitat. Results are used regionally and nationally to determine scientifically sound approaches for conserving living marine resources, restoring habitat productivity and function, assessing the impacts of toxic substances on the health and safety of fishery resources, and responding to environmental emergencies from the release of toxic materials. As Director, he provided leadership in the formation of the Watershed Program to address a crucial need for the agency to recover Pacific salmon under the Endangered Species Act. Through this program the agency successfully filled a critical science gap and now has relevant ecological research programs in place to inform managers for the recovery and conservation of Pacific salmon. John was given the NOAA Administrator's Award, one of the highest awards given to NOAA employees, for this work.

John also serves as Co-Director for NOAA's West Coast Center for Oceans and Human Health located at the Northwest Fisheries Science Center. This new national initiative, which involves NOAA, National Science Foundation and National Institute of Environmental Health Sciences funded programs, recognizes that the condition of the ocean can have a direct effect on the health and well being of humans. The West Coast Center's goal is to understand how humans impact coastal and ocean resources and to assess how the oceans affect the health and well-being of people. Understanding these inter-relationships will lead to better predictions and forecasts of serious threats to human health from viruses, bacteria, biotoxins, and chemical contaminants that can be present in the oceans and seafood and identify ways to improve the quality of ocean resources now and in the future. In addition, John also serves on NOAA's Integrated Water Resource Services national team which is taking a national perspective to improve freshwater-related forecasts, and link hydrologic information and products to ecological assessments of watersheds and estuarine and near coastal systems. In 2005, he was selected, and currently works, as Deputy Science and Research Director for the Northwest Fisheries Science Center of NOAA Fisheries.

Outside of NOAA and PICES, John enjoys fishing on the Skagit River, alpine skiing in Washington, and helping out as a "farm hand" on his wife's farm. There is always another project – fruit trees to prune, a patch of garden needing weeding, something to be harvested, or feeding and caring for the chickens and sheep. It may seem like a great deal of work, but it is a great break from work and science and provides endless opportunities for physical work and getting away from the desk, e-mails, and the computer.

Sinjae Yoo is a research scientist with KORDI (Korea Ocean Research and Development Institute) and is based in Ansan, Korea. Sinjae received his B.S. and M.S. in Oceanography from the Seoul National University, and his Ph.D. in Ecology and Evolution from the State University of New York at Stony Brook. His scientific interests include long-term change in primary production and phytoplankton dynamics in various marine environments. Sinjae regularly lectures at various universities and has been involved in many research projects including the Yellow Sea Large Marine Ecosystem. He was a panel member of IOCCG and Coastal-GOOS, and served on the Advisory Committee for the Korea Science and Engineering Foundation. Sinjae also chairs the newly established Korean IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) program. Over the years, Sinjae has been involved with PICES, serving as a member of the MODEL Task Team, the Biological Oceanography Committee, the Writing Team of the Study Group on Future Integrative Scientific Program(s) and the Science Board, and now as **Vice-Chairman of the Science Board**.

MONITOR Technical Committee

Hiroya Sugisaki was born and raised in Kanagawa prefecture, near Tokyo, Japan. Since childhood, Hiroya has loved all kinds of animals, and he often enjoys birding and bugging and has kept aquaria filled with tropical fish and reptiles since he was 5 years old. Hiroya received his B.Sc. from the Faculty of Agriculture, University of Tokyo, in 1986, and his M.Sc. (1988) and Ph.D. (1991) degrees from the Ocean Research Institute, University of Tokyo. His graduate research was focused on the ecology of pelagic amphipods, especially inter-specific relationships of carnivorous mesozooplankton in the North Pacific.

He has been employed by the Fisheries Research Agency of Japan since 1992, and worked at the Tohoku National Fisheries Research Institute (TNFRI) until 2006. His main area of research was predator–prey relationships and competition for food between larval and juvenile fishes (*e.g.*, Japanese sardine, Pacific saury) and mesozooplankton, mainly in the Oyashio cold water region and Oyashio–Kuroshio transition region. He initiated and carried out various projects related to the study of mechanisms of long-term variability of stock size of pelagic fishes. In 1997, he studied the survival mechanism of early life stages of walleye pollock at FOCI (Fisheries Oceanography Coordinated Investigations, Alaska Fisheries Science Center, NOAA). Since October 2006, he has been working at the National Research Institute of Fisheries Science in Yokohama, where his research has expanded to include the Kuroshio warm water region.

After Dr. Kazuko Odate retired from TNFRI, Hiroya became the curator of, and contributed new samples to, the famous Odate Collection of zooplankton samples (in photo: *Hiroya Sugisaki (right) with Dr. Kazuko Odate, the originator of the Odate Collection*). Since 2002, he has re-analyzed the species composition of the Odate Collection as a good example for the field monitoring data set of long-term variation of the ocean ecosystem, and organized the research project on long-term variation of ocean ecosystem/climate interactions by re-analyzing the species composition of the Odate Collection, called the Odate Project. Hiroya thinks that the information from long-term continuous field monitoring data is very important for understanding the mechanisms of the variation of ecosystem and forecasting ecosystem status, and as **Chairman of MONITOR**, he wishes to encourage activities related to monitoring ocean ecosystems for the future science.

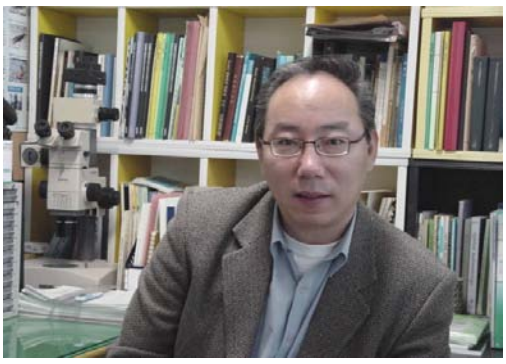
Phil Mundy has a B.S. in Zoology from the University of Maryland, an M.S. in Biology from the University of Alabama, and a Ph.D. in Fisheries from the University of Washington. Before joining the Exxon Valdez Oil Spill Trustee Council (EVOSTC), Phil was Assistant Professor (Department of Oceanography, Old Dominion University), Associate Professor (School of Ocean and Fisheries Sciences, University of Alaska), Chief Fisheries Scientist (Alaska Department of Fish and Game) and Science Program Director (Columbia River Inter-Tribal Fish Commission). Phil has served as an advisor on fishery management to a wide variety of governmental organizations and private interests, including the Pacific Salmon Commission, the North Pacific Fishery Management Council, the Alaska Board of Fisheries, the U.S. Army Corps of Engineers, the Northwest Power and Conservation (Planning) Council, and Preston, Gates and Ellis. Phil has been the Director of the Auke Bay Laboratories (ABL) Division since 2005. At EVOSTC, Phil led the development of the Gulf Ecosystem Monitoring (GEM) program, and served as an editor and contributing author of a book for GEM, "*Gulf of Alaska Biology and Oceanography*" (2005). Also at EVOSTC, he helped launch the North Pacific Research Board (NPRB) as a charter board member and advisor on integrated ecosystem planning and implementation, and also served on the Steering Committee of the U.S. Global Ocean Observing System, which helped initiate the nation's Integrated Ocean Observing System (IOOS) effort. Phil's emphasis as ABL Director is to enable the observations and models needed for the ecosystem approach to fisheries management. Working with NPRB, he was one of the authors of the Bering Sea Integrated Ecosystem Research Plan, a contributor to the development of the draft Gulf of Alaska Integrated Ecosystem Research Plan, and a contributor to the development of standards for selecting ecosystem-level models as a member of the NPRB's Ecosystem Modeling Committee. In PICES, Phil has been active in MONITOR since 2004, and led the Study Group to develop a strategy for GOOS in 2006–2007. He will continue fostering international cooperation in ocean observing for fisheries as **Vice-Chairman of MONITOR**.

Technical Committee on Data Exchange (TCODE)

Bernard Megrey was born in the steel and auto-making regions of the Great Lakes. He received his B.S. in Environmental Science from Cleveland State University in 1974, and a M.Sc. in Systems Ecology from Miami University of Ohio in 1978. After his Masters, Bernard moved to the West Coast and attended the University of Washington's fisheries science program and was affiliated for several years with the Center for Quantitative Science. He received his Ph.D. in Fisheries Science from the University of Washington in 1989. Bernard currently is a Research Fisheries Biologist with NOAA's Alaska Fisheries Science Center in Seattle, where he has worked since 1982. Presently he serves as a leader for the Modeling, Prediction and Databases team with NOAA's Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), a professional group of simulation modelers, fisheries biologists, computer and network technical support staff, database managers, and web page designers. He has over 25 years' research experience studying fisheries oceanography, fisheries population dynamics and stock assessment techniques applied to exploited North Pacific fish populations, the relationships of the biophysical environment to recruitment variability, numerical simulation modeling of marine ecosystems, impacts of climate change on marine ecosystems, comparative ecosystem analysis, and the application of computer technology to fisheries research and natural resource management.

Bernard has participated in PICES activities since its inception, attending every PICES Annual Meeting since the first one in 1992. His involvement with PICES has included serving as a member and, for five years, as Chairman of the MODEL Task Team, where he co-led the development of the NEMURO suite of models. This effort recently culminated in a publication of a special issue of *Ecological Modelling*. He has also been a TCODE member since 1997 and Vice-Chairman since 2005. For the past 4 years he has co-directed the PICES Metadata Federation Project, which seeks to establish a one-stop portal for all North Pacific ecosystem bio-physical marine ecosystem metadata held by all PICES member countries. He will continue leading this effort, now as **TCODE Chairman**.

In addition to PICES, Bernard is active in other regional, national, and international organizations including: the International Council for the Exploration of the Seas (ICES), where he has served as an editor of the *ICES Journal of Fisheries Science* for the past five years; the Ecosystems of the Subarctic Seas (ESSAS), where he was on the Science Planning Committee and is a member of the Scientific Steering Committee; GLOBEC, where he was a contributor to the Focus 3 Working Group on Predictive and Modeling Capabilities; the American Fisheries Society, where he has held several officer and committee positions; and the American Institute of Fisheries Research Biologists. Relevant to the NW Pacific, Bernard co-directs NOAA's North Pacific Ecosystem Metadatabase (formerly the Bering Sea Ecosystem Metadatabase), and co-chairs the Data Management and Communications Committee for the Alaska Ocean Observing System.



Kyu-Kui Jung was born and raised in Busan (Pusan), Korea. He received his B.S. in Geology from Pusan National University in 1983, and his M.Sc. and D.Sc. degrees in Geology and Paleontology from Tohoku University of Sendai, Japan, in 1985 and 1988, respectively. His graduate research involved biostratigraphy and paleoenvironmental reconstructions of Cenozoic sedimentary rocks, and ecological and morphological studies of microscopic shell-bearing Protozoa, foraminifera in modern and ancient marine sediments. Kyu-Kui was a lecturer on micropaleontology and sedimentology at Pusan National University from 1990–1996, and now he is a Research Marine Geologist with the National Fisheries Research and Development Institute, where he has worked since 1997. His current research is focused on the development of foraminiferal proxies for marine environment monitoring and assessments, and forecasting and monitoring of the oceanographic conditions in the seas around Korea.

Kyu-Kui co-directed the Korea Oceanographic Data and Information Service (KODIS), a metadata system, and managed the Korean Delayed Mode Data Base of the North-East Asian Regional GOOS. He has also served as a member of TCODE since 2005. His wide experience in studying the long-term evolution of marine ecosystems and managing oceanographic data and information is an asset for the **TCODE Vice-Chairman** position.

A new PICES award for monitoring and data management activities

Background and aims

Progress in many aspects of marine science is based on ocean observations, monitoring, and the management and distribution of the data provided by these activities. It is widely recognized that these fundamental activities often lack the glamour that is attributed to the scientific achievements that rely on monitoring and observation. Monitoring activities are declining, especially in PICES member countries with severe financial constraints. With this in mind, it was proposed at the 2006 Annual Meeting in Yokohama, Japan, that a new PICES award be established to acknowledge monitoring and data management activities contributing to the progress of marine science in the North Pacific. The principles of the award were approved at the 2007 inter-sessional Science Board/Governing Council meeting, also in Yokohama, and the name and description of the award were finalized at the 2007 Annual Meeting in Victoria, Canada.

The PICES Ocean Monitoring Service Award (POMA) aims to recognize organizations, groups and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring and data management in the North Pacific. The award also strives to enlighten the public on the importance of those activities as fundamentals of marine science. It draws attention to an important aspect of the PICES Convention that is not so much in the limelight: "*to promote the collection and exchange of information and data related to marine scientific research in the area concerned*." The POMA will be presented for the first time at the upcoming PICES Seventeenth Annual Meeting in Dalian, China.

Eligibility

Awards will be for significant contributions to the progress of marine science in the North Pacific through their long-term monitoring operations and/or management of data associated with ocean conditions and marine bio-resources in the North Pacific. Recipients may include, for example, research vessels, research or administrative institutes, or portions thereof, involved in monitoring, data management and distribution, or technical groups. Outstanding individual efforts will also be recognized.

Nomination and selection

Nominations may be made by individuals or groups from PICES member countries and should be sent with supporting documentation to the Executive Secretary (bychkov@pices.int) by the date specified below in the "Call for nominations" notice. Two PICES Technical Committees, MONITOR and TCODE, will review the nominations and provide recommendations to Science Board prior to their inter-sessional meeting. Science Board will select the awardees. Considerations include a balance in the field of activities (oceanographic observation, bio-resources monitoring, management of data, *etc*.) and present and previous recipients. Those nominated to Science Board by MONITOR and TCODE but not selected are rolled over to the following year in order to keep a pool of potential candidates.

Award and presentation

The award consists of a certificate signed by the PICES Chairman and the PICES Science Board Chairman, which will be presented by the PICES Chairman to the recipients (or their representative) at a formal ceremony during the PICES Annual Meeting. No financial support from PICES will be provided to the recipient to attend the Annual Meeting where the award is given. Should any representative be unable to attend the Annual Meeting, a Delegate of the recipient's country will receive the award on the recipient's behalf.

Call for nominations

We are now soliciting nominations for the **2008 Wooster Award** and the **2008 POMA**. The closing date for nominations for both awards is **March 15, 2008**. Both awards will be presented during the Opening Session of PICES XVII in Dalian, China.

Nominations should include the following information: nominee's name, institutional affiliation and title, address and biographical resume, and statement of justification for the nomination.

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P.O. Box 6000,
9860 West Saanich Road,
Sidney, B.C., Canada. V8L 4B2
Tel: 1 (250) 363-6366
Fax: 1 (250) 363-6827
E-mail: secretariat@pices.int
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