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2010 PICES Science: A Note from the Former Science Board Chairman

My tenure as Science Board Chairman has come to an end. I truly enjoyed the time I could serve in furthering the cooperative international science we do in PICES, and I look forward to continuing to be involved in the activities of the Organization. I can look back over the last three years and be proud of the work that Science Board did to put FUTURE (*Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems*) on a firm foundation as our next-generation integrative science program. The acceptance in the international science community of the cutting-edge nature of FUTURE has confirmed for me that we did develop Science and Implementation Plans that have the potential to advance our understanding of North Pacific ecosystems and to project and forecast ecosystem responses to climate change and human activities in our coastal regions. We have set a high bar but it is not out of reach.

I also 'retire' from the Science Board knowing that it is in the good hands of Sinjae Yoo as our next Science Board Chairman, and that we have three very competent Chairmen of the FUTURE Advisory Panels: Thomas Therriault (AICE), Hiroaki Saito (COVE), and Robin Brown (SOFE). I am assuming a new role as U.S. national delegate to PICES, stepping into the position very competently filled by Samuel Pooley who is stepping down from PICES but not out of international science activities. Sam will be devoting more time to regional North Pacific science activities and organizations, which will have connections to PICES in the future. Here I should also thank Michael Dagg and Michael Foreman who completed their terms as Chairmen of the Biological Oceanography (BIO) and Physical Oceanography and Climate (POC) Committees. On behalf of Science Board I want to acknowledge the outstanding service to PICES by the 'Mikes' – they are worthy examples for future Chairmen of our Standing Committees to emulate.

I can report again that PICES was very productive in 2010, both in sponsoring and co-hosting significant symposia and workshops and in making our science available to the science community and beyond. We either supported or helped support and arrange 15 inter-sessional symposia, sessions, workshops and meetings convened at various locations around the North Pacific and the world at-large. The premier event of the year was the very successful symposium on "*Climate change effects on fish and fisheries*" held in April 2010 Sendai, Japan. PICES was the major international sponsor of this event, along with ICES and FAO. The response to the symposium exceeded our expectations, with over 350 abstracts submitted, and almost 400 scientists from 37 countries attending. It was an outstanding symposium and venue, and again a well-deserved thanks to our Japanese hosts. Sendai was not our only joint effort with other organizations. PICES was also an active sponsor for the European Summer School ClimECO2 held in August in Brest, France, and the IMBER IMBIZO2 held in October in Crete.

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The two 'Mikes', Mike Foreman (left) and Mike Dagg (right) receiving PICES certificates of appreciation for their terms as POC and BIO Chairmen from John Stein.

A Science Board scrum before announcements are made for best presentations at the Closing Session (clockwise from left) Steve Rumrill, Sinjae Yoo, John Stein, Mike Foreman, Mike Dagg, Tom Therriault and Robin Brown.

In addition to symposia and workshops PICES publications are a very important record of the activities and scientific findings of the Organization. A dynamic and balanced publications program is needed for efficient communication with a highly varied audience. The end of 2009 through 2010 saw a busy year for publishing the outcomes of a number of PICES-sponsored activities. Here, I highlight some special primary journal issues:

- *Marine Ecology Progress Series* (2009, Vol. 393) – papers from the PICES-2007 Topic Session on "*Phenology and climate change in the North Pacific*";
- *Deep Sea Research II* (2009, Vol. 56, Is. 26) – results from the second Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study (SEEDS-II);
- *Deep Sea Research II* (2010, Vol. 57, Is. 7–8) – papers on krill biology and ecology from the 4th International Zooplankton Production Symposium (Gijón, Spain);
- *Continental Shelf Research* (2010, Vol. 30, No. 6) – a special issue on tidal dynamics of marginal seas dedicated to Prof. Alexei Nekrasov;
- *Deep Sea Research II* (2010, Vol. 57, Is. 17–18) – results from the Oceanic Ecosystem Comparison in the Subarctic Pacific (OECOS) experiment;
- *ICES Journal of Marine Science* (2010, Vol. 67, Is. 9) – papers from the 2009 symposium on "*Rebuilding depleted fish stocks: Biology, ecology, social science and management strategies*".

The most significant accomplishment in publishing our science was the much anticipated second North Pacific Ecosystem Status Report (PICES Special Publication No. 4). This major report was published in the summer of 2010 and is nearly 400 pages and follows the 1998–2002 period of the first edition with another 5-year period covering 2003–2008. It updates the ecosystems of the coastal and oceanic regions throughout the North Pacific Ocean by addressing system components from climate and hydrography through to fish, birds and mammals. This was a major undertaking by PICES, and special recognition must be given to all the authors and contributors to the individual chapters and especially to the editors, Skip McKinnell and Michael Dagg. Without their dedicated effort, long hours and attention to the details we would not have the high quality volume that we do.

Our Scientific Report Series serves an important function in providing a venue for publication of the full work of our expert groups. In 2010, the final reports of the Working Group on *Ecosystem-based Management Science and its Application in the North Pacific*, and of the Advisory Panel on *Micronekton Sampling Inter-calibration Experiment* were published as PICES Scientific Reports No. 37 and No. 38, respectively.

We also worked to make PICES publications more accessible to member country scientists. This year the *Guide to Best Practices for Ocean CO_2 Measurements*, (PICES Special Publication No. 3, 2007), was translated into Korean and Chinese languages.

We have continued our high priority actions to build capacity in science and technology. Knowledge transfer and education are essential in this effort, and our Section on *Ecology of Harmful Algal Blooms* (HAB-S), with support from the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF), has continued a multi-year project to improve capacity for testing seafood for harmful algal bloom toxins in developing Pacific countries outside of the PICES region. Building this capacity should increase the safety of exported seafood and improve safety of seafood consumed within the country. The 2010 course for the detection, sampling and analysis of harmful aquatic organisms was developed and then conducted with a number of institutions in Guatemala. The course included lectures and hands-on training classes to insure that the participants could effectively use the required equipment and properly conduct the toxin assays. Also with support from MAFF, a demonstration workshop on "*An introduction to rapid assessment survey (RAS) methodologies for application in developing countries*"

was held in July 2010, at the Marine Station of Kobe University's Center for Inland Seas, Japan. The focus of the workshop was on hands-on training of researchers from mostly developing Southeast Asian countries concerned about the potential introduction of non-indigenous marine species and provided participants with the tools to conduct their own surveys. Preparations are in progress for several capacity development events in 2011 and 2012:

- PICES/MAFF HAB training course for a South Pacific Island community, spring 2011, Fiji;
- PICES/MAFF RAS demonstration workshop for Southeastern Asian countries, summer 2011, Thailand;
- 5th SOLAS Summer School (co-sponsored by PICES), September 2011, Cargèse, Corsica, France;
- NOWPAP/PICES/WESTPAC training course on "*Remote sensing data analysis*", October 2011, Vladivostok, Russia, immediately prior to PICES-2011;
- 2nd ICES/PICES Early Career Scientist Conference on "*Oceans of change*", April 2012, Palma de Mallorca, Spain.

Many of the scientific and capacity building issues addressed by PICES are not unique to the North Pacific, and concern the entire world. It is, therefore, of value to expand cooperation with other international scientific organizations and programs at regional and global scales. At the PICES 2010 Annual Meeting in Portland, Oregon, observers from 35 international and regional organizations and programs were present, surpassing 30 observers in 2009 and 21 in 2008, and demonstrating that we are continuing to build our international relationships in productive ways.

Besides being well attended, PICES-2010 covered a broad range of timely and very relevant marine science issues. We appreciate that Dr. Larry Robinson, Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Administrator for the National Oceanic and Atmospheric Administration, gave opening remarks on the behalf of the United States, and that Luis Valdés, Head of the Section for Ocean Science of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, addressed the participants in connection with the 50th anniversary of IOC.

About 430 scientists and managers from 16 countries attended a full-day Science Board Symposium led by a keynote by Dr. Jack Barth, 16 Topic and 3 Paper Sessions, 5 Workshops and 26 business meetings of the committees and expert groups took place, and 376 talks and posters were presented. Those are some of the facts, but our meeting is about the science in the North Pacific and globally, so it is important that I acknowledge some of the key PICES awards for scientific excellence. I must start with congratulating Dr. Jeffrey Polovina (NOAA's Pacific Islands Fisheries Science Center, U.S.A.), the recipient of the 2010 Wooster Award, and follow with acknowledging the Station Papa/Line-P monitoring program, the recipient of the 2010 PICES Ocean Monitoring Service Award (POMA). We also presented awards for best papers and posters, and I encourage you to visit the PICES website (http://www.pices.int/publications/presentations/) and see who the worthy recipients were this year. I will, however, mention that the best presentation at the Science Board Symposium was by Dr. Shin-ichi Ito (Tohoku National Fisheries Research Institute, FRA, Japan) who gave an outstanding talk on the projection of Pacific saury response to future climate change.

A full house in attendance at the Science Board Symposium.

Dr. Shin-ichi Ito addresses the audience at the Science Board Symposium.

Dr. Tokio Wada (holding a glass of wine) enjoying a good joke at the Chairman's Reception at PICES-2010 in Portland.

Some high spirited enthusiasm being generated during bowling, the host country's demonstration sport.

A fine turnout at the Poster Session.

Some of PICES' finest scientists enjoying a game of Wii.

Now I will turn to some future activities. The most important is our next Annual Meeting, which will take place in Khabarovsk, Russia. The theme for the meeting will be "*Mechanisms of marine ecosystem reorganization in the North Pacific Ocean*". As I have mentioned previously it is never too early to start making arrangements for attending this meeting. By all accounts, Khabarovsk will be an excellent venue, a beautiful city and, as pointed out by one of my Russian colleagues, the Amur River which runs through the city makes the Columbia/Willamette River system that runs through Portland, seem like a small tributary. This is just a point to further spark your interest in attending PICES-2011.

I want to close with where I started. I have enjoyed my time immensely as Chairman of Science Board and I hope that you feel my service was of value. I also must acknowledge the patience of the PICES Secretariat when I could not devote as much time to PICES as it deserved, especially during the time I spent in the Gulf of Mexico responding to concerns over seafood safety following a major oil spill. Finally, I want to take a moment to look forward to the possibilities and challenges for PICES. I do see a bright future for the Organization. We have a forward- looking, high quality science initiative in FUTURE; there were a number of new young scientists at PICES-2010 that I hope will stay engaged with PICES; our collaborations with other international science organizations are either growing or strengthening in very positive directions; and PICES is well recognized for its strengths in the science of climate and climate change effects on marine ecosystems. On the challenge side, I see that we will need to build on our strengths during tough economic times. The negative pressures on our member countries' budgets supporting both existing and new science programs will be large as the global economy struggles to recover and some countries work to reduce budget deficits. There will also be challenges to cultivate the next generation of leaders in PICES, and there will likely be shrinking budgets to support travel, limiting opportunities for attendance at workshops and symposia which are critical to vibrant international science collaboration. I see the glass as half full, however, and I am confident that the scientific value of PICES is well recognized, and as such, the Organization has the resilience to weather these times. I also believe PICES has the agility to find the opportunities that will be available to those who are working to do the best science on pressing regional and global issues of great societal concern. PICES has the people, the scientific track record and respect to be a relevant, responsive and reliable international science organization, and I look forward to being part of PICES as we go forward. So it is thank you for the opportunity to serve but it is not so long.

John Stein, former Science Board Chairman

2010 PICES Awards

The presentation ceremony for two prestigious PICES awards took place on October 25, 2010, during the Opening Session at PICES-2010 in Portland, Oregon, U.S.A.

Wooster Award

In 2000, PICES established an annual award for scientists who have made significant contributions to North Pacific marine science; have achieved sustained excellence in research, teaching, administration, or a combination of these in the area of the North Pacific; 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 Professor Warren S. Wooster, a principal founder and the first Chairman of PICES, a world-renowned researcher of climate variability and fisheries production. He was not only a distinguished scientist, but also an ambassador of international scientific cooperation. Though Professor Wooster passed away in October 2008, his spirit will live in our minds through this Award. Award description, nomination process and selection criteria are posted on the PICES website at http://www.pices.int/Wooster_Award/default.aspx. Prior recipients of the Wooster Award were Michael Mullin (2001), Yutaka Nagata (2002), William Pearcy (2003), Paul LeBlond (2004), Daniel Ware (2005), Makoto Kashiwai (2006), Kenneth Denman (2007), Charles Miller (2008) and Kuh Kim (2009).

The presentation ceremony was conducted by Drs. Tokio Wada (PICES Chairman) and John Stein (PICES Science Board Chairman). After Dr. Wada introduced the award, the following Science Board citation was read by Dr. Stein (reading of the citation was accompanied by a slide show dedicated to Dr. Jeffrey Polovina):

It gives me great pleasure to announce that the Wooster Award for 2010 is being given to Dr. Jeffrey J. Polovina, world-renowned oceanographer with NOAA's Pacific Islands Fisheries Science Center. Dr. Polovina's groundbreaking contributions to climate and marine ecosystem research epitomize the PICES approach of integrating oceanographic factors and biological modeling to significantly advance ecosystem management.

During an exemplary career that spans 30 years, one would never guess that Dr. Polovina did not start out in fisheries. Regardless, his insights as a trained mathematician and statistician may have formed the basis of a landmark scientific achievement in the 1980s—the development of an innovative marine ecosystem model, ECOPATH, to describe energy flow through a coral reef food web. ECOPATH was the first model to apply a type of statistics called "path analysis" to the field of marine ecology, and Dr. Polovina's role in its development was recognized as one of NOAA's Top Ten scientific breakthroughs in the agency's first 200 years. The model's elegant simplicity and ability to accurately identify ecological relationships has since revolutionized scientists' ability to understand complex marine ecosystems around the world.

Much like the ocean itself, the scope of Dr. Polovina's innovative scientific research is wide and deep. With over 115 publications to his name, Dr. Polovina has demonstrated incredible breadth in his theoretical, analytical, and direct approaches to tackle some of the most challenging questions about marine ecosystems and the species that inhabit them. For over a decade, he and his team have made extensive use of satellite remotely-sensed oceanographic data to better understand ecosystem dynamics in the central North Pacific. By combining remotely-sensed data with electronic tracking data from large pelagic animals, Dr. Polovina provided remarkable new insights into the migration and forage habitats of loggerhead sea turtles, bigeye tuna, whale sharks, and whales. His research interests also include the applications of remote sensing and ocean circulation models to fisheries issues and, particularly, protected species of the Hawaiian Islands. Moreover, his distinguished career is anchored by early studies on the impact of climate change on marine fisheries as well as more recent discoveries of how global warming may be contributing to the world's expanding biological ocean deserts.

Dr. Polovina has worn many hats in his service to the PICES community. His significant roles have included: co-convening a major session on Pacific climate variability for the 2000 PICES "Beyond El-Niño" Conference, co-guest-editing a PICES special issue on the marine ecosystem impacts of climate variability in 2001, and helping organize the 2002 PICES symposium on "Transitional Areas in the North Pacific". More recently, he served as a member of the Study Group on Fisheries and Ecosystem Responses to Recent Regime Shifts and was honored to deliver the keynote lecture at PICES-2004 on the applications of electronic tags as oceanographic sensors.

Dr. Polovina's contributions to the international scientific community and award recognition may have thrust him into the limelight, but behind the scenes he is equally engaged in mentoring and training the next generation of scientists. He has served as a strong advocate of his staff scientists' participation in PICES activities, as evident in the contributions of Drs. Michael Seki, Réka Domokos, Evan Howell and Donald Kobayashi at past PICES meetings and, hopefully, for years to come.

Please join me in congratulating Dr. Jeffrey Polovina as the recipient of the 2010 Wooster Award.

A commemorative plaque was presented to Dr. Polovina (a permanent plaque identifying all Wooster Award recipients resides at the PICES Secretariat), who accepted the award with the following remarks:

Thank you, Drs. Wada and Stein. What a surprising and amazing honor! I am especially humbled, given the outstanding scientific talent in the PICES community and that represented by the previous awardees. This award is especially significant to me for several reasons. In the late 1980s, we observed ecosystem changes in the Hawaiian Archipelago and invited Dr. Wooster to Hawaii to help us develop a research program to understand those changes. Thus, Dr. Wooster's guidance helped shape the direction of much of my subsequent research on decadal variation. Secondly, while much of my research focuses on the subtropical ecosystem south of the PICES geographic area of interest, the PICES community represents my intellectual home. Its approach of addressing large spatial-scale dynamics, physical-biological linkages, and complete ecosystems has always had great appeal to me. Lastly, I would like to acknowledge that my achievements are the result of contributions from many wonderful colleagues, mentors, and co-authors, and I am truly grateful to the collaborations over many years with the talented staff of the Ecosystems and Oceanography Division of the Pacific Islands Fisheries Science Center.

Left photo: Dr. Jeffrey Polovina posing with Dr. John Stein (left, PICES Science Board Chairman) and Dr. Larry Robinson (right, Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Administrator for the U.S. National Oceanic and Atmospheric Administration) after receiving the 2010 Wooster Award. Right photo: Getting inspiration from a juvenile Hawaiian green sea turtle in preparing for the PICES-2004 keynote lecture on "Send out the turtle fleet"; George Balazs, leader of the Pacific Islands Fisheries Science Center marine turtle research program, holds the turtle.

POMA Award

Progress in many aspects of marine science is based on ocean observations, monitoring, and management and dissemination of data provided by these activities. However, these activities are often behind the scenes and so inconspicuous that they are seldom evaluated appropriately. To remedy this, a PICES Ocean Monitoring Service Award (POMA) was established in 2007 to recognize the sustained accomplishments of those engaged in monitoring, data management, and communication. This award aims to acknowledge organizations, groups and outstanding individuals who have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring and data management (www.pices.int/awards/POMA_award/POMA_award.aspx). The first award was presented in 2008 to the training ship T/S *Oshoro-maru* of Hokkaido University, Japan, for her long-term ecological monitoring activities in the northern North Pacific, and the 2009 award was given to Dr. Bernard A. Megrey of NOAA-Fisheries' Alaska Fisheries Science Center and Mr. S. Allen Macklin of NOAA's Pacific Marine Environmental Laboratory for their sustained efforts, vision, and leadership in building an inventory of biophysical data for the North Pacific, and creating the PICES Marine Metadata Federation.

At the presentation ceremony, Dr. Wada introduced the award, and Dr. Stein read the Science Board citation:

It is with great pleasure for me to announce that the 2010 POMA award goes to the Station Papa/Line-P monitoring program.

The seeds that grew into Line-P were sown during the Second World War. With the increase in the number of trans-Pacific flights, there was a need to monitor marine weather systems in the North Pacific. In 1943, the first vessel to occupy Station Peter, as it was then known, was the U.S. Coast Guard cutter Haida, and since then many ships have occupied Line-P and Station Papa. The first hydrographic casts at the station began in 1959, and this was the start of Line-P observations. And for the past 60 years, Ocean Station Papa and Line-P have contributed to the region's only multi-decadal time series of oceanographic conditions for the Northeast Pacific Ocean. Today, the Line-P oceanographic sampling program is comprised of 27 hydrographic stations leading to Station Papa, and

forms the backbone for cutting-edge, multi-disciplinary research on ocean dynamics, biology and chemistry.

Throughout its history, the rich data provided by this unique monitoring program have given scientists around the world opportunities to revolutionize the field of ocean science and participate in international projects that probe today's most pressing challenges in the physics, biology and chemistry of the ocean—including studies of El Niño, ocean storms, and iron enrichment. The long-term surveys along Line-P have also served as an integral component of global reports on the dynamics and status of our oceans, as well as a training ground for the next generation of oceanographers who have completed (or someday imagine completing) graduate research degrees on Line-P.

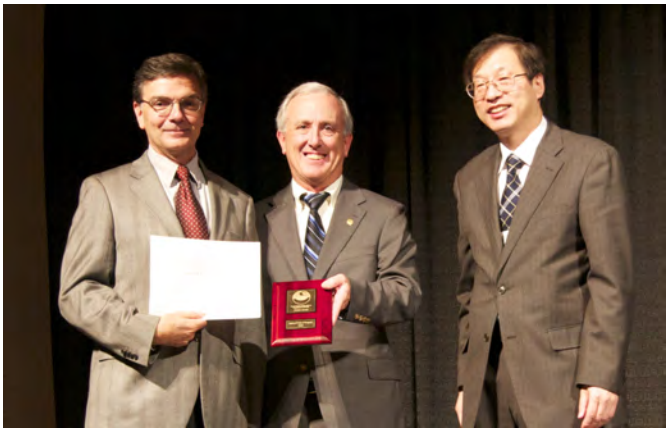
The Line-P archive provides a unique picture of the mean state in one part of our global oceans, and has proven critical in developing our ideas of how the ocean evolves. There are far too many people involved in this monitoring program to list. But there are managers who have ensured excellence in ocean sampling along Line-P. In chronological order, they are John P. Tully to whom we owe the original concept, Sus Tabata who years ago showed the power of a long time series, Frank Whitney who managed the program as it expanded to become a training ground for students and PhD theses, and finally, Marie Robert, who is presently juggling the myriad of demands from many universities and other research laboratories.

Please join me in congratulating Dr. Bill Crawford, Head of the State of the Ocean section at the Institute of Ocean Sciences at Fisheries and Oceans Canada, who is receiving the 2010 POMA Award on behalf of the thousands of people, past and present, who contributed to the Station Papa/Line-P monitoring program for the past six decades. Their sustained efforts, extraordinary vision, and dedicated leadership have built an invaluable resource that captures the changing biophysical conditions of the North Pacific and have had a profound impact on the development of ocean science.

Reading of the citation was accompanied by a slide show dedicated to the various people who have contributed to the program for the past six decades. A commemorative plaque (a permanent one identifying all POMA recipients resides at the PICES Secretariat) and a certificate were presented to Dr. William Crawford who accepted the award with the following remarks of appreciation:

I was honoured when asked to accept this award on behalf of Marie Robert and the Station Papa/Line-P monitoring program. My role is mainly administrative, as many of the Line-P scientists are in my section of Fisheries and Oceans Canada. This morning I compiled a list of 36 scientists who stand out among the thousands of persons who contributed to this program over the past years. I admit it is biased to recent years because my knowledge of the start of the program is limited. In mostly chronological order: John Tully, Sus Tabata, Tim Parsons, Robin Lebrasseur, John Strickland, Cary McAllister, John Garrett, Bob Stewart, Cedric Mann, John Davis, C.S. Wong, Paul Harrison, Ken Denman, Peter Niiler, John Love, Reg Bigham, Bernard Minkley, Laura Richards, Frank Whitney, Tim Soutar, Howard Freeland, Robin Brown, Wendy Richardson, Mike Arychuk, Marie Robert, Ron Bellegay, Janet Barwell-Clarke, Lisa Miller, Keith Johnson, Sophie Johannessen, Angelica Peña, Jim Christian, Hugh MacLean, Doug Anderson, David Mackas, and our data quality queen: Germaine Gatien.

On behalf of Fisheries and Oceans Canada, Marie Robert (godmother), the three godfathers (John Tully, Sus Tabata and Frank Whitney), the list of 36, and the cast of thousands, thank you, PICES, for this great honour.



Left photo: Two early "godfathers" of the Station Papa/Line-P monitoring program, Drs. John P. Tully (front row, with the pipe) and Sus Tabata (front row, right). Right photo: Dr. William Crawford (left) accepting the POMA from Dr. John Stein (center, PICES Science Board Chairman) and Dr. Tokio Wada (right, PICES Chairman).

We congratulate Dr. Jeffrey Polovina, and all those who contributed to the Station Papa/Line-P monitoring program, as recipients of the Wooster and POMA awards for 2010.

The First Year of FUTURE: A Progress Report

by Sinjae Yoo, Thomas Therriault, Hiroaki Saito and Robin Brown

Where do we stand?

FUTURE is here. After four year's gestation, FUTURE (*Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems*) was born in 2009 and christened as the second integrative science program of PICES. During its life span of ten years, this program is expected to generate a wealth of information and understanding about how ecosystems respond to changes.

Why do we need an integrative science program in PICES? The Strategic Plan of PICES clearly dictates its mission as "*integration of scientific knowledge on the North Pacific Ocean, along with its marginal seas*". To fulfill this mission, PICES requires to synthesize and disseminate knowledge and design appropriate multi-national research programs in response to identified needs. An integrated science program plays a central role in these efforts as it provides the roadmap for scientific activities.

The Climate Change and Carrying Capacity Program (CCCC) was the first integrated scientific program of PICES. CCCC, implemented from 1996–2006, was one of the five regional programs of GLOBEC (Global Ocean Ecosystem Dynamics), thus placing North Pacific science into a global synthesis. CCCC had two scientific questions: (1) how to determine the carrying capacity for higher trophic levels in North Pacific ecosystems and (2) how ocean conditions affect the carrying capacity. Although CCCC was a very successful program and enhanced our understanding of ecosystem processes under climate variability in the North Pacific, its ultimate goal "*to forecast the consequences of climate variability on the ecosystems of the subarctic Pacific*" was not fulfilled.

Through the early discussions in PICES, consensus on requirements for a new science program was identified. First, the scope should be shifted from climate variability (CCCC) to global change (FUTURE). Second, CCCC focused on open oceans, but the next program should be expanded to also include coastal regions. Third, a new capacity of forecasting ecosystem changes should be built in to move beyond simple understanding mechanisms and processes. Fourth, a human dimension should be included that would not only strengthen the research of two-way interactions between nature and humans but also effectively convey this knowledge and predictions to human society.

Based on these requirements, three key questions were developed by PICES scientists and adopted by the Organization as declarations of priorities for FUTURE research activities:

(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?

These questions beg us to develop a deeper understanding of ecosystem functioning and to have a forecasting ability built upon this understanding. They also require a new knowledge of how natural ecosystems and human societies interact and change. In addition to the scientific questions, new tasks were identified for making and disseminating useful products for human society. Certainly, this is a new and unknown territory for PICES but also an exciting opportunity for the Organization to grow. Incorporating the requirements of FUTURE science, the Implementation Plan for the program defines two objectives. The first is the scientific understanding and ability to forecast ecosystem changes. The second is to make useful scientific products and to provide these scientific products to society. To achieve this second objective, engagement with potential clients is essential.

In preparation of the FUTURE Implementation Plan, it became clear that the functional structure of the program should be improved. In its implementation, CCCC had its own structure and operated in a somewhat independent way. This resulted in less involvement by the general PICES community than desired. To remedy this, it was agreed that a FUTURE-specific organizational structure would be limited to coordination and direction while the actual work would be done by existing or newly formed expert groups. Thus, three Advisory Panels were born to provide continuing direction, leadership, coordination, and synthesis within PICES toward attaining FUTURE goals: AICE (Anthropogenic Influences on Coastal Ecosystems), COVE (Climate and Oceanographic Variability and Ecosystems), and SOFE (Status, Outlook, Forecast and Engagement). These Advisory Panels are expected to recommend specific activities for consideration by Science Board which serves as the Scientific Steering Committee (SSC) for FUTURE.

As the first year is critical for the success and growth of major programs, PICES made every effort to foster FUTURE. The Advisory Panels needed to develop detailed work plans, and for this purpose several activities took place in 2010:

- At the 2010 inter-sessional Science Board meeting (April 23–24, Sendai, Japan), one full day was dedicated to FUTURE – it was the first time that Science Board met as the FUTURE SSC. The main objectives of the meeting were to: (1) review the draft work plans for

the Advisory Panels, and (2) clarify the process for revising terms of reference for existing expert groups and approving new expert groups to meet FUTURE goals. At this meeting, Science Board strongly supported the idea of convening a 3-day workshop to advance work plans for FUTURE Advisory Panels and to share ideas on the many common threads they are encountering in moving FUTURE forward.

- The inter-sessional workshop, supported by the Korean government, was held from August 16–18, 2010, in Seoul, Korea. In addition to Advisory Panel members, workshop attendees included representatives from most expert groups associated with these Panels. The goal of the workshop was to expedite the early phase of FUTURE implementation by identifying priority topics and activities for the Advisory Panels for the first triennium (2010–2012) and discussing the potential for existing and new expert groups to address these priorities. The specific outcomes for Science Board review were the work plans for the early phase of FUTURE and recommendations for new expert groups.
- At PICES-2010, the Advisory Panels met concurrently (½ day) and then jointly (½ day) to: (1) review their terms of reference, (2) complete their workplan for the first triennium, and (3) finalize their proposals for new expert groups.

The following are results of what has been reviewed, discussed and planned during and after these events.

Surveying PICES priorities

At our inter-sessional workshop we had considerable discussion about what the priority areas of research should be in support of FUTURE implementation, given the key goal of understanding and forecasting how ecosystems (and the societies that depend on them) respond to natural or anthropogenic stressors. To ensure FUTURE remains relevant to all member countries, a survey was developed and circulated to PICES members *via* Standing Committees. A matrix of major stressors for both coastal and oceanic systems around the North Pacific was developed based on input providing both country and committee perspectives. Although the survey identified regional pressures, it also highlighted a number of high priority stressors across the North Pacific, including climate change, loss of sea ice, hypoxia, organic pollutants, habitat loss, invasive species, harmful algal blooms, and capture fisheries, just to name a few.

Existing capacity

The FUTURE Implementation Plan mandates to achieve the objectives of the program using expert groups. These groups belong to the regular PICES structure, *i.e.*, Governing

Group photo of the inter-sessional FUTURE workshop participants: front row (left to right) – Jongoh Nam (Korea), Hiroaki Saito (Japan), Young-Jae Ro (Korea), Se-Jong Ju (Korea) and Toru Suzuki (Japan); back row – Sinjae Yoo (Science Board Chairman), Suam Kim (Korea), Keyseok Choe (Korea), Masahide Kaeriyama (Japan), Alexander Bychkov (Secretariat), Igor Shevchenko (Russia), Vyacheslav Lobanov (Russia), Phillip Mundy (U.S.A.), Dohoon Kim (Korea), Robin Brown (Canada), Changkyu Lee (Korea), Thomas Therriault (Canada), Steven Bograd (U.S.A.), Jacquelynne King (Canada) and Chul Park (Korea). Absent in the photo: Toyomitsu Horii (Japan), Kyung-Il Chang (Korea), Sukgeun Jung (Korea), Young-Shil Kang (Korea), Hyoung-Chul Shin (Korea). Emanuele Di Lorenzo (U.S.A.), Harold Batchelder (U.S.A.) and Shin-ichi Ito (Japan) participated in discussions by WebEx/Skype.

Council, Science Board, Scientific and Technical Committees. Depending on the scope and lifespan, expert groups are established in the form of Study Groups, Working Groups, Advisory Panels, and Sections. FUTURE Advisory Panels will direct and coordinate the other expert groups' activities in close consultation with Scientific and Technical Committees, and synthesize FUTURE results. Therefore, to address specific scientific questions and make ecosystem-related products, Advisory Panels review the activities of existing expert groups and suggest new expert groups to be established by the relevant Scientific and Technical Committees. At the 2010 meetings, existing expert groups that potentially contribute to FUTURE objectives were reviewed and recommendations were made to adjust their terms of reference to better reflect FUTURE needs. In addition, new expert groups were proposed to fill gaps in implementing high-priority FUTURE activities identified during these events.

WG 20 on *Evaluations of Climate Change Projections*

This Working Group, with a lifespan from 2006–2010, was under the Physical Oceanography and Climate Committee (POC). Most of the tasks have been completed, and the final WG 20 report is being written. These tasks included analyzing and evaluating climate change projections for the North Pacific and its marginal seas based on predictions from the latest global and regional models submitted to the Inter-governmental Panel on Climate Change (IPCC) for their 4th Assessment Report (AR4). WG 20 also aimed to facilitate the development of higher-resolution regional ocean and coupled atmosphere–ocean models. RCMs (regional circulation models) have been developed or are under development for the California shelf, Washington–Oregon shelf, British Columbia shelf, the Northeast Pacific and the Bering Sea, and the Kuroshio region based on national activities underway. The Working Group made several recommendations including continuation of evaluating IPCC GCM (global circulation models) and RCM results, continuation of analyzing seasonal and decadal projections and variability, establishing live access servers to archive and provide easy access to results from RCMs. Since these are necessary activities for forecasting, they should be incorporated to new expert groups in support of FUTURE science.

WG 21 on *Non-indigenous Aquatic Species*

This Working Group is under the Marine Environmental Quality Committee (MEQ). It was approved at the 2005 PICES Annual Meeting, and its terms of reference were revised and lifespan was extended until October 2012 to reflect involvement of WG 21 in a project on "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*" supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. The main tasks of this Working Group are to assess the status of non-indigenous aquatic species (NIS) in the North Pacific, to assemble an inventory of expertise and programs related to NIS in PICES member countries, and to summarize initiatives and best practices on prevention and mitigation measures. Other important tasks are the development of a comprehensive NIS database and a taxonomy initiative which includes Rapid Assessment Surveys to collect initial baseline data and inter-calibrate species collection and identification methods that allow comparisons of invasions within and among nations and can reveal mechanisms and consequences of invasions. WG 21 activities touch on all three key FUTURE research themes, as NIS can represent a significant stressor in aquatic ecosystems, be reflective of ecosystem changes, and humans are a major agent of their introduction and redistribution, often resulting in societal changes. Thus, this Working Group is very closely aligned with AICE but has linkages to both COVE and SOFE.

WG 22 on *Iron Supply and its Impact on Biogeochemistry and Ecosystems in the North Pacific Ocean*

The parent committee of this Working Group was the Biological Oceanography Committee (BIO) and its term was 2007–2010. Major tasks for WG 22 were to compile dissolved iron biogeochemistry data in the North Pacific, identify the major sources of transported iron, and identify gaps related to experimental and modeling activities. This Working Group addressed the second key question of FUTURE since iron can regulate ecosystem responses as natural and anthropogenic forcing. The impact of ocean acidification on bioavailability of iron is an open question. The role of iron as a potential regulator of harmful algal blooms in coastal ecosystems was not addressed although it was among the WG 22 terms of reference. Since iron is a modulator of ecosystem productivity and function, and iron availability is likely to change under ocean acidification and anthropogenic activities, a follow-up group is required on some of these issues.

WG 23 on *Comparative Ecology of Krill in Coastal and Oceanic Waters in the North Pacific*

This Working Group, with a lifespan from 2008–2011 was established under BIO. The group focuses on the unique ecological characteristics of krill that allow it to populate and dominate in the North Pacific. To understand this question, a comparative analysis of krill biology around the North Pacific rim was adopted. WG 23 also aims to facilitate the inclusion of krill in ecosystem models so as to explore their role in coastal and oceanic food chains, and to address how climate change affects krill distribution and production, which is closely related to the mandate of COVE.

WG 24 on *Environmental Interactions of Marine Aquaculture*

This Working Group is under MEQ and the Fishery Science Committee (FIS) and its term is from 2008–2011. The major tasks of this group are to facilitate methods to assess and model the interactions of aquaculture with

surrounding environments. It also aims to assess methods to detect, identify, evaluate and report on infectious disease events and potential interactions between wild and farmed marine animals. It is linked to FUTURE through key questions (2) and (3) as aquaculture is not only an anthropogenic forcing function, but is also influenced by climate. Aquaculture has important social and economic connotations and thus is related to AICE and SOFE.

Joint PICES/ICES WG on *Forecasting Climate Change Impacts on Fish and Shellfish*

Within PICES, this Working Group, with a lifespan from 2009–2012, is under FIS and POC. In collaboration with relevant expert groups from both PICES and ICES, its goal is to develop frameworks and methodologies for forecasting the impacts of climate change on marine ecosystems, with particular emphasis on the distribution, abundance and production of commercial fish and shellfish. Since this group aims to explore forecasting techniques, including estimating and communicating uncertainty in forecasts, there is a very important connection to SOFE. It also studies strategies for research and management under climate change scenarios, given the limitations of forecasts. Under the leadership of the group, a very successful science symposium was convened in April 2010 to present, discuss and publish forecasts of climate change impacts on the world's marine ecosystems, with particular emphasis on commercial fish and shellfish resources. While this symposium covered a wide range of forecasting issues from climate variability to human societies, this group needs to focus on specific issues, aligning with other expert groups. The group will continue to be a nucleus of ICES-PICES cooperation, enabling a broader comparison and synthesis beyond the North Pacific.

Section on *Carbon and Climate* (CC-S)

This Section was established under POC and BIO in 2005. Its major task is to understand the role of carbon biogeochemistry in a changing ocean. It facilitates ongoing and planned national and international syntheses of carbon cycle research studies in the North Pacific and beyond. CC-S oversaw the publication of the *Guide to Best Practices for Ocean CO_2 Measurements* (PICES Special Publication No. 3, 2007). The Guide is now used worldwide and is considered the definitive reference for the ocean CO_2 system. Another significant undertaking of CC-S is the data synthesis project known as PACIFICA. PACIFICA has collected biogeochemical data (DIC, TA, nutrients, oxygen, and salinity) from more than 200 cruises in the Pacific and has implemented a set of algorithms for crossover analysis that permits the construction of a basin-wide, consistently calibrated dataset. The Section also addresses ocean acidification, de-oxygenation (hypoxia), and productivity: some key issues for FUTURE. CC-S anticipates a shift in focus from carbon biogeochemistry toward biological impacts of ocean acidification, and the terms of reference were revised in 2008 to reflect this. The Section anticipates particularly strong involvement with COVE, but will likely play an important role in AICE and SOFE as well.

Section on *Harmful Algal Blooms* (HAB-S)

The Section was formed in 2003 under the direction of MEQ. The major tasks of HAB-S are to develop monitoring and reporting procedures of harmful algal blooms, build a shared event database, and study mitigation means according to the specific interest of each PICES member country. Building the database is a joint effort with IOC and ICES. The tasks also include enhancing public awareness and education. In 2007, with support from MAFF, the Section initiated a PICES Seafood Safety Project that focuses on preparing and teaching country-specific training courses most required to ensure seafood safety in Pacific countries outside of the PICES region. As harmful algal blooms are a global problem in coastal areas, with significant societal implications, this Section is closely linked to AICE and SOFE. To some extent, it also linked to COVE, as HAB-S is related to all the three scientific questions. The Section will be submitting revised terms of reference at PICES-2011 to ensure that its activities are aligned with FUTURE needs.

SG on *Human Dimensions* (SG-HD)

The FUTURE Implementation Plan calls for PICES scientists to make the societal implications of their science more explicit and accessible through long-term engagement and communication activities among scientists, decision makers, stakeholders, and across sectors. This Study Group reviewed the role of social sciences practices applied in decision-making in marine sectors in the PICES member countries, focusing on ecosystem-based fisheries management (EBFM). They found that EBFM challenges are different between the eastern and western sides of the North Pacific, and that approaches are very diverse in the member countries. There is a need to develop indicators for social–ecological systems for which collaborations with social science are required. Spatial scope also was an important issue for identifying stakeholders, defining objectives, conducting research, and implementing policies. SG-HD is expected to produce a draft of its final report by January 2011, and the final report and recommendations by PICES-2011. Human dimensions is one of the new areas where PICES needs to build its capacity, and a new Working Group related to these issues is likely to be proposed at PICES-2011.

SG on *Communications* (SG-COM)

This Study Group was established to explore effective ways for better communication both within and outside PICES. Although the Study Group had completed its tasks in 2009, its recommendations are relevant to the engagement issues of SOFE. These include defining

principal audiences for scientific and other products in PICES, exploring various methods of dissemination of scientific publications, and utilizing news media and website communication. SG-COM recognized that FUTURE will face new challenges with communicating *Outlooks* and *Forecasts*, and these require an order of magnitude greater degree of communication sophistication. The Study Group recommended that Science Board consider creating an *ad hoc* committee consisting of professionals from all PICES member countries with experience in science communications (including forecasts and risk/uncertainty). This committee would plan and implement specific PICES communications under a designated PICES structure. In the future, SOFE could provide recommendations on this topic.

New expert groups

After review and discussion during the 2010 inter-sessional FUTURE workshop and PICES-2010, three new Working Groups were proposed. Among these, the first one was approved by Governing Council in Portland (2010), but the other two were put on hold pending further review and revisions to their proposed terms of reference.

WG 26 on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences*

This Working Group, with a lifespan from 2011–2014, was established under BIO to study the biology and role of jellyfish in coastal and oceanic marine food webs and to assess the impacts of jellyfish blooms on natural and human systems. This group is closely related to AICE and SOFE, as jellyfish alter the food web and interfere with fisheries and aquaculture activities. The major tasks of the Working Group include understanding the changes in abundance in relation to regional environmental and climate changes, assessing the impacts of jellyfish blooms on marine ecosystems and socio-economies such as fisheries and aquaculture, and evaluating methodologies for predicting blooms and for diminishing their impact on marine and human systems, including bloom forecast modeling and the modification of fishing gears.

WG on *Ecosystem Responses to Multiple Stressors*

The proposal for this Working Group is being revised. If approved, it will be under MEQ and BIO, with a 3-year lifespan. It is anticipated that this group will focus on multiple emerging stressors in North Pacific ecosystems, such as increased temperature, change in iron supply, HAB events, invasive species, hypoxia and eutrophication, and ocean acidification. These multiple stressors can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single stressor responses. The emerging stressors will vary by region, and critical stressors in PICES' regional ecosystems should be identified. Comparative studies on North Pacific ecosystem responses to multiple stressors will help determine how ecosystems might change in the future, and also identify ecosystems that are vulnerable to natural and anthropogenic forcing. This Working Group will be able to address issues not resolved by WG 22 (iron chemistry in a low pH ocean, anthropogenic dust flux), WG 23 (hypoxia impact on euphausiids), and WG 21 (non-indigenous marine species) thereby highlighting the need for integrative studies.

WG on *North Pacific Climate Variability and Change*

The proposal for this Working Group is also being revised. If approved, it will be under POC and the Technical Committee on Monitoring (MONITOR). This group will build on the work of WG 20, and its objective is to develop essential mechanistic understandings of North Pacific climate variability and change that can better guide the formulation of process-based hypotheses underlying the links between ecosystem dynamics and climate. The group also aims to develop conceptual models or frameworks of North Pacific climate variability and change that can be readily used by ecosystem scientists to explore hypotheses on the links between ecosystem dynamics and climate. The new Working Group will coordinate, in conjunction with ecosystem scientists, the development and implementation of process-based models to hindcast the variability of available long-term biological time series and explore forecasting.

FUTURE-related meetings in 2011

The majority of sessions and workshops to be convened at the 2011 PICES Annual Meeting are relevant to FUTURE. In addition two inter-sessional workshops are specifically planned to advance FUTURE science.

Indicators of status and change within North Pacific marine ecosystems: A FUTURE workshop

To answer the key scientific questions of FUTURE, some conceptual and operational issues have to be solved. For example, ecosystem resilience and vulnerability are not operationally defined. Metrics of ecosystem status are required to measure impacts of stressors and monitor change. Ecosystem indicators also could be used to identify systems that are resilient or vulnerable to stressors. In order to ensure that scientists have the ability to detect ecosystem-level changes in a consistent and standardized way, common metrics must be developed. Further, in an attempt to understand the amount of inherent variability in marine ecosystems, these metrics also need to incorporate measures of uncertainty that can be conveyed to end users, including managers and policy makers. The goals of this workshop, to be held April 26–28, 2011, in Honolulu (U.S.A.), will be to identify: (1) the means of determining ecosystem resilience or vulnerability; (2) ecosystem-level indicators of status and change, including but not limited to fisheries-based indicators; (3) methods to characterize uncertainty in these indicators; (4) common ecosystem indicators to be used for regional comparisons by the PICES community.

International workshop on "Development and application of Regional Climate Models"

While the global coupled general circulation models (GCMs) may be capable of capturing large-scale mean climate behaviour, they often cannot be directly used for assessing regional climate impacts, mainly due to their coarse spatial scale. Furthermore, they are usually not successful in capturing regionally important physical processes and reproducing higher order statistics and extreme events. Regional climate modeling has been introduced to fill the gap between the GCMs and the growing demand of climate predictions and scenarios on highly-resolved spatio-temporal scales. Various approaches and parameterizations have been adopted in existing regional climate models (RCMs). This 2-day workshop, to be convened October 11–22, 2011, in Incheon (Korea), will provide a platform to discuss various aspects of regional climate modeling such as different approaches, downscaling, parameterizations, and coupling to the GCMs. It will also encompass the coupling of RCMs to ecosystem models.

Summary

The key elements of FUTURE are the three overarching scientific questions and engagement with society through the provision of useful scientific products. During the first year of FUTURE, endeavours were made to prepare for advancing some key elements. By reviewing existing and recently disbanded expert groups, gaps were identified and new groups were established or are under development. The Working Group on *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences* will address the three science questions and will contribute to FUTURE ecosystem products. The Working Group on *Ecosystem Responses to Multiple Stressors* will focus on the first two scientific questions at the ecosystem level. With existing expert groups, these new groups will tackle the questions on how natural and anthropogenic pressures are causing changes in oceanic and coastal ecosystems. For outlook and forecast on ecosystem changes, climate–ocean–ecosystem models are needed, and the Working Group on *North Pacific Climate Variability* will take on this issue. The human dimension element is a new territory for PICES to explore. As the Study Group on *Human Dimensions* completes its tasks, it is anticipated that a Working Group to tackle human dimension issues will be formed. In 2011, various FUTURE-related meetings are planned, including two international workshops: a workshop on "*Indicators of status and change within North Pacific marine ecosystems*" in April and a workshop on "*Development and application of Regional Climate Models*" in October.

The new implementation structure of FUTURE overall seems to be working well. Science Board is undertaking the role of Scientific Steering Committee for the program, and thereby is involving Scientific and Technical Committees in FUTURE work. FUTURE Advisory Panels are acting as coordinators, guiding expert groups to action. This new structure solves the problem of isolating the integrative science program from the other parts of the Organization. However, improvements should be made for better communication between expert groups and FUTURE Advisory Panels. There were concerns that communication is less effective in some cases, and efforts will be made to set efficient two-way communication. Within FUTURE Advisory Panels, sometimes participation is lacking even among PICES member countries. Since member countries have only one, or very rarely, two representatives on each Panel, their active involvement is necessary to ensure that FUTURE is successful in providing products desired by each member country.

Since the role of PICES in the integrative science program is the coordination of international cooperation, national research projects form the basis of FUTURE. During the 2010 inter-sessional workshop, relevant national research projects were briefly reviewed. In all member countries, there seem to be many scientific projects that are potentially related to FUTURE objectives. It was premature to conceive coordinating the directions of national projects at that time, as we are only at an early stage of FUTURE. In the coming years though, it will be necessary to review how these national projects can better be coordinated to enhance the PICES FUTURE program.

Dr. Sinjae Yoo (sjyoo@kordi.re.kr), as Chairman of Science Board, leads the FUTURE Scientific Steering Committee. Drs. Thomas Therriault (Thomas.Therriault@dfo-mpo.gc.ca) and Hiroaki Saito (hsaito@affrc.go.jp) chair the FUTURE Advisory Panels on Anthropogenic Influences on Coastal Ecosystems (AICE) and Climate and Oceanographic Variability and Ecosystems (COVE), respectively. Mr. Robin Brown (robin.brown@dfo-mpo.gc.ca) leads the Advisory Panel on Status, Outlook, Forecast and Engagement (SOFE). Brief introductions for Sinjae, Tom, Hiroaki and Robin can be found in PICES Press, 2010, Vol. 18 (2).

New Chairmen in PICES

Governing Council

At PICES-2010, Dr. Lev Bocharov (Russia) was elected Chairman and Dr. Laura Richard (Canada) was elected Vice-Chairman of PICES. PICES is grateful to Dr. Tokio Wada (Japan) for this dedicated service as Chairman of the Organization since October 2006. He will continue serving PICES in the advisory capacity as Past-Chairman.

Lev Bocharov was born on August 20, 1950, in Crimea (Russia). In 1972, he graduated with honours from the Far Eastern State University with a degree in "physics and mathematical support of automatic control systems". He had completed his post-graduate studies in 1978 under the supervision of academician Yury Zolotov, receiving his Ph.D. in Mathematics. In 1994, Lev defended his thesis on "*The information technology of short-term fishery forecasting*" and became a Doctor of Technical Science. In 1995, he was elected as an associate member of the Russian Academy of Natural Sciences, and became professor and a full member of that Academy in 2010. Lev is one of the founders and leading experts in a new research field on complex analysis and forecasting of marine ecosystems. He has authored more than 120 scientific publications, including research papers and books. His scientific interests include the use of satellite and aircraft data in marine studies, development of databases, simulation studies of marine ecosystems and fishery forecasting.

For more than 30 years, Lev has led major research activities at TINRO-Centre. He started as Head of the Laboratory for Mathematical Methods of Research in 1979, became Deputy Director for Science in 1983, and Director-General in 1997. Lev also serves as Chairman of the Board of Directors for the Association of the Far Eastern Fisheries Scientific Organizations, and Chairman of the Science and Publishing Boards of TINRO-Centre, member of the "Izvestiya TINRO" (TINRO Proceedings) editorial board and member of the editorial boards for the journals "Fisheries" and "Fisheries Issues".

Lev is a person with wide and progressive views, and is known as a man of principles in issues on the rational use and management of Far Eastern biological resources based on state interests and federal legislation. The successful and fruitful activities of Lev as a scientist and manager stems from his long experience in the field of fisheries, and high scientific and professional skills. It was Lev who initiated the transfer of 10 research vessels to TINRO-Centre, which turned out to be a break-through in organizing marine research activities. Ten years ago, he commenced the reorganization of the planning and management of fishery research studies in the Russian Far East, and since then, all these activities have been based on multi-purpose research programs.

Lev uses his scientific knowledge and management expertise for the development of scientific cooperation in the North Pacific. He has been involved in PICES as a member of the Technical Committee on Data Exchange (TCODE) since 1994. He has been representing Russia as a national delegate on the PICES Governing Council since 1999. Under his leadership, TINRO-Centre hosted two PICES Annual Meetings in Vladivostok: in 1999 and 2005. Lev has served as Vice-Chairman of PICES since 2006, and was elected Chairman of PICES in 2010.

Lev has received numerous awards for his outstanding scientific and management achievements in fisheries, including the medal "For Services to the Country", the medal "For Services to the Development of Russian Fisheries" and many others.

Arts are among the numerous interests of Lev. His knowledge of Russian paintings, Japanese graphic arts and netsuke are as good as that of a professional art expert. Following TINRO's motto "*A sound mind is a sound body*", Lev is keen on sports, particularly basketball, and actively participates in friendly competitions between the TINRO-Centre team and other domestic and foreign teams.

In his private life, Lev is a devoted and happy family man. His wife Irina provides support to her beloved husband and is proud of him. They have a daughter Ksenia and two grandsons: 7 year-old Gleb and 2 month-old Ruslan.

Laura was born in Halifax, Nova Scotia, on the east coast of Canada. As a child, she spent her summers around water – swimming in lakes and beachcombing along the seashore. Laura became fascinated by marine life and, by the age of 12, she decided to make marine biology her career. She completed a B.Sc. in Biology from Dalhousie University in 1976, winning the Governor General's Gold Medal for the highest marks in her graduating class. She then went on to complete M.Sc. and Ph.D. degrees in Zoology from the University of British Columbia. Laura managed to combine her love of beaches with science – her Ph.D. research focused on a sandy beach amphipod and its beetle predator. All the action was nocturnal, and she became known locally for wandering along beaches at night.

Laura was fortunate to find a post-doctoral position at the Pacific Biological Station in Nanaimo, British Columbia, where she was hired by Dr. Glen Jamieson (former PICES Marine Environmental Quality Chairman) to work on Dungeness crabs. A year later, in 1983, Laura started her career as a groundfish scientist for Fisheries and Oceans Canada at the Pacific Biological Station. She was tasked with conducting assessments of various species of rockfish (*Sebastes*), groundfish and salmon. Much of her research focused on the development of quantitative methods for stock assessment. In 1995, she received the Deputy Minister's Commendation Award for her scientific support to Pacific groundfish management plans.

In 1998, Laura shifted to managing research when she was appointed as the Acting Regional Director Science for Fisheries and Oceans Canada in British Columbia and the Yukon. She was confirmed as Regional Director Science in 2002 and continues to hold that position.

Laura has been a Canadian delegate to the PICES Governing Council and a member of the Fisheries Science Committee and the Finance and Administration Committee (F&A) since 2000. She held two terms as F&A Chair (2004 to 2008) and participated in several study groups. She also plays lead roles in other international organizations. Since 2001, she has been the Chair or Co-Chair of the Committee on Scientific Co-operation under the Pacific Salmon Commission (Chair/Co-Chair alternates annually between Canada and the United States). In addition, since 2005, she has been Canada's lead Commissioner at the International Pacific Halibut Commission. In that role, she works with different harvest sectors to apply science advice to make decisions on fishery quotas.

Laura enjoys keeping physically active through walking, hiking and nature watching (when it is not raining in British Columbia). Yoga also helps her stay focused. Whenever possible, she travels to see research in action, such as during a transit of the Northwest Passage (see photo) in the summer of 2008.

Science Board

In 2006, to facilitate the continuity of Science Board affairs, the Governing Council established a Science Board Chairman-elect position to allow the election of the Science Board Chairman one year before the official change of the chairmanship. At PICES-2009, Dr. Sinjae Yoo (Korea; left) was unanimously elected for this position. At PICES-2010, he assumed duties of Science Board Chairman, replacing Dr. John Stein (U.S.A.). At the same meeting, Dr. Thomas Therriault (Canada, right) was elected Science Board Vice-Chairman. Brief introductions for Sinjae and Tom can be found in PICES Press, 2010, Vol. 18 (2). PICES thanks Dr. Stein for leading Science Board since 2007. He will continue to contribute to PICES as a U.S. national delegate on the Governing Council.

Biological Oceanography Committee

At PICES-2010, Dr. Atsushi Tsuda (Japan) was elected as Chairman of the Biological Oceanographic Committee (BIO). PICES thanks Dr. Michael Dagg (U.S.A.) for this dedicated service as Chairman of BIO since October 2004. He will continue to contribute to activities of the Organization as Vice-Chairman of the Committee.

Dr. Atsushi Tsuda is an Associate Professor at the Atmosphere and Ocean Research Institute, University of Tokyo, Japan. He received his B.Sc. in Fisheries from Hokkaido University and his Ph.D. in Agriculture from the University of Tokyo.

Atsushi was born and raised in Tokyo. In his childhood, he often went to the Tokyo Bay for fishing with his parents, and developed a respect for the ocean and marine life. During his undergraduate years, after Atsushi took a course on planktonology from Professor Takashi Minoda and met friendly and hardworking graduate students from the Laboratory of Plankton at Hokkaido University, the direction of his future research was decided.

Atsushi started his graduate course at the Ocean Research Institute, University of Tokyo, working on copepod ecology, especially grazing. His Ph.D. supervisor was Professor Takahisa Nemoto. After completion of his thesis, Atsushi moved to the Biological Oceanographic Section of the Hokkaido National Fisheries Research Institute as a research scientist in 1996. He served, with Dr. Hiroaki Saito and colleagues at the institute, on the *A-line* monitoring programme for 7 years. For several years in Hokkaido, he studied mainly the biology and ecology of copepods, focusing on the *Neocalanus* species and their role in fish population dynamics under the VENFISH (The Comprehensive Study of the Variation of the Oceanic Environment and Fish Populations in the Northwestern Pacific) project. Atsushi then became involved, along with Drs. Shigenobu Takeda, Jun Nishioka and Hiroaki Saito, in iron fertilization experiments in the subarctic Pacific (SEEDS-I, SERIES, and SEEDS-II) which were recommended by the PICES Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean* (IFEP-AP).

Atsushi began his association with PICES by attending the 1996 PICES Annual Meeting. Later, he became a member of IFEP-AP and BIO. Atsushi is very excited to be serving on the BIO Committee and leading BIO now as Chairman, as goals of the Committee largely overlap with his scientific interests.

Atsushi is an enthusiastic fly fisherman and bird watcher. He always carries a pair of binoculars during PICES Annual Meetings. His lifelong list of birds includes 942 species and his Japanese list includes 401 species. The latest addition to the Japanese list is the Golden-crowned Sparrow in the Chiba Prefecture.

Mike Dagg was born in Vancouver, Canada, but did not stay long because his father was in the Canadian Air Force and moved a lot. Mike attended 11 schools before finishing high school, did his undergraduate work at Mount Allison University in New Brunswick (Canada), then completed a Master's degree at the University of Victoria (Canada) before moving to the University of Washington in Seattle (U.S.A.) for his Ph.D. He has lived in the United States since then, initially as a research scientist at Brookhaven National Laboratory in New York, and then as a research scientist at the Louisiana Universities Marine Consortium (LUMCON). He has recently moved to the Seattle area as an initial step towards retirement from LUMCON, which is anticipated to be in June 2012.

At Brookhaven Laboratory, he worked primarily on copepod feeding and the roles of zooplankton in the ecosystems of the New York Bight and Georges Bank areas, but also participated in research programs in the Peru upwelling area and the Bering Sea. As these programs began winding down, he moved to LUMCON, a new research laboratory on the coast of the Gulf of Mexico. Since then, he has primarily divided his research efforts between the coastal regions of the northern Gulf of Mexico and the Pacific Northwest, including the Bering Sea, the Gulf of Alaska, the open Pacific, and Dabob Bay, a fjord in Washington State (U.S.A.). Thematically, most of his oceanographic research has been on the various contributions of mesozooplankton to carbon and nitrogen cycling in the

ocean, but much effort has also been made towards understanding basic biological behavior (feeding, egg production) of important copepods in these oceanic systems. These patterns are continuing with current research projects: one in the Gulf of Mexico examining zooplankton contributions to organic matter flux in shallow coastal waters that become hypoxic every summer, and a second in Monterey Bay and coastal California looking at the role of zooplankton feeding in reducing flux of organic matter below the photic zone. Both projects are collaborations with other investigators.

Mike was not involved heavily in teaching because LUMCON is not a degree granting institution. However, adjunct appointments at Tulane University and Louisiana State University allowed some involvement with graduate students and teaching.

In recent years, Mike has been active in two organizations in the Pacific Northwest. He served on the Science Advisory Panel of the North Pacific Research Board for 6 years before stepping down from that position in August 2010. In PICES, Mike has been a member of BIO for the past 9 years, acting as Chairman for two 3-year terms before ending last October. He is now serving as Vice-Chairman for a single 3-year term, and is looking forward with great pleasure to continuing involvement in PICES.

Outside of science, Mike has spent countless hours over the years at various sports, including basketball, running, hiking, mountain-biking, and skiing. These have mostly been displaced now by more age-appropriate activities such as biking, gardening and drinking wine. Additional hobbies include photography, reading, cooking and riding around on his Vespa.

Physical Oceanography and Climate Committee

At PICES-2010, Dr. Kyung-Il Chang (Korea) was elected as Chairman of the Physical Oceanography and Climate Committee (POC). PICES thanks Drs. Michael Foreman (Canada) and Ichiro Yasuda (Japan) for their dedicated service as Chairman and Vice-Chairman of POC, respectively, since October 2004. Dr. Foreman will continue to contribute to PICES as Vice-Chairman of the Committee, and Dr. Yasuda will serve as a POC member.

After his birth in Seoul, in 1958, Kyung-Il Chang moved from place to place within Korea for several years with his father who was a Korean army officer. When he reached the age of 9 years, his family settled down in Seoul, and he has lived in this city since then. Kyung-Il was very much interested in playing soccer during his middle and high school years. After entering the College of Natural Sciences at Seoul National University (SNU) in 1977 and enrolling in the Department of Oceanography in 1978, Kyung-Il set up a University's skin and scuba club with his colleagues and absorbed himself in its activities during his undergraduate and M.Sc. course years. After completing the M.Sc. course in 1984, with a major in physical oceanography, and two years of military service, Kyung-Il became a researcher at the Korea Ocean Research and Development Institute (KORDI). He was with KORDI for 19 years until moving to SNU as an associate professor in 2005.

While at KORDI, Kyung-Il spent about 3½ years in the United Kingdom for his Ph.D. studies. He received his Ph.D. in 1994 from the Department of Oceanography, University of Southampton, UK. His research topic was the shelfward penetration of the Kuroshio in the East China Sea. Kyung-Il used a numerical model for his thesis and soon became interested in models and modeling experiments, while struggling to resolve problems he encountered trying to become more familiar with new skills in studying oceanography. He worked as a postdoctoral fellow at University of California at Los Angeles (UCLA) from 1997 to 1998 with Prof. Michael Ghil. Being supported by a joint program of UCLA and LANL (Los Alamos

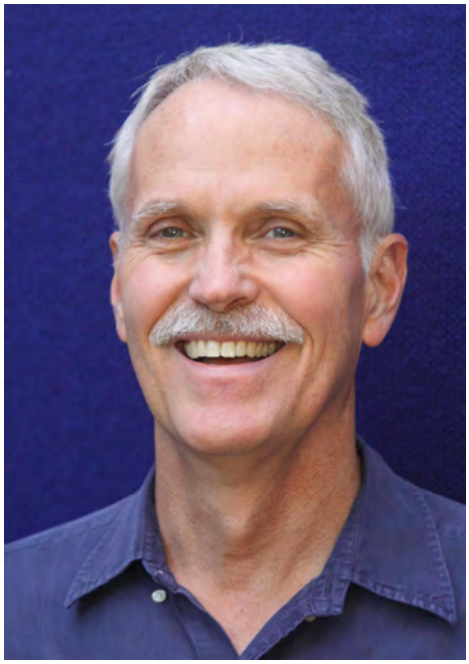
National Laboratory), Kyung-Il spent most of his time at LANL carrying out numerical modeling experiments to determine how a simple barotropic wind-driven double gyre becomes finally chaotic.

Kyung-Il has long been working on various aspects of physical oceanography of the East Sea: deep circulation and currents, hydrography and currents in Korea Strait, and interaction of near-inertial waves with mesoscale eddies. In 1996, he led a KORDI in-house project entitled "*East Sea Marine Science Program (ESMASP) – Science and Implementation Plan*", which motivated his interest in studying the East Sea (Sea of Japan). In preparation for an extensive ESMASP report, participation in a winter 2005 CREAMS (Circulation Research of the East Asian Marginal Seas) expedition on board the R/V *Gordienko* gave him strong inspiration to study the East Sea, although it was a hard cruise.

After coming back from his postdoc studies at UCLA, Kyung-Il has been mainly involved in research projects on the oceanography of the East Sea at both KORDI and SNU. He participated in long-term moored current measurements at a location (EC1) in the deep East Sea in 1996, which was initiated by Prof. Kuh Kim at SNU, Dr. Sang-Kyung Byun at KORDI, and Dr. Nelson Hogg at WHOI. The EC1 mooring has been jointly maintained by KORDI and SNU for 15 years since then. With support from KORDI's in-house projects, Kyung-Il was also involved in the CREAMS-II Program, collaborating with scientists supported by the U.S. ONR (Office of Naval Research) JES (Japan/East Sea) Program between 1998 and 2002. As part of the Program, he joined two research cruises on board the R/V *Roger Revelle* in Korea Strait to deploy an array of current meters and in the southern East Sea to make high-resolution observations using an undulating SeaSoar.

Kyung-Il also collaborated with biologists to investigate the role of mesoscale eddies in shaping surface chlorophyll distribution. Recently, he has been actively involved in the Korea CREAMS/PICES Program in East Asian Marginal Seas (EAST), an official program of PICES, since 2006. Through this project, he successfully deployed a bio-optical mooring in the southwestern East Sea in 2010 for the first time during the transition period from winter to spring bloom in the region. The mooring clearly captured the spring bloom, and the results suggest an important role of subsurface cold water advection in triggering the bloom. He intends to expand and extend bio-optical moorings in the next stage of the Korea EAST Program to understand physical–biological interactions in the southwestern East Sea, which has recently been recognized as a very productive region.

Kyung-Il made the first connection with PICES at the end of the 1990s, by attending a CCCC workshop in Nemuro, Japan. He was one of conveners and local organizers for the first PICES Summer School on "*Ocean circulation and ecosystem modeling*" in August 2006 in Busan. He hosted the CREAMS/PICES workshop on "*Model/data inter-comparison for the Japan/East Sea*" also held in Busan in 2006, and served as one of guest editors for a special issue of the *Journal of Marine Systems* published in 2009, which contained a collection of papers presented at the workshop. Kyung-Il has been a member of POC since 2006 and a member of the CREAMS/PICES Advisory Panel since 2009, and he is now serving as Chairman of POC.



Dr. Michael Foreman is a Research Scientist at the Institute of Ocean Sciences (Fisheries and Oceans Canada) and an Adjunct Professor at the University of Victoria and University of British Columbia. Originally educated as an applied mathematician, he fell into oceanography 37 years ago when the only other job offer he had after graduating was working for IBM as a salesman. Though he becomes sea-sick easily and seldom ventures into the field, the "fall" turned out to be the right career choice (at least from his perspective; colleagues and his financial adviser may argue otherwise). His current research includes coastal biophysical modeling, climate change modeling and analyses, data assimilation, satellite altimetry analyses, and the analysis, prediction and modeling of tides. He was Chairman of the Physical and Oceanographic and Climate Committee from October 2004 to October 2010, Co-Chairman of Working Group on *Evaluations of Climate Change Projections* from October 2004 to October 2010, and is a member of the PICES/ICES Working Group on *Climate Change Impacts on Fish and Shellfish*. Though an avid golfer and general sports nut, his sporting advice is no longer sought by PICES after the curling event that he arranged at PICES-2007 was fortunate to avoid personal injury litigation.

Technical Committee on Data Exchange

At PICES-2010, Dr. Toru Suzuki (Japan) was elected as Chairman of the Technical Committee on Data Exchange (TCODE) to replace the late Dr. Bernard Megrey (U.S.A.). Dr. Hernan Garcia (U.S.A.) was elected TCODE Vice-Chairman to replace Dr. Kyu-Kui Jung (Korea), who will continue to serve as a TCODE member.

Dr. Toru Suzuki is the general manager of the Research Division at the Marine Information Research Center (MIRC), Japan Hydrographic Association. He received his B.Sc. (1990), M.Sc. (1992) and Ph.D. (1997) degrees in Fisheries from Tokyo University of Fisheries (the present Tokyo University of Marine Science and Technology). Toru's background is physical oceanography, and he has worked for oceanographic and bathymetric data management and quality control in MIRC since 1997 with Dr. Yutaka Nagata, Professor Emeritus of the University of Tokyo, the first Chairman of POC and the recipient of the 2002 PICES Wooster Award. Toru also generates some oceanographic and bathymetric data products for enlightenment and popularization. For example, he installed the exhibition of OmniGlobe® (www.arcsience.com), a 60-inch spherical display with some oceanographic and bathymetric contents and a 3-D physical terrain model of 90-inch squares in the Northwest Pacific region (www.stm-usa.com) in the Museum of Maritime Science in Tokyo, and provided the bathymetric grid data at 30 arc-second intervals around Japan to Google™ Earth.

Toru has attended PICES Annual Meetings since 1999 in Vladivostok and was a member of Working Group on *Biogeochemical Data Integration and Synthesis* (2001–2005) He also is a member of the Section on *Carbon and Climate* (2005–present), TCODE (2007–present), and FUTURE Advisory Panel on *Climate, Oceanographic Variability and Ecosystems* (2009–present). Toru serves as a member of the Group of Experts on *Biological and Chemical Data Management and Exchange Practices* of the IOC Committee on International Oceanographic Data and Information Exchange (IODE GE-BICH).

Toru was born and raised in Akita prefecture, the northeast area of Japan that experiences heavy snowfall in winter, so he has enjoyed skiing since his childhood. After leaving his hometown, he always looks for snow and holidays. Toru is a big fan of Yokohama Baystars, one of Japan's professional baseball teams, and his mood, therefore, has been not good for several years. He is also a big fan of the Japanese national football (soccer) team and does not miss watching their games at a pub or a stadium in a year of the FIFA World Cup, if he is fortunate to get a valuable ticket. When not working, Toru enjoys tasting microbrews, betting at big horse races, listening to classical music and opera, and infrequently playing a trumpet.

Dr. Hernan Garcia is an oceanographer at NOAA's Ocean Climate Laboratory, National Oceanographic Data Center (NODC). He received his Ph.D. (1996) in Chemical Oceanography from the College of Oceanic and Atmospheric Sciences, Oregon State University. He works processing large amounts of historical chemical and physical oceanographic data to help interpret seasonal to decadal scale oceanic changes in dissolved oxygen and nutrients.

Hernan has attended PICES Annual Meetings since 2004 and is a member of the Section on *Carbon and Climate* (CC-S) and TCODE. He also serves as a member of the Group of Experts on *Biological and Chemical Data Management and Exchange Practices* of the IOC Committee on International Oceanographic Data and Information Exchange (IODE GE-BICH). Hernan likes camping, collecting old oceanographic instruments, and flying remote control airplanes. He is a huge fan of the Beatles and listens to R&R.

Pacific Ocean Interior Carbon Data Synthesis, PACIFICA, in Progress

by Masao Ishii, Toru Suzuki and Robert Key

Data managers and research groups that measure ocean CO_2 parameters and their related chemical and physical components at depths in the Pacific Ocean have been brought together under the PICES Section on *Carbon and Climate* (CC-S), co-chaired by Drs. James Christian (Canada) and Toshiro Saino (Japan). In 2006, CC-S started the activity of data synthesis for the interior of the Pacific Ocean. This activity and the data collection were later named "PACIFICA".

Natural seawater is a "salty soda pop", although it does not visibly evolve bubbles of CO_2 because it is weakly basic (pH ~8), and CO_2 is mostly dissolved in the form of non-volatile bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions. The total content of these carbonate species in seawater, *i.e.*, dissolved inorganic carbon (DIC) concentration, is around 2,000 µmol kg^{-1} (1 µmol = 1×10^{-6} mole), roughly equivalent to a small spoonful of sodium bicarbonate powder, per kilogram of seawater. The total DIC in the world oceans, 40,000 PgC (1 PgC = 1×10^{15} gC), is about 50 times as much CO_2 as in the atmosphere. With this great ability to store DIC, the oceans also represent a key sink for CO_2 that is released by fossil fuel combustion and land use changes, and are thus contributing to global warming. However, the uptake of CO_2 by the oceans is chemically equivalent to the addition of carbonic acid (H_2CO_3), and causes a perturbation to the carbonate chemistry in seawater. This perturbation is commonly referred to as "ocean acidification" and is recognized as "the other CO_2 problem" (Doney *et al.*, 2009) that threatens marine biology and ecosystems worldwide.

One challenge for oceanographers is to detect the tiny but important signals of anthropogenic DIC increase and acidification in seawater and their temporal evolution from observations. For this purpose, the tolerance allowed for DIC analysis is on the order of 1/1000, which is comparable to the ratio of a single krill to a blue whale in length. The acquisition of such high quality of DIC data became possible after development of the coulometric technique for DIC measurement (Johnson *et al.*, 1985), the availability of certified reference materials (Dickson, 2001), and publication of a Guide to Best Practices for Ocean CO_2 Measurements (DOE, 1994; Dickson *et al.*, 2007). With growing social and scientific concerns about the carbon cycle and climate change, a significant volume of data were collected from more than 12,000 oceanographic stations in the world's oceans during the 1990s by international programs such as the Joint Global Ocean Flux Study (JGOFS), the World Ocean Circulation Experiment (WOCE) and related projects. These data have been synthesized to generate a unified data set in a cooperative effort of the Global Ocean Data Analysis Project (GLODAP) (Key *et al.*, 2004). Using this database with unprecedented quality and quantity, the distributions and total inventory of anthropogenic CO_2 as well as the natural component of DIC due to air–sea CO_2 exchange in the ocean was evaluated globally for the first time (Sabine *et al.*, 2004; Sarmiento and Gruber, 2006). These scientists are further stimulating the development of forward and inverse ocean carbon cycle models. Among the most important aspects of GLODAP is that it has provided a benchmark against which future observational studies will be compared to understand changes related to the increasing anthropogenic CO_2 emission and climate change.

An activity to expand the ocean's interior CO_2 data collection, CARINA (Carbon Dioxide in the Atlantic Ocean), was also been initiated in Europe by Ludger Mintrop and Douglas Wallace as an informal project. Funded in 2005 as a component of the European Union's project CARBOOCEAN, the data collection in CARINA was expanded to the Arctic and Southern oceans. The database is now available from the Carbon Dioxide Information Analysis Center (CDIAC; http//cidiac.ornl.gov/oceans/CARINA/). It was in early 2007 that some researchers who were involved in CARINA and also in CC-S kicked off planning the expansion of data collection in the Pacific Ocean.

The activity for Pacific Ocean interior carbon data collection, PACIFICA, was cooperatively promoted at PICES-2007 (Victoria, Canada) and at PICES-2008 (Dalian, China). Collecting data sets and converting the data format were initiated after PICES-2007. Following these meetings, 2- to 3-day technical hands-on workshops were held three times: at PICES-2009 (Jeju, Korea), at the CC-S inter-sessional workshop in June 2010 (Tokyo, Japan), and at PICES-2010 (Portland, U.S.A.). At these workshops, the status of data collection was reviewed, details of method for data quality control were discussed, and its practices were advanced.

For data collection, we targeted cruises in the North Pacific and its marginal seas, and the South Pacific north of 30ºS. First priority was given to the data sets of post-WOCE cruises with high-quality discrete hydrographic/chemical data such as DIC, total alkalinity (TA), pH, dissolved oxygen, nutrients (nitrate + nitrite, phosphate, silicic acid) and chlorofluorocarbons (CFCs). Historical data sets that had not been incorporated into GLODAP were merged into PACIFICA. Metadata that describes methods of analysis, information on quality control and list of related publications are also an important component of the database.

Participants of the inter-sessional PACIFICA Workshop (June 2–4, 2010, JAMSTEC Office, Tokyo, Japan); 20 persons from 4 countries (Canada, Japan, Korea and U.S.A.) were in attendance.

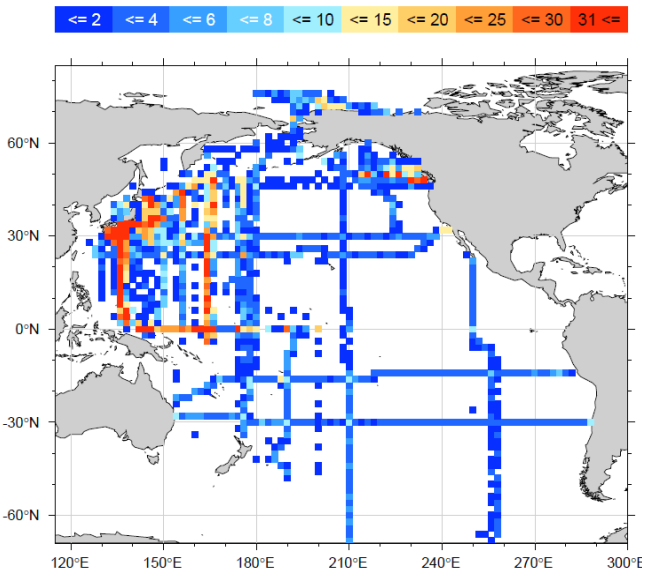


Fig. 1 Distribution and density of hydrographic/hydrochemical stations in the PACIFICA data collection in 2º x 2º pixels.

Data sets from a total of 305 cruises conducted between 1985 and 2009 were acquired (Fig. 1). The list of cruises is available at http://cdiac.ornl.gov/oceans/PACIFICA/ and http://pacifica.pices.jp/table/. Many of these data sets have already been publicly available from various data centers, research organizations and programs. As yet unopened high-quality data sets that the Principle Investigators gave permission to release have also been collected. The format of all these data sets has been converted to the "WHP-Exchange Format" (http://cchdo.ucsd.edu/WHP_Exchange_Description.pdf). The collection includes 16 CLIVAR Repeat Hydrography cruises conducted after 2001 that tracked the same sections as the WOCE Hydrographic Program in the 1990s. In spite of the growing concern for the acidification in marginal seas, the number of data sets from marginal seas is, so far, limited. Synthesizing the data of ocean CO_2 parameters in marginal seas will be the major subject for the next phase of expanding data collection.

One of the merits of PACIFICA is that it will go through a 2nd level quality control (2nd level QC). The 2nd level QC is an activity to correct for the systematic errors to develop a processed "new database" that is consistent among cruises. On the other hand, the 1st level QC is an activity that individual data providers should deal with to create an "original data set" that is consistent within a cruise. The 1st level QC includes works to assign questionable and bad data in the data set on the basis of the sampling and analytical conditions. Effectively, the 2nd level QC focuses on accuracy while the 1st level QC is focused on precision. Experience has shown that the 2nd level QC team has to redo the 1st level QC by examining vertical profiles, property-property plots and so on. In fact, we have gone back and forth between the 1st and 2nd level QCs several times. Errors in data formatting have also been found during these processes. These data quality control measures are critical, but are usually tedious.

Data sets in PACIFICA are now undergoing a 2nd level QC using the method as developed by the CARINA team (Key *et al.*, 2010; Tanhua *et al.*, 2010) with some modifications to apply to the Pacific Ocean. This method is based on crossover analysis followed by the inversion of those results (Fig. 2). In crossover analysis, data in deep layers (>2000 m or >1500 m), where no change is expected over

the time period, are compared from two different cruises at nearby stations. Results of a huge number of crossover analyses are then analyzed by an inversion technique to determine the optimum systematic offset for each cruise and parameter. The inversion results are then examined by experts for each particular geographic region and type of measurement. Since the inversion technique will identify real temporal changes as well as measurement bias, care is taken to segregate the two signals. Finally, a table of "required" adjustments is accepted. In order to have an offset applied, the measurement offset must exceed a minimum bias amount that is different for each type of measurement. Three *ad hoc* groups were organized: for salinity, CO_2 parameters, and dissolved oxygen and nutrients. Since CFCs are usually not detectable in deep layers, a different method that is based on the relationship between CFC-11 and CFC-12 saturation levels in the surface layer (Steinfeldt *et al*., 2010) was used for the 2nd level QC.

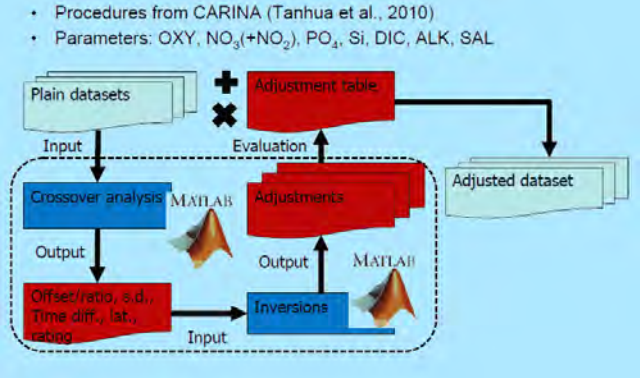


Fig. 2 Outline of the second level quality control (2nd level QC).

In the process of the 2nd level QC for PACIFICA, data sets from several WOCE cruises with basin-wide high-quality data and those from the Hawaii Ocean Time-series (HOT) have also been used to create a database consistent with GLODAP, HOT, and CARINA. Good news from applying the 2nd level QC is that, so far, the use of reference materials in fact helps us to obtain high-quality data (data of CO_2 parameters and nutrients from the cruises in which reference materials had been used are mostly consistent with each other, and no offset correction is needed for these cruises). These results demonstrate that it is critical to develop and appropriately use reference materials in collecting high-quality data for chemical components in the ocean.

Once the 2nd level QC for each parameter is completed, the accepted offsets will be applied to create the fully calibrated PACIFICA data product. PACIFICA, along with the original uncorrected data files, will be publicly available from the Marine Information Research Center (MIRC), Japan, and CDIAC.

We hope that PACIFICA, in conjunction with GLODAP and CARINA, will become a foundation to evaluate anthropogenic CO_2, ocean acidification, and natural or climate change-driven variability in biogeochemical dynamics in the Pacific Ocean from regional to basin scales.

"Models come and go, but a good data set lasts forever." (Paul Quay, 2002: *Science*, 298, 2344).

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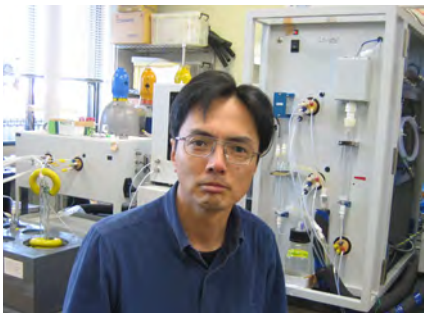
Acknowledgments

We are deeply grateful to the original measurement teams and their support staff who struggled to collect data from individual cruises. None of the synthesis efforts for PACIFICA would have been possible without their hard work. We also thank PICES for providing us this opportunity to talk about PACIFICA, and for their financial support.



Dr. Masao Ishii (mishii@mri-jma.go.jp) is a Research Scientist in the Geochemical Research Department at the Meteorological Research Institute, Meteorological Agency of Japan. Masao completed his graduate work in analytical and physical chemistry at Nagoya University and became a chemical oceanographer at the institute. His research interests focus on the marine carbon cycle, and he aims to understand the natural and anthropogenic changes in ocean CO_2 by observations. Within PICES, Masao has been a member of the Section on Carbon and Climate since 2008. He serves also as a committee member for the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) and is a scientific steering group member for the International Ocean Carbon Coordination Project (IOCCP).

Brief details on Dr. Toru Suzuki (Suzuki@mirc.jha.jp) can be found on page 19.

Dr. Robert M. Key (key@princeton.edu) is Research Oceanographer in the Atmospheric and Oceanographic Sciences program at Princeton University. He has been heavily involved in all of the major U.S. programs designed to investigate ocean mixing, ventilation and carbon chemistry including Transient Tracers in the Ocean (TTONAS and TTOTAS), the South Atlantic Ventilation Experiment (SAVE), the World Ocean Circulation Experiment (WOCE) and the Repeat Hydrography portion of the Climate Variability and Predictability program (CLIVAR). During WOCE and CLIVAR, Bob has been lead PI for the U.S. radiocarbon program and participated actively in the carbon dioxide measurement programs. After completion of the WOCE field work, he was the lead investigator in producing the GLODAP data products and was strongly involved in subsequent determination of the global ocean anthropogenic CO_2 distribution and inventory. Bob had lead responsibility for assembly of the CARINA data, participated in the 2nd QC, and assembled the final data products. His research interests focus on large-scale ocean circulation and mixing problems, especially those critical to the global carbon cycle.

2011 PICES Calendar

- 5th Zooplankton Production Symposium on "*Population connections, community dynamics and climate variability*" (primary international sponsors: PICES and ICES), March 14–18, 2011, Pucón, Chile (www.pices.int/zooplankton2011.aspx);
- FUTURE Workshop on "*Indicators of status and change within North Pacific marine ecosystems*", April 26–28, 2011, Honolulu, U.S.A. (www.pices.int/meetings/descriptions.aspx#description4)
- ICES/PICES workshop on "*Reaction of northern hemisphere ecosystems to climate events: A comparison*", May 2–6, 2011, Hamburg, Germany (www.pices.int/meetings/descriptions.aspx#description5);
- Second ESSAS (Ecosystem Studies of Sub-Arctic Seas) Open Science Meeting on "*Comparative studies of climate effects on polar and sub-polar ocean ecosystems: Progress in observation and prediction*" and associated workshops, May 22–26, 2011, Seattle, U.S.A. (www.pices.int/essas2011.aspx);
- 7th International Conference on "*Marine bioinvasions*" (co-sponsored by PICES), August 23–25, 2011, Barcelona, Spain (www.icmb.info/);
- Joint Theme Sessions at the 2011 ICES Annual Science Conference, September 19–23, 2011, Gdansk, Poland:
  - *Atmospheric forcing of Northern hemisphere ocean gyres and their subsequent impact on the adjacent marine climate and ecosystems*;
  - *Atlantic redfish and Pacific rockfish: Comparing biology, ecology, assessment and management strategies for Sebastes* spp.;
  - *Recruitment processes: Early life history dynamics – from eggs to juveniles*;
  - *Surplus production models: Quantitative tools to manage exploited fisheries and compare the productivity of marine ecosystems*;
- PICES Annual Meeting, October 14–23, 2011, Khabarovsk, Russia (www.pices.int/pices2011.aspx);
- International workshop on "*Development and application of Regional Climate Models*", October 11–12, 2011, Incheon, Korea (www.pices.int/meetings/descriptions.aspx#description8);
- International NPAFC-led workshop on "*Explanations for the high abundance of pink and chum salmon and future trends*" (co-sponsored by PICES), October 30–31, 2011, Nanaimo, Canada (http://www.npafc.org/new/events/workshops/2011Workshop1stAnnouncement.pdf).

Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management

by Gordon Kruse

Since the 1990s, fisheries managers have been advised to broaden their scope of awareness beyond single-species considerations. Reasons for this broader approach include: the typical poor performance of single-species fishery management worldwide, heightened awareness of interactions among fisheries and ecosystems, a growing understanding of the functional value of ecosystems to humans, and recognition of a wider range of societal objectives for marine ecosystems beyond fishery catches. As a result, fisheries management has been shifting toward ecosystem-based fisheries management (EBFM), also called an ecosystem approach to fisheries (EAF). An EAF strives to balance diverse societal objectives by taking into account the knowledge and uncertainties of biotic, abiotic, and human components of ecosystems and their interactions, and applying an integrated approach to fisheries within ecologically meaningful boundaries. This ecosystem approach is an important component of the new PICES Science Program on *Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems* (FUTURE). Indeed, in recent years, PICES has convened several working groups and numerous topic sessions on ecosystem-based approaches to fisheries at their annual meetings.

Considerable progress has been made by organizations, such as the Food and Agriculture Organization of the United Nations (FAO), International Council for the Exploration of the Sea (ICES), PICES and others to develop the conceptual framework, rationale, and international consensus toward such ecosystem approaches. Efforts have been directed toward developing new modeling tools and ecosystem indicators that can be used for implementation. However, substantial challenges still remain, including the need to develop operational objectives, requirements for more empirical information and associated increased costs of implementation, and practical matters of implementing the ecosystem approach by institutions that have failed to successfully implement single-species management.

These considerations motivated an international symposium titled "*Ecosystems 2010: Global progress on ecosystem-based fisheries management*", which was convened November 8–11, 2010, at the Captain Cook Hotel in Anchorage, Alaska, U.S.A. The Symposium Steering Committee included Drs. Gordon Kruse (Chairman, U.S.A.), Howard Browman (ICES, Norway), David Christie (Alaska Sea Grant, U.S.A.), Kevern Cochrane (FAO, Italy), Diana Evans (North Pacific Fishery Management Council, U.S.A.), Glen Jamieson (Department of Fisheries and Oceans, Canada), Patricia Livingston (NOAA Fisheries Service, U.S.A.), Douglas Woodby (Alaska Department of Fish and Game, U.S.A.), and Chang-Ik Zhang (PICES, Republic of Korea). Members of the Steering Committee organized the scientific aspects of the symposium, chaired sessions, and will serve as editors for the symposium proceedings.

The symposium was co-sponsored by PICES, ICES, FAO, and multiple U.S. regional sponsors, including Alaska Sea Grant, NOAA Fisheries Service, North Pacific Fishery Management Council, North Pacific Research Board, Alaska Department of Fish and Game, and the Pollock Conservation Cooperative Research Center. Other supporting organizations included the Institute for Marine Research (Bergen, Norway), School of Fisheries and Ocean Sciences of the University of Alaska Fairbanks (U.S.A.), and Marine Conservation Alliance (U.S.A.). The symposium was hosted by Alaska Sea Grant which handled all meeting logistics. This symposium was part of an ongoing Alaska Sea Grant symposium series; specifically it was the 26th Lowell Wakefield Fisheries Symposium (http://seagrant.uaf.edu/conferences/wakefield/index.html).

The symposium attracted broad international interest and was attended by 108 registered participants from 19 countries: Argentina, Australia, Brazil, Canada, Estonia, India, Italy, Japan, Korea, Malaysia, New Zealand, Norway, Pakistan, South Africa, Sweden, Taiwan, Thailand, United Kingdom, and U.S.A. This size and diversity fostered a very collegial atmosphere to discuss and contrast approaches in many regions of the world. The keynote and seven invited speakers further emphasized the international focus of this symposium with presentations on seven contrasting marine ecosystems: Thailand, Korea, Japan, Australia, Namibia, Norway, and Atlantic Canada.

The goals of *Ecosystems 2010* were to: (1) evaluate global progress toward EBFM by reviewing regional case studies, development of new analytical tools and practical approaches toward future progress, and (2) offer explicit, practical advice for future progress in implementation of EBFM. To meet these goals, oral presentations and posters were organized along four main themes: (1) progress on regional applications, (2) new analytical tools and evaluation of ecosystem indicators, (3) human dimensions, and (4) case studies and practical solutions.

Alaska Sea Grant Director, Dr. David Christie, and Steering Committee Chairman, Dr. Gordon Kruse, opened the symposium with welcoming addresses. The keynote speaker was Dr. Howard Browman, who kicked off the

symposium with a provocative and challenging "devil's advocate" position. He questioned the extent to which EBFM can be operationalized, whether ecological principles have been incorporated into EBFM and, in fact, whether ecology is necessary to meet the main objectives of EBFM. Finally, he considered whether we have the resources needed to apply EBFM broadly and completely, and whether EBFM will really improve the sustainable management of marine resources.

All sessions were conducted in plenary to maximize involvement of all participants. The first Topic Session addressed "*Progress on regional applications*" and spanned just over one full day. It was chaired by Drs. Douglas Woodby and Kwame Koranteng (FAO, Ghana). An invited talk was given by Dr. Chris O'Brien (Thailand) on the Bay of Bengal Large Marine Ecosystem (BOBLME) Project. He described the strategies and challenges associated with working simultaneously in eight developing countries to implement the BOBLME Project. They are attempting to integrate ecological, economic, social, and governance aspects into the management of three trans-boundary fisheries, as well as into an overall strategic plan for coordinated management and remediation of the degraded Bay of Bengal marine ecosystem. The challenge is daunting, as the regional fisheries involve 380,000 fishing vessels, with landings valued at US $6.0 billion, and 4.5 million people employed in the fishing industry. Lessons learned are likely most relevant to PICES countries in the western North Pacific. This interesting session also included examples of other regional EBFM applications in very diverse regions such as India, Thailand, Sweden, South Africa, west coast of Canada, New England (U.S.A.), and even tropical river systems of Brazil.

The second full-day Topic Session addressed *"New analytical tools and evaluation of ecosystem indicators"*. It was chaired by PICES representatives, Patricia Livingston and Dr. Chang-Ik Zhang, and included two invited talks. In the first, Dr. Rick Fletcher (Australia) introduced an EBFM framework to set priorities based on risk assessment. The framework integrates individual fishery level risks and outcomes at a regional level so as to develop a practical, prioritized agency planning process. An example of applying this step-wise, hierarchical approach was given for the West Coast Bioregion of Western Australia. Over 600 ecological assets, social and economic outcomes, governance systems, and external drivers were identified. However, these were consolidated into just 24 department-level priorities ranging from urgent to very low after applying the hierarchical approach, which culminated in a multi-criteria analysis. The approach appears to be remarkably successful, as these EBFM-based assets and priorities now form the basis for all planning and budget setting processes in the agency, plus they are facilitating improved linkages with other government agencies and regional level processes. In the second talk, Dr. Zhang reviewed new analytical tools

Ross F. Tallman, Fisheries and Oceans Canada, discusses his poster "Management of Ecosystem Effects, Potential and Realized, in Emerging Arctic Fisheries in South Baffin Island" at the evening poster session and reception at the 26th Lowell Wakefield Fisheries Symposium.

for EBFM assessment and management. He gave two examples showing how ecosystem-based assessments can assist fisheries management in practice. The first was the Marine Stewardship Council's Fishery Assessment Methodology, and the second was the Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) developed by Dr. Zhang and colleagues. Other presentations in this session addressed ecosystem indicators, integrated ecosystem assessments, and models ranging from multi-species surplus production models to full ecosystem models.

The third Topic Session spanned a half-day and addressed *"Human dimensions"*. It was chaired by Drs. Glen Jamieson and Diana Evans, and also included two invited talks. In the first, Dr. Anthony Charles (Canada) examined the human context for EBFM, as part of a multi-objective "systems" approach, as well as the human dimensions of implementing ecosystem-based management. He emphasized a number of challenges, including the challenge to scale up or scale down new governance initiatives to fit the multiple scales of fished ecosystems. Dr. Mitsutaku Makino (PICES, Japan) spoke about fisheries at the Shiretoko World Natural Heritage site. He pointed out that a key to effective management is the participation of the fisheries sector from the beginning of the planning process. Involvement of stakeholders requires a very large number of frequent public meetings. A notable benefit of this involvement is "buy-in" of the stakeholders to the management actions, resulting in a considerable reduction of the administrative costs for conservation measures. Lessons learned from this case study of co-management may be particularly helpful to other situations in the world where large numbers of small-scale fishers harvest a wide range of species. Other interesting talks in this session covered social aspects of overfishing of small-scale fishery resources in Estonia, governance models in Western Australia, development of spatially explicit, decision-support tools for public involvement along the west coast of the U.S. and Canada, and conflict resolution methods for design of marine protected areas in Taiwan, among others.

The final Topic Session addressed *"Case studies and practical solutions."* It was chaired by Drs. Gordon Kruse and Howard Browman (Norway). Dr. Johann Augustyn (Namibia) delivered the first invited talk on EBFM in the Benguela Current region. The Benguela Current Commission involves Namibia, Angola, and South Africa. These three countries have established structures and mechanisms to manage their fisheries using an ecosystem approach to varying degrees, and they have also initiated research projects to develop ecosystem indicators to monitor progress. In the second talk, Dr. Robert Stephenson (Canada) reported on progress toward EBFM in the Gulf of Maine. In this region, there have been many advances in the understanding of ecosystem processes and progress in networking of people and information. Remaining impediments include the need for enhanced monitoring and information about this complex ecosystem to support evolving management, as well as the need for changes in governance to support cross-disciplinary and inter-jurisdictional considerations. In other presentations in this session, Dr. Kwame Koranteng discussed the approach to EBFM in a number of developing countries and regions around the world, current progress, and practical obstacles that are being encountered. The session was concluded with four talks addressing case studies of EBFM involving considerations of marine mammals, fishing, climate, and other factors in marine ecosystems of the Gulf of Alaska and eastern Bering Sea.

The symposium was concluded with a panel discussion, which included Drs. Howard Browman, Rick Fletcher, Glen Jamieson (Chairman), Kwame Koranteng, Mitsutaku Makino, and Patricia Livingston. Panelists offered their perspectives on the take-home messages from the symposium, and meeting participants posed questions and proffered their insights.

Based on the panel discussion, it appears that the symposium achieved a general consensus on several aspects of EBFM. There was a convergence on broad ecosystem management objectives, principles, approaches, tools, and involvement of stakeholders. A clear consensus also emerged on the need to conduct risk assessments to set priorities. In general, the greatest risk identified for many of the regions of the world is the lack of effective governance. Rectifying this central problem is a prerequisite for any form of sound fishery management. Other common struggles include the difficulty to obtain clear operational objectives from policy makers and the need to develop practical approaches that can be implemented in developing countries with limited fiscal resources. In developed countries, ecosystem models have been constructed to improve understanding of ecosystem dynamics in many regions, but it remains unclear whether these models are capable of providing explicit management advice, such as prescription of biological reference points and total allowable catches.

Kwame Koranteng of the Ghana Oceanographic Data Centre speaks at the panel discussion on "Necessary steps for future progress. What's next?".

In conclusion, this symposium was another outstanding successful collaboration of PICES with other international organizations. It was a pleasure and privilege for me to work with PICES, ICES, FAO, and other colleagues from around the world on this topic, which is very relevant to the PICES FUTURE program. Details about this symposium, *"Ecosystems 2010: Global progress on ecosystem-based fisheries management"*, including the program, copies of presentations, and book of abstracts are available on the symposium website at http://seagrant.uaf.edu/conferences/2010/wakefield-ecosystems/index.php. Accepted papers presented at the symposium will be published in a peer-reviewed, edited book expected to be completed in late 2011. The book will be available electronically over the Internet for easy and affordable access to the PICES community.

Dr. Gordon Kruse (Gordon.Kruse@alaska.edu) is the President's Professor of Fisheries and Oceanography at the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks. He maintains broad interests in stock assessment modeling, population dynamics, fishery oceanography, and fishery and ecosystem-based management strategies. Gordon has worked in Alaska for 27 years on a diversity of invertebrate and fish species, with an emphasis on commercially important crab species. He teaches graduate courses in Marine Ecosystems, Management of Renewable Marine Resources, and other topics. Gordon is the former Chairman and current Vice-Chairman of the PICES Fishery Science Committee.

PICES 2010 Rapid Assessment Survey

by Graham Gillespie, John Chapman and Thomas Therriault

Status and trends of non-indigenous species (NIS) are of enormous interest in the North Pacific, but establishing extensive international cooperation required to investigate the problem has been difficult. In 2006, PICES Working Group 21 on *Non-indigenous Aquatic Species* was formed to increase understanding of marine non-indigenous species in the North Pacific. In 2007, two initiatives were started in a 5-year PICES project on "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*" supported by a voluntary contribution from the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan. The first initiative, led by Dr. Henry Lee II (U.S. Environmental Protection Agency) was to develop a comprehensive database for non-indigenous species. The second was a taxonomy initiative that included rapid assessment and collector surveys in PICES member countries. Dr. Thomas Therriault (Fisheries and Oceans Canada) has served as the principal investigator of this initiative and organized rapid assessment surveys in 2008 in Dalian, China (see PICES Press 17(1): 30–32) and in 2009 in Jeju, Korea (see PICES Press 18(1): 38–40). The third rapid assessment survey was conducted in Oregon, U.S.A., just prior to the 2010 PICES Annual Meeting in Portland.

PICES Rapid Assessment Surveys (RAS) serve to collect initial baseline data and inter-calibrate species collection and identification methods that allow distinction of native, non-indigenous, and cryptogenic species. Standardized RAS data permit comparisons of invasions within and among countries and can reveal mechanisms and consequences of invasions. PICES RAS also support international cooperation that is critical for resolving NIS, their origins, mechanisms of dispersal, effects and impacts.

International ports are particularly important recipients of organisms associated with ballast water, ballast sediment or hull fouling, and often have high levels of secondary traffic (recreational or small craft, aquaculture transfers) to adjacent

Participants in the 2010 Oregon Rapid Assessment Survey of non-indigenous, cryptogenic and native species: Front row (left to right): Gayle Hansen, Gyo Itani, Thomas Therriault, Takeaki Hanyuda; middle row: Darlene Smith, Toshio Furota, in front of Katie Marko next to Leslie Harris, John Markham, Gretchen Lambert, Sylvia Yamada; back row: Vasily Radashevsky, Ralph Breitenstein, John Chapman, Graham Gillespie, Charles Lambert, Loren Curran. (Not shown: Donnelle Breitenstein, Jack Chapman, Ian Chun, Faith Cole, Caroline Emch-Wei, John Estabrook, Jeff Fischer, Brian Fodness, Bruce Hansen and Vallorie Hodges).

ports. International ports also tend to be more disturbed than other less urbanized estuaries and bays, possibly enhancing invasion success. New invasions, transoceanic transport mechanisms and vector pathways of dispersal are more readily identified and managed when they can be tracked among major ports. Before PICES-2010, intertidal and shallow subtidal habitats of two Oregon estuaries (Coos Bay and Yaquina Bay) were sampled using fouling plates (collectors), traps for macrofauna (primarily fish and crabs), scrapings of floats and pilings, and by diver collections. Additionally, a seawater reservoir tank at the Hatfield Marine Science Center in Yaquina Bay was drained and sampled for fouling organisms. These qualitative surveys measured species diversity within each location. Classification of species as native, non-native or cryptogenic occurred following species identification based on literature accounts and analyses by RAS team members.

The 2010 investigative team consisted of the authors of this article, Toshio Furota (Toho University, Japan), Gayle Hansen (Environmental Protection Agency, U.S.A.), Takeaki Hanyuda (Kobe University Research Center for Inland Seas, Japan), Leslie Harris (Natural History Museum of Los Angeles County, U.S.A.), Gyo Itani (Kochi University, Japan), Charles and Gretchen Lambert (University of Washington, Friday Harbor, U.S.A.), John Markham (Arch Cape Marine Laboratory, U.S.A.), Vasily Radashevsky (A.V. Zhirmunsky Institute of Marine Biology, Russia) and Sylvia Yamada (Oregon State University, Corvallis, U.S.A.). Volunteer divers and laboratory assistants included Donnelle and Ralph Breitenstein, Jack Chapman, Ian Chun, Faith Cole, Lorne Curran, Carolyn Emch-Wei, John Estabrook, Jeff Fischer, Brian Fodness, Bruce Hansen, Vallorie Hodges, Katie Marko, and Darlene Smith. Laboratory space, equipment, and reference material were graciously provided by the Hatfield Marine Science Center, Oregon State University, Newport, U.S.A. Additional funding and/or support was provided by Fisheries and Oceans Canada, Oregon Sea Grant, University of Guelph, U.S. Environmental Protection Agency, Ralph and Donnelle Breitenstein and Liu Xin (Oregon Oyster, Inc.).

On October 18, the team worked through samples provided to the Hatfield Science Center laboratory and was treated to a welcome reception at the Rogue Brewery in Newport. The reception featured microbrews and food provided by Oregon Oyster, Inc. Investigators and volunteers participated in a day-long field trip on October 19 that included collections from public and commercial boat docks in Charleston Harbor and the City of Coos Bay. Surface collections were supplemented with dive collections from low intertidal and subtidal zones and collection plates from Yaquina Bay. The team completed sample processing on October 20 and was then invited to a wrap-up social at the home of Henry Lee and Debbie Reusser.

Participants in the survey also contributed to presentations given at the WG 21 meeting and the Topic Session on "*Anthropogenic forcing in North Pacific coastal ecosystems: Understanding changes in ecosystem structure and function*" convened at PICES-2010. These talks and posters helped to facilitate cooperation and exchange between experts from PICES member countries. Topics included the WG 21 atlas of non-indigenous species in the North Pacific (Henry Lee II and Debbie Reusser); invasions, island biogeography and human welfare (John Chapman); propagule pressure in *Didemnum vexillum* (John Chapman *et al*.); *Didemnum* in New Zealand and other tunicate news (Gretchen and Charles Lambert); *Hediste* genetics (Toshio Furota and Hiroaki Toshuji); *Orthione griffensis* in Japan (Gyo Itani, Yukari Miyoshi and Hiroshi Kume); molecular elucidation of introduced seaweeds (Takeaki Hanyuda and Hiroshi Kawai); family Spionidae (Vasily Radashevsky); what makes better taxonomy (Leslie Harris); and green crab assessment in Yaquina Bay (Sylvia Yamada, Graham Gillespie and Katie Marko).

PICES RAS participants (left to right) Katie Marko, Graham Gillespie and Sylvia Yamada display non-indigenous European green crabs captured in Yaquina Bay.

Preliminary results of the Oregon RAS included 191 taxa from 400 sample lots. Nearly all taxa were identified to the species level, although many are provisional identifications and work is ongoing to resolve these. Twenty-five species of polychaete represent first records of these species in one or more of the sampled Oregon estuaries, and eight species of polychaete represent new records in Oregon. It is possible that other non-indigenous species were encountered but identifications and classifications are pending. In collaboration with the Barcode of Life Project, many incomplete identifications will be explored further using molecular methods.

A significant advantage of these surveys is the opportunity for taxonomists to examine material from different areas and exchange ideas directly with other taxonomists of the same taxa and with other invasion ecologists. The participation of ascidian taxonomists in our survey allowed the identification of the second Pacific record of the introduced North Atlantic sea grape *Molgula citrina*, which was also the first Pacific record south of Alaska. Another

advantage is the comparison of collecting techniques and the development of standards. During this survey, Canadian and U.S. methods to trap European green crab *Carcinus maenas* were contrasted, allowing a unique opportunity to inter-calibrate methods used among PICES member countries. Other special projects examined the distribution of the invasive tunicate *Didemnum vexillum* in Coos and Yaquina Bays and the Umpqua triangle, genetic samples of the algae *Ulva* and the nereid worm *Hediste* to determine possible Asian or North American origins, and infection rates of bopyrid isopod parasites in the Eastern and Western North Pacific.

The 2008 rapid assessment survey in Dalian (China) identified a total of 119 taxa, three of which (all bivalve molluscs) were classified as non-indigenous. The 2009 survey in Jeju (Korea) identified 213 taxa with four (one bivalve mollusc, one cirriped, one amphipod and one polychaete) designated as non-indigenous. The Oregon survey yielded at least 14 species that were classified as non-indigenous: four algae, six ascidians, three polychaetes and one crustacean. Many identifications remain provisional; therefore, the total number of species and number of non-indigenous species may increase for all surveys.

Introductions reduce the wealth of every nation, and no country can deal with introductions alone. The PICES surveys provide critical information and a mechanism to foster the international cooperation needed for each nation to detect and manage its introduced species.

Graham Gillespie (Graham.Gillespie@dfo-mpo.gc.ca) is Head of the Shellfish Section at the Pacific Biological Station, Fisheries and Oceans Canada (DFO) in Nanaimo, British Columbia. Graham conducts stock assessments for commercially important species, provides scientific advice for the SARA-listed Olympia oyster and participates in ecosystem-level research involving these groups. He also coordinates an Aquatic Invasive Species program that examines distribution, dispersal and impacts of intertidal non-indigenous species on the Pacific Coast of Canada. Graham is a member of PICES WG 21 on Non-indigenous Aquatic Species and WG 24 on Environmental Interactions of Marine Aquaculture.

John Chapman (John.Chapman@oregonstate.edu) is a marine biological invasions ecologist at the Hatfield Marine Science Center, in Newport, Oregon, U.S.A. In addition to the PICES surveys in 2009 and 2010, John's recent research has included the 1000 AD Viking species introductions across the North Atlantic, the systematics of shallow water gammaridean amphipod crustaceans of the northeast Pacific and the ecology of introduced and native bopyrid isopods on their burrowing shrimp hosts of the North Pacific. John also teaches lower and upper division Aquatic Biological Invasions through the departments of Biology and Fisheries and Wildlife at Oregon State University.

Dr. Thomas Therriault (Thomas.Therriault@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada (DFO) at the Pacific Biological Station in Nanaimo, British Columbia. Tom is working on a number of aquatic invasive species research questions both within DFO and through the Canadian Aquatic Invasive Species Network (CAISN). He is the Principal Investigator for the Taxonomy Initiative of PICES WG 21 on Non-indigenous Aquatic Species ((under the project on "Development of the prevention systems for harmful organisms' expansion in the Pacific Rim" supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan) that includes rapid assessment surveys (RAS) for non-indigenous species. Within PICES, Tom serves as Vice-Chairman of Science Board and leads the FUTURE Advisory Panel on Anthropogenic Influences on Coastal Ecosystems (AICE). He is a member of the Marine Environmental Quality Committee (MEQ) and the P/ICES Study Group on Developing a Framework for Scientific Cooperation in the Northern Hemisphere.

PICES Workshop on "*An Introduction to Rapid Assessment Survey Methodologies for Application in Developing Countries*"

by Thomas Therriault

Since its inception in 2006, PICES Working Group 21 (http://www.pices.int/members/working_groups/wg21.aspx) has been advancing our understanding of marine non-indigenous species in the northern Pacific Ocean. Rapid Assessment Surveys (RAS) are one approach to quickly characterize the native, non-native, and cryptogenic species present in different locations. These qualitative surveys allow rapid depiction of the species composition within each location surveyed, not the abundance of any specific species. Quantitative surveys to estimate population sizes could be done subsequently, if needed, but are too time consuming for rapid assessments. Although specific methods vary slightly based on habitats being sampled or taxonomic groups being characterized, WG 21 has developed methodologies that have been used within PICES member countries to identify non-indigenous species in both inter-tidal and sub-tidal habitats. To date, RAS have been conducted in Dalian (China) in 2008, Jeju (Korea) in 2009, and most recently near Newport (Oregon, U.S.A.) in 2010 (*see related PICES Press article in this issue*). Data from each of these surveys have been archived in the PICES WG 21 database of marine and estuarine species. However, given the global nature of biological invasions, it is critical to engage researchers working on this important topic outside of PICES' six member countries, especially in locations adjacent to the PICES region where the potential transport of non-indigenous species is expected to be high. PICES WG 21 is working with other international organizations to share information on global invaders, but there remain fundamental gaps within developing countries. Thus, a demonstration workshop on "*An introduction to rapid assessment survey methodologies for application in developing countries*" was held to provide participants from developing countries with the tools to conduct their own surveys. In addition, the workshop provided a clear context to why this type of activity is essential both locally and globally, and how information on non-native species can be shared between developing and PICES member countries to benefit all. PICES co-sponsored this workshop with the Fisheries Research Agency (FRA) of Japan and Kobe University's Research Center for Inland Seas. The workshop was co-convened by Drs. Hiroshi Kawai (Kobe University, Japan), Hisashi Yokoyama (National Research Institute of Aquaculture, FRA) and Dr. Thomas Therriault (Fisheries and Oceans Canada), and focused on hands-on training of researchers from mostly developing Southeast Asian countries concerned about the potential introduction of non-indigenous marine species. From July 13–15, 2010, participants from Malaysia, Thailand, Singapore, Indonesia, Vietnam, the Philippines and Japan were invited to the Marine Station of Kobe University's Center for Inland Seas (Awaji Island, Hyogo Prefecture, Japan) to learn about PICES activities on non-indigenous marine species and to receive training in Rapid Assessment Survey techniques.

RAS workshop participants at the sampling site in the inner part of Osaka Bay, Japan: Front row (l-r): Dr. Tan Koh Siang (Singapore), Dr. Roike Montolalu (Indonesia), Dr. Hisashi Yokoyama (Japan), Takashi Nozawa (Japan) and Dr. Takeaki Hanyuda (Japan); middle row (l-r): Dr. Thomas Therriault (Canada), Dr. Teodora Bagarinao (Philippines) and Dr. Lim Phaik-Eem (Malaysia); back row (l-r): Dr. Akira Kurihara (Japan), Dr. Hiroshi Kawai (Japan), Dr. Takeo Kurihara (Japan), Dr. Paul Geraldina (Philippines), and Dr. Michio Otani (Japan); missing from the photograph: Dr. Suchana (Apple) Chavanich (Thailand).

RAS workshop participants getting ready to visit collection sites: Front row (l-r): Dr. Michio Otani (Japan), Dr. Lim Phaik-Eem (Malaysia), Dr. Tan Koh Siang (Singapore), Dr. Takeaki Hanyuda (Japan) and Dr. Takeo Kurihara (Japan); back row (l-r): Dr. Hisashi Yokoyama (Japan), Takashi Nozawa (Japan), Dr. Zhongmin Sun (China), Dr. Paul Geraldina (Philippines), Dr. Roike Montolalu (Indonesia), Dr. Thomas Therriault (Canada), Dr. Hiroshi Kawai (Japan), Dr. Teodora Bagarinao (Philippines); missing from the photograph: Dr. Suchana (Apple) Chavanich (Thailand) and Dr. Akira Kurihara (Japan).

RAS workshop participants at the Kobe University Marine Station sorting and identifying material collected from surveys on Awaji Island, Japan.

The workshop exposed participants to (1) a background about marine non-indigenous species and why vigilance is required, using a series of short lectures, (2) hands-on experience in making field collections in a variety of coastal environments, and (3) laboratory experience using keys and reference material to identify the organisms collected. Since the workshop focused on background and techniques, actual taxonomic experts were not utilized in this demonstration, but would play a critical role in actual RAS. Taxonomic experts have a broad knowledge of their taxonomic group amassed over time spent studying thousands of individuals from different geographical areas to resolve identifications – skills taxonomic generalists must develop to confidently resolve identifications (and potential invasion status). Further, given that taxonomy for some species will be controversial and that reference collections are important to document the occurrence of non-indigenous species, it is imperative that voucher specimens be maintained for future reference.

Workshop participants visited a number of sites around Osaka Bay where they were shown techniques to sample a variety of different habitats. On the first day, we visited a site on Awaji Island where participants made timed walk collections in two different inter-tidal habitats, one exposed directly to Osaka Bay with no development, and the other a small enclosed basin with shoreline development and small boat anchorages. These inter-tidal collections were supplemented with snorkelling collections made in the shallow sub-tidal environment directly adjacent to the shore, providing excellent specimens of crabs, bivalves, and tunicates. Loaded with bags of samples, participants returned to the Marine Station where they spent the afternoon identifying the treasures they had collected. On the second day, we focused on the application of collector plates to monitor for the introduction (and/or spread) of fouling organisms like algae, tunicates, and bryozoans that have received much attention in the invasion literature lately. Dr. Kawai and his colleagues have utilized these collectors to monitor changes in algae and invertebrate species in different parts of Osaka Bay over the past few years. Participants were able to observe first-hand differences in fouling communities between a study site in the inner part of Osaka Bay (highly developed) and another near the Marine Station on the outer part of the Bay (relatively pristine). Again, samples were collected and returned to the laboratory for further processing. As thunderstorms pounded the Marine Station on the third day, participants were introduced to the PICES WG 21 database on marine and estuarine species developed by Dr. Henry Lee II and Ms. Debbie Reusser. This hierarchical database, built on marine eco-regions of the world, can allow researchers from developing countries to archive their data in a systematic way that is then directly available both to them and to PICES member countries.

The positive feedback from workshop participants was overwhelming, with many participants eager to initiate aspects of RAS within their home countries. In fact, the feedback on this type of outreach and training activity was so encouraging that Drs. Therriault and Kawai are working with Dr. Apple Chavanich to host a larger demonstration workshop in 2011 in Bangkok, Thailand.

Dr. Thomas Therriault (Thomas.Therriault@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada (DFO) at the Pacific Biological Station in Nanaimo, British Columbia. Tom is working on a number of aquatic invasive species research questions both within DFO and through the Canadian Aquatic Invasive Species Network (CAISN). He is the Principal Investigator for the Taxonomy Initiative of PICES WG 21 on Non-indigenous Aquatic Species (under the project on "Development of the prevention systems for harmful organisms' expansion in the Pacific Rim" supported by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan) that includes rapid assessment surveys (RAS) for non-indigenous species. Within PICES, Tom serves as Vice-Chairman of Science Board and leads the FUTURE Advisory Panel on Anthropogenic Influences on Coastal Ecosystems (AICE). He is a member of the Marine Environmental Quality (MEQ) Committee and the P/ICES Study Group on Developing a Framework for Scientific Cooperation in Northern Hemisphere Marine Science.

The State of the Western North Pacific in the First Half of 2010

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 2010, 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, MetOp/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 the 9 regions indicated in the bottom panel.

In February and March, SSTs were above normal from 35°N, 170°E to 20°N, 125°E. In May, negative SST anomalies were found in the wide area between 20°N and 40°N, and positive SST anomalies prevailed in the seas south of 20°N. In the South China Sea, positive SST anomalies exceeding +1°C appeared during the entire period, except in April. Negative SST anomalies exceeding –1°C prevailed in the seas east of Japan around 40°N, 140°E (regions 2 and 4 in Fig. 2) by June. In February and March SSTs were above normal in the seas south of Japan (regions 6, 7 and 9 in Fig. 2), where SST anomalies turned negative in May. From March to May SSTs were below normal in the Japan Sea and the East China Sea.

Kuroshio and Oyashio

Figure 3 shows a time series outlining the location of the Kuroshio path from January to June of 2010, at intervals of 10 days. After April, the Kuroshio took a nearshore non-large-meander path off the coast to the south of Honshu Island (between 135°E and 140°E). East of 135°E, several small perturbations propagated eastward along the Kuroshio from February to April. Corresponding to the passage of each perturbation, the latitude of Kuroshio axis over the Izu Ridge moved north and south.

Figure 4 presents the subsurface temperature at a depth of 100 m in the seas east of Japan for March 2010. This chart is based on the numerical ocean data assimilation system (JMA's Ocean Comprehensive Analysis System).

The Oyashio cold water (defined as areas with temperatures of 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). From January to March of 2010, the coastal branch of the Oyashio cold water was located south of its normal position (Fig. 5). The southernmost point in March was at 37.5°N, 142°E, or 100 km south of the normal location.

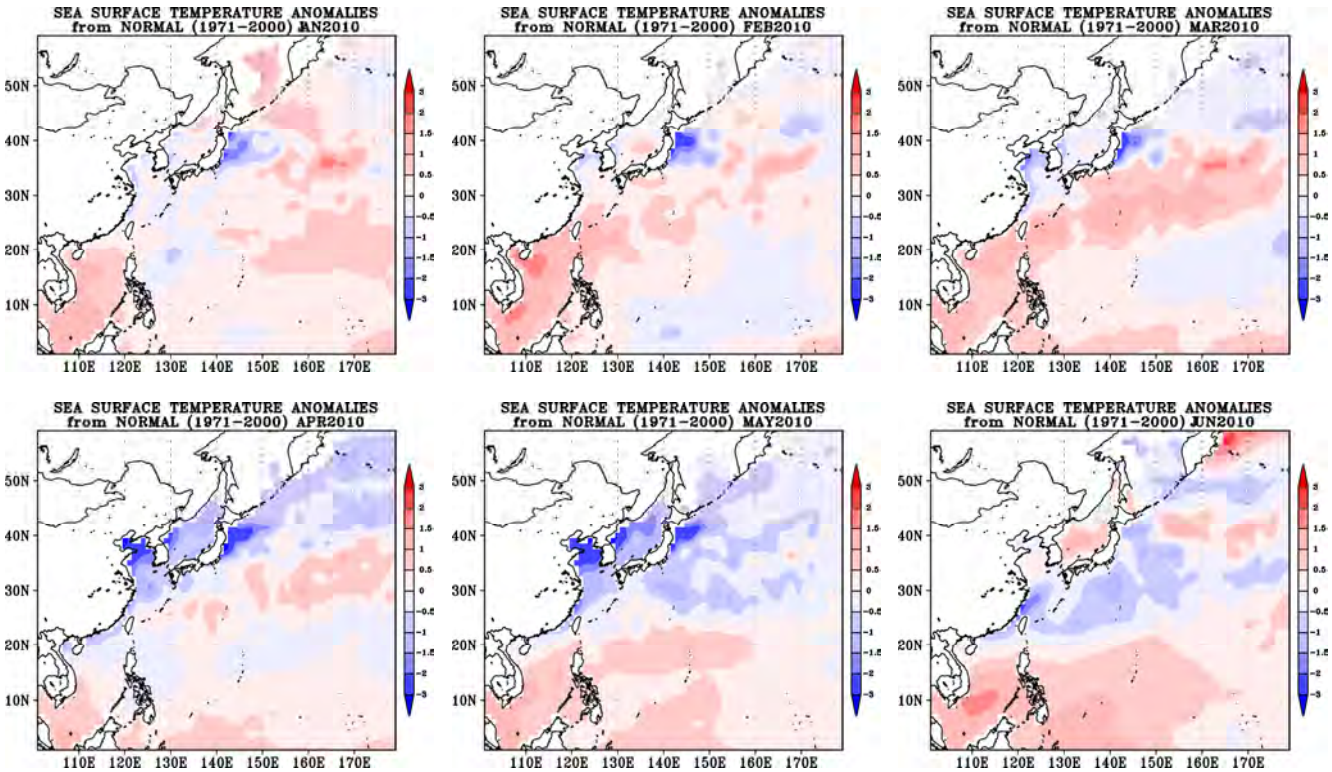


Fig. 1 Monthly mean sea surface temperature anomalies (°C) from January to June 2010. Anomalies are deviations from JMA's 1971–2000 climatology.

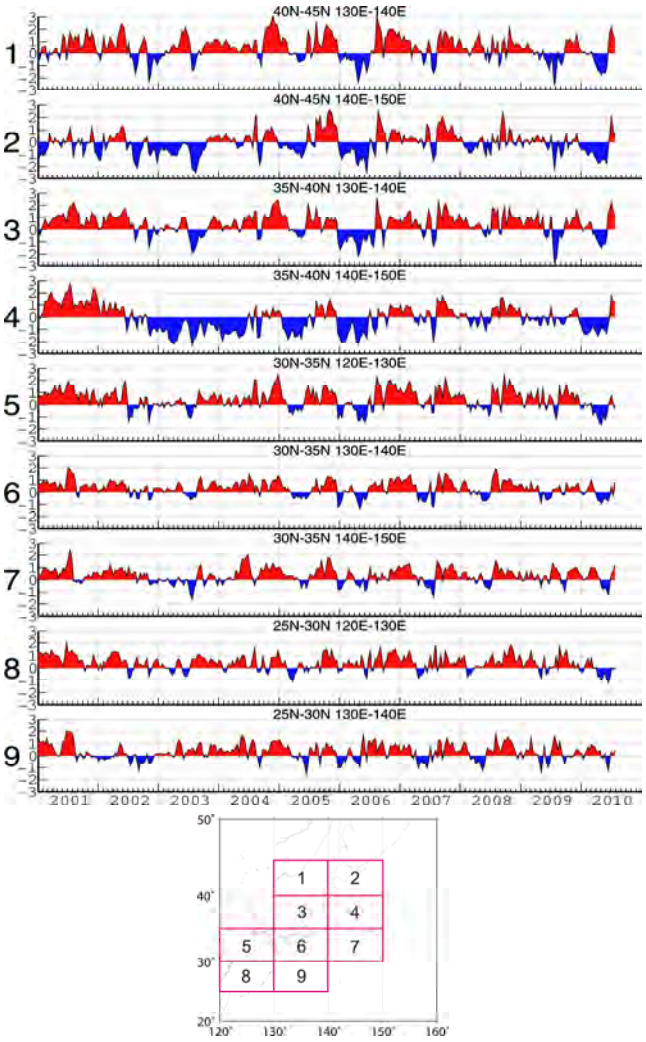


Fig. 2 Time series of 10-day mean sea surface temperature anomalies (°C) averaged for the sub-areas shown in the bottom panel. Anomalies are deviations from JMA's 1971–2000 climatology.

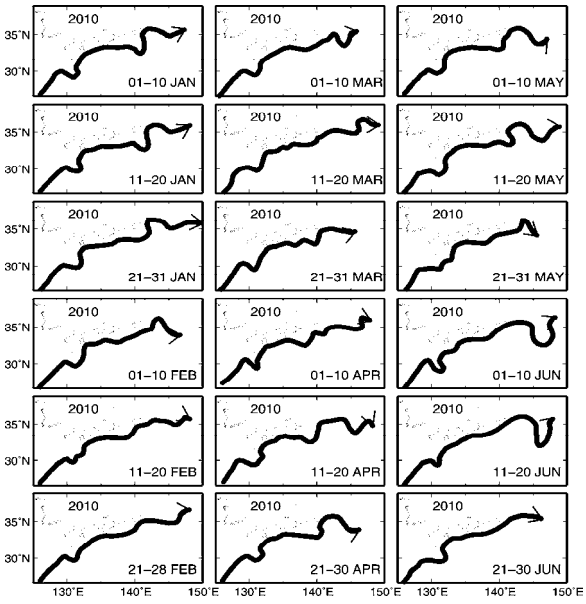


Fig. 3 Location of the Kuroshio path from January to June 2010.

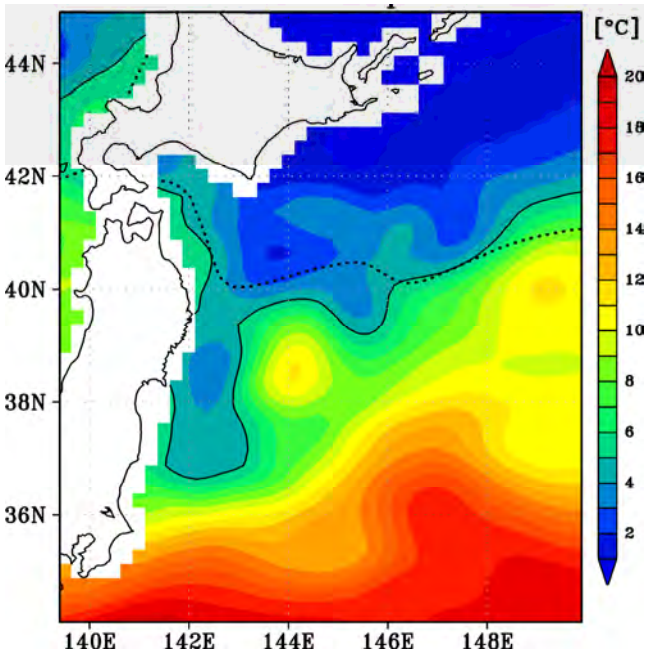


Fig. 4 Subsurface temperatures (°C) at a depth of 100 m east of Japan for March 2010. The solid line denotes the 5°C isotherm, while the dotted line is its climatology (30-year average values from 1971 to 2000).

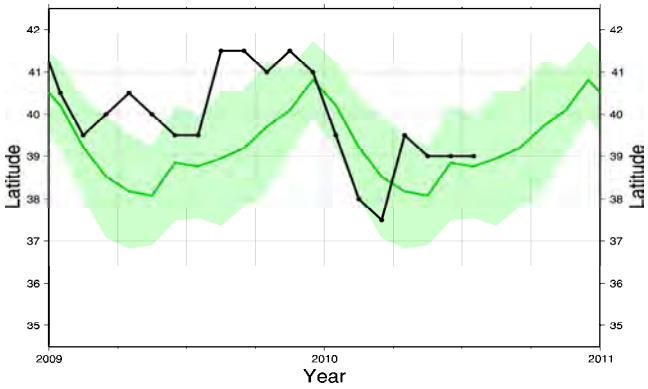


Fig. 5 The southernmost position of the coastal branch of the Oyashio cold water from January 2009 to July 2010 (black line), and the 30-year average values (green line), with a range of one standard deviation (green shading) from 1971 to 2000.

Sea ice in the Sea of Okhotsk

The sea ice extent in the Sea of Okhotsk was below normal from December 2009 to February 2010, and turned above normal in April 2010 (Fig. 6). It reached its seasonal maximum of 111.41 × 10^4 km^2 on March 10, which was less than that of the normal season (122.83 × 10^4 km^2).

Figure 7 presents interannual variations in the maximum sea ice extent (red lines) and accumulated sea ice extent (green lines) in the Sea of Okhotsk from 1971 to 2010. Although the sea ice extent in the Sea of Okhotsk shows large interannual variations, there is a slight decreasing trend of 174[55–294] × 10^4 km^2 per decade (the numbers in

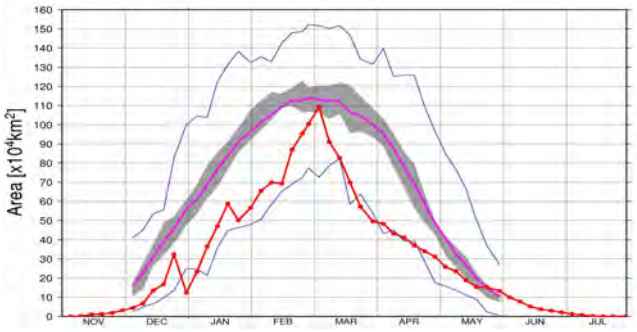


Fig. 6 Time series of sea ice extent in the Sea of Okhotsk from November to July (red line: 2009–2010 analysis; pink line: JMA's 1971–2000 climatology; blue lines: maximum/minimum sea ice extent since 1971; gray area: normal range).

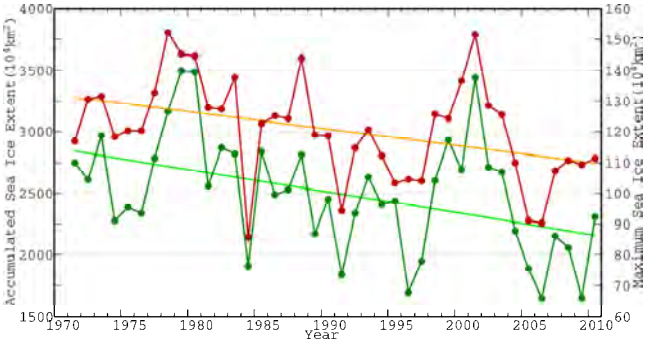
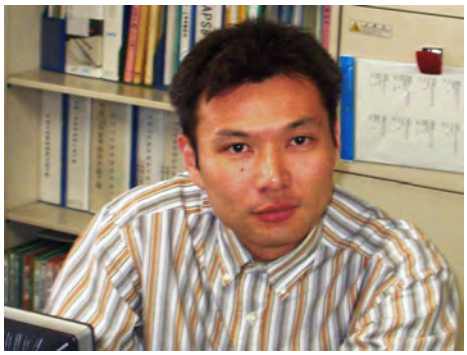


Fig. 7 Interannual variations in the maximum sea ice extent (red lines) and accumulated sea ice extent (green lines) in the Sea of Okhotsk from 1971 to 2010. The accumulated sea ice extent is defined as the sum of 5-day sea ice extents from December to May.

square brackets indicate the two-sided 95% confidence interval) in the accumulated sea ice extent and another slight decreasing trend of 5.5[1.3–9.7] × 10^4 km^2 (equivalent to 3.5% of the area of the Sea of Okhotsk) per decade in the maximum extent.



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 Interns

We offer sincere thanks to Ms. Tatiana Semenova (left), the 2010 PICES intern, who will soon complete her term at the PICES Secretariat and return to her home institution, TINRO-Centre, in Vladivostok, Russia. Many of you had an opportunity to meet and enjoy communicating with Tatiana at PICES-2010 in Portland (Oregon, U.S.A.), or at the PICES Secretariat office. It was a true pleasure working with Tatiana, and we appreciate her dedicated efforts during this past year and wish her a very successful career. We are sure that those of you, who are going to attend PICES-2011, will see Tatiana again in Khabarovsk, as she is already heavily involved in preparing this Annual Meeting.

We are pleased to announce that Ms. Jeongim Mok (right) will join the Secretariat in May as the 2011 PICES Intern. She has a Master's Degree in Environmental Engineering from the Korea University in Seoul. Jeongim worked in the private sector, in the Department of Marine Conservation at the Ministry of Maritime Affairs and Fisheries (MOMAF), and is now with the Department of Marine Policy at the Ministry of Land, Transport and Maritime Affairs (MLTM) providing administrative support for Ocean Expo-2012 which will be held in Yeosu, Korea. Besides her passion for marine conservation, Jeongim loves bicycling along the Yangjae and Han riverside, which has beautiful scenery and convenient bike-only lanes, and spending spare time in coffee shops, reading books. We look forward to Jeongim's involvement in PICES activities.

The State of the Bering Sea in 2010

by Skip McKinnell

Sea surface temperature

Since 1981, the dominant component of sea surface temperature (SST) variation within the Bering Sea is pan-regional (all locations are positively correlated with the dominant EOF (empirical orthogonal function). Hence, the leading EOF1 is somewhat of a Bering Sea thermometer (Fig. 1, left). While it accounts for 45% of the covariance, 19% is also associated with the subdominant EOF2, which has an interesting temporal pattern (Fig. 1, right). Since the fall of 2005, almost no positive values of EOF2 have occurred. The timing coincides with a shift to a colder eastern Bering Sea (Fig. 2) that appeared at the M2 mooring on the eastern Bering Sea shelf at the end of 2005.

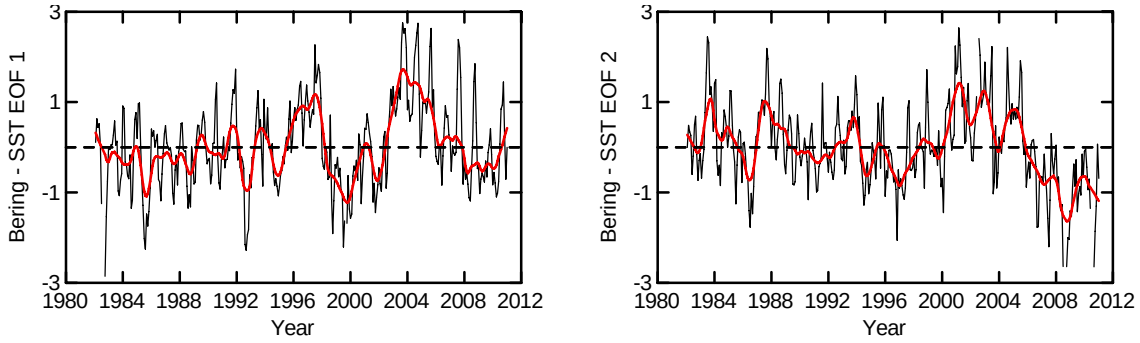


Fig. 1 EOF1 (46%) and EOF2 (19%) based on monthly average OIv2SST data for all grid points located within the Bering Sea, from January 1982 to December 2010.

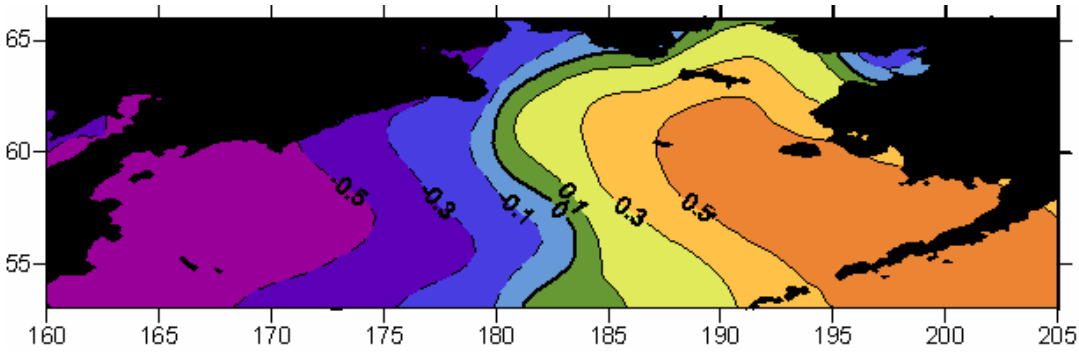


Fig. 2 Spatial pattern of the second empirical orthogonal function (EOF2) for Bering Sea SSTs. Negative (positive) values of EOF2 in Fig. 1 (right) are associated with cold (warm) surface temperature on the Alaskan side and the reverse on the Russian side.

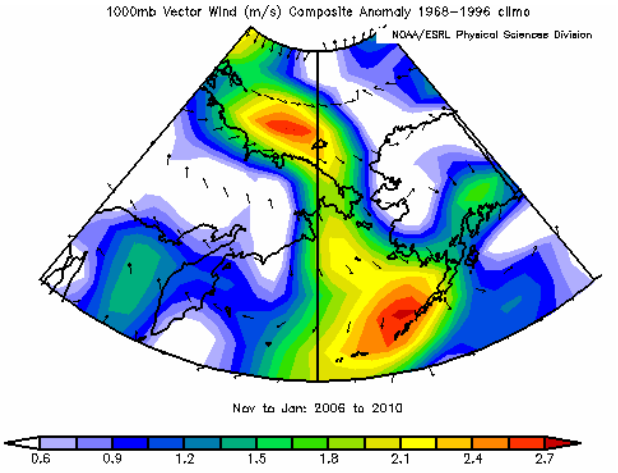


Fig. 3 Vector wind anomalies from the NCEP/NCAR re-analysis; November–January composites from 2006–2010.

At least some of the cold is related to the wind (Fig. 3). The SST-based EOF2 is significantly negatively correlated with sea level pressure (SLP) over the Bering Sea in each month from November to January. Positive SLP anomalies tend to coincide with negative EOF2 (East Cold West Warm – ECW^2 pattern), whereas negative SLP anomalies are associated with the opposite EW^{2}C pattern. Since the fall of 2005, EOF2 has been in a generally persistent ECW^2 pattern where anticyclonic atmospheric circulation (higher pressure) over the Bering Sea has cooled the Alaskan coast and warmed the Russian coast. Average November to January vector wind anomalies during 2006–2010 have been equatorward in the eastern Bering Sea, where the strongest anomalies can be found (Fig. 3). Weaker, but poleward wind anomalies occurred over Russia. SLP patterns indicate differences in winter as well (Fig. 4), with generally positive anomalies after 2005.

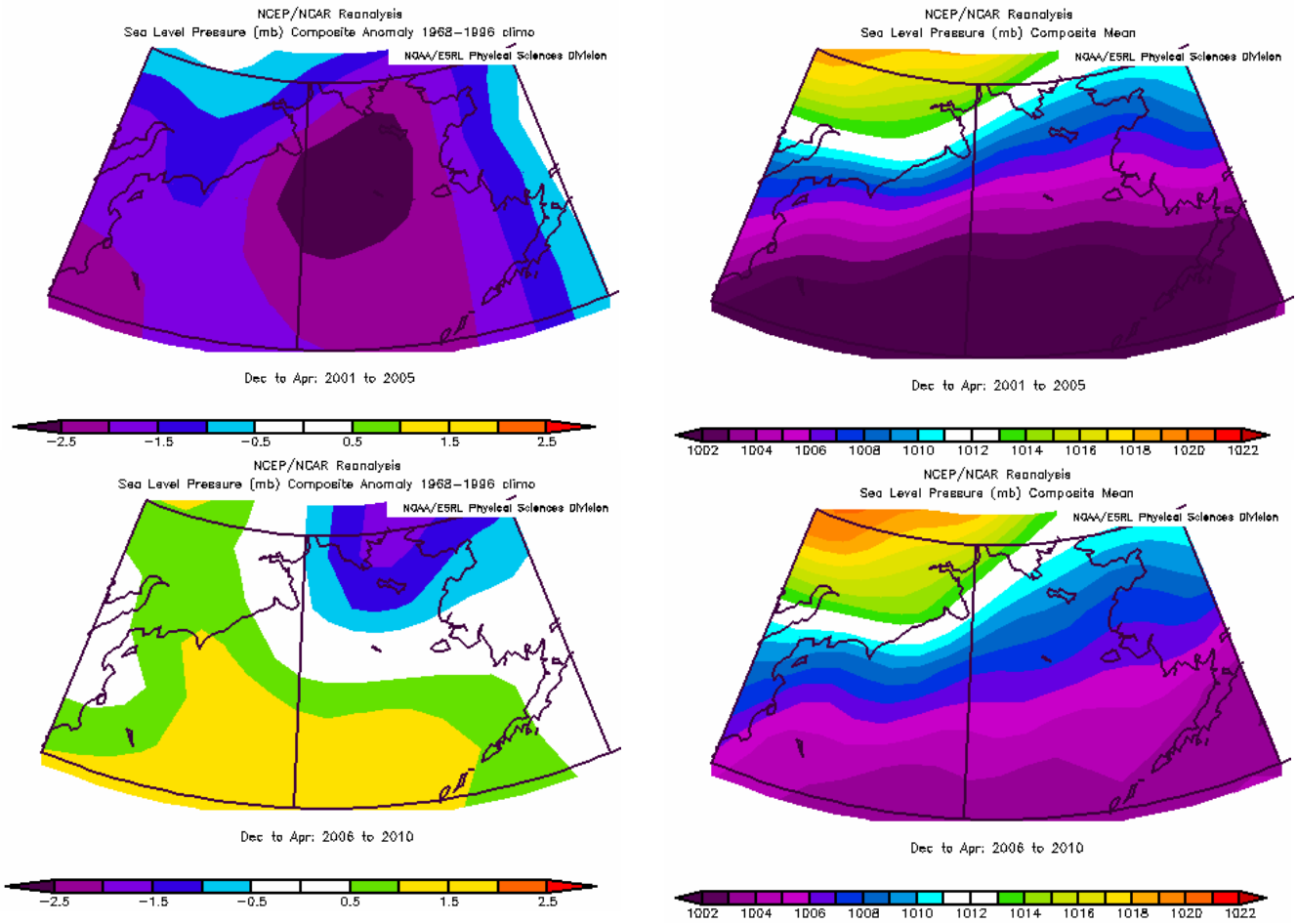


Fig. 4 Winter (DJFMA) sea level pressure anomalies (left) from 2001–2005 (upper) and from 2006–2010 (lower). Average winter (DJFMA) sea level pressures (right) for the same periods. Note the lighter shade of pale on the lower right panel compared to the upper.

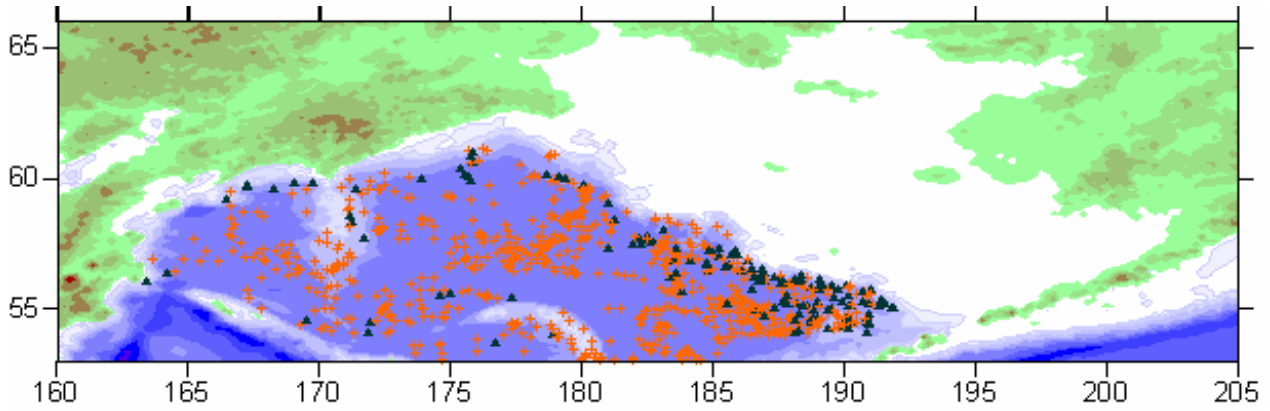


Fig 5 Locations of Argo profiles from January to April (2003–2010) indicating those deeper (orange) or shallower (black) than 100 m, when measured as the depth of the maximum rate of change in density. Mixed layers tend to be shallower around the perimeter of the Deep Basin in all winter months.

Project Argo in the Bering Sea Deep Basin

In January of 2010, there were 16 Argo floats in the Bering Sea Deep Basin going about their business of reporting pressures, temperatures and salinities. By the end of the year, there were 50% more Argo profiles recorded in the Basin than in the previous largest reporting year (2009). In the winter of 2010, each profile exhibited a classic winter pattern with a generally homogeneous water column from near-surface to depth, followed by an abrupt increase in density where the effect of winter winds and heat flux had yet to penetrate fully. Where this maximum rate of change in water density occurs is one potential indicator of the depth of the mixed layer.

Average Mixed Layer Depth (MLD) determined in this way indicates that the month of March is the time of deepest vertical mixing in the Deep Basin. There is a spatial pattern in MLD in the Deep Basin (Fig) that must be considered when developing a statistic for the entire Basin. After adjusting for location, it appears that average MLD in winter increased significantly in 2007 and this state of nature has persisted through 2010 (Fig. 6). Perhaps much of the deeper average MLD can be attributed to colder average winter air temperatures in the region as there is little evidence of higher average wind speed in these years.

As concentrations of nutrients that are important for biological productivity tend to increase rapidly with depth just below the mixed layer in the Deep Basin (Shiomoto 1999), it is reasonable to assume that increasing the MLD will increase the average pre-bloom nutrient concentrations and set the stage for greater production. It was rather disappointing to have sought out evidence of this in the average May chlorophyll (remotely sensed) in the Deep Basin, only to find that it was lower in 2007 and 2008 than in winters from 2003 to 2006 (Hunt *et al*. 2010). Perchance it was hidden in the sub-surface.

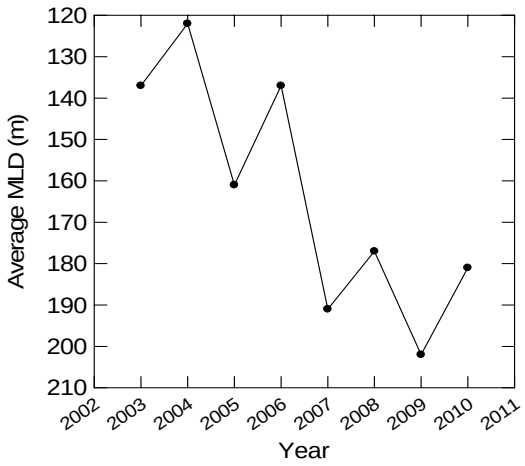


Fig. 1 March average mixed layer depth (m) determined from maximum rate of change in density with depth in the Deep Basin, 2003–2010. From data made available by Project Argo.

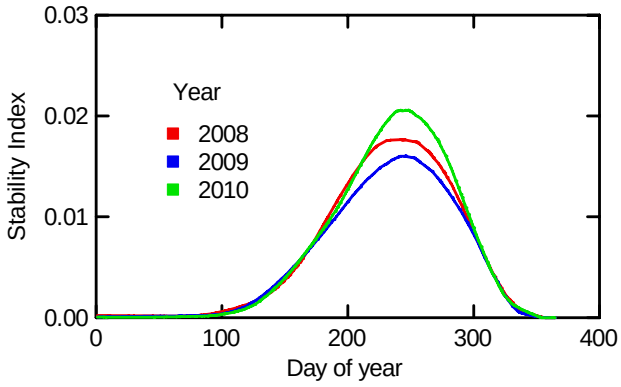


Fig. 2 Smoothed water column stability index for the Deep Basin of the Bering Sea for 2008-2010. From data made available by Project Argo.

The stability of a water column (resistance to vertical mixing) is an important factor affecting productivity in the Deep Basin of the Bering Sea. Overall, there appears to be variation in the degree of stability achieved in summer (Fig. 7). While exploring her idea about an optimal stability window, Gargett (2001) developed an index of water column stability for the west coast of Vancouver Island based on the average density difference between the surface layer and a deeper layer (60–80 m). Applying this index to the Deep Basin, only for years with greater numbers of profiles, indicates that water column stability tended to be higher in 2010 and lower in 2009, with 2008 being somewhat intermediate (Fig. 7).

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Dr. Skip McKinnell (mckinnell@pices.int) is the Deputy Executive Secretary of the North Pacific Marine Science Organization. He looks forward to Dr. Jeff Napp's return as a regular contributor of the Bering Sea article.

The State of the Northeast Pacific in 2010

by William Crawford and Marie Robert

El Niño–Southern Oscillation (ENSO) weather patterns have dominated the Northeast Pacific Ocean for the past few years. From 2008 to early 2009, temperature anomalies were typical of La Niña, coinciding with La Niña sea surface temperature (SST) anomalies on the Pacific Equator. Although the Tropical Pacific switched to a full El Niño by mid-2009, it was not until early 2010 that the temperature anomalies in the Northeast Pacific took on the pattern of an El Niño winter, as shown in the SST anomalies in March 2010 (Fig. 1a). By summer 2010, SST in the Tropical Pacific Ocean had reverted to La Niña conditions, characterized by the negative SST anomalies on the Pacific Equator in July–September (Fig. 1b). La Niña strengthened in the Tropical Pacific through the remainder of 2010, ending the year with very negative temperature anomalies on the Equator in December 2010 (Fig 1c).

In typical La Niña winters in the Northeast Pacific Ocean, the SST anomalies along the coast continue to fall more into negative numbers from December to March. The SST anomaly pattern of March 2008, the most recent full La Niña winter, is shown in Figure 1d. Although each ENSO brings somewhat different weather and SST patterns, we might expect the SST anomalies of March 2011 to resemble the pattern of March 2008 (Fig. 1d) if this 2010–2011 La Niña follows tradition.

SST anomalies for March of 2008 and 2010 reveal typical ENSO features on the Equator and also in the Northeast Pacific Ocean, as illustrated in Figure 1:

1. Warm water on the Equator in El Niño (Fig. 1a), cool in La Niña (Fig. 1d). An anomaly of more than 0.5°C for most of a year is a necessary condition for an event to be labelled El Niño, with positive anomalies in El Niño and negative in La Niña.
2. Warm water along the west coast of North America in El Niño winters (Fig. 1a), cool in La Niña (Fig. 1d). Both northward propagating coastal trapped waves and

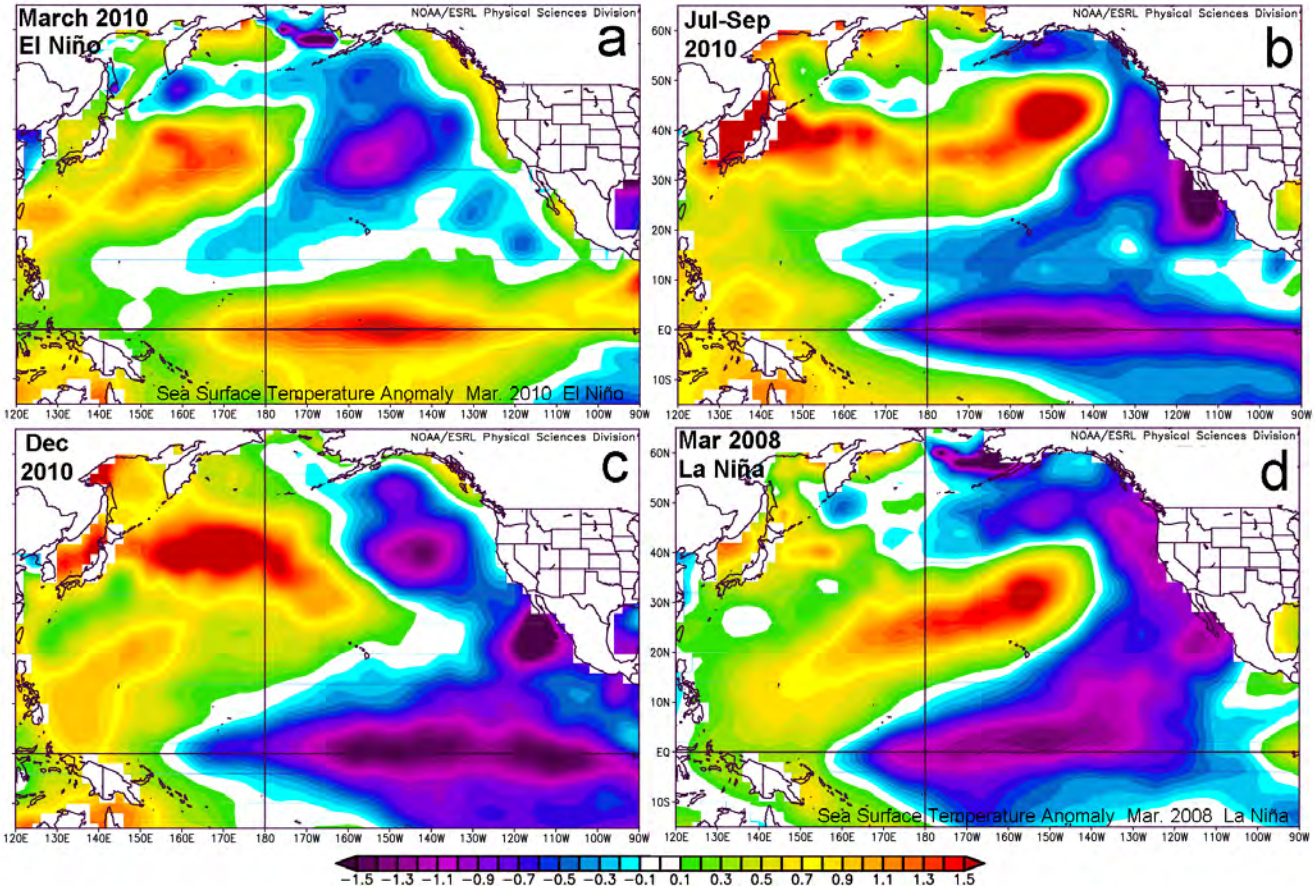


Fig. 1 Average sea surface temperature (SST) anomalies of the Pacific Ocean over the months of March 2010 (a), July–September 2010 (b), December 2010 (c), and March 2008 (d). Colour contours are based on NOAA Extended SST anomalies. Colour scale is in °C, at intervals of 0.1°C, as indicated in the scale bar at bottom. These images were prepared by on-line data display software of NOAA. Readers can create their own contour maps by accessing this Internet site: http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl.

stronger downwelling winds along this coast contribute to the warming during El Niño, with downwelling winds generally dominating north of San Francisco, California. Downwelling winds are much weaker from Oregon to Alaska and upwelling winds can increase off southern California during La Niña. The warm-water band along the west coast of North America in March 2010 was smaller than typical for El Niño winters, perhaps due to the relatively late arrival of southerly winds in this ENSO event.

3. Cool water near 150°W to 170°W and 30°N to 40°N during El Niño (Fig. 1a), generally due to positive wind vorticity in and south of the Aleutian Low. The Aleutian Low increased in strength and expanded to the south in each of the previous six El Niño winters in the Northern Hemisphere. With La Niña (Fig 1d), the Aleutian Low moves northward, and the North Pacific High strengthens and expands, bringing divergent surface currents and relatively cool surface temperatures to this deep-sea region.

The shift from El Niño to La Niña conditions along the continental margin of the Northeast Pacific was captured by water property measurements of the Line P Program. This program measures ocean properties in the Northeast Pacific three times per year along the track shown in Figure 2. Most funding for this program is provided by the Canadian Department of Fisheries and Oceans, with partners at universities in Canada and the United States, and support for ocean moorings from NOAA.

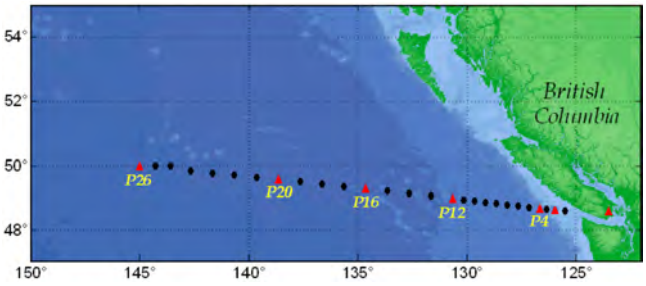


Fig. 2 Stations sampled by the Line P Program in winter, spring and summer every year. Red symbols denote stations with intensive chemical and biological sampling. P26 is also known as Ocean Station Papa.

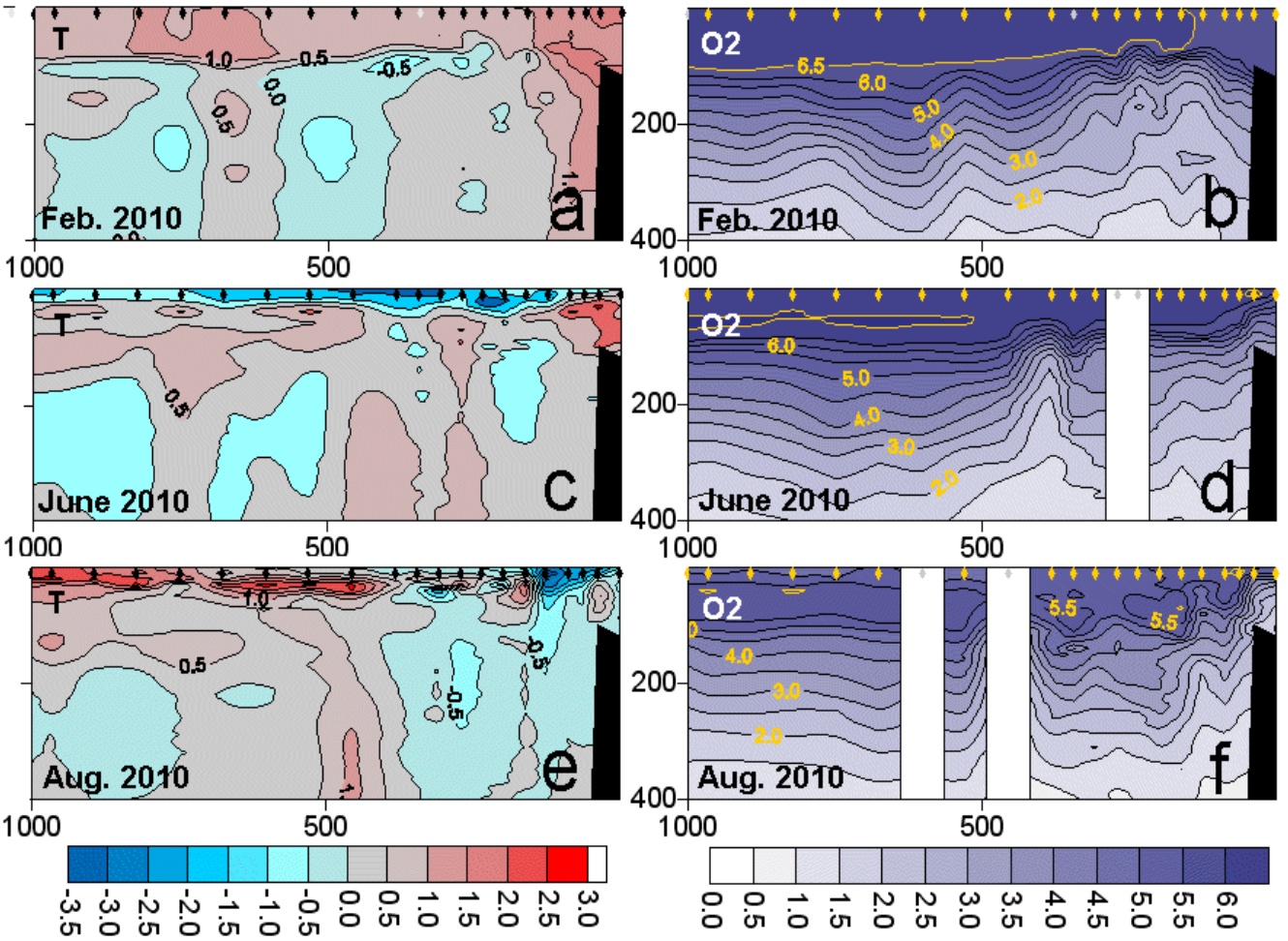


Fig. 3 Contour plots of temperature anomalies (left, °C) and oxygen concentrations (right, ml/L) along the eastern end of Line P in February (a, b), June (c, d) and August (e, f) 2010. The continental shelf of Vancouver Island is at right of each panel.

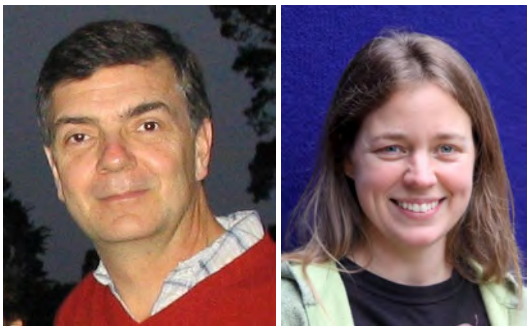
A characteristic feature of El Niño winters in the Northeast Pacific Ocean is a much more intense Aleutian Low Pressure System, and the 2009–2010 El Niño winter saw exceptionally low pressure and severe storms. The February 2010 Line P cruise encountered too many storms and was unable to reach Ocean Station Papa. These storms were so intense that the average air pressure in January to February 2010 at 46°N, 143°W was 13 millibars below normal, the lowest since the massive El Niño of 1982–1983.

In Figure 3, we present the temperature anomalies and oxygen concentrations of 2010 along the eastern-most 1000 km of Line P to show how shifting wind patterns changed water properties during this year. The Line P stations begin near shore, where stronger southerly winds of the El Niño winter storms brought warmer surface waters in early 2010. Ekman downwelling caused these warm waters to penetrate and mix to the bottom of the continental shelf in March 2010 (Fig. 3a). This coastal warming during El Niño winters normally extends far into the Northeast Pacific, generally west of P26, so the continuous layer of anomalously warm surface water all across Figure 1a was expected.

Although these surface waters were anomalously warm, they carried more oxygen than the deeper waters they displaced on the continental shelf. The oxygen contours in February 2010 sloped downward on the continental margin, as surface waters mixed and downwelled to the bottom (Fig. 3b). Such downwelling was not observed in the previous two winters, and oxygen concentrations in bottom water on the shelf were lower than in March 2010. By June 2010 as upwelling winds arrived, the positive SST anomalies (Fig 3c) and lower oxygen waters (Fig. 3d) advected onto the bottom of the continental shelf. The upwelling winds along Vancouver Island were stronger than normal in July–September 2010, perhaps due to La Niña conditions.

By August 2010, the Line P cruise encountered negative SST anomalies on the continental shelf and out to 400 km from shore, with only a trace of positive temperature anomalies at mid-depth (Fig 3e). This surface cooling might be attributed to stronger upwelling winds here in this summer. The oxygen concentrations (Fig. 3f) declined from those measured in June, as is normal for this region, but did not fall to the very low levels of August 2009, perhaps due to the strong aeration during the previous winter. The oxygen concentration in August 2010 was about 1.0 ml/L near bottom in mid-shelf in 150 m of water, which is typical for summer, but higher than in the late summers of 2006 and 2009. In these two years the near-bottom oxygen concentration dropped to 0.7 ml/L on the southern Vancouver Island shelf, and even lower along Oregon and Washington.

We have associated ENSO cycles with changes in SST and sub-surface oxygen concentrations of the Northeast Pacific from 2008 to 2010. Changes in SST can also be associated with the Pacific Decadal Oscillation (PDO) and the North Pacific Gyre Oscillation (NPGO), and in previous decades these modes of climate variability have been useful, or even needed, to account for the many patterns of SST variability. However, since 1998 the PDO and ENSO patterns have generally aligned in a way to support each other in their impact of SST in the Northeast Pacific, with the result that qualitative predictions of SST anomalies based only on ENSO (and in some regions only on PDO) have been relatively reliable. Given the surprises in climate variability in the past, we do not expect this alignment to continue.



Dr. William (Bill) Crawford (bill.crawford@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences in Sidney, British Columbia. He is co-editor of Canada's annual State of the Pacific Ocean Report and serves as president of the Canadian Meteorological and Oceanographic Society.

Marie Robert (marie.robert@dfo-mpo.gc.ca), also with the Institute of Ocean Sciences of Fisheries and Oceans Canada, co-ordinates the Line P program. She leads each of the three cruises per year, and in between these cruises she coordinates products and future research of this program. Line P received the PICES Ocean Monitoring Service Award (POMA) in October 2010.

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