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The 2012 Inter-sessional Science Board Meeting: A Note from Science Board Chairman

The 2012 inter-sessional Science Board meeting (ISB-2012) was held May 24–25, in Busan, Korea, back to back with a workshop to develop a roadmap for our integrative science program, FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems). I thank the Korean Government for hosting both these events. I also would like to welcome two new Science Board members, Dr. Elizabeth Logerwell (Chair of the Fishery Science Committee) and Dr. Igor Shevchenko (representative of Russia).

There were two important events during the first half of 2012 (see the articles in this issue for further details). The 2nd PICES/ICES Conference for Early Career Scientists on "*Oceans of Change*" (April 24–27, Majorca, Spain) was a huge success, with excellent presentations from 130 attendees selected from 550 applicants. The main objective of this conference series was to encourage the next generation of ocean scientists meet early in their career to share knowledge and to build networks across disciplines and international borders. The 2nd international symposium on the "*Effects of Climate Change on the World's Oceans*" was convened from May 13–20, in Yeosu, Korea, in conjunction with Ocean Expo-2012. As with the first version of this symposium (May 2008, in Gijón, Spain), PICES, ICES (International Council for the Exploration of the Sea) and IOC (Intergovernmental Oceanographic Commission of UNESCO) were the major sponsors. More than 300 scientists from 31 countries attended. Ten topic sessions and seven workshops dealt with various issues ranging from projections of climate change impacts on ecosystems and genetic and physiological responses to ocean observations and human dimensions. After having the first two symposia in Europe and Asia, planning has begun for the next symposium in this series to take place in 2015 or 2016 in South America.

Immediately after the Yeosu symposium, PICES moved down the coast to Busan for a FUTURE workshop from May 22–24. FUTURE is the central science program of PICES whose goals are to be achieved by 2019. Since inauguration of the program at PICES-2009, we have been building up its

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Group photo of ISB-2012 participants.

activity. At the request from Science Board, four new expert groups were approved at PICES-2011: Section on *Climate Change and Marine Ecosystems* (S-CCME), Section on *Human Dimension* (S-HD), Working Group on *Regional Climate Modeling* (WG 29) and Study Group on *Marine Pollutants* (SG-MP) This was a big breakthrough for FUTURE as the program is now equipped with expert groups that can undertake the tasks identified in the Science Plan and Implementation Plan. Together with the existing expert groups, FUTURE has enough power to move forward. However, with more "elements" comes a need for a better coordination. Complicated connections among expert groups require well-planned coordinated efforts with specified products and information flows. About 40 participants representing expert groups and member countries reviewed the plans of the existing expert groups, identified gaps and necessary actions to deal with these gaps, and discussed potential FUTURE products and their users, and communication strategy. A detailed workshop report is included in this issue of PICES Press.

At ISB-2012, the first agenda item was on interactions with other international organizations and programs that have steadily strengthened in the past years. This year is not an exception, and we have many excellent proposals on the table. Since PICES and ICES built a formal framework for cooperation in 2011, we are streamlining the Topic Session/Workshop submission-selection process for joint sessions and increasing joint activities.

Science Board discussed and approved joint activities and future plans for collaboration with SCOR (Scientific Committee on Oceanic Research) and IOC, among others. A 2-day SCOR/PICES workshop on "*Global patterns of phytoplankton dynamics in coastal ecosystems*" and a 1-day SCOR WG 137 meeting will be held in conjunction with PICES-2012. Planning is underway for a small workshop in the spring of 2013 and a larger Open Science Meeting the following year to discuss linkages between harmful algal blooms and climate change. This effort is supported by ICES, IOC, SCOR and PICES.

It is known that the effects of climate change in the ocean were under-represented in previous assessment reports of the Intergovernmental Panel on Climate Change (IPCC). This was unfortunate because the ocean plays an important role in climate change. Changes in marine ecosystems affect society and have significant socio-economic implications. Starting from the IPCC 5th Assessment Report, PICES scientists are making contributions. Members of the Section on *Carbon and Climate* (S-CC) are the lead authors of Working Group 1 chapters 3 (Observations: Oceans) and 6 (Carbon and Other Biogeochemical Cycles). The Biological Oceanography Committee (BIO) recently reviewed an early draft of a section of the Working Group 2 chapter on "High latitude spring bloom systems." PICES scientists were encouraged to register as reviewers of the draft WG 2 report. I expect that PICES' contributions to future IPCC ARs will be greatly enhanced as FUTURE program advances.

Skip McKinnell (PICES Secretariat) and Atsushi Tsuda (BIO Chairman, Japan) discuss the IPCC 5th Assessment Report.

PICES scientists also attended the meeting of the Pacific Implementation Panel of CLIVAR (Climate Variability and Predictability Program) held from April 28–29, 2012, in Noumea, New Caledonia, to speak about PICES activities and seek closer collaboration with CLIVAR as it widens its scope on issues relevant to PICES. CLIVAR is co-sponsoring (along with ICES) a Topic Session (S3) on "*Challenges un understanding Northern Hemisphere ocean climate variability and change*" at PICES-2012.

The Working Group on *North Pacific Climate Variability and Change* (WG 27) and the FUTURE Advisory Panel on *Climate, Oceanographic Variability and Ecosystems* (AP-COVE) are organizing, jointly with US-GLOBEC and ICES, an international workshop on "*Forecasting ecosystem indicators with climate-driven process models*" to be held September 8–10, 2012, in Friday Harbor, USA.

The Technical Committee on Data Exchange (TCODE) is participating in the International Oceanographic Data and Information Exchange of IOC (IODE) activities. I can foresee that cooperation with these and other international organizations and programs will continue to be stronger.

A significant part of ISB-2012 was dedicated to reports from the Chairmen of all PICES Scientific and Technical Committees about their activities since PICES-2011. Science Board reviewed the plans of each Committee's subsidiary bodies for publications, workshops, participation at other meetings, and budgetary issues. I am pleased to report that all Committees are doing well, except for a few delays. Two long-standing expert groups are re-energizing their activities for the future. The Advisory Panel on *Marine Birds and Mammals* (AP-MBM) is planning a workshop to evaluate the feasibility of updating a report on prey consumption by marine birds and mammals (and now predatory fishes) that was published 12 years ago. The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB) is revising its terms of reference to be more in line with FUTURE objectives.

It was good news to learn that a 5-year PICES project on "*Marine ecosystem health and human well-being*" will be funded by the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF). The overall goal of the project is to identify the relationships between sustainable human communities and productive marine ecosystems in the North Pacific under the concept of fishery social-ecological systems. It is linked directly with the FUTURE Key Scientific Question 3 "How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?" The project will integrate, support and expand the activities of several PICES expert groups, including the Section on *Human Dimensions*, Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*, Working Group on *Non-indigenous Aquatic Species* and Section on *Ecology of Harmful Algal Blooms in the North Pacific*. Science Board agreed that the project would make a very important contribution to FUTURE and approved the proposed outline and principles of the project. Drs. Ian Perry (Canada) and Mitsutaku Makino (Japan) were appointed as the Principal Investigators. Their first job is to select a project team and initiate preparations for its first meeting at PICES-2012.

Science Board reviewed capacity building activities, another high priority issue for PICES. Several events will be supported in 2012–2013 and beyond:

- PICES will co-sponsored the IMBER ClimECO3 Summer School on "*A view towards Earth System models: Human-natural system interactions in the marine world*" (July 23–28, 2012, Ankara, Turkey) by providing travel funds and arranging additional support (through national programs/agencies) for 5 early career scientists from PICES member countries.
- The first PICES Summer School in North America on "*Ocean observing systems and ecosystem monitoring*" will be held in August 2013, in Newport, Oregon, USA. This 5-day course will consist of classroom lectures, laboratory demonstrations of interdisciplinary ocean sensors, an introduction to ocean observing platforms and fieldwork on a research vessel to deploy ocean observing equipment at sea. Techniques of data quality control and data processing of time series will also be demonstrated. A willingness was expressed to host a PICES Summer School in Korea in 2014.
- China successfully hosted the first UNESCO/IOC Ocean Dynamics and Climate training course in 2011, in Qingdao, and is planning to host the next course in 2013, tentatively on air–sea interactions. PICES was invited co-sponsor this effort, and Science Board agreed to discuss the proposal at PICES-2012 when more details are known.
- Science Board continues to strongly support the series of PICES/ICES Conferences for Early Career Scientists. Given that previous conferences took place in North America and Europe, perhaps the next one could be held in Asia. It was agreed to look into the matter at PICES-2012.

A PICES Visiting Scientist Program was approved in 2001 but never used. With the implementation of FUTURE, the plan is to resurrect the Visiting Scientist Program to provide additional resources in developing FUTURE products. Science Board is receptive to the idea, and discussed such issues as defining explicit tasks, advertizing, and selecting agencies to be approached. Science Board will revisit this matter at PICES-2012.

Now is the time to write your proposals for scientific activities at PICES-2013 in Nanaimo, Canada. A new web-based system to manage PICES topic session and workshop proposals has been developed to streamline the process of submitting, reviewing and, ranking all the proposals. The goal is to provide an open and transparent process that will improve the efficiency of developing a scientific program for an Annual Meeting. Science Board fully endorsed the pilot, and offered some suggestions for improvement. The pilot will run for one year to evaluate its effectiveness. Submissions for PICES-2013 will close September 7, 2012, to be followed by a period of about 3 weeks to allow Committee members and FUTURE Advisory Panel members to evaluate (vote on) the proposals. Results will be available for comparison.

As is normal practice at the ISB, Science Board met *in camera* to decide on the recipients for PICES awards for 2012. The Wooster Award is given annually to an individual who has made significant contributions to North Pacific marine science, and the PICES Ocean Monitoring Service Award (POMA) is to acknowledge monitoring and data management activities that contribute to the progress of marine science in the North Pacific. The recipients will be announced during the Opening Session at PICES-2012.

Russia offered to host an inter-sessional Science Board meeting in 2013. Potential venues in eastern and western Russia were considered. If the latter is chosen, it will provide an opportunity to hold a joint PICES/ICES workshop to stimulate activity under the new Framework for PICES-ICES Scientific Cooperation. Discussions are underway with ICES leaders about topics of shared interest with PICES.

Science Board will recommend to Governing Council that it convene a FUTURE Open Science Meeting in 2014. It will provide a mid-term opportunity for the FUTURE Scientific Steering Committee to review the progress made to date in answering the Key Scientific Questions and, by opening the event to the general marine science community, to get input on filling gaps in the program and making mid-course corrections FUTURE's future.

Finally, the next Annual Meeting (PICES-2012) will be held from October 12–21, 2012, in Hiroshima, Japan. The overall theme of PICES-2012 is "*Effects of natural and anthropogenic stressors in North Pacific ecosystems: Scientific challenges and possible solutions*". Many interesting sessions and workshops, covering a wide range of topics, are planned. In addition to these scientific attractions, there will be lots of interesting sights to enjoy. Hiroshima is known as the City of Water, with six rivers flowing through it. I hope to see you all in the City of Water!

Sinjae Yoo, Science Board Chairman

PICES Interns

We offer sincere thanks to Ms. Jeongim Mok (left), the 2011 PICES intern, who completed her term at the PICES Secretariat last April and is now with the Department of Marine Policy at the Ministry of Land, Transport and Maritime Affairs (MLTM), in Seoul, Korea. Many of you had an opportunity to communicate with Jeongim at the 2011 ESSAS Open Science Meeting in Seattle (USA), PICES-2011 in Khabarovsk (Russia) and in the PICES Secretariat office. It was easy and enjoyable working with Jeongim, and we appreciate her dedicated efforts during this past year and wish her a very successful career. We do hope to see her again at various PICES events in Korea.

We are pleased to announce that Dr. Zhuojun Ma (right) joined the Secretariat in July as the 2012 PICES Intern. He obtained his PhD in Biology from the Tsinghua University in Beijing. Zhuojun has worked as a project manager and deputy director in the Division of Academic Exchange and Cooperation at the Chinese Academy of Fishery Science (CAFS). Besides his research interests in biomineralization and in marine biology, Zhuojun is fascinated by the science of fish behavior and has years of experience in tropical freshwater fish breeding, especially in breeding African cichlid and stingray. He is also a good swimmer and likes to spend his spare time in Nature. We look forward to Zhuojun's involvement in PICES activities.

2012 Inter-sessional Workshop on a Roadmap for FUTURE

by Sinjae Yoo, Hal Batchelder, Thomas Therriault and Hiroaki Saito

Background

By the end of 2011, four new expert groups were established for the PICES FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) science program, which now has the minimal number of expert groups required to undertake the tasks identified in the FUTURE Science Plan and Implementation Plan. These expert groups will interact and exchange information and products that contribute to fulfilling the FUTURE objectives. Understanding the roles and responsibilities of each expert group within the FUTURE framework and conducting the necessary work in concert with other groups in a timely manner are vital for the success of FUTURE. A 2.5-day inter-sessional workshop was held May 22–24 in Busan, Korea, to develop a higher level coordination plan where tasks and roles of expert groups, information flows, and products were specified and aligned. A total of 42 participants representing expert groups and PICES member countries gathered and reviewed the plans of the existing expert groups, identified potential new expert groups, and discussed a roadmap where outputs and products of FUTURE are specified within a timeline.

FUTURE objectives and expert groups

FUTURE products/outcomes are described under the two Objectives in the Implementation Plan:

(1) Understanding critical processes in the North Pacific;
(2) Engagement with human society with useful products such as status reports, outlooks, and forecasts.

Expert groups that are responsible for each Objective gave short presentations, which were followed by discussions.

For Objective 1, there are three overarching Key Scientific Questions: (1) What determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing? (2) How do ecosystems respond to natural and anthropogenic forcing, and how might they change in the future? (3) How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems? The review began with a summary report of the results of the FUTURE Workshop on "*Indicators of status and change within North Pacific marine ecosystems*" held April 26–28, 2011, in Honolulu, USA, to tackle the major issues of the Key Scientific Question 1: ecosystem indicators and assessments, ecosystem resilience, and indicator uncertainty (PICES Press, Vol. 19, No. 2, pp. 5–8). The workshop recommended that FUTURE develop a framework to be used for identifying and calculating indicators for the common descriptors and attributes for North Pacific ecosystems. Through the discussion there was also a consensus that the concept of ecosystem resilience is still poorly developed and many aspects need to be studied. This requires an expert group to deal with theoretical and operational issues of resiliency and vulnerability. A tangible outcome from the workshop was the establishment of a Working Group on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* (WG 28). This group will focus mainly on Key Scientific Questions 1 and 3, and analyze the regional activities/stressors, habitats, vulnerabilities, and potential indicators in the North Pacific. Based on this analysis, a database of activities/stressors, habitats, and vulnerabilities of these habitats will be developed to produce indicators suitable for member countries. WG 28 will also provide new information which will enable a working

Group photo of the workshop participants.

group to be formed in the next 2–3 years that will address the ecosystem resilience issue.

The Working Group on *North Pacific Climate Variability and Change* (WG 27) will develop mechanism-based conceptual frameworks that link climate variability and ecosystem change in the North Pacific. Results from this expert group will be utilized in developing models for forecasting the ecosystem changes, and thereby address Key Scientific Question 2. WG 27 will also develop a method to identify and provide uncertainty estimates of decadal variability in recent historical climate and ecosystem time series.

The Working Group on *Regional Climate Modeling* (WG 29) will evaluate the projections from the 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and examine how to downscale the outputs from global climate-ocean models so that these outputs (circulation, mixed layer depth, *etc*.) can be used in regional ecosystem models. The current gaps are limited biogeochemical modeling and upper trophic level modeling, limited regional coverage, and nonexistent or inadequate boundary conditions.

The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (S-HAB) interests in ecosystem disruption of primary producers, which will propagate through food webs, is related to the Key Scientific Question 2 and 3. Although it is not possible (yet) to predict the occurrence of HABs, it may be feasible to produce ecosystem 'market' reports which forecast how HABs may respond to specific temporal or spatial changes in ocean conditions.

The Section on *Carbon and Climate* (S-CC) will provide expertise in ocean biogeochemistry and acidification and produce data products related to ocean acidification and de-oxygenation.

The authors of this article, Thomas Therriault (Canada/AICE), Hiroaki Saito (Japan/COVE), Hal Batchelder (USA/SOFE) and Sinjae Yoo (Science Board Chairman, discuss FUTURE objectives.

The goals of the Section on *Climate Change Effects on Marine Ecosystems* (S-CCME) are to build predictive capability of the impacts on fish and fisheries of future climate change, such as that from IPCC AR5 assessments. S-CCME will evaluate and project climate change impacts on marine ecosystems through international collaboration with organizations such as ICES. This group is expected to play a central role in FUTURE by producing a regional synthesis.

Users and products

Scientists are the primary users of the products from FUTURE Objective 1, as this is basically about scientific understanding. FUTURE Objective 2 aims to provide products to various segments of human society, which will face significant challenges, especially in coastal ecosystems that provide many ecosystem services, but are most vulnerable to sea-level rise, overexploitation of living marine resources, and anthropogenic pollution, among others. The users of the products from Objective 2 remain ill-defined. The discussion in the workshop naturally continued with the question about who the users are. The question is fundamental—FUTURE has to identify who the users are, and engage them to determine what products they desire and whether those are attainable. PICES is strongly linked with fisheries agencies, but there is a need to have a broader engagement. The Organization is a leader in ecosystem-climate variability research but the anticipated products of FUTURE are beyond the scope of what PICES has produced in the past. However, it is important for PICES to maintain scientific excellence. One dilemma is that our scientific capability is weaker at making predictions on short time scales than on longer time scales, yet society needs short-term predictions for management. Societal priorities are also on the emerging "hot topic" issues, which demand advice suitable for rapid responses. Recent drastic changes have made people want to know about new problems. For example, in China after the green algal blooms in 2008, there were public requests for scientists to provide advice on algae and jellyfish. FUTURE products should address pressing societal needs and goals.

Draft proposal on NPESR

The North Pacific Ecosystem Status Reports (NPESR) of PICES have been highly valued. The first edition was published in 2004 and the second in 2010. These reports provide a test case for future FUTURE products. Phil Mundy, representing the FUTURE Advisory Panel on *Status, Outlooks, Forecasts, and Engagement* (SOFE), presented a draft proposal for updating and expanding NPESR in the future. It was suggested that NPESR should be incrementally updated annually-to-biennially through a web-based system, with more detailed analysis at five- or six-year intervals.

The workshop participants are debating scientific and communication issues during coffee breaks; left photo, left to right: Shin-ichi Ito (Japan), Enrique Curchitser (USA), Igor Shevchenko (Russia) and Chan Joo Jang (Korea); right photo: Mark Wells (USA), Jackie King (Canada) and Hiroaki Saito (Japan).

The proposal also described some details on the organization of a writing team, quality assurance, maintenance of the database, review processes, and establishment of target group focused outreach products. A suite of agreed variables for each PICES region would be developed through specific processes. For example by use of an "indicator selection framework" (role for WG 28 and FUTURE Advisory Panel on *Climate, Oceanographic Variability and Ecosystems*, COVE) to select time series in climate physics (WG 27), nutrients, phytoplankton and zooplankton (Biological Oceanography Committee, BIO), birds, fish and mammals (BIO and Fishery Science Committee, FIS), economics and social impacts (Section on *Human Dimensions*, S-HD). Note that "indicators" in this context are observables of known measurement error; variables (sea surface temperature, fluorescence, dissolved inorganic carbon, dissolved oxygen, population estimates, *etc*.). The workshop participants agreed that the improvement of NPESR should be incremental and built upon the existing reports. As an efficient and inexpensive way of producing and updating reports, developing automating software using open source tools such as R- and S-weave were suggested. This software provides templates into which authors can input and update their data easily. This will facilitate making a standardized version which would be easier to produce and therefore, would be easier to translate into other languages to suit the specific needs of PICES member countries. Synthesis is a valuable part of NPESR, yet has been not fully accomplished in the previous versions. Trans-regional synthesis would be of great value. Timing and frequency of production of the electronic updates will be variable depending on regional needs and data availability. Since the report will be based on national monitoring activities, a question came up on whether all member countries are producing annual reports of all of their collected observations. It turned out that not all the countries are making annual reports and not all of the data collected (especially fisheries data) are openly available for wide distribution.

Communication strategy

There are communication issues on several levels in pursuing the goals of FUTURE. Communication within and across expert groups needs to become more efficient. A FUTURE web site is being constructed and could facilitate better communication among FUTURE scientists. Data exchange and sharing are also important issues for FUTURE science. Igor Shevchenko (TCODE) presented his experience with PICES Metadata Federation Project. He reviewed the characteristics of oceanographic data and how data sharing can facilitate research on various levels. Since biological data are the area where data sharing is least efficient, he made recommendations on how to improve the situation.

Outreach with the general public or targeted sectors beyond fisheries management is a new area where PICES has little experience, and consequently outreach has lagged some of the other FUTURE activities. However, SOFE is working to remedy the situation. Public outreach documents need to be created soon after the information is available, while the topic is still new. Ideally, outreach documents would be produced in English first, then translated into Japanese, Korean, Chinese and Russian as desired by PICES member countries. It was suggested that the highlights of the Yeosu symposium on "*Effects of Climate Change on the World's Oceans*" held in May 2012, could be disseminated to the public using this approach.

Another question on outreach is whether we need the help of specialists in making outreach products such as brochures, press releases, web design. The consensus of the workshop participants is that PICES does not presently have the resources and expertise to produce outreach documents, and that a long-term strategy is necessary.

Gaps and actions

The gaps identified from the previous discussions were revisited, with questions on new expert groups to fill the gaps. Ecosystem resilience is one area that we continue to study to answer the Key Scientific Question 1. A new working group on ecosystem resilience could possibly be formed based on the outcomes from WG 28 and S-CCME. This group could develop the theoretical framework, operational definition, and metrics for ecosystem resilience. S-HD will contribute in tackling economic and human-related issues in ecosystem resilience.

Counter-intuitively, FUTURE needs to develop greater capacity in coastal ecosystem modeling, despite ongoing work on this by WG 27, WG 29 and S-CCME. Significant gaps remain. For instance, WG 29 has limited capacity to develop biogeochemical models and higher trophic level models. S-CC has identified gaps in understanding and predicting future hypoxia because of limited information on benthic processes and coastal chemistry. S-HAB has also identified the high-resolution multi-species lower trophic model in coastal regions as a gap. Current ecosystem models do not adequately represent harmful algal species as state variables; without such an effort, ecosystem models are not capable of developing blooms of HAB species. All of these examples require some level of capacity building in coastal ecosystem modeling. Developing a Regional Ocean Climate Model Inter-comparison Project (ROCMIP) and/or establishing a Working Group on Earth System Modeling (WG-ESM) were suggested. At the same time, PICES has limited resources and there are other areas that require capacity building. It may be reasonable to defer action on some of these topics/gaps until WG 27, WG 29, and S-CCME provide their first products and have a better basis for assessing gaps in PICES modeling capacity.

The FUTURE Science Plan explicitly identifies the quantification of uncertainty of outlooks and forecasts as a goal. WG 27 will look into this issue and provide uncertainty estimates of decadal variability in recent historical climate and ecosystem time series. S-CCME and WG 28 will evaluate our skill on dealing with uncertainty, and will collaborate with each other on assessing the vulnerability of coastal communities, particularly related to food security. This assessment could be based on future economic scenarios or societal change scenarios, which S-HD will certainly be asked to provide.

The FUTURE workshop in session.

Products to be made in 2–3 years

Given that we do not know at the moment all the potential users of FUTURE products and their needs, the workshop participants agreed to take an adaptive approach in developing the products, that is, focus on products that are ready now or will be within next 2–3 years, and contact potential users to obtain feedback that will make products better or more relevant to end users (beyond scientists). The process of improving products must be accomplished through 2-way engagement of PICES scientists and targeted audiences. During this discussion, the following list of potential FUTURE products that are "doable" within 2–3 years was developed:

- Index/Atlas of non-indigenous species
- Global atlas/analysis distribution shift of fish/shellfish
- Indicators of cumulative stresses
- Circulation/mixed layer depth projections
- CMIP5 analysis of derived variables
- Press releases of FUTURE Symposium activities
- Core indicators from the Working Group on *Ecosystem-based Management Science and its Application to the North Pacific* (WG 19)
- Characteristics of North Pacific indices in modern models
- Yearly report on 'hot topics' products
- Expert group summary at the end of their term
- Update Wiki FUTURE site http://en.wikipedia.org/wiki/North_Pacific_Marine_Science_Organization
- Educational materials to engage early career scientists in PICES
- S-HD newsletter (seasonal, electronic)
- S-CCME briefing/news (non-periodic)
- Climate index links to original sources

Next steps – A roadmap for FUTURE

The workshop also discussed the next steps for FUTURE and future (lowercase!) meetings/workshops. The FUTURE Scientific Steering Committee will draft a roadmap for FUTURE that summarizes the outcomes and suggestions from the workshop. A draft will be reviewed and discussed at the next joint meeting of FUTURE Advisory Panels at PICES-2012 before being finalized. An inter-sessional FUTURE workshop in the spring of 2013 in western Russia will be planned to facilitate S-CCME activities, which will coordinate scientific participation and exchange between PICES and ICES. Another possible FUTURE meeting next year is a WG 29 workshop to deal with scientific issues related to regional downscale modeling, proposed by Seoul National University. A FUTURE Open Science Meeting (OSM) was also brought up at the workshop. By 2014, FUTURE will be approaching its fifth year, about the right time to evaluate what has been achieved and what has not. Also it will be a good time to adjust course, if needed, and to know where we are going. There was some discussion about the format and timing of the FUTURE OSM, and the consensus was that it should be in the spring of 2014, but the place is yet to be decided.

Second Symposium on "Effects of Climate Change on the World's Oceans"

by Suam Kim, Luis Valdés, Svein Sundby and Hiroaki Saito

Ocean Expo 2012, Yeosu, Korea.

Like the first in Gijón, Spain, in 2008, the 2nd international symposium on "*Effects of Climate Change on the World's Oceans*" was organized jointly by PICES (North Pacific Marine Science Organization), ICES (International Council for the Exploration of the Sea), and IOC (Intergovernmental Oceanographic Commission of UNESCO). It was convened from May 15–19, 2012, in a newly constructed conference centre located on the Ocean Expo 2012 site in Yeosu, Korea. Our symposium was the first of several international scientific events related to the Ocean Expo theme of "The Living Ocean and Coast – Diversity of Resources and Sustainable Activities." The venue offered a unique blend of carnival on the outside and science on the inside that is rarely encountered at marine conferences. A total of 326 participants from 31 countries contributed 208 oral and 79 poster presentations to the symposium. Each day began with a plenary session that featured three talks by invited speakers. The remainder of the day was occupied by parallel Theme Sessions (see a Text Box for the list of sessions). In addition, seven workshops were held in conjunction with the symposium, and their reports can be found in this issue of PICES Press.

The symposium venue.

Symposium Theme Sessions

1. Climate variability *versus* anthropogenic impacts; analysing their separate and combined effects on long-term physical, biogeochemical and ecological patterns
2. Systematic, sustained and integrated global ocean observations
3. Projections of climate change impacts on marine ecosystems and their uncertainty
4. Climate change effects on living marine resources: From physics to fish, marine mammals, and seabirds, to fishermen and fishery-dependent communities
5. From genes to ecosystems: genetic and physiological responses to climate change
6. Marine spatial planning and risk management in the context of climate change: The living ocean and coast under changing climate
7. Coastal and low-lying areas
8. Trend and impacts of de-oxygenation in oceanic and coastal ecosystems
9. Marine tipping points in the earth system
10. Changes in the marine carbon cycle

It was apparent to the participants of the 2008 Gijón Symposium that the Fourth Assessment Report (AR 4) of the Intergovernmental Panel on Climate Change (IPCC), released in 2007, had placed only limited emphasis on impacts of climate change on marine ecosystems. After Gijón, the marine science community took the initiative to accelerate research and publication on a diversity of oceanic themes so that the emerging Fifth Assessment Report (AR5) will have two chapters dedicated to marine ecosystems and biogeochemistry.

The marine scientific community is concerned about a rich variety of issues related to climate change but the overarching messages from the symposium are important.

Ecosystem responses to climate change are diverse – because critical factors and processes, structure and function vary among regions. Marine ecosystems are not responding to globally-averaged climate change, but to the nature of climate change in each region.
Ecosystem responses are a combination of climate change and natural climate variability – at various periods from inter-annual to multi-decadal. Care should be taken not to interpret all kinds of past climate change as anthropogenic climate change. Moreover, not all observed changes are due to ocean climate change.

A better understanding of local and regional processes is needed – to improve global models and interpret their results, and because many of the critical ecosystem processes are only captured by downscaling.

Impact studies should be used to define what kind of physical processes are to be studied – because the physical science does not resolve ocean processes that are needed for impact studies on marine ecosystems. Natural climate variability has clear impacts on regional marine ecosystems but they are poorly represented by global climate models. Examples include variations in upwelling regions and inflow of warm Atlantic water to the Arctic.

Model validation – is not a new theme, but it becomes increasingly important as model output becomes more influential. We need to continuously work on evaluating the relevance of the processes in models and to validate their results against observations….and we still need faster computers.

Corinne Le Quere summarizes the outcomes from the symposium.

At the Closing Session, Corinne Le Quere (UK) offered a remarkable overview of the week and suggested cutting-edge research directions for future marine ecosystem science. High concentrations of carbon dioxide and other greenhouse gases in the atmosphere are causing ocean warming and ocean acidification, both of which are affecting marine ecosystems of the World's Oceans. Warming has direct impacts on ice caps, sea level, seasonal stratification, species distribution and migratory routes, physiology, and phenology. There is consistency in observed anomalies of temperature, salinity, sea level, heat content, snow and ice cover, and humidity through last century. Understanding will improve from emerging modeling techniques that will refine the anthropogenic and natural components of change.

Ocean acidification is a partner of increasing atmospheric carbon dioxide. The oceans are now more acidic than they have been for the last 800,000 years. Increasing acidity reduces the oceans' capacity to absorb carbon dioxide, leaving more anthropogenic emissions in the atmosphere. Observed trends in carbonate system parameters appear to be persistent and coherent. Global observations are incomplete but they are progressing to a better quantitative understanding. Ocean acidification is causing irreversible changes in the chemistry of the oceans. Acidification also is reducing the availability of carbonate minerals that are important building blocks for marine plants and animals. This change will have adverse impacts in marine biodiversity, particularly species that rely on calcareous structures like coral reefs, shellfish, and echinoderms, *etc*.

Other stressors of anthropogenic origin, such as the transport of invasive species, eutrophication, fisheries, pollution and coastal urbanization have detrimental effects on marine ecosystems. They tend to generate non-linear ecosystem responses causing significant changes in biodiversity, oxygen

Cross-cutting Research Directions

- Multi-variable detection and attribution
- Decadal predictions
- Non-linearity and tipping points in ice melt and ocean currents
- Detection of ocean pCO_2 trend and inventory departures from expected values
- Attribution of the contribution of increasing atmospheric CO_2, climate variability and climate change on regional trends
- Impact of ecosystems changes on the ocean carbon cycle
- Stock and vulnerability of coastal carbon and their valuation
- Quantifying the uncertainty in trends
- Impacts of ocean acidification in marine biota
- Attribution of recent oxygen changes to climate change and/or variability
- Explanation of the tropical deoxygenation
- Effective impact on marine life
- Effective management practices to reduce coastal deoxygenation
- Integrating multiple data streams (including genetic) into information
- Understanding the impact of multiple stresses, including climate change, fisheries, ocean acidification and deoxygenationon species, size distribution, life stages and trophic dynamics
- Ecosystem shifts and tipping points
- Capacity of ecosystems to adapt
- Integrating ecosystems, fish, and fishers in models
- Management options in coastal areas and socio-economic impact (including livelihoods and adaptation to climate change)
- Attribution of the climate change contribution to individual events

Left photo: Opening remarks by the symposium convenors, Luis Valdés (IOC) and Hiroaki Saito (PICES). Right photo: Closing remarks by the symposium convenors, Suam Kim (Korea) and Svein Sundby (ICES).

depletion, water circulation, and habitats (Fig. 1). Existing subsurface oxygen trends offer only an incomplete understanding of patterns of change. The full implications of deoxygenation are still poorly known. Oxygen stress causes the reduction in available habitat and growth performance on fish.

Food web structures, and the distribution and abundance of marine life have been altered in accordance with expectations from ocean warming. Qualitative trends in ecosystem components are persistent and coherent, but data are inadequate for a quantitative understanding.

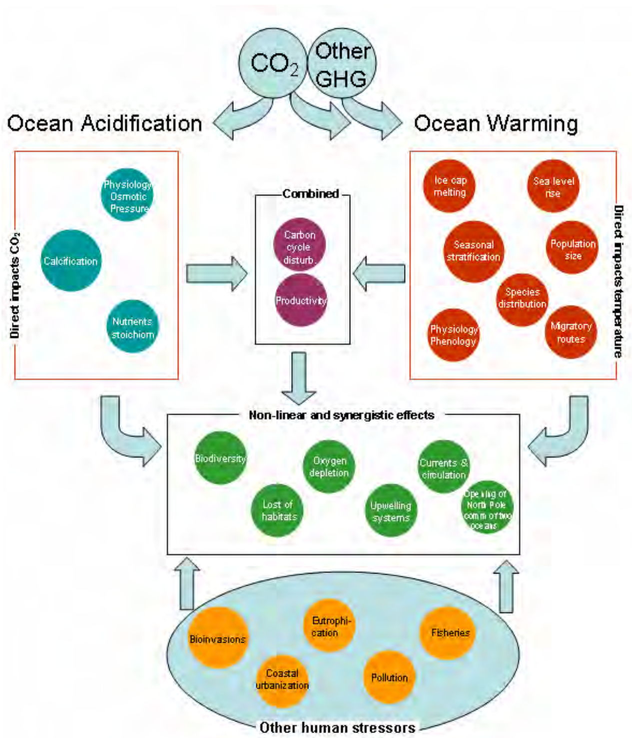

Fig. 1 Conceptual model of oceanic stressors (Reid, P. C., and Valdés, L. 2011. ICES status report on climate change in the North Atlantic. ICES Cooperative Research Report No. 310, 262 pp).

There is a consensus among policymakers to accept a world that is 2ºC warmer on average. While it may be an acceptable threshold for terrestrial ecosystems, it is probably too high for marine ecosystems. Research should be encouraged to evaluate the effects of higher ocean temperatures on marine life, especially in subtropical coastal waters or enclosed seas, where the stability of proteins may be compromised. Integrated analysis and marine spatial planning should be the basis for the efficient management of marine resources so that more and new research has to be done to fully understand and evaluate the impacts of climate change.

The symposium aimed to bring together experts from different disciplines to exchange observations, results, models and ideas at a global scale and to discuss the opportunities to mitigate and protect the marine environment and its living resources. Societies are demanding the sustainable use and management of natural resources and solutions that will mitigate the impacts of global warming. During the next decade, social pressure will encourage policymakers to reach agreements regarding limits on carbon emissions and establish limits for other anthropogenic impacts. The human dimension of climate change in the oceans is very often ignored so that information received by the general public about climate change is incomplete and biased to the terrestrial experience. To bridge the gap between what the scientific community understands about marine climate change impacts and what the public knows and cares about, the gap must first be identified. To have oceanic observations with better spatial and temporal resolution is a crucial and necessary step to take the pulse of the oceans at a planetary scale. A survey at global scale (~50 countries) was proposed as a tool to identify gaps. A new program entitled "*Future Earth: Research for global sustainability*" indicated that interdisciplinary research on global environmental change for sustainable development will be conducted through international research coordination starting from 2013.

Symposium in session – the first plenary.

Discussion around posters.

Les grandes dames of international marine science: Ann Bucklin (left) and Anne Hollowed (right).

Interactions: Villy Christensen (Canada, left), Dosoo Jang (Korea, center) and Icarus Allen (UK, right).

Interactions: Sinjae Yoo (Korea, left) and Joji Ishizaka (Japan, right).

Interactions: Young Jae Ro (Korea, left) and Jack Barth (USA, right).

Interactions: Lothar Stramma (Germany, left), Martin Visbeck (Gerrmany, center) and Peter Brewer (USA, right).

Dr. Wendy Watson-Wright addresses the participants at the Opening Ceremony (left); Dr. Lev Bocharov, PICES Chairman, welcomes the participants at the Symposium Dinner (center); Dr. Michael Sinclair, President of ICES, toasts the participants at the Welcome Reception (right).

Awards for best presentations by early career scientists were given to: Jong-Yeon Park (Korea Ocean Research and Development Institute, Korea) for his talk on "*Bio-physical interaction in the tropical Pacific*", to Marie-Fanny Racault (Plymouth Marine Laboratory, UK) for her presentation on "*Integration of ecological indicators with the global network of ocean observations*", to Malin Pinsky (Princeton University, USA) for his paper on "*How predictable are species distribution shifts? Testing ecological hypotheses against four decades of observations*", to Jennifer Sunday (Simon Fraser University, Canada) for her talk on "*Marine species' latitudinal distributions conform better to their thermal tolerance than terrestrial species: Implications for range shifts*", and to K. Allison Smith (Princeton University, USA) for her presentation on "*Predicting future habitat changes above oxygen minimum zones*".

Selected papers from oral and poster presentations from the symposium and workshops will be included in a special issue of the ICES *Journal of Marine Science* scheduled for publication in July 2013. In addition, it is anticipated that selected sessions and workshops will develop their own proposals for special volumes.

As the symposium convenors, we would like to sincerely thank all those who participated in organizing this event. The symposium was made possible by the hard work of the local organizers, the Korea Ocean Research and Development Institute (KORDI) and Korea Oceanographic Commission (KOC). Special thanks go to the staff of the International Cooperation Department of KORDI who put an enormous amount of time and effort into making this symposium a success. The PICES Secretariat is to be thanked for providing professional assistance in the planning, development, coordination and the smooth running of the symposium. In addition to primary international (PICES, ICES and IOC), the following organizations and agencies made financial or in-kind contributions to the symposium:

- Expo 2012 Yeosu Korea
- Ministry of Land, Transport and Maritime Affairs (Korea)
- East Asian Seas Time Series Research Project (Korea)
- Fisheries and Oceans Canada
- Food and Agriculture Organization of the United Nations
- Global Ocean Observing System
- Institute for Marine and Antarctic Studies (Australia)
- Integrated Marine Biogeochemical Ecosystem Research
- International Pacific Halibut Commission
- Korea Meteorological Administration
- Korea Tourism Organization
- National Aeronautics and Space Administration (USA)
- National Fisheries Research and Development Institute (Korea)
- National Oceanographic and Atmospheric Administration (USA)
- North Pacific Anadromous Fish Commission
- North Pacific Research Board (USA)
- Ocean Climate Change: Analysis, Projection, Adaptation Project (Korea)
- Pukyong National University (Korea)
- Pusan National University (Korea)
- Scientific Committee on Oceanic Research (SCOR)
- United Nations Environment Programme
- World Climate Research Programme
- Yeosu City

Without support these sponsors provided, it would have been impossible to convene a symposium of global scope.

2012 Yeosu Workshop on "Framework for Ocean Observing"

by David Checkley and Candyce Clark

A workshop to discuss the Framework for Ocean Observing (FOO) was held on May 18, 2012, at the 2nd International Symposium on "*Effects of Climate Change on the World's Oceans*" in Yeosu, Korea. Approximately forty symposium participants attended the workshop co-convened by the authors of this article. Albert Fischer (Intergovernmental Oceanographic Commission), Pedro Monteiro (Council for Scientific and Industrial Research, South Africa), and Martin Visbeck (GEOMAR, Germany) served as panelists.

Albert Fischer introduced FOO that had its genesis at the OceanObs'09 conference (Venice, 2009). The conference concluded with a call for a collective vision for the coming decade of ocean observations for societal benefit. Amongst other things, it was proposed to develop a Framework for planning and moving forward with an enhanced global sustained ocean observing system over the next decade, integrating new physical, biogeochemical and biological observations by expanding and building on present efforts. The follow-on FOO (http://www.oceanobs09.net/foo/) consists of recommendations for best practices for observing and a multi-level structure to facilitate global observing (Fig. 1). The Framework and its coordination processes are organized around **"**Essential Ocean Variables" (EOVs, Fig. 2), rather than by specific observing system, platform, program, or region. New EOVs meeting societal requirements will be carried out according to their readiness levels, allowing timely implementation of components that are already mature, while encouraging innovation and formal efforts to improve readiness and build capacity in ocean observations.

Sanae Chiba (JAMSTEC, Japan) described the Global Alliance of Continuous Plankton Recorder Surveys (GACS). The Continuous Plankton Recorder is an excellent example of a biological sampler that has been used for decades worldwide, collecting information about the plankton that has provided insights into its response to climate variability and change. The formation of a global alliance and augmentation to the sampler are also valuable examples of global reach and methods development, whilst maintaining consistency hence comparability.

Each workshop attendee was then asked to recommend one or more EOVs. This led to a rich discussion of diverse aspects of biological sampling. Common measurements that might lead to EOVs included size structure, taxonomic diversity, and biogeographic boundaries.

Size structure was the most commonly mentioned biological feature to be measured. The exact variables (*e.g.*, size - spectrum slope) were not discussed. Zooplankton, phyto plankton, and particles were proposed for measurement. While size structure may be a necessary feature to characterize, it is not sufficient (see below in regard to

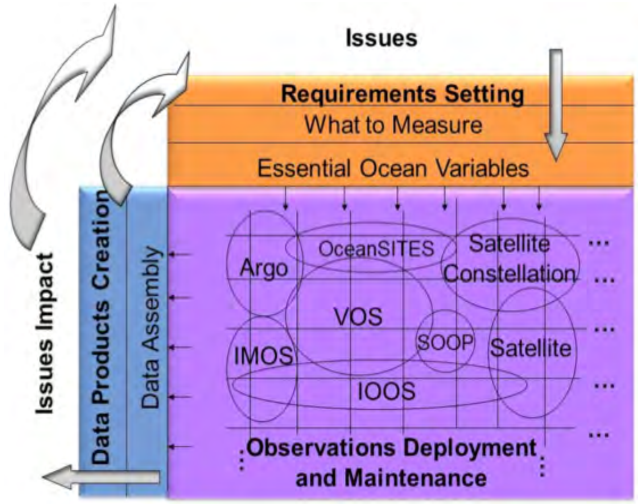

Fig. 1 Structure of the Framework for Ocean Observing. How ocean observing activities fit into the systems model of the Framework. The critical feedback loop between observing system outputs and science-driven requirements is shown. (Observation system examples are illustrative only, not comprehensive.) (Source: Framework for Ocean Observing)

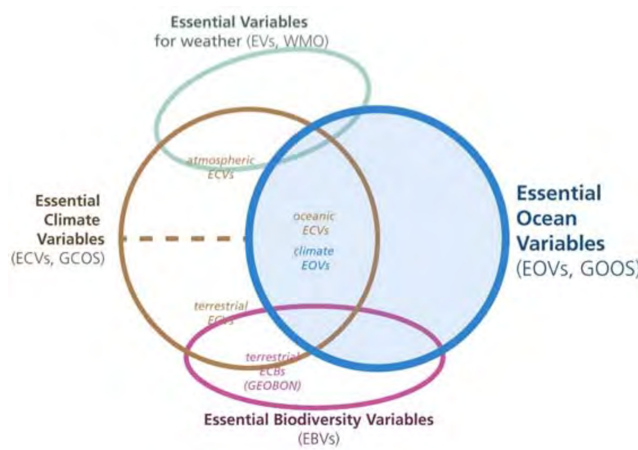

*Fig. 2 Conceptual overlap of Essential Ocean Variables (EOVs) in a Venn diagram. **Essential Variables** defined by the World Meteorological Organization for weather forecasting inspired **Essential Ocean Variables** later defined by the Global Climate Observing System. The concept has been adopted for **Essential Biological Variables** on land by the Group on Earth Observations Biodiversity Observation Network. The Framework for Ocean Observing processes will define ocean observing EOVs. Overlap among these groups is shown, which argues for the need to adopt a consistent approach. (Source: Framework for Ocean Observing)*

taxonomic diversity). It was also noted that production, not only standing stock (amount), is important.

Taxonomic diversity was the second primary biological feature to be measured. All taxa were noted, from viruses and bacteria to seabirds and whales, including the phytoplankton (*e.g*., coccolithophorids and nitrogen-fixers) and zooplankton (*e.g*., copepods, euphausiids, and gelatinous forms), micronekton, and top predators, and both mero- and holoplankton. Sentinel species might be given priority, as might indicators (*e.g*., the ratio of diatom to non-diatom phytoplankton and plant pigments). Functional relationships, not only abundance, are important to consider. Collected samples might be stored for future genetic analysis. Measurements of biodiversity should be considered.

The third primary biological feature was boundaries. These might be considered in space (*e.g*., biogeography) and time (*e.g*., phenology). Oceanic, in contrast to coastal, areas provide special challenges for observing. The concept of biogeographical provinces, and how these might change, was noted.

A variety of methods issues were raised. The importance of measuring rates, not only amounts, was noted by many attendees. Examples included production (*e.g*., Ar/O_2 for primary production), water-column respiration, extracellular enzyme activity of bacteria, particle sinking rates, carbon export, and sediment oxygen demand. The response time of systems, populations, and individuals was mentioned. The usefulness of the contemporaneous measurement, in both time and space, of different variables was noted. A new water sampler has been incorporated into some of the Continuous Plankton Recorders.

Finally, some general considerations regarding FOO were made. Nothing is 'in or out'. The observing system will remain a mosaic of evolving and increasingly integrated observing entities. It was noted that even the current measurement of ocean temperature is a patchwork. There will be overlap among disciplines, including physics, biology, and biogeochemistry, both in current and future systems that use new technologies. Both the benthos and the pelagos must be considered. Capacity development with a two-way dialogue and benefits for all is necessary, for observing occurs in waters of and between all countries, developing and developed. As stated in the Framework, observations support science and research, policy decisions and the regulatory process and are taxpayer funded, and hence must have public support. Broad-scale and, at times, global observing already exists, with examples including: temperature, sea surface height, wind, phytoplankton, and salinity from *in situ* and satellites; fish catch and abundance from fisheries; plankton from the GACS and fishery oceanography programs such as CalCOFI and those of ICES; oxygen from some Argo floats, all of which also measure temperature and salinity. As Carl Wunsch (Massachusetts Institute of Technology) said at OceanObs'09, "*Sustaining such a system … is truly an intergenerational problem … people who perhaps will be in a position to solve these climate problems decades or longer in the future…are likely to look back at us 50 or 100 years hence and ask what were they thinking, why were not they making these measurements, why didn't they calibrate them?*"

Dr. David Checkley (dcheckley@ucsd.edu) is a Professor of Oceanography at the Scripps Institution of Oceanography, where he teaches graduate courses in biological oceanography, fisheries oceanography, and pelagic ecology. His research is on the effects of climate on plankton and fish, the effects ocean acidification on fish, and the role of zooplankton and other particles in the biological pump. He also develops instruments for observing plankton and particles.

Dr. Candyce Clark (Candyce.Clark@noaa.gov) is a Program Manager for NOAA's Climate Program Office where she handles many of the ocean observing programs for climate. She also serves as Observations Program Chair for the Joint WMO-IOC Technical Commision for Oceanography and Marine Metoreology (JCOMM), one of the original FOO sponsors. A marine biologist by education, she has spent the last three decades working on the international coordination and use of ocean and climate information.

2012 Yeosu Workshop on "Climate Change Projections"

by Enrique Curchitser and Icarus Allen

A 2-day workshop on "*Climate change projections for marine ecosystems: Best practices, limitations and interpretations*" was held on May 13–14, 2012, preceding the 2nd International Symposium on "*Effects of Climate Change on the World's Ocean*" convened in Yeosu, Korea. The goal of the workshop was to explore different approaches to modeling the impacts of climate change and variability on marine ecosystems and to highlight their strengths and limitations. A significant motivation was to bring together both global and regional modelers whose communities often work separately. A particular interest of the convenors (co-authors of this article) was to insure that the definition of an ecosystem included higher trophic levels and both direct and indirect anthropogenic influences. The tone for the workshop was set by the opening remarks of Icarus Allen (Plymouth Marine Laboratory, UK) who discussed the scientific interest in understanding how ecosystems respond to climate change, the propagation of the climate signal through an ecosystem, difficulties in making future projections, issues with downscaling, whole ecosystem approaches, and anthropogenic effects questions of how to deal with uncertainty. The need to take risks in our approaches to these problems was indicated.

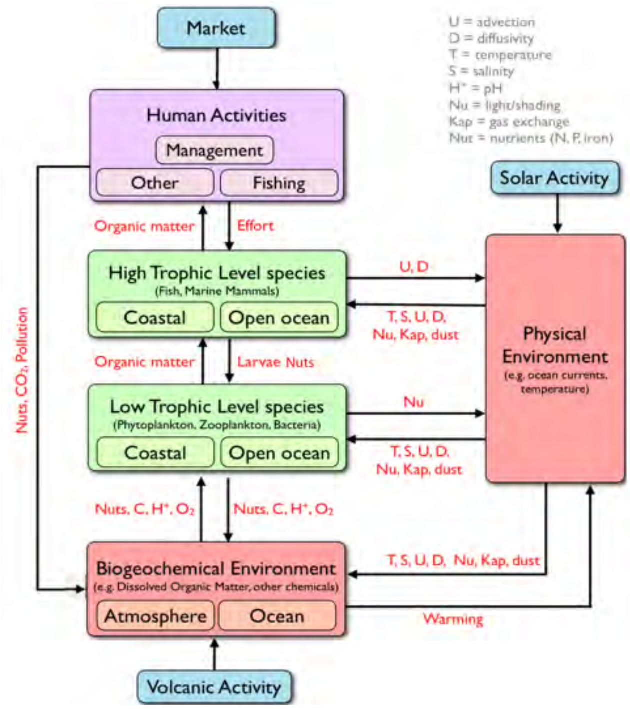

Fig. 1 Schematic diagram of the Nereus modeling framework. The model is being used to concurrently study the effects of climate change and human activity (such as fishing) on global fish stocks. Nereus takes a global approach to the problem simultaneously modeling 1000 species of fish and over 250 different fishing fleets (see http://www.nereusprogram.org/ for details).

Over the two days, about 40 scientists participated in the workshop. Invited talks by Villy Christiansen and William Cheung (University of British Columbia, Canada), Jason Holt (National Oceanographic Centre, UK), Charles Stock (NOAA's Geophysical Fluid Dynamics Laboratory, USA dealt with research using both global and regional climate models coupled with marine ecosystem models. Together with submitted contributions, a range of models was presented which included global and regional coupled physics, fish and fishers.

Dr. Christiansen started the workshop with a talk about the NEREUS project led by the University of British Columbia. The work is motivated by the question of "Will there be fish for coming generations?" and the realization that many fisheries have collapsed across the globe. The project takes a global approach and models the ecosystem from biogeochemistry to the market. It includes on the order of 1000 fish species and nearly 250 fishing fleets (Fig. 1). NEREUS is also a leader in outreach activities, producing visualizations of model data for the public at large.

Dr. Holt tackled the topic of climate drivers on coastal marine ecosystems. His emphasis was on downscaling global climate models to the broad continental shelves of northern Europe and exploring the physical mechanisms (the interplay of turbulence, mixing and nutrient supply) that exert controls over phytoplankton growth. He presented several considerations for the treatment of uncertainty in complex coupled bio-physical models.

Dr. Stock described his work on using IPCC-class models to assess the impact of climate change on living marine resources. He described some of the challenges of using global models: resolution, separating variability and trends and the fact that these models were not designed to address marine ecosystems, in particular on regional scales (Fig. 2). However, an understanding of the functioning of coupled global climate models and the careful design of ecosystem models can yield insight into ecosystem functioning under projected climate change scenarios.

Dr. Cheung focused on the modeling of large-scale effects of global change on marine ecosystems and fisheries. The motivating issues were ocean warming, de-oxygenation, acidification and overfishing. His presentation dealt with the question of the combined effect of these issues on fisheries

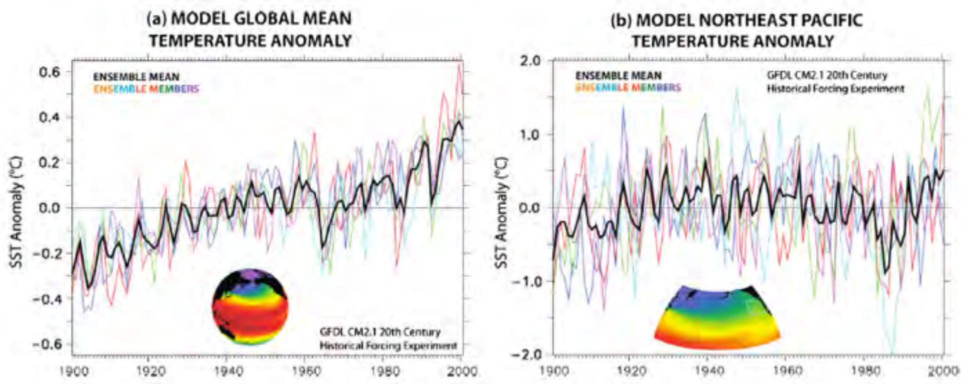

Fig. 2 Temperature anomalies from an ensemble of future projections using the GFDL CM2.1 model. Left: Global mean, Right: Northeast Pacific. This figure illustrates the difference in global and regional variability in the climate model suggesting needed caveats when evaluating global models on a regional basis and interpreting regional ecosystem responses to a global climate signal. Stock et al., 2011. Prog. Oceanog. 88, 1–27.

and explored the sensitivity of model results to projected climate scenarios. His model results suggest that by 2050 warming may cause regions in the tropics to lose catch potential, while high-latitude regions may gain. However, global catch potential is predicted to decrease.

Further presentations at the workshop discussed various approaches to linking climate and ecosystem models, and several threads emerged from these presentations:

- How useful these models are for management, planning and policy purposes,
- The need, advantage and issues of downscaled climate solutions, and
- The validity of regional interpretations of global climate model results.

The topic of model resolution and the multi-scale nature of the problem (both in physics and biology) permeated throughout the presentations and the ensuing discussions. In particular, the participants articulated the needs of coastal ecosystem research that are not necessarily well served by global climate models. A significant amount of time was devoted to a discussion on the communication of model results and model uncertainty to a variety of constituents. The challenge of taking research models and developing them to be useful tools for operational oceanography or management strategy evaluation was also discussed (Fig. 3).

It was recognized at the workshop that as we move forward in trying to make projections of future ecosystem health under likely climate change, it is important for the regional ecosystem and global climate communities to continue working together. Current modeling capacities are inadequate for some of the questions that are being posed. In particular, the challenge of making policy-relevant predictions over the next 2 or 3 decades in the face of a modeled climate signal, which is indistinguishable from the natural variability of the system, was noted. The participants agreed that at present, the community is not ready to describe "best practices", but enough different approaches exist that we can contrast "current" practices. A review manuscript on state-of-the-art approaches highlighting their strengths and weaknesses for making projections of particular ecosystems is expected as the outcome from the workshop.

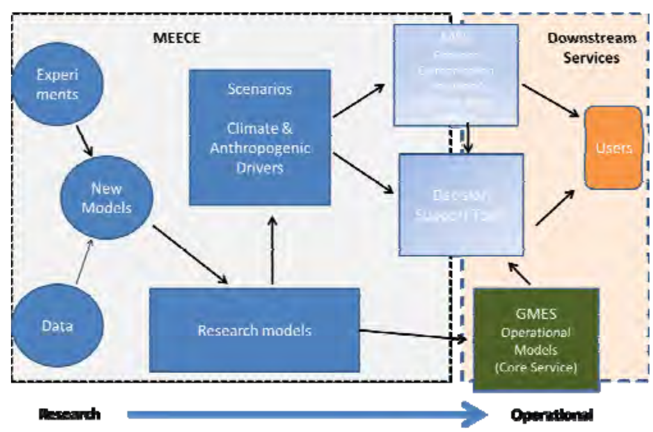

Fig. 3 Schematic of the model development process illustrating the challenge of building research models and pulling them through to operational and decision support tools.

Dr. Enrique Curchitser (enrique@marine.rutgers.edu) is an Associate Professor at Rutgers University (USA). His main research interests are at the intersection of climate and ecosystems. His current projects range from downscaled coupled bio-physical modeling of the California Current and Bering Sea, the impact of climate change on coral bleaching in the Coral Triangle and the role of the Gulf Stream in the climate and social systems of the northeast U.S. Within PICES, he is a member of the Physical Oceanography and Climate Committee and Working Group 27 on Climate Variability and Change in the North Pacific, and co-chairs Working Group 29 on Regional Climate Modeling.

Dr. J. Icarus Allen (jia@pml.ac.uk) is Head of Science for marine ecosystem modelling at the Plymouth Marine Laboratory (UK). His main research interests are the response of marine ecosystem to combinations of climatic and anthropogenic change, ecosystem model skill assessment and operational oceanography. He is a member of the ICES Working Group on Integrative Physical-Biological and Ecosystem Modelling (WGIPEM) and leads the EC FP7 Marine Ecosystem Evolution in a Changing Environment (MEECE) project.

2012 Yeosu Workshop on "Coastal Blue Carbon"

by Gabriel Grimsditch and Ik Kyo Chung

During the first week of the World Expo 2012 in Yeosu, Korea, a workshop on "*Coastal blue carbon: Mitigation opportunities and vulnerability to climate change*" was convened on May 14, 2012, at the symposium on "*The Effects of Climate Change on the World's Oceans*". The workshop was co-organized and co-sponsored by Pusan National University and the United Nations Environment Programme (UNEP).

Coastal ecosystems, in particular, mangroves, tidal salt marshes, seagrass beds, and possibly seaweed beds, hold large reservoirs of carbon in their biomass and soils and sink atmospheric CO_2 through primary production. This carbon is becoming known as 'blue carbon' because it is associated with marine ecosystems. Recent scientific syntheses have placed the global total estimated emissions from degraded and converted coastal wetlands each year at between 300 and 900 million tons of CO_2, approximately equal to the annual CO_2 emissions from energy and industry for Poland and for Germany, respectively (Murray *et al*., 2011). The rates of carbon sequestration and storage in these coastal ecosystems are comparable to, and often higher than, the rates in carbon-rich terrestrial ecosystems such as tropical rainforests or freshwater peatlands. Unlike most terrestrial systems, which reach soil carbon equilibrium within decades, deposition of CO_2 in coastal ecosystem sediment can continue over millennia. However, when degraded or destroyed, these systems can become sources of carbon dioxide emissions, due to oxidization of biomass and organic matter stored in the soil. The rate of emissions is particularly high in the decade immediately after disturbance, but continues as long as oxidation of sediment occurs. Current rates of loss of mangroves, seagrass beds and salt marshes, driven largely by human activities such as conversion, coastal development and over-harvesting, estimated to be between 0.7 and 2% a year, are among the highest rates of loss of any ecosystem on the planet. This is of considerable concern with respect to their role in carbon sequestration and emissions (Duarte *et al*., 2005; Crooks *et al*., 2011).

Seaweed beds and kelp forests are also ecosystems of interest for blue carbon sequestration and storage. However, unlike other blue carbon ecosystems, seaweed and kelp do not have soil substrates and thus do not retain large amounts of carbon in sediments, although they can act as carbon sinks by reducing dissolved inorganic carbon. Korean researchers are exploring the inclusion of seaweed and kelp in Clean Development Mechanisms.

As nature-based approaches for the mitigation of climate change are increasingly seen as part of the solution, blue carbon has recently been receiving greater international attention. This has stimulated renewed interest in better management, conservation and restoration of coastal ecosystems including mangrove forests, seagrass meadows, tidal salt marshes, and seaweed beds for the purpose of climate change mitigation. However, this has also highlighted a number of gaps in our scientific knowledge of these issues which are critical to developing blue carbon projects for the international carbon market, be it voluntary or regulated. The workshop in Yeosu focused on some of these important questions.

In the invited talk on "Vegetated coastal habitats as intense carbon sinks: Understanding and using blue carbon strategies", Nuria Marba (Institut Mediterrani d'Estudis Avançats, Spain) gave an overview of current scientific

Group photo of the workshop participants, left to right, back row; Calvyn Sondak, Yun-Xiang Mao, Luis Valdés, Jin Ae Lee, Jong Gyu Kim, Manipadma Jena, Kwang Seok Park, Jim Davie, Elvira Poloczanska, Andy Steven, front row; Guanghui Lin, Gail Chumura, Ik Kyo Chung,, Gabriel Grimsditch, Núria Marbà, Stephen Crooks.

knowledge including gaps and uncertainties in the data. She pointed out that a replanted seagrass meadow selling credits on the carbon market could recoup the costs of restoration within 50 years.

In his presentation on "The UNEP Blue Carbon Initiative", Gabriel Grimsditch (UNEP) reviewed UNEP's efforts to support the development of methodologies for assessing blue carbon stocks, ongoing scientific research and pilot projects around the world and noted that the Global Environmental Facility (GEF) has pledged support to a global project on blue carbon science and on-the-ground action.

In his talk on "Predicting the response of coastal marshes and mangroves to sea level rise and human impacts: State of science and information needs", Stephen Crooks (Philip Williams and Associates, USA) explored the carbon dioxide emissions from drained wetlands, provided options for restoring these wetlands in order to restore carbon sequestration functions, and presented a set of potential restoration metrics he has developed through this work.

The talk on "Effects of tidal regimes, mariculture and restoration on carbon pools and fluxes in subtropical mangrove ecosystems of China: Implications for blue carbon management" by Guanghui Lin (Tsinghua University, China) reviewed mangrove conservation efforts and carbon fluxes in China. He indicated that the invasive saltmarsh species *Spartina* and its competition with mangroves was a threat to the ecosystem in the country, but also noted that mangrove restoration efforts in China have been relatively successful.

In her presentation on "Assessing the permanence of blue carbon sinks with rising sea levels", Gail Chmura (McGill University, Canada) examined the vulnerability of tidal wetlands to sea-level rise and coastal squeeze, and consequently the permanence of their carbon stocks. She pointed out that Lidar technology is a cost-effective and accurate method to collect data for assessing the vulnerability of coastal ecosystems to changes in sea level.

In his talk on "The potential of ecological mangrove rehabilitation to contribute to reduced greenhouse gas emissions from deforested and degraded mangrove areas in Indonesia", James Davie (Mangrove Action Project, Indonesia) described the challenges and successes surrounding a mangrove restoration project aimed at creating carbon benefits in Indonesia, and noted that maintaining local hydrology in restoration areas was crucial for the success of these types of projects.

On behalf of Gordon Ajonina (Wildlife Conservation Society, Cameroon), Gabriel Grimsditch gave a talk on "Mangroves and carbon in west and central Africa" to describe research being undertaken on carbon and ecosystem services in mangroves of Central Africa, and suggested that this was the first time that carbon was being quantified for mangroves in this region, and that the results would advise national REDD (Reducing Emissions from Deforestation and Forest Degradation) strategies.

The presentation on "Kelp forest/seaweed beds as a mitigation and adaptation measure: Korean project overview" by Ik Kyo Chung (Pusan National University, Korea) examined the role of seaweed ecosystems in carbon sequestration. He indicated that seaweed had so far not been considered in the international blue carbon debate because these ecosystems do not store carbon in soil, yet seaweed is highly productive and grows at fast rates thus accumulating carbon in its biomass.

The roundtable discussions following the presentations focused on two important and innovative blue carbon issues. The first issue concerned best practices for developing carbon market projects based on coastal ecosystems and their abilities to sequestrated carbon. As

Round table discussion in the afternoon session.

methodologies for carbon market projects in mangroves and salt marshes either have been approved or are in the process of development, we are beginning to see the emergence of projects to manage and restore these ecosystems for carbon credits. However, best practices for feasibility assessments, landscape and permanence considerations, leakage, baselines, future scenarios and restoration practices are often not implemented in these fledgling carbon market projects, increasing their likelihood of failure. Appropriate guidance for assessing the feasibility and then implementing the activities either do not exist or have yet to be recognized by project developers. The need and potential for this type of guidance for coastal blue carbon market projects was apparent, and this workshop explored how such guidance could be developed and disseminated to ensure that project developers have the best information available.

Another important, and regionally pertinent, issue discussed was the potential for macroalgae such as kelp or seaweed to act as a carbon sink. Although macroalgae naturally photosynthesize and absorb carbon dioxide through primary production, growing up to 0.6 m per day in some cases, it is not clear whether this carbon is sequestered and stored for the long term and whether it is thus effective for climate change mitigation. This is because seaweeds do not put down deep sediments and instead grow on rocky substrates. Most of the carbon is stored in the fast-growing biomass, and the long-term fate of this carbon is often unclear. However, it only takes 3 to 5 years to develop the climax stage for newly established macroalgal habitats in the marine environment, compared to terrestrial ecosystems which take more than 50 years.

Seaweed farming for food, fertilizer, paper and biofuel is a growth sector, especially in East Asian countries such as Korea, and the possibilities for the carbon market should be explored. Ik Kyo Chung showed that farmed seaweed (*i.e*., not a natural community) sequestered between 15.7 and 16.6 tons of CO_2 per hectare per year, clearly indicating its potential as a carbon sink. Questions can be raised, though, about the permanence of this carbon sequestration, and we need to explore the fate of the carbon if seaweed is used as biofuel, fertilizer, paper or food. A global issues paper outlining the current state of knowledge and the necessary questions to address would be an interesting step in raising the profile of this innovative form of blue carbon. Professor Chung even proposed the Coastal Use and Coastal Use Change Aquatic Vegetation as the coastal equivalent of the UNFCCC/IPCC category Land Use and Land Use Change Forests.

The workshop was thought-provoking, and showed once again that the full potential of blue carbon is still a long way from being realized. A workshop report has been posted on the "Blue Carbon Blog" (http://bluecarbonblog.blogspot.kr/2012/05/blue-carbon-at-world-expo-2012.html), and reported by Ms. Manipadma Jena of the Inter Press Service (http://bluecarbonblog.blogspot.kr/2012/05/can-blue-forests-mitigate-climate.html).

Gabriel Grimsditch (Gabriel.Grimsditch@unep.org) has been a Programme Officer with the UNEP (United Nation Environmental Programme) Freshwater and Marine Ecosystems Branch for the last 3 years where he specializes in climate change and oceans. Before joining UNEP, Gabriel worked for the IUCN (International Union for Conservation of Nature) Global Marine Programme and was based at the Coastal Oceans Research and Development in the Indian Ocean (CORDIO) office in Mombasa, Kenya. There he worked with partners to study coral reefs, resilience and climate change and has published various peer-reviewed articles and grey literature with the main focuses being coral reef resilience, carbon storage and sequestration in coastal ecosystems, and ecosystem-based adaptation. Gabriel obtained a B.S. degree from Manchester University and an M.S. degree from University College London.

Dr. Ik Kyo Chung (ikchung@pusan.ac.kr) has been a professor at the Department of Oceanography, Pusan National University, since August 1988. His research areas are seaweed ecophysiology and aquaculture. Recently, Ik Kyo led the project on "Greenhouse gas emissions reduction using seaweeds" from the Korean Ministry of Land, Transport and Maritime Affairs (2006–2011). As a member of the Korean Society of Phycology since 1987, he was the Editor-in-Chief of Algae from 1999-2005. Presently Ik Kyo serves as President of the Korean Chapter of the World Aquaculture Society. He obtained his B.S. and M.S. degree in Botany from Seoul National University in 1976, and his M.S. degree in Marine Environmental Science in 1985 and Ph.D. degree in Oceanography from the State University of New York at Stony Brook in 1987.

Polar Comparisons: Summary of 2012 Yeosu Workshop

by Kenneth Drinkwater, George Hunt, Eugene Murphy and Jinping Zhao

A 1-day workshop on "*Effects of climate change on advective fluxes in high latitude regions*" was held on May 14, 2012, prior to the 2nd International Symposium on "*Effects of Climate Change on the World's Oceans*" in Yeosu, Korea. Co-sponsored by ESSAS (Ecosystem Studies of Sub-Arctic Seas) and ICED (Integrating Climate and Ecosystem Dynamics in the Southern Ocean), both regional programs under IMBER (Integrated Marine Biogeochemistry and Ecosystem Research), the workshop was co-chaired by the authors of this article, and attended by 32 scientists from 10 different countries, with another 20 scientists contributing to the workshop presentations. The aim of the workshop was to review the advection of water masses within and between polar and subpolar regions, examine their forcing mechanisms, and consider what their role is on the ecology of these high latitude regions. This included the direct advection of heat, salt and nutrient fluxes, as well as direct and indirect effects on the flora and fauna. For higher trophic levels, such as marine mammals and seabirds, the effects of advection were indirect. New insights were sought through comparisons between the Arctic and Antarctic regions. Recent ecological changes and their links to climate variability were investigated, and in keeping with the major theme of the Symposium, the workshop also focused upon likely scenarios for the advective fluxes and their possible changes under future anthropogenic climate change. The workshop included 11 commissioned disciplinary presentations by teams consisting of experts from both the Arctic and Antarctic. They covered atmospheric climate, physical oceanography, biogeochemistry, microbes, ice biota, phytoplankton, zooplankton, benthic pelagic coupling, fish, marine mammals and seabirds. These teams put together presentations on the climate as well as effects on organisms, with special emphasis on the role of advective fluxes. Two presentations were also given based on submitted abstracts. After the presentations, three participants provided their thoughts on what they considered to be highlights of the workshop and what future research was needed as a lead-in to a general discussion. Prior to the end of the workshop, a discussion was held on writing up the results of the presentations and whether a working group should be formed under IMBER to carry forward the comparative studies of the Arctic and Antarctic.

Following the introduction to the workshop, the first disciplinary presentation was on atmospheric changes. Air temperatures have been warming over the Arctic but they have cooled slightly over most of the Antarctic. The polar vortex around Antarctica has strengthened in recent decades, resulting in stronger anticyclonic (clockwise) winds which, in turn, has led to the continent becoming more isolated atmospherically from the rest of the southern hemisphere. This change is related to an increase in the atmospheric pressure gradient between the Antarctic and the mid-latitudes and is linked to the Ozone Hole. In contrast, the Arctic vortex has weakened, resulting in winter outbreaks delivering cold Arctic air masses southwards to the United States and into Europe. The weakening of the Arctic vortex is related to the warming of the Arctic, which has reduced latitudinal atmospheric pressure gradients. Thus, we have the surprising result that warming in the north has caused extreme cold events over the northern continents.

Winds and currents play important roles in the advection of heat and salt, both into and out of the Arctic and clockwise around Antarctica. In the Arctic, the ocean has warmed through increased advection of warm waters from the south, as well as air-sea heat fluxes. This warming has led to significant reductions in both the areal coverage of sea ice and in the amount of multi-year ice (Fig. 1). With thinner ice and lower ice concentrations, it has been easier for the winds to move the ice around, and currents in the Arctic have been observed to have sped up in recent years. In the Antarctic, the sea-ice decline has been less, with the major reduction around the Western Antarctic Peninsula being offset by some regions where ice coverage has been increasing. In future, the Antarctic and Arctic waters are expected to become warmer, resulting in further reductions in sea-ice extent.

Fig. 1 Sea ice in the Arctic is disappearing at a rapid rate due to recent warming.

Phytoplankton production in both Polar Regions is strongly seasonal and controlled largely by light availability. In the Antarctic, iron is in short supply and therefore, represents another limiting factor on the total amount of primary production in the Southern Ocean. In contrast, there is sufficient iron in the Arctic. There, melting ice provides the vertical stratification necessary for initiation of the spring bloom, but once the nutrients are used up, primary production is limited because strong stratification limits the amount of new nutrients that can be mixed into the euphotic zone. Decreasing sea-ice coverage in the future is expected to result in higher light levels and a longer production period, resulting in higher primary production. Advection also plays a prominent role in primary production. For example, transport of deep water onto the West Antarctic Peninsula shelf brings nutrient-rich waters shoreward, contributing to the high phytoplankton production in these regions. In the Arctic, currents passing through the Bering Strait from the Pacific carry high nutrients and phytoplankton from the Bering Sea into the Chukchi Sea, resulting in higher production than would otherwise be the case. With the warming in the Arctic, large-sized phytoplankton are being replaced by smaller plankton, a process that is expected to continue with increased warming. The reduction in sea ice will mean a decline in the sea-ice associated algae and phytoplankton, which has been estimated to represent upwards of 50% of the total primary production in the deep Arctic Ocean.

Pelagic/benthic coupling is more important within the Arctic than the Antarctic because of the much greater area of shallow seas. In those regions with seasonal ice coverage, primary production occurs mostly in a very intense spring bloom, and a large percentage sinks to the sea floor. Some changes in benthic production have been observed, *e.g.* in the Chirikov Basin in the northern Bering Sea. There is evidence of reduced carbon supply to the benthos and a shift in bivalve species. This has the potential to affect seabirds such as eider ducks which feed on the bivalves. Where there is a likelihood of greater stratification over some of the shelf areas of the Arctic, a weakening of pelagic/benthic coupling is expected. Changes in the zooplankton community may also lead to changes in the coupling, depending on what the zooplankton feed upon and their fecal pellet production and sinking rates.

There are indications that krill (*Euphausia superba*), the dominant zooplankton species in Antarctic waters, have been declining during recent years. Concurrent with this decrease has been a rise in salps in some areas. The change in the ecosystem structure from krill to salps, or to other smaller zooplankton (*e.g.* copepods), results in a less energy-efficient ecosystem, with less energy available for higher trophic levels. Krill are ice-associated organisms. Many of those produced around the Antarctic Peninsula are transported by local currents to the area around South Georgia, an important breeding area for both marine mammals and seabirds, several species of which forage primarily on krill. The loss of sea ice off the Western Peninsula may have contributed to a decline in krill and, consequently, less krill may have been transported towards South Georgia in recent years.

In the subarctic, increased advection of Atlantic waters farther north, for example off Iceland, has resulted in a corresponding increase in zooplankton biomass in recent years. Direct advection of zooplankton into the Arctic also occurs. Indeed, during summer, the Chukchi Sea zooplankton community is dominated by Bering Sea fauna, which has been advected through the Bering Strait. Little is known about zooplankton variability in the central Arctic Ocean due to a lack of data.

Some fish species may move into the Arctic under future warming, mostly through the movement of adults from the Atlantic Ocean. Which species will be able to survive and become resident populations is unclear at this time. Larval transport may contribute to the movement of fish as well, but whether these larvae will be able to grow and survive in the Arctic is unknown. Ice-dependent fish, such as polar cod, are expected to decline in abundance in parallel with the disappearance of the sea ice.

Ice-dependent marine mammals, such as some seals, walrus and polar bears, and seabirds, including penguins, have been stressed by the loss of ice, with significant declines in abundance of certain species in both the Arctic and the Antarctic. These declines are caused by a combination of an absence of sea ice for hauling out, foraging, or mating encounters, or shifts in prey abundance or availability. Further reductions in sea ice are expected to lead to greater population losses of those affected species.

Advection plays an important role in terms of generating hotspots which attract marine mammals and seabirds to feed. Examples of a few significant feeding hotspots include Unimak Pass in the Aleutian Islands (Fig. 2), canyons in the Beaufort, Chukchi, Bering and Barents seas, and Margarite Bay off the West Antarctic Peninsula. It is not only the concentration of prey in these hotspots that is important but also the quality of the prey.

Fig. 2 Shearwaters and whales feeding near Unimak Pass in the Aleutians. Photo by Mike Britton, North Gulf Oceanic Society (NGOS), copyright Mike Brittain.

In addition to the requested disciplinary contributions, there were two submitted papers presented at the workshop. The first focused on estimates of new primary production (NPP) from satellite imagery and showed a positive relationship of NPP with SST (sea surface temperature) in both the Arctic and the Antarctic. This suggests that under future warming, there is likely to be a slight increase in NPP in the two areas. The other presentation compared copepod collections in 1964 and 2004 during the austral summer in the sub-Antarctic region of the western Indian Ocean. An increase in the carnivorous components in recent years suggests the possibility of an altered trophic structure.

One feature that differentiates the Arctic and the Antarctic is that the former is mostly a closed system while the latter is entirely open. Another feature is the difference in the connectivity or residence times, with relatively rapid connectivity around the Antarctic (scale of years) whereas in the Arctic it is much longer (decades to a century or longer). It is clear that large changes in the polar and subpolar regions are expected under anthropogenic climate change. Many participants stressed the need for increased observations and time series from these crucial areas.

At the end of the workshop the possibility of writing a paper or papers on the workshop results was discussed. No definite decision was made but the co-convenors will survey all those involved in the disciplinary groups to determine their interest in pursuing journal publications. A Working Group under IMBER will be formed to continue the comparisons of Arctic and Antarctic ecosystems, and those involved in the writing of any papers will be the initial members of such a working group.




Dr. Kenneth Drinkwater (ken.drinkwater@imr.no) is a fisheries oceanographer working at the Institute of Marine Research in Bergen, Norway. He has been conducting research on climate variability and its effects on the marine ecosystem, with a special interest in fish populations, mostly in the subarctic regions of the Atlantic Ocean. Ken is Co-Chairman of the Scientific Steering Committee (SSC) of the IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) Regional Program ESSAS (Ecosystem Studies of Sub-Arctic Seas) and of the newly-formed ESSAS Working Group on Arctic-Subarctic Interactions. He is also on the SSC of IMBER and on the Scientific Steering Group of CLIVAR (Climate Variability and Predictability Program).

Dr. George Hunt (geohunt2@uw.edu) is Research Professor in the School of Aquatic and Fishery Sciences at the University of Washington. In 2005 he retired from the University of California, Irvine, after teaching and doing research there for 35 years. Now, he divides his time between Seattle and Friday Harbor, Washington. George began his career studying the behavioral and reproductive ecology of gulls in southern California and British Columbia. This work led to studies of seabird reproductive ecology on the Pribilof Islands and of the foraging ecology of seabirds in the Bering Sea, the Barents Sea, the North Water Polynya, and the Southern Ocean. More recently, he has participated in ecosystem-level studies of the southeastern Bering Sea, the Aleutian Archipelago, and in studies comparing the Barents Sea with the Bering Sea and the Chukchi Sea. George was the Chairman of the Scientific Steering Committee (SSC) of BEST (Bering Ecosystem Study) and Co-Chairman of the SSC of the IMBER Regional Program ESSAS (Ecosystem Studies of Sub-Arctic Seas). In PICES, he led Working Group 11 on Prey Consumption by Marine Mammals and Seabirds in the PICES Area, was founding Chairman of the Advisory Panel on Marine Birds and Mammals, and was a member of the CFAME (Climate Forcing and Marine Ecosystem Response) Task Team.

Dr. Eugene Murphy (ejmu@bas.ac.uk) is an ecological modeler with the British Antarctic Survey in Cambridge, UK. His main research interests include krill ecology, the general structure and function of the Southern Ocean ecosystems, and responses to physical oceanographic and climate forcing. Eugene is presently the chair of the ICED (Integrating Climate and Ecosystem Dynamics in the Southern Ocean) regional program of IMBER that focuses upon the Southern Ocean and is on the SSC of IMBER.

Dr. Jinping Zhao (jpzhao@ouc.edu.cn) is a physical oceanographer at the College of Physical and Environmental Oceanography, Ocean University of China, in Qingdao. His polar-related research is focused on physical oceanography and sea ice, ocean circulation and global climate change. Current research programs include studies of the structure of Arctic Circumpolar Boundary Current and its impact on climate change, adjustment of the thermal structure in the Arctic Ocean and its feedback during global change processes, interaction of sea-ice decline and upper ocean warming, and associated climatological and ecological processes.

2012 Yeosu Workshop on "Climate Change and Range Shifts in the Oceans: Detection, Prediction and Adaptation"

by Gretta Pecl, Amanda Bates, Stewart Frusher, Alistair Hobday, Warwick Sauer, Renae Tobin, David Vousden and Thomas Wernberg

A 1-day workshop on "*Climate change and range shifts in the ocean: Detection, prediction and adaptation*" was convened on May 20, 2012, immediately after the 2nd International Symposium on *"Effects of the Climate Change on the World's Oceans"* held from May 15–19 in Yeosu, Korea. Over 40 scientists, resource managers and policy advisors gathered to explore issues associated with ecosystem level impacts arising from the increasing frequency of species shifting their range.

Climate change driven changes in the phenology, distribution and abundance of marine species are being reported around the globe[1-3]. Range shifts in marine taxa have been described for waters around all continents, including Antarctica, and the Pacific Islands[4]. Distributional changes are the most commonly reported, sometimes involving shifts of 100's of km. Changes in exploited species may subsequently affect the utilization of marine resources with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion[5-7]. Despite this importance, there are currently limitations to the detection and prediction of range shifts. Overcoming these limitations is critical for policy adaptation to manage shifting marine resources in order to enhance food security[8] and minimize negative socio-economic consequences. Additionally, range shifts will not occur uniformly around the world as climate change is not impacting all areas equally. Regions where ocean warming is occurring most rapidly (marine hotspots) represent an opportunity to quickly advance our understanding of current and likely future changes.

The un-replicated nature of species' range shifts renders attribution of causality notoriously difficult[9]. However, some 75% of marine range shifts reported in the peer-reviewed literature have been polewards in direction – symptomatic of broad-scale environmental changes such as those predicted under global climate change scenarios[4]. In light of even the most conservative future climate change projections[10], coupled with the available evidence that climate change is likely responsible for shifts in many species' biogeographic ranges, more research is needed to understand the full extent of realized and potential future range shifts in marine taxa, and in particular, the role that climate change plays in these shifts[10]. Because range shifts affect the distribution and abundance of harvested marine resources, as well as the dynamics of the ecosystems that underpin the productivity of marine resources, examining the diverse consequences of climate change-induced marine range shifts is critical. Although range shifts have been documented in the marine environment, far fewer studies consider the mechanisms of range-shifting dynamics[11,12], and even fewer the socioeconomic consequences or optimal management responses[13]. Likewise, the appropriateness of existing or potential management responses has not been comprehensively explored[14]. As the climate continues to change, range shifts driven by this globally ubiquitous process will likely broaden in both number and geographic extent. Considering the ecological, socioeconomic, and management implications of these changes before they occur is essential to mitigating the negative effects of the global redistribution of species and for developing effective adaptive response strategies and to seize opportunities.

The ultimate aim of the workshop was to draft a manuscript assessing ecosystem-level impacts of the increasing frequency of single-species range shifts, and evaluating our capacity for prediction and adaptation to these likely impacts. In doing so, we will develop a conceptual framework that links the responses of science, management, policy and governance to shifting marine resources at relevant spatial and temporal time scales. This is a necessary task to lay the groundwork to develop contextually relevant response strategies to ensure sustainable resource use, management and food security under a changing climate. The workshop had three objectives (Fig. 1), achieved through break-out sessions involving small group work:

1. Identify the key biological and ecosystem responses to increasing range shifts;
2. Determine the possible impacts (negative or positive) that will result from various responses;
3. Highlight potential adaptations in the human-system that may minimise impacts or maximise opportunities arising from range shifts.

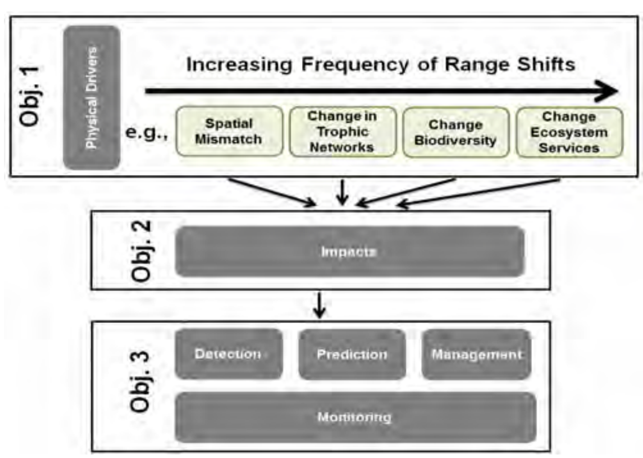

Fig. 1 Aims of the range shift workshop.

To set the scene for the day, three talks were prepared by the convening team building on the themes of detection, prediction and adaptation.

Detection: Thomas Wernberg began with a presentation outlining methods to quantify climate-driven range extensions and contractions at different time scales, and highlighting several important issues associated with the detection of such responses. While species distribution changes are the most commonly detected, and subsequently reported, response to climate change, within assemblages, only ~30 to 80% of species present have been observed to shift in a polewards direction with increasing environmental temperature (Fig. 2). Moreover, of the species that have shifted, the rate of range extension towards the poles (leading range boundary), or contraction away from the equator (trailing range boundary), varies in both space and time. However, it is currently unknown how much of the variability in range response between species and at different scales is a product of our capacity to detect range shifts in the first place. Are the generic biological monitoring programs that are presently underway sensitive enough to detect climate-forced distributional changes? By identifying knowledge gaps in the methods used to detect range shifts over space and time, we can rethink monitoring strategies in a range shift context to optimize prediction capabilities and therefore, be pro-active about resource management required as range shifts occur.

Prediction: Alistair Hobday then presented a talk about the role and potential of monitoring and modelling in predicting species range shifts in the ocean. Detailed investigation of ocean warming hotspots, or regions of rapid warming, can advance our understanding of climate-driven distributional change in marine species, and indicate to what capacity we may be able to predict biological responses. This presentation highlighted the various modelling approaches to predict species' vulnerability to ocean warming at both trailing and leading range boundaries. Several discussion points were raised, such as whether it is possible to gather the data required to identify species traits or parameterize species-specific models for entire assemblages in order to compare the shifting potential of different species within the timeframes required to implement adaptation strategies. How 'typical' prediction approaches can be supported by real-time monitoring to provide critical baselines and early identification of shifting species to enable timely human responses to range shifts, was also discussed.

Adaptation: Warwick Sauer introduced the topic of adaptation, highlighting the possible responses that could be undertaken in the human system in terms of marine resource management, policy and governance. Distributional changes in exploited species may affect the utilization of marine resources, with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion. Thus, contextually relevant response strategies to ensure sustainable resource use, management and food security should be robust to uncertainty in both detection and prediction of species shifts. The group subsequently explored the question of whether emerging trends in biological data sets are sufficiently reliable to enable management and policy actions to be taken even in the absence of higher confidence limits.

The final discussion session focused on several key issues that were raised throughout the day in the smaller break-out groups, and included questions such as:

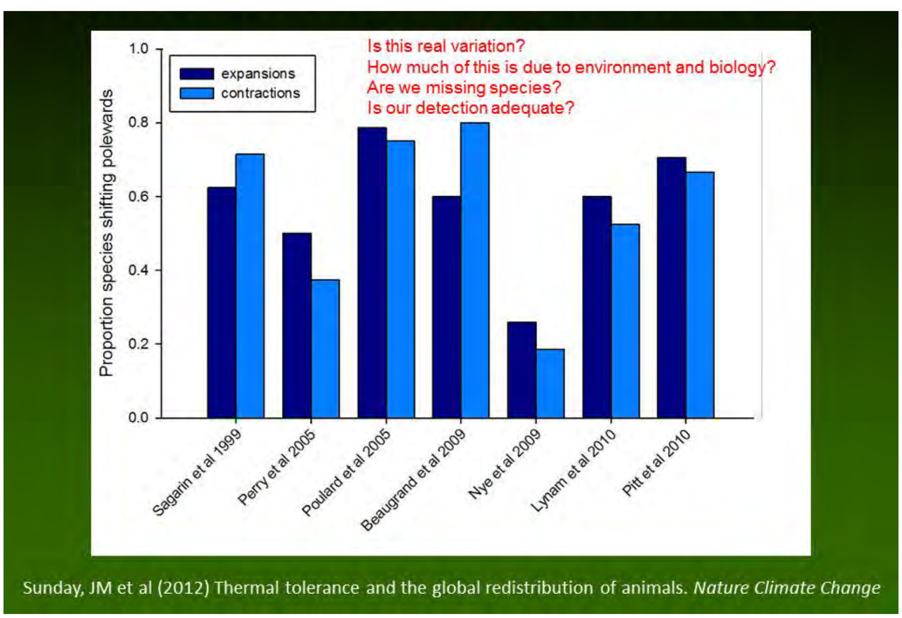

Fig. 2 The proportion of species identified as shifting polewards, from a variety of studies around the world, is highly variable. Some of this is most probably genuine variation in the assemblage level responses due to temporal and spatial patterns in environmental factors and differences among species in their biology. However, some of this variation may also be associated with particular sampling approaches and our capacity to detect range shifts in particular species[15].

Fig. 3 Four evidence-based approaches to the detection of single-species range shifts in marine systems.

1. What will be the major implications of increased frequency of range shifts for ecosystem goods and services?
2. Will there be differences among trophic levels or marine systems in their resilience to range shifts? Can we expect different trophic levels or marine systems to display different levels of responsiveness to climate warming?
3. Are regions experiencing high rates of range shifts likely to be more unpredictable?
4. Can we predict what increasing 'tropicalisation' of temperate systems will look like? And what is a better general term than 'tropicalisation' that applies to all ecosystems, *e.g*., polar regions becoming more temperate?
5. What human activities will magnify range shifts?

The workshop participants represented an inter-disciplinary team from around the globe and were successful in their endeavor to identify knowledge gaps in the detection and prediction of range shifts at different temporal and spatial scales. Adaptation responses to the predicted changes should be robust to uncertainty in both detection and prediction, and shared experience is critical to minimize independent adaptation failures.

The workshop was sponsored by the Institute for Marine and Antarctic Studies (IMAS) at the University of Tasmania.

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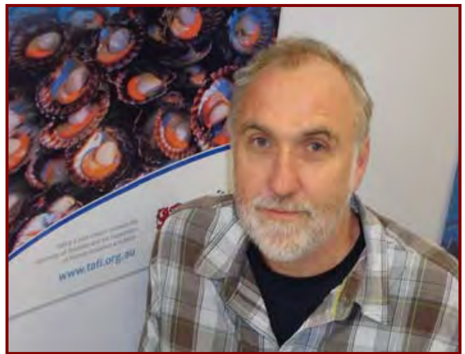


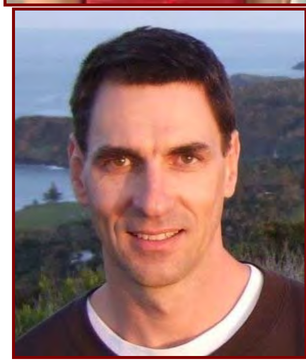

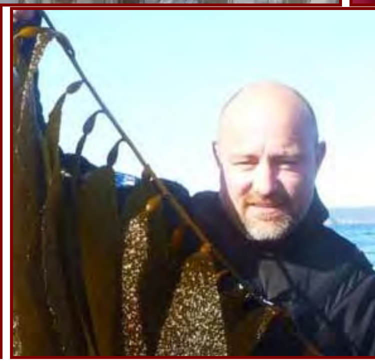


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Dr. Stewart Frusher (Stewart.Frusher@utas.edu.au) is Associate Professor at the Institute for Marine and Antarctic Studies where he leads the Estuaries and Coasts Program. Stewart co-convenes the bio-physical node of Australia's Adaptation Network for Marine Biodiversity and Resources with Dr. Hobday. His interests are in providing the research to sustainably manage fisheries resources so that they can continue to provide social and economic benefits to society. He has extensive experience in crustacean resources and is becoming more involved in the development of interdisciplinary teams to address fisheries issues.

Dr. Amanda Bates (Amanda.Bates@utas.edu.au) is a Research Fellow with an interest in relating animal physiology and health to species patterns in a changing climate. Amanda has studied thermal tolerances in diverse organisms from Antarctica to the deep sea to advance both general ecological understanding of the processes driving the redistribution of species with recent warming and applied management issues. She is working with collaborators to generate a theoretical framework for detecting and predicting the range responses of ectotherms to warming environmental temperatures.

Dr. Alistair Hobday (Alistair.Hobday@csiro.au) is a Principal Research Scientist at CSIRO in Australia, and leads the Marine Climate Impacts and Adaptation research area (http://www.cmar.csiro.au/climateimpacts). His research has focused on the physical drivers and impacts of climate change on the distribution of marine species around Australia and recently assisted with development on national strategy to respond to climate risks. With Dr. Frusher, Alistair co-convenes the bio-physical node of Australia's Adaptation Network for Marine Biodiversity and Resources. He is also Co-Chairman of the international GLOBEC/IMBER program CLIOTOP (Climate Impacts on Top Ocean Predators).

Dr. Warwick Sauer (W.Sauer@ru.ac.za) is Professor and Head of the Department of Ichthyology and Fisheries Science at Rhodes University in South Africa. His interests are in fisheries ecology and management, particularly in the translation of science into practical fisheries management. Warwick serves on a number of management bodies and has been involved in numerous regional research projects covering Sub Saharan Africa and the western Indian Ocean. He currently is a member of the Project Coordination Unit for the Agulhas and Somali Large Marine Ecosystem Project, and coordinates training and capacity building initiatives across the Agulhas region.

Dr. Thomas Wernberg (thomas.wernberg@uwa.edu.au) is an Australian Research Council Future Fellow based at the Oceans Institute of the University of Western Australia in Perth. His research centres on the ecology of shallow sub-tidal habitats. Thomas' work integrates physiology, ecology and biogeography to try to understand how marine organisms and habitats respond to stressors such as eutrophication, invasive species and climate change and variability

Dr. Renae Tobin (renae.tobin@jcu.edu.au) is a Research Fellow at James Cook University, Australia. Specialising in social science, but with a background in ecology, she provides essential interdisciplinary links in multiple projects. Renae's research is generally stakeholder (industry and management) driven, and hence highly diverse ranging from exploring regional co-management for inshore fisheries to developing long-term social and economic monitoring programs.

2012 Yeosu Workshop on "Beyond Dispersion"

by William Stockhausen, Sukyung Kang and Carolina Parada

A 1-day workshop on "*Beyond dispersion: Integrating individual-based models for bioenergetics and behavior with biophysical transport models to predict influences of climate change on recruitment processes in marine species*" was held on May 20, 2012, immediately following the 2nd International Symposium on "*Effects of Climate Change on the World's Oceans*" convened in Yeosu, Korea. Future climate change is expected to influence the abundance and distribution of marine fish species in complex ways, including changes in the local environmental characteristics and transport pathways experienced by early life stages that are typically pelagic, such as eggs and larvae. To date, numerous coupled biophysical models (CBPMs) with individual-based model (IBM) subcomponents have been developed to study the influence of oceanographic transport patterns on dispersion of early life stages and recruitment variability in marine fish species. In many of these models, advective oceanographic processes are hypothesized to be the main determinant of recruitment variability; simulated individuals in the models are regarded primarily as passive particles or drifters and "success" is judged by the relative number of simulated particles that end up being advected to suitable juvenile nursery grounds. While these models represent a significant step in our ability to understand and predict the effects of climate change on recruitment, they ignore important effects (temperature/salinity stress, food availability, *etc*.) on growth and survival associated with the environmental conditions encountered by (simulated) individuals along their drift trajectories. Although bioenergetics models typically include such effects and can be used to address the impact of local environmental variation on the growth and survival of eggs and larvae, few bioenergetics models have been targeted toward early marine life stages, few CBPMs incorporate bioenergetic considerations, and fewer still have been used to address the potential impact of climate change on marine species. The workshop was intended to discuss the state-of-the-art for incorporating IBMs within CBPMs, together with current challenges and future directions.

The workshop consisted of 5 presentations in the morning followed by a productive afternoon discussion period. Altogether, 19 people participated in the workshop. In addition, it featured what had to be the largest banner of all sessions and workshops (Fig. 1).

Following initial remarks by workshop co-conveners, Sukyung Kang and William Stockhausen, the first invited speaker, Myron Peck (University of Hamburg, Germany), discussed recent advances in, and future challenges to, integrating physiology, behavior and physical constraints into coupled IBMs/CBPMs for the early life stages of marine fish. In a wide-ranging talk, he highlighted the diverse physiological mechanisms and responses to environmental conditions that need to be accounted for in modeling the growth and survival of early (and later) life stages of marine fishes on an individual basis. These include direct effects of temperature and size on growth and survival through egg development rates, hatching success, size-at-hatch, yolk sac utilization rates, routine metabolism

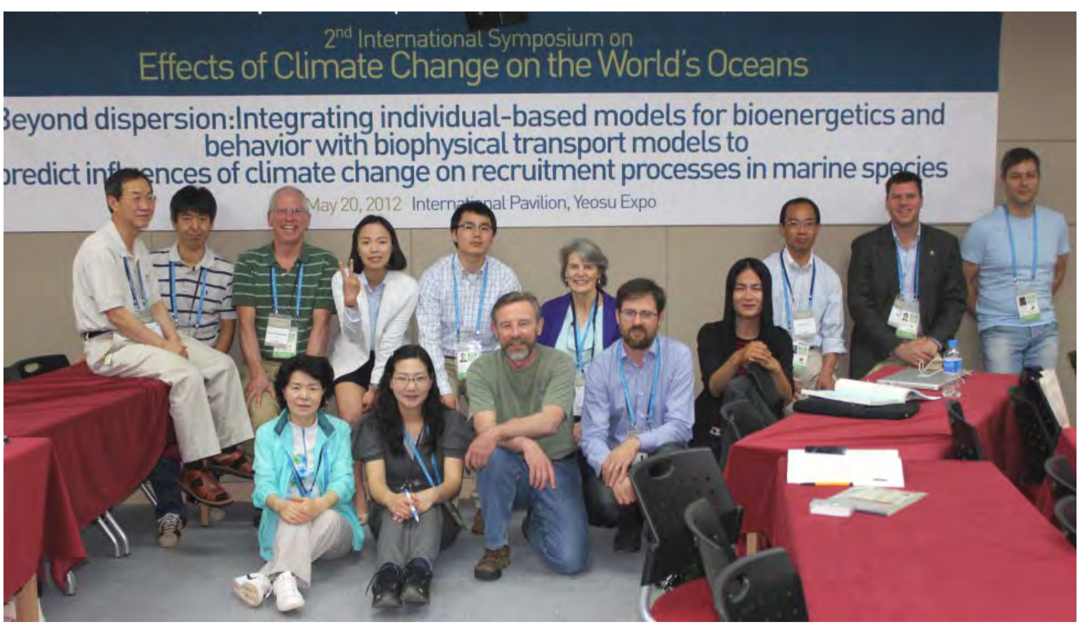


Fig. 1 The workshop: participants and banner (photo credit: Sukgeun Jung).

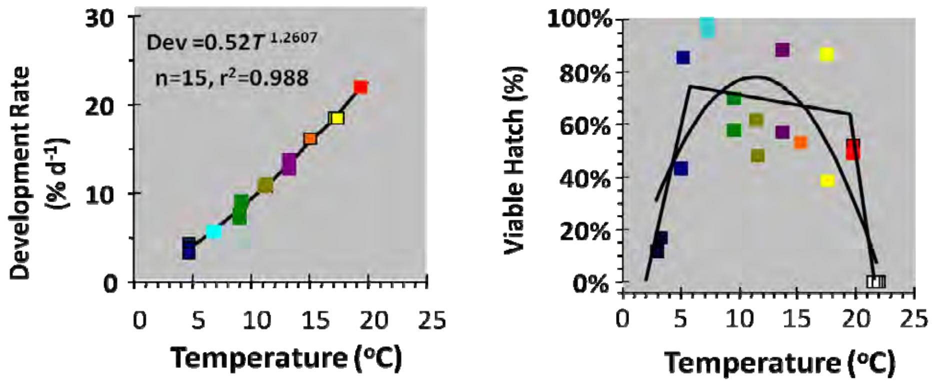


Fig. 2 Effects of temperature on egg development rates and hatching success in Baltic herring (Clupea harengus) (based on Peck et al., 2012).

rates and swimming speed (*e.g.*, Fig. 2). Parental effects on egg survival, environmental effects on success of the first feeding, changes in diet composition and prey energy content, flexibility in foraging behavior, and species interactions were also discussed. The importance of increased knowledge of the growth physiology of target species and the need for modelers to conduct sensitivity studies to identify critical model parameters were stressed among his recommendations.

Shin-Ichi Ito (Tohoku National Fisheries Research Institute, Japan), the second invited speaker, discussed the need to incorporate feeding and spawning migrations in models for growth and survival of marine fishes. He presented results from a comparison of such models for Japanese sardine (*Sardinops melanostictus*) in the western North Pacific (Fig. 3) and highlighted the importance of confronting observed spatial patterns (based on field data) with multiple alternative models because different behavioral mechanisms can give rise to similar spatial patterns. Authors of the recounted study were able to eliminate two of four hypothesized behavioral mechanisms for observed sardine feeding migrations from further consideration; however, they were unable to discriminate between the remaining two mechanisms, even though the behavioral bases for these models were quite different (predator avoidance *vs*. extended kinesis). He also presented a rather novel approach, based on artificial neural networks, to "forcing" a spawning migration pattern when hypothesized behavioral mechanisms were inadequate to reproduce observed movement patterns.

Fittingly (given the venue), the other speakers presented talks featuring models and data relevant to Korean marine systems. Jung-Jin Kim (Pukyong National University, Korea) used a coupled IBM/CBPM to infer current seasonal spawning grounds for Korean common squid (*Todarodes pacificus*) in the western Pacific from field data for larval occurrence. He then used IPCC model runs to drive a regional ocean model to predict changes in spawning grounds under future climate change. Sukgeun Jung (Jeju National University, Korea) presented preliminary results for a coupled IBM/CBPM for Pacific anchovy (*Engraulis japonicus*) in Korean waters. And finally, Min-Jung Kim (National Fisheries Research and Development Institute, Korea) presented results from diet studies on Pacific anchovy in the southern coastal waters of Korea. Her talk highlighted the spatiotemporal and ontogenetic variability in anchovy diets in southern Korean waters due to variability in prey species composition and abundance, plasticity in feeding strategies, and ontogenetic differences.

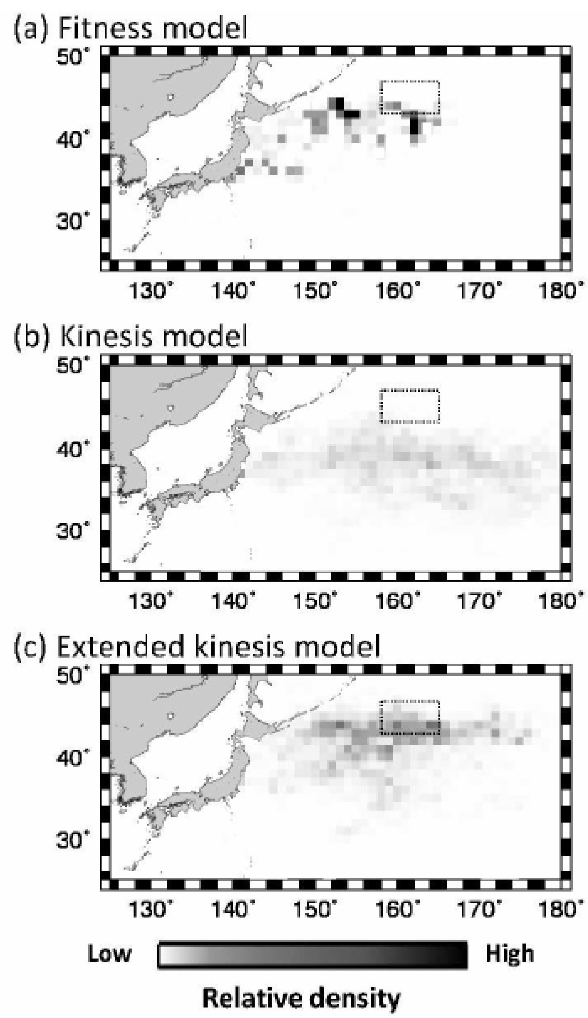


Fig. 3 Results from three alternative feeding migration models for Japanese sardine (from Okunishi et al., 2012).

A key outcome from discussions following the presentations was the recognition that one aspect of the impact of future climate change on species abundance and distribution patterns will occur through changes in the growth rates, and subsequent survival, of individuals. However, these changes may not be predictable from simple statistical relationships based upon (current) growth rates and expected changes in temperature. Instead, it is likely that future changes will be due to the dynamic interaction of several factors, including indirect effects on the abundance, composition, and relative energy content of key prey species. These indirect effects will act in concert with direct effects such as changes in water circulation patterns and temperature that will influence the spatial overlap and metabolic processes of predators and prey. Thus, one important recommendation stemming from the discussions was that IBMs used to predict the impact of future climate change on species abundance and distribution should incorporate mechanistic bioenergetics models that account for effects of changes in prey abundance, energetic content and species composition on individual growth rates. Workshop participants also acknowledged a general lack of data on the physiology of many fish and shellfish species, even for commercially- and/or ecologically-important ones, as well as a scarcity of marine physiologists who could potentially address these issues.

A list of additional recommendations from the workshop include:

- incorporating life cycle closure within physiologically-based models to capture climate impacts on various life stages (and identify potential climate-driven bottlenecks to recruitment), with a recognition of stage-specific differences in growth physiology, diets, and tolerance to environmental factors;
- increasing process-level understanding of the factors controlling fish migration patterns, particularly spawning migrations, and the environmental factors that regulate behaviorally-mediated movements or the evolution of observed behaviors of different life stages; and
- conducting more basic, controlled laboratory experiments on the growth physiology of species, including those designed to capture the interactive effects of multiple factors (*e.g*., temperature *x* prey species *x* pH).

For more details on some workshop-related research, see:

Okunishi, T., S.-I. Ito, D. Ambe, A. Takasuka, T. Kameda, K. Tadokoro, T. Setou, K. Komatsu, A. Kawabata, H. Kubota, T. Ichikawa, H. Sugisaki, T. Hashioka, Y. Yamanaka, N. Yoshie and T. Watanabe. 2012. A modeling approach to evaluate growth and movement for recruitment success of Japanese sardine (*Sardinops melanostictus*) in the western Pacific. Fish. Oceanog. 21: 44–57. doi: 10.1111/j.1365-2419.2011.00608.x.

Peck, M., P. Kanstinger, L. Holste, and M. Martin. 2012. Thermal windows supporting survival of the earliest life stages of Baltic herring (*Clupea harengus*). ICES J. Mar. Sci. 69(4): 529–536.

Dr. William T. ("Buck") Stockhausen (william.stockhausen@noaa.gov) is a Research Fishery Biologist with the U.S. National Marine Fisheries Service's Alaska Fisheries Science Center in Seattle, Washington, USA. His research interests include fisheries stock assessment, recruitment processes, individual-based modeling (IBM) and coupled biophysical models. He is currently working on developing DisMELS (the Dispersal Model for Early Life Stages), a coupled biophysical/IBM modeling framework, to investigate recruitment processes for arrowtooth flounder (Atheresthes stomias), Pacific ocean perch (Sebastes alutus), and other species in the Gulf of Alaska for the North Pacific Research Board's Gulf of Alaska Integrated Ecosystem Research Program.

Dr. Sukyung Kang (kangsk@nfrdi.go.kr) is a Fisheries Oceanographer with the National Fisheries Research and Development Institute (NFRDI), Korea. She has been a member of the North Pacific Anadromous Fish Commission (NPAFC) for Korea for the last five years and was a member of the joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish. Her research interests include the impacts of climatic and oceanographic variability on small pelagic fish, as well as the use of otolith chemistry information for stock identification and habitat characteristics of fishes.

Dr. Carolina Parada (cparada@inpesca.cl) is a Research Scientist at the Fisheries Research Institute (INPESCA) in Chile and a Research Associate to the Geophysical Department at the University of Concepción-Chile. She is also one of the Principle Investigators in the modeling component of the North Pacific Research Board's Gulf of Alaska Integrated Ecosystem Research Program. Carolina has been working with biophysical models since 1999 and applying these models to larval drift, connectivity and pre-recruitment variability studies for various pelagic and benthic species in different regions. Her work focuses on biophysical modeling and links to population dynamics and the environment, and transport and connectivity of small pelagic and highly migratory species in the Humboldt Current system. Her current research interests include ecosystem modeling focused on the impact of climate variability and change on fish populations and their fisheries.

2012 Yeosu Workshop on "Public Perception of Climate Change"

by Catharina J.M. Philippart and Dohoon Kim

During the 2nd International Symposium on "*Effects of Climate Change on the World's Oceans*" in Yeosu, Korea, the authors of this article convened a workshop on "*Public perception on climate change*". This workshop started with three presentations and was followed by a discussion at which 13 persons participated, originating from Australia, France, Germany, Japan, the Netherlands, Korea, the UK and the USA.

Dr. Paul Buckley (Centre for Environment, Fisheries and Aquaculture Science, UK) presented results of the EU project CLAMER (Climate Change and European Marine Ecosystem Research) which recently completed the first major poll to focus specifically on marine climate change. In total, some 10,000 European citizens from 10 different countries, spanning seas from the Arctic to the Mediterranean, took part in the poll (http://www.clamer.eu/awareness). Awareness and concern about marine climate change issues was set in the context of wider marine environmental issues (*e.g*., pollution, overfishing and habitat destruction) and country and demographic differences examined. With regard to marine environmental issues the public know and care about, it was pollution, a non-climate change issue that came out top, although a range of more "visible" climate change related issues (melting sea ice, sea level rise and flooding, erosion and extreme events) also scored highly (Fig. 1).

Fig 1 Results of an European survey on public perception on climate change to the open-ended question "When you are thinking about the coastline or the sea, what are the three most important environmental matters that come to mind?"

Dr. Tae-goun Kim (Korea Maritime University, Korea) shared his results with regard to the public perception of wetland restoration benefits in Louisiana, USA. In August 2005, a storm surge destroyed most of the levees of New Orleans (Louisiana) resulting in flooding of most parts of the city. This worst engineering disaster in the history of the USA prompted a scientific debate on the possible benefits of wetland restoration for reducing the impacts of such a storm surge. Results of a referendum-style contingent-valuation survey indicated that the public perceives both a strong relationship between increased wetland loss and increased storm risk and a substantial likelihood of increased storm-protection benefits from wetland restoration. However, respondents expressed that they were less likely to believe the improved storm reduction benefits from restoration when they perceived a high frequency of severe storms. Hurricane protection benefits were the most important factor explaining a willingness to pay for wetland restoration to prevent expected future land losses in coastal Louisiana.

Dr. Mitsutaku Makino (Fisheries Research Agency, Japan) presented Japanese examples of outreach and adaptation strategies for climate change at three different scales. He first introduced a national campaign aimed at the general public, called "Challenge 25" that aims at a reduction of CO_2 emissions by 25% by the year 2020. This campaign promotes 25 easily understandable and easy to do activities in everyday life by which the public can help to reach this goal. The second example addressed the recovery of infrastructure after the Great Eastern Japan Earthquake in March 2011, which destroyed or severely damaged many coastal communities and fisheries industries. The Local Recovery Plans against the Earthquake, part of the National Strategy for the Recovery, advocate for the development of alternative energy industries. For example, Ishinomaki-city announced a plan to build a Smart Community, *i.e*., a "safe, secure and eco-friendly town" with energy self-support by introducing various alternative energy generators.

Dr. Catharina J.M. Philippart (katja.philippart@nioz.nl) is an estuarine ecologist at the Royal Netherlands Institute for Sea Research. She studies environmental impacts, including climate change, on coastal ecosystems, with a focus on trophic interactions between primary producers and consumers.

Dr. Dohoon Kim (delaware310@nfrdi.go.kr) is a fisheries economist at the National Fisheries Research and Development Institute, Republic of Korea. He is strongly involved in the development of socioeconomic indicators for an ecosystem-based fisheries management approach.

(*continued on p. 50)*

PICES Working Group 20: Accomplishments and Legacy

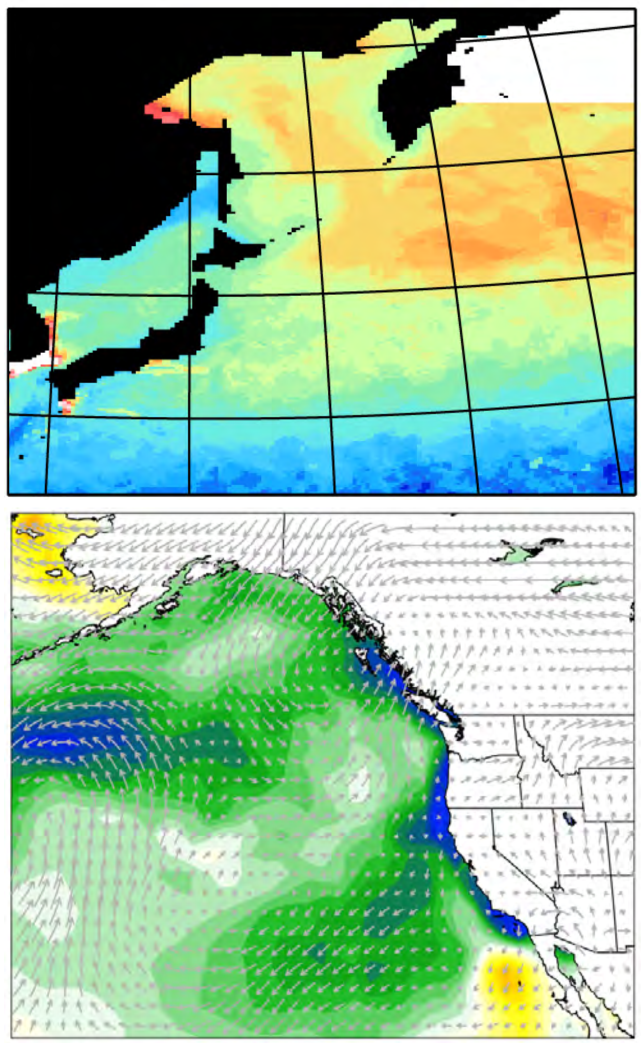
by *Michael Foreman, Emanuele Di Lorenzo and Chan Joo Jang*

PICES Working Group on *Evaluations of Climate Change Projections* (WG 20) was approved at the 2006 PICES Annual Meeting (PICES-2006) in Yokohama, Japan. As previous climate studies within PICES had generally been retrospective, it was felt that the upcoming 2007 release of the 4th Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), and the Global Climate Model (GCM) projections associated with it, could provide a credible set of forecasts for forward-looking ecosystem studies in the North Pacific. Accordingly, the motivation for creating the working group was to evaluate these IPCC projections and, where possible, to downscale them to sufficiently fine spatial scales so that they would be useful for continental shelf and coastal ecosystem studies. Though WG 20 was originally assigned a 3-year term, this was extended to 4 years at PICES-2008 (Dalian, China) in order to allow collaborations with the soon-to-be created ICES/PICES Working Group on *Climate Change Impacts on Fish and Shellfish*. The Physical Oceanography and Climate Committee (POC) was the only parent committee of WG 20, and Michael Foreman (Canada) and Yasuhiro Yamanaka (Japan) co-chaired the working group. The terms of reference (TOR) of WG 20 are listed below:

1. Analyze and evaluate climate change projections for the North Pacific and its marginal seas based on predictions from the latest global and regional models submitted to the Intergovernmental Panel on Climate Change (IPCC) for their 4th Assessment Report;
2. Facilitate analyses of climate effects on marine ecosystems and ecosystem feedbacks to climate by, for example computing an ensemble of the IPCC model projections for the North Pacific and making these projections available to other PICES groups such as CFAME (*Climate Forcing and Marine Ecosystem Response*) Task Team;
3. Facilitate the development of higher-resolution regional ocean and coupled atmosphere-ocean models that are forced by, and take their boundary conditions from, IPCC global or regional models;
4. Facilitate the development of local and regional data sets (*e.g.*, SST, river flow, sea ice cover) by incorporating information from climate model projections as well as observations and historical re-analyses;
5. Ensure effective two-way communication with the Climate Variability and Predictability Program (CLIVAR);
6. Convene workshops/sessions to evaluate and compare results;
7. Publish a final report summarizing results.

WG 20 completed its tenure in October 2010, and a final report summarizing its accomplishments and providing recommendations can be downloaded from the PICES website (http://www.pices.int/publications/scientific_reports/default.aspx).

With the IPCC 5th Assessment Report (AR5) presently in preparation and various chapters scheduled for release over the next two years, it is timely to review these recommendations and their status with respect to present and future PICES activities.



Two examples of member activities applied to Working Group 20's first and third terms of reference. Top: A regional ecosystem model version of COCO-NEMURO applied to the lower trophic level marine ecosystem simulating the timing of maximum chlorophyll concentration (dark blue is January, red is June) in the spring bloom in the Kuroshio-Oyashio system. (See Yamanaka et al. for more details.) Bottom: A Northeast Pacific regional climate model nested in the CCSM global climate model relative to the CCSM model showing sea surface temperature (dark blue is –3.0°C and red is +3.0°) and wind anomalies (maximum is approximately 1.5 m/s) in August. (See Curchitser et al. for more details.)

1. Though it was not recommended that a new working group be established to evaluate the projections from AR5, a need to continue this work was foreseen and several PICES members have started to analyse the associated global climate model output that is now available on the CMIP5 archive (http://cmip-pcmdi.llnl.gov/cmip5/data_portal.html). It is expected that updates on these analyses will be regularly reported at PICES Annual Meetings and in particular, those of the Advisory Panels on *Climate, Oceanographic Variability and Ecosystems* (AP-COVE) and *Status, Outlooks, Forecasts, and Engagement* (AP-SOFE) and the Section on *Climate Change Effects on Marine Ecosystems* (S-CCME). For example, WG 29 (see below) is planning to analyse CMIP5 projections, especially changes in ecosystem-related variables, including mixed layer depth or stratification, focusing on the North Pacific.
2. A new working group (WG 27) to investigate North Pacific climate variability and change was created in 2011 with the goal to develop essential understandings of the mechanisms of North Pacific climate variability and change that can better guide the formulation of process-based hypotheses underlying the links between physical climate (*e.g.*, Pacific Decadal Oscillation, North Pacific Gyre Oscillation, El Niño) and ecosystem dynamics (http://wg27.pices.int).
3. A working group on *Regional Climate Modeling* (WG 29) was formed last year to ensure that the work beginning under TOR#3 of WG 20 would be continued (http://www.pices.int/members/working_groups/wg29.aspx).

Though live-access servers or ftp sites have yet to be created to archive and provide easy access to results from North Pacific regional climate models (recommendation 4), analogous to the global climate model output available *via* CMIP5, this could certainly be done for the various models associated with WG 29 and would be a natural consequence of their TOR#1, "Assemble a comprehensive review of existing regional climate modeling efforts". This work could be performed in collaboration with WG 27, as there is certainly an overlap with their TOR#5, "Provide improved metrics to test the mechanisms of climate variability and change in IPCC models, and in coordination with other PICES working groups and FUTURE Advisory Panels, assist in evaluating those models and providing regional climate forecasts over the North Pacific."

And though links to websites that provide access to global and regional climate model output, and a guide for using them (recommendation 5) have yet to be made available on the PICES website, this could also be easily done. WG 27 has already created its own website (http://wg27.pices.int) and at least initially, this might be a home for this information.

In short, though WG 20 was successful in meeting most of its terms of reference over its short 4-year timeframe, the work that it began is continuing though other PICES expert groups and can be expected to play an important role in the second PICES integrative scientific program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems).



Dr. Michael Foreman (mike.foreman@dfo-mpo.gc.ca) is a Research Scientist at the Institute of Ocean Sciences (Fisheries and Oceans Canada). His current research includes coastal biophysical modeling, climate change modeling and analyses, data assimilation, satellite altimetry analyses, and the analysis, prediction and modeling of tides. Within PICES, Mike was Chairman of the Physical and Oceanographic and Climate Committee (POC) from 2005 to 2010, Co-Chairman of WG 20 from 2006 to 2010, and is a member of the Section on Climate Change Effects on Marine Ecosystems (S-CCME) and Working Groups 27 and 29.

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Dr. Chan Joo Jang (cjjang@kordi.re.kr) is a Research Scientist at the Korea Ocean Research and Development Institute (KORDI). His research interests include climate change analysis and modeling, observation and modeling for ocean turbulence mixing, and physical-biogeochemical couple modeling. He co-chairs WG 29 on Regional Climate Modeling, and is a member of POC and WG 27.

The State of the Western North Pacific in the Second Half of 2011

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 2011, computed with respect to JMA's (Japan Meteorological Agency) 1971–2000 climatology. Monthly mean SSTs are calculated from JMA's MGDSST (**M**erged satellite and *in-situ* data **G**lobal **D**aily **SST**), which is based on NOAA/AVHRR data, MetOp/AVHRR data, AQUA/AMSR-E data, and *in-situ* observations.

Time series of 10-day mean SST anomalies are presented in Figure 2 for 9 regions indicated in the bottom panel. In July, SSTs were above normal north of 30ºN and east of 170ºE. The positive SST anomalies extended westward, and anomalies exceeding +1ºC prevailed east of 145ºE in September. These anomalies shrunk after October and were observed only east of 165ºE in December. SSTs were below normal in the seas south of Japan (around 20ºN, 130ºE) in July. The negative SST anomalies extended eastward, and anomalies exceeding –1ºC appeared around 25ºN, 140ºE in September. In November, positive SST anomalies exceeding +1ºC prevailed in regions 3, 5, 6, 8 and 9 (Fig.2).

Kuroshio path

Figure 3 shows time series of the location of the Kuroshio path. During the reviewed period, the Kuroshio took a non-large-meandering path off the coast to the south of Honshu Island (between 135ºE and 140ºE). The latitude of the Kuroshio axis at the Izu Ridge (~140ºE) was about 34ºN (south of Miyake Island) during most of this time. From the end of September to the beginning of October, the Kuroshio was flowing at about 33ºN (around Hachijo Island).

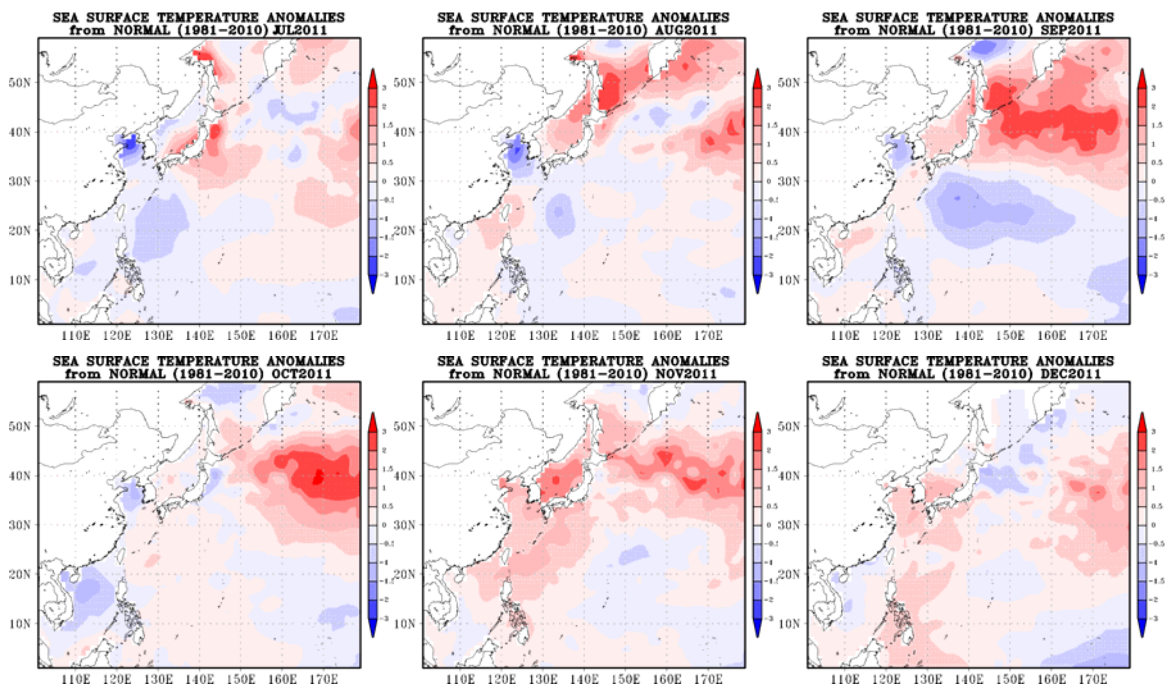


Fig. 1 Monthly mean SST anomalies (°C) from July to December 2011. Anomalies are deviations from JMA's 1971–2000 climatology.

Shiro Ishizaki (s_ishizaki@met.kishou.go.jp) is a Scientific Officer of the Office of Marine Prediction at the Japan Meteorological Agency. 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 $\times$ 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.

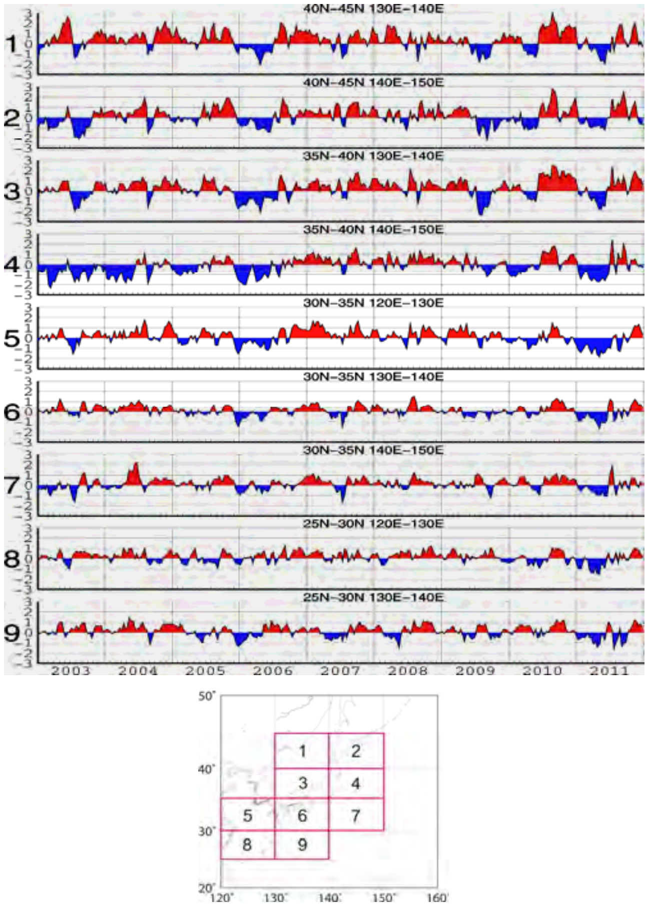


Fig. 2 *Time series of 10-day mean SST anomalies (°C) averaged for the sub-areas shown in the bottom panel. Anomalies are deviations from JMA's 1971–2000 climatology.*

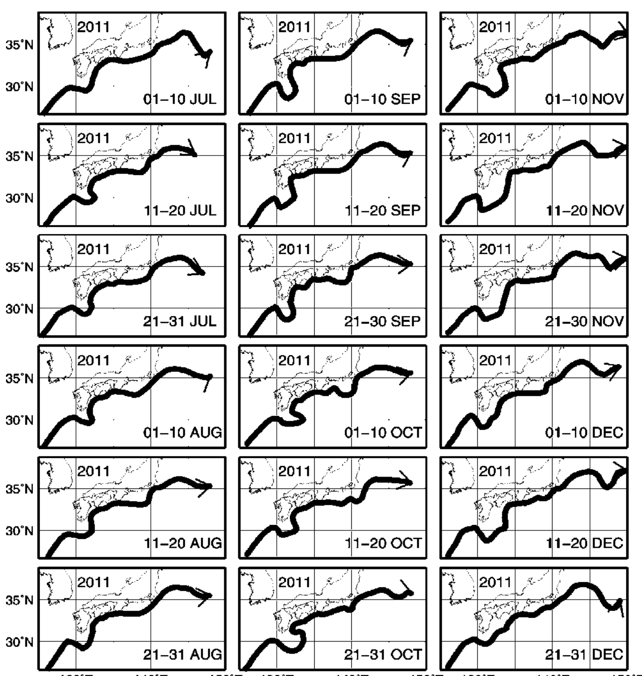


Fig. 3 *Location of the Kuroshio path from July to December 2011.*

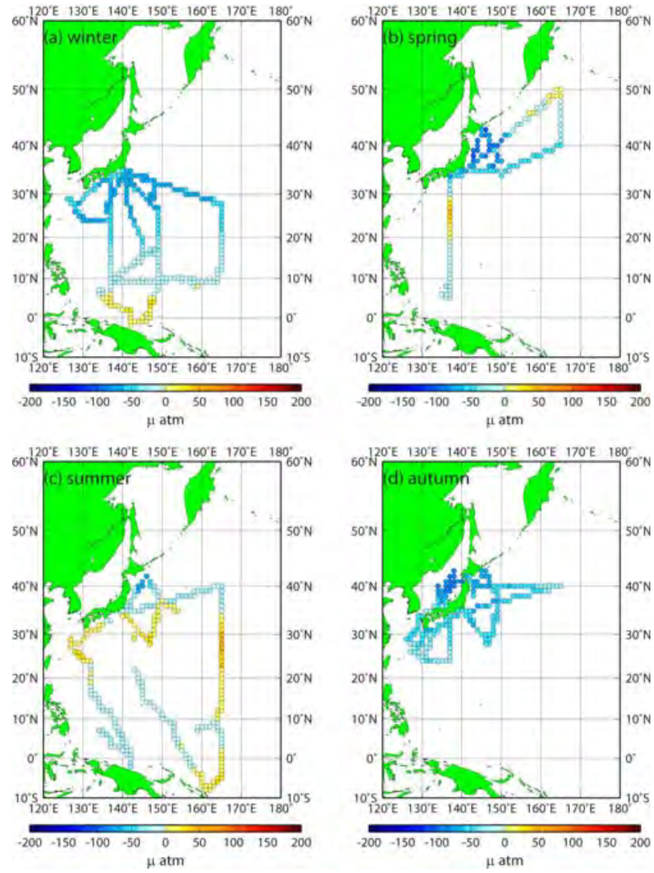


Fig. 4 *Difference in CO_2 partial pressure between the ocean and the atmosphere in the western North Pacific in 2011: (a) winter (January–March), (b) spring (April–June), (c) summer (July–September) and (d) autumn (October –December).*

Carbon dioxide

JMA has been conducting observations for carbon dioxide (CO_2) in the ocean and atmosphere in the western North Pacific on board the R/V *Ryofu Maru* and R/V *Keifu Maru*. Figure 4 illustrates the distribution of the difference in CO_2 partial pressure (pCO_2) between the surface seawater and the overlying air (denoted as ΔpCO_2) observed in the western North Pacific for each season of 2011. 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.

In the winter and autumn of 2011, the ocean widely acted as a CO_2 sink, with the exception of the equatorial region. In the spring and summer, subtropical regions turned into a weak CO_2 source due to thermodynamically increased pCO_2 in seasonally warmed seawater. The greatest negative value of ΔpCO_2 (–107 μatm) was found around 40ºN, 145ºE in spring, and was probably caused by enhanced biological activity.

Another Cold Winter in the Gulf of Alaska

by Skip McKinnell, William Crawford and Howard Freeland

The surface of the Gulf of Alaska in winter is often determined by the state of the El Niño-Southern Oscillation cycle. The La Niña that followed the 2010 El Niño began to abate late in the winter of 2012 and by the boreal spring, the equatorial Pacific was ENSO-neutral. The eastern equatorial Pacific is warmer than average by up to 2°C (Fig. 1), and the central equatorial Pacific is warming with an increased risk of a swing to El Niño in the fall of 2012 (forecast: http://www.bom.gov.au/climate/enso). Cold sea surface temperature (SST) anomalies in April/May 2012 were pervasive in the eastern North Pacific (Fig. 2).

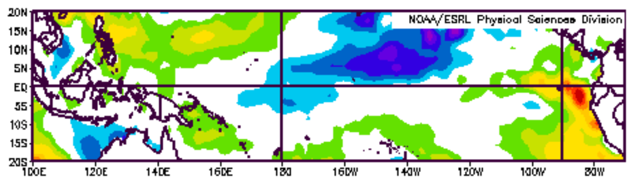


Fig. 1 Average sea surface temperature (SST) anomalies (°C) in the tropical Pacific during April/May 2012. Anomalies range from -2°C to +2°C. Figure courtesy of NOAA/ESRL Physical Sciences Division.

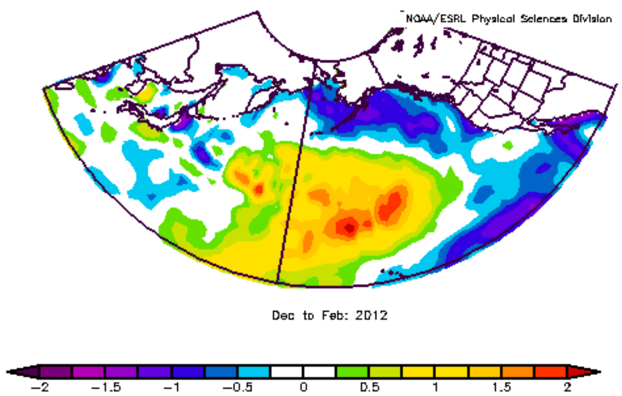


Fig. 2 Winter SST anomalies in the North Pacific. Much of the Gulf of Alaska was below the 1981–2010 average. Figure courtesy of NOAA/ESRL Physical Sciences Division.

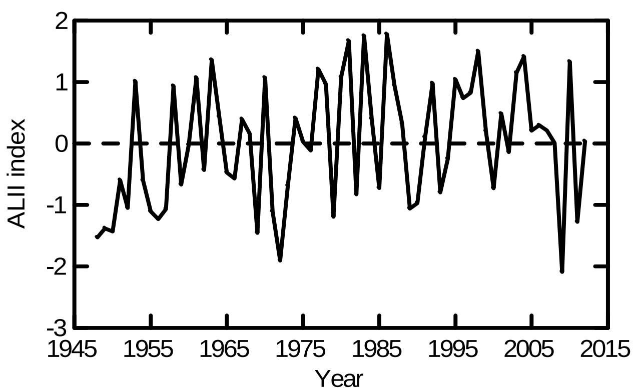


Fig. 3 A winter (DJF) Aleutian Low index computed from the integral of area-weighted average sea level pressure > 1008.5 hPa (data source: NCEP/NCAR Re-analysis).

Recent winters have featured extreme Aleutian Lows (in both directions), but the winter of 2012 was at the long-term average (Fig. 3). Strong Aleutian Lows are generally associated with warmer SST in the Northeast Pacific and years with weak Aleutian Lows are colder. Coastal SST was cooler than expected from Aleutian Low activity (Fig. 4) and the anomalies can be related to anomalies in wind direction. Anomalous winter westerlies can provide for colder winters (Fig. 5).

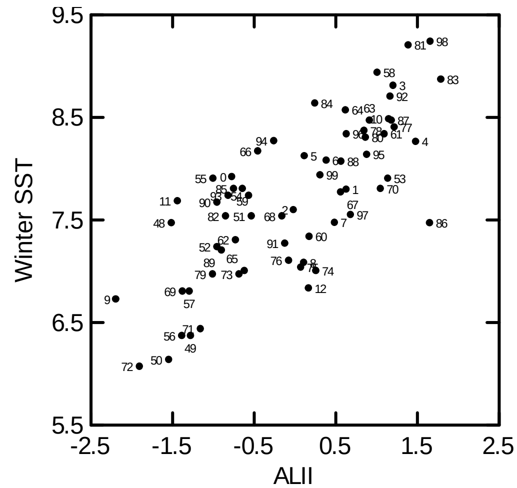


Fig. 4 Coastal winter (DJF) sea surface temperature (SST) versus winter Aleutian Low activity from 1948 to 2012. Point labels indicate the year of January/February for each average value. The winter of 2011/2012 (indicated by 12) was a strong negative anomaly. SST data are courtesy of Institute of Ocean Sciences, Fisheries and Oceans Canada, and sea level pressure data for the ALII are courtesy of the NCEP/NCAR Re-analysis.

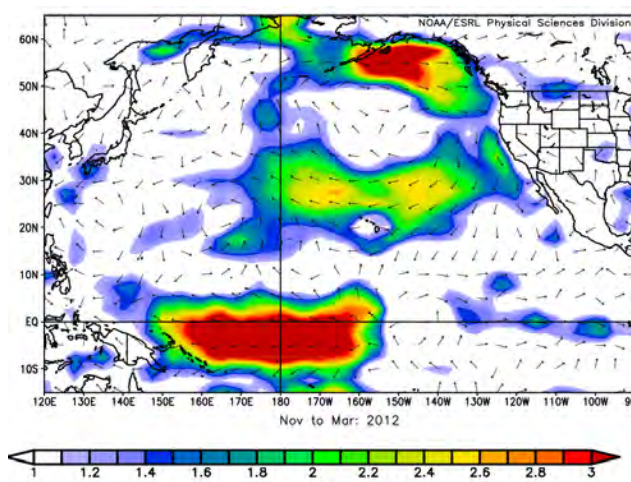


Fig. 5 Winter anomalies in wind speed (arrows indicate direction of the anomaly) in 2012. Enhanced zonal winds over the Gulf of Alaska brought cooler air and sea temperatures to the North American west coast. Units are m/s. Figure courtesy of NOAA/ESRL Physical Sciences Division.

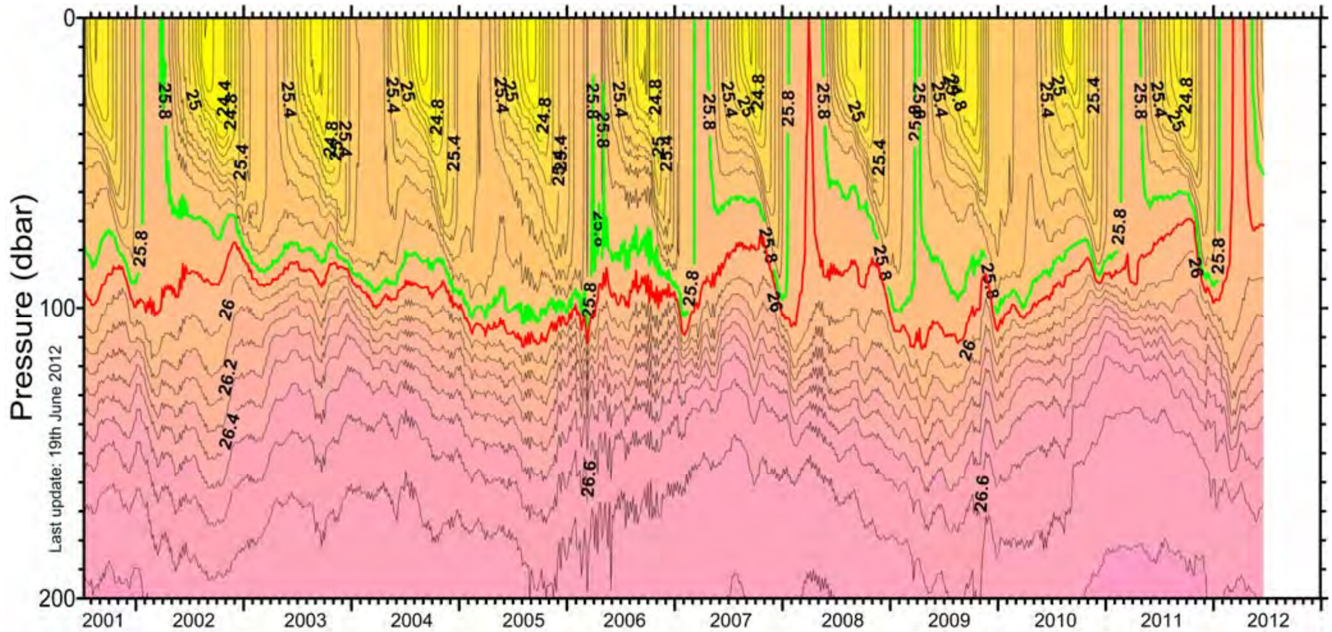


Fig. 6 Density contours at Station Papa estimated from Argo profiles. The winter of 2012 features a rare ventilation of the 25.9 contour (red). It suggests that nutrient concentrations in the surface waters of the Gulf of Alaska will be higher than average in spring. Regularly updated figures can be found at http://www.pac.dfo-mpo.gc.ca/science/oceans/data/projects/argo/LineP/P_St.gif.

The cold temperatures observed in coastal regions were reflected in a deeper than average mixed layer depth in the Northeast Pacific (Fig. 6). The Gulf of Alaska develops a seasonal surface stratification and shallow mixed layer in the summer and fall that deepens through the winter until March or April. In 2012, the 25.9σ_θ density contour reached the surface at Station Papa for approximately 2 months. This had not occurred in any winter since Argo profiles first became available in 2001. Ventilation of denser layers increases oxygen concentrations at depth and increases nutrient concentrations in the surface waters.



Dr. Skip McKinnell (mckinnell@pices.int) is the Deputy Executive Secretary of PICES. For two years (2008–2010) he served as an author and Editor-in-Chief of the PICES North Pacific Ecosystem Status Report.

Dr. William (Bill) Crawford (bill.crawford@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences in Sidney, British Columbia. He is co-editor of Canada's annual State of the Pacific Ocean Report for Canada's Pacific Coast, and is fascinated with changes in ocean climate and its impact on ecosystems.

Dr. Howard Freeland (howard.freeland@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences, in Sidney, British Columbia. Howard has conducted research on the changing circulation of the Northeast Pacific and the climatic status of the oceans. His overwhelming interest over that last 12 years has been the steady development of the international Argo project. Howard is shown visiting an old friend, Baba Yaga, in Khabarovsk.

The Bering Sea: Current Status and Recent Trends

by Jeffrey Napp

Current status of the Bering Sea ecosystem

The eastern Bering Sea remained cold in the winter of 2011/2012 and the spring of 2012. It was the sixth year in a sequence of cold years that began in 2007 and reflects the presence of a moderate La Niña (for the second cold season in a row), along with a mostly positive Arctic Oscillation (AO). The air pressure pattern in winter was higher than average over eastern Siberia and the northeastern Pacific Ocean and lower than average over northwestern Canada. This atmospheric pattern produced average wind anomalies of 1–2 m/s from the west to the northwest over the Bering Sea shelf, and air temperatures were from 2–4°C colder than average. Two periods of extremely cold air extended over the Bering Sea to the interior of Alaska: mid-December to early January and mid-January to early February. During spring, strongly positive air pressure anomalies occurred south of the western Aleutians along with negative air pressure anomalies over the Yukon Territory. This configuration, which is characteristic of previous La Niñas, was accompanied by average wind anomalies of 2–3 m/s and cold air temperatures.

An important consequence of the winter and spring atmospheric patterns was another heavy-ice year. Sea ice extent for the eastern Bering Sea was the highest observed since 1980. In the western Bering Sea, the areal extent of sea ice was at or above the average of recent years (1979 to present). Strong northerly winds in late spring opened large polynyas in the northern Bering Sea shelf and delayed the retreat of the ice in the south. St. Paul Island was surrounded by ice for a record number of days (more than 100). The ice remained in Bristol Bay until early May, making it difficult for non-ice strengthened hulled ships to reach NOAA mooring M2 (56.87°N, 164.03°W) for its semi-annual maintenance. By mid-June, the southern ice edge was still around 60°N (Fig. 1), but there was a large lead of open water extending from north of St. Matthew Island to St. Lawrence Island. The region north of Bering Strait, however, had low concentrations of sea ice, and there was an area just offshore of Alaska's northern slope that was open.

Sea surface temperatures (SSTs) over the entire eastern Bering Sea were colder than average by up to more than 2°C (Fig. 2). A time series of the first EOF of SST for the Bering Sea reveals the largest negative values since the time series began in 1980 (Fig. 3). Thus, a well-developed cold pool over the southeastern Bering Sea shelf is expected this summer.

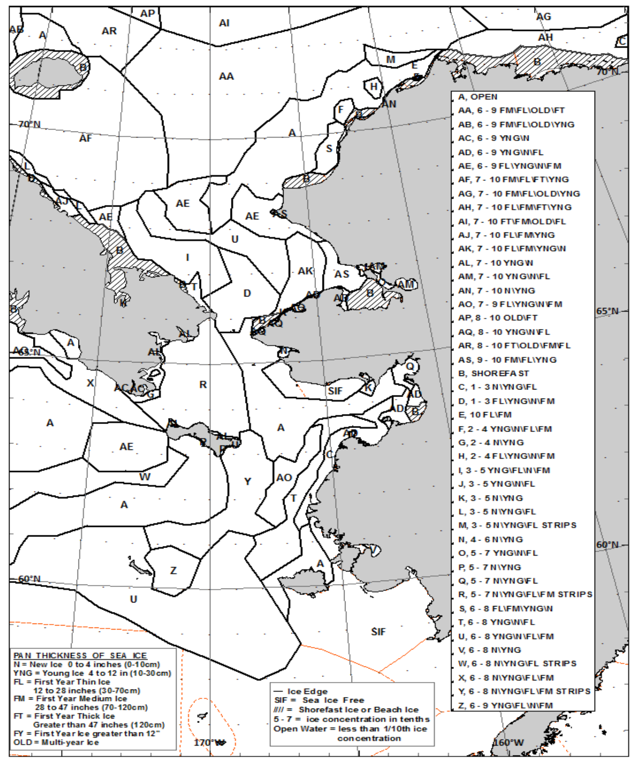
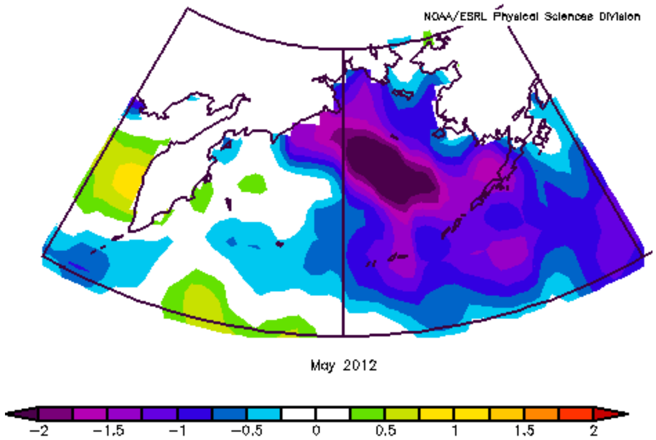


Fig. 1 NOAA National Weather Service sea ice analysis for June 13, 2012.

2012 Bering Sea field season

A very full field season for the Bering Sea is planned for the spring and summer. NOAA's Alaska Fisheries Science Center had a spring oceanography/plankton survey in May, and there was a cooperative aerial survey of ice-associated seals in the Bering and Okhotsk Seas by NOAA and multiple institutions in the Russian Federation, including the Marine Mammal Commission and the Scientific Research Institute "Giprorybflot" of the Fisheries Agency of Russia. This survey used advanced imaging systems and statistics to provide the first comprehensive estimates of ice associated seals for the region. It yielded 36,000 km of effort trackline data, with 885,000 high resolution images and 3.6×10^6 thermal images on the U.S. side of the dateline (Fig. 4). NOAA's Alaska Fisheries Science Center will also have a summer shelf bottom trawl survey, a summer shelf midwater trawl survey, a summer Aleutian Island bottom trawl survey, and a late summer ecosystem survey (oceanography, plankton, surface trawl, and acoustic midwater trawl). Hokkaido University's T/S *Oshoro Maru* will operate in the Aleutian Islands and eastern Bering Sea shelf in June.



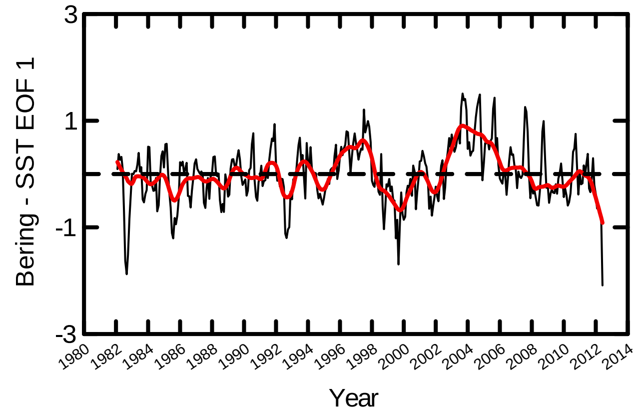


Fig. 2 (left) NOAA Sea Surface Temperature anomalies (deviations from 1981–2010 climatology) for May 2012.
Fig. 3 (right) Time series of Bering Sea SST EOF 1. Red line is a loess smoother trend. Analysis and figure courtesy of S. McKinnell (PICES).

There are also multiple cruises scheduled for the Chukchi Sea and Arctic Ocean this year. The AOOS web page (http://data.aoos.org/maps/arctic_assets/) is one place to find recent and planned cruises to the Arctic Ocean. Expect multiple ships (both science and industry) to be working in that area during the ice-free period this summer. This includes ships from the U.S. (e.g. USCG Ice Breaker *Healy*, charter vessels F/V *Bristol Explorer*, F/V *Aquila*), Japan (R/V *Mirai*), Russian Federation (R/V *Professor Khromov*), China and Korea. This is a full field year for the Russian-American Long-Term Census of the Arctic (RUSALCA) that will emphasize sampling in the western Chukchi Sea (Fig. 5).

In addition to RUSALCA and many oil industry-sponsored research programs, NOAA, with support from the U.S. Bureau of Ocean Energy Management (BOEM) will conduct an ecosystem survey comprised of oceanography, plankton, surface and acoustic midwater trawls, bottom trawls, and seabird distributions on the U.S. side of the Chukchi Sea during August (Fig. 6). There is also a new U.S. multi-disciplinary investigation being conducted in the eastern Chukchi Sea over Hannah Shoal with support from the BOEM (http://www.boem.gov/BOEM-Newsroom/Press-Releases/2011/press09202011.aspx).

Upcoming science meetings and special journal issue

Meetings in 2012 and 2013 that may host sessions or talks of interest to scientists working in the Bering Sea include:

- PICES Annual Meeting, October 12–21, 2012, Hiroshima, Japan;
- ICES/PICES International Symposium on "*Forage fish interactions*", November 12–14, 2012, Nantes, France;
- Alaska Marine Science Symposium, January 21–25, 2013, Anchorage, USA;
- Lowell Wakefield Symposium on "*Responses of Arctic marine ecosystems to climate change*", March 26–29, 2013, Anchorage, USA.

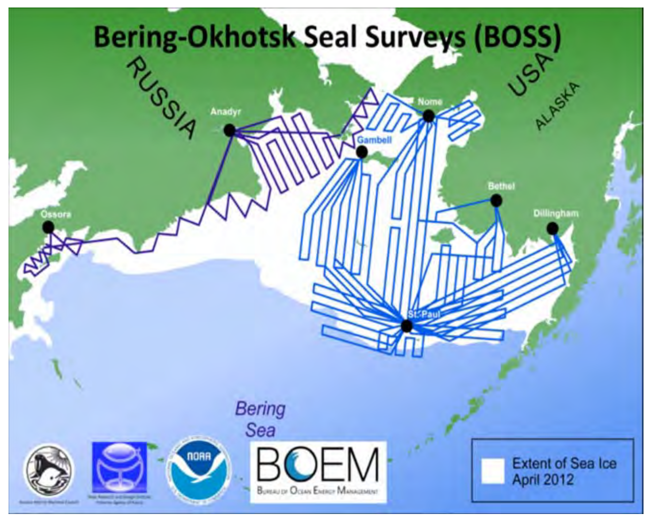


Fig. 4 Proposed track lines for the international Bering-Okhotsk Seal Surveys (BOSS). Figure courtesy of P. Boveng (NOAA's Alaska Fisheries Science Center).

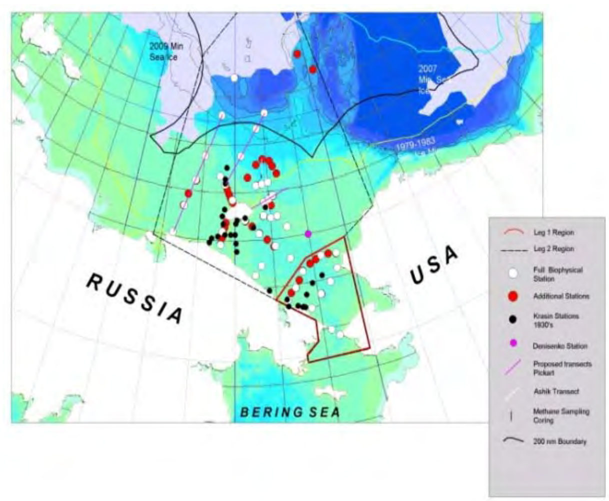


Fig. 5 Proposed station locations for the 2012 RUSALCA ecosystem study of Bering Strait and the western Chukchi Sea. Figure courtesy of M. Busby.

Fig. 6 Draft station plan for the NOAA 2012 ecosystem survey of the eastern Chukchi Sea.

A collection of 23 original scientific papers on the Bering Sea was published in a special issue of *Deep-Sea Research II* (Vol. 65–70; June 15, 2012) to highlight results of research contributed by investigators from the U.S. National Science Foundation-sponsored Bering Sea Ecosystem Study (BEST) and the U.S. North Pacific Research Board-sponsored Bering Sea Integrated Ecosystem Program (BSIERP). This is the first major publication focused on the Bering Sea since 2002, and it acknowledges the important contributions of Dr. Clarence Pautzke (Fig. 7), who retired as the Executive Director of the North Pacific Research Board in 2011, to research in the North Pacific Ocean and in particular the eastern Bering Sea.

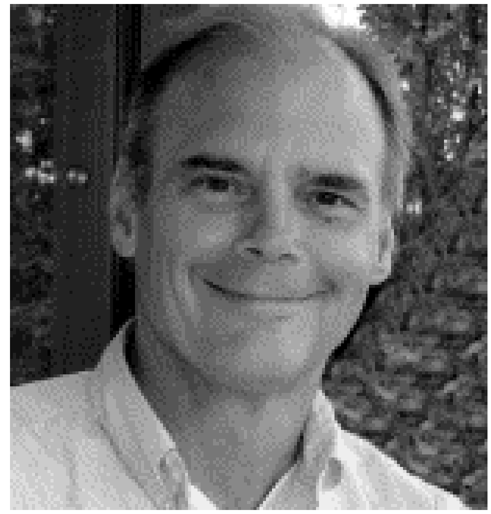


Fig. 7 Dr. Clarence Pautzke, retired Executive Director of the North Pacific Research Board. Photo from DSR II, 2012, Vol. 65–70

Additional research articles from the Bering Sea Program, and the Ecosystem Studies of the Subarctic Seas (ESSAS) Open Science Meeting in May 2011 are currently under peer review for a second special issue. This second issue includes research into the human dimensions of climate change and resource utilization around the eastern Bering Sea. The Bering Sea Program has plans for two additional special issues (total of four). The deadline for submission of manuscripts to the third special issue will be November/December of 2012.

Acknowledgements: Many thanks to the following Piceans who helped create this report: Drs. Nicholas Bond, Skip McKinnell, Phyllis Stabeno, and Mr. Morgan Busby.

I want to thank all of those who have contributed time and news to this column over the last several years. The willingness among scientists within PICES to share data and expertise across international and language borders is one of the organization's greatest strengths. I have greatly enjoyed assembling the community's information for this report and I wish the next lead author of this Bering Sea column, Dr. Lisa Eisner, the best of luck and much fun in continuing this tradition.

Dr. Jeffrey 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. He 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 member of the Scientific Steering Committee (SAB) for the Bering Sea Project. Jeff is also a member of the PICES Technical Committee on Monitoring.

PICES/ICES 2012 Conference for Early Career Marine Scientists

by Bryan Black

From April 23–27, 2012, 130 early career scientists gathered on the Mediterranean island of Majorca (Spain) to discuss emerging topics in marine science, to begin establishing international collaborations, and to build skills in communication, grant writing, and collaborative research. Generously supported by ICES and PICES, with additional contributions from the National Oceanic and Atmospheric Administration (NOAA, USA) and the North Pacific Research Board (NPRB, USA), the second ICES/PICES Conference for Early Career Scientists (CECS) followed on the success of the first event held 5 years earlier in Baltimore (USA). Underscoring the global interest in the conference, over 550 applications were received from 53 countries. With rare exceptions, all invited participants and organizers were less than 36 years of age or within 5 years of receiving a Ph.D., including graduate students, post-doctoral researchers, junior faculty, and research scientists.

CECS-2012 was organized under the theme "*Oceans of Change*" and divided into three sessions: (1) *Impact of Change of Marine Ecosystems*, which addressed physical, biological, and geochemical responses to long-term change, (2) *Human Interactions with the Marine Environment*, which dealt with anthropogenic impacts on the marine environment, and (3) *New Tools and Views in a Changing Ocean*, which focused on the state-of-the-art techniques for ocean monitoring and exploration. Each session was opened by a senior keynote speaker, Joaquin Tintoré (Spain), Anne Hollowed (USA), and Jack Barth (USA), followed by two highly-accomplished early career keynote speakers: Marta Coll (Spain), Akinori Takasuka (Japan), Monique Messié (USA), Eun Jung Choy (Korea), Abigail McQuatters-Gollop (UK), and Malin Pinsky (USA). CECS-2012 featured 89 contributed talks and 28 posters. The topics discussed were diverse and provided participants with a wide selection of current issues in marine science. Yet several recurring themes emerged, reflecting opportunities and challenges early career scientists will face in the coming years. These included: the automation of ocean monitoring and associated emerging technologies, managing and analyzing increasingly large and complex datasets, the growing complexity and sophistication of computer modeling, managing natural resources under increased human impacts and global change, and the importance of working as interdisciplinary groups to address issues that span multiple spatial, temporal, and biological scales. Indeed, some of the most frequent keywords in the titles of contributed talks were climate, change, ecosystem, model, management, global, interactions, assessment, and acidification. The quality of presentations was superb, and after a very difficult selection process, Kristy Kroeker (*Ocean acidification affects recruitment and competition in benthic communities surrounding natural* CO_2 *vents*), Jameal Samhouri (*Risky business: Linking land- and sea-based activities to risk in coastal ecosystems*), and Robin Kodner (*Phytoplankton in a changing world: What we can learn from Metanomics Technologies*) were chosen for best oral presentations awards, while David Nicholson (*Dissolved gas tracers as new constraints for ecosystem-biogeochemistry models*) was given an award for best poster.

Two afternoon workshops were also held as part of the CECS-2012. The first of these was led by Martin Pastoors (The Netherlands) who discussed a number of helpful techniques to improve science communication with the main points of focusing on message, using the power of image, and thinking like a journalist. Next, Wojciech Wawrzynski (ICES) shared his experience at improving communication among marine researchers and managers.

The second workshop was co-led by Jack Barth and Joaquin Tintoré who addressed techniques for pursuing funding and writing proposals, with particular emphasis on writing as clearly as possible, volunteering to serve on panels, knowing success rates and levels of funding available through the given funding agency, and most importantly, never giving up! Skip McKinnell (PICES), Adi Kellermann (ICES), Poul Degnbol (ICES), Anne Hollowed (USA) and Søren Pedersen (ICES) provided an overview of life as a scientist in ICES and PICES as well as resources these organizations have to offer young scientists.

Clockwise from top left: (1) Ignacio Catalán, local organizer, welcomes participants at Bellver Castle; (2) Welcome Reception at Bellver Castle; (3) Adi Kellerman (ICES Secretariat) and Nina Overgaard Therkildsen (Denmark) at the poster session; (4) Anne Hollowed (USA) and Marta Varela (Spain) on the Majorca north coast; (5) Dafne Eerks-Medrano (USA) and Martin Pastoors (The Netherlands) chat during the poster session; (6) Closing banquet and awards ceremony. Photos by Bryan Black and Hanna Na.

In addition to talks and workshops, CECS-2012 included a number of social events. On the first night, a Welcome Reception was held at Bellver Castle, a 14th century fortress with spectacular views of the nighttime lights of Palma. A mid-week break allowed participants to explore the mountainous north coast of Majorca Island with a stop in the village of Valldemossa to tour its narrow cobblestone streets and monastery where Frédéric Chopin composed his 24 preludes. Throughout the meeting, there were numerous opportunities to explore Mediterranean beaches and the towns near the conference hotel. Almost certainly, the new friendships and collaborations initiated on outings, during breaks, and at shared meals will be among the most valued and lasting outcomes of the CECS-2012.

Clockwise from top left: (1) Participants tour Valldemossa in the mountains of Majorca; (2) Mountains of the Majorca north coast; (3) Skip McKinnell (PICES Secretariat) explains the role of PICES. Photos by Bryan Black and Hanna Na.

The conference took 2.5 years to plan, and there are many people to thank. First, we are grateful to ICES, PICES, NOAA and NPRB for their generous financial support. Many thanks to Adi Kellermann (ICES), Søren Pedersen (ICES), and Skip McKinnell (PICES), for their help with logistics and expert advice to the CECS-2012 Scientific Steering Committee. We also appreciated the very helpful suggestions from Julie Keister, Franz Mueter and Elizabeth North (USA) based on their experiences in organizing CECS-2007. Special thanks to local organizers Ignacio A. Catalán Alemany and the Mediterranean Institute for Advanced Studies for arranging so many of the conference details, including conference facilities, accommodations, shuttles, outings and banquets. And thanks to the other members of the Scientific Steering Committee (Ignasio Catalán, Helen Findlay, Hanna Na, Nina Overgaard Therkildsen, Marta Varela, and Naoki Yoshie) for their efforts in planning the scientific program and meeting logistics. Finally, and most importantly, thanks to all the meeting participants whose enthusiasm and exceptional scientific contributions made CECS 2012 such a wonderful and enjoyable experience!

Dr. Bryan Black (bryan.black@oregonstate.edu) is an Associate Professor at Oregon State University Hatfield Marine Science Center in Newport, Oregon, a member of the CECS-2012 Scientific Steering Committee, and a not quite so early career scientist who studies growth increments in long-lived marine, freshwater, and terrestrial organisms.

Completion of the PICES Seafood Safety Project – Indonesia

by Charles Trick, Vera Trainer, Mark Wells and William Cochlan

Since 2007, the PICES Seafood Safety Project has worked to develop a community-based system for the assessment of marine biotoxins that are transferred through the food chain to impact seafood security and community health. While most PICES member countries are protected by a fully-developed, national food inspection plan or by regulation by government health authorities, many more nations are at risk of human illness and death through unregulated shellfish consumption during toxic events. Under our mandate, we focused on seafood that was contaminated with marine toxins derived from periodic outbreaks of harmful algal bloom species (HABs). The outcome of our work has been the development of community-based phytoplankton monitoring networks, connected with two levels of toxin analysis: (1) lateral flow (test-strip) and enzyme-linked immunosorbent (ELISA) assays followed by (2) the traditional, internationally-recognized instrument of toxin verification – the mouse bioassay.

The project is funded by a voluntary contribution from Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF), through the Fisheries Agency of Japan (JFA), and is conducted by the PICES Section on *Ecology of Harmful Algal Blooms in the North Pacific*, with Dr. Vera Trainer, who co-chairs the Section, as the Principal Investigator of this effort. The criteria for country selection in the project were: (1) the magnitude of the HAB problem, (2) the need for training, and (3) the likelihood of sustainability. These were assessed through conversations with individuals at national and regional meetings and by evaluating responses to a specifically designed questionnaire distributed via the IOC (Intergovernmental Oceanographic Commission of UNESCO) network.

After the development, implementation and sustainable success of our training classes in the Philippines (PICES Press, 2009, 17 (2): 5–7) and Guatemala (PICES Press, 2010, 18 (2): 32–35), the final chosen location for implementation of the project was Indonesia. In September 2011, a trio of PICES researchers visited the headquarters of Lembaga Ilmu Pengetahuan Indonesia (LIPI; Indonesian Institute of Sciences) and the Pusat Penelitian Oseanografi (Research Center for Oceanography) in Jakarta, as well as the LIPI facility on Lombok Island to initiate stakeholder discussions. The primary management of Indonesian marine responses is LIPI's responsibility, and they served as our host for facilitating future efforts with both government and academic scientists. Meetings with these researchers confirmed both a solid interest in HABs, and the need for new strategies to minimize the consumption of toxin-tainted marine products.

In February 2012, the PICES team consisting of the authors of this article and Mr. Julian Herndon (San Francisco State University) initiated 10 days of training and mentoring. In the first phase of the seafood training course, we invited two target groups: researchers responsible for the analytical aspects of the nutrient and phytoplankton biomass analysis (critical for the marine monitoring program) and researchers responsible for the analysis of toxins in marine products.

For the first group of 8 researchers, William Cochlan and Julian Herndon gave background lectures on the value of measuring nutrients for ecological and anthropogenic studies, the specific theoretical foundations of analysis, the critical need for quality control and self-evaluation, and a review of standard operating procedures for preparing standards, evaluating methods, and laboratory and environmental safety. The remaining time was spent in intensive 'hands-on' exercises, with lecturers providing trouble-shooting advice and mentoring. The outcome of this intensive 3-day course was a reinvigorated cadre of marine monitoring chemists, and an upgrade in the expectations of their marine monitoring program.

Coincident to the marine chemistry course was an intensive marine biotoxin course that attracted 12 researchers from LIPI and several marine research-focused academic institutions. Mark Wells and Vera Trainer gave a series of lectures on the different marine toxins in Indonesian waters, and the theory behind the analytical approaches to the measuring the toxins. After the theoretical presentations, the class became heavily involved in several practical exercises in the extraction, isolation and confirmation of toxins in shellfish. The participants of both training courses gained considerable expertise in their fields of responsibility and are now able to work as independent scientists on marine environmental chemistry and toxin analysis.

These two training courses were followed by a 2-day lecture series focused on the monitoring of Indonesian waters for HAB species and was attended by 45 people. Using the "Responsible Sentinel Approach" where knowledgeable and trained scientists can then train students and community members to watch for the 'symptoms of change', the PICES team led the class through a series of lectures that covered anthropogenic changes in coastal waters, sampling and measurement, the critical needs for monitoring projects, and the importance of phytoplankton in healthy, coastal ecosystems. The team then focused on HAB recognition and taxonomy, phytoplankton quantification and microscope care. This HABs-centric approach enables the participants to develop an appreciation for the taxonomy of the phyto-

Clockwise from top left: (1) Participants and instructors of the training course in Jakarta, Indonesia; (2) Participants and instructors of the training course in Lombok Island, Indonesia; (3) Julian Herndon (San Francisco State University, USA) demonstrates methods for nutrient analysis; (4) Charles Trick (Western University, Canada) lectures on phytoplankton identification; (5) Students prepare samples for rapid toxin testing; (6) The children who are benefiting from a microscope donated to the Main Center for Mariculture Development, Lampung, Indonesia.

plankton through the initial recognition of the key problem species, and then the expansion to other prevalent, but non-harmful taxa. The participants in this group were primarily academic scientists as well as LIPI and public health researchers. Based on the enthusiastic exchange of questions, they gained considerable understanding of the topic.

The lecture series was followed by a focused workshop for LIPI and academic researchers, including faculty and graduate students from Mataram University, University 45, and Hasanuddin University from the southern islands of Indonesia. A total of 14 individuals participated in a 3-day workshop at the LIPI Mataram Research Station on Lombok Island. The curriculum included an abbreviated series of lectures, considerable 'hands-on' collection and analysis of phytoplankton communities, and measurements of abiotic oceanographic parameters.

Our trip ended with a short visit to the Secretariat of WESTPAC (IOC Sub-Committee for the Western Pacific) to outline the PICES Seafood Safety strategy and discuss linking WESTPAC training with the need for Indonesian aquaculture and mariculture advancement.

The Indonesia training had the same outcome as our previous efforts in the Philippines and Guatemala – an engagement with communities that are concerned with HABs, toxin-contaminated seafood, and the monitoring of coastal resources. By all measures, this has been a very successful enterprise between PICES scientists and the funding body, MAFF (Japan). We have successfully avoided 'helicopter science': and have embedded ourselves into the decision making of three enthusiastic communities to ensure sustainability in current and emerging fisheries while attempting to safeguard the health of their citizenry from HABs.

Dr. Vera Trainer (vera.l.trainer@noaa.gov) is a Program Manager of the Marine Biotoxin group at the Northwest Fisheries Science Center, USA. Her current research activities include refinement of analytical methods for both marine toxin and toxigenic species detection, assessment of environmental conditions that influence toxic bloom development, and understanding how shellfish cope with toxins in their environment. In her spare time Vera climbs mountains.

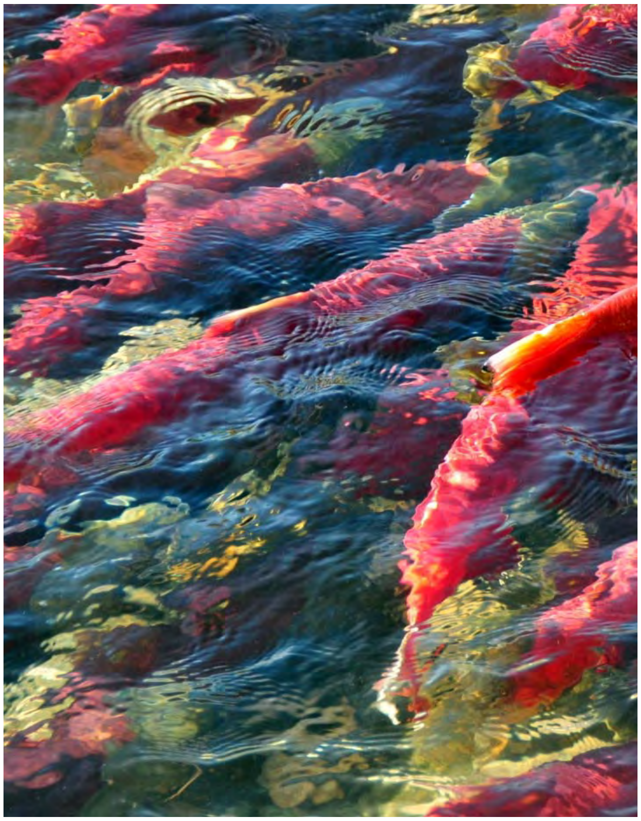
Dr. Mark Wells (mlwells@maine.edu) is a Professor of Oceanography in the School of Marine Sciences, University of Maine, USA. His current work spans the study of toxin production associated with harmful algal blooms, the interaction of trace metal chemistry with phytoplankton production in coastal and offshore seawaters, and the implementation of nanoscience and engineering concepts into the next generation sensor development for bioactive metals, phytoplankton community composition, and other indicators of ecosystem health.

Dr. Charles Trick (trick@uwo.ca) is the Beryl Ivey Chair for Ecosystem Health at Western University, Canada, a position that emphasizes the merging of science, health/medicine, social and psychological aspects of environmental programs. Since receiving his Ph.D. in Oceanography, Charlie has worked in a variety of different coastal and open ocean projects. He has recently completed a sustainability assessment of the Persian Gulf and continues his research in harmful algal blooms.

Dr. William Cochlan (cochlan@sfsu.edu) is a Senior Research Scientist at Romberg Tiburon Center for Environmental Studies, San Francisco State University, USA. His key research questions revolve around factors that control phytoplankton growth, their nutrition and distribution in the ocean. His research on harmful algal blooms and other phytoplankton covers multiple interactions of light and macro- and micro-nutrients affecting the physiology of marine phytoplankton.

Oceanography Improves Salmon Forecasts

by Skip McKinnell



Sockeye salmon spawners in the Adams River, 2010.

Regular international dialogue about Pacific salmon biology on the North American coast dates back to the first IPSIF (International Pacific Salmon Investigations Federation) meeting in Seattle in 1925. Its 2012 incarnation was the 14th annual gathering (in the modern era) of oceanographers, marine ecologists, biologists, and even parasitologists showing how progress is being made to unravel some of the mysteries of the life, health, and death of Pacific salmon in the ocean. Special thanks to Prof. Jessica Miller (Oregon State University) and her students and colleagues for their spectacular local arrangements in the beautiful seaside town of Newport, Oregon. Neither the snowfall nor the torrential rains on the first two days of spring (March 21–22) prevented the appointment with science in Newport.

Skip McKinnell (PICES) started the first day with a state of "climate/ocean/salmon" triad. Brian Beckman and Bill Peterson (NWFSC), and Marc Trudel (PBS) generously contributed to his presentation with updates of their ocean-going sampling of juvenile salmon during the previous year. It has been a traditional part of the meeting to review how the ocean had changed during the past year (Fig. 1), and whether it was likely to be good or bad for the survival of salmon along the west coast. Greater understanding of the ecological interconnections has allowed considerable progress to be made in forecasting returns and survival.

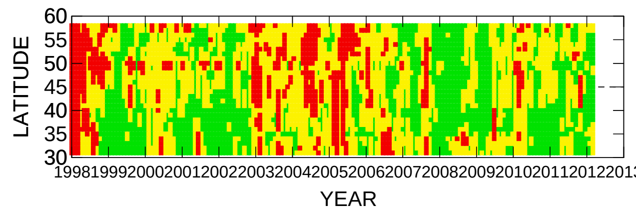


Fig. 1 Monthly sea surface temperatures (SST) adjacent to the North American coast from Mexico to Alaska by 1° latitude blocks. Colours represent SSTs in the upper (red), middle (yellow), and lower (green) thirds of observed SSTs in each calendar month from January 1998 to February 2012. This reflects a pattern of variability during the period of years when the annual salmon ocean ecology meetings have been convened.

The remainder of the first morning was spent hearing from various speakers about forecasting methods and performance from Alaska to California. This session was capped off at the workshop banquet with the annual best forecaster award going to Joe Orsi (Alaska Fisheries Science Center, Juneau, USA) for remarkable and sustained success in forecasting pink salmon returns in Southeast Alaska. There will be tough competition for the award at next year's meeting. Bill Peterson's oceanographic team made a forecast of 160,000 adult spring chinook returning to Bonneville Dam (Columbia River) in 2012 and the return was 158,089. That performance will be tough to beat. It shows the benefit of having representative samples of salmon abundance in the sea as late as possible in their life history. That juvenile salmon abundance and associated ocean ecology at the end of summer growth after ocean entry can provide relatively reliable forecasts of returns one and two years later gives strong support to the idea that cohort abundance is established in most years by the end of the first summer.

The second session on *Understanding and Integrating Survival in the Columbia River Basin* captured the attention of the local audience because it addressed issues that are associated with marine survival in Columbia River salmon. The lower reaches of the Columbia River form the border between Oregon and Washington State and, historically, it was the single largest source of wild chinook salmon in the world. The third session on *Growth and Foraging Ecology* dealt primarily with getting past the correlations to the mechanics of how ocean ecosystem variability affects growth and survival. The workshop ended with a general session on various topics, including Atlantic salmon migration timing in Spain. According to a tradition of rotating the meetings along the coast, the next annual salmon ecology workshop is scheduled for British Columbia.

2012 GEOHAB Open Science Meeting

by Suzanne Roy and Vera Pospelova

Coastal regions are environments where blooms of harmful algae (HABs) can cause great damage. These regions are submitted to increasing urban development and often support productive fisheries, aquaculture and tourism. HABs can have a negative impact on these activities, with consequent economic loss. The international Global Ecology and Oceanography of Harmful Algal Blooms program (GEOHAB), co-sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC), set up a series of Core Research Projects to develop our understanding of HABs through a comparative approach among similar sites around the world where these harmful events occur.

The Core Research Project on "HABs in Fjords and Coastal Embayments" recently held its second Open Science Meeting to highlight progress in interpreting life history and growth dynamics of HABs in such environments. This meeting took place on May 28–29, 2012, at the School of Earth and Ocean Sciences (SEOS), University of Victoria, Victoria, Canada. Twenty-four people attended from ten different countries. Co-convened by the authors of this article, the meeting hosted six keynote presentations, six contributed talks and six posters on five major themes. These comprised: (1) a review of recent research programs that have included life cycle approaches (SEED in Europe, and ECOHAB-Gulf of Maine and GOMTOX in USA), (2) particularities of HABs in tropical embayments affected by monsoons, (3) interactions associated with allelochemicals and toxins and their effects on bloom phases and growth dynamics of HABs in small-scale coastal systems, (4) genetic diversity and population heterogeneity and their relevance to HABs in small-scale systems, and (5) the role of physical forcing and scale in coastal HABs dynamics.

In their review of recent programs, Esther Garces (Institut Ciències del Mar, CSIC, Spain) and Don Anderson (Woods Hole Oceanographic Institution, USA) summarized the major findings from these studies and pointed out that unexpected complexities in the life cycle of several species, including the reversibility of the sexual stage and the production of asexual resting cysts, were found. A heteromorphic life cycle represents an advantageous survival strategy for a population since it allows the allocation of the species biomass into stages of different size ranges, morphology and ecological niche. A reproductive barrier was identified between toxic and non-toxic strains of one species (*Alexandrium tamarense*): matings between these strains produce cysts which germinate but are not viable (Brosnahan *et al*. 2010 Deep-Sea Research II 57: 175–189). Introduction of non-toxic strains in a region with toxic species could represent a mitigation strategy, leading to a reduction in the viable cyst population needed to initiate future algal blooms. In the Gulf of Maine, efforts have been devoted towards the characterization of cyst seedbeds, identification of the links between blooms and the abundance of cysts in surface sediments, and development of a numerical model of *Alexandrium fundyense* population dynamics. The mapping of cysts in fall or winter has been shown to be a good predictor of regional bloom magnitude for the following spring or summer, although some exceptions occur. Other groups (*e.g*., Cheryl Greengrove and colleagues mostly from the University of Washington, Tacoma, USA) are also testing this cyst mapping hypothesis.

Participants to the GEOHAB Open Science Meeting on "Progress in Interpreting Life History and Coastal Dynamics of Harmful Algal Blooms in Fjords and Coastal Environments". From left to right, front row: Faiza Al-Yamani, Nicky Haigh, Svetlana Esenkulova, Rhodora Azanza, Cheryl Greengrove, Suzanne Roy, Vera Pospelova, Julie Masura and Lincoln Mackenzie; back row: Marina Montresor, Paul Harrison, Drew Lucas, Allan Cembella, Manuel Bringué, Deana L. Erdner, Andrea Price, Esther Garces, Don Anderson and Arielle Kobryn.

In tropical environments, Rhodora Azanza (Marine Science Institute, University of the Philippines) presented some research undertaken by the GEOHAB-endorsed project, PhilHABs. She stressed the influence of the monsoon-related changes affecting the temperature, salinity and stratification conditions of local bays. *Pyrodinium bahamense* var. *compressum* is a toxic species that used to dominate before the year 2000, in association with the southwest monsoon (warmer waters, lower salinities and strong stratification). This dinoflagellate produces resistant cysts which have been recorded in more than 30 bays or regions of the Philippines. It has seemingly been replaced by its major predator, *Noctilucascintillans*, since that time. *Gymnodiniumcatenatum* and *Alexandrium* spp. are also present, associated with the northeast monsoon. Aside from the strong influence of the monsoons, some of the variability in incidence of these blooms may be attributed to ENSO events, but analysis is still underway.

In the last decade, a great deal of work on allelochemicals was undertaken by Allan Cembella (Alfred Wegener Institute for Polar and Marine Research, Germany) who examined their role as bioactive molecules that can change the interactions among species. Among the chemical compounds of interest with respect to HABs, trace organics and anthropogenic substances do not seem to be major driving factors affecting the dynamics of HABs. In contrast, marine natural products comprise a large number of bioactive molecules, including toxins, several of which have not been identified. More than 120 species of eukaryotic microalgae produce toxic bioactive substances. These compounds are not stress metabolites in most cases since they are found when cells are actively growing. The role of toxins is still under debate: putative roles include competition, communication, grazing, and cell recognition. Their effects on HAB dynamics can be through competitive exclusion of other microalgae, suppression of grazers or auto-stimulatory effects. Chemically-mediated reversal of predator-prey interactions can also take place (Tillmann 2003, Aquatic Microbial Ecology. 32: 73-84). Recent studies emphasize the identification of biosynthetic genes responsible for microalgal toxins and identification of the factors regulating their expression. Available results indicate a large degree of variability in toxin profiles among clones of a particular species taken from the same station. Unraveling the factors controlling this variability will be an active field of research for the next decade.

The development of molecular tools has enabled progress in obtaining information on the biodiversity of organisms responsible for HABs. Marina Montresor (Stazione Zoologica Anton Dohrn, Italy) reviewed the genetic diversity and population heterogeneity relevant to HABs in small-scale systems. She highlighted three important advancements in the last decade: (1) the development of integrated approaches helping to circumscribe species and evidence for cryptic diversity in many microalgal lineages, (2) evidence for intra-specific genetic diversity and for the organization of species into distinct populations, and (3) evidence for genotypic diversity and phenotypic variability. The capability to model population dynamics of harmful algae and predict HAB events is based on our knowledge of the temporal and spatial distribution patterns of the species. Delineation of HAB species is particularly important if cryptic species exist, and especially when toxic and non-toxic cryptic species co-occur in the same area (Touzet *et al*. 2010, Protist 161: 370–384). Cryptic species occur not only in dinoflagellates, but also in diatoms, particularly in the genus *Pseudonitzschia*. Recent studies have shown that intra-specific diversity is generally high in marine microalgae. This may reflect a winning strategy to live in an ever-changing physical, chemical and biological environment where temporal variability in selecting pressures can favour the maintenance of diversity. Coastal semi-enclosed systems can represent the ideal setting to test fine-scale population structure and diversity, offering a less complex setting amenable to small-scale investigations in time and space.

Finally, Drew Lucas (Scripps Institution of Oceanography, USA) presented a physical oceanographer's outlook of HAB patterns and persistence in coastal environments, examining the factors which affect these patterns at various spatial scales, from the mesoscale (> 100 km) to the small scale (10 cm to m). He argued that HAB patterns are difficult to predict because dynamical spatial scales are at least eight orders of magnitude, and several physical factors affect local circulation and modify the conditions favorable for retention and growth of harmful algae and for transport onshore, where shellfish intoxication can occur. Future studies pertinent to HAB events should emphasize the small horizontal scale and focus on internal waves and tidal pulsing.

A talk by Paul Harrison (University of British Columbia, Canada) was on the questionable link between N:P ratios and red tides in Tolo Harbour (Hong Kong), and one by

Dr. Suzanne Roy (suzanne_roy@uqar.ca) is a biological oceanographer at the Institut des Sciences de la Mer of the Université du Québec à Rimouski, Canada. Suzanne is interested in the fate of microalgal populations, including local harmful algae. She uses microalgal pigmentation to address changes in population structure with respect to environmental stress factors such as UV radiation or climate change and is also working in bioinvasions associated with ship transport. She is in charge of GEOHAB's Core Research Project on "HABs in Fjords and Coastal Embayments".

Dr. Vera Pospelova (vpospe@uvic.ca) is a palynologist at University of Victoria, Canada, who is interested in applications of dinoflagellate cysts for environmental and paleoenvironmental reconstructions. Her work focuses on the distribution and diversity of modern dinoflagellate cysts in temporal and subtropical waters of the Pacific and Atlantic coasts of Canada and the United States, and on the development of dinoflagellate cysts as biological indicators of environmental conditions in estuaries to the extent that cyst records can be reliably used to assess environmental change at high-resolution scales.

Hak Gyoon Kim (Pukyong National University, Korea) was on fish-killing blooms by *Cochlodinium polykrikoides* in Korea. The two co-conveners presented their own recent studies on dinoflagellates (including harmful species) in ballast water and ballast sediment from ships visiting major ports in Canada (Suzanne Roy) and on reconstruction of past environmental conditions, helping to trace past blooms, using cysts of dinoflagellates found in the sediments of B.C.'s west coast (Vera Pospelova).

Among our contributors, PICES offered the best student presentation award. Considering that we had only one oral presentation by a student, we decided to offer a "participation award" instead. Arielle Kobryn was presented with a native art ornament for her oral presentation, and Manuel Bringué and Andrea Price were awarded with the UVic logo mugs for their poster presentations.

(*continued. from p. 31*)

The third example related to an adaptation strategy for fisheries being presently enrolled at Shiretoko, a Japanese World Natural Heritage site. It became clear that at the fisheries sector level, more concrete science-based adaptive strategy is required. Local fishers were found to be eager to know and cooperate, for example by assisting in the monitoring of the local-level ecosystem changes.

During the rest of the workshop, we jointly explored the effectiveness of different approaches for promoting the climate change messages to a wider audience. Trends and developments in the scope of outreach activities were discussed. Most importantly, we addressed the ways in which marine scientists can be involved in supplying the information on the effects of climate change on the world's oceans in such a way as to create engagement, in addition to merely increasing public knowledge. The outcome of the workshop, including recommendations with regard to outreach programs and communicating with the public, stakeholders and policy makers, will be submitted as a joint manuscript (authored by all participants), "*Public perception on climate change within the marine environment*", to a special symposium issue of the ICES Journal of Marine Science.

Shin-ichi Ito awarded 2011 Uda Prize

The 2011 Uda Prize being given to Dr. Shin-ichi Ito by Prof. Yasunori Sakurai, president of JSFO.

The Uda Prize, established in 1995 by the Japanese Society of Fisheries Oceanography (JSFO), in honor of Dr. Michitaka Uda, a pioneer of fisheries oceanography in Japan, is given annually to an individual who has made significant scientific contributions to fisheries oceanography. The 2011 Uda Prize was awarded to Dr. Shin-ichi Ito (Tohoku National Fisheries Research Institute, Fisheries Research Agency) in recognition of his research on physical-ecological interactions in the North Pacific and Japanese coastal area. The presentation ceremony took place on March 30, 2012, at the spring meeting of the Oceanographic Society of Japan.

Shin-ichi balances field observations and modeling in his work. He has promoted continuous monitoring in the Kuroshio–Oyashio mixed region and along the A-line (off Hokkaido), and has constructed a 'real-time ocean weather map providing system' for wide use by fishers. As a member of the PICES MODEL Task Team, he also contributed greatly to the development of the NEMURO.FISH model. Shin-ichi has been working especially hard ever since March 11, 2011, the day of the Great East Japan Earthquake, – he has been onboard a research vessel every month to study the after-effects of the tsunami.

PICES extends its sincere congratulations to Dr. Ito.

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