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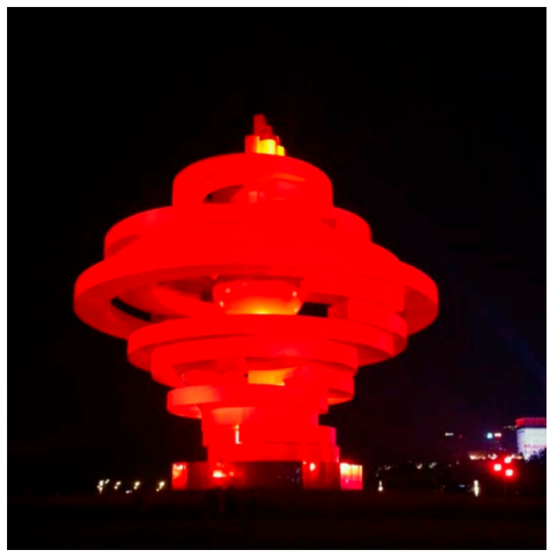
Newsletter of the North Pacific Marine Science Organization

PICES science in 2015: A note from the Science Board Chairman

It is remarkable how PICES as an organization continues to grow, including receiving increased international recognition for its broad scientific expertise on various marine science issues. For example, in support of "Oceans Day" at COP21 (United Nations Conference on Climate Change, November 30–December 11, 2015, Paris, France), PICES, along with long-time collaborators ICES and IOC, released a joint statement about climate change impacts on the world's oceans. This statement was largely based on the diverse scientific contributions from the 3rd PICES/ICES/IOC Symposium on "*Effects of climate change on the world's oceans*" held March 23–27, 2015 in Santos City, Brazil (see PICES Press, Vol. 23, No. 2). This is an important example of how our scientific expertise, generated *via* symposia and workshops, peer-reviewed literature, periodic PICES scientific reports, exchange of ideas and information among scientists, capacity building, and collaborations with other international organizations can be translated for policy makers and stakeholders, including the general public. However, strategic collaborations, such as those with ICES or IOC noted here, must be developed by both organizations over time. In 2015 PICES continued to foster collaborations with the North Pacific Anadromous Fish Commission (NPAFC) using the framework for strategic collaboration that was adopted in 2014, by supporting their "*Pacific salmon and steelhead production in a changing climate*" symposium in Kobe, Japan, May 17–19, 2015. I am also pleased to announce that two additional frameworks are now in place: one with the Northwest Pacific Action Plan (NOWPAP) and another with the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC), so be sure to look for future PICES Press articles related to expanded cooperation with these organizations.



"May Wind" at night, May Fourth Square, Qingdao.

In This Issue

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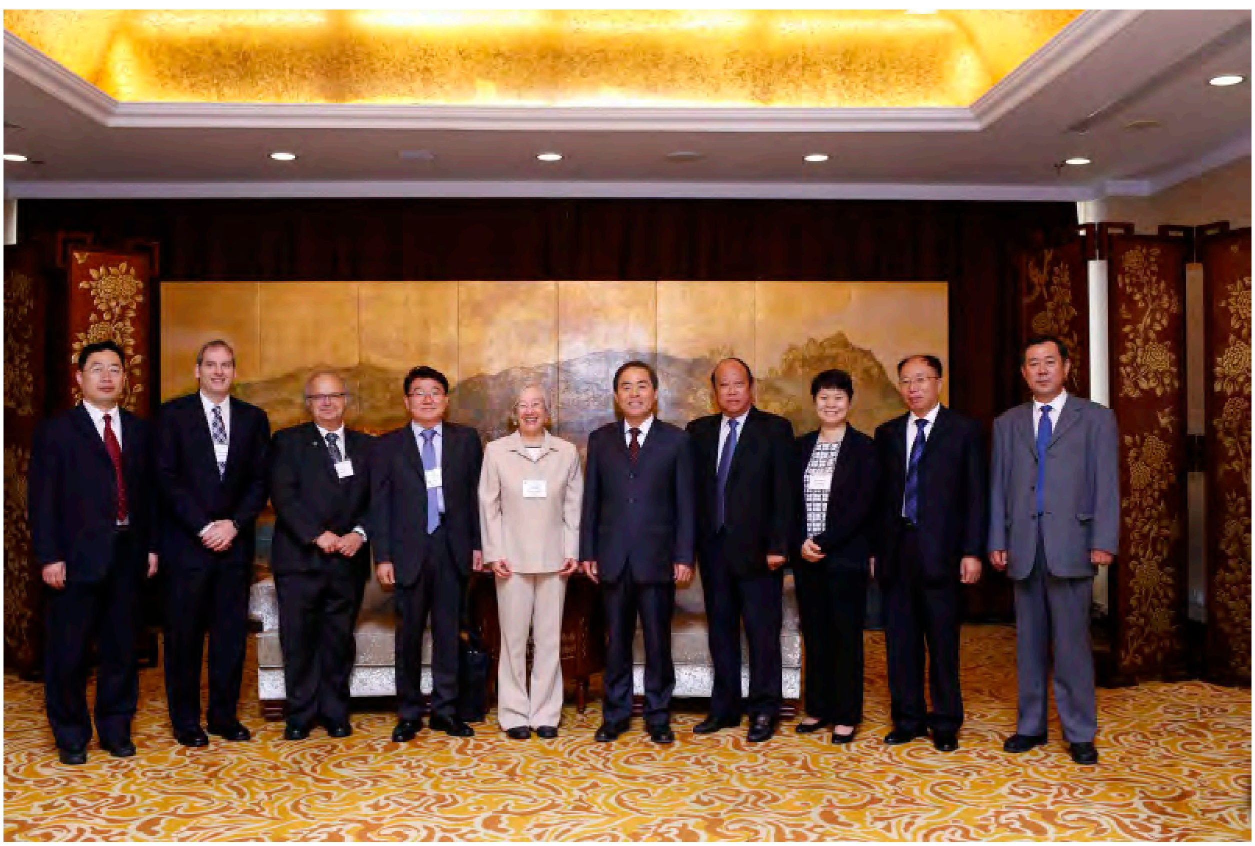
Participants at the PICES-2015 Science Board meeting (back row, from left) Steven Bograd (FUTURE SSC), Chuanlin Huo (MEQ), Harold (Hal) Batchelder (PICES Secretariat), Elizabeth Logerwell (FIS), Igor Shevchenko (representing Russia), Kyung-Il Chang (POC); (front row, from left) Hiroaki Saito (FUTURE SSC and Science Board Chairman-elect), Toru Suzuki (TCODE), Jennifer Boldt (MONITOR), Angelica Peña (BIO), and Thomas Therriault (Science Board Chairman).



Science Board and Governing Council with honoured guests prior to the Opening Session of PICES-2015. (From left) Prof. Fangli Qiao (Governing Council, China), Dr. Thomas Therriault (Science Board Chairman), Mr. Robin Brown (Executive Secretary), Prof. Chul Park (PICES Vice-Chairman), Dr. Laura Richards (PICES Chairman), Mr. Lianzeng Chen (Deputy Administrator of State Oceanic Administration (SOA) of China), Mr. Zhenxi Xu (Deputy Mayor of Qingdao), Dr. Haiwen Zhang (Director General of Department of International Cooperation of SOA), Prof. Deyi Ma (Director-General, First Institute of Oceanography, SOA), and Mr. Chengpu Yu (Director General of Qingdao Ocean and Fisheries Bureau).

PICES, as an intergovernmental organization, delivers science primarily through its expert groups. At PICES-2015, Governing Council agreed to support two new Study Groups, two new Working Groups, and established the Section on *Marine Birds and Mammals* (which replaced an existing Advisory Panel). A Study Group on *Climate and Ecosystem Predictability* (SG-CEP) was formed to build on the outcomes from Working Groups 27, 28 and 29 (*North Pacific Climate Variability and Change*; *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*; *Regional Climate Modeling*) and, collaborating with CLIVAR, is developing terms of reference for a joint CLIVAR/PICES working group that will focus on climate and ecosystem predictions. With the completion of WG 28, a Study Group on *Common Ecosystem Reference Points across PICES Member Countries* (SG-CERP) will attempt to advance FUTURE by trying to understand what determines an ecosystem's intrinsic resilience and vulnerability to natural and anthropogenic forcing – a central paradigm of the FUTURE program. Following a successful workshop on "*Effects of climate change on the biologically-driven ocean carbon pumps*" at the 3rd Climate Change Symposium, noted above, a joint PICES/ICES Working Group on *Climate Change and Biologically-driven Ocean Carbon Sequestration* (WG 33) was formed to characterize and assess biologically-driven ocean carbon pumps and their impact on environment and climate. Information provided by this Working Group will help decision makers in establishing climate policy, including adaptation. Based on framework recommendations of the joint ISC/PICES Study Group for *Scientific Cooperation of ISC and PICES*, a joint ISC/PICES Working Group on *Ocean Conditions and the Distribution and Productivity of Highly Migratory Fish* (WG 34) was established to focus on deriving habitat models relating albacore tuna distributions to oceanographic conditions as well as investigating the mechanisms regulating albacore productivity.

As I mentioned earlier, our scientific excellence is recognized by a number of international organizations and the cooperative work we do with them. Since our 2014 Annual Meeting in Yeosu, Korea, PICES has contributed to meetings, workshops, and symposia with ICES, IMBER, IOC, NOWPAP, NPAFC, and SCOR. Besides the Climate Change Symposium, PICES co-sponsored two other major meetings in 2015 – the International Symposium on *"Harmful algal blooms and climate change*" in Göteburg, Sweden, in May (see the article on p. 16) and the PICES/ICES Workshop on "*Modelling effects of climate change on fish and fisheries*" in August in Seattle, USA (see page 20). In addition, PICES and ICES will be co-sponsoring the 6th International Zooplankton Production Symposium on "*New challenges in a changing ocean*" in Bergen, Norway in May.

Besides convening symposia, PICES also serves as a co-sponsor of theme sessions at meetings led by other organizations. In 2015, PICES supported Invited Speaker, Dr. Shin-ichi Ito, to present at the session on "*Transformative pathways to sustain marine ecosystems and their services under climate change* at the International Scientific Conference on "*Our common future under climate change*" held in Paris, France, in July 2015 (see page 18). PICES provided co-convenors for three ICES/PICES theme sessions at the ICES Annual Science Conference in Copenhagen, Denmark, in September 2015: "*Ecosystem monitoring in practice*" (Dr. Jack Barth), "*Ocean acidification: understanding chemical, biological and biochemical responses in marine ecosystems*" (Dr. Tsuneo Ono), and "*Managing marine ecosystem services in a changing climate*" (Dr. Keith Criddle), and co-sponsored IMBER's 3rd CLIOTOP symposium on the "*Future of oceanic animals in a changing ocean*", held September 14–18, 2015, in San Sebastian, Spain, by providing support for Keynote Speaker, Dr. Emanuele Di Lorenzo, for the theme session on "*Integrated modelling to project and explore future patterns*".

There are two high priority PICES initiatives that I will briefly highlight here – FUTURE and NPESR. In response to a review of the first 5 years of PICES' integrative science program, FUTURE, the governance of FUTURE was restructured by establishing a Scientific Steering Committee (SSC) to provide leadership and scientific direction to the program. In March 2015, the SSC had a productive first meeting in La Jolla, USA. For more details, see the SSC's article on p. 14. The FUTURE SSC continued discussions on how to deliver useful products from this complex integrated scientific program at PICES-2015 in Qingdao. Expect to see additional details of FUTURE objectives and products shortly.

The first and second North Pacific Ecosystem Status Reports, published in 2004 and 2010, respectively, have proven to be extremely important PICES contributions to the scientific community (*e.g.*, used extensively in the UN's First World Ocean Assessment) and contracting parties. The third iteration (NPESR3) will differ from the first two. Rather than a published book, it will be based largely on archived time series datasets available to users in near real time. SG-NPESR3 should be ready to have example components on display at PICES-2016 in San Diego, USA.

Capacity building is a significant activity of PICES. A major component of our capacity building strategy is summer schools or training workshops related to marine sciences. However, for 2015 no proposals were made for PICES to host a summer school, nor was the timing right to co-sponsor the capacity building activities of other major programs due to conflicts with PICES commitments.

Thus, we had no major summer schools, so saved money and stayed home! Another aspect of capacity building is providing travel support for early career scientists (ECS) to attend international symposia and regional marine science conferences sponsored or co-sponsored by PICES. In 2015 we did some of this, with the largest efforts devoted to funding participation of ECS from all PICES member countries to the Climate Change Symposium, and scientists from China and Russia to the Harmful Algal Bloom Symposium (both mentioned above). PICES is interested in hearing suggestions for capacity building, including PICES-hosted summer schools. If you have thoughts about potential capacity building opportunities, contact me or the PICES Secretariat, as we are always looking for new ideas.

Highlights of PICES-2015

Workshop 6 on "Best practices for and scientific progress from North Pacific Coastal Ocean Observing Systems".

Meeting of the Working Group on Emerging Topics in Marine Pollution (WG 31).

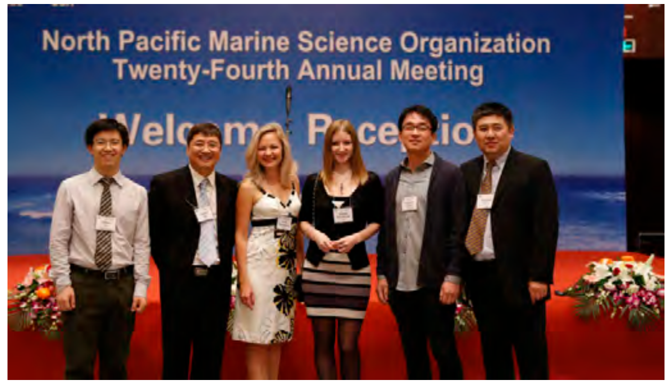
Meeting of the Study Group on North Pacific Ecosystem Status Report.

Participants at the FUTURE Mini-Symposium.

Genesis of a joint PICES-ICES working group.

Opening Session on Day 1.

Dr. Anne Hollowed being congratulated upon receiving the Wooster Award.



PICES interns – past and present. (From left) Dr. Jinwen Liu, Dr. Gongke Tan, Ms. Anna Skvortsova, Ms. Tatiana Semenova, Mr. Keyseok Choe, Dr. Chuanlin Huo.

Drs. Vadim Navrotsky, Vyacheslav Lobanov, Deyi Ma, Baohua Liu and Gongke Tan enjoying a glass of wine at the Welcome Reception.

PICES-2015 volunteers with (front, middle) Drs. Jinwen Liu, Gongke Tan and Ms. Christina Chiu.

Topic Session S3 on"Eastern-western approaches to fisheries: Resource utilization and ecosystem impacts" drew a large audience.

Dr. Toyomitsu Horii sharing a joke with MEQ Chairman, Dr. Chuanlin Huo.

Attentive audience listening to Invited Speaker, Dr. Tangdong Qu, at Topic Session S5 on "Ocean circulation of the Western Pacific and its response to climate change".

Invited Speaker, Dr. Richard Bellerby, talking to a packed audience at Topic Session S6 on "Ocean Acidification Observation Network for the North Pacific and adjacent areas of the Arctic Ocean".

FIS Chairman, Dr. Elizabeth (Libby) Logerwell, introducing the FIS Paper Session.

Invited Speaker, Dr. Daniel Lew, giving his talk at Topic Session S8 on "Marine ecosystem services and economics of marine living resources".

The Poster Session as one of the highlights at the Annual Meeting.

Participants playing jianzi, a traditional Chinese national sport at PICES-2015.

The winning team at jianzi during the PICES sport event.

Dr. Mitstaku Makino receiving a certificate for Best Presentation in the Science Board Symposium from Dr. Thomas Therriault.

Toasting with Tsingtao beer at the Chairman's Reception at the Tsingtao Brewery and Beer Museum.

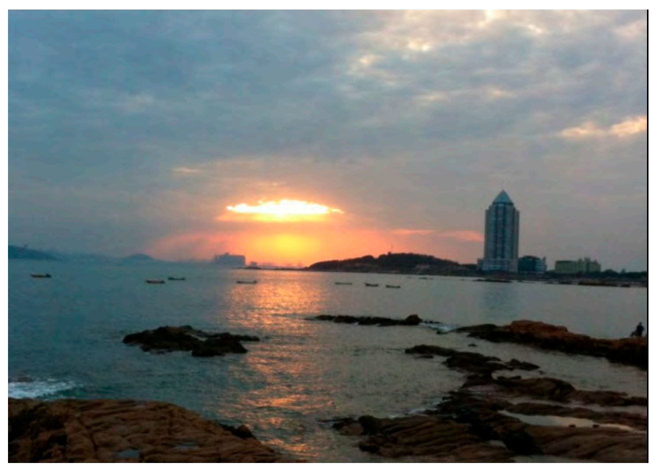
Seawall walk along Fushan Bay, Qingdao. Photo courtesy of Jinwen Liu.

PICES is involved in two major initiatives funded by the Government of Japan. We are continuing to make significant advancements in both our 5-year PICES project on **Mar**ine Ecosystem Health on Human **We**ll-**B**eing (MarWeB) and 3-year project on "*Effects of marine debris caused by the Great Tsunami of 2011*". For example, the latter project reached its mid-point in 2015 and hosted a very productive workshop on "*How to best assess the risk of Japanese tsunami marine debris as a vector in delivering invasive species to the coasts of North America and Hawaii*". Although single species risk assessment models have become fairly common in invasive species research, assessing the risk posed by a vector is much more complicated, and workshop participants worked hard to develop a conceptual model for tsunami debris that will be applied to existing field observations over the next few months.

We completed a very successful Annual Meeting in Qingdao, the sailing venue for the 2008 Summer Olympic Games. We thank Mr. Lianzeng Chen, Deputy Administrator of the State Oceanic Administration of China, and Mr. Zhenxi Xu, Deputy Mayor of Qingdao, for their opening remarks and warm welcome to PICES. The Meeting theme, "*Change and sustainability of the North Pacific*", attracted 508 participants from 15 countries. Twenty-one organizations were represented at PICES-2015, four of which sponsored workshops and/or topic sessions. The Meeting began with a Keynote Lecture by Prof. Lixin Wu (Ocean University of China, Qingdao) on "*Multiscale processes of Pacific Western Boundary Currents and their roles in climate*". A total of 221 oral presentations and 145 posters were presented during the Meeting which consisted of a Science Board Symposium, 10 Topic Sessions, four Contributed Paper Sessions, and six Workshops. Many of the presentations can be found on PICES' 2015 Annual Meeting presentations page.

I am happy to announce that during our Annual Meeting, Science Board unanimously elected Dr. Hiroaki Saito (Japan) as Chairman-elect, which means he will assume my position at the end of my term following PICES-2016. This should ensure a smooth transition at Science Board.

The Annual Meeting gives PICES an opportunity to recognize exceptional contributions to North Pacific marine science in the form of the Wooster Award and POMA (PICES Ocean Monitoring Service Award). The 2015 Wooster Award was presented to Dr. Anne B. Hollowed, a Senior Scientist with NOAA's National Marine Fisheries Service at the Alaska Fisheries Science Center in Seattle, for her sustained excellence in research, integrated across marine science disciplines, much of which has been in association with PICES. In her 33-year research career, she has published more than 75 peer-reviewed publications and demonstrated extraordinary leadership at regional, national and international levels related to the impact of climate change on marine ecosystems. For the 2015 POMA, the recipient was TINRO-Centre of Russia for its Macrofauna Inventory. This collection is a 12-volume compilation of very detailed observations of the abundance and distribution of a variety of species in the Northwest Pacific Ocean. This series of publications is a unique contribution and is of special value for future comparisons and ecosystem monitoring in the Northwest Pacific, especially given ongoing global climate change and the expansion of industrial development.



Sunset off the waters of Qingdao. Photo courtesy of Jinwen Liu.

Finally, our next Annual Meeting will be our 25th Anniversary Meeting. PICES-2016, with the theme, "*25 years of PICES: Celebrating the past, imagining the future*", will take place in San Diego, USA, November 1–13, 2016. I look forward to seeing you there or at other Anniversary events taking place during 2016.

Thomas Therriault
Science Board Chairman

2015 PICES awards

The presentation ceremony for two prestigious PICES awards took place on October 19, 2015, during the Opening Session at the 2015 PICES Annual Meeting in Qingdao, China.

Wooster Award

In 2000, PICES established an annual award for scientists who have made significant contributions to North Pacific marine science and have achieved sustained excellence in research, teaching, administration, or a combination of these in the area of the North Pacific. The award was named in honour of Professor Warren Wooster, a principal founder and the first Chairman of PICES. Prior recipients of the Wooster Award were Michael Mullin (USA; 2001), Yutaka Nagata (Japan; 2002), William Pearcy (USA; 2003), Paul LeBlond (Canada; 2004), Daniel Ware (Canada; 2005), Makoto Kashiwai (Japan; 2006), Kenneth Denman (Canada; 2007), Charles Miller (USA; 2008), Kuh Kim (Korea; 2009), Jeffrey Polovina (USA; 2010), Bernard Megrey (USA; 2011), Richard Beamish (Canada; 2012), Vera Alexander (USA; 2013) and Fangli Qiao (China; 2014).

The 2015 award presentation ceremony was conducted by Drs. Laura Richards (Chairman of PICES) and Thomas Therriault (Chairman of Science Board). Dr. Therriault announced that the 2015 Wooster Award was being given to Dr. Anne B. Hollowed (National Marine Fisheries Service, NOAA, USA), and read the following Science Board citation which was accompanied by a slide show dedicated to Dr. Hollowed:

In 2000, PICES Governing Council approved the establishment of an award named in honour of Professor Warren S. Wooster, a principal founder and the first Chairman of PICES, and a world-renowned researcher and statesman in the area of climate variability and fisheries production. The criteria for selection are sustained excellence in research, teaching, administration or a combination of the three in the area of North Pacific marine science. Special consideration is given to individuals who have worked in integrating the disciplines of marine science, and preference is given to individuals who were or are currently actively involved in PICES activities.

Please join me in congratulating the recipient of the 2015 Wooster Award, Dr. Anne Babcock Hollowed, a Senior Scientist with NOAA's National Marine Fisheries at the Alaska Fisheries Science Center in Seattle, for her sustained excellence in research, integrated across marine science disciplines, much of which has been in association with PICES. In her 33-year research career, she has published more than 75 peer-reviewed publications and demonstrated extraordinary leadership at regional, national and international levels related to the impact of climate change on marine ecosystems.

Anne was brought up in Minnesota. For those of you unfamiliar with the geography of the United States, the important thing to know is that this is roughly equidistant from the Atlantic, Pacific and Arctic Oceans that touch the United States (or pretty much as far away as one can get from any ocean) – an appropriate birthplace for a preeminent marine scientist.

As a teenager, Anne stood out among her peers as uniquely skilled at mechanics. While the other girls were learning to cook and master domestic challenges, Anne repaired bicycles. Lots of them…. First for her family, then for the neighbors' kids, and pretty soon, she had a cottage industry going, with bicycles coming in from all around the Lowry Hill neighborhood.

The kids would be called in for dinner, and there Anne would sit on the curb, working away trying to solve a mechanical puzzle and get the machine working properly again. She's always loved solving complex problems, staying focused until she discovers the solution.

Anne's education path shows her interest in multi-disciplinary work:

- *B.A. Biology and Geology, Lawrence University, Appleton, Wisconsin, 1978;*
- *M.Sc. Biological Oceanography, Old Dominion University, Norfolk, Virginia, 1982;*
- *Ph.D. Fisheries, University of Washington, Seattle, Washington, 1990.*

Her Ph.D. studies at the University of Washington were under the tutelage and mentorship of Dr. Warren Wooster.

Dr. Anne B. Hollowed accepting the Wooster Award from Dr. Thomas Therriault, PICES Science Board Chairman, and Dr. Laura Richards, PICES Chairman

Anne's scientific career started out with the assessment of groundfish stocks in the North Pacific and Bering Sea, but this quickly expanded to include impacts of fishing and climate change on marine ecosystems. She played a leadership role in the development and execution of the PICES/GLOBEC Climate Change and Carrying Capacity Program (the 4 C's Program), the ICES/PICES Section on Climate Change Effects on Marine Ecosystems and the PICES FUTURE program, all in addition to her contributions to several important national research programs. She has taken her passion and commitment to the global level and served as a Lead Author for the Intergovernmental Panel on Climate Change (IPCC) Working Group II, writing the impact assessment of climate change for the Polar Regions. Anne's contributions go beyond the publication of research results. She has played a key role in the design and implementation of large research programs in the US. This includes the very difficult task of convincing higher authorities that these programs are worthy of funding and support.

There are many scientists who have benefited from her efforts and in the final analysis, the agencies that supported these programs have been rewarded. Anne's CV includes an impressive array of awards and recognition from NOAA, the Department of Commerce, ICES and others but there are a couple of recent awards that I think are great illustrations of Anne's contributions. In 2013, Anne received a NOAA Fisheries Employee of the Year Award in the Supervisor Category and in 2014 she was presented the NOAA Administrator's Award for her contributions to the 5^{th} *IPCC Assessment Report. It is impressive that she could manage such an individual scientific contribution while still attending to (at the highest levels of achievement) the research group that she leads up.*

Family is also a really important part of Anne's life and the years of tending to a young family (three children – John Jr., Thomas and Madolyn) when both partners are engaged in full-time careers is not without its challenges. Apparently, there was a day when Anne and her husband John sent daughter Madolyn off to school when she was feeling a little ill. The story goes that husband John dosed Madolyn with medicine to make her feel better but as it turned out the dose might have been a little too strong, and Madolyn fell asleep at school. The teachers were concerned and one of them quickly found Madolyn's brother and asked him to call his mother, Doctor Hollowed – she'd know what to do! He laughed and said "Sorry, she's not that kind of a doctor, she's a Fish Doctor!" Anne's three children are pursuing education and careers in medicine – not one interdisciplinary marine scientist in the lot!

Please join me in congratulating Dr. Anne Babcock Hollowed as the recipient of the 2015 Wooster Award.

Dr. Anne B. Hollowed, 2015 Wooster Award recipient.

Dr. Hollowed accepted the award with the following remarks:

I wish Warren was here. I've watched individuals receive this award and am so honored to be among those that have gone before me. I just can't thank you enough. I'm just stunned – really, I'm just speechless. All of you know how much each one of you means to me, both as colleagues in our scientific efforts, but as well our pursuit in becoming friends across multiple nations. Keep at it. Thank you so much. I am so honored.

PICES Ocean Monitoring Service Award

Progress in many aspects of marine science is based on ocean observations, monitoring, and management and dissemination of data. In 2007, a PICES Ocean Monitoring Service Award (POMA) was established to recognize the sustained accomplishments of those engaged in these activities. Prior recipients of the award were the training ship T/S *Oshoro-maru* (Japan) in 2008; Dr. Bernard Megrey and Mr. Allen Macklin (NOAA, USA), leaders of the PICES Metadata Federation Project, in 2009; the Station P/Line P (Canada) Monitoring Program in 2010; the Network of Serial Oceanographic Observations (Korea) in 2011; the California Cooperative Fisheries Investigations in 2012, the A-line Monitoring Program in 2013 (Japan), and the Trans-Pacific Volunteer Observing Ship (VOS) Survey Program in 2014 (Korea).

Drs. Richards and Therriault conducted the POMA presentation ceremony. Dr. Therriault announced that the 2015 award was being given to the TINRO-Centre of Russia for their Macrofauna Inventory, and read the following Science Board citation (reading of the citation was accompanied by a slide show dedicated to the Program):

The PICES Ocean Monitoring Service Award (POMA) recognizes organizations, groups and outstanding individuals that have contributed significantly to the advancement of marine science in the North Pacific through long-term ocean monitoring and data management. The award also strives to enlighten the public on the importance of those activities as fundamental to marine science. It draws attention to an important aspect of the PICES Convention that is less appreciated: "to promote the collection and exchange of information and data related to marine scientific research in the area concerned".

Please join me in congratulating the recipient of the 2015 POMA Award, which is the TINRO-Centre of Russia for their Macrofauna Inventory.

To "increase understanding of climatic and anthropogenic impacts and consequences on marine ecosystems" (a FUTURE Objective) it is imperative to have observations (data) about the abundance and distribution of species. The TINRO-Centre Macrofauna Inventory is an outstanding example of this. The inventory is a twelve volume compilation of very detailed observations of the abundance and distribution of species (nekton, pelagic macrofauna and benthic macrofauna) in the Northwest Pacific Ocean. This is an immense contribution:

- *7,186 pages in 12 volumes,*
- *33 years of data (1997 to 2010),*
- *177 research cruises with 25,835 pelagic trawls,*
- *220 research cruises with 30,510 benthic trawls,*
- *summarized by species (825 in pelagic trawls;1306 in the benthic trawls), by seasons (4) and by biostatistical areas (48),*
- *summarized by depth range,*
- *further summarized by size/age groups for some well-studied species,*
- *and even further stratified by four separate regimes:*
  - *before 1990, when the pelagic ecosystem was dominated by sardines and pollock,*
  - *1991–1995, a transition period with sharp declines in abundance,*
  - *1996–2005, a period of low abundance,*
  - *2005–2010, a period characterized by high abundance of Pacific salmon.*

This is an impressive array of stations and samples, with some large databases in the background to archive, summarize and analyze these data. This series of publications is a unique contribution and is of special value for future comparisons and ecosystem monitoring in the Northwest Pacific, given ongoing global climate change and the expansion of industrial development in this region. Ladies and gentlemen, please join me in congratulating TINRO, who is represented here by Dr. Vladimir Kulik, as the recipient of the 2015 PICES Ocean Monitoring Service Award.

Dr. Kulik provided the following remarks of appreciation:

It is a very great honor for me and many other co-authors who made this award possible. The main authors are Dr. Igor Volvenko and Dr. Vyacheslav Shuntov who made tremendous efforts to put together so many stations and filter out valuable information from trawl charts and figure out with the aim to produce a series of reference Tables on the distribution and abundance of nekton and macrofauna of the Russian Far Eastern Seas and Northwest Pacific Ocean in accessible format. Definitely, these cruises could not be promoted and published without efforts of the technical staff of TINRO-Centre including crew members and field researchers.

I would like to say special thanks to the director of TINRO-Centre, Dr. Lev Bocharov, for making this huge work publicly available. Thank you.

Dr. Vladimir Kulik posing with Dr. Laura Richards, PICES Chairman, and Dr. Thomas Therriault, PICES Science Board Chairman, upon acceptance of the POMA (left photo), and making an acceptance speech on behalf of colleagues (right photo).

We congratulate Dr. Anne B. Hollowed, and Dr. Vladimir Kulik and colleagues as recipients of the Wooster and POMA awards for 2015.

Face to face with oceanographers: PICES outreach of ocean science to Qingdao public schools

by Harold (Hal) Batchelder

Prior to PICES-2015, the Local Organizing Committee (LOC) in Qingdao, China, contacted the Secretariat with an extraordinary request—would we please identify several PICES scientists from outside of China to present short lectures on marine science to several school classes during the week of PICES Annual Meeting (October 14–25)? It sounded like an excellent opportunity for PICES scientists to contribute marine expertise to a younger than normal, and probably quite receptive audience. Follow-up correspondence between the Secretariat and LOC led to the author contacting a subset of the PICES community to gauge interest in this outreach activity. Very quickly (within 3 days) we learned that there was enthusiastic interest and many more scientist volunteers ready to participate than could be accommodated. With this early positive response, I was comfortable moving forward with Mr. Yafeng Yang (Deputy Division Director, SOA) from LOC to select scientific topics and specific science experts that would be appropriate for each individual school.

During the Welcome Reception on Monday evening (October 19), Mr. Yang coordinated a brief "meet and greet" of representatives (teachers and principals) of the three schools and the marine scientists selected to give classroom lectures. This was useful in that it allowed the scientists to meet beforehand with the teachers whose classes they would visit.

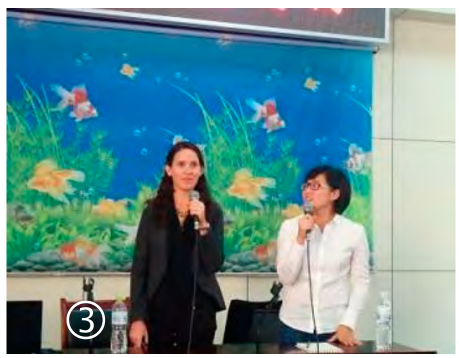
Three scientists, one from China and two from other PICES member countries, accompanied by a translator/interpreter visited one school each day, Tuesday to Thursday, during the Annual Meeting. Translation services were provided by Ms. Qian Qu, (Department of International Cooperation of the National Oceanographic Center, Qingdao). Also visiting each school was the author accompanied by journalists from the newspaper, *China Ocean News* and/or PICES photographers. We visited the Qingdao Tong'an Road Primary School (Tuesday AM; 6th grade students), the No. 39 Middle School in Qingdao (Wednesday PM; 10th grade students), and the Shinan Experimental Primary School (Thursday PM; 5th and 6th grade students). The visiting scientists were warmly welcomed at each school. The school administrators and classroom teachers provided us with background information about the school and a tour of the facilities, which, in two cases, included on-site marine museums where students provided overviews of their marine collections (in very good English; Photo 1). At the Middle School, which has affiliations and receives contributions from the First Institute of Oceanography (FIO), Ocean University of China (OUC) and other marine institutions in Qingdao, we also visited the geological, chemical and biological laboratories where the students have access to and gain experience with advanced analytical equipment (*e.g.*, atomic absorption and mass spectrometers, flow cytometers, and polymerase chain reaction technology).

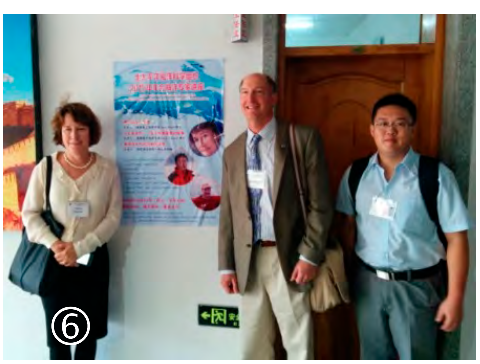
(Photo 1) Tong'an Road Primary School 6th grader describing (in English) marine fish within the school's collection.

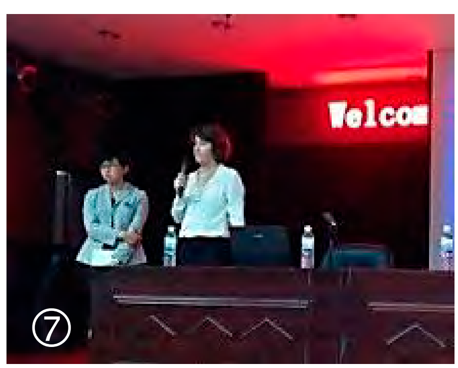
For each school visit, the non-Chinese scientists were selected jointly by LOC and the Secretariat, taking into consideration the age of the student audiences and the topics offered by the scientist volunteers. Tong'an Road Primary School was the first school we visited. The school (grades 1–6), which is affiliated with the China Ocean Association, began a curriculum in 2002 that emphasizes marine biology and geology. Every year, each grade goes on a field trip to one of the dozen islands offshore near Qingdao so that by the time a student graduates to Middle School, he or she has visited six different islands to learn about geological features, marine organisms and ocean processes. The students are very proud of their marine science collection and are enthusiastic about marine science. After we were introduced to the school administrators, we watched a video of 3rd graders on an ocean field trip. We were then escorted to a packed lecture hall of about 150 6th graders who welcomed us. For the visit to this school, the presenters and topics were: 1) Dr. Suam Kim (Pukyong National University, Korea); "*Where do fishes go when temperatures warm?*" (Photo 2); 2) Dr. Cathryn Clark Murray (PICES Secretariat); "*The effects of debris on the ocean*" (Photo 3); and 3) Dr. Nengfei Wang (First Institute of Oceanography, Qingdao) "*Experiences in the Antarctic Great Wall Station*" (Photo 4). The first speaker, Dr. Kim, engaged the students by asking them questions during his lecture. At first the students were reluctant to raise their hands and answer. Eventually, one student did, and provided an answer (*via* our translator) which opened the floodgates on audience participation—almost every schoolchild's hand went up on future queries and during the question period after the lecture. Thereafter, the students never hesitated to ask or answer questions. At the conclusion of the three talks, a number of the students presented each of the scientists with the school mascots—male and female stuffed dolphins. After photos of the scientists and students were taken (Photo 5), we were treated to a buffet lunch at the school.

On Wednesday afternoon, Dr. Jack Barth (Oregon State University, USA; "*Robotic exploration of our planet Ocean*") and Dr. Vera Trainer (National Oceanic and Atmospheric Administration Northwest Fisheries Science Center, USA; "*What's blooming in the water?—The story of harmful algae*") joined Dr. Lin Liu, (First Institute of Oceanography, Qingdao; "*Interaction between ocean and air*") in providing lectures (Photos 6, 7) to approximately 150 10th grade students of the No. 39 Middle School (Photo 8). Because this visit was longer than the other two due to the tours to see the well-equipped laboratories, the school hosted the visitors to an excellent dinner in the school cafeteria. The facilities of No. 39 Middle School, which was established in 1952 and educates about 2800 students each year, are quite advanced. It is well connected with the First Institute of Oceanography and the Ocean University China, and other marine institutions in Qingdao. The importance of marine science programs in schools was aptly noted by Dr. Trainer, who wrote in the Middle School visitor book, "Keep up the great work! You are the scientists of our future."

On Thursday afternoon, Dr. Sukyung Kang (Photo 9; National Fisheries Research and Development Institute, Korea; "*How do you tell a fish's age?*"), Dr. Steven Bograd (Photo 10; NOAA Southwest Fisheries Science Center, USA; "*Tracking ocean animals throughout the North Pacific*") and Dr. ChengJun Sun (Photo 11; First Institute of Oceanography, Qingdao; "*Marine biofouling*") presented their talks to approximately 100 5th and 6th grade students of the Shinan Experimental Primary School.







At the Tong'an Road Primary School, Dr. Suam Kim and interpreter, Ms. Qian Qu (Photo 2), Dr. Cathryn Clark Murray and Ms. Qu (Photo 3), Dr. Nengfei Wang (Photo 4), and Dr. Murray with students (Photo 5). (Photo 6) Drs. Vera Trainer, Jack Barth, and Lin Liu posing with a poster advertising their lectures at the No. 39 Middle School and (Photo 7) Dr. Trainer answering questions, with Ms. Qu standing by to translate.

(Photo 8) Attentive 10^{th} graders at No. 39 Middle School; (Photo 9) 5^{th}–6^{th} grade students at Shinan Experimental Primary School. (Standing, from left to right) one of the classroom teachers, Ms. Qu, and Dr. Sukyung Kang. A warm welcome to PICES is written on the chalk board; (Photo 10) at Shinan Experimental Primary School Dr. Steven Bograd explains why large marine animals migrate and (Photo 11) Dr. ChenJun Sun talks about marine biofouling.

The students in all three schools were sponges for information, and very engaged. Most were attentive and took notes during the lectures. When the question and answer period began, it started slowly, but shortly gained speed and became competitive. I was very impressed by the students' overall knowledge of marine biology/ecology. This was perhaps most evident during the questions received by Dr. Kang after her lecture on using otoliths to determine the age of fish. I am quite sure that when I was in the 5^{th} grade I had never heard of otoliths (fish ear bones). At the conclusion of the event, I remarked to the teacher that her students asked very pertinent and advanced questions about otoliths and the maximum age fish could achieve in the ocean. She informed me that students at Shinan Experimental Primary first learned about otoliths in the 2^{nd} grade!

In addition to the presentations made at these schools, a poster describing some of the accomplishments and timeline of activities of PICES during its first 25 years was translated into Chinese by our current PICES intern from China, Dr. Jinwen Liu. Copies were made so the poster could be displayed and left with each school that we visited.

The school visits were so successful that they may become a regular activity at future Annual Meetings if there is early expressed interest by the host country, and commitment by a local coordinator to identify the schools and facilitate the visits. We thank Mr. Yang for suggesting this event, for providing us with information about the specific schools and classes so that appropriate lecturers and science subjects could be matched with the school audiences in advance of scientist departures from their home countries, and for making the travel arrangements to and from the schools. All of the speakers who participated were enthusiastic about the activity before and after the event. The competition was stiff —the other PICES scientists who volunteered but were not selected were disappointed they could not engage in this capacity building endeavour. Those not selected in 2015 may have opportunities in the future. In addition to acknowledging the contributions from the lecturers, PICES recognizes the important support provided by the State Oceanic Administration of China, the First Institute of Oceanography, the local government of Qingdao, and the three Qingdao schools that invited the Organization to participate in this face-to-face engagement on ocean science.

Hal Batchelder spent his early life in Massachusetts, USA (where he grew up to appreciate the ocean and marine life). After obtaining his M.Sc. and Ph.D. in Oceanography he worked at ocean institutions on both the Atlantic and Pacific coasts of the United States, most recently at Oregon State University from 2000 to 2014. In 2014 he became the Deputy Executive Secretary at the PICES Secretariat—a position which he is enjoying immensely.

An update on the FUTURE science program

by Steven Bograd, Hiroaki Saito and Emanuele Di Lorenzo

FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) was established in 2009 as the flagship science program of PICES. In 2014, at the mid-point of the program, PICES established a FUTURE Evaluation Team to review progress towards achieving the goals of FUTURE as set out in the Science and Implementation plans. The report of the Evaluation Team identified a number of organizational and implementation impediments to advancing FUTURE science, and made several recommendations to advance FUTURE and PICES in the coming years. Foremost among the recommendations was the establishment of a FUTURE steering committee, separate from the PICES Science Board, that would provide leadership and scientific direction to the program. Following these recommendations, Governing Council agreed to the formation and composition of a FUTURE Scientific Steering Committee (SSC) at the PICES 2014 Annual Meeting in Yeosu, Korea. See membership and revised terms of reference of the FUTURE SSC.

The FUTURE SSC held its inaugural meeting at NOAA's Southwest Fisheries Science Center in La Jolla, California, USA, on March 1–3, 2015 (Fig. 1). The principal objectives of this meeting were to:

1. Refine the terms of reference of the FUTURE SSC;
2. Establish linkages between SSC members and existing PICES Expert Groups; and
3. Develop an initial action plan for the FUTURE SSC.

Key outcomes of the meeting included the identification of potential new working groups to address FUTURE objectives in the remaining years of the program, as well as identification of SSC liaisons to each of the more than 20 Committees and expert groups of PICES. The goal of the liaisons is to enhance communication of FUTURE goals and accomplishments throughout the Organization, and to provide feedback from the expert groups to the SSC. At PICES-2015 in Qingdao, China, the SSC hosted a FUTURE Mini-Symposium to review the new governance structure, discuss progress and goals of the SSC, and hear reports from each expert group on recent accomplishments and planned activities in support of FUTURE. The SSC will host another FUTURE Mini-Symposium at the PICES-2016 in San Diego, USA, in addition to a plenary session dedicated to FUTURE-related topics.

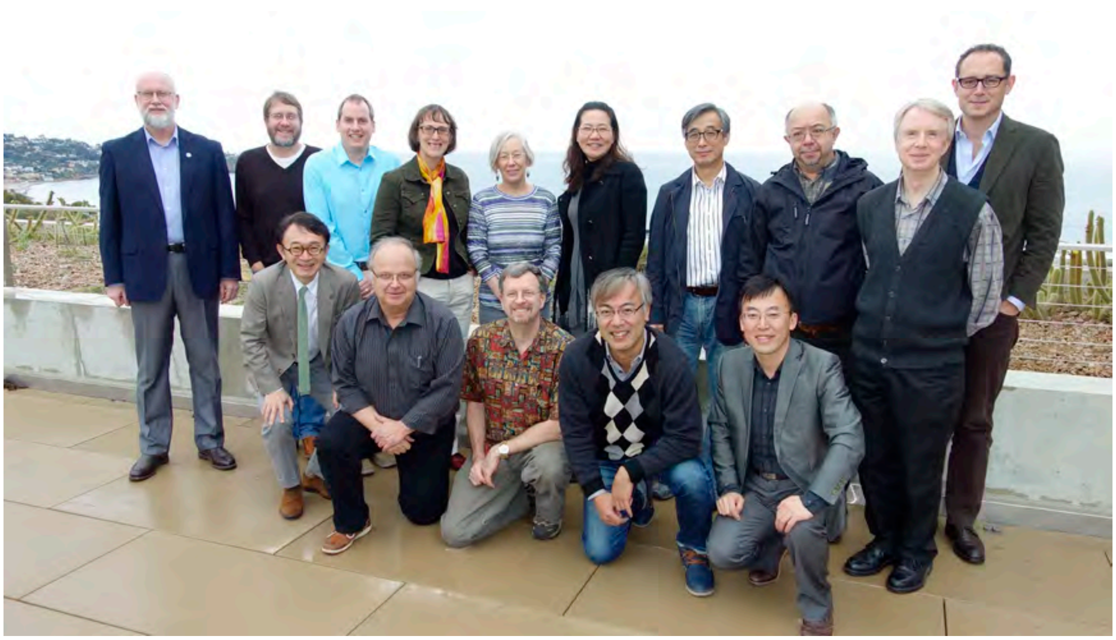


Fig. 1 Members of the FUTURE Scientific Steering Committee at their inaugural meeting in La Jolla, California, USA, in March 2015. (Front row, left to right) Hiroaki Saito (Japan, FUTURE SSC Co-Chairman), Robin Brown (PICES Executive Secretary), Harold (Hal) Batchelder (PICES Deputy Executive Secretary), Mitsutaku Makino (Japan), and Guangshui Na (China). (Back row, left to right) Vyacheslav Lobanov (Russia), Steven Bograd (USA, FUTURE SSC Co-Chairman), Thomas Therriault (Science Board Chairman), Jacquelynne King (Canada), Laura Richards (PICES Chairman), Sukyung Kang (Korea), Sinjae Yoo (Korea), Oleg Katugin (Russia), Ian Perry (Canada) and Emanuele Di Lorenzo (USA). Unable to attend were FUTURE SSC members, Fangli Qiao (China) and Toyomitsu Horii (Japan).

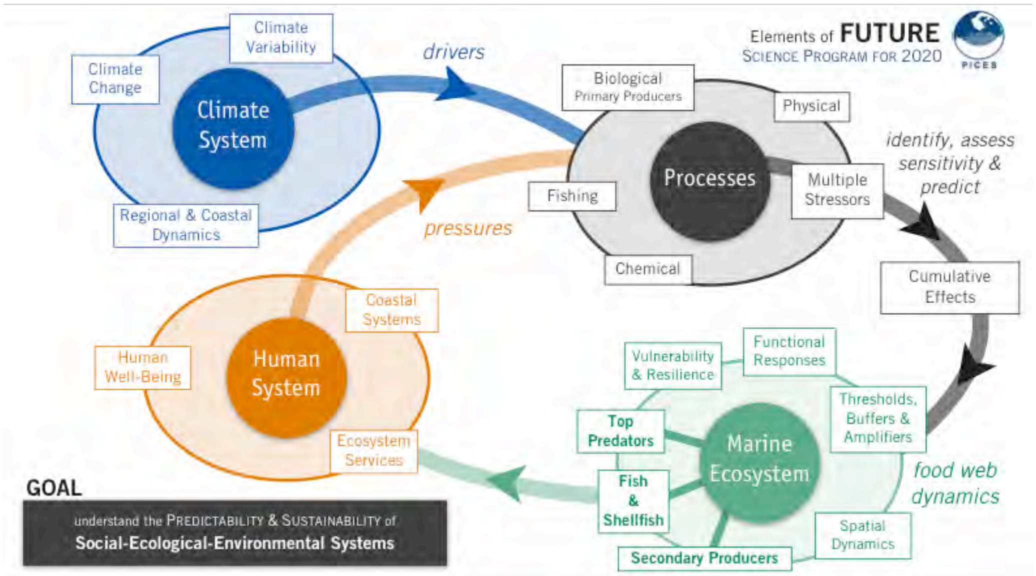


Fig. 2 Conceptual diagram of the FUTURE science program. Diagram developed by Emanuele Di Lorenzo.

The SSC continues to discuss ways in which the FUTURE science program can holistically link and synthesize many of the activities of PICES (Fig. 2). With this new governance structure, FUTURE is poised to achieve its objective of improving our understanding and communication of the future of North Pacific ecosystems and the potential impacts of human activities on the North Pacific.

Dr. Steven Bograd (steven.bograd@noaa.gov) is a physical oceanographer at NOAA's Southwest Fisheries Science Center, Environmental Research Division, in Pacific Grove, California. Steven is currently involved in a number of research projects studying climate variability and its impacts on the marine ecosystems of the North Pacific Ocean, and is Editor-in-Chief of Fisheries Oceanography. Steven has been active in PICES for many years, and is a member of Science Board, the Physical Oceanography Committee, and WG 27 on North Pacific Climate Variability and Change. He co-chairs the FUTURE Scientific Steering Committee with Hiroaki Saito.

Dr. Hiroaki Saito (hsaito@aori.u-tokyo.ac.jp) is an Associate Professor at the Atmosphere and Ocean Research Institute, the University of Tokyo. He has a broad range of interests but his focus lies in the role of marine organisms in food-web dynamics and biogeochemical cycles. He is one of the establishing members of the A-line monitoring programme for the western North Pacific. He was a core member of the SEEDS I, II and SERIES Fe fertilization experiments, led the DEEP (2002–2007), SUPRFISH (2007–2012) projects, and is leading the SKED project (2011–2021). He has also been involved in IMBER, and was Chairman of IMBER-Japan from 2004–2008. In PICES, Hiroaki is a member of the Study Group on Revising the Strategic Plan, co-chairs the FUTURE Scientific Steering Committee with Steven Bograd, and is Chairman-elect of Science Board.

Dr. Emanuele (Manu) Di Lorenzo (edl@gatech.edu) is a Professor of Ocean and Climate Dynamics in the School of Earth and Atmospheric Sciences, Georgia Institute of Technology (USA). His research interests and experience span a wide range of topics from physical oceanography to ocean climate and marine ecosystems. More specific focus is on dynamics of basin and regional ocean circulation, inverse modeling, Pacific low-frequency variability, and impacts of large-scale climate variability on marine ecosystem dynamics (http://www.oces.us). He serves on the CLIVAR ENSO Diversity Working Group and is a member of the CLIVAR POS Panel. In PICES, Manu co-chairs Working Group 27 on North Pacific Climate Variability and Change and leads the Study Group on Socio-Ecological-Environmental Systems (SG-SEES). He is a member of the Physical Oceanography Committee, Study Group on Climate and Ecosystem Predictability (SG-CEP), Section on Human Dimensions of Marine Systems (S-HD) and FUTURE Scientific Steering Committee.

International Scientific Symposium on "*Harmful algal blooms and climate change*"

by Mark L. Wells and Vera L. Trainer

There is emerging evidence that climate change will impact coastal and offshore marine phytoplankton communities, and projections that this change may include increases in the frequency and severity of harmful algal blooms (HABs). Climate change processes already are causing shifts in phytoplankton community composition, but the projections on climate: HAB effects, independent of other anthropogenic impacts, remain speculative. Although there are many intuitive linkages, these scenarios are founded on limited and often conflicting experimental data so that the scientific debate at this time cannot establish whether a link exists between HABs and climate change, let alone how dramatic a change in HABs might be expected in the future.

An International Scientific Symposium on "*Harmful algal blooms and climate change*" was held in Göteborg, Sweden, May 19–22, 2015, to better explore how climate change may alter environmental drivers affecting the prevalence and expansion of HABs in coastal and offshore waters (see also a related article in PICES Press, 2015, Vol. 23, No. 2, pp. 25–27). The Symposium was jointly sponsored by PICES, the Swedish Research Council (FORMAS), GEOHAB, the Swedish Meteorological and Hydrological Institute, and the University of Gothenburg, and was endorsed by ICES, IOC and SCOR. Fifty-eight participants (Fig. 1) attended from around the globe to discuss how to achieve the goal of eventually providing "market forecasts" for changes anticipated due to climate impacts on HABs.

The symposium highlighted key overview presentations and contemporary insights, supported by a larger number of posters describing details of current climate related HAB research. Two mid-morning poster sessions were held, with 60 second talks given by poster authors to facilitate interest and discussion during the sessions. Substantial time was allotted to multiple daily breakout sessions, where subgroups discussed different topics important to establishing climate change and HAB linkages. The breakout groups reported their findings to all participants at the end of each day for further discussion and refinement. Each breakout topic group was tasked to:

1) List the critical research focal points needed to better delineate the ecological niches of HABs;
2) Prioritize these research foci over the next 5–10 years;
3) Identify what new tools, experimental strategies, observation infrastructures, and linkages to other programs are needed; and
4) Identify key species/strains for converging HABs/ climate research to accelerate our advancement in understanding.

Breakout discussions on the first day of the Symposium targeted how HAB prevalence can be affected by changes in temperature, salinity, and light, increased stratification, and the complex regulation by grazing. Fresh and marine cyanobacterial blooms (Fig. 2), ocean acidification, and HAB impacts on fisheries and aquaculture were considered on the second day, while benthic HABs (*e.g.*, ciguatera fish poisoning), climate driven changes in nutrient flux, and HAB modelling approaches were discussed on Day3. The final day of the Symposium considered the need for an increased role of molecular methods in HAB research, the HAB-related components of future integrated observing systems, and the necessity for developing a Best Practices Manual for HAB research to enable quantitative inter-comparison among studies.

Fig. 1 Participants of the International Symposium on "Harmful algal blooms and climate change" May 19–22, 2015, in Göteborg, Sweden.

Fig. 2 Cyanobacteria blooms now occur commonly in the Baltic Sea. Photo courtesy of the Swedish Coast Guard.

Despite the large number of "known unknown" factors related to HABs and climate change, the Symposium participants identified a small subset of likely HAB changes, primarily associated with large-scale shifts in HAB spatial and temporal distributions in the future. These included latitudinal range expansion of warm water HAB species at the expense of cold-water species, and changes in seasonal windows of opportunity for certain HABs. The participants also determined the key steps needed to improve HAB forecasting, including improving connections between observational and ecological studies and regional and global scale modelling efforts.

There was broad agreement that a subset of key sentinel sites be established among earth observing networks to enhance long-term trend analysis of HAB–climate associations. Drawing definitive links between climate-driven environmental changes and differences in HAB prevalence depends upon these critical time series. To this end, several international organizations, including the International Panel of Harmful Algal Blooms (UNESCO), ICES, PICES, The Oslo-Paris Convention (OSPAR), the Baltic Marine Environment Protection Commission (HELCOM), the Global Ocean Observing System (GOOS) and national and local programs, are continuing their efforts to coordinate observations and trend analysis of plankton data, link these to climate change science, and contribute to the newly developing UNESCO-IOC Global HAB Status Report. The Scientific Steering Committee of the newly formed GlobalHAB, the replacement for GEOHAB, is being formed and will include expertise on freshwater HABs, benthic HABs, satellite, observation systems, ecology, oceanography, toxins, human health links, economic links, and will have representation from all regions. PICES will have representation on the small executive committee to ensure a collaborative functioning with global committees that share similar aims.

The collective findings from the Symposium highlight the challenges that must be overcome to allow for substantive advances in understanding the linkages between HABs and climate change. Establishing these linkages will be far more complex than forecasting climate driven changes in ocean stratification or global primary production. Nevertheless, as global populations increasingly turn to marine resources for food supplies over less environmentally sustainable agriculture-based practices, this understanding will be a critical to advance continued access to safe seafood.

Although long considered a unique threat to human health, HABs now are recognized to be a component of a broader array of disruptive plankton systems that influence and shape coastal and oceanic ecosystems, including fisheries success, marine animal health and human well-being of coastal communities. Greater coordination of HABs and climate science research will underpin not only the protection of public health in the future oceans, but also will provide enhanced forecasting of climate change effects on wild and aquaculture fisheries and the broader sphere of ocean health.

Dr. Mark L. Wells (mlwells@maine.edu) is a Professor of Oceanography in the School of Marine Sciences, University of Maine. His fields and topics of research are marine biogeochemistry, trace metal chemistry, and biological oceanography with emphasis on harmful algal blooms. In PICES he is a member of the Section on Ecology of Harmful Algal Blooms in the North Pacific and has chaired or co-chaired two international meetings on climate change effects on harmful algal blooms.

Dr. Vera Trainer (vera.l.trainer@noaa.gov) is a Supervisory Oceanographer with the Marine Biotoxin Program at the Northwest Fisheries Science Center, Seattle, USA. She is the Co-Chair of the PICES Section on Ecology of Harmful Algal Blooms in the North Pacific and is the President of the International Society for the Study of Harmful Algae (ISSHA). 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 characterizing the spatial extent of new toxins such as azaspiracids.

International Scientific Conference on "*Our common future under climate change*"

by Shin-ichi Ito

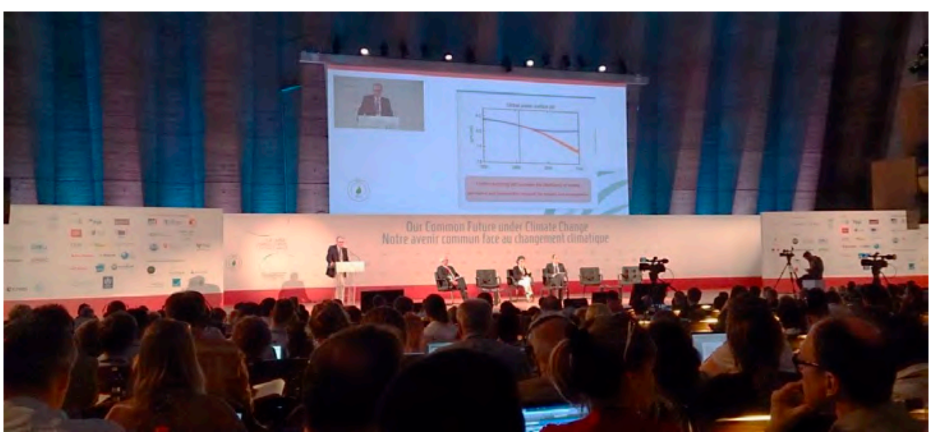
An International Scientific Conference on "*Our common future under climate change*" (CFCC15) took place at UNESCO Headquarters in Paris, France, from July 7–10, 2015. It was organized by the International Council for Science, Future Earth and UNESCO. More than 2,000 climate experts from almost 100 countries gathered to share the latest information on climate change and to develop effective solutions for a sustainable future in advance of the Climate Conference (COP21; November 30–December 12, 2015). The aim of the Conference was to provide the latest scientific knowledge to the negotiators and policy makers attending COP21 to help in their political decision making.

Based on the current information on climate change summarized in the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (AR5), the participants discussed issues related to the contents of the AR5, climate change impact material not included in AR5, the latest information found after AR5, actions taken towards AR6, and the mitigations strengthened after AR5.

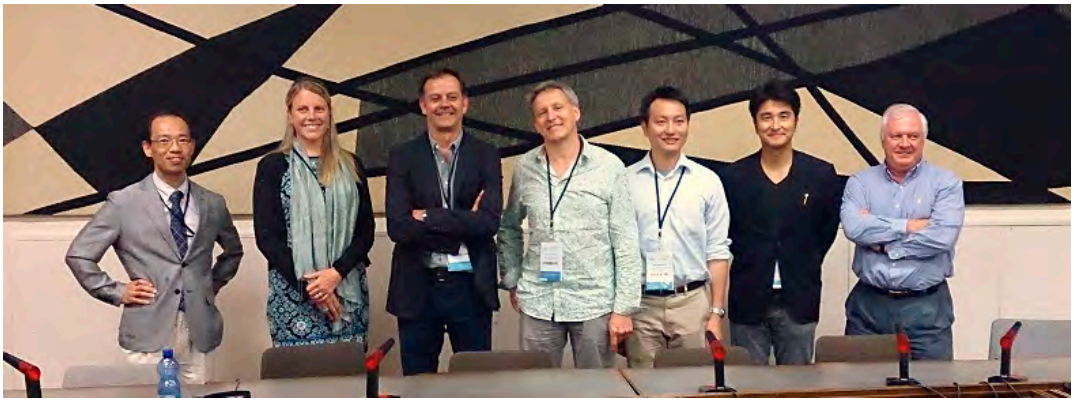
I was impressed with how much attention was paid to communicating with the public during the conference: highlights and topics were uploaded to blogs, and press conferences were held every day. I was also pleased that the ocean received a lot of attention during the conference. For example, during the press conference on the first day, the release stated, "*Many communities are already feeling the impacts of climate change—from Sami herders in the Arctic to oyster farmers on the west coast of the US, to those who find themselves in the paths of increasingly extreme droughts, floods or hurricanes. With this in mind, the scientific conference will assess a wide variety of evidence-based solutions.*" In addition, the oceanographer, Dr. Thomas Stocker (University of Bern, Switzerland) summarized the IPCC AR5 in a keynote presentation, and Professor William Cheung's (University of British Columbia, Canada) future predictions on fisheries were cited in many keynote presentations.

The 4-day conference was composed of four plenary sessions, 20 large parallel sessions and 145 small parallel sessions, including two large and eight small parallel sessions on the ocean. Unfortunately, seven of the eight small parallel sessions on the ocean were concentrated on the second day, which made it hard for the participants to visit all the sessions.

The past Co-Chairman of the PICES/ICES Section (Initiative) on *Climate Change Effects on Marine Ecosystems* (S-CCME), Dr. Manuel Barange, and the Head of the Ocean Science Section, IOC, Dr. Louis Valdés, co-convened a session on "*Transformative pathways to sustain marine ecosystems and their services under climate change*". During the session, Dr. Barange reported on the outcomes from the 3rd International Symposium on the "*Effects of climate change on the world's oceans*" (March 21–27, 2015; Santos, Brazil), Dr. Cheung discussed the possibility of improving the climate-resilience in fisheries through rebuilding fish stocks in an uncertain future, and I talked about the challenges and advances in climate projection methodology and its use in projecting future oceans by reviewing PICES Working Group (WG 20) on *Evaluations of Climate Change Projections*, Working Group (WG 29) on *Regional Climate Modeling* and S-CCME outcomes with co-authors Drs. Enrique Curchitser, Chan Joo Jang, and Muyin Wang. Since most of the ocean-related small sessions were held in parallel, the number of participants at each session was limited. However, the transformative pathways session with two contributing oral and 10 poster presentations covered wide range of topics.



Plenary session on the first day of the International Scientific Conference on "Our common future under climate change", July 7–10, 2015, Paris, France.



Co-convenors and oral speakers of the parallel session on "Transformative pathways to sustain marine ecosystems and their services under climate change". (From left) Drs. Shin-ichi Ito (PICES, S-CCME), Kirstin Holsman (NOAA, USA), Manuel Barange (ICES, S-CCME), Patrick Lehodey (Collecte Localisation Satellites, France), William Cheung (University of British Columbia, Canada), Yoshitaka Ota (University of British Columbia, Canada), and Louis Valdés (IOC).

The key findings of the session included:

1) Robust scientific evidence of climate change impacts on marine ecosystems: distribution changes, production changes, phenological changes, and ocean acidification, with consequences for social and economically dependent communities;
2) Identification of key parameters to consider when modelling climate change impacts on marine ecosystems: model resolution, selection, uncertainty, use of multi-models approach and inter-comparison;
3) Climate model improvements: the models are now able to better represent past changes and identify biases in temperature in order to correct them, but they still have significant uncertainties and biases in the ocean domain, particularly in upwelling and western boundary current regions;
4) The impacts of climate change on marine ecosystems affect human security, with social and political consequences (*e.g.*, cultural impacts on indigenous people and potential changes in fisheries management).

The session also summarized research goals:

a) Research should focus on detailing the general trends highlighted by recent research: heterogeneity of distribution changes and habitat impacts on adaptive capacity, impacts of climate change on upwelling ecosystems, and ocean acidification;
b) The need for a global zooplankton observing system as a key compartment in ecosystem functioning that is predicted to be greatly affected by climate change;
c) The need to better understand and model the possible changes in sea ice cover that can greatly affect marine ecosystems in high latitudes;
d) The need to systematically quantify the full range of uncertainties, including the potential for biological acclimation and adaptation to climate change and interactions between fishing and climate change on marine ecosystems and fisheries;
e) The need to better understand the impacts of climate change on society since it will have notably social, cultural, and political consequences.

The participants summarized the session with the following four take-home messages for:

- *Policy-makers/COP21 negotiators and practitioners* – it is important to continue the effort in rebuilding fisheries. There is a need to focus on the tropics where severe impacts are predicted. A 2° increase in temperature already corresponds to important impacts on marine ecosystems that have to be accounted for.
- *The private sector* – it is important to account for climate change, especially changes in distribution that can greatly impact future fisheries and associated management.
- *NGOs/citizens* – climate change impacts cascade through society, but with possible feedback effects. It is important to track research progress and increase public awareness of future potential impacts since society can amplify/reduce them.
- *Scientists* – it is important to focus research on detailing trends highlighted by recent research, and to communicate research to society. Uncertainty should not be considered a brake on communicating results.

Finally, I would like to share what the atmosphere of the conference was like with the readers. At the opening session, Ms. Irina Bokova, Director General of UNESCO, stated, "*Our future depends on the linkages we build between science and policy. Climate change is much more than a scientific and technical challenge. It is a human, social, ethical challenge that is nourished by scientific thinking.*" Ms. Najat Vallaud-Belkacem, French Minister of National Education, Higher Education and Research, encouraged participants with the words, "*You are bringing today, from all over the world, the solutions we need to prepare for the future.*" Ms. Ségolène Royal, French Minister for the Environment, Energy and Sustainable Development, echoed "*We have won the battle of ideas, now we must win the battle for action.*" During the conference, participants discussed the meaning of the 2°C warming in the global surface temperature that is one of the

(Continued on page 28)

PICES/ICES Workshop on "*Modelling effects of climate change on fish and fisheries*"

by Anne B. Hollowed, Kirstin Holsman and Trond Kristiansen

Seattle, USA, was the scene for a second inter-sessional workshop of the PICES/ICES Section (Strategic Initiative) on *Climate Change Effects on Marine Ecosystems* (S-CCME). The Workshop on "*Modelling effects of climate change on fish and fisheries*" took place on August 10–12, 2015 and was attended by 63 scientists from 10 countries (Fig. 1). The workshop was convened by Drs. Anne Hollowed (USA), Kirstin Holsman (USA), Shin-ichi Ito (Japan), Michio Kawamiya (Japan), Trond Kristiansen (Norway), Myron Peck (Germany), John Pinnegar (UK), and Cisco Werner (USA) and was funded by PICES, ICES, the Norwegian Research Council, NOAA's Climate Program Office and NOAA Fisheries. The goal of the workshop was to formalize the approach for a multi-national projection modelling effort to develop scenarios for the implications of climate change on fish and fisheries in several of the PICES and ICES regions. Sixteen regions were identified where integrated modelling teams could be formed to project the effects of climate change on fish and fisheries.

The objectives of the workshop were to identify: (1) a suite of representative future fishing and ecosystem scenarios that could be employed for use in evaluating climate change effects on fish and fisheries; (2) a suite of climate models and representative concentration pathways that would be used to project climate change; and (3) suites of single species climate enhanced projection models, multispecies climate enhanced projection models, full food web models (*e.g.*, EcoSIM), and coupled bio-physical ecosystem models that would be used to project the implications of (1) and (2) on commercially important marine fish stocks in the northern hemisphere.

The first day of the meeting was devoted to background talks and discussion sessions to orient participants to the proposed tasking. A total of 10 talks were presented on Day 1 with facilitated discussions on focused topics. Days 2 and 3 were kicked off by six "lightning talks" to set the stage followed by facilitated discussions and breakout groups. The intra-disciplinary breakout groups focused on regional climate modelling, modelling biological responses, and modelling fish-dependent community responses. Breakout session convenors reported in plenary on the key recommendations of the intra-disciplinary sessions.

Key findings

Dr. William Cheung (Canada) noted that the Ocean Systems chapter of the 5th Assessment Report of the Inter-governmental Panel on Climate Change identified seven ocean biomes: spring bloom systems, equatorial upwelling systems, semi-enclosed seas, coastal upwelling systems, eastern boundary current upwelling systems, subtropical gyres, and the deep ocean. These biomes may be useful to the group in the future when comparing results.

Dr. Vidar Lien (Norway) gave a summary on behalf of Dr. Svein Sundby (Norway). He concluded that ocean fluxes in temperature, wind stress, sea ice and stratification are key processes that must be modelled correctly to realistically project the future productivity of ocean systems.

Fig. 1 Participants of the PICES/ICES S-CCME Workshop on "Modelling effects of climate change on fish and fisheries" (August 10 –12, 2015, Seattle).

Dr. Charles Stock (USA) summarized the innovations that are under development for the next generation of global climate models and earth systems models. He noted that the modelling teams are making a concerted effort to address and improve representation of key regional processes (Meehl *et al*., 2014). The performance of next generation models in reconstructing past climate variability has improved. A key issue for the workshop multi-national projection modelling teams will be the difficulty in identifying on what time scales climate change can be distinguished from climate variability.

Dr. Tyler Eddy (Canada) provided an overview of a complementary Fisheries and Marine Ecosystems Model Intercomparison project (FISH-MIP; Maury *et al.*, 2013). FISH-MIP is focused on projecting the implications of climate change on a global scale. FISH-MIP scientists have selected a suite of AR5 models that will be used in this experiment: ISPL-CM5ALR, GFDL-ESM2M, NORESM1, and CESM-BGC. They are simulating ecosystem responses to projected changes in ocean conditions derived from global climate model projections under Representative Concentration Pathways (RCP) 4.5 and 8.5.

Breakout group discussions focused on the following topics:

- BG1: Regional climate modelling (Moderator: Charles Stock, Geophysical Fluid Dynamics Laboratory),
- BG2: Modelling biological responses (Moderator: Kirstin Holsman, Alaska Fisheries Science Center),
- BG3: Modelling fish-dependent community responses (Moderator: Alan Haynie, Alaska Fisheries Science Center).

The regional climate modelling breakout group (BG1) concluded that despite advances in higher-resolution atmosphere and cryosphere modelling systems under development for the 6th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6), downscaling will be necessary in most regions to resolve the mesoscale biophysical features needed to project responses of fish and fisheries. This finding was consistent with the recommendations from Vidar Lien's talk that emphasized the importance of capturing critical ocean fluxes at finer scales in the projected ocean system. The group encouraged regional modelling teams to consider using nutrients projected from earth systems models as additional boundary conditions for regional ocean models. BG1 also explored the strengths and weaknesses of different downscaling methods. They recommended that retrospective comparisons of downscaled ocean conditions and global model projections should evaluate issues of the spatial representation of key ocean features. BG1 also recommended that regional biases between downscaled ocean conditions arising from biases in global physical or earth systems models should be addressed and that the ocean modelling community should first synthesize the information known about the mechanisms underlying projected patterns of basin-scale climate variability to inform the regional downscaling approaches. The group discussed the pros and cons of selecting a common suite of global models for use in conducting the proposed multi-national regional projection effort. BG1 concluded that since the overarching goal of the multi-national regional ecosystem modelling effort was to provide reasonable scenarios for the responses of fish and fisheries to changing climate conditions, and fish and fisheries both respond to mesoscale ocean conditions, that the regional modelling teams should select suites of models that best span the range of projected climate futures for each region. BG1 recognized that this finding could lead to a condition where a common suite of global boundary conditions may not be selected. BG1 identified two recommended time horizons; midcentury (50-year projections) and century (100-year projections). Global climate models that use different emission scenarios do not diverge until midcentury; for analyses at the 20- to 30-year scale the group recommended that a single emission scenario from several models may best span the range of projected outcomes. This would produce sufficient uncertainty to test management strategies on the short- to medium-term timescale. However, for longer projection periods, emission scenarios increasingly influence climate trajectories; thus it is important to use multiple scenarios for >50 year projections.

The breakout group on modelling biological responses (BG 2) reviewed the similarities and differences between the various shelf regions of the Northern Hemisphere (Table 1). After discussing the diversity of approaches applied in each area, the group concluded that common models across regions were not as important as common emission scenarios. Regional differences in suites of bio-physical projection models available were identified. Thus finding a common modelling approach that could be applied across all regions may not be feasible. The group recommended that each regional modelling team strive to use the best available information for their region to derive estimates of climate change impacts on fish and fisheries. With that caveat, comparable outputs from models are essential to make cross-regional comparisons. The group recommended minimally that information on spatial distributions, phenology, biomass, catch and probability distributions of thresholds and biological reference points would greatly advance the understanding of common patterns in climate impacts across regions and facilitate comparisons and coupling of biological models among regions. BG2 identified common end-users of biological models, which reflected the fishery focus of the workshop: fisheries management councils, IPCC working groups, protected species management, and marine protected area development and management. Despite the variety of models used in each region, BG2 was able to group model types by their focal responses into three main categories: (1) species-specific responses (*e.g*., single and multi-species assessment models), (2) ecosystem-wide responses

Table 1 Identified regions in the Northern Hemisphere where preliminary bio-physical models could be applied.

Region	Country(s)	Preliminary Suite of Models
East China Sea	China	EwE, Size Spectral
Korean coastal waters	Korea	SSCEM, IBM, EwE
Japanese coastal waters	Japan	SSCEM, IBM, Fish2Fishers
Sea of Okhotsk and Western Bering	Russia	SSCEM
Western Canadian shelf	Canada	OSMOSE (size-based IBM), Atlantis
Strait of Georgia (Western Canada)	Canada	EwE, OSMOSE
Scotian Shelf (Atlantic Canada)	Canada	EwE
Southeast Bering Sea	USA	SSCEM, MSCEM, EwE, Size Spectral, End-to-End
Chukchi Sea/Beaufort Sea	USA	to be determined in 2016
Gulf of Alaska	USA	SSCEM, MSCEM, EwE
California Current	USA	SSCEM, Atlantis, Fish2Fishers
Central Pacific	USA	EwE, Size Spectral
Gulf of Mexico	USA	SSCEM, Atlantis, IBM
Georges Bank/Gulf of Maine	USA	SSCEM, Atlantis
Barents Sea	Norway	Atlantis, IBM
Norwegian Sea	Norway	MSCESM, Size Spectral, IBM
North Sea	UK, Ireland, France, Norway, Germany	SSCEM, MSCEM, Size Spectral, EwE, IBM, Atlantis
Baltic Sea	Denmark, Germany	MSCEM, IBM, Size Spectral

IBM – Individual based model; EwE – Ecopath with Ecosim; OSMOSE – Object-oriented Simulator of Marine ecOSystem Exploitation; SSCEM – Single species climate enhanced projection models; MSCEM – Multi-species climate enhanced projection models; Fish2Fishers – full life cycle IBM

(*e.g.*, topology and bottom-up *versus* top-down controls, regime shifts), and (3) specific indicators of ecosystem condition (*e.g.*, changes in mean trophic level, primary production, *etc*.). BG2 noted that all models are sensitive to methods of downscaling from global models.

After discussion in plenary, workshop participants recommended:

- Multiple models are needed to delineate climate impacts from the effects of model assumptions (*e.g.*, species interactions, distribution, *etc*.). While common models across regions might aid cross-regional comparisons, they are not necessary. Instead, cross-regional comparisons should focus on synthesis of outcomes across the range of climate change uncertainty rather than coordination of specific model choices.
- Products should include an evaluation of tradeoffs between management actions under a range of emission scenarios. To inform tradeoff analyses, estimates of confidence – and in some cases, probability distributions – around mean responses will be needed.
- It is important to consider and model dynamic management and policy responses (rather than assume static policy responses), as policy can influence biological response as much as climate in most areas.
- Regional modelling teams might consider using models of different levels of complexity to characterize the contributions of scenario uncertainty, parameter uncertainty and structural uncertainty (see Payne *et al*., 2015).

The breakout group on modelling fish-dependent community responses (BG3) noted that when projecting forward 20 to 100 years, the modelling teams will need to recognize regional differences in estimating the value of fisheries. For example, some regions may place a high value on the efficiency of the fishery to maximize profit while others may place a higher value on jobs or the quality of the environment. These value systems will need to be noted and incorporated into the scenarios used to project future fisheries. The group also noted that if management strategy evaluations are planned, some effort to standardize measures of relative fishery dependence will be needed. Throughout the breakout session participants reflected back to Dr. John Pinnegar's opening presentation on Day 1. This presentation emphasized that biological reference points used for fisheries management are based on knowledge gained from the past. To prepare for an uncertain future, it will be important to develop a flexible management enterprise to facilitate adaptation of fishers to the evolving fishing opportunities. BG3 also noted that future climate is expected to impact fisheries-dependent communities in multiple ways. For example, the following changes could occur:

- Sea level rise – requires adjustments to infrastructure;
- Shifts in fish distributions – requires changes in fishery distribution relative to ports;
- Changes in fish condition – impacts product quality and quantity tradeoffs.

Conclusions

The workshop was a success and will result in a number of papers that will be submitted to the peer reviewed literature. The group identified 18 potential regions where there was sufficient data to model the effects of climate change on fish and fisheries (Table 1) and recommended that a socio-economic workshop be convened in 2016 in conjunction with MSEAS 2016 in Brest, France, to address the range of possible management responses and development of "storylines", and socio-economic and fisheries pathways. The group clarified how the S-CCME project is separate and distinct from a similar modelling activity, FISH-MIP, and recognized that implementing models using RCP 4.5 and 8.5 would aid in synthesis of FISH-MIP and S-CCME results.

The group aims to complete and publish the scenarios by 2019/2020.

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The mussel *Mytilus galloprovincialis* on Japanese tsunami marine debris: A potential model species to characterize a novel transport vector

by Jessica A. Miller, James T. Carlton, John W. Chapman, Jonathan B. Geller and Greg Ruiz

Introduction

An unexpected outcome of the tragic 2011 Great East Japan Earthquake and ensuing tsunami was that many living Japanese coastal species were transported more than 5000 km on debris items that made landfall in the Hawaiian Archipelago and in North America. The unexpected arrival of a large concrete dock from Misawa, Japan, on a beach just north of Newport, Oregon in June 2012 demonstrated that certain tsunami debris items could serve as oceanic transport vectors for Japanese coastal species.

Therefore, grants from Oregon Sea Grant and the National Science Foundation supported our initial efforts to track Japanese Tsunami Marine Debris (JTMD) and characterize the biodiversity arriving along the Pacific coast of the United States and Canada and in Hawaii, and we continued this effort as part of the PICES ADRIFT (Assessing Debris-Related Impact from the Tsunami) project with generous funding from the Ministry of Environment of Japan (Clarke Murray *et al*., 2015). We focused on characterizing the biota associated with JTMD; the objects that we considered as JTMD had clear identification such as a serial or registration number that was linked to an object lost during the Great Tsunami of 2011 or had clear biological evidence of originating primarily from the Tohoku coast of Japan. The majority of JTMD biota arrived as adults whereas other vectors, such as ballast water, known to successfully transport non-native species, typically involve early life stages, such as larvae. Therefore, one of our research priorities was to learn more about the settlement and growth history, size structure, and reproductive status of the more abundant JTMD species to better understand factors that contributed to their successful oceanic transit.

The blue mussel *Mytilus galloprovincialis* (hereafter, *Mytilus*) is a non-native species from the Mediterranean that is established in Japan (and on the Pacific coast of North America) and is common on JTMD, being present on more than 60% of the items that we classified as JTMD. As this species is a predominantly intertidal and shallow subtidal filter-feeder known to grow well in relatively warm and saline waters, it is noteworthy that so many individuals arrived in apparently good condition at relatively large sizes. We used this coastal filter-feeding species as a model to explore size, reproduction, growth, and dispersal patterns of JTMD biota. We determined the reproductive status and size frequency distributions of *Mytilus* arriving on JTMD items (docks, pallets, totes, and skiffs) collected from 2012 to 2014. We further resolved aspects of the growth and dispersal history of *Mytilus* on 11 of those JTMD items by completing chemical and structural analysis on the shells of representative mussels. Coastal waters typically display higher concentrations of certain trace metals, such as barium (Ba), than offshore, open ocean waters. Therefore, the hypothesis was that trace metal composition of the mussel shells could be used to identify shell growth that occurred in Japanese coastal waters (relatively high Ba), open ocean waters (relatively low Ba), and potentially US coastal waters (relatively high Ba) if adequate shell growth occurred.

Size and reproduction of* Mytilus *on JTMD

Based on 20 JTMD items, the size class distributions of initial mussel arrivals were normally distributed, which indicated that these JTMD items were likely colonized with biota prior to the tsunami. However, mussels arriving on later JTMD items displayed truncated or skewed size distributions (Fig. 1). This observation, in conjunction with the occurrence of JTMD items from northern Japan arriving with species found only in more southerly locations and the collection of terrestrial origin debris colonized with *Mytilus* and other Japanese biota, indicated that at least some biota settled on these items after the tsunami. From 2012 to 2013, the mean size of *Mytilus* increased by 10 to 19 mm/year on items arriving in Oregon and Washington but not in Hawaii (Fig. 2), suggesting that at least some portion of the biofouling community on JTMD items traveling in more northerly waters continue to grow 2+ years after the tsunami. However, in 2014 there was no observed increase in size of *Mytilus* collected in Oregon and Washington. Furthermore, mussels with mature or maturing gametes arrived through 2014. For 35 JTMD items collected from 2012 to 2014, reproductive individuals were observed in Hawaii (<17% of all mussels examined) and Oregon and Washington (>60%) (Fig. 3), which indicates that they may have released gametes in coastal waters.

Growth and dispersal history of* Mytilus *on JTMD

For chemical and structural analysis, we prepared thin sections of the *Mytilus* shells and focused on the umbo region (Fig. 4), which includes shell deposited throughout the life of each individual. We quantified the Ba/Ca pattern within the shells for a representative sample of individuals across the size distribution on selected JTMD items using laser ablation inductively-coupled plasma mass spectrometry. We observed the hypothesized pattern of elevated Ba/Ca during presumed residence in coastal waters (Fig. 5). The patterns of shell Ba/Ca were remarkably consistent within individuals of similar sizes on the same JTMD item. Interestingly, for many JTMD items, we detected a peak (usually >2× background) in Ba/Ca, followed by a period of low Ba/Ca, and finally a gradual elevation of Ba/Ca at the outer shell edge. Although peaks in bivalve shell Ba/Ca have been observed in several taxa, the causes of these peaks remains unclear. Potential hypotheses include consumption of large amounts of senescent phytoplankton post-bloom and/or the consumption of barite particles (Gillikin *et al*., 2008; Thebault *et al*., 2009). However, background shell Ba/Ca is well-correlated with water Ba/Ca levels. In this instance, it is possible that the peaks observed in so many JTMD *Mytilus* were directly related to the tsunami. The tsunami was associated with the delivery of a tremendous amount of Ba-rich terrestrial sediments and debris into the coastal zone, the disturbance of large regions of high-Ba pore water, and potentially facilitated an enhanced spring bloom in NW Pacific coastal waters off Japan – all of which could contribute to increased shell Ba in bivalves.

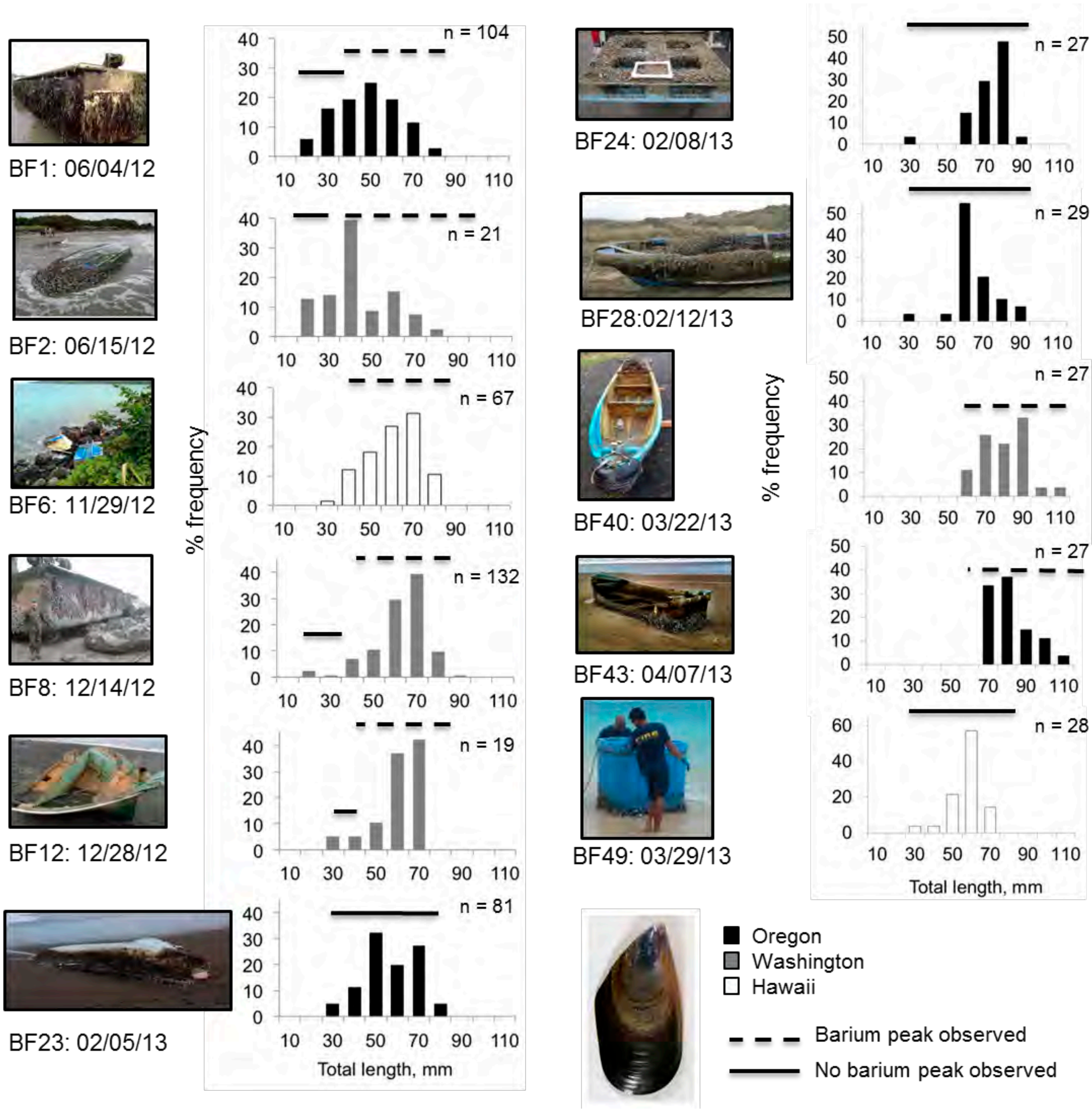

Fig. 1 Size frequency distribution for total shell length (mm) of Mytilus galloprovincialis *on Japanese Tsunami Marine Debris (JTMD) items. Each sampled item was given a unique identification (Biofouling 1 [BF1]). The estimated date of item arrival on local beaches is included along with mussel sample size for each item. The lines above each histogram indicated the size range across which a prominent peak in shell Ba/Ca was observed (dashed line) or not (solid line).*

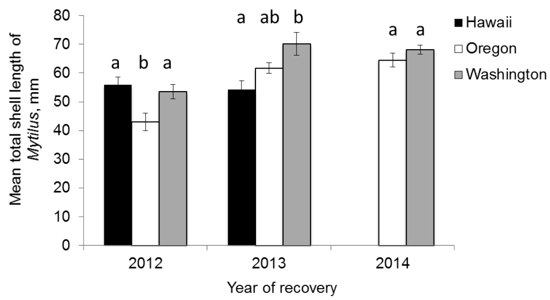

Fig. 2 Mean length (±2 SE) of Mytilus *recovered on JTMD. Letters indicate groups that are statistically similar within years. Across years,* Mytilus *from Hawaii were equivalent in size in 2012 and 2013 whereas Oregon and Washington samples increased in size in 2013, compared with 2012, but then stabilized. Washington samples were larger than those for Oregon and Hawaii in 2012 and 2013 but not in 2014. Total n = 1067.*

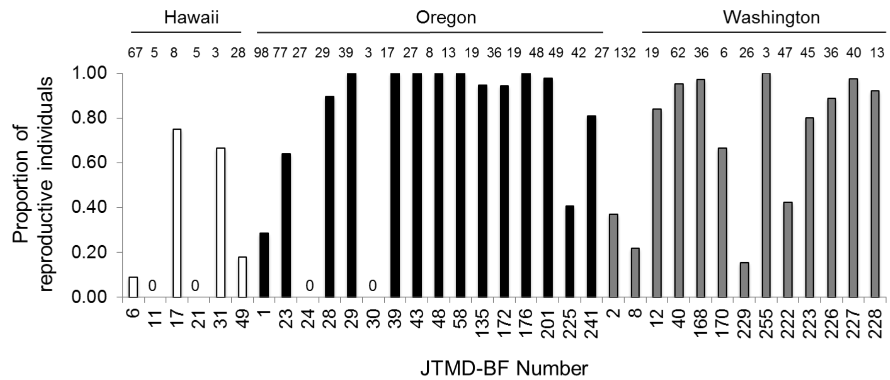

Fig. 3 Proportion of Mytilus *with mature or maturing gametes on various JTMD BF items recovered in Hawaii, Oregon, and Washington. Sample sizes are included at top of graph. JTMD-BF number is along the x-axis and is arranged chronologically within each region with the earliest recoveries (2012) on the left. Mean proportion of reproductive individuals was lowest in Hawaii (0.164, P < 0.01), intermediate in Washington (0.608), and greatest in Oregon (0.693). The difference between Washington and Oregon was marginally significant (P = 0.05).*

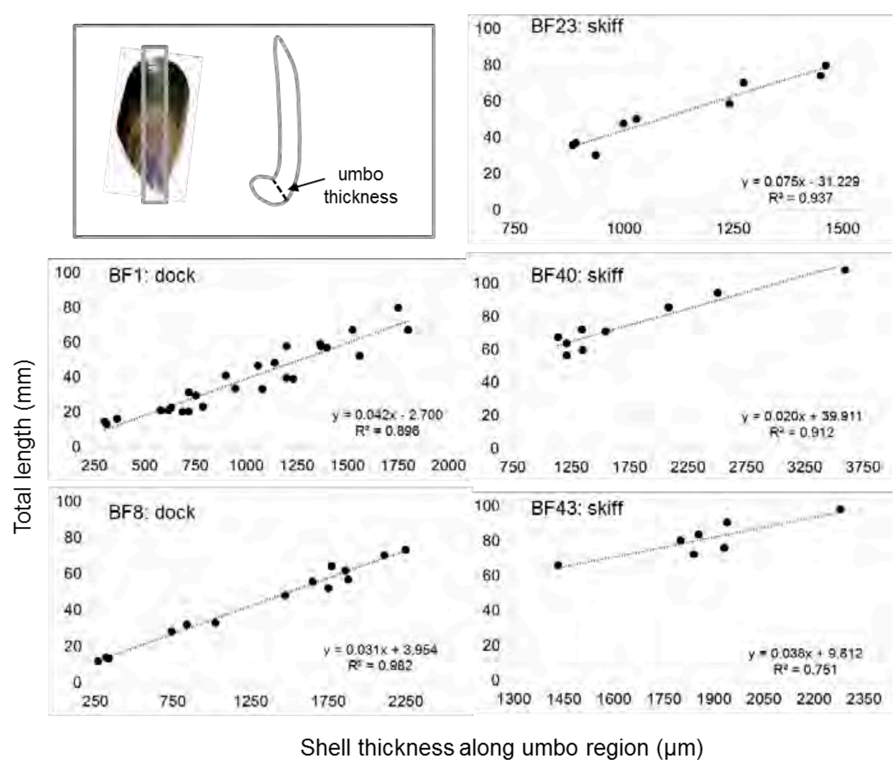

Fig. 4 Back-calculation models for Mytilus *on JTMD BF items collected in 2012 and 2013 showing the relationship between shell length and umbo thickness for five JTMD items. An example of a cross-section that was polished, measured, and ablated (umbo thickness) is shown in the upper left panel. Note that the scale of the shell thickness axis varies among graphs.*

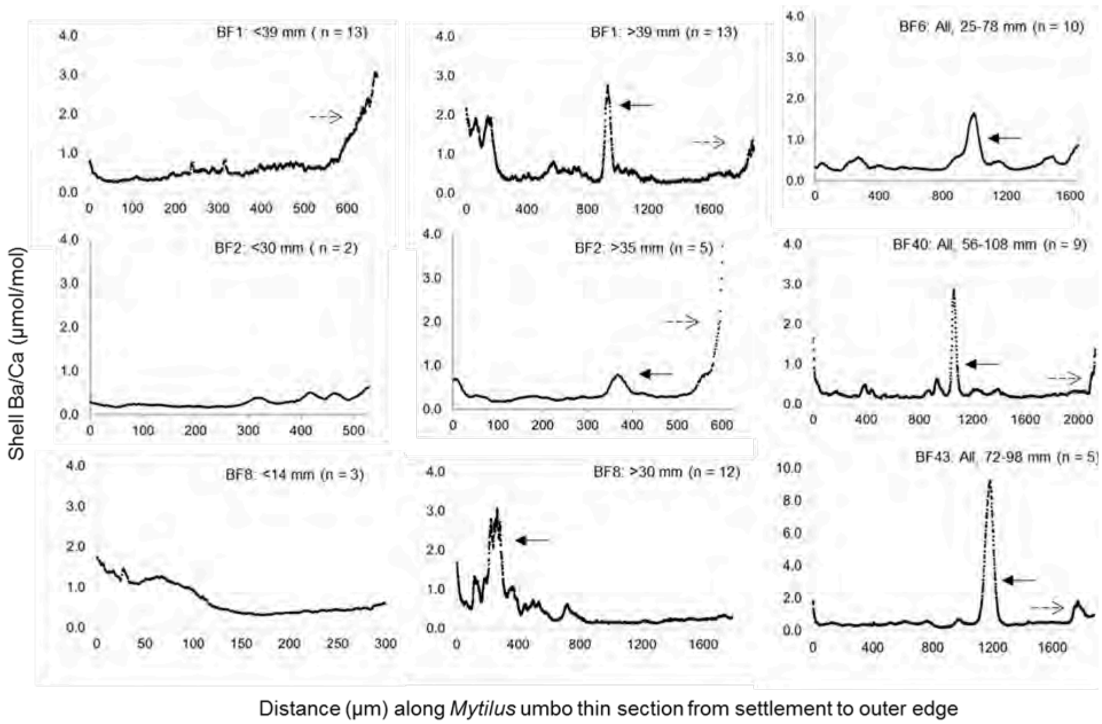

Fig. 5 Representative Ba/Ca profiles across the umbo growth axis for Mytilus *from selected JTMD BF items. Note, for BF1 (Misawa Dock 1), BF2 (skiff), and BF8 (Misawa Dock 2) the smaller shells do not display a peak in shell Ba/Ca prior to the gradual increase at the outer shell edge. The solid arrow indicates the initial Ba/Ca peak that is interpreted as occurring in the NW Pacific, potentially related to the tsunami, and the open arrow is interpreted as arrival in NE Pacific coastal waters.*

Based on the Ba/Ca profiles, we separated shell growth into two categories: 1) "oceanic growth" identified as shell growth during periods of low Ba/Ca after the earlier Ba/Ca peak, if present, and 2) NE Pacific coastal water growth identified as the region with gradual increase in shell Ba/Ca at the outer edge of each shell. We then estimated the total shell length at distinct points in time based on back-calculation models of umbo width and total shell length ($R^2 > 0.75$; Fig. 4). This approach allowed us to generate growth estimates (mm/day) for individual *Mytilus* shells during oceanic transit (low shell Ba/Ca). Additionally, we estimated total shell deposition during residence in coastal waters of the NE Pacific (*i.e.*, shell deposition during the gradually increasing shell Ba/Ca at the outer shell edge). As we have no specific estimates of days of coastal residency, these growth values are presented as total shell deposition.

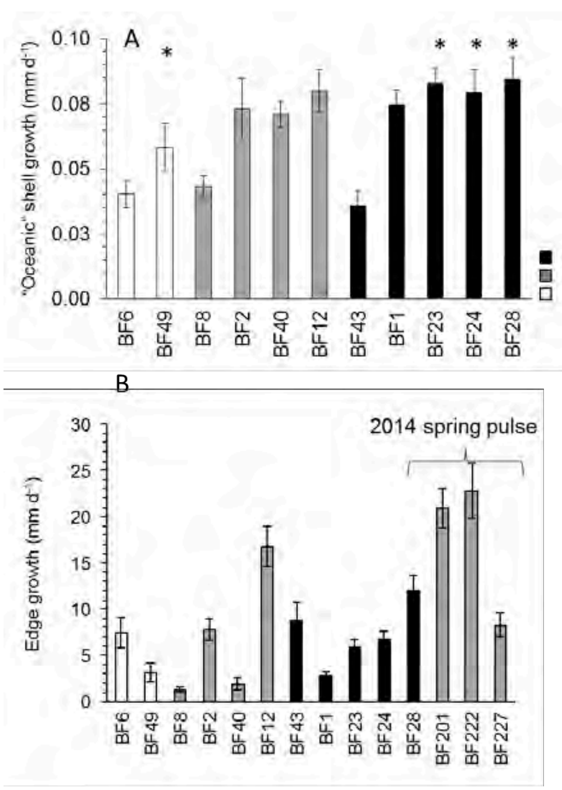

Fig. 6 Right: (A) Mean (±2 SE) "oceanic" shell growth of Mytilus *based on chemical (Ba/Ca) and structural analysis of shells. Growth was estimated based on an empirical relationship between umbo width to total shell length for each debris item. Oceanic growth was defined as all shell deposition prior to gradual elevation of Ba/Ca at the outer shell edge or, for those individuals that displayed a peak in Ba/Ca, the shell deposition after the peak in shell Ba/Ca to the elevation of shell Ba/Ca at the outer edge, indicative of arrival in NE Pacific coastal waters. The total oceanic growth was divided by the days between the tsunami (March 11, 2011) and the date of recovery for each JTMD item. Those BF items with an "*" did not display a marked peak in Ba/Ca prior to the shell edge. (B) The estimated growth for JTMD* Mytilus *on the items identified in (A) and three additional JTMD items collected in spring 2014. Edge growth estimates represent shell deposition during periods with moderately elevated Ba/Ca, presumably indicative of NE Pacific coastal waters.*

The JTMD *Mytilus* grew an average of 0.06 ± 0.017 mm/day (mean ±2 SE) during transit and displayed variable shell growth (1 to 23 mm) during coastal residency in the NE Pacific (Fig. 6). Therefore, although slower than growth rates attained in coastal locations or culture settings (~0.12–

0.16 mm/day) (Peteiro *et al*., 2006; Cubillo *et al*., 2012), the JTMD mussels were growing during their oceanic transit and arrived in many locations capable of reproduction after 15 to 40+ months at sea.

In summary, we used the blue mussel *M. galloprovincialis* to provide information on the settlement and growth history of biota successfully transported across the Pacific on debris generated from the Great Tsunami of 2011. Although there is much we do not yet know about the JTMD biota, detailed examination of certain common species can provide novel insights on JTMD as a transport vector and aid efforts to evaluate the potential risks associated with its arrival in the coastal waters of North America and Hawaii.

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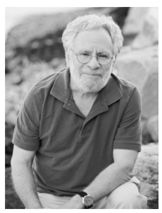


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(Continued from page 19)

negotiation targets of COP21. Many data showed a two in three probability that holding warming to 2°C or less will require limiting future carbon dioxide emissions to about 900 billion tons, roughly 20 times the annual emissions in 2014. The time when that emission limit is exceeded is very soon. Optimistic news came from Mr. Fatih Birol, Executive Director of the International Energy Agency, who stated, "*For the first time, energy-related CO_2 emissions stalled despite the global economy expanding 3% in 2014.*" I felt a sense of guilt while writing this report seated in an airplane, watching the jet engine outside of my window. More details can be found in the conference Outcome Statement.

Acknowledgement: I appreciate PICES support for my travel to the conference.

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Moving towards more sustainable shrimp and tilapia aquaculture in Karawang, Indonesia

by Mark L. Wells, Mitsutaku Makino, and Masahito Hirota and Ian Perry

Marine and brackish water aquaculture provides much of the world's shrimp and fish supplies to markets (FAO, 2014) and represents a growing source of nutrition and economic strength in developing nations. This situation is particularly true for Indonesia which is undertaking an enormous expansion of pond aquaculture development over the next several years. However, large-scale pond aquaculture introduces large quantities of nitrogen and phosphorus into coastal waters. The challenge for Indonesia will be to achieve this expansion without eutrophication of coastal regions, and the resulting devastation to the natural cultural, fisheries and tourism resources.

Brackish water pond aquaculture can be broadly separated into two strategies: high intensity systems having shrimp densities, for example, from 300-400 per m^3, and low intensity pond systems at an order of magnitude lower densities. High intensity systems offer high economic returns but require relatively large initial investment, and hyper-strict controls of growth and feeding conditions to avoid disaster, akin to a high-wire acrobatic act. Once these requirements have been successfully met, there is little incentive to experiment with these lucrative operations to mitigate nutrient waste generation.

Low intensity pond aquaculture, on the other hand, is a "lower tech" approach where conditions can stray more from the knife edge constraints of high intensity aquaculture system operations. This greater leeway in pond conditions makes low intensity growing operations more widespread, where they dominate the aquaculture industry in many developing nations. This is particularly true for most Indonesian growers.

As part of its work to develop an expanded concept of ecosystem approaches which includes people (Social-Ecological Systems approach), the PICES Marine Ecosystem Health and Human Well-being (MarWeB; see Perry and Makino, 2013) project has been testing approaches to multitrophic aquaculture in Indonesia. This project is funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan through the Fisheries Research Agency of Japan (FRA). The PICES project team is collaborating with the Agency for the Assessment and Application of Technology (BPPT), Indonesia, and the National Center for Brackishwater Aquaculture, Karawang, Indonesia. The purpose of the project has been to incorporate the macroalga *Gracilaria* and the clam *Anadara* into shrimp and tilapia pond aquaculture (*i.e.*, co-culture) and to evaluate their effects on dissolved nutrient concentrations in pond waters. Co-culture methods, where species are mixed within the pond, are more challenging than sequential pond systems (*i.e.*, a product pond and a mitigation pond) but are far more practical if the right formula can be developed. A secondary benefit of multitrophic aquaculture is that the pond by-products, in this case harvestable biomass of *Gracilaria* and *Anadara*, can provide additional economic benefits to growers, greater nutrition and job creation to the surrounding communities, which themselves cannot afford the shrimp produced for export markets.

The two experiments performed to date have provided good insights to the operational and scientific challenges of co-culturing shrimp and tilapia with macroalgae and bivalves. Brackishwater ponds in the experimental system range from 1000–4000 m^2 in area but with a depth of 1 m (Fig. 1). These systems are maintained to prevent light from reaching the pond floor (to avoid the massive growth of aquatic grasses), have high trophic transfer efficiencies (*e.g.*, 1 kg of tilapia produced per 1.3 kg of feed added), but still generate high excess nutrient loads (~0.1 mole N/L, or approximately 10,000 times that in coastal waters).

The initial project goals have been to establish methods of co-culture that do not jeopardize the health or production of shrimp and tilapia. Results from the two experiments to date clearly show no detrimental health effects from co-culturing (Fig. 2) and indeed fish production may be slightly greater in the presence of seaweed and bivalves. It seems clear that, at least at the levels used in our experiments, farmers can benefit using the multitrophic strategy by increasing the economic yield in their ponds.

Fig. 1 *A 1000 m^2 brackishwater pond containing tilapia, seen here as the orange discolouration at the pond surface during feeding. The* Gracilaria *was placed in net pens at several places within the pond to prevent tilapia feeding upon it.*

Fig. 2 A passive net sample of shrimp from the co-cultured pond. The shrimp, attracted to the bottom placed net with food, are raised by hand to measure their size and appearance as an indication of their health.

The impact of co-culture on reducing dissolved nutrient levels has been less successful. Analysis of the last experiment completed in November 2015 is still underway, but the co-culture conditions appear not to have significantly decreased dissolved nutrient concentrations. A lower ratio of *Gracilaria* and *Anadara* to product (shrimp or tilapia biomass) was used in these initial experiments to minimize the chance of negative impacts. The next experiment planned for 2016 will test the effects of higher quantities of algae and bivalves.

A positive outcome of the multitrophic strategy was the creation of a phytoplankton assemblage dominated by diatoms, relative to dominance by flagellates in the standard, product-only ponds. Diatom-dominated pond systems are coveted because they impart desirable flavour characteristics that bring higher prices.

A major challenge to scientists working to increase the sustainability of low intensity brackishwater pond aquaculture is that the individuals and community organizations operating these farms are critically dependent on their success. Failed experiments can have drastic real-world impacts on these communities. Working with our colleagues at BPPT and the National Center for Brackishwater Aquaculture in Karawang has provided an important venue to facilitate the development of strategies for more sustainable pond aquaculture, and through their interactions with local farmers help to implement these practices in the future.

Acknowledgements: The authors express their deep appreciation to Dr. Suhendar Sachoemar (BPPT) and Mr. Warih Hardanu and his staff at NCBA who have dedicated so much effort to this project.

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Dr. Mark L. Wells (mlwells@maine.edu) is a Professor of Oceanography in the School of Marine Sciences, University of Maine. His fields and topics of research are marine biogeochemistry, trace metal chemistry, and biological oceanography with emphasis on harmful algal blooms. In PICES he is a member of the Section on Ecology of Harmful Algal Blooms in the North Pacific and MarWeB Project Science Team, and has chaired or co-chaired two international meetings on climate change effects on harmful algal blooms.

Dr. Mitsutaku Makino (mmakino@affrc.go.jp) is Head of the Fisheries Management Research Group, National Research Institute of Fisheries Science, Fisheries Research Agency of Japan. He specializes in fisheries and ecosystem-based management analysis. He teaches in several universities in Japan, and currently serves as an Editor of ICES Journal of Marine Science. His book entitled "Fisheries Management in Japan" was published by Springer in 2011. Within PICES he co-chairs the MarWeB project and Section on Human Dimensions of Marine Systems.

Dr. Masahito Hirota (mmhirota@affrc.go.jp) is a Senior Researcher at the National Research Institute of Fisheries, Fisheries Research Agency, Japan. Masahito's field of research is studying the commodity chain mechanism from a social science aspect, mainly in South East Asian countries, with the aim to communicate with scientists in different fields and exchange knowledge to raise awareness about human well-being. Within PICES, he is a member of the Fishery Science Committee and Section on Human Dimension of Marine Systems. Masahito also serves on the MarWeB Project Science Team, leading activities on seafood business and supply chain management.

Dr. Ian Perry (Ian.Perry@dfo-mpo.gc.ca) is a Research Scientist with Canada's Department of Fisheries, Oceans, and the Canadian Coast Guard, at the Pacific Biological Station in Nanaimo and the Institute of Ocean Sciences in Sidney, BC. His research expertise includes the effects of the environment on finfish and invertebrates; the structure and function of marine ecosystems; ecosystem-based approaches to the management of marine resources; the human dimensions of marine ecosystem changes; and scientific leadership of international and inter-governmental programs on marine ecosystems and global change. Within PICES Ian co-chairs the MarWeB project and Working Group (WG 28) on Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors, and is a member of the Section on Human Dimensions of Marine Systems.

New leadership in PICES

Science Board

In 2006, to facilitate the continuity of Science Board affairs, Governing Council established a Science Board Chairman-elect position to allow for the election of the Science Board Chairman one year before the official change of the chairmanship. At PICES-2015, Dr. Hiroaki Saito (Japan, Vice-Chairman of Science Board) was unanimously elected as Science Board Chairman-elect. Hiroaki's biography can be found in PICES Press, 2014, Vol. 22, No. 1.

Biological Oceanography Committee

At PICES-2015, Dr. Se-Jong Ju (Korea) was elected Vice-Chairman of the Biological Oceanography Committee (BIO). PICES thanks Dr. Atsushi Tsuda (Japan) for his dedicated service as Vice-Chairman of BIO since October 2013. Dr. Tsuda will continue to contribute to activities of the Organization as a member of BIO.

Dr. Se-Jong Ju is a Research Scientist at the Korea Institute of Ocean Science and Technology (KIOST) and an affiliated Professor at the Korea University of Science and Technology. He received his B.Sc. and M.Sc. in Oceanography from Inha University, Korea, and his Ph.D. in the Marine-Estuarine-Environmental-Science Program from the University of Maryland at College Park, USA.

Se-Jong was born and raised in Busan, which is the largest port city in Korea. His father, who worked as a ship engineer, often took him to the ship, where he felt that the sea was the most mysterious and adventurous place in the universe. However, he never imagined to be an oceanographer at that time. His future changed when he met a brilliant and hardworking new faculty member, Prof. Yong-Chul Park who is a chemical oceanographer, in his sophomore year in the college. From that point, his passion to study oceanography became stronger. In 1988, he completed his Master degree at the Department of Oceanography at Inha University, working on nutrient chemistry in the East Sea (Japan Sea) followed by military service in the Korean Army for 3 years.

Se-Jong started his Ph.D. studies at the University of Maryland, USA. In the second year of his Ph.D. program, he moved to the Chesapeake Biological Laboratory to do research on estimating the age of blue crab using biochemical approaches under Prof. H. Rodger Harvey. After completing his degree in 2000, Se-Jong had the opportunity to work on krill biology, especially their feeding, aging, *etc*., through US GLOBEC programs for 5 years. During that time, he participated in his first PICES Annual Meeting in Seoul, Korea, in 2003. After he returned to his home country as a research scientist in 2006, he served as a member of the Working Group on *Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim* (WG 23). Se-Jong has been a member of BIO for the past 5 years. He is also a member of the Study Group on *North Pacific Ecosystem Status Report*.

Beyond science, Se-Jong loves playing baseball and currently is a chairman of KIOST's baseball team. He also likes to participate in most of the sports events at PICES Annual Meetings.

Section on *Ecology of Harmful Algal Blooms in the North Pacific*

At PICES-2015, Dr. Douding Lu (China) was elected as Co-Chairman of the Section on Ecology of Harmful Algal Blooms in the North Pacific (S-HAB). Dr. Lu replaces Dr. Shigeru Itakura who stepped down. PICES is grateful to Dr. Itakura for his dedicated service as Co-Chairman of S-HAB since July 2013. Dr. Itakura takes up duties as a member of Governing Council, representing Japan, and will continue serving as a member of S-HAB.

Dr. Douding Lu is a Senior Scientist in the Laboratory of Marine Ecosystem and Biogeochemistry at the Second Institute of Oceanography (SIO) of the State Oceanic Administration (SOA) located in Hangzhou, China. He is an executive member of the Chinese Society of Phycology, and a Science Steering Committee member of EASTHAB.

Douding graduated from China Ocean University in 1979. He worked as visiting scientist at Florida Institute of Technology with Prof. Dean R. Norris in 1985 and at Trondheim Biological Station, Norwegian University of Science and Technology under Prof. Egil Sakshaug in 1995–1996. Douding's research interests mainly focus on taxonomy and bloom dynamics of marine harmful algae, particularly toxic dinoflagellates. He has authored over 100 scientific papers including 23 SCI publications.

Douding has been involved in a number of national projects such as Chinese Ecology and Oceanography on harmful Algal Blooms (CEOHAB), national basic research program, high tech projects, national science foundation of China as well as regional cooperative initiatives such as EASTHAB and GEOHAB Asia. He was a Chinese partner in the bilateral cooperative project with Dr. Jeanette Goebel at the State Agency of Nature and Environment, Schleswig-Holstein, and with Dr. Ulrich Horstmann at the Institute of Marine Science in Kiel, Germany.

He has participated in a number of international scientific symposiums as an invited speaker including the 2007 PICES Annual Meeting in Victoria, Canada (Topic Session S6: *Blooms of dinoflagellates in the East China Sea – possible linkages to physical processes*). Together with Dr. Vera Trainer (USA), he served as a convenor for Workshop W1 on "*Contrasting conditions for success of fish-killing flagellate species in the western and eastern Pacific – A comparative ecosystem approach*" during the 2015 PICES Annual Meeting held in Qingdao, China.

In his spare time, Douding enjoys keeping physically active through walking, hiking and nature watching.

Call for Wooster Award and POMA nominations

We are now soliciting nominations for the **2016** Wooster Award and the **2016** POMA. The closing date for nominations for both awards is **March 31, 2016**. Both awards will be presented during the Opening Session of PICES-2016 (PICES' 25th Anniversary) in San Diego, USA.

Send your nominations to robin.brown@pices.int at the PICES Secretariat and include the following information: nominee's name, title, institutional affiliation and address, CV, and statement of justification for the nomination.

Alexander S. Bychkov – Connecting regional organizations on a global scale

by Adi Kellermann

When I met Alex for the first time, his voice came out of a telephone. I was in the first month of my employment with the ICES Secretariat. Our General Secretary, when preparing for the call, said, "You'll see. We'll be able to settle the matter with him swiftly on the phone." And so it went. The issue was to postpone an already agreed-upon science symposium with preparations at an early stage but nonetheless, in full speed by one year. Meaning it was not trivial but Alex had a brilliant idea how to tackle it. We managed to proceed exactly the way he had foreseen. This was just the beginning of a splendid cooperation between PICES and ICES.

It turned out that managing common issues and settling problems on the phone was Alex's favourite way of dealing with me and ICES. And it also turned out to be the most efficient way. I remember numerous occasions when he caught me on the phone during a presentation up on stage, in the middle of a meeting at whatever time of day, at the security in airports, at home late at night in the kitchen at the stove or walking the dog, and – yes, of course, in the bathroom as well. It was always an enjoyable chat and we were always eager to achieve a common view and agree on solutions even if it took substantial time on occasion, and usually we did have several items on the agenda.

It is Alex's gentle and diplomatic character and temperament that makes getting along with him so easy and comfortable. What is more, Alex has outstanding organizational skills and is remarkably adept in how to organize and prepare a scientific conference. During the many joint ventures of our two Organizations in the past, and still today, he was always one step ahead of everybody else and able to identify problems before they even surfaced. This was most often the topic of our remote and face-to-face debates: discuss ways and means on how to prevent things from going up the spout or de-escalate controversies before they end up in one-way streets. In this and certainly as well in other ways, Alex has been instrumental to the successful cooperation between PICES and ICES over at least the past 11 years that I had the pleasure to team up with him. I should not close without mentioning Skip McKinnell here, Alex's Deputy and my partner in the PICES Secretariat when it came to the very practical matters of science cooperation. Working with both these gentlemen belongs to the most inspiring moments in my work in ICES.

Dr. Adolf (Adi) Kellermann (adi@ices.dk) is Head of Science Programme of ICES and works in the Secretariat in Copenhagen, Denmark.

Japanese translation of "*Guide to Best Practices for Ocean CO_2 Measurements*" toward the support of sustainable high-quality observations

by Masao Ishii

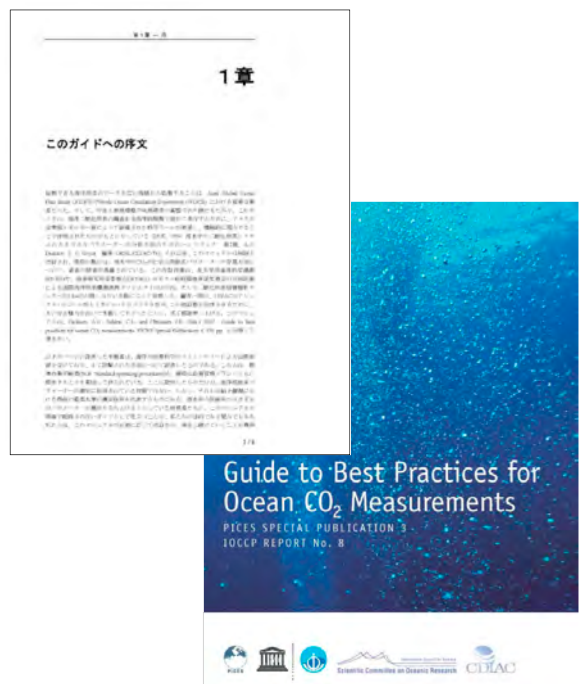
High-quality measurements of CO_2 system variables such as total dissolved inorganic carbon, total alkalinity, partial pressure (or fugacity) of CO_2, and pH in seawater are essential for biogeochemical studies of the ocean. Together with other variables such as dissolved oxygen, macro- and trace nutrients, and transient tracers, as well as various physical properties, these data are used to study the carbon cycle in the ocean and the global carbon budget including exchanges among the various carbon reservoirs on earth. Important applications include evaluating net community production/respiration, quantifying CO_2 flux across the air–sea interface, and assessing anthropogenic CO_2 uptake into the ocean and the resulting ocean acidification. For these purposes, measurements of CO_2 system variables have to have high precision and accuracy and be comparable across both time and space.

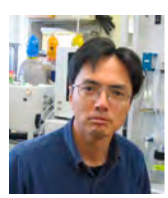
The "Guide to Best Practices for Ocean CO_2 Measurements", published as PICES Special Publication 3 in 2007, has supported these high-quality measurements by documenting recommended standard operating procedures (SOPs) for sampling, analysis, calibration, computation, *etc*. It also provides an outline of solution chemistry of CO_2 in sea water, general principles of analytical quality assurance appropriate to oceanic CO_2 measurement, and physical and thermodynamic data required for computations. The guide was edited by Andrew G. Dickson, Christopher L. Sabine and James R. Christian based on the earlier handbook published by the U.S. Department of Energy in 1994. The role of this "handbook" and "guide" has been important for Japanese researchers who have made measurements of CO_2 system variables and who have contributed to the various international programs such as WOCE, JGOFS and on-going SOLAS, IMBER, and GO-SHIP repeat hydrography. In light of its importance in sustaining measurements of CO_2 and biogeochemistry in the era of global change, this guide will play an important role for many years to come.

In September 2015, the Oceanographic Society of Japan published the "Guideline for the Oceanographic Measurements" on-line. This is a compilation of methodologies for the measurement of many physical, chemical and biological ocean variables. In concert with this activity, the author translated the majority of chapters and SOPs of the "Guide to Best Practices for Ocean CO_2 Measurements" into Japanese. The Japanese translation is available from the website of the Carbon Dioxide Information Analysis Center (CDIAC).

To translate the guide into Japanese and other languages may not be critical to the international global change research effort. However, it is presumed to help students, technicians, and researchers who are engaged in measuring ocean CO_2 to better understand the methods of analysis and quality assurance. The translator hopes that the Japanese version of this guide will encourage sustainable high-quality measurements of the changes in ocean CO_2 and biogeochemistry and thereby develop ocean biogeochemical studies as well as mitigate ocean acidification and climate change.

The full guide is also available at CDIAC in Korean, and a few chapters in Spanish. A Chinese translation exists but has not been posted at CDIAC. Readers who wish to obtain a copy of the Korean or Chinese versions are encouraged to get in touch with the Korean and Chinese contacts listed at CDIAC. A group in Iran has requested permission to translate the guide into Persian.





Dr. Masao Ishii (mishii@mri-jma.go.jp) is a Research Scientist in the Department of Oceanography and Geochemistry at the Meteorological Research Institute, Japan Meteorological Agency. His research interests focus on the marine carbon cycle, and he aims to understand the natural and anthropogenic changes in ocean CO_2 by observations. Masao is a member of the PICES Section on Carbon and Climate. He serves also as a committee member for the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) and is a scientific steering group member for the International Ocean Carbon Coordination Project (IOCCP) and scientific steering committee member of Integrated Marine Biogeochemistry and Ecosystem Research (IMBER).

Global ocean carbon dioxide (CO_2) uptake: Distribution and temporal variation

by Toshiya Nakano and Yosuke Iida

The ocean is a major sink for anthropogenic carbon dioxide (CO_2) emitted as a result of human activities, and it is important to estimate with low uncertainty the amount of oceanic CO_2 uptake for better understanding of the global carbon cycle. The Japan Meteorological Agency (JMA) developed an empirical method for estimating global monthly CO_2 partial pressure in surface seawater (pCO_2) and sea–air CO_2 flux fields based on the relationships between surface pCO_2 and other oceanographic parameters such as sea surface temperature, salinity and chlorophyll-*a* (Iida *et al*., 2015). JMA publishes data on the global states of surface pCO_2 and sea–air CO_2 flux, and on trends in the CO_2 uptake of the global ocean.

Figure 1 shows estimated distributions of annual pCO_2 and sea-air CO_2 flux for 2013. It was found that the ocean releases CO_2 into the atmosphere in equatorial regions and the northern Indian Ocean, where seawater with high CO_2 concentration wells up, and absorbs CO_2 in other regions. Low temperatures in winter and biological CO_2 consumption in spring/autumn result in low pCO_2 and high CO_2 uptake, especially in the mid-to-high latitudes.

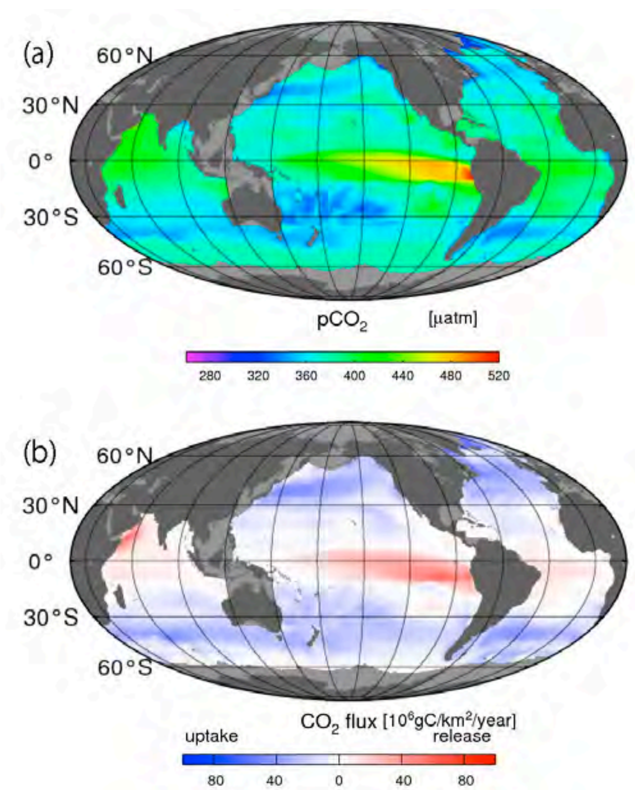


Fig. 1 Distributions of global ocean (a) pCO_2 and (b) sea–air CO_2 flux for 2013. The blue/red areas in (b) indicate ocean uptake/release of CO_2 from/into the atmosphere. Grey parts are outside the region analyzed.

Figure 2 shows monthly and annual variations in global ocean CO_2 uptake. The mean annual contemporary CO_2 uptake is estimated at 1.9 GtC/yr. Global ocean CO_2 uptake is affected by the variability of global SST distribution and biological activity, decreasing in boreal summer and increasing in boreal winter. The estimated annual global ocean CO_2 uptake has increased since the mid-1990s.

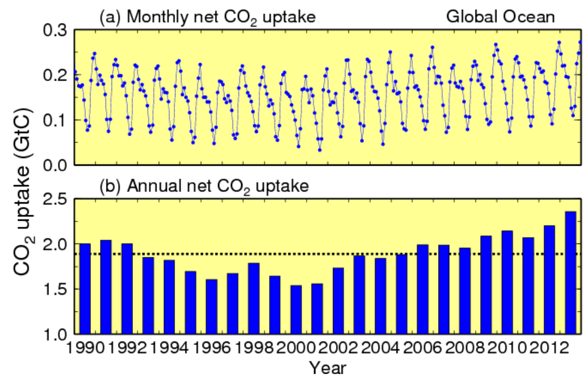


Fig. 2 Time-series representation of (a) monthly and (b) annual oceanic CO_2 uptake from 1990 to 2013. The dotted line in (b) shows the 1.9 GtC average for the period from 1990 to 2013.

For more details, see:
http://www.data.jma.go.jp/gmd/kaiyou/english/oceanic_carbon_cycle_index.html
and
http://www.data.jma.go.jp/gmd/kaiyou/english/co2_flux/co2_flux_en.html.

Reference

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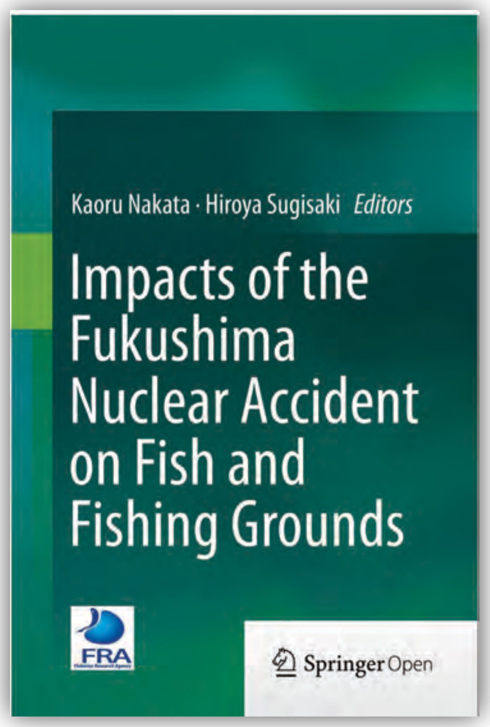
Dr. Toshiya Nakano (nakano_t@met.kishou.go.jp; left) and Mr. Yosuke Iida (iida-ysk@met.kishou.go.jp; right) work at the Marine Environment Monitoring and Analysis Center, Marine Division at the Japan Meteorological Agency. Their group is tasked with issuing assessments of long-term variations of the marine environment including state-of-the-ocean climate such as ocean heat content, ocean structure and water properties, and carbon cycle such as carbon uptake, carbon inventory and ocean acidification.

For the e-bookshelf: *"Impacts of the Fukushima Nuclear Accident on Fish and Fishing Grounds"*

by Kaoru Nakata and Hiroya Sugisaki



Clockwise from top: R/V Soyo-maru used for radionuclide sampling the waters around Japan after the FNPP accident. Sediment sampler, fish samples ready for analysis, germanium semiconductor detector at the FRA laboratory at the National Research Institute of Fisheries Science in Yokohama used for sampling seawater, ocean sediments and marine organisms.

As a result of the gigantic tsunami caused by the Great East Japan Earthquake on March 11, 2011, all power supplies to the nuclear reactors at Tokyo Electric Power's Fukushima Nuclear Power Plant (FNPP) were lost resulting in a core meltdown and hydrogen explosion. As a result of this accident, a large amount of radionuclides was released into the environment, which contaminated both marine and freshwater systems.

Even before this accident, the Fisheries Research Agency (FRA) already possessed well designed facilities and equipment for analyzing radioactivity of marine creatures, water and sediments because it had been monitoring marine radioactivity since the 1950s, mainly research on the effects of atomic bomb experiments, on the fisheries. FRA scientists started monitoring radionuclides in fish and their habitats just after the Fukushima accident occurred. FRA collected samples from all over Japan and analyzed their radioactivity immediately. Based on this large amount of original *in situ* data, the FRA scientist team for radioactivity research on the FNPP accident published the open access book "*Impact of the Fukushima Nuclear Accident on Fish and Fishing Grounds*". This book contains the results of 3 years of intensive monitoring and investigation, and discusses the future prospects for recovery from the contamination.

The book can be downloaded for free or purchased as a hard covered edition from Springer International Publishing.

Contents of the book include:

Part I Seawater and Plankton
Information on the spatiotemporal distribution of radiocesium concentrations from FNPP in seawater and plankters is important for comprehending the accumulation and dynamics of radioactive materials in pelagic ecosystems. The dispersion process of FNPP-derived radioactive cesium is summarized, and temporal variability of radioactive cesium in zooplankton off northeastern Japan is reported. The concentrations off the Pacific coast of northeastern Japan had decreased to the level seen before the accident by late 2013.

■ Chapter 1, K. Nakata and H. Sugisaki
Introduction: Overview of Our Research on Impacts of the Fukushima Dai-ichi Nuclear Power Plant Accident on Fish and Fishing Grounds

■ Chapter 2, H. Kaeriyama
^{134}Cs and ^{137}Cs in the Seawater Around Japan and in the North Pacific

■ Chapter 3, H. Kaeriyama
Temporal Changes in ^{137}Cs Concentration in Zooplankton and Seawater off the Joban–Sanriku Coast, and in Sendai Bay, after the Fukushima Dai-ichi Nuclear Accident

Part II Sediment and Benthos

The spatiotemporal distribution of radiocesium concentrations in marine sediments, and transportation mechanisms from sediment to benthos through the benthic ecosystem is discussed in this section. The results indicate that the intake of radiocesium through the benthic food web is limited for benthic organisms.

■ Chapter 4, D. Ambe *et al*.
Three-Dimensional Distribution of Radiocesium in Sea Sediment Derived from the Fukushima Dai-ichi Nuclear Power Plant

■ Chapter 5, T. Ono *et al*.
Radiocesium Concentrations in the Organic Fraction of Sea Sediments

■ Chapter 6, H. Yagi *et al*.
Bottom Turbidity, Boundary Layer Dynamics, and Associated Transport of Suspended Particulate Materials off the Fukushima Coast

■ Chapter 7, Y. Shigenobu *et al*.
Investigation of Radiocesium Translation from Contaminated Sediment to Benthic Organisms

Part III Marine Fish

Part III deals with the characteristics of temporal variations of radiocesium concentrations and their background mechanisms for small epipelagic fish and demersal fish. The different mechanisms of radiocesium dynamics in various fish species (sardine, anchovy, cod, and flounder) are precisely reported using field research data.

■ Chapter 8, T. Morita *et al*.
Detection of ^{131}I, ^{134}Cs, and ^{137}Cs Released into the Atmosphere from FNPP in Small Epipelagic Fishes, Japanese Sardine and Japanese Anchovy, off the Kanto Area, Japan

■ Chapter 9, K. Takagi *et al*.
Radiocesium Concentration of Small Epipelagic Fishes (Sardine and Japanese Anchovy) off the Kashima-Boso Area

■ Chapter 10, Y. Narimatsu *et al*.
Why Do the Radionuclide Concentrations of Pacific Cod Depend on the Body Size?

■ Chapter 11, Y. Kurita *et al*.
Radiocesium Contamination Histories of Japanese Flounder (*Paralichthys olivaceus*) after the 2011 Fukushima Nuclear Power Plant Accident

Part IV Mechanisms of Severe Contamination in Fish

Decreasing trends of radiocesium have generally been found in fish 1 year after the FNPP accident. Exceptions to this trend were greenlings with extremely high radiocesium concentrations that were caught in August 2012. The causes and mechanisms for the occurrence of the high radiocesium-contaminated fish are studied.

■ Chapter 12, Y. Shigenobu *et al*.
Evaluating the Probability of Catching Fat Greenlings (*Hexagrammos otakii*) Highly Contaminated with Radiocesium off the Coast of Fukushima

■ Chapter 13, T. Watanabe *et al*.
Analysis of the Contamination Process of the Extremely Contaminated Fat Greenling by Fukushima-Derived Radioactive Material

■ Chapter 14, K. Fujimoto *et al*.
Contamination Levels of Radioactive Cesium in Fat Greenling Caught at the Main Port of the Fukushima Dai-ichi Nuclear Power Plant

Part V Freshwater Systems

Contamination of the freshwater system, rivers and lakes of northeastern Japan, by the FNPP accident is primarily by fallout from the FNPP through the atmosphere. The spatiotemporal distribution and dynamics of radiocesium concentrations in the freshwater ecosystem is different than in marine ecosystems. The patterns and temporal dynamics of radiocesium concentration in freshwater ecosystems are reported.

■ Chapter 15, K. Matsuda *et al*.
Comparison of the Radioactive Cesium Contamination Level of Fish and their Habitat among Three Lakes in Fukushima Prefecture, Japan, after the Fukushima Fallout

■ Chapter 16, K. Takagi *et al*.
Radiocesium Concentrations and Body Size of Freshwater Fish in Lake Hayama 1 Year after the Fukushima Dai-Ichi Nuclear Power Plant Accident

■ Chapter 17, J. Tsuboi *et al*.
Spatiotemporal Monitoring of ^{134}Cs and ^{137}Cs in Ayu, *Plecoglossus altivelis*, a Microalgae-Grazing Fish, and in Their Freshwater Habitats in Fukushima

■ Chapter 18, S. Yamamoto *et al*.
Radiocesium Concentrations in the Muscle and Eggs of Salmonids from Lake Chuzenji, Japan, after the Fukushima Fallout

■ Chapter 19, S. Yamamoto *et al*.
Assessment of Radiocesium Accumulation by Hatchery-Reared Salmonids after the Fukushima Nuclear Accident

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PICES interns

We are pleased to announce that Dr. Jinwen Liu joined the Secretariat as PICES intern in August 2015. Many of you already had the opportunity to meet Jinwen at PICES-2015 in Qingdao, China, where he helped with the registration and meeting coordination. Jinwen studied at L'Observatoire Océanologique de Villefranche-sur-mer (LOV), CNRS-UPMC, France, for 2 years under a joint Ph.D. program, and obtained his doctorate in Environmental Science from Xiamen University in Xiamen, China. Jinwen is a researcher at the Third Institute of Oceanography (TIO), State Oceanic Administration of China (SOA). He has been engaged in marine science research for about 9 years, and his research interests focus on marine carbon cycling with detailed study in ocean acidification, eutrophication and hypoxia in the coastal ocean, especially in river estuaries. Jinwen is very active in academic pursuits and has joined several research projects and published several academic papers. He also has participated in more than 10 international conferences and has been involved in organizing and implementing about 20 scientific surveys and several workshops. He enjoys travelling, and spending his spare time enjoying nature.

We express our sincere appreciation to Ms. Anna Skvortsova who completed her term as PICES intern with the Secretariat in June 2015 and who returned to her home institution, TINRO-Centre, in Vladivostok, Russia. Anna provided valuable support in administrative activities at the office and assistance with activities at PICES-2014. We wish her the very best in her career and look forward to seeing her at future PICES events.

WANTED

Photographs for the PICES Memory Book

As part of its 25th Anniversary activities, PICES is creating an electronic photographic book of the more important events in PICES' 25-year history and the people who contributed most to make them happen. Sadly, the early history of the record (before digital cameras) is incomplete.

If you or a colleague have photographs of the following events, and are willing to share them with the Secretariat, we would love to add them to the collection, and potentially to the Memory Book. The list of events/activities where photographs are wanted includes:

1. PICES I (Victoria, Canada, 1992) – there are no known photographs of this annual meeting;
2. PICES II (Seattle, USA, 1993) – colour photographs preferred (but will accept good-quality black and white images);
3. Developing the PICES-GLOBEC Climate Change and Carrying Capacity (CCCC) Scientific Program (meetings in Nemuro, Japan, 1994);
4. Earliest CCCC Task Team meetings/workshops, 1990s;
5. Meetings of the original 6 working groups, 1992–1994;
6. Working Group 7 meeting in Vancouver, Canada, 1994;
7. Developing the Vancouver Harbour Practical Workshop by Working Group 8, 1995–1998 (there are photos of the fieldwork in 1999).

Please send them to mckinnell@shaw.ca and rrutka@pices.int by March 31, 2016.

PICES calendar of events

9th International Conference on Marine Bioinvasions, – *Hulls, harbours and other invasion spots*
January 19–21, 2016, Sydney, Australia (co-sponsored by PICES)

6th PICES/ICES Zooplankton Production Symposium – *New challenges in a changing ocean*
May 9–13, 2016, Bergen, Norway

MSEAS 2016 – *Understanding marine socio-ecological systems: including the human dimension in Integrated Ecosystem Assessments*
May 30–June 3, 2016, Brest France (co-sponsored by PICES)

IMBER's ClimEco5 – *Towards more resilient oceans: Predicting and projecting future changes in the ocean and their impacts on human societies*
August 10–17, 2016, Natal, Brazil (co-sponsored by PICES)

CLIVAR Open Science Conference – *Charting the course for future climate and ocean research*
September 19–23, 2016, Qingdao, China (co-sponsored by PICES)

PICES-2016 – *25 Years of PICES: Celebrating the past, imagining the future*
November 1–13, 2016, San Diego, USA

PICES/ICES Symposium – *Drivers of small pelagic fish resources*
March 6–11, 2017, Victoria, Canada

PICES/ICES Early Career Scientist Conference
May 29–June 2, 2017, Busan, Korea

Daniel Ware Memorial Award

Dr. Daniel M. Ware passed away July 31, 2005 after a long and distinguished career in fisheries science and oceanography. His 30-year career was spent in government at the Bedford Institute of Oceanography on Canada's Atlantic coast and on the Pacific coast at the Pacific Biological Station. Dr. Ware was the first Chairman of the PICES Science Board, serving from October, 1992 to November, 1995. For his lifetime contributions in ocean sciences, Dr. Ware was awarded the prestigious Timothy R. Parsons Medal in 2005 and in the same year, to recognize his scientific expertise and contribution to North Pacific marine science, Dr. Ware received (posthumously) the Wooster Award, named in honour of Professor Warren S. Wooster, a principal founder and first Chairman of PICES, at the PICES Annual Meeting.

A group of friends and colleagues have established the Dr. Daniel M. Ware Memorial Award at Vancouver Island University (VIU) in Nanaimo, British Columbia. This award will support a scholarship to be awarded (based on academic excellence) to a Fisheries Science student entering their final year of undergraduate study. VIU has offered to match donations made to this fund and will provide a receipt for charitable donation.

If you are interested in contributing or need further information, please contact Robin Brown (Robin.Brown@pices.int).

The state of the western North Pacific during the 2015 warm season

by Takashi Yoshida

The development of a strong El Niño was a significant oceanographic event in the 2015 warm season. In September 2015, the NiNO.3 SST was above normal with a deviation of +2.6°C, which is the second-highest value for September since 1950. Sea surface temperatures (SSTs) were remarkably above normal from the area near the dateline to the South American coast over the equatorial Pacific. The El Niño continued to develop in the equatorial Pacific during the season, but no significant relationship was found between this event and conditions in the western North Pacific. In April, positive SST anomalies were observed from south of Japan to east of the Kuril Islands, and negative SST anomalies were observed from east of the Philippines to near 30ºN, 160ºW (Fig. 1). From May to

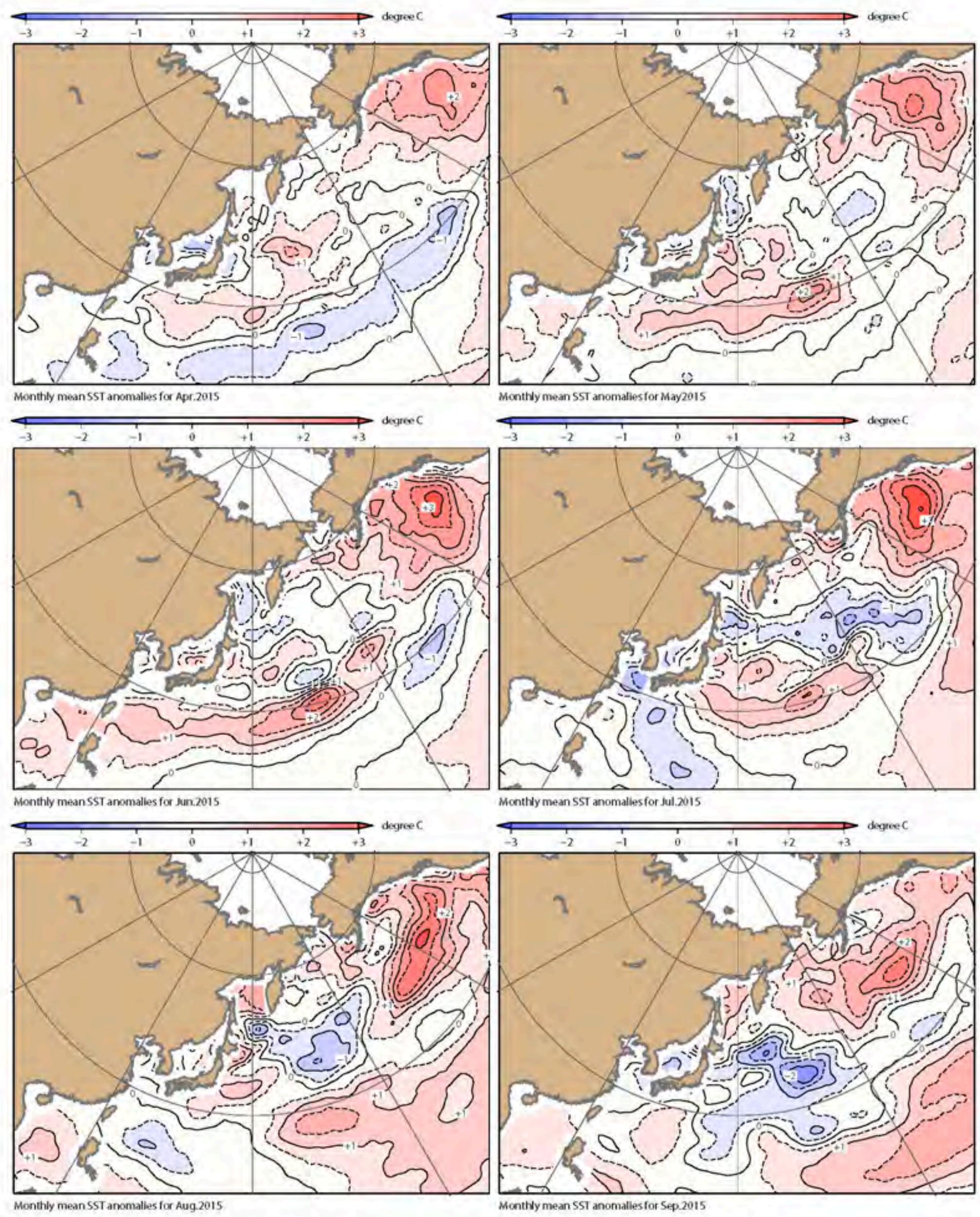

Fig. 1 Monthly mean sea surface temperature (SST) anomalies from April to September 2015. Monthly mean SSTs are based on the Japan Meteorological Agency's (JMA's) COBE-SST (Centennial in situ Observation-Based Estimates of variability of SST and marine meteorological variables). Anomalies are deviations from the 1981–2010 climatology.

July, positive SST anomalies were observed along 30ºN from the area near Japan to the dateline. In August and September, negative SST anomalies developed in the sea east of Japan.

A northward intrusion of warm water into the Oyashio area of cold water south of Hokkaido was another significant event. The intrusion developed in April and persisted into September and brought remarkably positive water temperature anomalies to the seas southeast of Hokkaido (Fig. 2). It is known that Pacific saury – a major pelagic commercial fish species – migrate southward along branches of the Oyashio water to the seas off the northeastern Japanese coast in autumn, and that the formation of saury fishing grounds is affected by local oceanography. About 85,000 tons of saury were landed at Japanese ports in 2015 as of October 31. This is less than 60% of the 2010–2014 5-year average and the lowest of any year in this period. The poor catch is considered to result from recent low-level saury stocks in the western part of the northwestern Pacific as well as local oceanographic factors such as the warm water intrusion.

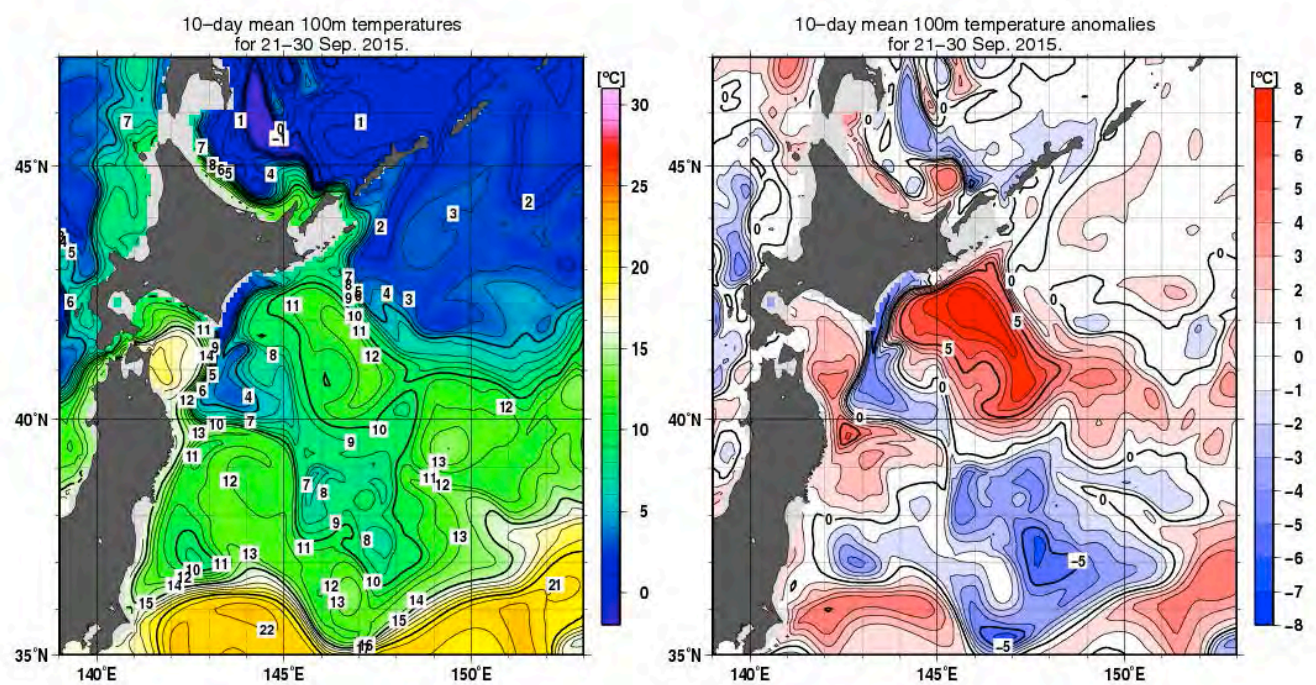

Fig. 2 Water temperature and related anomalies at a depth of 100 m in the sea east of Japan for the last 10 days of September 2015. Anomalies are deviations from the 1982–2010 climatology.

Dr. Takashi Yoshida (tyoshida@met.kishou.go.jp) is the Head of the Office of Marine Prediction at the Japan Meteorological Agency in Tokyo. His group is tasked with issuing various oceanographic products, including wave analysis, coastal sea level monitoring, ocean temperature and current monitoring, sea ice analysis and their forecasts. He was involved in PICES as a member of Working Group 6 on "Subarctic Gyre" and contributed Western Pacific assessments to PICES Press previously in the 1990s.

The Bering Sea: Current status and recent trends

by Lisa Eisner

Climate and oceanography

The period of April through September 2015 featured positive sea surface temperature (SST) anomalies across much of the Bering Sea, with particularly warm water on the southeast portion of the shelf (Fig. 1). The positive temperature anomalies represent a continuation of a warm period that began in 2014 after a relatively cold interval from 2007 into 2013. At the end of the summer of 2015, the depth-averaged temperature at Mooring 2 (near 57°N, 164°W) was at a maximum in a record extending back to 1995 (Fig. 2). The warmth can be attributed in part to the relatively mild winter of 2014–2015, especially on the Bering Sea shelf, where the ice did not extend as far south as usual, with the result being also a smaller cold pool. In other words, the extreme warmth during August to September 2015 on the Bering Sea shelf was not so much due to enhanced summer heating but rather due more to pre-existing positive temperature anomalies, especially at depth.

The atmospheric forcing during the spring and summer of 2015 was fairly typical in a time-averaged sense but there was quite a difference between the first and second half of the period. A trough centered near the dateline and lower than normal sea level pressure (SLP) for the Bering Sea was present during April through June 2015 (Fig. 3, left plot), with a ridge of higher than normal SLP prevailing the following three months of July through September 2015 (Fig. 3, right plot). The latter feature was associated with somewhat weaker than usual winds over the southeast Bering Sea shelf but also enhanced cloudiness, presumably due to the low stratus and sea fog that often accompanies settled weather in the region during the summer months.

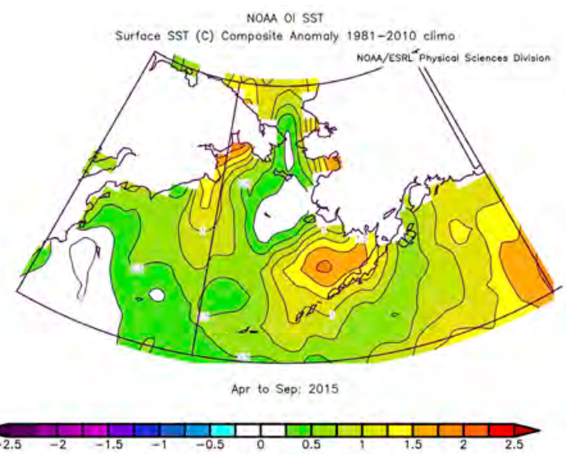

Fig. 1 Mean sea surface temperature (SST; °C) anomalies (deviations from 1981–2010 climatology) for April to September 2015. Figure courtesy of Nick Bond.

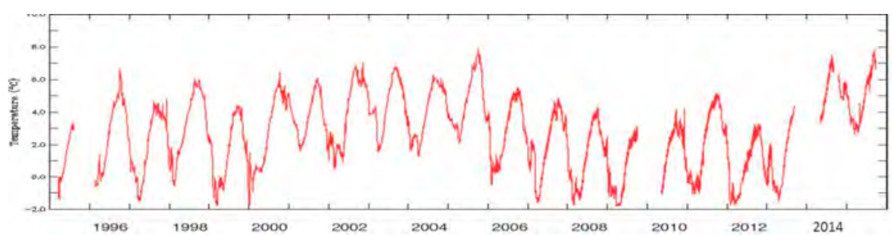

Fig. 2 Pacific Marine Environmental Laboratory (PMEL, NOAA) Bering Sea Mooring 2 mean water column temperature, 1995–2015. Figure courtesy of Phyllis Stabeno.

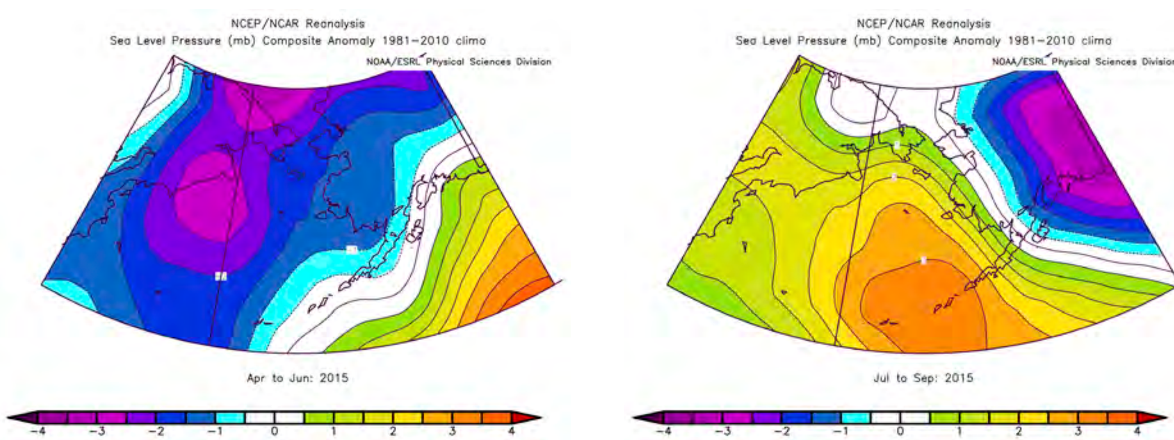

Fig. 3 NOAA mean sea level pressure (mb) anomaly (deviations from 1981–2010 climatology) for April to June (left) and July to September (right), 2015. Figure courtesy of Nick Bond.

A strong El Niño developed in 2015, and is apt to impact the North Pacific atmosphere–ocean system during the upcoming winter into spring. El Niño tends to be accompanied by a deeper than normal and eastward-displaced Aleutian low during winter, typically with a reduction in the frequency and intensity of arctic-air outbreaks for interior Alaska and the Bering Sea shelf. The climate models used for seasonal weather predictions are unanimous in projecting positive temperature anomalies for the Bering Sea shelf through spring of 2016, with lesser anomalies and greater uncertainty for the western Bering Sea.

At sea zooplankton community rapid assessment

In spring 2015, the NOAA Ecosystem and Fisheries-Oceanography Coordinated Investigations group (EcoFOCI) at the Alaska Fisheries Science Center (AFSC) initiated at sea zooplankton community rapid assessments to provide a near real time index of zooplankton adundances. The method, which is a rough count of zooplankton (from paired 20 / 60 cm oblique bongo tows to 10 m off bottom), uses coarse categories and standard zooplankton sorting methods. The categories chosen are ecologically important and are highly influenced by cold and warm years. The categories are small copepods, large copepods, and euphausiids. Small copepods are less than or equal to 2 mm total length and include species such as *Pseudocalanus* spp. Large copepods are those greater than 2 mm total length and include *Calanus marshallae/glacialis* and *Neocalanus* spp. The euphausiid category comprises all life stages. Detailed information on these taxa will be provided after in-lab processing protocols have been followed (one year+ post survey).

The plankton community at six stations along the 70 m isobath on the southern Bering Sea shelf was assessed in May 2015 (Fig. 4). Small copepods made up the majority of the plankton at four out of the six stations. Large copepods were present at all six stations but were in lower numbers than small copepods at most stations. Euphausiid larvae / juveniles were present only at three out of the six stations. The zooplankton community appeared to be different near the ice edge, with increases in lipid-rich taxa (large copepods and larval / juvenile euphausiids) and an absence of small copepods. This change was accompanied by a bloom of diatoms (chains of *Thalassiosira* sp.) as verified by onboard phytoplankton image analysis.

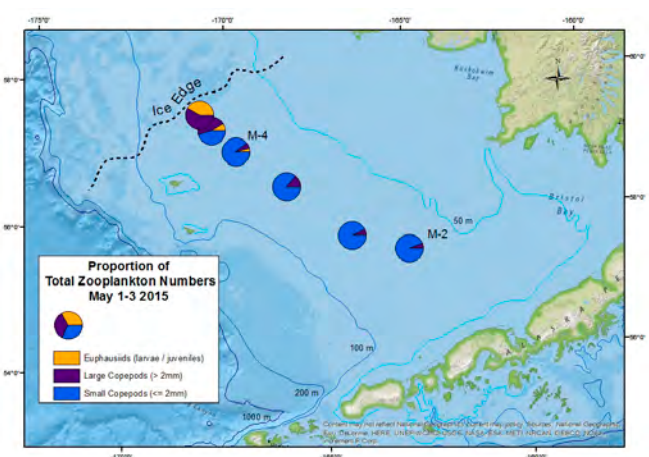

Fig. 4 Proportion of total zooplankton abundance by euphausiids, large copepods, and small copepods at six stations along the 70-m isobath during early May in the eastern Bering Sea. Figure courtesy of Colleen Harpold.

Sea surface temperatures were warmer than average and the ice retreated early. However, the ice was blown back down into the study area prior to the survey (P. Stabeno, pers. comm.). These data show that a secondary phytoplankton bloom and associated large copepods can occur at the ice edge after an initial sea ice retreat, even in a warm year.

Eastern Bering Sea integrated ecosystem surveys

The AFSC Recruitment Process Alliance (a collaboration with EcoFOCI, PMEL, Ecosystem Monitoring and Assessment (EMA) and other AFSC programs) conducted a special fisheries oceanography survey in September 2015 onboard the NOAA Ship *Oscar Dyson* to evaluate the effects of 2 years of climate warming on the southeastern Bering Sea ecosystem. A new midwater trawl was used to obliquely sample the entire water column for fish and jellyfish, in contrast to the larger midwater trawls that were used to sample the surface (top 20 m) in past years. Fewer age-0 pollock were caught on this survey, compared with past years; however, it is not known if this is due to the gear change. Diets of age-0 pollock consisted of large copepods although often stomachs were found empty, even at the end of the day. At sea rapid assessment of zooplankton (described earlier) indicated that communities often consisted of large copepods (mainly *C. marshallae/ glacialis* C5) with abundances similar to those observed in cold years (peak at 59.7°N, low end of the range). These preliminary data suggest that the zooplankton community had not completely switched to a warm year, small copepod dominated community.

A bloom of coccolithophores (small calcareous phytoplankton), was observed over the middle shelf (Fig. 5) although it appeared less extensive than in 2014. The pycnocline depth in the south middle shelf was deeper than average for September (30 m compared to 20 m) and diatoms were observed at many stations, suggesting that fall conditions were underway. Special projects included phytoplankton taxonomic characterization by imaging live samples, a jellyfish diet study and evaluation of starvation effects on *C. marshallae/glacialis* genetics and lipids (see http://www.afsc.noaa.gov/Science_blog/SoutheasternBeringSea3.htm).

A pelagic trawl and oceanographic survey was conducted by EMA, NOAA in the northern Bering Sea from August 28 to September 21, 2015, with vessel support provided

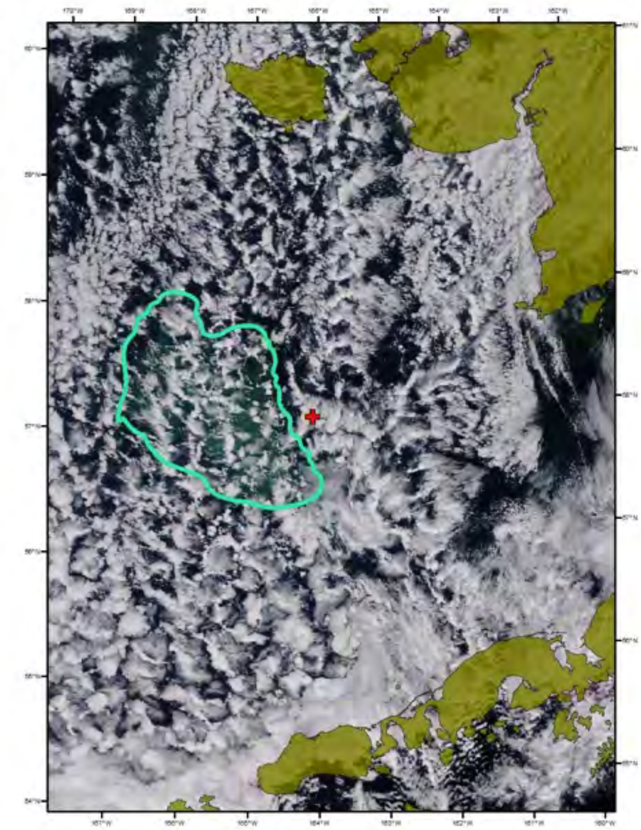

Fig. 5 Approximate location of the coccolithophore bloom during September 2015. Figure courtesy of Alex Andrews.

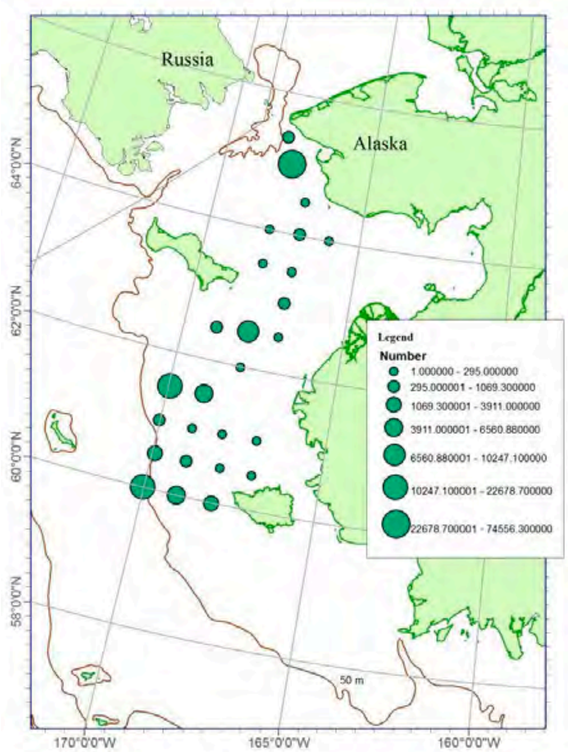

Fig. 6 Catch (abundance) per unit effort (CPUE) for age-0 pollock in the northeastern Bering Sea during late August through September 2015. Figure courtesy of Jim Murphy.

by the ADFG Chinook Salmon Research Initiative. Survey results are used to evaluate: 1) stock-specific juvenile Chinook salmon abundance, 2) marine ecosystem impacts of warming SST and 3) critical periods of Yukon River Chinook salmon. Jellyfish species comprised the largest catch biomass at 2,869 kg (mostly *Chrysaora melanaster*), followed by forage fish species (955 kg), groundfish species (474 kg) (mostly age-0 pollock at 396 kg), salmon species (396 kg), and other fish (23 kg). Age-0 pollock catches were relatively high with a catch biomass similar to the combined catch of all species and life history stages of salmon (396 kg). Significant numbers of age-0 pollock were present in the Bering Strait region (Fig. 6), which is unusual based on historic catches in this region. The preliminary abundance estimate for Canadian-origin Chinook salmon from the Yukon River is approximately two million juveniles. This is the third highest abundance estimate of juvenile Chinook salmon since 2003 and reflects continued improvement of early life history productivity for this stock group.

Adult pollock and cod abundance and biomass

In 2015, abundance of pollock from bottom trawl surveys (AFSC, NOAA) decreased by 7% (11.8 to 11.0 billion) and biomass decreased by 15% (7.43 to 6.39 mmt) from 2014 levels. For Pacific cod, the biomass was unchanged; however, abundance decreased 13% from 1.13 billion to 986 million. The 2015 survey results for both species were well above the long-term survey means.

Impacts of bottom temperature on crab spatial distribution

Bottom temperature has significant impacts on many aspects of crab biology in the eastern Bering Sea. In particular, the extent of the cold pool, a body of cold (<2°C) subsurface water that occurs in the summer and varies with winter conditions (*e.g.*, the extent of sea ice) alters crab migration patterns and spatial distribution. In cold years, the cold pool extends farther south and east into Bristol Bay, and is more retracted in warm years. In Bristol Bay, female red king crabs generally avoid the cold pool, perhaps to prevent delayed embryogenesis. As a result, spring distributions of mature female red king crabs are typically aggregated towards the margins along the Alaska Peninsula in cold years, compared to warm years where mature females are more centrally located in Bristol Bay (Fig. 7). It is hypothesized that this northward shift in adult spatial distribution may reduce larval supply to optimal habitat located along the Alaska Peninsula and in inner Bristol Bay because of the location of larvae relative to oceanographic processes. If this mechanism is true, then recruitment success of Bristol Bay red king crab may be reduced in warm years relative to cold years. See http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-308.pdf for more information.

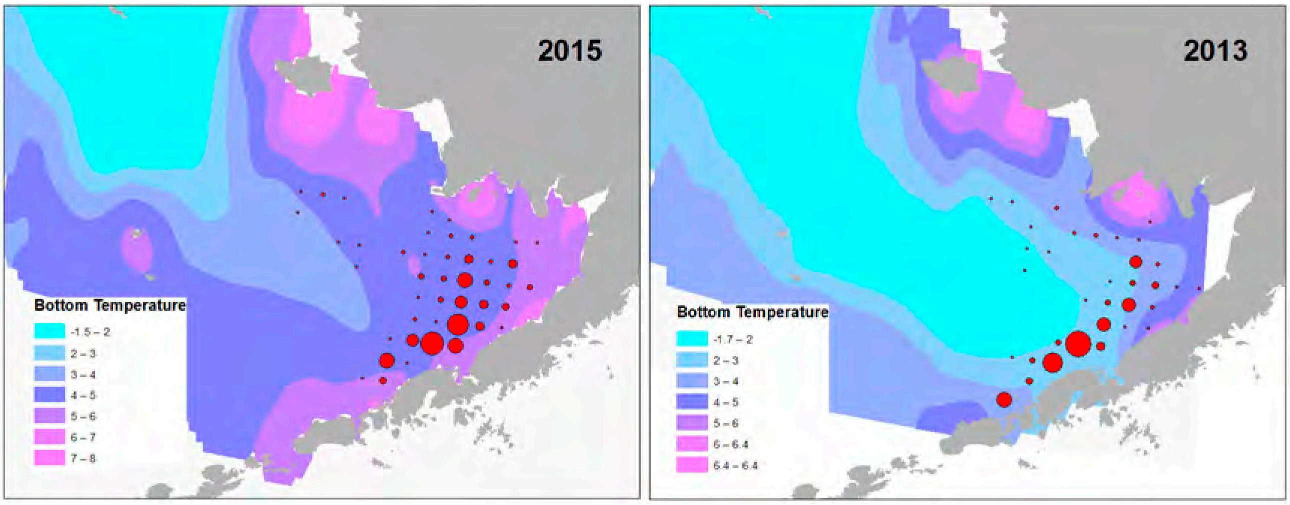

Fig. 7 2013 and 2015 are examples of recent years with contrasting bottom temperature conditions. The cold pool (<2°C) is indicated by light blue. Red dots indicate mature female red king crabs. The size of the dots corresponds to relative abundance. Figure courtesy of Dr. Ben Daly.

Upcoming Bering Sea surveys

- The AFSC, NOAA will conduct its annual bottom trawl survey and an acoustic trawl survey from May through early August 2016;
- The AFSC and PMEL (including EcoFOCI), NOAA will conduct oceanography, ichthyoplankton and pelagic fish surveys on board the NOAA Ship *Oscar Dyson* on the southeastern shelf from early May to mid-June, and late August to early October 2016;
- The AFSC NOAA will conduct fisheries oceanography surveys on the northeastern shelf from late August to late September 2016.

Acknowledgements: Many thanks to the scientists who helped create this report: Dr. Nicholas Bond and Dr. Phyllis Stabeno at NOAA, PMEL; Alex Andrews, Dr. Ben Daly, Colleen Harpold, Dr. Robert Lauth and Jim Murphy at NOAA, AFSC.

Dr. Lisa Eisner (lisa.eisner@noaa.gov) is a Biological/Fisheries Oceanographer at the Alaska Fisheries Science Center of NOAA-Fisheries in Juneau, Alaska, and Seattle, Washington. Her research focuses on oceanographic processes that influence phytoplankton and zooplankton dynamics and fisheries in the eastern Bering and Chukchi seas. She has been the lead oceanographer for the U.S. component of the BASIS program (Bering Aleutian Salmon International Surveys). She is a member of PICES' Technical Committee on Monitoring (MONITOR) and is a co-PI on current (and past) eastern Bering Sea and Chukchi Sea research programs.

The Blob (Part Three): Going, going, gone?

by William Peterson, Nicholas Bond and Marie Robert

The Blob, Part One (pp. 36–38, PICES Press, 2015, Vol. 23 No. 1) documented conditions which resulted in the formation of the warm water Blob in the Gulf of Alaska during autumn 2013. We reported on the spread of the Blob in 2014 across the entire North Pacific to the Oyashio, Sea of Okhotsk, into the Bering Sea, south to the Transition Zone and to waters offshore of the California Current. In February and June 2014, waters of the Gulf of Alaska along Line P had anomalies of +2 to +4°C to depths of 100 m; the western North Pacific warmed an equal amount during the summer of 2014. For the eastern North Pacific and the California Current, offshore Ekman transport associated with coastal upwelling kept the Blob well offshore during summer 2014.

In the Blob Part Two (pp. 44–46, PICES Press, 2015, Vol 23, No. 2), it was noted that by summer 2014 the effects of the Blob in the western Pacific began to diminish but remained a prominent feature in the Northeast Pacific. In mid-September (September 14 to be exact), northerly winds ceased and the Blob moved shoreward into shelf waters off southern British Columbia, Washington and Oregon, raising coastal sea surface temperatures (SSTs) by 6°C over a 6-hour period off Newport, Oregon! By early November 2014, the Blob was firmly entrenched in coastal waters off Oregon for example, with an 80-m thick mixed layer and 2–3°C anomalies. Similar anomalies were seen in February 2015 off Newport. Hydrographic properties along Line P were similar to 2014, showing a 100-m thick upper mixed layer with +2 to +3°C anomalies during the February and June 2015 surveys.

During Phase Three of the Blob, the subject of this essay, we discuss the physical oceanographic features that continued through summer/fall 2015, and some ecosystem impacts. SST anomalies in the Northeast Pacific for July to early December 2015 are shown in Figure 1. Note the moderation of the strongly positive SST anomalies off the coast of the Pacific Northwest, but that very warm temperatures continued along the west coast in the southern portion of the California Current System. Hydrographic sections along Line P in August 2015 (Fig. 2) show that mixed layer depths had returned to normal (although there remains a 2–3°C SST anomaly; you can see the temperature anomaly graphs from previous August cruises on the Line P website). Similarly, off Newport mixed layer depths are 'normal' but with SST anomalies similar to those along Line P. SST at a buoy in outer shelf waters off Newport had a +2°C anomaly for one year, from mid-October 2014 to early November 2015 (Fig. 3). Note also that in August, a 3–4°C anomaly was seen off Newport, similar to the anomalies seen along Line P.

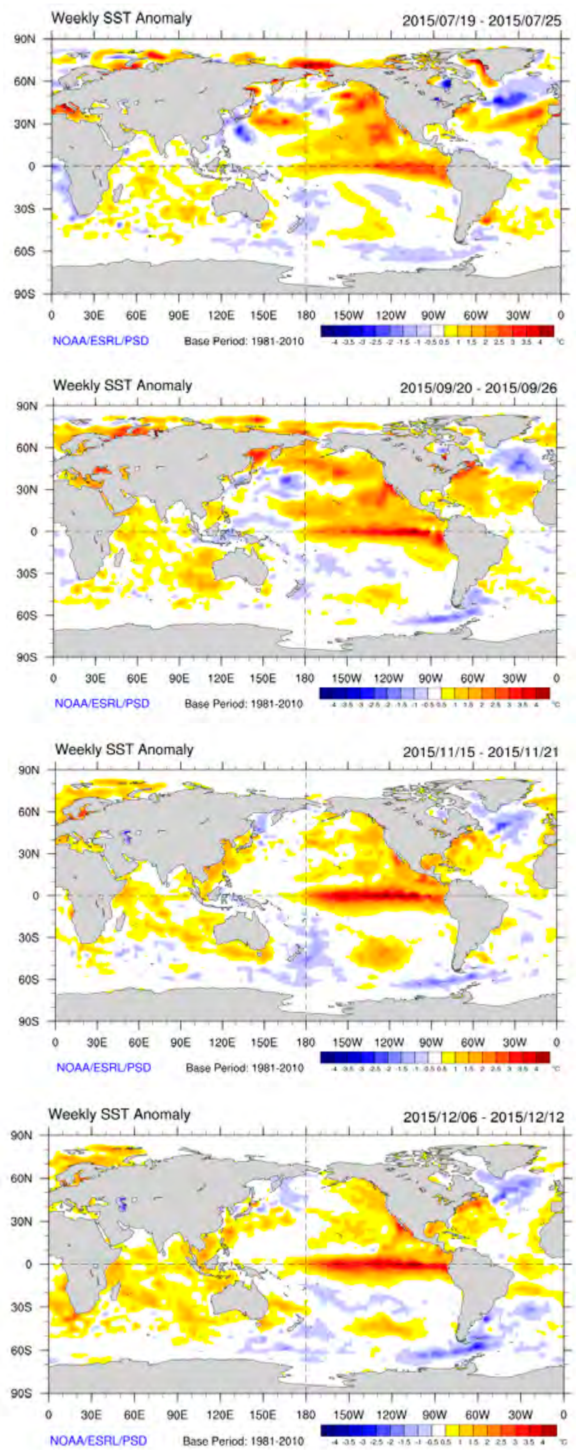

Fig. 1 Spatial pattern of sea surface temperature (SST) across the North Pacific from July, September, November and early December 2015 showing the remnants (July) and decay (December) of the Blob. Also clearly seen is the status of SST at the Equator and the El Niño event that is presently underway.

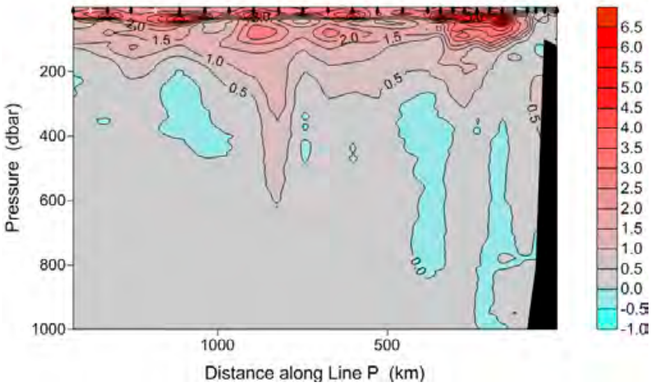

Fig. 2 *Temperature anomaly along Line P in August 2015 (with respect to the 1956–1991 averages). Compare this to sections shown in PICES Press,2015, [Vol. 23, No. 1] and [Vol. 23, No. 2] to see the changes in mixed layer depths, from 100 m in 2014 and 2015, to approximately a more 'normal' thickness of 30 m by summer 2015.*

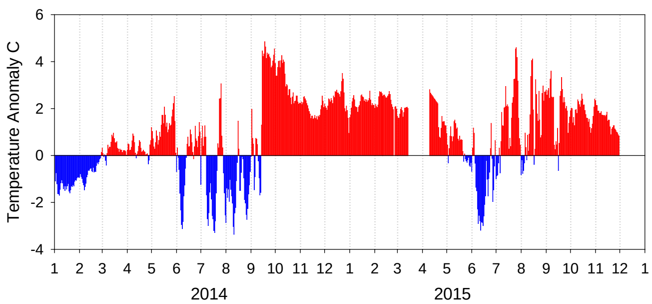

Fig. 3 *Sea surface temperature anomalies at NOAA Buoy 46050 (averaging period 1991–2014), off Newport, Oregon, showing that apart from a strong upwelling event in June 2015, SST anomalies remained approximately 2°C above climatology for one year (mid-October 2014 to early November 2015). By late November anomalies had declined to <1°C.*

The decrease in the SST anomalies in the southern Gulf of Alaska and offshore of the Pacific Northwest from November into December 2015 can be attributed to a regional atmospheric circulation pattern that produced surface wind anomalies from the northwest (not shown). This pattern is atypical during El Niño winters. The North Pacific atmospheric response to El Niño is more robust near the beginning of the calendar year, and if the remainder of the winter of 2015/16 runs true to form, the Aleutian low will be deeper than normal and displaced to the southeast of its usual location. This would result in continued cooling of the upper ocean west of roughly 140°W but maintenance, and perhaps even enhancement, of the positive SST anomalies along the coast from California to the Gulf of Alaska. While we may be witnessing the demise of the Blob, it does not appear that the Northeast Pacific is necessarily returning to a near-normal state.

Ecosystem impacts have not yet been fully documented. However, to date three types of responses are clear. First, many unusual species were found: media reports documented northward displacement of tropical and subtropical reptile and fish species on the order of several 1000 km into the Northeast Pacific. Moonfish (opah) and swordfish were caught off central Oregon (45°N), green and olive ridley turtles were found off Washington and Oregon, and a yellow-bellied sea snake (*Pelamis pelamis*) washed up on a beach near Los Angeles. Sunfish, pomfret and pompano were caught commonly in the Gulf of Alaska. Analysis of W. Peterson's 20+ year time series of copepods in shelf and slope waters off Oregon revealed that the Blob brought to the Northern California Current (NCC) a total of 18 species of warm-water copepods, 11 of which were new records for the NCC shelf/slope, and seven additional species were known to occur only in waters far offshore of Oregon or during big El Niño events (1983, 1998). Many of these copepod species had North Pacific Gyre and/or North Pacific Transition Zone affinities indicating that the source of the warm Blob was from far offshore and from the south. Oregon shelf copepod species richness anomalies reached a peak in August 2015 (Fig. 4) but after that anomalies declined and by early November, turned negative. The copepod species seen now are the same as those seen during any normal winter, with a dominance of subtropical neritic species that are transported to Oregon from coastal waters of central/ southern California waters by the Davidson Current which runs northward from October to March in most years.

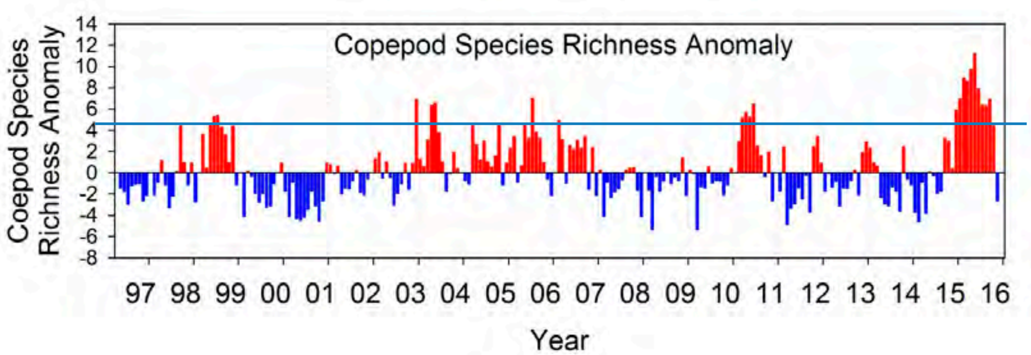

Fig. 4 *The anomaly of copepod species richness (i.e., the number of species in a sample) at a station 5 miles (8 km) off the coast of Oregon along the Newport Hydrographic Line. The averaging period is 1996–2014. The horizontal blue line indicates a + 5 species anomaly, one that is commonly seen during the positive phase of the Pacific Decadal Oscillation (PDO) and El Niño events. Note that the peak anomaly of >10 species was seen in May 2015 in association with the Blob. The November 2015 sample (– 2 species anomaly) contained the 'normal' number of species seen during winter.*

Second, there were economic impacts on commercial fisheries. Sockeye and summer-run Chinook salmon migrating back to the Columbia River in summer 2015 experienced high mortality because river waters were anomalously warm as a result of a Blob-related drought and subsequent low flows; coho salmon returns to the Columbia River in autumn 2015 were the lowest in at least 25 years. Impacts on juvenile salmon that migrated to the sea in spring/summer 2015 will not be known for several years.

Third, the year 2015 witnessed perhaps the largest and most wide-spread harmful algal bloom in recorded history; a bloom of the diatom *Pseudonitzschia*, that began in April 2015, extended from southern California into the coastal Gulf of Alaska. The bloom became extraordinarily toxic such that in May 2015, the State management agencies ordered a closure of the razor clam (*Siliqua patula*) fishery off Washington and Oregon. Subsequent blooms in June and August resulted in toxicity remaining high throughout the remainder of the year leading to a ban on the harvest of Dungeness crabs off California, Oregon and Washington in November 2015. However, as of early December 2015, razor clams (a food source for Dungeness crabs) are no longer testing positive for domoic acid. Thus it is expected that the crab fishery will open soon, which is important since the annual value of this fishery coast-wide is ~$200M US.

The Blob is on the wane, but over the course of nearly two years, it has provided a fascinating natural experiment and a window through which we may have observed the impacts of a future warmer ocean on the pelagic ecosystem and associated fisheries of the California Current (and perhaps across the entire North Pacific). Given that global climate models are unable to anticipate "warm events" such as the Blob or major El Niño events with much lead time, it behooves us to maintain existing marine observation programs and begin others so that ecosystem impacts can be more closely tracked. Finally, given the prognosis for the present El Niño, we expect that abnormally warm conditions will continue along the west coast of North America well into 2016, and so there may well be another chapter (or more) to this story.



Dr. William (Bill) Peterson (bill.peterson@noaa.gov) is an oceanographer and Senior Scientist with the Northwest Fisheries Science Center, based in Newport, Oregon, at the Hatfield Marine Science Center. Bill is a Team Leader for the "Climate Change and Ocean Productivity" program. One of the core activities of this program is the biweekly oceanographic cruises carried out by his laboratory along the Newport Hydrographic Line, where hydrography, nutrients, chlorophyll, zooplankton and krill are measured. This ongoing activity was initiated in 1996. A key outcome of these monitoring cruises is that the data are now used to forecast successfully the returns of salmon to the Columbia River and coastal rivers of Washington. Bill has been active within PICES since his first meeting (1998), serving on the Executive Committee of the Climate Change and Carrying Capacity (CCCC) Program Implementation Panel, as Chairman of the CCCC REX (Regional Experiment) Task Team. He served as member of the FUTURE Advisory Panel on Status, Outlooks, Forecasts and Engagement, and as Co-Chairman of Working Group (WG 23) on Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim. Currently he is a member of the Biological Oceanography Committee.

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