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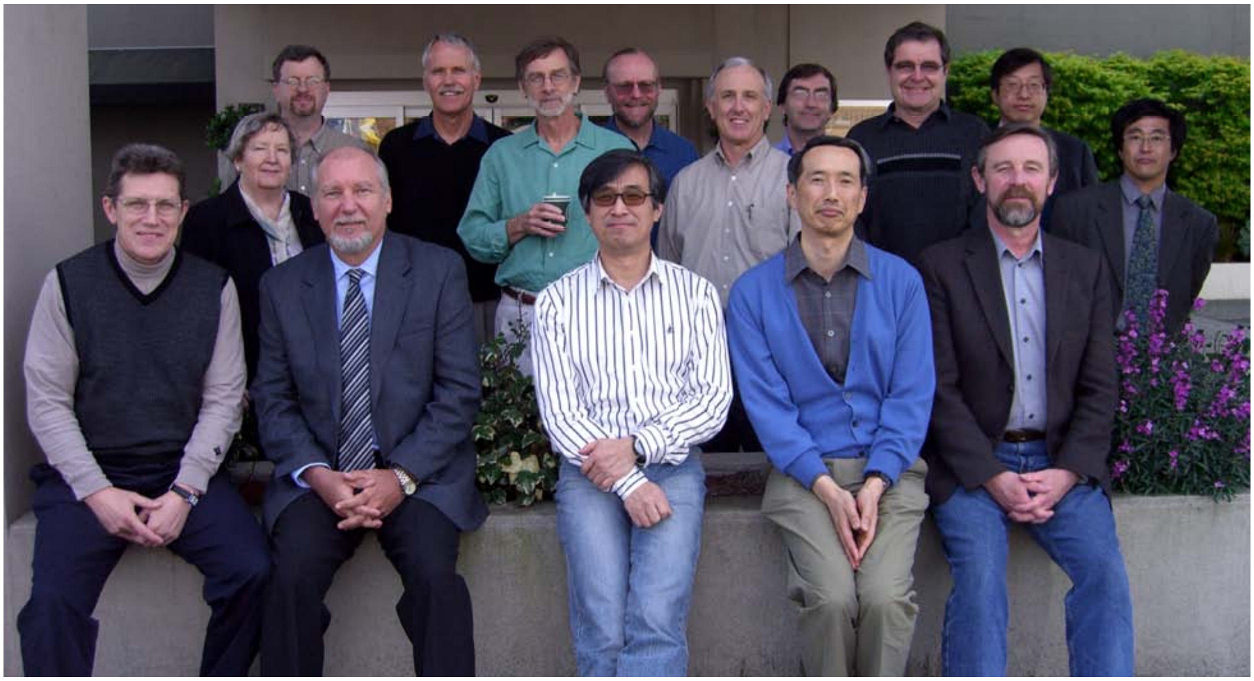
The 2008 Inter-Sessional Science Board Meeting

The PICES Science Board met for one day on April 25, 2008, in Seattle, U.S.A., following a 2-day workshop to develop an Implementation Plan for a new PICES scientific program on "*Forecasting and Understanding **T**rends, **U**ncertainty and **R**esponses of North Pacific **E**cosystems*" (FUTURE). The major agenda items were to review mid-term activities of the Scientific and Technical Committees, status of preparation for the 2008 Annual Meeting in Dalian, China, and other business, including discussion of the outcomes and follow-up actions from the FUTURE Implementation Plan workshop. Within this issue of PICES Press is a summary of the workshop results. I hope you will take time to read this article because it provides a report on the status of the formation of the Implementation Plan Writing Team and its membership, highlights the approach to developing the Implementation Plan and the timeline for completing the plan and starting FUTURE.

We welcomed Drs. Bernard Megrey, Chairman of the Technical Committee on Data Exchange (TCODE), and Hiroya Sugisaki, Chairman of the Technical Committee on Monitoring (MONITOR), to their first inter-sessional Science Board gathering. These two Committees had responsibilities to evaluate nominations for the first PICES Ocean Monitoring Service Award (POMA), a new annual award to be given in recognition of contributions to the progress of marine science in the North Pacific through long-term ocean monitoring and data management of various ocean conditions and marine resources. Since this was the first time we had solicited candidates for this award, we took some time to review the process and make some relatively minor changes in the award description to clarify the steps and responsibilities of TCODE and MONITOR. In addition to the first recipient of the POMA award, Science Board also selected the next recipient of the Wooster Award. Both award recipients will be announced and presented at the Opening Session of the PICES Annual Meeting in Dalian.

Some highlights from the Committees are as follows. Changes to the Terms of Reference for the Section on *Carbon and Climate* (under the Physical Oceanography and Climate (POC) and Biological Oceanography (BIO) Committees) were approved. The details of the revisions can be found at http://www.pices.int/members/default.aspx. Science Board also endorsed a request from POC for PICES to support the publication of a collection of papers on "*Tides in Marginal Seas*" as a special issue of a primary journal in memory of the Russian physical oceanographer, Professor Alexei Nekrasov, who passed away recently. The Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (under the Marine Environmental Quality (MEQ) Committee) proposed to establish a Task Team in FUTURE entitled



Participants at the 2008 inter-sessional Science Board meeting (April 25, 2008, Seattle, U.S.A.). Seated (left to right): Igor Shevchenko, Bernard Megrey, Sinjae Yoo, Michio Kishi, Skip M[c]Kinnell; standing (left to right): Vera Alexander, Harold Batchelder, Michael Foreman, Michael Dagg, Gordon Kruse, John Stein, Alexander Bychkov, Glen Jamieson, Tokio Wada, Hiroya Sugisaki.

"***P****ICES* ***U****nderstanding,* ***L****inking and* ***S****ynthesis of* ***E****cosystems*" (PULSE), whose emphasis will be on developing a more integrative, science-based ecosystem-scale understanding of the human dimension in FUTURE. This Task Team will be a good place to engage social scientists. Science Board agreed to pass on the proposal to the FUTURE Writing Team.

Each year, Science Board reviews its high priority activities. While implementing FUTURE is currently the highest priority, developing the North Pacific ecosystem status report, capacity building and international exchange also feature prominently. Science Board continued to discuss the best approach for preparing the next ecosystem status report. All agreed that this is a key product of PICES, and dedicated attention is needed to oversee its development. The job is time-consuming and takes significant resources to accomplish. Science Board is committed to this important effort but it will involve some additional fund-raising. On a more positive note, at our last Annual Meeting, Science Board recommended that PICES Deputy Executive Secretary, Dr. Skip McKinnell, lead the effort to develop the next version of the report. He will begin to contact regional experts to participate as lead authors.

A central role for PICES is the coordination of science activities. In that regard, our collaboration with other relevant organizations and programs is important. We have successful interactions with several organizations and are always looking to where other fruitful contacts are possible. One such organization is the Northwest Pacific Action Plan (NOWPAP). Dr. Sinjae Yoo, Vice-Chairman of Science Board, recommended that it would be mutually beneficial for PICES and NOWPAP to become more involved with each other's activities, especially in the development of FUTURE. Science Board supported the recommendation to send an expert on eutrophication to a Yellow Sea Large Marine Ecosystem (YSLME)-NOWPAP workshop on that topic to be held in Senyang, China, in June 2008. In addition, ICES and PICES continue to work together and are organizing a symposium on "*Rebuilding depleted fish stocks – Biology, ecology, social science and management strategies*" in Warnemünde/Rostock, Germany, from November 2–5, 2009. Science Board agreed that Dr. Gordon Kruse, Chairman of the Fishery Science Committee should serve as a PICES co-convenor of the symposium, and that the Organization should consider supporting either a PICES member of the Scientific Steering Committee (preferably from Asia) or a plenary speaker from the Pacific to attend.

In closing, the week of April 21, 2008, was a busy and productive week for PICES. We discussed the approach to developing the Implementation Plan for FUTURE and established a Writing Team to implement this task. We also reviewed mid-term progress and many aspects of the day-to-day business of our Organization. It was an excellent opportunity to come together, and we took full advantage of it to complete some work that will be central to important activities at our Annual Meeting. I look forward to seeing my PICES colleagues in Dalian, China.

John Stein
PICES Science Board Chairman
E-mail: John.E.Stein@noaa.gov

FUTURE – From Science Plan to Implementation Plan

By John E. Stein

At the PICES Sixteenth Annual Meeting (October 2007, Victoria, Canada), Governing Council had provisionally approved the Science Plan for a new PICES integrative scientific program on "***F****orecasting and* ***U****nderstanding* ***T****rends,* ***U****ncertainty and* ***R****esponses of North Pacific* ***E****cosystems*" (FUTURE). In mid-February 2008, the final version of the Science Plan was widely circulated and posted on the PICES website. The next step in developing the program was taken at a FUTURE Implementation Plan workshop held April 23–24, 2008, in Seattle, U.S.A. The goals of the workshop were to discuss: the organizing principles for implementing FUTURE, the framework for an organizational structure, potential membership and co-chairmanship for the Implementation Plan Writing Team (IP-WT), and a timeline for developing the plan. Attendees of the workshop included practically all members of our Study Group on *Future Integrative Scientific Program(s)* (SG-FISP), Science Plan Writing Team (SP-WT) and Science Board, and several invitees. Some Governing Council members participated in the workshop, which was valuable to the deliberations.

On the first day, major elements of the agenda were: a review of the ICES Science Plan since ICES is our sister organization on marine issues, presentations on major expectations for forecasts, the human dimension, and communication of science products from FUTURE. Each country gave a presentation on current national programs and programs under planning that are relevant to FUTURE. On the second day, we discussed the charge to be given to the IP-WT and delved into establishing the potential membership and co-chairmanship of this team.

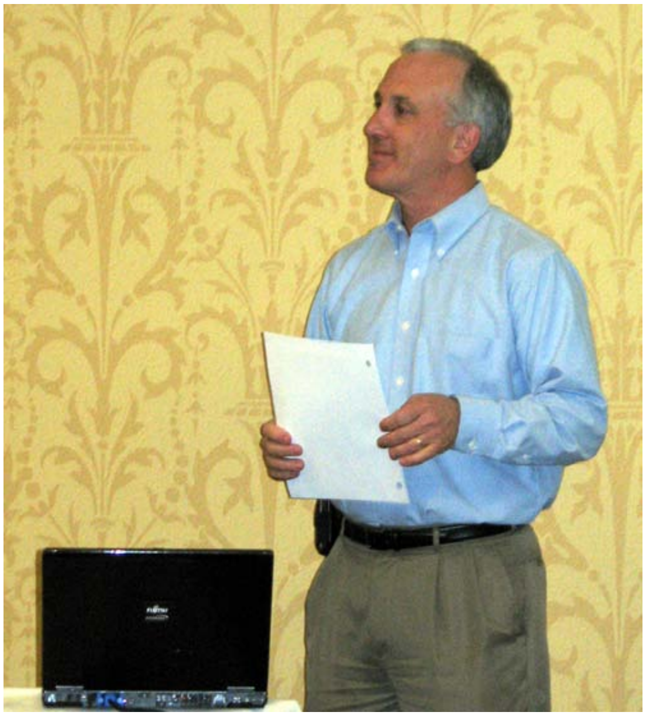
FUTURE Implementation Plan workshop in session (April 23, 2008, Seattle, U.S.A.).

Consensus was reached on the following. The Implementation Plan must clearly identify what we need to understand, forecast and communicate, and will use a matrix of key questions versus expected products. This will provide a starting point for describing a pathway for answering the key questions and sub-questions and producing key products. Task Teams under FUTURE should be product-oriented and facilitate coordination among national and international programs. The IP-WT will identify a provisional set of Task Teams and propose terms of reference for each of them. A Scientific Steering Committee (SSC) for FUTURE will be established with the role and responsibilities to oversee tasks, work plans and products, and they may refine the Task Team structure if needed as the Program develops and evolves. The organizational structure of FUTURE will link to national projects and PICES Committees. The latter point was an area of broad agreement, because it is important that all committees are fully engaged with this major science effort to help insure that all of the scientific capabilities within the Organization are contributing. As such, a major task of the SSC will be to insure effective communication with relevant international and national programs and with the Committees of PICES. The membership of the SSC will have national and Committee representation to help meet this objective.

Some of the key initial products for the IP-WT to consider are: coordinated monitoring, risk assessments (*e.g.*, management strategy evaluations), improved understanding (biological response to climate forcing at various time scales), operational forecasts (nowcasts to 20- to 30-year projection of biological response to change), regional assessments of topical issues (*e.g.*, mariculture, HABs, *etc.*), IPCC-type reports of North Pacific ecosystems (including summary reports that are policy relevant), capacity building (*e.g.*, social science), and public awareness of ecosystem change in the North Pacific. As I mentioned, this is an initial list that may be revised by either the IP-WT or the SSC of FUTURE.

Finally, a timeline for completing the Implementation Plan, leaving time for comments and review by the PICES community, was discussed. The following is a list of the anticipated steps that will allow for a first meeting of the FUTURE SSC in April 2009. The IP-WT will work by correspondence to develop a first draft of the Implementation Plan by September 2008. It will be posted on the PICES website and reviewed by the SG-FISP, Science Board and Governing Council. You may recall that we are convening a Science Board Symposium entitled "*Beyond observations to achieving understanding and forecasting in a changing North Pacific: Forward to the FUTURE*" at PICES XVII in Dalian, China, as part of the implementation of FUTURE. An Open Forum will be also held there to provide the PICES scientific community an opportunity to express views on the draft Implementation Plan. The draft Plan, together with comments from the Open Forum and Science Board will be considered by Governing Council in the hope of obtaining provisional approval at the Annual Meeting. Following the Annual Meeting, the Implementation Plan will be revised and submitted for final approval to Governing Council in February–March 2009. This should permit a first meeting of the SSC of FUTURE in April 2009.

As in all cases, the quality of the products from PICES depends on the willingness of scientists to take on key assignments, and to put in the extra time to complete the work, a list of potential members and Co-Chairmen for the IP-WT was prepared and circulated to Council. The IP-WT was established in May, and all PICES member countries appointed their experts to serve on the team and supported Drs. James Overland (U.S.A.) and Hiroaki Saito (Japan) as IP-WT Co-Chairmen. The other members of the IP-WT are: Michael Foreman and Jake Rice (Canada); Xianshi Jin, Fangli Qiao, Sun Song, and Mingyuan Zhu (China); Masahide Kaeriyama, Orio Yamamura, and Ichiro Yasuda (Japan); Jung-Hwa Choi, Se-Jong, Ju Joon-Yong Yang, and Sinjae Yoo (Korea); Oleg Katugin and Vyacheslav Lobanov (Russia); and David Fluharty, Anne Hollowed, and Nathan Mantua (U.S.A.). In addition, Julie Kiester (U.S.A.) will currently serve on the IP-WT as an *ex-officio* member.



Dr. John Stein, PICES Science Board Chairman and Deputy-Director of the Northwest Fisheries Science Center in Seattle, U.S.A., chaired the workshop to its fulfilling conclusion.

In closing, I am more convinced than ever that FUTURE is coming at the right time. There is broad interest for the scientific community to provide improved outlooks and forecasts of the status and trends in ecosystem conditions, and in my view this interest has increased considerably very recently. Events ranging from natural disasters to speculation that the effects of climate change are evident in the collapses of fisheries have heightened the interest. In my own region, the closure of a major segment of the salmon fishery on the west coast of the United States has decision makers, managers and the public asking for improved projections of what the future may hold. I think the science and PICES are at a point where we can begin to provide information that is relevant to this demand. We have a receptive audience and now it is up to us to synthesize what we already know, increase our understanding in several key areas, and step forward and present an outlook of what we see as the likely status and trends in ecosystem conditions. The FUTURE is here.

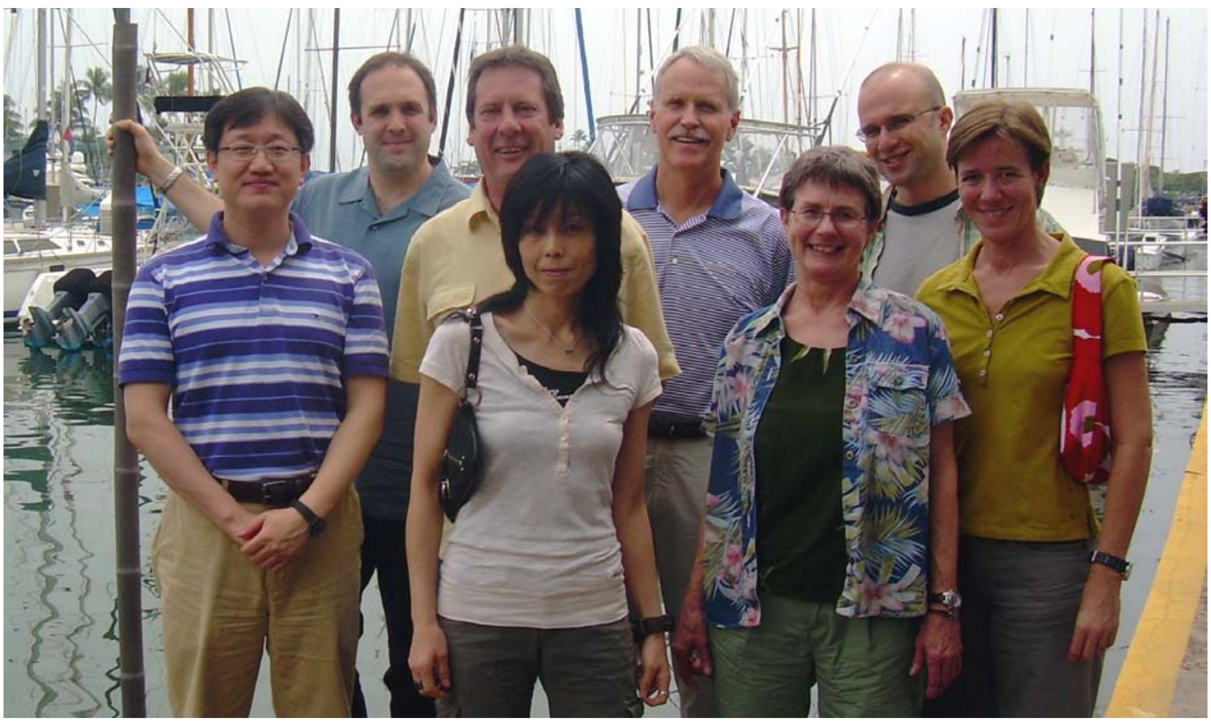
CFAME Task Team Workshop – Linking and Visualising

by Kerim Aydin

An inter-sessional workshop of PICES CFAME (Climate Forcing and Marine Ecosystem Response) Task Team on "*Linking and visualizing climate-forcing mechanisms and marine ecosystem changes: A comparative approach*" was held on April 15–17, 2008, in Honolulu, U.S.A. The workshop brought together three ecosystem comparison teams which have been working together since May 2007 on the California Current (CC), the Kuroshio/Oyashio (K/O), and the East China/Yellow Seas (ECS/YS). Prior to the workshop, team leaders who were responsible for developing ecosystem mechanism tables (Vera Agostini for CC, Akihiko Yatsu for K/O, and Young-Shil Kang for ECS/YS) coordinated a review of the details of these tables and provided explicit descriptions of ecological processes and their relation to climate. This information was given to graduate students working with Brenda Norcross, who produced summary drafts and figures documenting the projected changes in ecosystem components based on future scenarios forecasted by IPCC climate scenarios for the three selected ecosystems. Drafts of the results were completed in January 2008 and circulated prior to the workshop.

At the workshop, CFAME members and invited guests reviewed draft versions of the graphic representations of ecosystem mechanisms relating to climate/ocean scenarios. Michael Foreman, Co-Chairman of PICES WG 20 on *Evaluations of Climate Change Projections*, provided immediate feedback as to the accuracy of the physical model results which drive our biological predictions. Each ecosystem team then worked to revise text and figures during the meeting and to finalize graphic representations of our knowledge of the physical processes affecting species' population dynamics. One figure for each of the three regions was prepared, showing likely impacts under climate warming.

After successfully completing this review, a schedule was established for final scientific publications. These include: a PICES Scientific Report and peer-reviewed manuscripts describing the past two years of CFAME work. The intention is to distribute the results widely as a contribution to forecasting future ecosystem states. The goal is to submit the PICES Scientific Report and an accompanying summary manuscript to a high-profile peer-reviewed journal immediately prior to the Seventeenth Annual Meeting of PICES in October, 2008. Three further manuscripts, one for each ecosystem, will be submitted to journals in late 2008 or early 2009. A critical requirement for meeting this goal is funding from PICES for a graphic artist to transform the CFAME figures into a unified set of images that provide both scientific explanation and communication with the public.



Participants of the 2008 inter-sessional CFAME workshop (April 15–17, 2008, Honolulu, U.S.A.). From left to right: Jae Bong Lee, Kerim Aydin, Sandy McFarlane, Sanae Chiba, Michael Foreman, Brenda Norcross, Christopher Harvey and Vera Agostini. Kerim Aydin (Kerim.Aydin@noaa.gov), the author of this article, is a Research Scientist with NOAA's Alaska Fisheries Science Center and Co-Chairman of CFAME.

PICES WG 21 Meets in Busan, Korea: The Database Meeting

by Thomas Thierrault

Non-indigenous species are a global concern because they are detrimental to native biodiversity and compromise ecosystem function. To better understand non-indigenous species in the North Pacific (and beyond), PICES established a Working Group (WG 21) on *Non-indigenous Aquatic Species* that had its inaugural meeting at PICES XV in October 2006, in Yokohama, Japan. In April 2007, the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Research Agency (FRA) of Japan, provided a voluntary contribution to PICES for a project entitled "*Development of the prevention systems for harmful organisms' expansion in the Pacific Rim*". This project is anticipated to run for five years (from April 1, 2007 to March 31, 2012), and has two distinct components: one on harmful algal blooms (HABs) and the other on marine non-indigenous species (MNIS). The intent of the funding is to develop international systems to collect, exchange and store relevant data, and to foster partnerships with non-PICES member countries and related international organizations, such as the International Council for the Exploration of the Sea (ICES). The contribution is from the Official Development Assistance (ODA) fund and thus, involvement of developing Pacific Rim countries is required in activities under this project. The project is conducted by two PICES expert groups under the Marine Environmental Quality Committee: Section on *Ecology of Harmful Algal Blooms in the North Pacific* (HAB Section) and WG 21. Each group oversees a specific sub-project. Within the non-indigenous species envelope, two specific initiatives have been identified. The first is the development of a comprehensive MNIS database, with Dr. Henry Lee II (U.S. Environment and Protection Agency) serving as the Principal Investigator. The second is a taxonomy initiative that includes rapid assessment surveys and associated collector surveys in PICES member countries, with Dr. Thomas Therriault (Fisheries and Oceans Canada) serving as the Principal Investigator.

Working Group 21, under the co-chairmanship of Ms. Darlene Smith (Canada) and Vasily Radashevsky (Russia) have focused recent efforts on the database initiative. Following initial discussions held at a joint meeting of PICES WG 21, ICES Working Group on *Introductions and Transfers of Marine Organisms* and ICES/IOC/IMO Working Group on *Ballast Waters and Other Ship Vectors* (May 25–26, 2007, in Cambridge, U.S.A., in conjunction with the 5th Conference on "*Marine Bioinvasions*"), a prototype MNIS database was developed by Dr. Henry Lee and Ms. Deborah Reusser based on the U.S. Environment and Protection Agency and the U.S. Geological Survey "Pacific Coast Ecosystem Information System" (PCEIS) spatial database. At a meeting of WG 21 convened during PICES XVI (October 26–27, 2007, in Victoria, Canada), it became evident that a subsequent meeting was required to beta-test the MNIS database and to develop standardized protocols. Dr. Yoon Lee (National Fisheries Research and Development Institute (NFRDI), Korea) graciously volunteered to host an inter-sessional meeting from March 3–5, 2008, at his institute in Busan. The purpose of the meeting was to reach an agreement on standards, data elements and data entry templates for the MNIS database that will be used to capture information on non-native species and allow sharing of this information, not only among PICES member countries, but more broadly with any community studying non-indigenous species. Species continue to be transported with increasing frequency to

Participants of the inter-sessional WG 21 database meeting (March 3–5, 2008, Busan, Korea).

new environments around the world, primarily *via* activities associated with international trade and commerce (*e.g.*, ballast waters, hull fouling, aquaculture, *etc*.), and once there, some impact ecosystem productivity and function, including local fisheries. Thus, it is critical to understand the distributions of these species in newly-invaded environments as well as in their native environments. This information is essential for undertaking risk assessments and will be a valuable tool to identify, and potentially mitigate, a variety of vectors and pathways.

Day 1 of the Busan meeting started with a round of introductions and opening remarks from our hosts. After reviewing the agenda and expected outcomes from this inter-sessional meeting, the participants quickly immersed themselves in the world of database structure and function. One of the initial discussions was on what scale the database should be developed and subsequently populated. Existing data on non-native species in PICES member countries has been collected at various scales; whereas some studies included latitude/longitude information for each non-indigenous species, others have focused at much larger spatial scales (*e.g.*, embayments or basins). It was decided that for our purpose of understanding non-indigenous species patterns in the North Pacific, it would be most informative if we worked at a fairly large spatial scale (although the database will allow input at much smaller spatial scales, thereby meeting the needs of all member countries while ensuring seamless merging of country databases for joint, large-scale analyses). After a quick review of existing papers on potential spatial scales for the database, we agreed to use the eco-regions identified in a recent paper by Spalding *et al*. (2007; *Bioscience* **57**: 573–582) that defined Marine Eco-regions of the World. The key benefit of this paper for marine non-indigenous species is that the eco-regions are defined for the globe and, given that any species has the potential to be moved anywhere around the globe, researchers can clearly identify the eco-regions to which the species is native and those for which it has invaded. Further, this will allow our MNIS database to be populated by other groups working on characterizing and documenting the distribution of marine non-indigenous species (*e.g.*, by ICES WGs).

Other issues discussed on the first day of the meeting centered on classification standards. When working on non-indigenous species, one needs to know that the species is not native to the ecosystem (eco-regions) where it has been identified. Several classification criteria were determined, including documentation within the database, in order to be able to classify a species as native or non-native. However, the participants did recognize that an increasing body of literature exists for a number of taxa, especially some of the more controversial ones, which suggests that for some species, we simply will not be able to resolve their invasion status, and these will need to be treated as cryptogenic (unknown origin). We also discussed how to identify if non-indigenous species have become established (self-sustaining population) compared to those that have not and represent "failed" introductions.

Graham Gillespie (Canada), Blake Feist (U.S.A.) and Evgeny Barabanshchikov (Russia) on an impromptu taxonomic survey at a Busan market.

Day 2 provided participants with some "alone time" with the database. After exploring the database by conducting hands-on data entry using our favorite non-indigenous species, we had a series of discussions on the pros and cons of including life history information for these species and on the level of detail that could be incorporated into the database. We also debated about who the end-users of the database likely would be and what their goals would be (*e.g.*, conducting risk assessments). By this point in the beta-testing it was very clear that with enough resources one could build the ultimate database that would include every potential bit of information a researcher could think of. However, it also became apparent that someone would need to serve as the gatekeeper for this database, and that databases do not simply remain error-free all by themselves. Thus, it was decided that, to the extent possible, we would include life history information into the database and that adequate documentation would need to be provided to implement this task. This is consistent with the necessity to add a citation for each species record in the database, thereby providing a mechanism to link an occurrence with a source for this information. After a visit to a local restaurant for lunch and a short stop at a local fish market, the group returned to NFRDI to continue their data entry quests. As expected, there were a number of minor issues identified and corrected with respect to the database itself, but considerable progress was made and the group was very satisfied with the beta-version. The key outstanding issue at the end of Day 2 was how to merge the individual country databases into a common database, or if the databases would be linked.

(*continued on page 15*)

ICES-PICES-IOC Symposium on Climate Change

by William T. Peterson

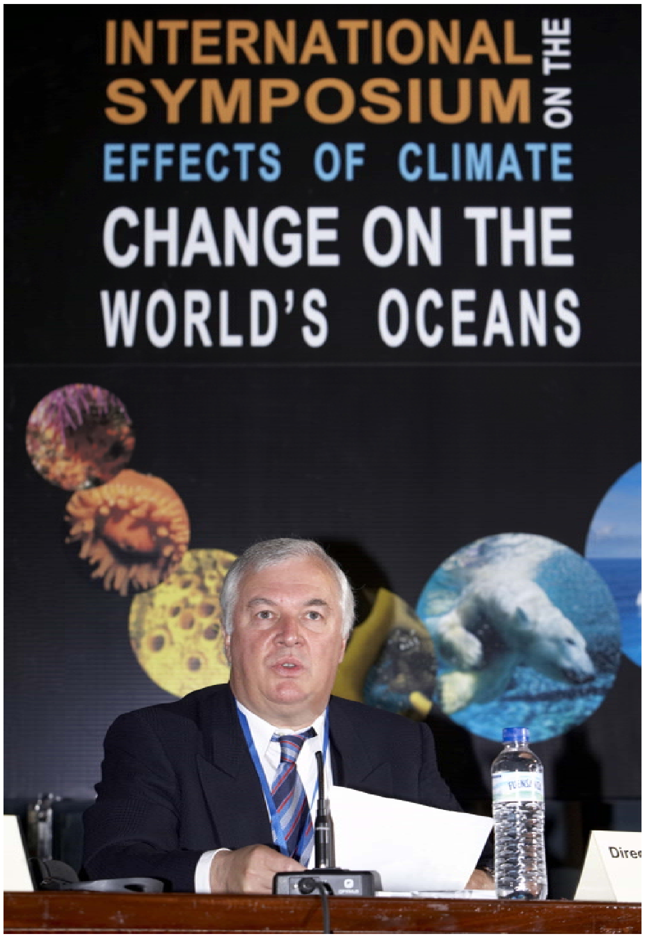
Thunderous applause ended the extraordinarily successful symposium on "*Effects of climate change on the world's oceans*", held from May 18–23, 2008, in northern Spain in the lovely seaside community of Gijón. With Dr. Luis Valdés saying "*I now declare this Symposium closed*", more than 2½ years of planning, fund-raising, and labouring over the scientific and logistical details resulted in the first international meeting to treat the broader issues of climate change and its effects on marine ecosystems and society. The objectives of the symposium were fulfilled. Views, ideas and data were exchanged by oceanographers from around the world to facilitate the development of new research directions and ideas.

The symposium was organized by the International Council for the Exploration of the Sea (ICES), North Pacific Marine Science Organization (PICES) and Intergovernmental Oceanographic Commission of UNESCO (IOC), and co-sponsored by the Global Ocean Ecosystem Dynamics (GLOBEC) project, Scientific Committee on Oceanic Research (SCOR), and the World Climate Research Programme (WCRP). Financial support was also provided by Fisheries and Oceans Canada, U.S. National Aeronautics and Space Administration, U.S. National Oceanic and Atmospheric Administration, Korea Ocean Research and Development Institute, and several Spanish sources (Asturias Science Plan 2006–2009, Ayuntamiento de Gijón, Port Authority of Gijón, and Sociedad Mixta de Turismo de Gijón). In addition to covering the costs of the facility and travel for plenary and invited speakers, these contributions enabled the participation of ~60 young scientists and scientists from countries with economies in transition. The local organization was responsibility of the Instituto Español de Oceanografía – Centro Oceanográfico de Gijón (IEO), and their staff worked together with members of the PICES Secretariat to ensure that all things progressed efficiently.

The primary sponsors were represented by three convenors: Luis Valdés, (ICES, Spain), William Peterson (PICES, U.S.A.) and John Church (IOC, Australia). The science was led by a Scientific Steering Committee (SSC) that included Richard Feely (U.S.A.), Michael Foreman (Canada), Roger Harris (UK), Ove Hoegh-Guldberg (Australia), Harald Leong (Norway), Liana McManus (U.S.A. and The Philippines), Jorge Sarmiento (U.S.A.) Martin Visbeck (Germany) and Akihiko Yatsu (Japan).

The full program of the symposium included 4 workshops and 5 topics divided into 10 Theme Sessions. The formal Opening Ceremony took place on Monday (May 19) morning and involved local political authorities and representatives of the primary international sponsors. Each day, a Plenary Session, with two 45-minutes talks, was held in the morning, followed by two parallel Theme Sessions. In addition to the scientific sessions, 3 full-day workshops were convened on Sunday (May 18), the day prior to the symposium; one more half-day workshop was organized on Wednesday (May 21). Posters were on display during the entire symposium, with all coffee breaks arranged in the poster area to maximize opportunities to see

Full attendance at the plenary session (first row, second from the right is Dr. John Church, former Chairman of the Joint Scientific Committee for the World Climate Research Programme and IOC convenor of the symposium).



Dr. Luis Valdés, ICES convenor of the symposium and local host.

Press conference featuring from left to right, Patricio Bernal (Executive Secretary of IOC), William Peterson (PICES convenor of the symposium) and Joe Horwood (President of ICES).

these contributions and to interact with the presenters. Two evening "Wine and Tapas" Poster Sessions (May 22 and May 24) were a highlight of the symposium, with high attendance and lively discussions. In total, 382 participants from 48 countries contributed 215 oral presentations (including 10 plenary and 20 invited talks) and 133 posters for this week-long event. Selected experts also had an opportunity to directly communicate their findings and thoughts on how climate change is affecting oceans and their ecosystems at daily press conferences with the regional and national media (press, radio and TV). In the evening of the first day, participants were invited to a Welcome Reception hosted by the Mayoress of Gijón at an old style restaurant (El Trole) in the suburbs of the city. Wednesday (May 21) afternoon was free for touring Gijón, and this was followed by a fabulous symposium dinner, where all participants enjoyed a traditional Asturian feast.

By design, the symposium covered a wide scope of topics, including: changes in oceanic circulation and physical characteristics of the oceans, climate modeling, changes in cycling of carbon and other biogeochemical elements, acidification of shallow seas, oligotrophy of temperate seas, impacts on lower and higher trophic levels, sea level rise and coastal erosion, *etc*. The symposium brought together global and regional data sets and models, and resulted in spirited discussions of climate change scenarios, revision of predictions from models and role of IPCC in assessing the predictions, reports on the effects of global warming in the oceans and methods for adaptation, and finally, the identification of challenges and "hot spots" for special consideration in the next 5 years.

Three general conclusions were reached at the symposium:

1. The global warming trend and increasing emissions of CO_2 and other greenhouse gases (GHG) are already affecting environmental conditions and biota in the oceans on a global scale.
2. We do not fully appreciate how large and deep these effects will be in the near future and we do not understand the mechanism and processes converting the individual responses of single species into shifts in the functioning regime of marine ecosystems.
3. We need to maintain the existing time series, establish more in some regions, do more experimental research, and develop more complex and higher resolution models.

Many other results can be highlighted. For example, experts studying CO_2 emissions described how atmospheric CO_2 is increasing at a rate of 4 parts per million (ppm) per year, instead of 3 ppm per year during the last decade. This acceleration indicates that the intermediate scenario portrayed in the Fourth Assessment Report of IPCC (IPCC AR4) is not the one we should consider, as future climate changes are likely to be much larger than what we have experienced. It was also confirmed that anthropogenic warming and sea level rise would continue for centuries, even if GHG concentrations were stabilized at or above today's levels. Furthermore, IPCC AR4 estimates 0.2 to 0.6 m sea level rise by 2095 (relative to 1990) from thermal expansion of sea water, contributions from glaciers and icecaps, and estimates of the contributions of ice sheets using the current generation of ice-sheet models. However, sea level could rise by an additional 0.1 to 0.2 m or more as a result of poorly understood dynamic responses of the ice sheets. It was noted that melting could potentially exceed precipitation as the earth warms, leading to an ongoing contribution to sea-level rise. The Greenland and West Antarctic Ice Sheets are “hot spots” to be monitored in the next decade. The response of the high latitude climate system to climate change is also uncertain due to poorly quantified feedbacks and thresholds associated with the ocean circulation models.

Hurricane intensity and the size of regions where they are formed will increase as the sea warms and accumulates more energy earlier in the year over a larger area. The combined effect of acidifying the world ocean and increasing its temperature has accelerated the bleaching of coral reefs. Corals are vulnerable to climate change and may disappear at CO_2 levels above 450–500 ppm or at a further temperature increase of 1ºC above today’s level. This change is risking not only the corals, but the entire biological community associated with them. This community includes several thousand species of different classes, and approximately 50% of these species may disappear. It was also noted that the size of oligotrophic oceanic gyres has increased over the last decade, and the depletion of nutrients in the surface layer should be explored in regional seas as well. The depletion of oxygen in upwelling areas should also be carefully observed in the following years.

Fisheries are affected by the cumulative and interactive effects of fishing, pollution, coastal development, and climate change. The ecosystem effects of fishing (such as habitat destruction, bycatch, species interactions and practices of selective catch of old fat female fish) were considered to have a greater influence on population dynamics than the effect of climate change. Nevertheless, climatic effects may be detected in the migratory routes of tuna and in geographic displacement of small pelagic fishes in the northern hemisphere (and east–west displacements in the southern hemisphere). Increased water temperatures are likely to shift species ranges to higher latitudes but are unlikely to lead to the extinction of present arctic fish species.

Many commented that observing marine ecosystems is significantly more difficult than observing terrestrial ecosystems. Besides, research in the oceans tends to be ephemeral and concentrated in coastal waters. Lack of accessibility to most marine ecosystems prevents many nations from investing the economic resources needed to establish permanent programs to monitor these seas. Satellite observing systems are effective but generally restricted only to seeing what is at the sea surface. Even shallow areas, such as sea grass meadows and coral reefs, remain hidden from satellites. New and powerful instruments are now available to observe the physical properties of oceans, but we continue to lack technologies to monitor biological communities with the proper spatial and

Lively discussions during the “Wine and Tapas” Poster Session at Palacio de Congresos de Gijón.

Group photo taken on the grounds of the restaurant El Trole prior to the Welcome Reception.

temporal resolution. The southern hemisphere and the Indian Ocean are vast regions that are poorly (or not at all) covered by monitoring programs. This causes bias in perceptions and in the predictions of models. It was suggested that international collaboration should be pursued to establish permanent research programs in these areas.

The last afternoon of the symposium was capped off with a review of the highlights and a lengthy discussion of impressions. John Church reminded us that climate change has become the environmental issue of our time, with a wide range of impacts that may have little effect upon us but certainly will affect our children's futures. He also noted that the marine science community has been slow to enter into the climate change debate, and gave as evidence the shortage of information on climate impacts on the ocean. Chapter 1 of Working Group II of IPCC AR4 lists only 30 marine data series (biological and physical) in the synthesis of climate impacts, compared with 622 series from the cryosphere and 527 series from terrestrial biological systems. Furthermore, only 4 out of 43 authors of this chapter were marine biologists, which results in a greater likelihood that changes in the ocean are under-represented.

IPCC criteria for accepting data in assessments demand that each time series be at least 20 years long and end in 1990 or later. One way to bolster confidence and enhance transparency in the IPCC process would be to provide the details of each time series used in the report as an appendix, as is the norm in large meta-analyses. In addition to identifying gaps, it would allow the broader scientific community to provide quality control of the data gathering and interpretations that underpin the assessment. The hope was expressed by many participants that this symposium has stimulated further engagement and further interactions among the IPCC and marine scientists. Many recognized that here is a clear need for the community of scientists to communicate with the community of policy and decision makers.

The need to maintain existing physical and biological time series was strongly emphasized. These will provide the data required to understand interdecadal variability underlying global warming, as well as the effects of the global warming per se. But exploring the effects of climate change cannot rely solely on observations. New experiments are needed, and ocean acidification is a clear example. Several people stressed the importance of good communication systems that would allow delivery of data in real-time and facilitate data exchange. An added value is that the community would have access to a greater variety of data. Finally, more complex and finer scale models are needed to provide accurate and timely information to the policymakers and to society.

A recurring theme of the discussions was the need to identify "mechanisms" which lead to ecosystem change. Correlations of physical variables collected at basin scales, with fish catches recorded locally, are not going to be very useful in our quest to understand, forecast and predict future fish catches and ecosystem productivity. Far more hypothesis testing will be necessary. Down-scaling from basin to regional scales, species life histories and physiological traits become important. There is a need for process studies of feeding, growth, respiration and mortality of key species to improve the parameters used in ecosystem models. Comparative ecosystem studies will continue to provide new insights into mechanisms through which ecosystems may respond to physical forcing. Moreover, there is a clear need to expand our knowledge of the rates at which species might be able to adapt to a rapidly changing planet.

The new challenges for the next 5–10 years include the study of non-linear effects on biological processes leading to shifts in ecosystems, the decadal variability underlying the signal of climate change, the rate of melting in Greenland, the acidification of the oceans, the expansion of oligotrophic gyres (how productive will the ocean be in the future), detrimental changes in upwelling systems, species sensitivity to climate change, and the interaction of climate change with other human impacts and activities.

Jane Lubchenco reminded us that there is no cohesive community of researchers to study adaptation and mitigation of societies to impacts of climate change on national and local economies and societies. Such studies are often piecemeal and anecdotal in nature. Thus, there is a need to integrate social science and natural science. Although these socio-economic studies are in their infancy, the child needs to develop very quickly. For managers and policy makers, major choices are on the horizon and decisions may have to be made that are based largely on values, economics, and politics rather than on a clear scientific understanding of a given problem. For this to change, scientists will need to become engaged with the policy community. And on this point, Andy Rosenberg reminded us that the scientific community must not be afraid to share with managers what is known about our science (but of course within the bounds of some uncertainty). After all, we do know far more about science than the managers and the best way to impart the knowledge is through frequent dialogue.

Several participants noted that the internet has provided access to current literature at a frightening pace, but it has come at a cost. Libraries, especially at marine stations, are becoming under-utilized and funds are being cut. This is a growing threat to the historical literature. Old papers can be an inspiration for new ideas. If nothing else, they are an untapped source of data and observations of our world as it was. Students may not be reading the classical papers any more because they are not available as pdf files on journal websites. Hence, they can fail to recognize the rich history of ideas in the marine literature.

A selection of papers from the symposium will be published as a special issue of the ICES *Journal of Marine Science* in the spring/summer of 2009. Guest Editors for this volume will be appointed accordingly with the disciplines of the manuscripts submitted for evaluation.

At the Panel Discussion on the last day, it was remarked that this was the largest and most important symposium that has ever been held on the effects of climate change on the oceans and that a follow-on symposium, patterned after the Gijón meeting, must occur within 3–5 years. Earlier dates in this range are needed if the work is expected to influence IPCC AR5. The marine science community is soliciting a host for the Second Symposium on "*The Effects of climate change on the world's oceans*".

At the Closing Ceremony, we also honored the early career scientists who gave the best talk and prepared the best poster. The recipients were: Laura M. Parker (University of Western Sydney, Australia) for her presentation on "The effect of ocean acidification and temperature on the fertilization and development of the Sydney rock oyster, *Saccostrea glomerata* (Gould, 1850)", and Meike Vogt (University of East Anglia, UK) for her poster on "The dynamics of dimethylsulphide and dimethylsuphoniopropionate in a global prognostic model". Honorable mentions were awarded to: Stephanie Henson (Princeton University, U.S.A.) for her talk on "Decadal changes in North Atlantic phytoplankton blooms", and Sam Dupont (Göteborg University, Sweden) for his poster on "CO_2-driven acidification radically affects larval survival and development in marine organisms".

As the symposium convenor representing PICES, I am satisfied that the PICES community was well represented by members of SSC and session co-convenors (Richard Feely, Michael Foreman and Akihiko Yatsu), by invited speakers (Sanae Chiba, Michio Kishi and Gordon Kruse), and by leaders of two workshops: on "*Zooplankton and climate: Response modes and linkages among regions, regimes, and trophic levels*" (David Mackas) and on "*Linking Global Climate Model output to (a) trends in commercial species productivity and (b) changes in broader biological communities in the world's oceans*" (Anne Hollowed, Thomas Okey and Michael Schirripa). Brief reports of these workshops are included in this issue of PICES Press. I am most proud of the PICES Secretariat who provided professional assistance in the planning, coordination and development of the symposium. Special thanks go to Julia Yazvenko who created and maintained the symposium website and the database, communicated with more than 400 potential participants, co-sponsors and convenors, and prepared (with Dawn Ashby of GLOBEC) the book of abstracts.

I also wish to express my sincere gratitude to Dr. Luis Valdés who, in addition to being the ICES convenor, led the Local Organizing Committee and put an enormous amount of time and efforts into making this symposium a success. His staff at IEO, and especially Audrey Lecornu, worked tirelessly before and during the symposium to assure that the show ran smoothly.

Dr. William (Bill) Peterson (Bill.Peterson@noaa.gov) is an oceanographer and zooplankton ecologist at the Hatfield Marine Science Center in Newport, Oregon. He works for NOAA's National Marine Fisheries Service, and his research focuses on climate effects on zooplankton, particularly euphausiids and copepods. Within PICES, Bill has served on several expert groups and is currently a member of the Biological Oceanography Committee and Co-Chairman of the Working Group on Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim.

Zooplankton and Climate: Response Modes and Linkages

by David L. Mackas

The 2008 International Symposium on "*Effects of climate change on the world's oceans*" included a 1-day open workshop, "*Zooplankton and climate: Response modes and linkages among regions, regimes and trophic levels*", which examined zooplankton time series and their links with ocean climate. Demographic characteristics of marine zooplankton make them especially suitable for exploring the mechanisms responsible for ecosystem variability at interannual to decadal time scales. The workshop was held on May 18 and designed as a forum for the viewing and discussion of time series analyses recently carried out by SCOR Working Group (WG 125) on *Global Comparison of Zooplankton Time Series* (http://wg125.net/), which also had a working meeting on May 15–16, at Instituto Español de Oceanografía's Centro Oceanográfico de Gijón. However, the May 18 workshop also included a number of excellent presentations by authors not formally associated with the SCOR Working Group.

The 16 presentations covered a wide but relevant range of topics: data 'tools'; the spatial 'zones of influence' for different modes of physical climate variability; a between-region comparison of trends and amplitudes for anomalies of total zooplankton biomass/biovolume; temperature effects on community size structure and seasonal timing (phenology); 'invasions and outbreaks' by gelatinous zooplankton; spatial and interannual variability of isotopic composition and trophic level; variability of species composition and diversity; and poleward displacements of zoogeographic distributions. In this article, I will give only a few graphical examples and an overall 'highlights and consensus' summary. The full list of presentation titles and abstracts (plus pdf copies of some of the presentations) can be accessed on the symposium website at www.pices.int/meetings/international_symposia/2008_symposia/Climate_change/structure.aspx. Many of these will also be written up for publication in an upcoming special issue of *Progress in Oceanography*.

There has been very good buy-in by the international community of marine zooplanktologists to the WG 125 goal of global comparison. We currently have access to over 100 multi-year zooplankton time series from over 25 countries (and are continuing to gain more). One consequence of this massive response is that WG 125 needed to assemble a suite of 'entry-level' data analysis and visualization tools that could be applied to compare across diverse sampling designs (frequent and regular sampling of a single near-shore station, seasonally-repeated survey grids, and more irregular repeat coverage within defined statistical areas); sampling methods (horizontal, vertical or oblique net tows with different net designs and mesh sizes); and measurement currencies (displacement volume, dry-weight biomass, carbon biomass, numeric abundance at varying levels of taxonomic aggregation). Our step-wise approach (implemented mostly by Todd O'Brien and illustrated in **Fig. 1**) has been to estimate average seasonal cycles from log-transformed raw time

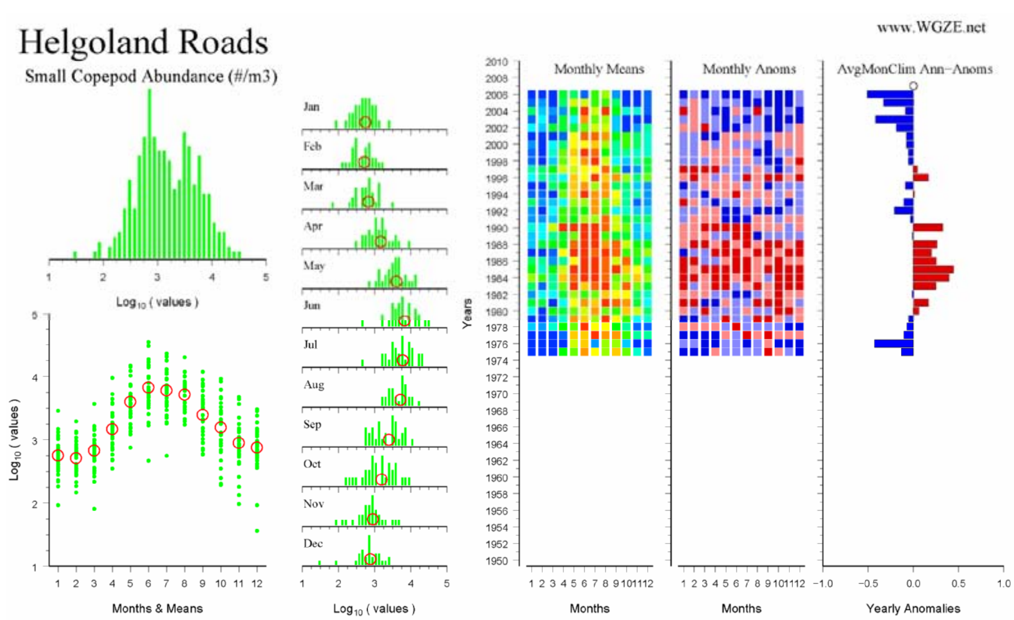


Fig. 1 Graphical output from the WG 125 toolkit, as applied to W. Greve's Helgoland Roads time series. The green dots and bars in the three left-side panels show overall and within-month frequency distributions of individual data points. Red circles overlaid on the bottom-left graph show the average seasonal cycle. Color-coded pixels in the middle panel show ranking of within-month means. The right-side panels show monthly and annual-average anomalies from the seasonal climatology.

series, then use these to calculate anomaly time series (multiplicative deviations from the seasonal climatology), and finally to display both data and anomalies as color-coded month-*versus*-year pixel grids that show which seasons/years have unusually high or low values of the variable being measured. These simple graphical displays have been useful not only for comparison among time series, but also for within-time-series quality control and hypothesis building.

Nearly all of our available zooplankton time series provide one or more indices of 'total amount': biovolume, biomass, or total abundance. How do the amplitudes of fluctuations and trends differ among regions? One approach is to classify and map time series based on the max-to-min or RMS 'span' of their anomaly time series (**Fig. 2** from O'Brien *et al.*). The strongest interannual variability was in the time series from sub-polar regions, from the eastern boundary current upwelling systems, and from the ocean margins off Korea and Japan. The weakest range of variation has been on mid-latitude continental shelf regions and marginal seas.

Another important question is which time series are most 'synchronous', and how their temporal correlations vary with spatial separation. Hal Batchelder presented a preliminary but interesting spatial auto-correlation analysis (**Fig. 3**) of the 'biomass' time series. He found that these time series tend to be positively but relatively weakly correlated across separations smaller than a few thousand kilometers, and that the spatial autocorrelation is stronger in the Pacific than in the Atlantic. However, there is no evidence supporting a 'global synchrony' similar to that suggested by catch time series of anchovy and sardines. Does this mean that fish 'regimes' are more teleconnected than zooplankton 'regimes'? Perhaps, but not necessarily – the zooplankton analysis is of a highly aggregated currency (total biomass), while the fish analyses are at species level. We are still working on the corresponding global species-level analysis for zooplankton, but comparisons within the California Current system show that the short-range spatial auto-correlation of zooplankton community variability is considerably stronger than the spatial autocorrelation of total zooplankton amount (**Fig. 3**). We need data to extend the species-level analysis to larger separations. Stay tuned,

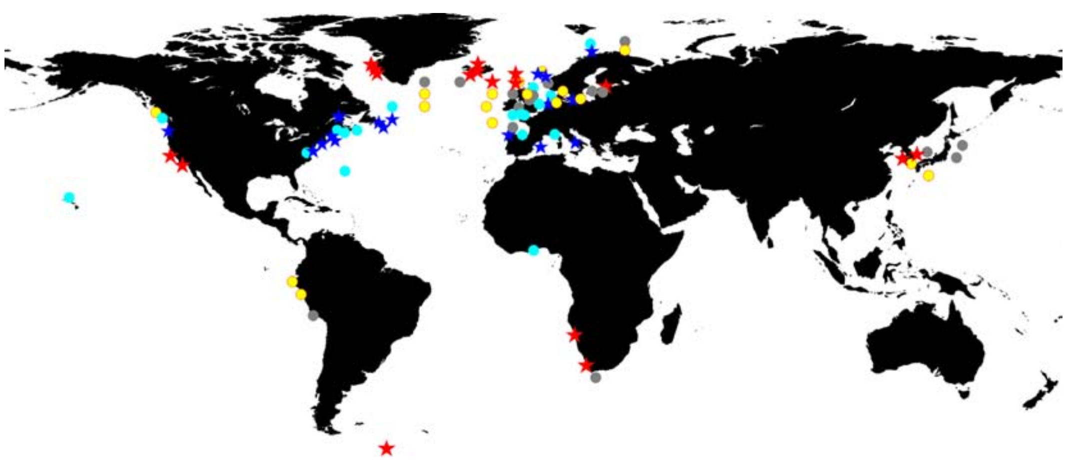


Fig. 2 Map of 'anomaly span'. Red and yellow symbols show locations of time series with a large interannual range; blue symbols have a much smaller range (some because they are brief). Grey symbols are intermediate.

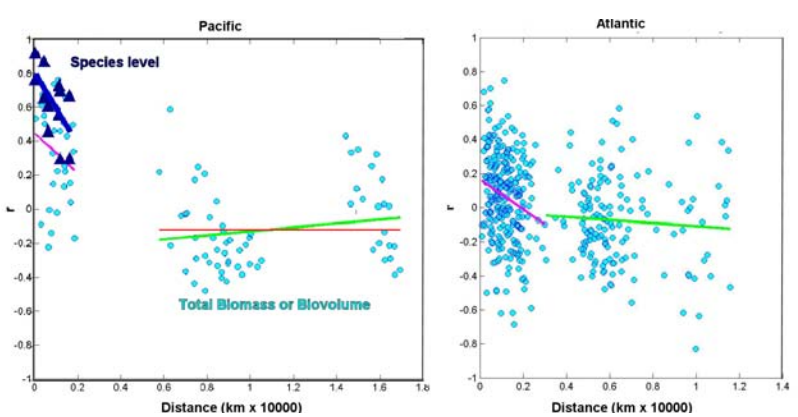


Fig. 3 Spatial correlograms for zooplankton anomaly time series from the Pacific (left, total biomass and community composition) and Atlantic (right, total biomass only). Data points are similarity (y-axis) vs. *separation (x-axis) of annual anomaly sequence for all pairs of time series with more than 12 years of overlap. Light blue circles are 'biomas/biovolume', dark blue triangles are species groups defined by zoogeographic zonation. In both oceans, correlation decays to zero at separations greater than a few thousand kilometers (*i.e.*, there is little or no global synchrony). However, 'local' correlation is stronger in the Pacific than in the Atlantic, and is much stronger at species level than for total biomass.*

we will be extending this analysis (and please join us if you have any suitable time series data).

What else stood out as strong climate linkages? As noted above, several papers (Conversi *et al*., Mackas *et al*., Schlueter *et al*.) examined changes in zooplankton seasonal timing. All found that zooplankton phenology is very sensitive to ocean climate as indexed by water temperature during the growing season for a given species. But a very interesting composite result was that the temperature dependence is not uniform across species and regions. High latitude and 'spring' species show earlier seasonal maxima in years when temperatures are higher. Subtropical 'fall bloom' species show the opposite pattern – later maxima when temperatures are higher, suggesting that their population responses track autumn cooling and de-stratification, rather than spring warming and stratification. Species richness, average body size, and success of 'invading' (or merely 'expanding') species also show strong relationships to ocean warming. Again, stay tuned.

Post-workshop tapas and time series (what could be better?) The Pacific-resident author (David Mackas, blue-shirted male, a.k.a 'Canadian frog') compares data and wine preferences with Euro-princess colleagues (clockwise from left) Lydia Yebra-Mora, Delphine Bonnet, Maité Alvarez-Ossorio, and Maria-Luz Fernandez de Puelles. Photo courtesy Maite (camera and email) and Antonio Bode (shutterbug). Commentary from Maité: "[Frog is obvious but] I don't see any crowns [on the princesses]".

Dr. David Mackas (Dave.Mackas@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences and Co-Chairman of SCOR WG 125. He is also a member of several PICES Committees and expert groups, including WG on Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim.

(*continued from page 7*)

Day 3 allowed the group to refocus on the outstanding issues that had been identified during the previous two days of database beta-testing, discussions, and problem solving. Representatives from each country had an opportunity to provide input on their expectations of the final version of the database that WG 21 expects to have fully operational (if not fully populated) in time for the rapid assessment surveys to be conducted at two locations in China, prior to PICES XVII in Dalian. With an identified path forward that all attendees were comfortable with, including specific interim deliverables and associated timelines, the field trip portion of the meeting began. First, it was a boat tour of the port of Busan, arranged by Dr. Yoon Lee in conjunction with the local port authority. The group then proceeded on to Busan New Port which is currently under development and will greatly increase the shipping traffic in this part of the world once the expansion is complete. The day ended with the last group dinner associated with this inter-sessional meeting that allowed the participants to continue developing research collaborations and a better understanding of how non-indigenous species are impact-ting various PICES member countries.

Our meeting was a tremendous success thanks to Dr. Lee and his staff. Not only were meeting facilities extremely comfortable, the group meals every evening allowed participants to mingle in a less formal setting. In addition, we were able to sample a number of local delicacies (food and drink) and take in some of the sights this region has to offer. WG 21 continues to make significant advances towards better understanding non-indigenous marine species in the North Pacific and the dedication of its members will ensure that we are successful in all our endeavors, including completion of the database we beta-tested at our recent meeting in Busan.

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, BC. Tom is working on aquatic invasive species (research, monitoring, risk assessment, and rapid response planning) both within DFO and through the Canadian Aquatic Invasive Species Network (CAISN). He also conducts research on forage fishes, notably eulachon and Pacific herring, from conservation and ecosystem perspectives. Tom is a Principal Investigator on the Taxonomy Initiative of PICES WG 21 that will include rapid assessment surveys for non-indigenous species in PICES member countries.

PICES Fishery Science Committee Workshop in Gijón

by Thomas A. Okey, Anne B. Hollowed, and Michael J. Schirripa

A workshop entitled "*Linking Global Climate Model output to (a) trends in commercial species productivity and (b) changes in broader biological communities in the world's oceans*" was convened on May 18, 2008, at the ICES/PICES/IOC International Symposium on the "*Effects of climate change on the world's oceans*" in Gijón, Spain. The workshop had the ultimate goal of facilitating a coordinated international research effort to forecast climate change impacts on the distribution and production of the world's major fisheries, and on the biological communities in which these fisheries are embedded. It was attended by 33 people from 13 nations and there was consensus that this group could initiate a coordinated international collaboration to advance research in marine climate impacts. Originally proposed separate workshops entitled "*Linking climate to trends in productivity of key commercial species in the world's oceans*" and "*Screening approaches and linking Global Climate Model output with ecosystem and population models*" were combined by the convenors because they were complementary. In retrospect, blending the two "schools" was fortuitous as it placed us in a better-than-expected position to initiate an effective international collaboration.

The specific objectives were: (1) to review the activities of existing programs within each nation; (2) to examine evidence for climate impacts on production of commercial fish species and other marine life; (3) to discuss the feasibility of developing medium- to long-term forecasts of climate impacts; (4) to discuss possible responses of commercial fisheries, human communities, and governments to climate-driven changes in marine life; and (5) to identify common or standard approaches to forecasting climate change impacts on commercial species and marine communities and ecosystems.

Workshop participants discussed climate scenarios to use in forecasting and the tools required for predicting climate impacts on commercial fish production and broader marine ecosystems. The workshop provided a forum to examine four components needed to complete the forecasts in a timely and coordinated fashion. These included IPCC scenarios, predictions of oceanographic impacts, modeling approaches, and regional scenarios for natural resource use and enhancement. The ecosystem component of the workshop surveyed a wide variety of approaches, such as vulnerability assessments for informing location choices for ecosystem modeling efforts and management prioritization, trophodynamic fishery ecosystem modeling (*i.e.*, Ecopath with Ecosim), climate envelope modeling, statistical approaches, and three dimensional high-resolution biogeochemical ecosystem modeling (*i.e.*, CCCC-NEMURO).

The workshop began with an introduction by Anne Hollowed (U.S.A.) who proposed: (1) an overarching goal of producing quantitative estimates of climate change effects on the marine ecosystem – biology – in the next 5 years; (2) a review of all the related international efforts in a paper that would lay out a path for collaboration development; (3) initiation of a coordinated international effort—broader than one basin; and (4) production of a special journal issue for showcasing forecasting approaches that are available and are being developed. She discussed three broad approaches representing different levels of advancement in the science of climate impact forecasting, listed in increasing order of sophistication:

1. IPCC scenarios downscaled to local regions and ecosystem indicators used to project future fish production using detailed management strategy evaluations;
2. IPCC scenarios downscaled to local regions and coupled to bio-physical models with higher trophic level feedbacks;
3. Fully coupled bio-physical models that operate at time and space scales relevant to coastal domains.

The main program of the workshop started with a round table discussion of existing national or international projects developing forecasting initiatives, including Quest-FISH (Jason Holt), Fisheries and the Environment (FATE; Anne Hollowed), PICES FUTURE (Michael Foreman), North Pacific Research Board Bering Sea Integrated Ecosystem Research Program (NPRB BSIERP; Clarence Pautzke), Climate Impacts on Oceanic Top Predators (CLIOTOP; Alistair Hobday), Ecosystem Studies of Sub-Arctic Seas (ESSAS; Harald Loeng), Evidencias e Impacto do Cambio Climático en Galicia (CLIGAL; Antonio Bode), and initiatives by the Ministry of Fisheries New Zealand (Mary Livingston). The rest of the morning was devoted to eight presentations of projects that linked Global Climate Model (GCM) output to trends in commercial species productivity.

Nicholas Bond (U.S.A.) presented "*A method for using IPCC model simulations to project changes in marine ecosystems*", in which he compared ensembles of hindcasted atmosphere–ocean model output to observed measurements, and used a tiered statistical approach to select a subset of models that performed well in representing regional oceanographic projections. This work indicated that different models have different strengths, so a particular question should use a tailored subset of models.

Mary Livingston (New Zealand) presented "*Climate change, oceanic response and possible effects on fish stocks in New Zealand waters*", in which she described how climate change related ecological trends have been equivocal in New Zealand during the last 50 years due to its oceanographic and ecological uniqueness and complexity and the paucity of long time series. Some of New Zealand's marine life might be quite vulnerable to climate and oceanographic changes due to a variety of factors, and thus there are plans to integrate climate impact studies with marine fisheries research and management.

Jae Bong Lee (Republic of Korea) presented "*Forecasting climate change impacts on distribution and abundance of jack mackerel around Korean waters*", in which he illustrated how variations in ocean conditions and warming of ocean water around Korea has influenced the distributions of jack mackerel in terms of their seasonal visitation to Korean waters from the East China Sea, and suggested that continued warming by 2100 may have considerable effects on these stocks around Korea. Future sea surface temperature (SST), ocean drift and other oceanographic variables projected with GCMs will be incorporated into a stock projection model to forecast future production scenarios.

Sukyung Kang (Republic of Korea) presented "*Techniques for forecasting climate-induced variation in the distribution and abundance of mackerels in the northwestern Pacific*", in which she described an exploration of the positive relationship between mackerel production and warm ocean conditions, and progress in forecasting the impact of climate change on mackerel production by downscaling forecasts of atmospheric/ocean conditions from GCMs to drive stock projection models.

Adriaan Rijnsdorp (The Netherlands) presented "*Effects of climate change on sole and plaice: Timing of spawning, length of the growth period and rate of growth*", in which he reviewed how increased temperatures since 1989 in coastal nursery grounds in the southeastern North Sea has had a negative impact on plaice and a positive effect on sole thus causing a shifting species composition as their habitat quality changes. Implications of physiological trade-offs in this changing system will make forecasting challenging.

Z. Teresa A'mar (U.S.A.) presented "*The impact on management performance of including indicators of environmental variability in management strategies for the Gulf of Alaska walleye pollock fishery*", in which she provided her management strategy evaluation (MSE) of the Gulf of Alaska walleye pollock fishery, with multiple indices of climate forcing incorporated into her overall modelling framework. The best performing management strategies were ones that were more responsive to fluctuations in productivity due to environmental influences.

Michael Schirripa (U.S.A.) presented "*Simulation testing two methods of including environmental data into stock assessments*", in which he described the development of environmental indicators of fish stock recruitment and provided both modelling and a statistical examples of how such indicators could be used in stock assessments and forecasting. Sea surface height (SSH) was the best predictor of recruitment in this analysis, as low SSH occurs when the California Current and upwelling are both strong, and this is associated with high productivity.

Alan Haynie (U.S.A.) presented "*Climate change and changing fisher behavior in the Bering Sea pollock fishery*", in which he discussed how fishermen will respond to changes in fish abundance driven by climate change, and that this will, in turn, have an impact on the ecosystem. The fisheries we observe today result from current stock distributions, abundances, and prices—all of these will change with climate. Spatial and market regulations that consider the relationship between fishermen and the environment will be most effective.

The morning session concluded with a discussion of the presentations and the outlook for forecasting commercial fisheries.

Thomas Okey, Pew Fellow in Marine Conservation, introduced the afternoon session by providing a framework highlighting complementary modelling approaches that could be used to explore climate impacts on marine biota and ecosystems. He described conceptual and qualitative models that are useful for proactive decision-making as a segue to the more quantitative approaches to linking GCM output to changes in broader marine communities.

Jorge Sarmiento (U.S.A.) presented "*Modeling response of ocean biology to climate warming using an empirical approach*", in which he compared global warming simulations from six climate models and the physical changes projected for six ocean biomes. All six models indicated increases in primary production at high latitudes, but the models did not agree with direction of change at mid-latitudes.

Taketo Hashioka (Japan) presented "*Future ecosystem changes projected by a 3-D high-resolution ecosystem model*", in which he described efforts to develop a high-resolution ecosystem model by linking COCO (CCSR Ocean Component Models) to NEMURO and NEMURO–FISH models. Projections included a 30% decrease in the Kuroshio, 10–30% decreases in Chl-*a*, a shift from diatoms to small phytoplankton, a spring bloom 10 days earlier, changes in phytoplankton biomass (*i.e*., 20% increase in the subarctic region and 25% decrease in the subarctic-subtropical transition region), and a 2° shift in the distribution of sardines.

William W.L. Cheung (Canada) presented a "*Dynamic bio-climate envelope model to predict climate-induced changes in distribution of marine fishes and invertebrates*", in which he provided a global assessment of climate-induced range shifts of 1066 commercial species throughout the world's oceans from changing temperature, habitat characteristics, and other mediators of dispersal and range occupation.

Alistair J. Hobday (Australia) presented "*Informing location choices for ecosystem model development using a vulnerability index*" as an Australian example of a quantitative vulnerability assessment that is used to identify the ecosystems, habitats, biological components, and human values most vulnerable to projected climate change, so that climate impact modelling and monitoring can be prioritized and targeted efficiently. The CSIRO Mk 3.5 model projections to 2070 provided indicators of climate change while non-climate indicators were derived from other Australian data sets.

Simone Libralato (Italy) presented "*Towards the integration of biogeochemical and food web models for a comprehensive description of marine ecosystem dynamics*", in which he reviewed the progress and outlooks for achieving end-to-end modelling (*e.g.*, from viruses to fishes, from nutrients to fisheries, including climatic changes) by linking biogeochemical models with trophodynamic models. He also summarized outcomes of the 2007 Trieste (Italy) workshop on "*Biogeochemical processes and fish dynamics in food web models for end-to-end conceptualisation of marine ecosystems: Theory and use of Ecopath with Ecosim*".

Steven Mackinson (UK) presented "*Which forcing factors fit? Using ecosystem models to investigate the relative influence of fishing and primary productivity on the dynamics of marine ecosystems*", in which he described dynamic fitting with Ecopath with Ecosim models to identify the main driving forces of fish stocks and marine ecosystems (*e.g*., fishing mortalities or proxies of primary production), to assess the relative importance of these factors across regions, and to evaluate whether similar groups in different ecosystems respond similarly?

Sheila Heymans (UK) presented "*The effects of climate change on the northern Benguela ecosystem*", in which she simulated the effect of global warming on the northern Benguela Current system by fitting a 1956 Ecopath with Ecosim model to 2000 conditions, and then simulating 50 years of SST rise. The ecological effects were evaluated by indices of ecosystem function and commercial gain.

The case studies presented during this workshop indicated the variety of approaches (and variations on similar approaches) for evaluating the impacts of climate change on marine life, biological communities, and ecosystem functions. Although the approaches appeared to be coordinated within communities of modellers, coordination was lacking at the global level. Most, if not all, of the presenters expressed the need to develop these approaches further, and there appeared to be consensus among participants that an international collaboration would be a good way to do this. A global coordination of teams and collaborators may prove to be a critical vehicle to use the increasingly refined physical and chemical projections from GCMs and regional models to evaluate impacts of climate change on the world's marine fisheries and ecosystems. The workshop described in this article may have been a key first step toward such a global collaboration.

Thomas Okey is a Pew Fellow in Marine Conservation with a focus on assessing the impacts of climate change on marine life and ecosystems in the contexts of fisheries and other anthropogenic stressors. He is the Scientist-in-Residence at Bamfield Marine Sciences Centre on Vancouver Island, Canada, and an Adjunct Professor in the School of Environmental Studies at the University of Victoria, Canada. He holds a B.S. in Biology and Environmental Studies from Saint Lawrence University in Canton, New York; a M.S. in Marine Science from Moss Landing Marine Laboratories; and a Ph.D. in Zoology from the University of British Columbia. He is the founder and Science Director of the Conservation Science Institute, which provides conservation science networking and communication.

Anne Hollowed is a Senior Scientist at the NOAA's Alaska Fisheries Science Center, in Seattle, U.S.A. She holds a M.S. in Oceanography from Old Dominion University, and a Ph.D. in Fisheries from the University of Washington. She is an Affiliate Associate Professor at the University of Washington and a Fellow of the Cooperative Institute for Arctic Research at the University of Alaska. Anne has served on panels for U.S. GLOBEC, PICES CCCC, the North Pacific Research Board, and Comparative Analysis of Marine Ecosystem Organization, and is a member of the Scientific and Statistical Committee of the North Pacific Fisheries Management Council.

Michael Schirripa has worked in fisheries science since 1985 for the U.S. Peace Corps, U.S. Forest Service, U.S. Fish & Wildlife, U.S. Parks, and NOAA Fisheries. He earned a B.S. from Michigan State University in fisheries and wildlife and M.S. and Ph.D. degrees in biology from Florida International University. Michael is a member of PICES Fishery Science Committee and is on the Steering Committee of NOAA's Fisheries and the Environment (FATE) Program. Michael recently moved from the NOAA's Northwest Fisheries Science Center in Newport, Oregon, to the NOAA's Southeast Fisheries Science Center in Miami, Florida.

The North Pacific Continuous Plankton Recorder Survey

by Sonia D. Batten

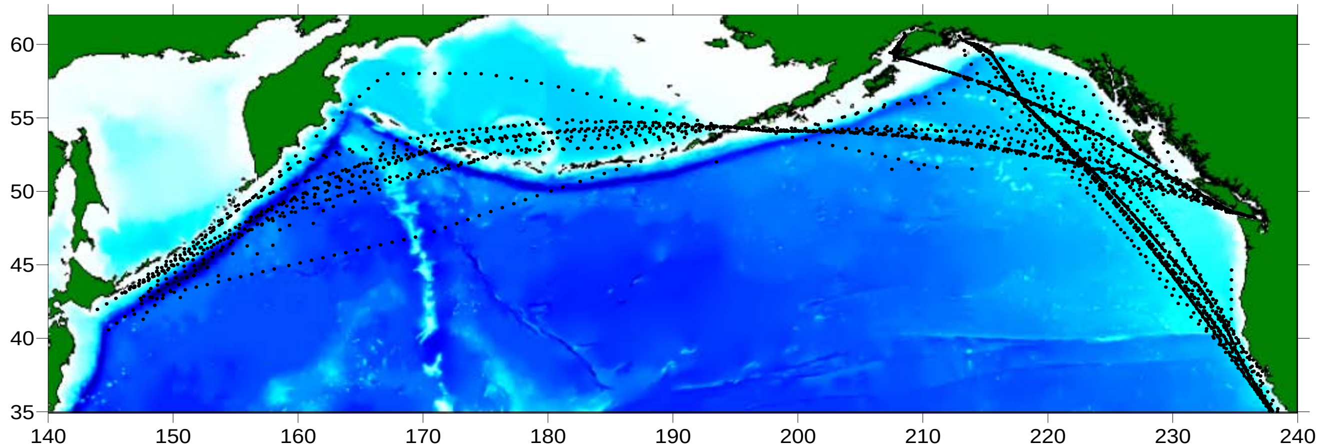


Fig. 1 Location of all processed CPR samples for 2000–2007. Data have recently been made available through the PICES website for selected areas (http://pices.int/projects/tcprsotnp/default.aspx) and all data are freely available by contacting Sonia Batten (soba@sahfos.ac.uk).

Some results from the North Pacific CPR survey

The Continuous Plankton Recorder (CPR) survey of the North Pacific is a PICES project now in its ninth year and facing an uncertain future. CPRs have been towed behind commercial ships along two (north–south and east–west) transects for a total of ~ nine times per year. Samples are collected with a filtering mesh and are then microscopically processed for plankton abundance in the laboratory. The survey, so far, has accumulated 3,648 processed samples (with approximately three times as many archived without processing), each representing 18 km of the transect (**Fig. 1**) and containing an abundance of data on over 290 phytoplankton and zooplankton taxa. A CTD with a fluorometer has been attached to the CPR sampling at the east–west transect in more recent years to provide supplementary environmental data.

Although still relatively short, the time series of CPR data covers a period when the dominant climate signal in the North Pacific, the Pacific Decadal Oscillation (PDO), switched with unusual frequency between warm/positive states (pre-1999 and 2003–2006) and cool/negative states (1999–2002 and 2007 to present). Responses to this variability are evident in the northeast Pacific (which has the greatest sampling resolution since both transects overlap there), and some examples are described here.

The dominant contributors to the spring mesozooplankton biomass are the copepods *Neocalanus plumchrus* and *N. flemingeri*. The timing of their peak abundance varies from year to year (Mackas *et al*., 1998; Mackas *et al*., 2007). Although the exact mechanism is not yet known, environmental forcing through water temperature, stratification effects and/or differential survival of the young copepodites produced during the late winter is likely to play a role. The CPR data show (**Fig. 2**) that at the start of the times series (2000–2001), when the PDO was negative and the northeast Pacific was somewhat cool, the peak in biomass was later in the year and the period of abundance was relatively long. In the warmer, PDO-positive years 2003–2005, the peak was earlier in the year and more focused, with a narrower period of abundance. The switch to cooler, PDO-negative conditions that took place in late 2006 has apparently caused the timing to shift back again to somewhat later in 2007, but it is not yet as late as in the earlier part of the time series. Only additional sampling will show whether several successive cool years are needed to shift the timing back further. It is expected that timing of peak prey abundance has an impact on higher trophic levels that depend on *Neocalanus* as a spring food resource, so determining the extent of its variability under rapidly alternating modes of the PDO will be important.

In addition to sampling during the period 2000–2007, a pilot transect from California to Alaska was also sampled in the summer of 1997. This was at the start of a strong El Niño event, and the CPR data provide a useful comparison with the warm conditions associated with a positive PDO that occurred in 2003–2005. The abundance of subtropical copepods commonly found off the Californian coast, but which extend further north into the subarctic Pacific (*Mesocalanus tenuicornis*, *Clausocalanus* spp. and *Corycaeus* spp.), was calculated for each sample on the north–south transect, and their northward extension in July–August was recorded (as 75% of the cumulative abundance from 48°N to the Alaskan shelf). **Figure 3** shows the latitude reached by subtropical copepods each summer, together with the spring temperature at Amphitrite Point lighthouse on the west coast of Vancouver Island (mean of February–May monthly mean sea surface temperature, SST).

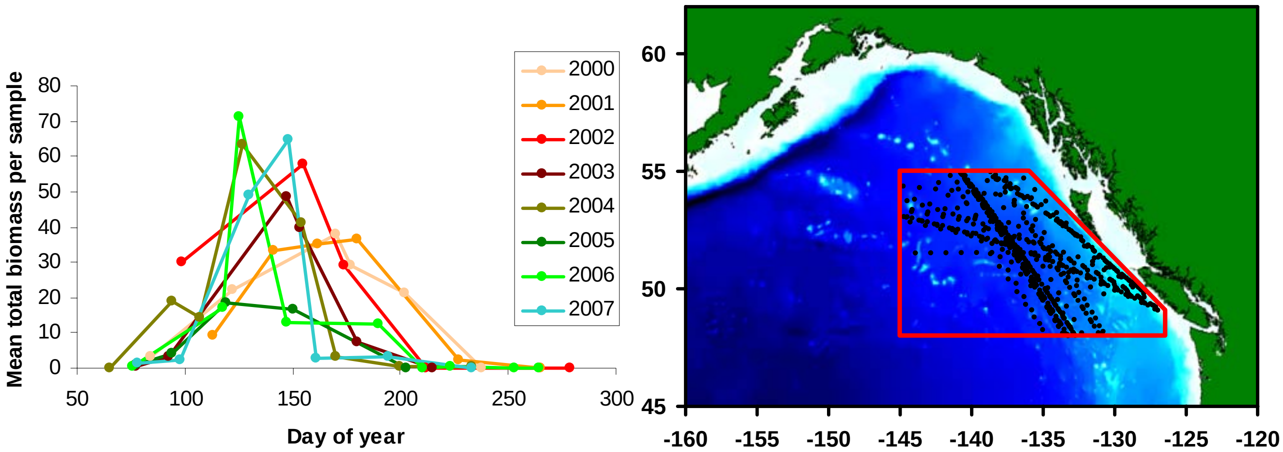


Fig. 2 The mean biomass of Neocalanus plumchrus *and* N. flemingeri *copepodites (stages 2–5) on each sampling of the region shown on the side map.*

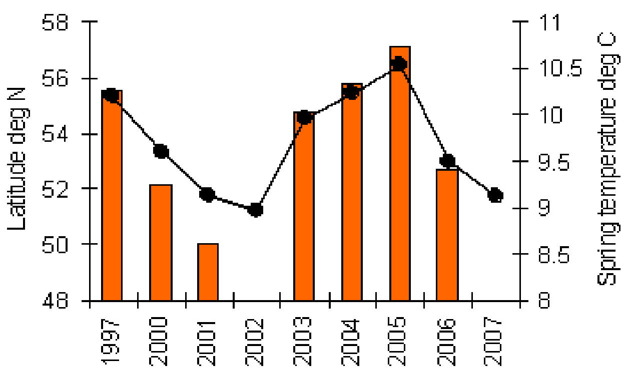


Fig. 3 Latitude where 75% of the cumulative abundance of subtropical copepods was reached (bars) and mean spring sea surface temperature at Amphitrite Point, Vancouver Island (line).

During the two coldest years (2002 and 2007) no subtropical copepods occurred north of 48°N in July and August, and for the remaining years the correlation between latitude and spring temperature was 0.99 ($p<0.01$), showing a very strong influence of spring temperature on copepod distribution.

Zooplankton respond to climate effects not only by changes in their absolute abundance (*e.g.*, McGowan *et al.* 1998) but by changes in community composition and diversity (*e.g.*, Peterson and Schwing, 2003; Mackas *et al.* 2004; Hooff and Peterson, 2006). Subtropical copepods make up only a small proportion of the subarctic community, so we undertook an analysis of the entire summer zooplankton community for the region shown in **Figure 2**. Data were restricted to July and August again, to allow the inclusion of the 1997 data, and the mean abundance of each of the 68 taxa that were found transformed ($\log(x + 1)$). Bray-Curtis similarities were calculated for pairs of years and the resulting matrix subjected to hierarchical clustering and Multi-Dimensional Scaling (MDS) analyses (**Fig. 4**).

These results show a clear separation of community composition between cold and warm years, with the transition years of 2003 and 2006 occurring in the centre of the MDS plot. The years of 1997 and 2007 both plot as distinctly different years, showing a greater difference than for any other pairs of years. Analysis is ongoing to determine which species are making the largest

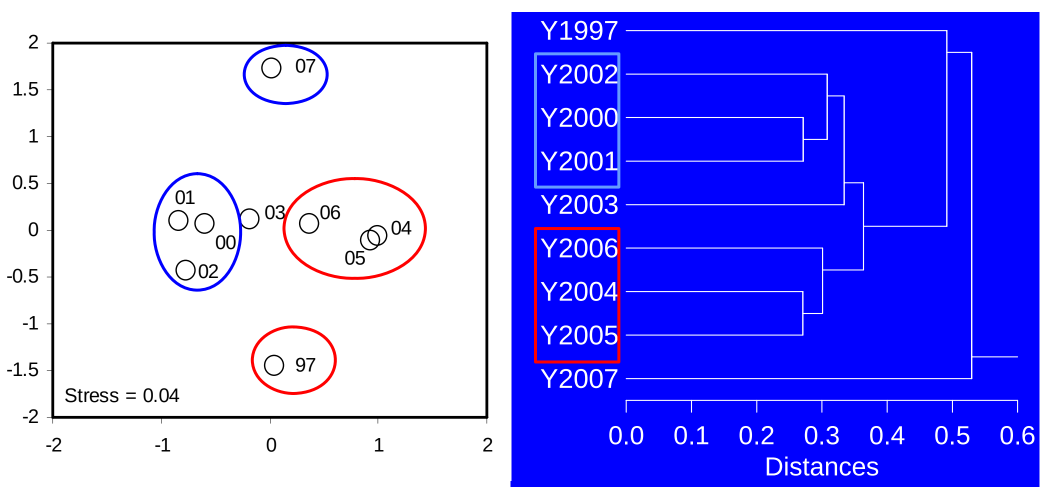


Fig. 4 Multi-Dimensional Scaling (MDS) analysis (left) and cluster analysis (right) of between year community composition similarities. Clusters of warm and cold years are indicated by coloured shapes.

contribution to these patterns. Different taxa are likely to have differing nutritional content, so this result suggests that not only the timing and abundance changes discussed earlier, but also community composition changes as a response to climate variability, will affect higher trophic levels by changing the availability of their prey.

The future

The survey has been funded in the past by the North Pacific Research Board and the Exxon Valdez Oil Spill Trustee Council. However, funding for 2008 is much reduced and only about one third of the normal sampling is planned. Although samples west of the Bering Sea will be collected in the spring and summer of 2008 so that summer sampling of the western Pacific is carried out for the ninth consecutive year, there is no funding to process them, and they will be archived for now in the hope that future funds can be found. Funding beyond 2008 is, as yet, non-existent.

PICES has invited several organizations to participate in a consortium to share the funding and secure the North Pacific CPR survey into the future. Other participants, particularly from the western Pacific, are welcome to join the consortium and help ensure that this valuable dataset continues to accumulate. Further details on the sampling, available data and bibliography can be seen on the PICES website at http://pices.int/projects/tcprsotnp/default.aspx. For information on joining the consortium please contact the PICES Executive Secretary, Dr. Alexander Bychkov (bychkov@pices.int).

Acknowledgements

The survey would not be possible without the generous involvement of the ships and their operating companies. Thanks are given to the officers, crew and land-based staff of Seaboard International's *Skaubryn* and Horizon's *Horizon Kodiak*. Thanks are also due to the North Pacific Research Board and the Exxon Valdez Oil Spill Trustee Council for their financial support.

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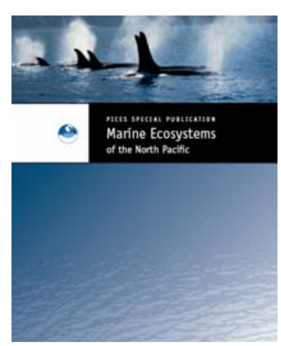
Dr. Sonia Batten (soba@sahfos.ac.uk) is a Biological Oceanographer with the Sir Alister Hardy Foundation for Ocean Science which is based in Plymouth, UK, and operates the Continuous Plankton Recorder Survey (CPR). She completed both B.Sc. and Ph.D. degrees at Southampton University, UK, and has been with SAHFOS for almost 14 years. The last 7 year Sonia spent in Nanaimo, British Columbia, coordinating the North Pacific CPR survey. Her main research interests include the role of zooplankton in large-scale oceanic ecosystems and the effects of the physical environment on their dynamics and zooplankton's interactions with higher and lower tropic levels. She contributes to the PICES CPR Advisory Panel and the Technical Committee on Monitoring.

PICES Ecosystem Status Report Wins Design Award

On May 26, 2008, the Society of Graphic Designers of Canada, Vancouver Island Chapter, presented a Merit Award for the design of the PICES Special Publication "*Marine Ecosystems of the North Pacific*". In total, 350 entries created over the last five years were judged by the panel and 35 awards were presented. The PICES entry was for the category "Books – Complete Design". The book design was the result of close collaboration between the designers at Anonymous Art and the staff of the PICES Secretariat.



Canada's Three Oceans (C3O): A Canadian Contribution to the International Polar Year

by Eddy Carmack, Fiona McLaughlin, Svein Vagle and Humfrey Melling

Introduction

The purpose of climate monitoring is to collect relevant, inter-comparable data over sustained periods of time so as to allow quantification of change within a system for decision-making purposes. This is the motivation of the "Canada's Three Oceans" (C3O) project, a Canadian contribution to the International Polar Year (IPY: 2007–2009). C3O aims to (1) build an integrated, consilient view of the physical, chemical and biological oceanic structure of subarctic and arctic waters around Canada; and (2) use this information to establish a sound scientific basis for a long-term arctic and subarctic ocean monitoring strategy. By this strategy C3O will address change within ocean domains, identify gateways and barriers, and investigate the causal mechanisms, consequences and stability of frontal boundaries separating juxtaposed ocean domains. C3O will thus establish a 'climate change fence' around all of Canada's three oceans that will allow scientists and policy-makers alike to have the data and understanding upon which to practice good governance, and to deal with emerging issues such as warming, species invasion, hypoxia and acidification.

The challenge of keeping watch on the waters around Canada is as immense as it is pressing; Canada has the longest national coastline (~230,000 km) in the world, over half of which (140,000 km) lies in the Arctic. Changes within the ice-cover, water column and ecosystems of Arctic Canada are inextricably linked to the global system in general and to the bordering subarctic Pacific and Atlantic in particular. It is within this high-latitude domain that the consequences of global change and climate variability are expected to be biggest and fastest.

Two facts, however, provide a toehold for meeting the C3O goals. First, the three oceans that border Canada are inter-connected by water masses flowing from the subarctic Pacific to the Arctic and then into the subarctic Atlantic, and this ocean 'continuum' offers a conceptual framework for integrated, climate-scale observations. Second, two science-capable icebreakers of the Canadian Coast Guard already carry out programs that, together, encircle Canada and follow these through-flowing water masses and their associated biogeography. These existing missions offer a logistical framework to support ancillary science programs. Spatial variability can be observed along ship transits (totalling more than 12,000 km in length) that serve to integrate measurements on climatic and macro-ecological scales, while temporal variability is then recorded by year-round moorings at key sites. The basic concept has been tested over the past decade, and the value of repeat hydrography is proven (*e.g.*, Grebmeier *et al*., 2006).

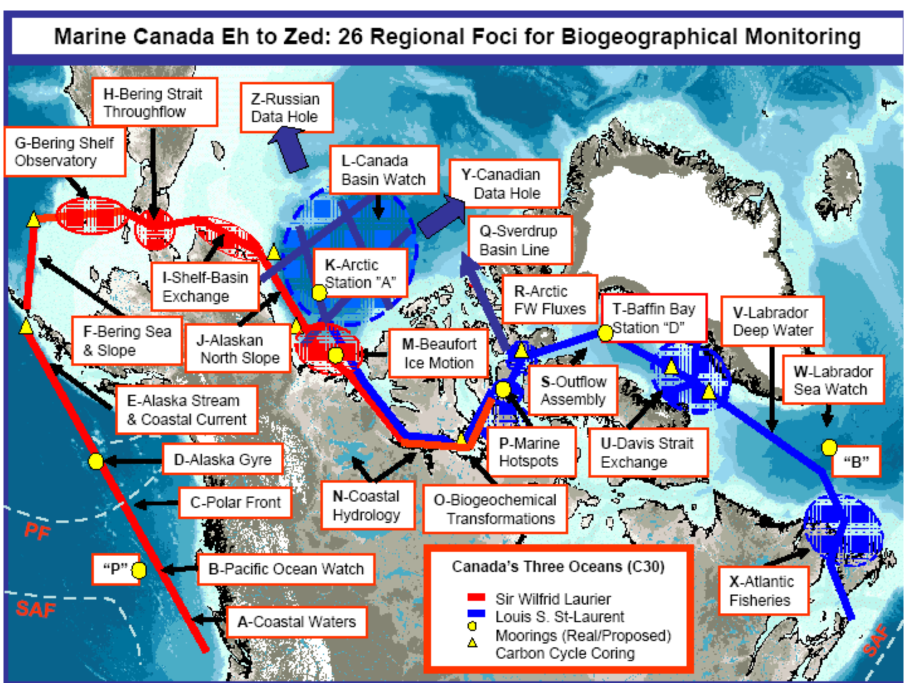


Fig. 1 Map of oceanographic stations occupied by C3O in 2007 by the CCGS Sir Wilfrid Laurier *departing from Victoria in the west and CCGS* Louis S. St-Laurent *departing from Dartmouth in the east. Letters are explained in the text.*

The scientific basis

Two lines of logic underpin the C3O effort. The first is that both observational and modelling results suggest that the major impact of climate change on the marine system will be the re-distribution of oceanic boundaries and habitats/biomes, and this dictates the need to carry out times series observations over very broad spatial domains. The scientific basis for this statement is laid out in the seminal work of Sarmiento *et al*. (2004) who used satellite data and coupled models to classify the major biomes of the global ocean, to identify their diagnostic properties, and to predict the consequences of climate warming. The second line of logic supporting the C3O strategy is that the oceans surrounding Canada are both geographically and dynamically inter-connected, and they share the common trait of permanent salinity stratification. The statement comes out of work of Carmack (2007) who noted that the global patterns of moisture transport and ocean circulation result in thermohaline distributions that force a 'downhill journey' of low salinity waters from the North Pacific to the Arctic and then into the North Atlantic. The Arctic Ocean – itself – acts as a double estuary, whereby waters entering from the North Atlantic become either denser through cooling (negative estuary) or lighter by freshening (positive estuary) as they circulate within the basin and then return to the North Atlantic as a variety of components of the ocean's thermohaline circulation (Aagaard and Carmack, 1989; Yamamoto-Kawai *et al*., 2006).

Study components

C3O is comprised of repeat transects to collect data along sections spanning the subarctic Pacific, Arctic and subarctic Atlantic (**Fig. 1**). The need for observations of contiguous domains that link to the climate scale is discussed briefly in Carmack and McLaughlin (2001). Along these tracks, specific sites or benchmarks are identified to address specific eco-domains and emerging issues. Special focus is placed on quantifying ice and ocean changes in the Canada Basin through a joint U.S./Canada/Japan study called the Beaufort Gyre Exploration Project (BGEP; see McLaughlin *et al*., 2004).

Conceptually, transects are divided into three parts: subarctic Pacific, Arctic and subarctic Atlantic (**Fig. 2**). The CCGS *Sir Wilfrid Laurier* carries out the subarctic Pacific line, the CCGS *Louis S. St-Laurent* carries out the subarctic Atlantic line, and both ships share Arctic assignments. Measurements include: (1) CTD/Rosette casts (with sensors for temperature (T), salinity (S), transmissivity, fluorescence, nitrate, oxygen and photosynthetically-available radiation); (2) water sampling for salinity, dissolved oxygen (O_2), nutrients (NO_3, NH_4, PO_4, and SiO_3), the dissolved and particulate carbon, dissolved and particulate nitrogen, ^{18}O, barium, CFCs and a suite of geochemical tracers, including ^{129}I and ^{137}Cs; (3) Rosette-mounted 300-kHz Lowered Acoustic Doppler Current Profiler (LADCP); (4) Lowered Deep-Sea Camera; (5) underway seawater pumping to obtain continuous observations of near surface (~5 m) water properties, including T, S, O_2, N_2, CO_2, CH_4 and fluorescence; (6) underway dual frequency (100 and 200 kHz) acoustic backscatter system; (7) an Underway Acoustic Doppler Current Profiler (UADCP); (8) expendable (X) profiling sensors (XBTs and XCTDs) and/or Underway (U) UCTD deployments are made at ~20 km spacing to increase resolution; (9) discrete sampling for abundance, bio-diversity and phylogeography of prokaryotes (virus and bacteria), picoplankton, nanoplankton and phytoplankton; (10) phytoplankton distributions by taxonomy and estimates of primary production and nutrient uptake dynamics by on-board incubation; (11) descriptions (distribution, taxonomy, abundance, stable isotope signatures, fatty acid content, genetics and growth rate) of zooplankton using vertical net hauls; (12) sampling of macrobenthic communities on the Canadian Arctic seafloor by benthic sampling and still and video photography; (13) underway observations of marine birds and mammals; (14) ship-based sampling; mooring deployments have been carried by partners WHOI, JAMSTEC, and CRREL.

Core observations in 2007: Marine Canada from A to Z

Over 120 CTD/R stations along approximately 15,000 km of ship track were occupied in 2007 during five separate legs involving the two ships and over 90 science personnel. In 2007, the Food Web Team worked aboard the CCGS *Louis S. St-Laurent*, while box coring was done aboard the CCGS *Sir Wilfrid Laurier*; the reverse is planned for 2008. Northern community consultation and outreach was carried out under the direction of DFO's National Centre for Arctic Aquatic Research Excellence (N-CAARE) [Schimnowski and Williams, leads].

A cartoon, corresponding to the map in Figure 1, depicts the 26 regional benchmarks *en route* clockwise around northern North America from Victoria to Halifax (**Fig. 2**). The matching sections of temperature, salinity, dissolved oxygen and chlorophyll fluorescence are shown in **Fig. 3**. Benchmarks are as follows: **A** identifies British Columbia coastal waters, an important habitat for Pacific salmon; **B** passes near Ocean Station "P", an icon of long-term time series; **C** crosses the Polar Front into **D**–the Gulf of Alaska gyre, characterized by a shallowing of the pycnocline, nutricline and hypoxic waters; **E** crosses the Alaskan Stream (AS) and Alaska Coastal Current (ACC), major freshwater (FW) transport corridors; **F** follows the flux of FW from the Pacific into the Bering Sea and the upwelling of nutrient-rich waters onto the slope and shelf; **G** crosses the Bering Sea shelf and near-bottom 'cold pool'; **H** is Bering Strait, the gateway of low salinity Pacific water into the Arctic Ocean; **I** is the Chukchi Sea, a site for production of cold halocline waters (HC) that drain into the Arctic Ocean via Barrow Canyon; **J** is the Alaskan North Slope coastal current connecting U.S. and Canadian coastal ecosystems; **K** is Arctic Ocean Station “A”, a times series maintained off and on since 1987; **L** is the Beaufort Gyre, the FW flywheel of the Arctic Ocean, in support of the Beaufort Gyre Exploration Project (BGEP); **M** denotes the ongoing monitoring of ice thickness and drift on the Canadian Beaufort Shelf; **N** is the coastal hydrology of the Canadian Beaufort Shelf and Arctic Archipelago, including lake and river characteris-tics; **O** represents physical and biogeochemical changes as ice and seawater (residence time ~ 5–10 years) transit the Canadian Arctic Archipelago; **P** represent various biological ‘hotspots’ *en route*, such as Bellot Strait, Gulf of Boothia and Barrow Strait, where physical processes produce and concentrate food for top predators; **Q** is the transit north across the poorly explored Sverdrup Basin; **R** is Arctic FW outflow through northern archipelago passages in support of CATS (Canadian Archipelago Through-flow Study) and ASOF (Arctic–Subarctic Ocean Fluxes) objectives; **S** is the “assembly” in northern Baffin Bay of Arctic outflow waters from Nares Strait (NS), Lancaster Sound (LS) and the West Greenland Current (WGC); **T** is Baffin Bay and its isolated deep water; **U** is Davis Strait and the

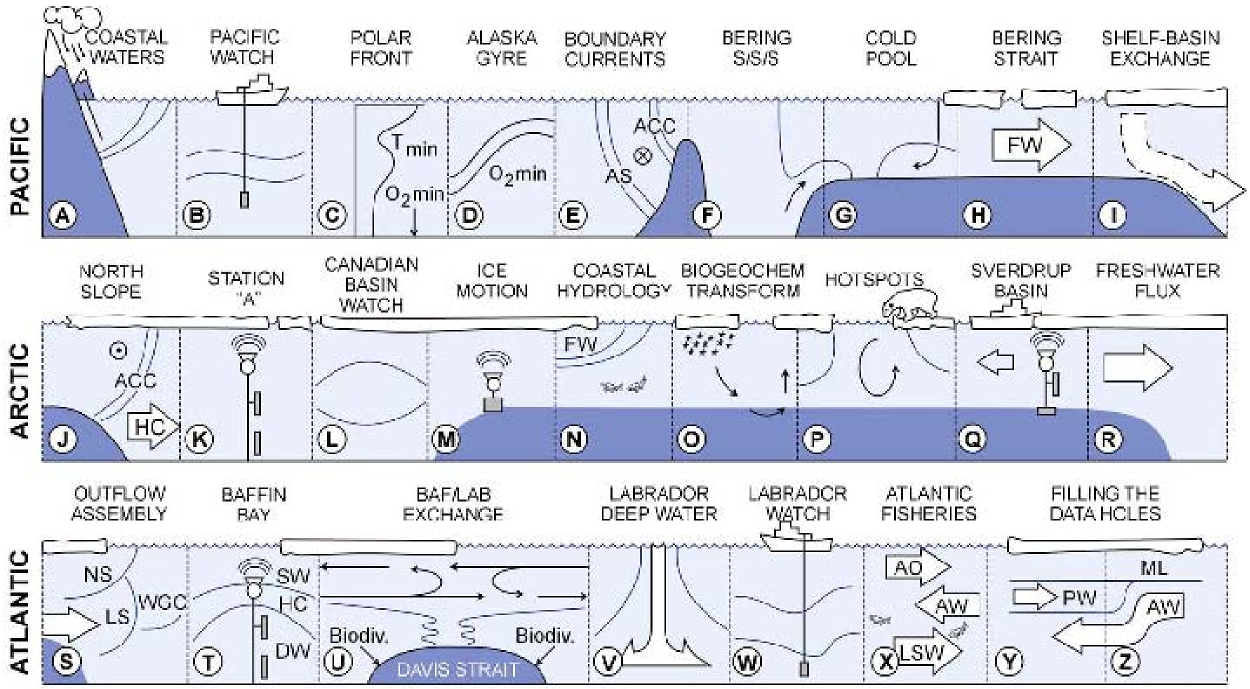


Fig. 2 Cartoon showing regional benchmarks along the C3O transect from the Pacific to the Atlantic via the Arctic. Letters and abbreviations are explained in the text.

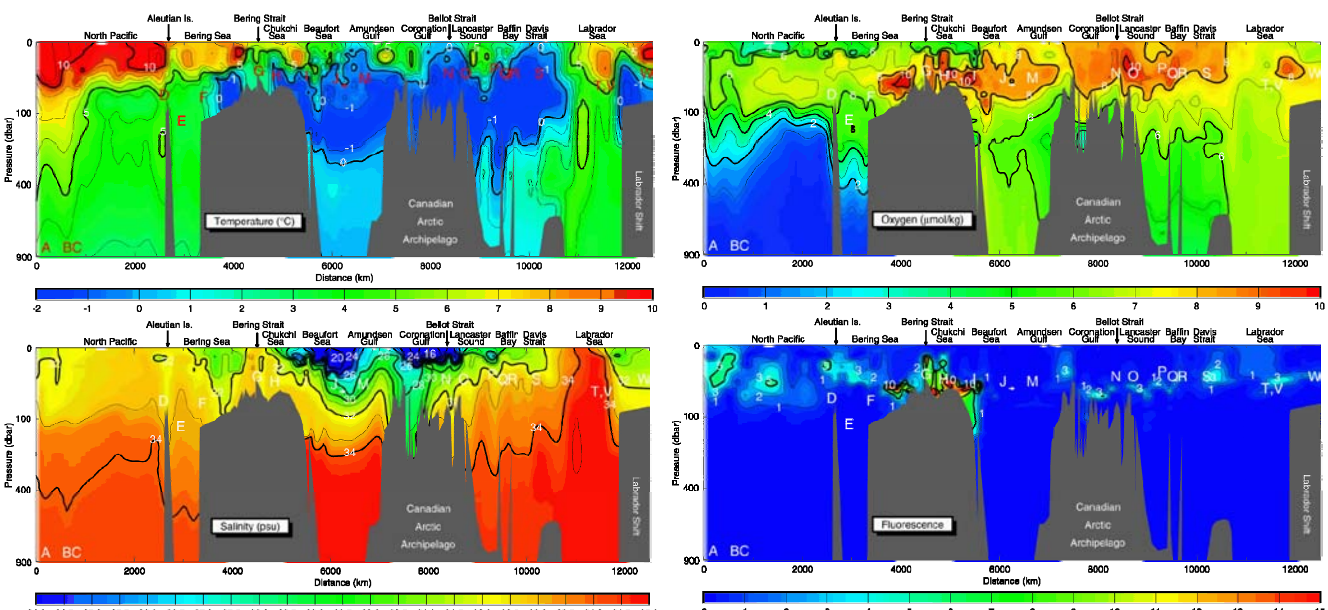


Fig. 3 Sections of temperature (top left), salinity (bottom left), dissolved oxygen (top right) and fluorescence (bottom right) along the C3O section from Victoria to Halifax (left to right). Letters are defined in the text.

bifurcations in the Baffin/Labrador and West Greenland currents, and the export of Arctic outflow waters; **V** is deep convection in the Labrador Sea; **W** passes near Ocean Station "B", another time-series icon; **X** represents the influence of arctic-derived waters on the physical habitat of the North Atlantic fisheries. Not shown above, but proposed, are hydrographic lines extending into the Canadian Hole (**Y**) and the Russian Hole (**Z**) of the Canada Basin where very little data exist and where the ice is quickly melting.

Summary

In 2007, C3O explored marine Canada from the surface to the seabed, from the smallest (virus) to the largest (whales) organisms, and from the Pacific to the Arctic to the Atlantic. Further, C3O is the only observationally-driven IPY project that shows the inter-connectedness of arctic and subarctic domains and how such domain boundaries may be affected by a changing climate. And while C3O is an IPY effort (2007–2011), its full scientific and social value will be realized when extended into the future – to 2050 and beyond – the time scales of social relevance as seen by international panels such as the Intergovernmental Panel on Climate Change and the Arctic Climate Impact Assessment. The requirement for a national commitment to a sustained, observationally-based ocean climate program is demonstrated by the uncertainties in climate model predictions, and a program to continually gauge, refine and update the real progress of change is urgently needed. Within the decade Northern Communities must be empowered to conduct as much marine monitoring as is possible. It is thus hoped that a major fraction of C3O monitoring methods will be turned over to local coastal communities and carried out by northern residents, following a community-based scientific franchise model.

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Dr. Eddy Carmack (Eddy.Carmack@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. Despite his enormous age, he maintains an indefatigable interest in the physical and biological dynamics of rivers, lakes and oceans and the consequences of natural and human systems to climate change. He leads the C3O effort.

Dr. Fiona McLaughlin (Fiona.McLaughlin@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. She applies novel geochemical methodologies to understand transport processes and time-scales in Arctic waters. Fiona is the Canadian Chief Scientist for the Canada/Japan/U.S. Beaufort Gyre Exploration Project.

Dr. Svein Vagle (Svein.Vagle@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. He uses acoustical methodologies to research mixing processes and to describe biological distributions in oceans, fjords and lakes. Svein is a hands-on scientist at home in all manner of ships and boats. He co-leads to C3O effort.

Dr. Humfrey Melling (Humfrey.Melling@dfo-mpo.gc.ca is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences. He has extensively researched marine cryospheric processes in Arctic seas, with foci on ice dynamics and ocean circulation. Humfrey is one of the few people in the world who can explain what is happening now! He leads the Canadian Arctic Through-flow Study (CATS).

New Surface Mooring at Station Papa Monitors Climate

by Robert Kamphaus, Meghan Cronin, Christopher Sabine, Steven Emerson, CHristian Meinig and Marie Robert

OCS Papa mooring in 4-m seas during February 2008 Line-P cruise.

Canadian weatherships endured winter storms in the Gulf of Alaska for 30 years (1951 to 1981) to monitor and report continuous meteorological and oceanographic observations from Ocean Weather Station Papa (50°N, 145°W). Since then, research vessels from various nations have visited the site at regular intervals from three to six times per year. A mooring was maintained there for two years (NOPP 1997–1999) and beginning last winter, a new mooring is continuing the legacy by re-occupying the station.

As one of the oldest oceanic stations, Station Papa is a critical component in the global network of OceanSITES reference stations. The University of Washington (UW), NOAA's Pacific Marine Environmental Laboratory (PMEL), and the Canadian Department of Fisheries and Oceans (DFO), with financial support from the U.S. National Science Foundation and NOAA's Office of Oceanic and Atmospheric Research have partnered to design, instrument, and maintain a new Ocean Climate Station (OCS) mooring for Station Papa (see photo). The OCS Papa surface mooring and a sub-surface acoustic Doppler current profiler (ADCP) mooring were deployed in June 2007 from the Canadian Coast Guard Ship *John P. Tully*. Anchored in 4200 meters of water, the 3-m diameter buoy design is based largely on NOAA's tsunami moorings that have survived in high-latitude conditions.

A suite of instruments provide near real-time access to key climate variables, including meteorological measurements, near-surface physical oceanographic properties, and air–sea CO_2 concentrations. Recovery of the deployed sensors, including several that do not transmit their data in real-time, will allow high-resolution quantification of ocean–atmosphere interactions, CO_2 and O_2 fluxes, currents, productivity, and the pH of oceanic waters. The mooring will be serviced in collaboration with scientists from DFO, Pacific Region, who visit OCS Papa as a component of their Line-P observations program.

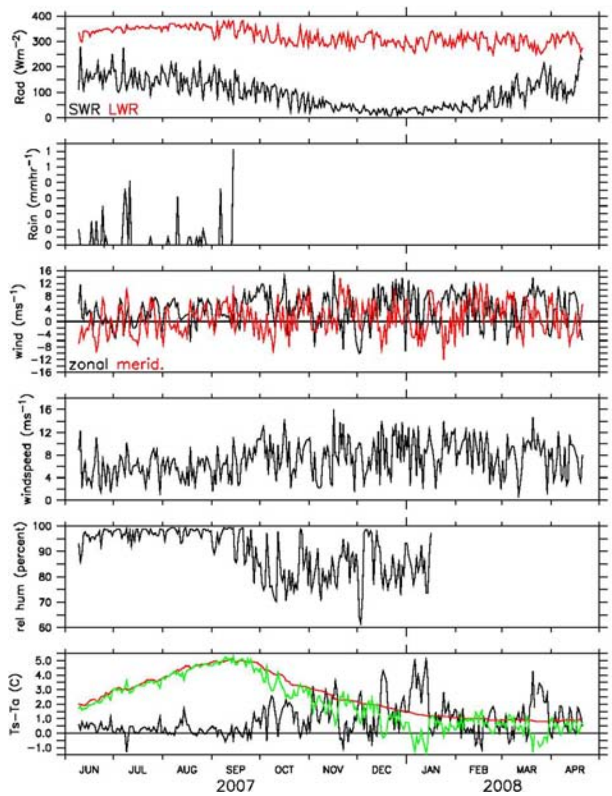


Fig. 1 OCS Papa time series. From top to bottom: short- and long-wave radiation, rain rate, U/V wind components, wind speed, relative humidity, and sea, air, and Δ temperatures.

The surface mooring has proved to be robust and reliable, providing near real-time hourly values from a suite of meteorological instruments and daily averages from both surface and subsurface instruments through the 2007–2008 winter season (**Fig. 1**). Data are transmitted to PMEL *via* Service Argos or Iridium and made available through the web (see: http://www.pmel.noaa.gov/stnP/). A subset of the meteorological data is also distributed *via* the Global Telecommunications System.

This is the first open-ocean mooring specifically designed to monitor ocean acidification. The OCS Papa mooring has been outfitted with a SAMI-pH sensor to directly measure acidity levels in the surface ocean. Monitoring pCO_2, O_2 and pH (**Fig. 2**) will allow a full description of the complex carbon chemistry at Station Papa and provide a better understanding of the processes controlling CO_2 variability at this site.

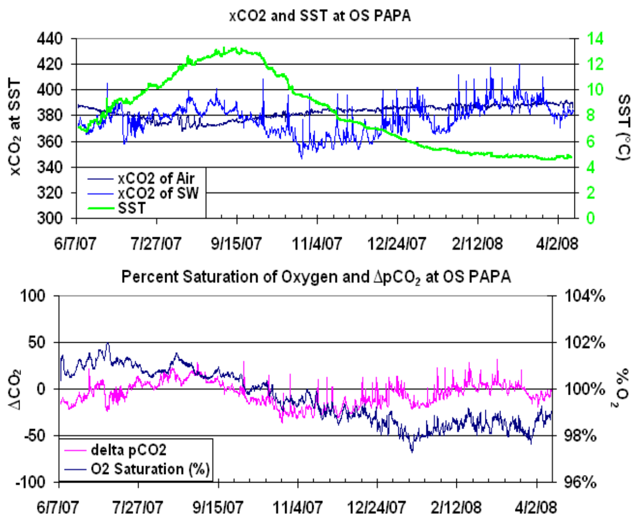


Fig. 2 CO_2 and O_2 data from the OCS Papa mooring (available at www.pmel.noaa.gov/co2/moorings/papa/data_145w_all.htm).

The valuable near real-time data will be augmented by high-resolution data after the sensors are recovered. Scientific analyses will produce improved understanding of surface heat fluxes, the mixed layer heat balance, mixed layer carbon dynamics, horizontal advection and entrainment velocities. In addition, episodic events such as freezing air temperatures and rapid carbon drawdown in surface waters will be investigated. Comparisons with similar data from the OceanSITES network could illustrate key differences in fluxes, cloud radiative forcing, carbon uptake, mixing, and eddies. The OCS Papa measurements also provide valuable data for assessing the accuracy of re-analyses of numerical weather predictions (NWP) and operational products.

Designed to be serviced every 6 months, the present mooring has been untended for over 9 months due to unfavorable weather conditions during the February 2008 servicing trip. A follow-on cruise is planned for June 2008. Upgrades will provide a significant increase in the near real-time transmission of subsurface data.

The OCS Papa surface mooring is funded until 2009 through a National Science Foundation Carbon and Water in the Earth System project “North Pacific Carbon Cycle” to Dr. Steven Emerson (UW). NOAA support is provided through the Office of Oceanic and Atmospheric Research. More information and data from the OCS Papa mooring can be found at http://www.pmel/noaa.gov/stnP/.

Robert Kamphaus (top left, Robert.A.Kamphaus@noaa.gov) is an Operations Manager for the National Oceanic and Atmospheric Administration (NOAA) Commissioned Corps assigned to the Ocean Climate Research Division (OCRD) at NOAA’s PMEL in Seattle.

Marie Robert (top right, Marie.Robert@dfo-mpo.gc.ca) is a Physical Oceanographer at the Institute for Ocean Sciences of Fisheries and Oceans Canada. She is the Coordinator of the Line P Program, managing research activities of this project, leading the cruises, and creating on-line products.

Christopher Sabine (bottom left, Chris.Sabine@noaa.gov) is an Oceanographer with OCRD at NOAA’s PMEL. He is an affiliate faculty at the UW School of Oceanography and a Senior Fellow of the Joint Institute for the Study of the Atmosphere and Ocean (JISAO), UW. His research focuses on discrete and moored inorganic carbon measurements in the oceans, including air–sea exchange of CO_2.

Meghan Cronin (bottom, second from left, Meghan.F.Cronin@noaa.gov) is also an Oceanographer with OCRD at NOAA’s PMEL, and an affiliate faculty at the UW School of Oceanography. She leads the Ocean Climate Stations program and her research interests include air–sea interaction and upper ocean dynamics. She is a Senior Fellow of JISAO.

Steven R. Emerson (bottom, second from right, emerson@u.washington.edu) is a Professor of chemical oceanography at the UW School of Oceanography. His research interests include cycling of metabolic gases and isotopes in surface waters, air–sea CO_2 exchange, and the effects of anoxic conditions on the solubility of metals in seawater. He is a Senior Fellow of JISAO and a member of the Board of Directors for the UW Program for Climate Change (PCC).

Christian Meinig (bottom, right, Christian.Meinig@noaa. gov) is an Engineer and the Leader of the Engineering Development Division at PMEL in Seattle.

The State of the Western North Pacific in the Second Half of 2007

by Shiro Ishizaki

Sea surface temperature

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

SSTs were generally below normal north of 30°N in July. In August, the negative SST anomalies in the seas adjacent to Japan turned positive and remained so for the rest of the year. These changes in SST anomalies were confirmed for regions 1 through 7 (**Fig. 2**). Positive SST anomalies exceeding +2°C prevailed east of Japan in September. In August, negative SST anomalies exceeding –2°C were found around 40°N, 165°E. These negative values had dwindled by September.

In November, positive SST anomalies dominated in the western equatorial Pacific (west of 150°E), while the negative values appeared east of 160°E along the equator. This contrasting distribution of SST anomalies corresponds to the pattern often observed during La Niña events.

Kuroshio path

Figure 3 shows a time series of the location of the Kuroshio path for this period. The Kuroshio took a small meandering path to the south of Honshu Island (between 135°E and 140°E) in August and November. When this small meander crossed the Izu Ridge (about 140°E), the latitude of the Kuroshio axis moved from north to south.

Carbon dioxide

JMA has been conducting observations for carbon dioxide (CO_2) in the surface ocean and atmosphere in the western North Pacific, on board the R/V *Ryofu Maru* and the R/V *Keifu Maru*. **Figure 4** illustrates the distribution of the difference in CO_2 partial pressure (pCO_2) between the surface seawater and the overlying air (denoted as ΔpCO_2) observed in the western North Pacific for each season of 2007. The sign of ΔpCO_2 determines the direction of CO_2 gas exchange across the air–sea interface, indicating that the ocean is a source (or sink) for atmospheric CO_2 in the case of positive (or negative) values of ΔpCO_2.

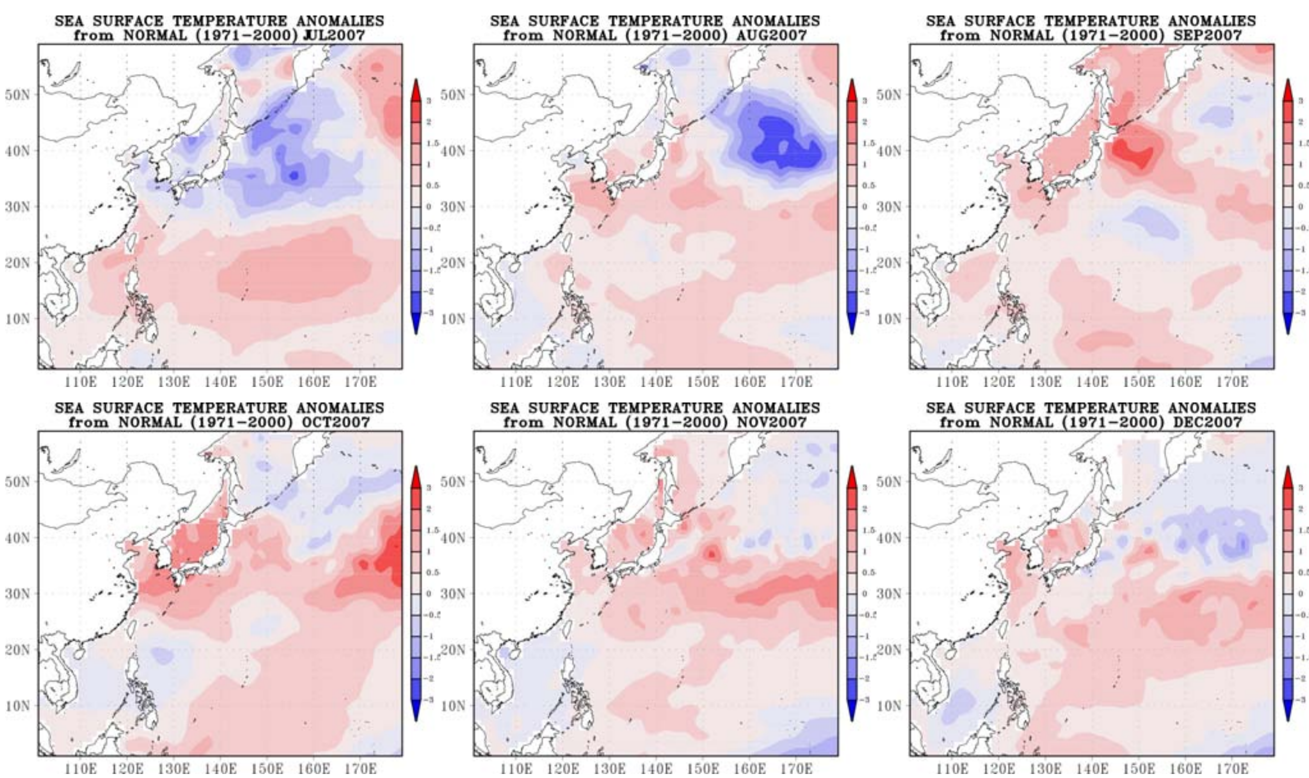
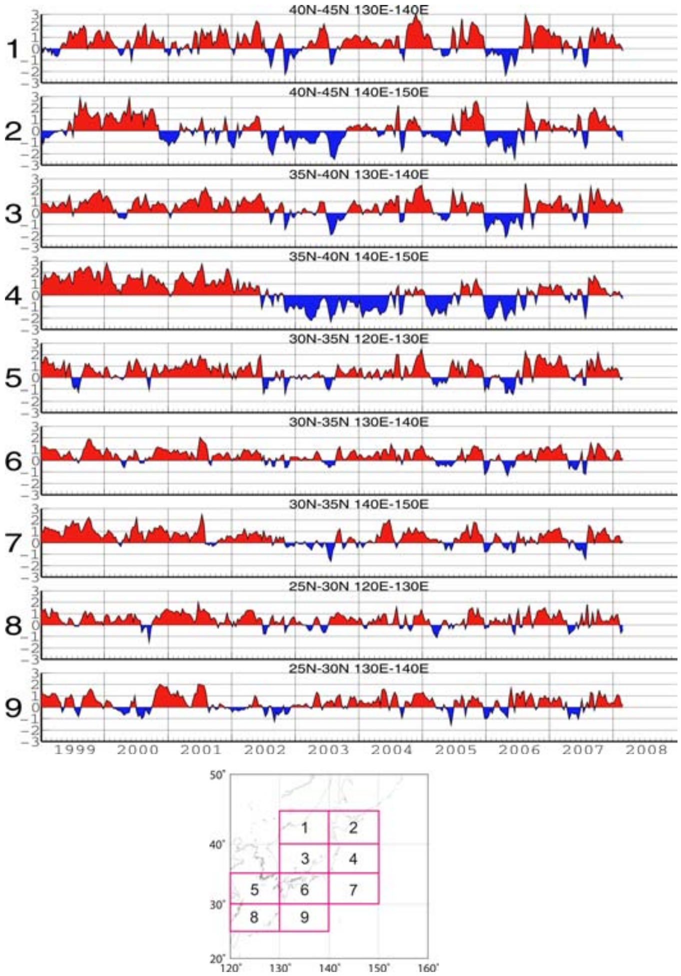
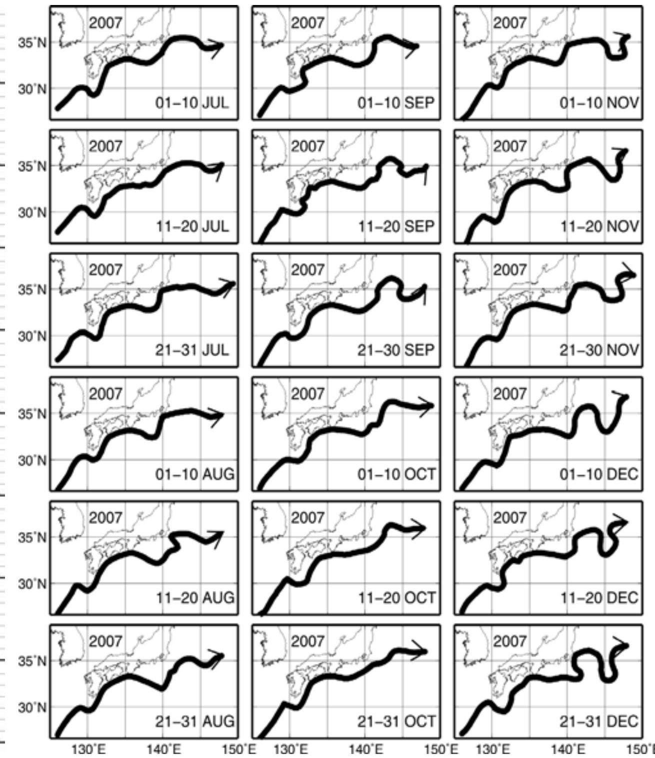


Fig. 1 Monthly mean SST anomalies (°C) from July to December 2007. Anomalies are deviations from JMA's 1971–2000 climatology.





Left column:

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

Right column:

Fig. 3 *Location of the Kuroshio path from July to December 2007.*

In the subtropical Pacific, oceanic pCO_2 was lower than atmospheric pCO_2 in the winter, spring and autumn of 2007, indicating that the region is a sink for atmospheric CO_2. On the other hand, CO_2 source regions were found in the summer of 2007. The equatorial Pacific acted as a weak CO_2 sink in winter, but the region turned into a CO_2 source (relatively higher between 157°E and 165°E) in the summer of 2007. The spring and summer seasons of the year were characterized by the La Niña event, and the eastern CO_2-rich surface water might have moved westward in response to zonal wind changes.

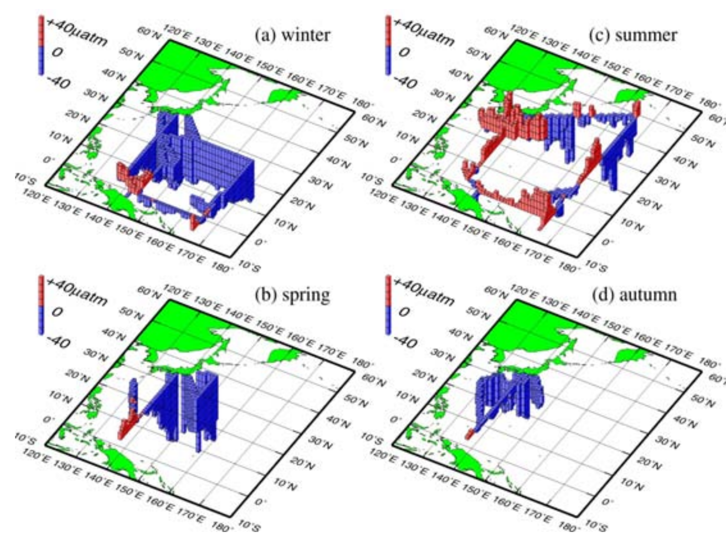


Fig. 4 *Difference in CO_2 partial pressure between the ocean and the atmosphere in the western North Pacific in 2007. Red/blue pillars show that oceanic pCO_2 is higher/lower than atmospheric pCO_2. Seasons are for the Northern Hemisphere.*

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.

The Bering Sea: Current Status and Recent Events

by Jeffrey M. Napp

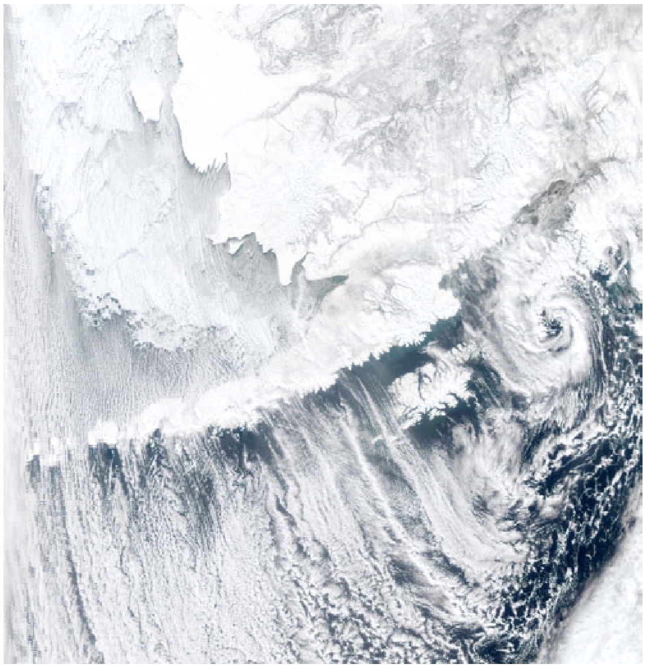


Fig. 1 Satellite image of Bering Sea and Gulf of Alaska (March 19, 2008). Extensive ice is evident over the Bering Sea shelf. Winds out of the north continued to push the ice farther south in March and substantial portions of the southern shelf were covered in May (courtesy of P. Stabeno and S. Salo, NOAA – PMEL).

Current status of the Bering Sea ecosystem

The Bering Sea cooled very quickly in the fall of 2007 but remained largely ice-free until the middle of December because the Arctic was warm. After December, the sea ice expanded quickly over the Bering Sea shelf, reaching St. Matthew Island in early January 2008 and St. Paul Island in late February 2008. Maximum ice occurred in late March (**Fig. 1**). Ice remained over substantial parts of the southern shelf in May and persisted in small pockets over the northern shelf until the latter half of June. This year (2008) was one of the most extensive ice years since the very cold period of the early 1970s. While the paradigm that the western Arctic must freeze before the Bering Sea can become ice-covered remained true in 2008, it was surprising how rapidly the Bering Sea could cool and become ice-covered.

The sea surface temperatures of the eastern Bering Sea and west coast of North America were several degrees colder than normal in June 2008 (**Fig. 2**). The monthly Pacific Decadal Oscillation index, (PDO, first EOF of North Pacific SSTs) switched from positive to negative values in September 2007, was strongly negative during the winter and spring 2008, and has remained so up to the publication of this article. Several times this decade the PDO has been negative (*e.g*., winter 2002, late fall 2005, fall 2006), but not nearly as strong or for as long as during this recent period. The negative PDO is attributed to La Niña on the equator and a stronger than normal subtropical high. These conditions create a strong flow across the central and eastern North Pacific. If this continues, we can expect a strong flow of subarctic waters into the California Current, with associated transport of subarctic fauna.

Ice and cold affected the biota as well during several expeditions that were set to study the importance of sea ice to this ecosystem. While there was a significant bloom of phytoplankton underneath the ice during the BEST/BSIERP spring cruise (see below), there was no evidence of a large-scale bloom on the middle or outer shelves.

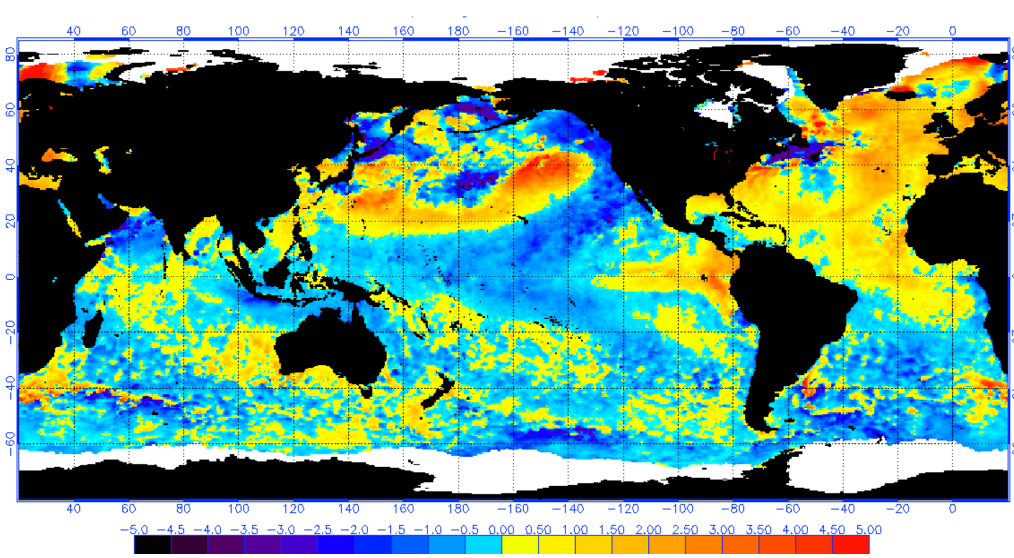


Fig. 2 NOAA/NESDIS sea surface temperature anomalies for June 16, 2008 (www.osdpd.noaa.gov/PSB/EPS/SST/data/anomnight.6.16.2008.gif).

Development of pollock and cod larvae along the Alaska Peninsula was somewhat delayed, in part due to the cold. The cold spring created excellent conditions for scientists who are seeking to learn how climate variability and loss of sea ice will influence the Bering Sea ecosystem. Scientists began their most recent attempts at understanding the eastern Bering Sea in the mid- to late 1990s. That period provided both warm and cool conditions, while 2000–2005 was warm. With the most recent collections in 2007 and 2008, scientists now have samples for both cool and warm phases of the region.

Next year in the Bering Sea ecosystem?

While correlations between ENSO and ice extent in the Bering Sea are not very high, there is a tendency during La Niña for more extensive ice in the Bering Sea. La Niña is weakening and the ENSO index is now neutral. In addition, the Arctic Oscillation (AO) has been strongly positive for the last two winters. A positive AO also tends to be associated with more extensive ice in the Bering Sea because it limits the propagation of storms from the south. These two large-scale climate patterns contributed to the cold and extensive ice formation in 2008. For 2009, there is considerable uncertainty in ENSO forecasts, but the spectra of the AO is red, so there is a tendency for patterns to repeat. One possible scenario for the winter of 2009 is a positive AO and neutral or even negative ENSO, and hence a continuation of the average to above average spring ice-extent that we saw during the winters of 2006–2008.

2008 activities in the Eastern Bering and Chukchi Seas

There are several ongoing projects with significant observation days this year. The U.S.–led **B**ering **E**cosystem **St**udy (BEST) and the **B**ering **S**ea **I**ntegrated **E**cosystem **R**esearch **P**rogram (BSIERP) have multiple cruises to the eastern Bering Sea (http://bsierp.nprb.org/cruises/cruise_calendar.html). The spring ice expedition by this partnership (March 31 to May 6) accomplished three major cross-shelf transects to the eastern Bering Sea using the U.S. Coast Guard Cutter (icebreaker) *Healy*. As this is being published, a shorter summer cruise (June 20 to July 18) is underway using the same platform. On the spring cruise, 12 scientific projects carried out a mix of process studies and observations. They collected many measurements of standing stock and rates in the ice, underneath the ice in the water column, and in the benthos. The cruise completed three cross-shelf transects, occupying stations along the 70-m isobath line, ice stations, and underway observations of marine mammals and seabirds. A final cruise report will soon be available on the BSIERP website. It is interesting to note that the extremely cold air temperatures initially made it difficult to conduct shipboard rate measurements because the outdoor incubations could not be kept ice-free.

There are other important expeditions to the Bering Sea this year. The Japanese Training Ship *Oshoro maru* from Hokkaido University is continuing its expanded geographic coverage of the eastern Bering Sea shelf and Chukchi Sea. A scheduled Russian–American Long-Term Census of the Arctic (RUSALCA) cruise aboard the Russian Research Vessel *Academic Lavrentiev* (August 27 to September 24) has been shortened. There were initially two legs: one to deploy moorings and another to make follow-up hydrographic, plankton and fisheries observations that began in 2004. At the time of this article, the hydrographic, plankton, and fisheries investigations (Leg 2) were postponed until the late summer of 2009. There are also reports that the Chinese icebreaker *Xue Long* will transit the Bering Sea in the fall for a cruise to the Chukchi Sea. Information about IPY Ocean projects can be viewed at http://www.ipy.org/index.php?ipy/content/projects/C34. A relevant question facing scientists and institutions in all PICES member countries is whether or not the rising prices of fuel will affect our abilities to fully execute existing research program implementation plans. Research and survey cruises to this remote, but economically important region may be negatively impacted.

A 1-day joint PICES/ESSAS workshop entitled "*Status of marine ecosystems in the sub-arctic and arctic seas – Preliminary results of IPY field monitoring in 2007 and 2008*" will be convened on October 24, 2008, at the PICES Seventeenth Annual Meeting in Dalian, China, for the presentation and discussion of results from IPY field projects. We hope to see you there!

Acknowledgements: Many thanks to the following PICEans who helped create this report: Drs. Nicholas Bond, James Overland and Phyllis Stabeno.

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

Recent Trends in Waters of the Subarctic NE Pacific

by William R. Crawford

The winter of 2007–2008 in the northeast Pacific Ocean felt the full impact of a strong La Niña, especially in January when it reached peak intensity. **Figure 1** compares average sea surface air pressure in January for the years 1949 to 2007 with the same feature for January 2008. The black arrows in each panel show geostrophic winds blowing toward the North American coast along these pressure contours. Note the prevailing southwesterly winds of typical years that bring warmer air toward the west coast of the United States and Canada. By contrast, the winds in January 2008 blew from the west-northwest with much cooler air temperatures. These anomalous winds are attributed to an eastward shift of the Aleutian Low (**L** in Fig. 1) in January 2008, together with the strengthening and westward shift of the North Pacific High (**H** in Fig. 1).

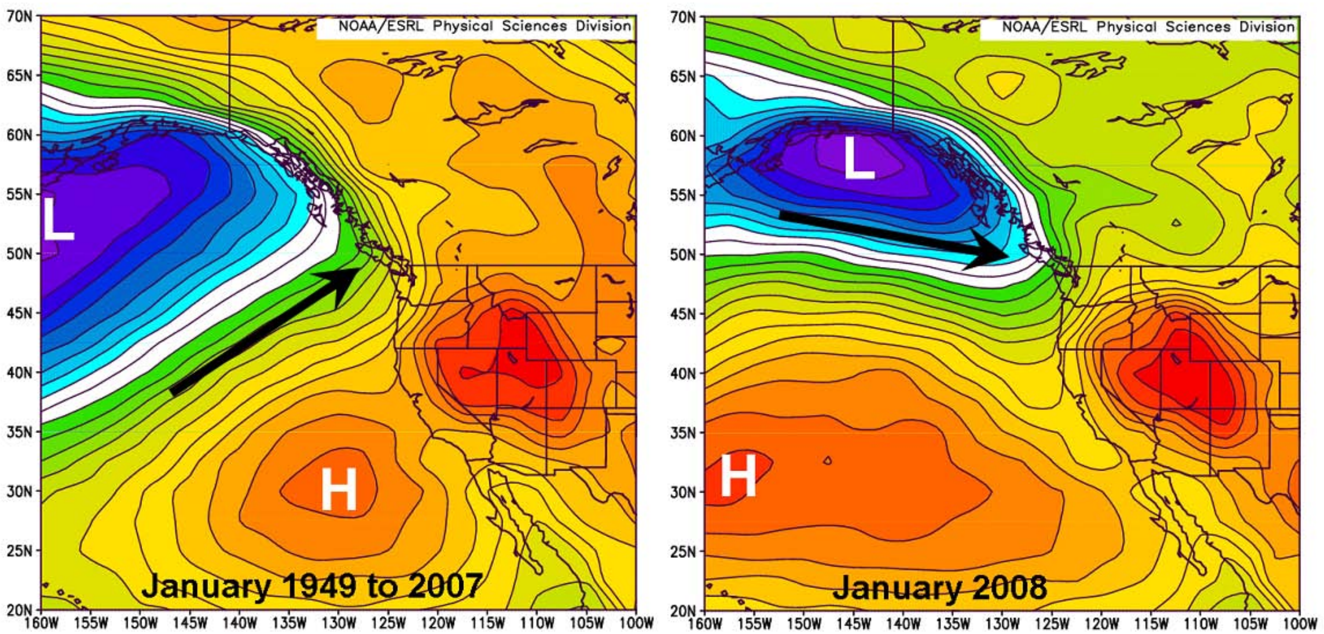


Fig. 1 Average sea surface pressure for January from 1949 to 2007 (left), and January 2008 (right) for western North America and the NE Pacific. Contours are at 1 mbar intervals. Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado.

This air pressure pattern set up the sea surface temperature (SST) anomaly pattern that was observed in January 2008 (**Fig. 2**). The largest negative anomalies lie on the equator, centred on the Niño 3.4 region, and along the entire west coast of North America. These two negative anomaly regions, together with the positive anomalies in the western and central Pacific, are typical of strong La Niña winters.

Figure 3 shows time series representing climate of the North Pacific Ocean plus El Niño and the Southern Oscillation Index (SOI). Most of these series display common variability, with blue regions prevailing prior to the regime shift near 1977, and red regions after that time. All time series shift from red toward blue for several years centred on 2000. This shift was accompanied by cooling of the ocean layer at 10 to 50 m depths in the eastern Gulf of Alaska (Line P) and along the west coast of Vancouver Island (Amphitrite Point), and in Niño 3.4 (Oceanic Niño Index). In general, this cooling aligns with La Niña, negative PDO and Aleutian Low Pressure Index, positive Victoria Mode and Southern Oscillation Index. Warming along Line P and at Amphitrite Point in 2002–2004 coincides with El Niño, positive PDO and negative PDO–Victoria Mode. Cooling since 2005 accompanies La Niña, with decreasing PDO and increasing PDO–Victoria Mode.

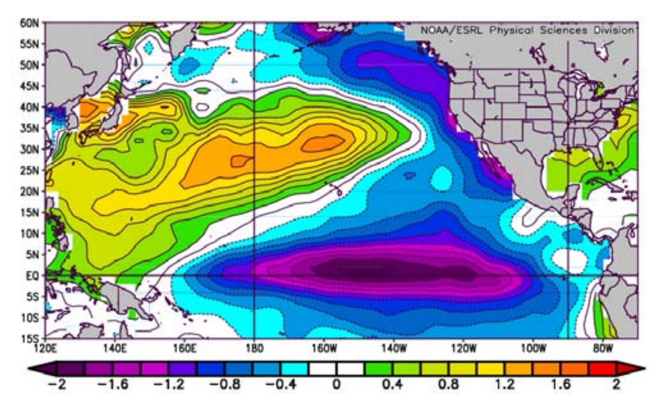


Fig. 2 Temperature anomalies (°C) in the Pacific Ocean north of 15°S for January 2008, referenced to January average temperatures of 1971 to 2000. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado.

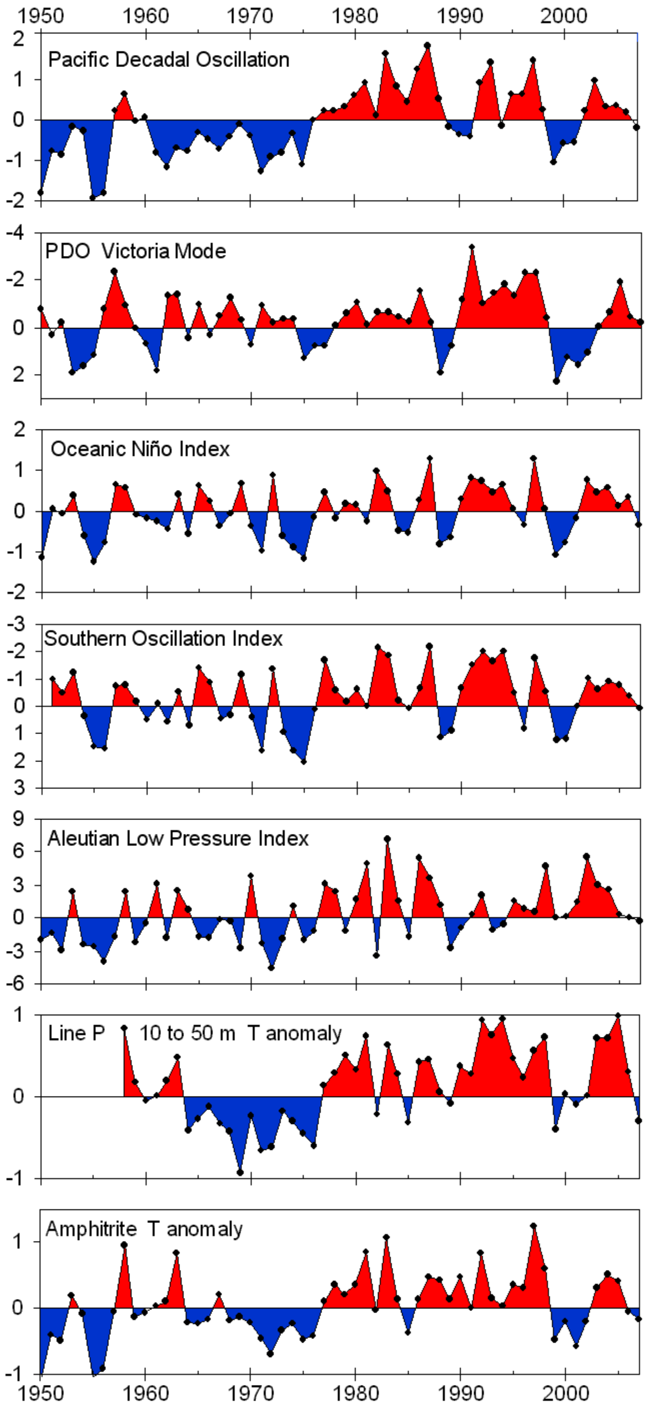


Fig. 3 *Annual indices of Pacific Ocean climate plus temperature anomalies (°C) of the Oceanic Niño Index and at Amphitrite Point and along Line P. The Southern Oscillation Index and the PDO–Victoria Mode are inverted so their variability is in phase with other series. Sources of time series and full description of these climate indices are in the State of the Ocean Report, DFO 2008 (sci.info.pac.dfo.ca/PSARC/OSR's/OSR.htm).*

These relationships generally hold, but there are several exceptions. For example, El Niño of 1972 was a major event in the tropical Pacific, but Line P and Amphitrite remained cool. Skip McKinnell at PICES has found that once a winter climate pattern becomes established over the tropical Pacific, its teleconnection to the Northeast Pacific has, over the last 60 years, provided a reliable leading indicator of ocean temperatures in spring (**Fig. 4**).

The bottom two panels in **Figure 3** reveal strong decadal and interannual variability in temperature that dominates the long-term trend. This temperature variability has caused significant changes in marine life along the west coast of Oregon to British Columbia, with boreal and sub-arctic zooplankton thriving in cool eras, Pacific hake penetrating much farther north in warm summers, and sardines increasing in numbers along the Canadian west coast in warm times. Numbers of sockeye salmon in rivers of the west coast of Vancouver Island tend to be lower if they went to sea as juveniles during a warm year. We expect this past variability provides insight into changes that will accompany future climate warming of the NE Pacific.

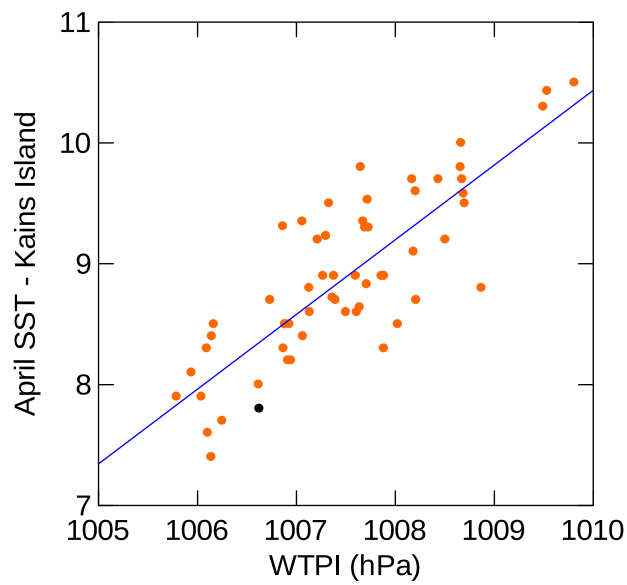
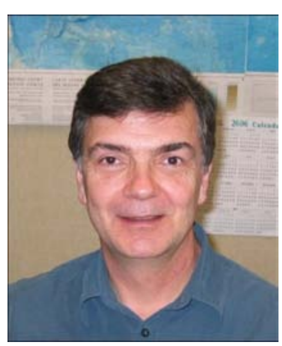


Fig. 4 *Mean April sea surface temperature (SST) at Kains Island, BC, Canada versus December/January average sea level pressure (SLP) in the Solomon Sea (1948–2008). The black dot represents 2008 and the coldest April since 1972. SST data are from Fisheries and Oceans Canada; SLP data are from NOAA/NCEP re-analysis.*



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

2009 Vintage of Fraser River Sockeye Salmon: A Complex Full Bodied Redd with Mysterious Bouquet

by The Sockeye Sommelier

Some stories about the biology of Pacific salmon are more compelling than others, and this is one. While catches in Japan, Russia and Alaska have been sustained at high levels, salmon fishermen from southern British Columbia in Canada to California in the United States have suffered from few fishing opportunities for at least a decade. From Vancouver Island south to California, young salmon that went to sea in 2005 were particularly hard hit by an unproductive coastal ocean that caused a total closure of the lucrative Fraser River sockeye salmon fishery in 2007. Expectations for returns in 2008 are better, but not by much. *Alors, quel dommage!*

Chilko Lake has been the largest producer of sockeye salmon in the Fraser River over the last 50 years. It is located in the lee of the Coastal Mountain Range, high upon the Chilcotin Plateau of British Columbia. The lake is so deep and cold that most colour-sensing satellites cannot detect any trace of the colour that indicates plankton growth at the base of the food web. Yet, adult sockeye salmon continue to spawn in the Chilko River and the newly hatched fry migrate into the chilly lake to feed for one or two years before heading downstream to the sea.

With the signing of the Pacific Salmon Treaty between Canada and the United States in 1985, Fisheries and Oceans Canada inherited a responsibility from the now defunct International Pacific Salmon Fisheries Commission to count the number of young sockeye leaving Chilko Lake each year. It is the only sockeye stock of the more than 30 in the complex Fraser River system where a long record has been maintained. As a consequence, it is the only site where long-term changes in freshwater and marine survival can be distinguished. Since the 1950s, the average number of smolts making the annual journey to the sea is 18.5 million 1-year olds and 0.6 million 2-year olds. When fewer leave the lake, it is generally a sign that fewer adult sockeye salmon will return to spawn two years later.

Amid all of the bad news, something truly remarkable and equally mysterious has happened to sockeye salmon in Chilko Lake. The number of smolts that left the lake in the spring of 2007 was twice the previous maximum (**Fig. 1**). Note that this is not twice the average, but double the maximum ever observed since records began in the 1950s. The mystery deepens when pausing to notice that their average size, mostly a result of growth in the lake during the spring/summer of 2006, was slightly above the long-term average. It is common practice in salmon biology to expect that a dramatic increase in numbers will coincide with a smaller body size if they are all competing for the same limited food supply in the lake.

Was this apparent miracle something that occurred only in 2006 while this opus vintage was feeding and growing? Apparently not. The average size of 1-year old smolts that went to sea the year before this bumper crop, and will return as adults in 2008, was the largest on record. Evidence of this tremendous growth appeared in 2007 when the 2-year olds of the same cohort emigrated with the bumper crop of 1-year olds. They were the largest 2-year olds ever observed. None of this spectacular growth can be explained solely by a low abundance of parents in 2004, as these levels have occurred frequently in the past, but without any sign of an accompanying growth spurt in the fry. Something truly mysterious began in 2005 that made Chilko Lake far more friendly for sockeye salmon than normal.

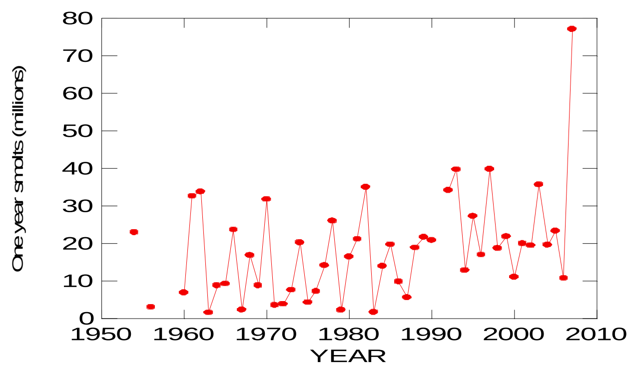


Fig. 1 Annual estimates of 1-year old sockeye smolts emigrating from Chilko Lake (Data from Fisheries and Oceans Canada).

So what to expect in 2009 from these 78 million smolts? One of two things will happen. Either the lowest marine survival of Chilko Lake sockeye in history will produce little benefit for anyone, or there will be a lot of Chilko Lake sockeye. There are not many options. Even at the lowest marine survival ever observed, returns to Chilko Lake alone would be ~1,000,000 sockeye. At the moment, there is no evidence that marine survival of this cohort will be so low. At average survival, returns will be about 6 million and if better than average (2007 was one of the more sockeye-friendly years to go to sea)…what a spectacular vintage it will be! For the moment the mystery around what happened in Chilko Lake in 2005-2006 remains unsolved. If anyone has a clue, be sure to pass it on. In the meantime, anticipating a fine vintage can be almost as much fun as tasting it. *Bon appetit!*

Pacific Biological Station Celebrates Centennial Anniversary, 1908–2008

by Mary Thiess

Pacific Biological Station (PBS) in 1912 (above) and 2008 (below). The original structure was demolished to accommodate in 1948 what is now known as the Clemens Wing (arrow inset).

PBS scientists in 1958 (photo taken at c. 50th anniversary). Seated (l-r): J.R. Brett, R.E. Foerster, A.W.H. Needler (Director), F.H.C. Taylor, J.D. Strickland, N.P. Fofonoff, W.E. Ricker, (Editor – Fisheries Research Board of Canada); standing (l-r): L. Margolis, F.C. Withler, F. Neave, F.C. Barber, W.P. Wickett, D.J. Milne, K.S. Ketchen, J.C. Stevenson (Assistant Director).

This year marks the 100th year of scientific research and discovery at the Pacific Biological Station in Nanaimo, British Columbia, Canada. The Station was established by the Government of Canada in 1908 to provide a facility for fishery and aquatic research on the Pacific coast. It quickly became a destination for many types of investigators, including marine biologists, naturalists, professors and keen amateur volunteers who explored the riches of the Pacific coast.

Research expanded to include fisheries science, botany, oceanography, aquaculture and enhancement, limnology, and many multi-disciplinary areas in between. The earliest studies focussed on collecting, identifying and enumerating the vast array of aquatic (and terrestrial) plants and animals near Departure Bay. Many noteworthy scientists have called the Station home during their lifetimes. William Ricker (fisheries), John Tully (oceanography), J. Roland Brett (physiology), Leo Margolis (parasitology), and Daniel Ware (ecology) were intimately linked to the research conducted at the Station during their lifetimes. Today, the Pacific Biological Station remains an eminent centre for fishery and aquatic research along the Canadian Pacific coast, and work conducted at the site continues to influence fisheries science around the world.

Many special events honoured the centennial. An Open House late April drew approximately 20,000 visitors. Staff created nearly 60 exhibits that highlighted current research programs. The Research Vessel *W.E. Ricker* was on hand for tours, and specially designed tanks showcased examples of local fishes and invertebrates. A public lecture series continuing throughout the summer and fall, started with a presentation by Mark Angelo, a Vancouver-based river conservationist and adventurer. A second lecture occurred in June with a panel discussion on climate change. The third lecture, scheduled for mid-September, will feature Alaskan artist/scientist Ray Troll. In Ottawa, during the Annual General Meeting of the American Fisheries Society, the 100th anniversary of Canadian aquatic science laboratories will be celebrated at an evening reception. An October gala in Nanaimo will wind up the centennial festivities with a reception and lectures by three of the Station's scientists.

Mary Thiess *(Mary.Thiess@dfo-mpo.gc.ca) works with Dr. Marc Trudel in the High Seas Salmon research program at the Pacific Biological Station. She has a M.Math degree in Biostatistics from the University of Waterloo and has been enjoying her work at the Pacific Biological Station since 2000.*

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