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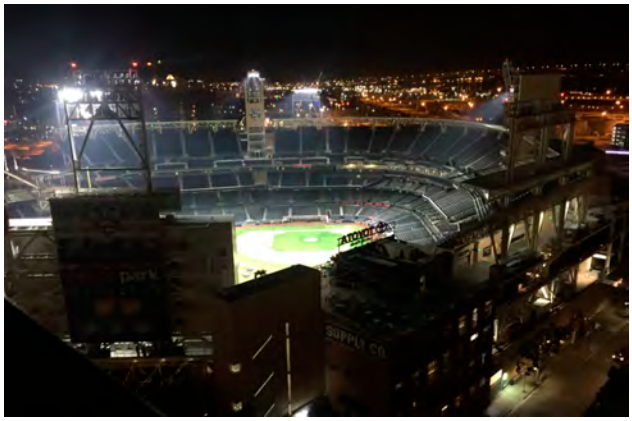
Newsletter of the North Pacific Marine Science Organization

PICES science in 2016: A note from the Science Board Chairman

PICES celebrated its 25th Annual Meeting in November 2016. Since its inception, PICES has grown from a fledging regional organization to one that is internationally recognized for its scientific achievements. To launch PICES' 25th Anniversary Year, we organized the Annual Meeting a little differently and some changes were so successful they may be incorporated into future annual meetings. Plenaries were held daily, followed by dedicated Topic Sessions. Posters were on display for most of the week, and there were two Wine and Cheese Sessions during the week, which allowed for greater interactions in a less formal setting. All of this took place in sunny San Diego, USA, where participants could explore the old Gaslamp District close to our venue.

To kick off the Annual Meeting, a 10-minute video was played highlighting PICES achievements via interviews with selected members of the PICES community on what the Organization meant to them. (The video proved so popular with the audience that it was shown again at the Closing Ceremony, and shorter versions are available for download and sharing!) Each year during the Opening Session we take a moment to recognize individuals or programs that have made significant contributions to our organization via the Wooster Award and the PICES Ocean Monitoring Service Award (POMA). However, this year a special PICES Chair Award was created to recognize the efforts of those who have worked hard to make PICES a success beyond strictly scientific contributions. Two of these awards were presented in San Diego: one was given to Dr. Richard Marasco for his tireless work to make PICES financially sustainable and encouraging scientists within his administration (NOAA) to become involved in PICES. A second was presented to former Executive Secretary, Dr. Alexander Bychkov, whose enterprise, dedication and vision steered the course of the Organization to what we recognize today. The Wooster Award was presented to Dr. Sei-Ichi Saitoh for his many contributions to marine science in the North Pacific and the POMA was given to Line 137°E for long time series observations off Japan, with Dr. Toshiya Nakano accepting on behalf of the program. You can read further details on the recipients in the following article.



Night scene of Petco Park, home of the San Diego Padres baseball team, located just steps away from the Annual Meeting venue at the OMNI Hotel.

In This Issue

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Science Board, from left: Steven Bograd (FUTURE SSC), Angelica Peña (BIO), Elizabeth Logerwell (FIS), Jennifer Boldt (MONITOR), Thomas Therriault (Science Board Chair), Harold (Hal) Batchelder (PICES Secretariat), Hiroaki Saito (FUTURE SSC and Science Board Chair-elect), Igor Shevchenko (representing Russia), Toru Suzuki (TCODE), Chuanlin Huo (MEQ), and Se-Jong Ju (BIO Vice-Chair); (missing) Michael Foreman (POC Vice-Chair).

Participants of the Governing Council meeting at PICES-2016, from left: Robin Brown (Executive Secretary), Takashi Ikeda (Japan), Dongmei Tang (China), Junichiro Otaka (Japan), Fangli Qiao (China), Kyungjin Kim (Korea), Chul Park (PICES Vice-Chair), Enrique Curchitser (USA), Man Wook Heo (Korea), Laura Richards (PICES Chair), John Stein (USA), Tokio Wada (PICES Past Chair), Lev Bocharov (Russia), Shigeru Itakura (Japan), Carmel Lowe (Canada), Ken Mori (Japan), Chika Fujimitsu (Japan), Hiroya Sugisaki (Japan), Oleg Katugin (Russia), Kim Houston (Canada), and Darlene Smith (Canada).

This Annual Meeting was special in other ways. Looking at the past is one way to see how far PICES has come. To recognize the achievements of others who helped shape the Organization, the former Chairs of Governing Council, Science Board, and Standing Committees were invited to the anniversary celebration. Whether it was to give a presentation, engage in discussions or simply to listen, it was a great time to connect past, present and potential future PICES leaders. In addition, a good number of the previous PICES Interns attended, further highlighting the success of this unique capacity building initiative. PICES-2016 emphasized how rare these unique opportunities arise for such a diverse and expansive organization.

We had a banner year in terms of PICES activities and accomplishments in marine science since our last Annual Meeting in Qingdao, China. Starting last January, PICES was a major sponsor of the 9th International Conference on Marine Bioinvasions in Sydney, Australia. This was the fifth Bioinvasions Conference PICES has supported and this iteration allowed the results of our PICES ADRIFT project, funded by the Ministry of the Environment (MoE) of Japan, to be shared with the international scientific community. An important aim of this conference series is the active participation of students and early career scientists, which aligns well with our capacity building mission. In May, we collaborated with our long-time strategic partner, ICES (the International Council for the Exploration of the Sea) to co-sponsor the 6th International Zooplankton Production Symposium in Bergen, Norway. It was a great success, bringing together almost 400 scientists from 38 countries to address a broad range of zooplankton

issues. Two weeks later, the ICES-led symposium on "*Understanding marine socio-ecological systems*" (MSEAS) was held in Brest, France. This event brought together scientists to discuss the study and management of marine ecosystems, especially the human dimension aspect. PICES had strong representation at this symposium through its members from the Section on *Human Dimensions of Marine Ecosystems* who gave presentations in a number of theme sessions. By all accounts, MSEAS was a huge success and we have already started discussions for a second event in Japan in 2020.

Dr. Laura Richards (PICES Chair) with Opening Ceremony guests, Dr. Margaret Leinen (Director of Scripps Institution of Oceanography) and Dr. Richard Spinrad (NOAA Chief Scientist). Others from left: Dr. Chul Park (PICES Vice-Chair), Mr. Robin Brown (Executive Secretary), Dr. John Stein (GC member, USA), Dr. Thomas Therriault (Science Board Chair), Dr. Enrique Curchitser (GC member, USA) and Dr. Cisco Werner (SWFSC, NOAA, LOC member).

We all recognize the importance of climate change and other marine stressors affecting the North Pacific Ocean, and periodic status reports have become essential to inform management on sustainable use of the marine environment. In this respect, PICES is well positioned to assess the status and provide forecasts of future conditions. To date, we have completed two North Pacific Ecosystem Status Reports, which are flagship products of the Organization. In June, the Study Group on *North Pacific Ecosystem Status Report* held a workshop in Sidney, Canada, to review and evaluate ecosystem time series observations from PICES member countries, which will be the building blocks of the third iteration of the Status Report expected within the next year.

Scientific excellence can take many forms, including the development of expert groups to address scientific knowledge gaps or the hosting/sponsoring of theme sessions/workshops to tackle a specific question. Perhaps the greatest change you will note in the structure of PICES following PICES-2016 is our new Human Dimensions Committee. This change represents a significant advancement that will allow PICES to better engage on human dimension elements both within PICES and beyond. In addition to the groups previously established at ISB-2016, we formed three more working groups at PICES-2016 – WG 36 (*Common Ecosystem Reference Points across PICES Member Countries*), WG 37 (*Zooplankton Production Methodologies, Application and Measurements in PICES Regions*), and WG 38 (*Mesoscale and Submesoscale Processes*). It is important to note that our FUTURE Scientific Steering Committee is now a parent (a first!), with WG 36 reporting directly to it. In addition, we contribute to the broader scientific community by supporting theme sessions and workshops. In September, we sponsored two theme sessions at the ICES Annual Science Conference in Riga, Latvia (and ICES co-sponsored two topic sessions at PICES-2016).

As you may recall from previous "Year in Review" updates, PICES has two projects that are nearing completion. The goal of the MarWeB (Marine Ecosystem Health and Human Well-Being) project, funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, is to identify the relationships between sustainable human communities and productive marine ecosystems, under the concept of social–ecological systems in fisheries, also known as "sato-umi" in Japan. The project has been using two case studies: one in Indonesia, working on the use of integrated multi-trophic aquaculture, and one in Guatemala, working on sustainable fisheries. This project has been very successful due to the bottom-up engagement approach with local managers and fishermen. The goal of the ADRIFT (Assessing the Debris-Related Impact of Tsunami) project, funded by the Ministry of the Environment (MoE) of Japan, is to assess and forecast the effects of debris, including those from invasive species, generated by the Great Tsunami that followed the 2011 earthquake off northeastern Japan. The project has been modeling the movement of marine debris from the tsunami across the Pacific, monitoring its landfall in the eastern Pacific, and assessing the risk of potential invasive species to coastal ecosystems of North America and Hawaii. The project hosted a special session (S8; *The effect of marine debris caused by the Great Tsunami of 2011*) at PICES-2016.

As a science organization, PICES communicates the results of its activities and achievements through a range of publications. We had several special issues, review papers and article contributions covering a diverse range of topics published in peer-reviewed journals since our last Annual Meeting. And let's not forget the book "*Fostering Marine Science and Internationalism: The Journey with PICES*" by Sara Tjossem, commissioned especially to mark PICES' 25th Anniversary. Sara did a book signing at the Meeting for any participant who requested one, and judging by the number of books that went out, it looks like it was a popular event.

Highlights of PICES-2016

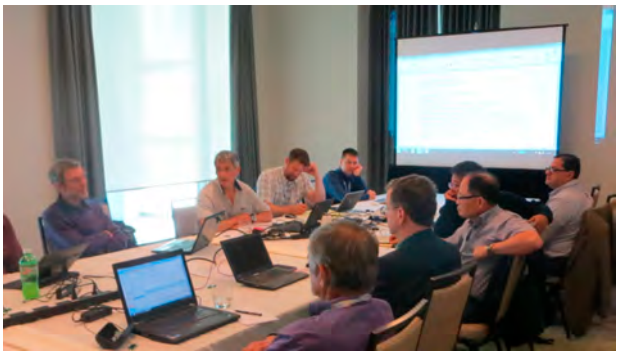
Tamara Russell presenting at the Workshop 2 on "Conditions promoting extreme Pseudo-nitzschia events in the eastern Pacific but not the western Pacific".

Hiroaki Saito and Steven Bograd chairing the FUTURE business meeting.

PICES film producer, Saskia Madlener and former PICES Executive Secretary, Alexander Bychkov.

Passing PICES science to the next generation – Sinjae Yoo (former Science Board Chair) with daughter, early career scientist Chaewon Yoo.

Sara Tjossem, author of "Fostering Marine Science and Internationalism", her second book on PICES, taking a break with George Hunt (USA).



Study Group on North Pacific Ecosystem Status Report business meeting in session.

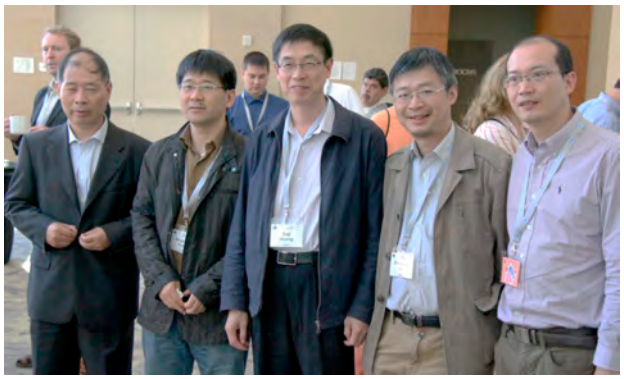
TCODE Committee meeting, with Toru Suzuki (middle, facing) conducting the meeting.

Richard Spinrad (NOAA Chief Scientist) and Jonathan Hare (USA) sharing some light banter.

The PICES Memory Book, a compilation of PICES people and events from the past 25 years was popular memento for participants to take home.

Attentive audience at the Plenary Session.

Ken Denman (Wooster Award 2007), Angelica Peña (BIO Chair) and Tetjana Ross (MONITOR) during a session coffee break.



Gathering of Chinese delegates, from left: Douding Lu, Jingsong Yang, Daji Huang, Dongfeng Xu and Yongling Zhu.

PICES interns, past and present, from left: Natalya Gartley (née Bessmertnaya), Chuanlin Huo, Keyseok Choe, Yongling Zhu, Tatiana Semenova, Zhuojun Ma, Anna Skvortsova, Jinwen Liu, and Minho Kang.

Discussing Korean news? From left: Suam Kim, Chang Seung, Mi Ok Park, Jeong Hee Shim, Chan Joo Jang, and Sukyung Kang.

Catching up on news with old friends: Ken Drinkwater in an animated conversation with Paul LeBlond.

Welcome Reception – good food and lots of conversation.

From left: Hiromichi Ueno, Shin-ichi Ito, Angelica Peña, Dimitris Politikos, Michio Kishi and Steven Bograd enjoying wine and conversation at the Welcome Reception.

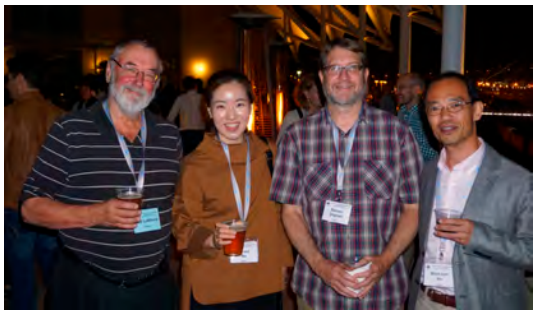
A distinguished gathering of some former Wooster Award recipients at PICES-2016, from left: Paul LeBlond (2004, Canada), Fangli Qiao (2014, China), Sei-Ichi Saitoh (2016, Japan), Makoto Kashiwai (2006, Japan), Vera Alexander (2013, USA), William Pearcy (2003, USA), Charles Miller (2008, USA), Anne Hollowed (2015, USA), Richard Beamish (2012, Canada), and Kenneth Denman (2007, Canada)

Four generations of scientists from Oregon State University. Plaid shirt: William Pearcy, major professor of Richard Brodeur (left) who was the major professor of Lorenzo Ciannelli (second from right) who is the major professor of Caren Barceló (right).

Dr. Laura Richards (PICES Chair) sitting with PICES-2016 Award recipients, from left: Alexander Bychkov and Richard Maresco (2016 PICES Chair Award), Sei-Ichi Saitoh (2016 Wooster Award), and Toshiya Nakano (representing the 2016 POMA).

Makoto Kashiwai (2006 Wooster Award recipient), Michael Foreman (POC Chair, 2004–2010) and Vyacheslav Lobanov (POC Chair, 1998–2001) during the Welcome Reception.

Nick Bond (Chair SG-CEP) and Skip McKinnell (Deputy Executive Secretary, 1999–2013) no doubt talking about Pacific climate variability.



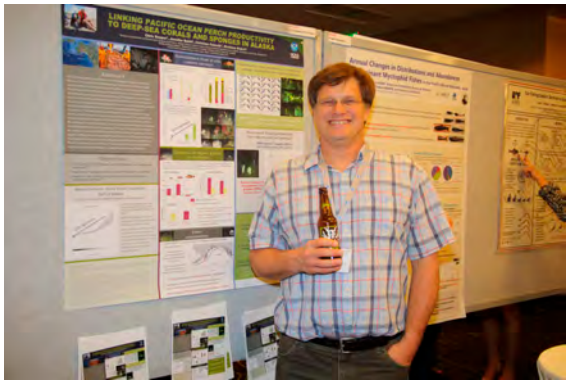
Paul LeBlond (Canada), Hanna Na (Korea), Steven Bograd (USA) and Shin-ichi Ito (Japan) toasting 25 years of PICES.

PICES Chair, Laura Richards, with Dick Beamish (2012 Wooster Award recipient) and Jake Rice (Special Friend of PICES)

Charlie Miller (2008 Wooster Award recipient) and Gordon Kruse (FIS Chair 2005–2008) enjoying discussions at the Poster Session.

The Poster Session, held over two days, proved to be very popular.

Early career scientists, Vladimir Kulik and Alexey Khoruzhiy.



Chris Rooper (USA) ready to talk poster results.

Talking science at the Poster Session. From left: Ed Urban (SCOR), Tom Therriault, and Richard Rivkin (PICES WG 33 Co-Chair).

Former PICES intern, Jinwen Liu (China), presenting at the popular Topic Session S7 on "New stage of ocean acidification studies".

Hally Stone making a presentation at Topic Session S11 on "Advances in understanding and modeling of physical processes in the North Pacific in the past 25 years of PICES and future directions.

Dr. Ryan Rykaczewski, Early Career Keynote Speaker

Naomi Harada, Invited Speaker

Youngji Joh, Early Career Scientist

Colleen Petrik, Early Career Plenary Speaker

Haruka Nishikawa, Early Career Scientist

Our flagship program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Ecosystems) continues to make advances in several initiatives, through its Scientific Steering Committee. During 2016, the FUTURE SSC held its second inter-sessional meeting to finalize its Phase II Implementation Plan which will help us to increase the understanding of climatic and anthropogenic impacts and consequences on marine ecosystems in the North Pacific. The SSC is also developing a number of FUTURE products and from this, will draft a synthesis paper. Besides identifying potential new expert groups to help complete its objectives, the SSC has, for the first time, taken on sole responsibility for directing the new expert group, WG 36, mentioned above.

International PICES swim team, its largest membership to date. PICES-2016 Swim Team member, Slava Lobanov is taking the picture.

One of PICES' high priority activities is capacity building. This was one of the visions our principal founder, Dr. Warren Wooster, had for PICES. One way to engage the next generation of scientists is to provide travel grants for students and early career scientists to attend symposia co-sponsored or organized by PICES, such as the Bioinvasions Conference and Zooplankton Symposium, described earlier and, of course, PICES Annual Meetings. At PICES-2016, we funded over 40 individuals. Another capacity building activity PICES is greatly involved in is summer schools and training courses, including those organized by collaborators. This year, we supported early career scientists at four such events: the Pacific Ecology and Evolution Conference (organized and run by students and early career scientists) held in Bamfield, Canada, IMBER's ClimEco5 Summer School in Natal, Brazil, an early career scientists symposium linked with the CLIVAR Open Science Conference in Qingdao, China, and the Nagoya University-led IHP Training Course on "*Coastal vulnerability and freshwater discharge*" in Nagoya, Japan.

Looking ahead in 2017, we have several exciting PICES organized or sponsored events planned (see the PICES calendar on page 13) including our next Annual Meeting which will be held September 20 to October 1, 2017 in Vladivostok, Russia. The theme of PICES-2017 is "*Environmental changes in the North Pacific and impacts on biological resources and ecosystem services*".

PICES athletes showing true PICES spirit in trying out the host country's social cycle sport event on the San Diego social scene.

Finally, my three-year term as Science Board Chairman has come to a close. It has been a great honour for me to have served PICES in this capacity (although my family is excited to see a bit more of me). The PICES family is truly unique and I know your next Science Board Chairman, Dr. Hiroaki Saito from Japan, can count on this family to support his efforts over the next three years. To mark this Anniversary Year, a timeline of PICES milestones and a lectures series on PICES achievements including: ecosystem indicators and ecosystem-based management; climate change/variability and marine ecosystems; and on the NEMURO suite of models is being developed. I look forward to seeing these and watching the continued evolution of PICES as the 25th Anniversary Year proceeds.

San Diego Harbor view.

Thomas Therriault
Science Board Chairman

2016 PICES awards

A presentation ceremony for PICES awards took place on November 7, 2016, during the Opening Session at the PICES 2016 Annual Meeting in San Diego, USA. Added to the prestigious Wooster Award and POMA, a third honour, the PICES Chair Award, was conferred for the first time on two recipients for outstanding contributions to PICES activities.

PICES Chair Award

The establishment of the PICES Chair Award was approved at the 2016 inter-sessional Governing Council meeting. It is given for sustained contributions to the development of the Organization that have allowed it to meet the purpose as set out in the Convention. The 2016 award presentation ceremony began with Dr. Laura Richards (Chair of PICES) introducing the award and announcing the first recipient.

As the Governing Council reviewed the progress of the Organization and looked forward to the next phase of the evolution of PICES, we discovered a gap. In this period, PICES has grown and matured dramatically and has become established as a major contributor in marine science and a valued partner with other organizations. This does not just "happen", particularly in an environment where the basic funding for the Organization (the annual fees) has only grown slowly. This requires the sustained contributions from inspired people, often working "behind the scenes". PICES has filled that gap with a new award, the PICES Chair Award – to recognize the sustained contributions to the development of the Organization.

I am pleased to announce that Dr. Richard (Rich) Marasco is being recognized with the PICES Chair Award for his "sustained contributions to the development of the Organization". In his leadership role, he designed a financial approach that allowed PICES to expand in the absence of real increases in the annual fees. He also worked tirelessly to build relationships across diverse cultures in PICES, and he advocated for the importance of PICES within his home organization, NOAA, encouraging younger scientists to take up leadership roles in PICES.

Accepting the Award, Dr. Marasco stated:

It was an honor and a privilege to be given the North Pacific Marine Science Organization Chair Award. Thank you so much. The award is very much appreciated.

Dr. Richards announced a second recipient of the award.

Council is very pleased to make another award – to Dr. Alexander (Alex) Bychkov. Dr. Bychkov was the PICES Executive Secretary from 1999–2014. His dedication and hard work are key drivers that have moved PICES from a regional North Pacific science organization to a well-respected and recognized truly global organization, leading important initiatives in climate change and marine ecosystem science. Alex has exhibited considerable talent for communication, and a tactful manner of persuasion, taking into account the different cultural experiences of PICES nations. If Alex asks someone to take on a role within PICES, there will be deep reason for his selection, and "no" is very rarely the response.

Upon receiving the award, Dr. Bychkov remarked:

Thank you! This is unexpected and very touching. I am truly honored to be selected as the recipient of the PICES Chair Award. PICES has been an incredibly important part of my life, and I always felt lucky for having an opportunity to work with and for such talented and friendly community.

Left: Dr. Richard Marasco, Chair of the PICES Finance and Administration Committee (F&A) from 1998–2004, accepting the PICES Chair Award from Dr. Laura Richards. Right: Dr. Alexander Bychkov, Deputy Executive Secretary from 1996-1999 and Executive Secretary from 1999–2014, upon acceptance of the PICES Chair Award.

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.

The Wooster Award presentation ceremony was conducted by Dr. Thomas Therriault (Chair of Science Board). Dr. Therriault announced that the 2016 Wooster Award was being given to Dr. Sei-Ichi Saitoh (Hokkaido University, Japan), and read the following Science Board citation which was accompanied by a slide show dedicated to Dr. Saitoh:

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 2016 Wooster Award, Dr. Sei-Ichi Saitoh.

Dr. Sei-Ichi Saitoh is a director and professor at the Hokkaido University Arctic Research Center, and a professor at the Graduate School of Fisheries Sciences at Hokkaido University, where he conducts research, advises graduate students, and teaches courses in satellite oceanography, marine-GIS, and fisheries oceanography. He has over 30-years' experience as a satellite oceanographer, fisheries oceanographer, GIS specialist, and consultant on fisheries issues in the North Pacific Ocean and its adjacent seas, including impacts of climate change. He has published over 100 peer-reviewed articles.

Sei-Ichi was born in Mikuni, Fukui Prefecture where his father was a kimono merchant. He lived in Fukui until high school where he enjoyed fishing and swimming. That was the starting point of his career as an oceanographer. Later, he entered Hokkaido University. At University he was a member of the Exploration Club where in 1971, during his first undergraduate year, he participated in the KINAMBO project, an experimental cruise across the Tsugaru Strait. KINAMBO is the Ainu word for sunfish drifting at the surface of ocean. The club failed three times and then the fourth time, when Sei-Ichi was on the drifter, they were successful.

In 1975, before starting graduate school, Sei-Ichi participated in an Expedition to the Aleutian Islands, which was the 15th Anniversary project of the Exploration Club. He enjoyed diving and climbing in the Aleutians. His photo of sea lions was published in a Japanese photo magazine. He has visited the same area on the Oshoro-maru multiple times since 1995.

After completing his PhD, Sei-Ichi joined the Japan Weather Association as a research engineer and continued to work on satellite remote sensing. In 1988, he married Ryoko, who has supported him in both his life and research. She has been a frequent participant at PICES annual meetings. In 1993, he returned to Hokkaido University as an associate professor. Sei-Ichi was a pioneer in using NOAA SST sensors and ocean color data from various satellites for fisheries oceanography. Using GIS, he merged satellite, environmental, and fisheries data to inform fishermen where to catch fish. He extended this to provide aquaculture facility sitings. Based on these scientific achievements, in 2014 the Japanese Society of Fisheries Oceanography awarded Dr. Saitoh the Uda Award.

Unlike many satellite oceanographers, Dr. Saitoh goes to sea regularly, participating in many oceanographic and fisheries surveys in the North Pacific, the Sea of Okhotsk, the Bering Sea and the Chukchi Sea. He was the lead investigator of International Polar Year cruises to the Arctic Ocean in 2007 and 2008 onboard the Oshoro-maru. Data obtained from these cruises has been openly shared and widely used by scientists from PICES and other organizations. He convened mini-symposia on marine ecological studies in the Bering Sea and North Pacific when the Oshoro-maru stopped in foreign ports.

Sei-Ichi has conducted research for scientific knowledge and has applied these for human well-being. He created the Traceable and Operational Resource and Environment Data Acquisition System (TOREDAS) to provide fishermen with near real-time forecasts for squid, saury and tuna fishing grounds. The system is used widely in Japan to reduce fuel expenses and improve fishers' financial conditions.

In PICES, Dr. Saitoh has been an active member of the Technical Committee on Monitoring (MONITOR). He co-chaired the MONITOR Task Team of CCCC and continued as vice-chair of the MONITOR Committee from 2004–2007. At PICES annual meetings, he has served as session or workshop convenor almost every year during the past decade. Outside of PICES, he has contributed to various international projects and organizations. Sei-Ichi has been co-chair of the Ecosystem Studies of the Subarctic Seas (ESSAS) program, was a member of the Science Council of Japan, and participated on national committees to SCOR (Scientific Committee on Oceanic Research) and IASC (International Arctic Science Committee).

Besides his many scientific activities, Sei-Ichi is dedicated to education. He served as a lecturer and committee member for the PICES summer schools held in 2009 and 2013. He has encouraged and financially supported his students and young scientists to attend PICES annual meetings. His students and post-docs have received 11 early career best poster or oral presentation awards at PICES annual meetings. This is evidence of his mentorship and skills in recruiting young scientists.

In April 2015, Hokkaido University launched a new national center for scientific research on the Arctic and surrounding region. Sei-Ichi was named as the first director of this new center and is guiding it toward comprehensive and integrated research in the Arctic.

Please join me in congratulating Dr. Sei-Ichi Saitoh as the recipient of the 2016 Wooster Award.

Dr. Sei-Ichi Saitoh, 2016 Wooster Award recipient, with Dr. Thomas Therriault (PICES Science Board Chair) and Dr. Laura Richards (PICES Chair).

Dr. Saitoh accepted the award with the following remarks:

Thank you, Drs. Thomas Therriault and Laura Richards.
It is a great honor for me to receive such a prestigious award. I was completely surprised to receive this award. I would like to take this opportunity to thank all who have conducted research and education with me, and to share with them the pleasure and honor of receiving this award.

I want to introduce an old story about Prof. Warren Wooster today. In 1984, 32 years ago, when I finished my PhD course, I looked for a postdoc position as a satellite oceanographer, in the United State. I wrote a letter to Dr. George Maul, who was a famous satellite oceanographer at the NOAA Atlantic Oceanographic and Meteorological Laboratory in Miami, and who is still active as a professor of oceanography at the Florida Institute of Technology. I asked him about the possibility of getting a position working on the application of satellite remote sensing to fisheries. He suggested that I write a letter to Prof. Warren Wooster, at the University of Washington, as an appropriate person for me to work with. At that time, I, however, hesitated and gave up writing a letter to him. Then, I started different carrier as a research engineer in the Japan Weather Association. In 1993, I began working at Hokkaido University, and started to participate in PICES annual meetings and met Prof. Wooster in the late 1990's for the first time. But, I had no chance to tell this story directly to him. If he was here, I could tell him not only this award, but also my story. At last, this award has made me reach Prof. Warren Wooster just today.

Lastly, I would like to acknowledge that my achievements are mainly the results of contributions from not only mentors and various colleagues, but also of the many excellent students and post-docs who have been my co-workers and co-authors. Thank you very much again.

Wooster Award recipients

2001	Michael Mullin (USA)
2002	Yutaka Nagata (Japan)
2003	William Pearcy (USA)
2004	Paul LeBlond (Canada)
2005	Daniel Ware (Canada)
2006	Makoto Kashiwai (Japan)
2007	Kenneth Denman (Canada)
2008	Charles Miller (USA)
2009	Kuh Kim (Korea)
2010	Jeffrey Polovina (USA)
2011	Bernard Megrey (USA)
2012	Richard Beamish (Canada)
2013	Vera Alexander (USA)
2014	Fangli Qiao (China)
2015	Anne B. Hollowed (USA)
2016	Sei-Ichi Saitoh (Japan)

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.

Dr. Therriault conducted the POMA presentation ceremony and read the following Science Board citation (reading of the citation was accompanied by a slide show describing award recipient):

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 2016 POMA Award, which is the Japan Meteorological Agency (JMA) 137°E Repeat Hydrographic Section.

The 137°E meridian was chosen for monitoring and investigating large-scale ocean variables because it crosses the major current systems in the North Pacific, including the Kuroshio and North Equatorial Current, and is least affected by local topography and bathymetry. Observations started in 1967 with the line running from 34°N to 1°S – a distance of 3900 km. Three different research vessels have been used to undertake the repeat observations along 137°E. Equipment has varied from a reversing thermometer and Nansen bottles in the early years to advanced, automated atmosphere and oceanic pCO_2 and pH sensors. A wide variety of oceanographic variables are measured with additional parameters measured in more recent years. All data are made available shortly after the completion of the cruise. Ocean carbon dioxide and related parameters collected through this survey has been instrumental for the PICES PACIFICA database, and also was included in the GLODAPv2 (Global Ocean Data Analysis Project). The data from this transect have contributed to more than 130 publications since 1967 and clarified the role of the ocean in global climate change.

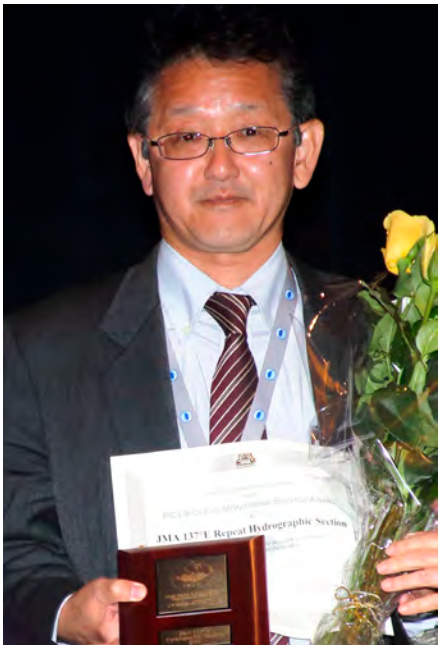
Ladies and gentlemen, please join me in congratulating JMA, who is represented here by Dr. Toshiya Nakano, as the recipient of the 2016 PICES Ocean Monitoring Service Award.

Dr. Toshiya Nakano, Head of the Marine Environment Monitoring and Analysis Center, Global Environment and Marine Department of the Japan Meteorological Agency, accepted the award on behalf of *137°E Repeat Hydrographic Section* with the following remarks of appreciation:

I am greatly honored to receive 2016 PICES Ocean Monitoring Service Award. On behalf of the team working on the 137°E repeat section, I express deep appreciation to all PICES members.

Hydrographic and biogeochemical measurements at 137°E section was started by Dr. Jotaro Masuzawa and his colleagues almost 50 years ago, in winter of 1967, five years after I was born. Half-century-long repeat survey at 137°E section has been playing an important role for demonstrating trends and variations in ocean circulation, warming, deoxygenation, acidification, and so on in the western North Pacific. We should be truly grateful to Dr. Masuzawa for his foresight 50 years ago. We are also grateful to the past and present captains and crews of R/V Ryofu Maru and Keifu Maru, and many staff members of the Marine Division, Japan Meteorological Agency, for their laudable half-century long observational efforts.

We believe the PICES award will strongly encourage JMA to keep these long-term observations and hope they will continue to help documenting the changes in the ocean in the upcoming decades, which hopefully indicate the success of Paris Agreement just became effective three days ago. Then we can receive this award 50 years later again. Thank you very much.



Dr. Toshiya Nakano accepting the 2016 POMA for the JMA 137°E Repeat Hydrographic Section.

PICES Ocean Monitoring Service Award recipients

2008	T/S *Oshoro-maru* (Japan)
2009	Dr. Bernard Megrey and Mr. Allen Macklin, leaders of the PICES Metadata Federation Project (USA)
2010	Station P/Line P Monitoring Program (Canada)
2011	Network of Serial Oceanographic Observations (Korea)
2012	California Cooperative Fisheries Investigations (USA)
2013	A-line Monitoring Program (Japan)
2014	Trans-Pacific Volunteer Observing Ship (VOS) Survey Program (Japan)
2015	TINRO-Centre Macrofauna Inventory (Russia)
2016	JMA 137°E Repeat Hydrographic Section (Japan)

We congratulate the 2016 Award recipients, Drs. Richard Marasco, Alexander Bychkov, Sei-Ichi Saitoh, and Dr. Toshiya Nakano and colleagues.

PICES calendar of events

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

Lowell Wakefield Fisheries Symposium – *Impacts of a changing environment on the dynamics of high-latitude fish and fisheries*
May 9–12, 2017, Anchorage, USA

PICES/ICES Early Career Scientist Conference – *Climate, oceans and society: Challenges and opportunities*
May 29–June 2, 2017, Busan, Korea

ESSAS Open Science Meeting – *Moving in, out and across the Subarctic and Arctic marine ecosystems*
June 11–15, 2017, Tromsø, Norway

ICES Annual Science Conference 2017
September 18–21, 2017, Fort Lauderdale, USA

PICES-2017 – *Environmental changes in the North Pacific and impacts on biological resources and ecosystem services*
September 20–October 1, 2017, Vladivostok, Russia

IMBER IMBIZO V – *Marine biosphere research for a sustainable ocean*
October 2–6, 2017, Woods Hole, USA

ICES/PICES/IOC/NOAA Fisheries 4th International Climate Change Symposium – *Effects of climate change on the world's oceans*
June 4–8, 2018, Washington, DC, USA

Call for Wooster Award, POMA, and PICES Chair Award nominations for PICES-2017

We are now soliciting nominations for the Wooster Award and the PICES Ocean Monitoring Service Award. The closing date for Wooster Award and POMA nominations is **March 31, 2017**. Closing date for the PICES Chair Award is **July 30, 2017**. The awards will be presented during the Opening Session of PICES-2017 in Vladivostok, Russia.

Send your nominations to PICES Executive Secretary and include the following information: nominee's name, title, institutional affiliation and address, CV, and statement of justification for the nomination.

Impressions of PICES from old friends

The launching of PICES' 25th Anniversary at PICES-2016 was an opportunity to ask a number of scientists who were active in PICES in earlier days, or who have been great friends of PICES for many years, what their impressions were about the Annual Meeting, and about the current state of PICES. After they had a chance to meet old friends and colleagues, to listen talks on PICES' scientific accomplishments and advancements to date, and to observe a younger generation of PICES scientists and new directions in the development of the Organization, we received a wide range of replies. All responders were happy with PICES' growth and presence on the world stage, but praise aside, there were several who noted a number of shortcomings and offered constructive criticism and suggestions on how PICES could do better. Here, mixed with the positives, are some provocative comments as food for thought from old friends.

Vera Alexander
PICES Chair, 2002–2006

The thing that struck me most was the large number of young people participating with great enthusiasm. This speaks well for the future of PICES, and was not so much a characteristic of the early years. I sat through some of the large co-ordinated program activities, and this program seems to be going well. The range of activities, from summer schools and other trainings to special meetings and workshops, address contemporary needs. It was also good to see an increased cooperation between PICES and ICES.

I wonder, though, whether there is any way to make the ocean scientific communities more aware of the output of PICES, such as the ecosystem status reports. These could be useful on a much wider scale than I believe is the situation at present.

The answer to the big question, *i.e.*, whether PICES is living up to the founder's dreams, is "yes". I think it is functioning well, maybe more so than anticipated.

Richard Beamish
Wooster Award recipient, 2012

The meeting this year was impressive for several reasons, including being a celebration of 25 years and bringing some old friends together.

It is clear that PICES has succeeded in bringing the ocean science community together around the North Pacific and is now a major international organization. This was a major objective of Warren Wooster and the rest of us. It is a major success that is a consequence of members as well as leadership within the organization, especially Alex Bychkov. I like the mixture of formality and informality. I have always liked the Russian approach of accepting that the social side of science is as important as the business side.

PICES is keeping up with its publications. The little over 50 reports are nicely spaced out over the 25 years and cover a wide range of relevant topics. I liked the emphasis on younger scientists, and PICES does posters right. The cooperation with other organizations is now well developed. Warren Wooster and I had many conversations about the need for a PICES, and, if Warren was around today, he could not be more pleased.

I saw PICES as the most effective way of understanding how climate and oceans affected the population dynamics of fish. This way of thinking was not at all popular in the 1980s. … PICES needs to be more involved in issues that are recognized by the public who are the patrons of PICES. The issue that is most relevant to people around the Subarctic Pacific is Pacific salmon. Years ago, PICES and NPAFC signed an agreement to work together, and there has been some cooperation but there needs to be much more. PICES has put much more efforts into small pelagic fishes that exclude salmon. PICES is still not recognized by the general public, and becoming more involved in the future of Pacific salmon is one way of letting people know about the importance of our science. … It is time for PICES and NPAFC to form a strong coalition with the objective of developing reliable forecasting models for all species of Pacific salmon. PICES can begin by being part of the international year of the salmon, but PICES needs a headline project to provide the science needed to manage salmon in a changing ocean. This is the emphasis on fish that is missing from PICES and an emphasis that is needed by the resource and for the public recognition of PICES.

John Davis
Founding Governing Council member;
F&A Committee Chair, 1992–1996

It is very clear that PICES has matured and flourished over the 25 years and is now very much accepted as the premier North Pacific science organization with many links to other organizations and recognized expertise. This made me feel really good that those of us who started the organizations and all the scientists who made it happen had a vision that matured and prospered and achieved a great deal.

The sheer size and diversity of the meeting was very impressive, particularly the Asian participation and the presence of young scientists who put together some very good talks and posters. It was fun to talk to them and see their enthusiasm. Perhaps a discussion session with a future orientation and the participation of young scientists and more mature scientists on a panel might be a good thing to feature at a coming meeting.

I really enjoyed the FUTURE mini-symposium and the focus on future planning. It is clear that the scientists and all the various committees, working groups and topics are making a strong contribution to a diverse body of science and are starting to think about where to go next. I did not see too much of this reflected in the 2016 Strategic Plan for PICES beyond very general objectives. Perhaps future strategic planning exercises might wish to focus more specifically on future directions and needs including outreach to the public, communication of key scientific findings and addressing the needs of sponsoring governments and their populations who will be demanding insights and responses to questions about the changing North Pacific and its natural resources as we enter new and uncertain times.

A big concern I have is about the need to position the organization to cope with the coming challenges. We may well be at a point where we are outside the range of physical, chemical and biological processes and phenomena we have grown used to, where we see big shifts in ecosystems or reach tipping points where the implications are not certain. I think scientists may have to pose scenarios which can be communicated to allow people to make choices about economic decisions, management strategies, regulatory measures, *etc*., where the likelihood of making precise predictions is not too certain. Some work on how to address this communication of science and prediction in the face of uncertainty may be a very useful topic for a group to pursue – perhaps as a sub-set of what the FUTURE group is doing.

From a housekeeping perspective, a number of talks were very difficult to understand, and I think session chair-persons and the organization need more rigor to try to raise the quality of presentations and intervene during a talk when the speaker is not using the microphone, not facing the audience or presenting dozens of complex slides full of acronyms that were obscure and had much too much detail. I know there are linguistic difficulties but if the speaker has a smaller set of very clear slides in English the audience, regardless of ethnicity, can likely all follow those without too much difficulty. This concern is a particularly important for a multi-nation, multi-lingual organization to focus on so that communication of the science is effective and the contribution of different scientists is clear, instructive, and stimulating.

Kenneth Denman
Wooster Award recipient, 2007

The PICES video and Memory Book were/are great and really appreciated. I was especially happy to see Alex Bychkov get the PICES Chair Award. The strong scientific focus in PICES will be his legacy.

As always, the scientific sessions were very good. My one criticism, and I received similar comments from others, was with the Science Board Symposium. Besides the keynote speaker, Ryan Rykaczewski, and a couple of others, the rest were not that interesting, especially the programmatic talks which were a bit too self-congratulatory, tending to dwell on the past rather than identifying future challenges and opportunities.

Overall, I think that the convenors for S1 were too concerned with pushing the right buttons rather than choosing speakers who could be counted on to give interesting and/or provocative talks.

Yukimasa Ishida
FIS Chair, 2002–2005

I felt that the relationship between Science Board and FUTURE is much more improved and organized compared with the relationship between Science Board and CCCC. It is clear that Science Board leads the science in PICES, developing and managing FUTURE with the guidance of Council. This is a good point. On the other hand, many scientific topics in PICES are related to FUTURE, so there is a little concern that scientific topics not related to FUTURE might disappear or decrease from the PICES agenda. I am not sure this view is right or not, but it is necessary for PICES to have flexibility.

I am happy to know that many scientists from various countries including Japan and from various international organizations attended the PICES meeting this year. For example, as you know, ISC (International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean) is specialized in tuna species and PICES has a wide range of scientific fields. In that sense, activities like joint PICES-ISC WG 34 will improve both the situation of ISC and PICES. Therefore, there is a possibility that PICES can play such a role, through its member countries with other organization.

I think that the PICES website is very helpful for scientists and students who cannot attend the meeting, especially, Presentations and Publications. I hope that these services will be continued and strengthened.

Paul LeBlond
Wooster Award recipient, 2004

As I recall the discussion at the University of Washington meeting which preceded the first PICES annual meeting in Victoria, the goal was to create an organization where countries around the North Pacific would share, in an official government sponsored manner, like in ICES, research aiming at understanding the ocean ecosystem. Some of the impetus came from fisheries issues, but the aim was broader. Scientists were to get to know each other and actually plan and implement common research projects, not just read or listen to each other's papers. Young scientists were to be involved, and PICES was to engage in public education about the ocean.

I think PICES has succeeded, through its annual meetings in successive member countries and through its broad research programs (like FUTURE), in bringing together the best ocean scientists of the North Pacific in common activities. The process is well engaged, and PICES has become an important player in international ocean science thanks to the dedication of individual researchers and people like Alex Bychkov, who have worked hard at facilitating this progress. Congratulations!

Patricia Livingston
Science Board Chair, 1996–1998

I left the PICES 25th Anniversary Meeting feeling that the Organization is doing extremely well. Not only was the Anniversary Meeting a very well planned and organized event from a scientific point of view, but it also provided great opportunities for PICES people throughout its history to get together and celebrate not only where PICES came from but to see the vision of where it is going. I read Sara Tjossem's book on the plane ride home and thought it was a comprehensive and accurate description of the PICES journey and done in an engaging style. I also enjoyed the PICES Memory Book; it was like going through a family album and was a fun way to look back at PICES people and events.

The videos that were shown at the beginning and at the end of the meeting were very powerful and well done. The structure of the meeting was good, and the topic sessions were highly relevant – I did have a tough time trying to decide which talks to see as there were so many interesting ones. Having plenary sessions beyond the Science Board Symposium was very nice. The caliber of the talks was very high, and I especially appreciated the young scientists' contributions, which were often the most enthusiastic and professional of the talks.

Jake Rice
SG-FISP, FUTURE Implementation Plan Writing Team

It was wonderful to renew old friendships and make new ones. It was also an opportunity to see how PICES science has progressed in 25 years (a time frame that looks very long to many, I am sure, but makes those of us who were at PICES 1 really feel what a short time that is in the task of advancing knowledge). In terms of impressions of the meeting and the science, I have four impressions that stand out.

The best first, of course. I was truly and deeply impressed with the quality of science – and communication of the science – by the "early career scientists" who were in attendance. I made a point of going to many of the talks by young career scientists or speaking to them at their posters. I was repeatedly very positively impressed with the scope and depth of the work being presented (regardless of exact topic) and the skill and clarity of the presentations (regardless of the first language of the speaker). If this illustrates the quality of the incoming generation of scientists, the future of PICES science is great indeed.

Second, attending the sessions on the topics that were the foundation of PICES work – oceanographic and ecological processes and models, and climate change - one could not help but be impressed with how deeply the science had drilled in 25 years. The benefits that flow from a continuity of collaborative science over two and a half decades showed clearly in the relevant sessions. The depth of knowledge and the keenness of the ongoing probing even further into these areas show the real maturity of PICES science and strength of collaboration.

But every coin has two sides, and my third impression is the other side of that coin about the continuity of PICES science in climate and ocean processes. In the past decade I have had the opportunity to broaden the scope of my own work, for example with the IPCC Working Group III on Mitigation rather than Adaptation, and working with the UN SDG implementation team on the food security and global hunger aspects of fisheries, rather than just the drivers of stock dynamics and sustainability questions. When I tried to bring in some of these different perspectives during discussion periods of sessions like FUTURE, or in other group settings, I often felt I was hitting an intellectual brick wall. No one said it bluntly, but the sense repeatedly was "But that's not what we do. We have not finished probing the depths of what we are already good at. We can still drill even deeper into the questions we have been pursuing for the past two decades, or if we reach out – it should be only in small steps and steps in directions where all the excellent tools and data we have already developed and tested can be taken with us." The challenges to the planet that need the talents and knowledge of the marine science expert community continue to diversify. I see a fearful tendency of some parts of PICES to not want to keep up with that diversification of challenges, and gaps between what is being done by the PICES expert community and what society needs from us are beginning to be apparent.

Now I hasten to say this is not a universal pattern from the meeting. For example, I was very, very impressed with the Human Dimensions meetings I attended. This is a complex field, fairly new to PICES, and the people at the meetings showed both vision and ambition. The discussions were excellent, as were the plans for a way forward. So there definitely is diversification – but in this area PICES is catching up with other parts of the global marine research community. The social science dimensions of marine research are not new. They are just new to PICES. But at least they are being embraced in an excellent way – just by a very small group within the PICES community.

And it is within those discussions that my fourth and final impression emerged. In the discussions at the Section on Human Dimensions, the leadership and participants were excellent, and when I did make some contributions, all my thoughts were treated with genuine interest and high respect. But I realized over the week that both there and otherwise through the PICES meeting, I was being treated as one of the Elders – wise enough and experienced -, but part of the past and not part of the future. It was a sobering message and one that has stayed with me since returning.

Luis Valdés
IOC-UNESCO Head of Ocean Science, 2009–2015

I realize that PICES is a living and dynamic community, and the recruitment of young scientist is a good policy in terms of preparing the replacement of many of us in the coming future. In the MONITOR meeting I was pleased to see the commitment of their members with PICES, but also their engagement with other international goals such as Nagoya, SDG14, biological module of GOOS, *etc*. In this regard, it is a strategic movement to anchor some of PICES' targets to UN priorities. By doing it in that way, PICES will empower its scientific community and gain in political influence in the international arena.

S-CCME Workshop W5, "*Modeling effects of climate change on fish and fisheries*"

by Anne B. Hollowed, Shin-ichi Ito and John Pinnegar

Introduction

The PICES/ICES Section (Strategic Initiative) on *Climate Change Impacts on Marine Ecosystems* (S-CCME/ SICCME) convened a 1-day FIS-sponsored workshop on November 4 at PICES-2016 in San Diego, USA. The workshop was attended by 46 scientists from eight countries. A similar workshop (WKSICCME Phase 1) was held in conjunction with the ICES Annual Science Conference in Riga, Latvia on September 24, 2016.

W5 was chaired by Drs. Anne Hollowed (USA, PICES), Shin-ichi Ito (Japan, PICES), and John Pinnegar (UK, ICES). It was organized as a Principal Investigators' meeting, providing an opportunity for scientists to discuss the progress of ongoing regional projection modeling nodes. The meeting is part of the roadmap of activities defined at a previous workshop held in Seattle, USA (August 2015, PICES Press Vol. 24, No. 1, pp. 20–23). The roadmap includes identifying regional modeling nodes, aligning common future scenarios, producing and comparing projections within and among regions, and publishing results by late 2018 for consideration by writing teams of the sixth Assessment Report of the Intergovernmental Panel on Climate Change and possibly by the Special Report on climate change and oceans and the cryosphere (SROCC). W5 focused discussions around four topics: i) ongoing regional projects, ii) common future scenarios, iii) advancements in the development of shared socioeconomic scenarios, and iv) issues related to global model selection and bias corrections.

Review of newly funded programs

S-CCME relies on ICES and PICES member countries to provide funding to support the projection modeling that forms the foundation of the Section. It was exciting to learn that many new programs have been funded and are actively striving to meet the goal of providing projected impacts of climate change on marine ecosystems in time for upcoming national and international reviews. These existing or emerging research projects hold great promise for the success of S-CCME.

Discussions of future scenarios

The participants discussed techniques for the development of future socioeconomic scenarios for use in evaluating the trade-offs of different climate change adaptation strategies in several regions. An example was provided within the European Climate change and European Aquatic Resources (CERES) project. Preliminary findings based on case studies of short-, medium- and long-term climate changes scenarios suggest that in the European Union possible developments in governance, social, technological and economic drivers may be just as important to fisheries as climate-driven changes in habitats and species. CERES investigators are combining outputs from physical/ biogeochemical modeling, with socioeconomic storylines to generate a set of combinations of environmental and socioeconomic projections for the fishery sector. A similar approach is being applied in the Alaska Climate Integrated Modeling project (ACLIM), focused on commercial

Participants of Workshop 5 at PICES-2106. Front row, from left: Alan Haynie (USA), Albert Hermann (USA), Cisco Werner (USA), Sukyung Kang (Korea), Phoebe Woodworth-Jefcoats (USA), John Pinnegar (UK), Angelica Peña (Canada); middle row, from left: Shin-ichi Ito (Japan), Michio Kawamiya (Japan), Anne Hollowed (USA), Jacquelynne King (Canada), Kelly Kearney (USA) , Ken Drinkwater (Norway), John Stein (USA), Gavin Fay (USA), Kirstin Holsman (USA), Elliott Hazen (USA), Tyler Eddy (Canada), Motomitsu Takahashi (Japan), Lingbo Li (USA), Sukgeun Jung (Korea), Suam Kim (Korea); back row, from left: Steven Bograd (USA), Franz Mueter (USA), and Jon Hare (USA).

fisheries in the Bering Sea. In the Bering Sea case study, analysts plan to define representative fishing pathways for use in a management strategy evaluation (MSE).

Presentation summaries

Michio Kawamiya (Invited, Japan) reviewed on-going research in Japan to evaluate and improve Global Climate Models and Earth System Models for use in the next Climate Model Inter-comparison Project (CMIP6). He reviewed a new activity, the ocean model inter-comparison project (OMIP), which focuses on evaluating the performance of global models in resolving ocean features. Modeling experiments are starting in early 2017 with 2018 as the target completion date. Preliminary results suggest moderate improvements in the CMIP6 model compared to the CMIP5. As a special project, analysts are focusing effort on responses for 1.5°C trends (the HAPPI-MIP project). This modeling experiment focuses on the implications of a half a degree additional warming prognosis and projected impacts. Time slice ensembles from several models will be examined.

John Pinnegar (Invited, UK) provided a brief overview of the CERES project. The 4-year (2016–2020) project has 26 European partners from 17 countries, including seven industry partners. The goal is to provide bottom-up (industry driven) and top-down (policy recommendations) solutions for how fisheries and aquaculture can adapt to from climate change. Physical projections (Representative Concentration Pathways [RCP] 4.5 and 8.5) will be downscaled using a suite of regional models. Abiotic changes are linked to direct (*e.g.*, physical) and indirect (*e.g.*, biological) impacts on the productivity of key aquaculture species (*e.g.*, salmon, shellfish, seabream, seabass, trout, cod, carp, *etc*.) and the distribution and productivity of target species of mixed pelagic, mixed demersal, and single-species (*e.g.*, bluefin tuna) fisheries. Biological consequences of climate change will feed into bioeconomic models and biological–socioeconomic vulnerability assessments (Fig. 1).

Stakeholder engagement includes both common-framing of future scenarios to be tested and mind-mapping (Bow-Tie analysis) to help envision perceived risks and mitigation strategies. The scenarios include four different "storylines" of the future (Fig. 2). Vulnerability assessments by species/region will take into account the exposure, sensitivity and adaptive capacity of not only species targeted by aquaculture and fisheries but also the industry (farms and fishers).

Dr. Pinnegar focused his talk on methods for developing scenarios for governance, and socioeconomic responses. CERES adopted a holistic approach that considers political, economic, social, technological, legal and environmental factors. CERES developed its socioeconomic scenarios using a modification of the IPCC's Shared Socioeconomic Pathways (SSPs) (Fujimori *et al*., 2016). One of the challenges associated with characterizing these future scenarios was the task of working out how much fish Europeans would be eating under each scenario given the projected population numbers for the periods 2050 and 2100.

Phoebe Woodworth–Jefcoats (USA) presented outcomes of a recent research project (Woodworth-Jefcoats *et al*., in press). In this study climate projections were used to assess the impact of climate change on epi-pelagic habitats in the Hawaiian Islands and central Pacific. Projections based on RCP 8.5 were run using a variety of global earth system models including the Canadian CanESM2, GFDL – ESM2G, GFDL – ESM 2M, and others.

Preliminary results showed a projected decline in potential carrying capacity which was related to metabolic demand coupled with reduction in zooplankton. These findings suggest that warming thermal habitat and declining food availability will reshape North Pacific epipelagic habitat with up to 3 to 4 fewer tuna and billfish species in sub-tropics, with a similar increase in temperate latitudes.

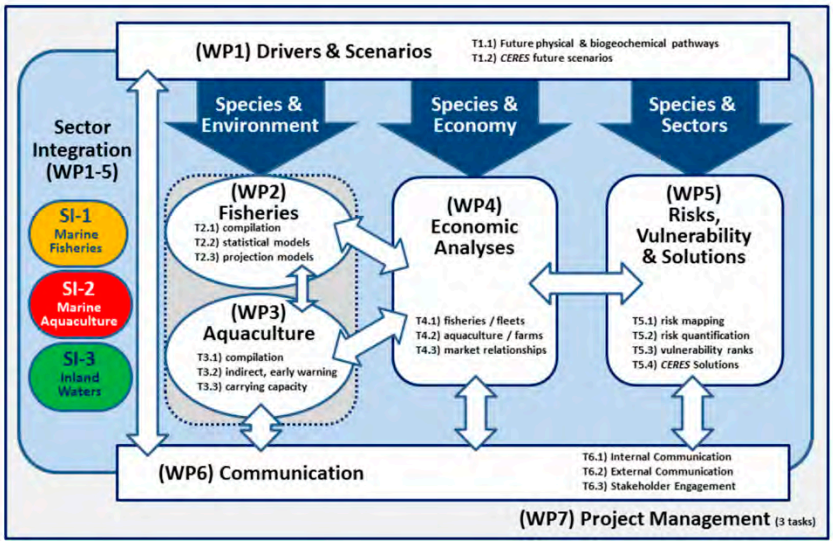


Fig. 1 Diagram of the project structure of CERES. WP = work package, T = Task.

Fig. 2 Diagram of and adaptation of shared socio-economic pathways (SSPs) for use in projecting representative fishing pathways proposed by CERES.

Kirstin Holsman (USA) provided an overview of the Alaska Climate change Integrated Modeling (ACLIM) project currently taking place in the Bering Sea. The ACLIM project is half-way through its 3-year funding period. ACLIM strives to integrate physical, biological, and socioeconomic models to quantitatively project climate change impacts on fish and fishing communities through multi-model analysis of alternative management strategies under different climate change scenarios in the Bering Sea (Alaska). ACLIM is a collaboration of 19 scientists from the National Marine Fisheries Service, the University of Washington, and NOAA's Pacific Marine Environmental Laboratory. The ACLIM project builds on a long history of research on the role of environmental forcing on the Bering Sea ecosystem. This body of research provided the foundation of observations and mechanistic linkages between environmental variability and ecosystem productivity. As part of the project, research scientists are projecting future environmental conditions using output from a suite of Global Climate Models (GCMs) under several representative concentration pathways (Fig. 3). Projected climate change scenarios are downscaled to a regional ocean model to capture core physical and biological features governing ecosystem responses. Projections show considerable spread in temperature outcomes between the different scenarios.

Sukgeun Jung (Korea) presented an updated analysis of climate change impacts on chub mackerel. Chub mackerel larval drift was simulated using an individual based model. Climate projections were downscaled to a regional ocean model for the region surrounding the Korean Peninsula. Dr. Jung also reported on the recent findings of Dr. Sinjae Yoo who compared simulated ocean conditions against observations.

Shin-ichi Ito (Japan) reviewed results from the Global Climate Change Effects on Fisheries and Aquaculture (GCCEFA) project. This integrated study also utilizes a long history of monitoring and process studies that inform the parameterization and selection of functional forms used in projection models. Of concern to S-CCME is that the current project will end in 2017, with no clear funding source to support and update projections.

The goal of the GCCEFA project was to develop tools to track shifts in fish migration in response to climate change and to develop adaptation strategies to respond to projected changes. Target species included Pacific saury and sardine. Results show the southward migration of Pacific saury will be delayed and the northward extent of the migration will be extended. The growth rate may also be delayed, altering the time required to reach maximum weight. These

factors suggest that the mean size of Pacific saury may decline under projected climate scenarios, with strong implications to fisheries which target larger size groups.

Two new developments are emerging from this research effort. The first is the extension of the North Pacific Ecosystem Model for Understanding Regional Oceanography (NEMURO) nutrient-phytoplankton-zooplankton (NPZ) component to include smaller plankton groups or iron limitation facilitated by introducing optimal uptake kinetics as nutrients. The second is the coupling of NEMURO models to a multispecies individual-based model as an end-to-end model. This model will allow modeling prey, predators, and fisheries as interacting units (Rose *et al*., 2015). When completed this will be a remarkable improvement allowing individual-based models to track the full life cycles of modeled species in a multi-species framework that incorporates fishing within a high resolution modeling environment.

Tyler Eddy (Canada) discussed on-going efforts to compare global and regional model projections of climate impacts on fish and fisheries by the Fish Model Intercomparison Project (FISH-MIP). FISH-MIP is a component of the Marine Ecosystems and Fisheries Sector of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP). It consists of a network of scientists studying 15 different models (10 global and 5 regional). FISH-MIP is using a standard selection of GCMs and RCPs and shared socioeconomic pathways (SSPs) to: (a) compare output of a range of global fisheries and ecosystem models, (b) compare output of a range of regional fisheries and ecosystem models within and across regions, (c) compare output of global and regional models in selected focus regions, and (d) engage in inter-sectoral comparison activities within the ISI-MIP framework (longer-term goal).

Jon Hare (USA) discussed a number of research projects focused on projecting the implications of climate variability and climate change on the distribution and abundance of marine species along the Northeast Continental Shelf Large Marine Ecosystem. The analytical methods ranged from qualitative vulnerability assessments (Hare *et al*., 2016) to quantitative Species Distribution Modeling (SDM) (Kleisner *et al*., 2016). Past and current species distribution modeling efforts were summarized with a focus on the statistical model used, the linkages to climate models, and the climate scenarios and time periods used in projections. Dr. Hare noted that essential next steps for future projection on species distribution shifts included studies of: seasonal migration, life history connectivity, process-based models, species interactions, high-resolution climate models or dynamical downscaling, social and economic effects, management/fishing scenarios, and complicated fleet dynamics in the Northeast United States.

Alan Haynie (USA) reported on the ICES/PICES Workshop on "*Economic modelling of the effects of climate change on fish and fisheries*" (WKSICCME_Econ) held in Brest, France, on June 3-4, 2016 and an Alaska-focused workshop held at the NOAA Fisheries Alaska Fisheries Science Center (AFSC) in August. The Brest workshop was associated with the larger ICES/PICES MSEAS Symposium on "*Understanding marine socio-*

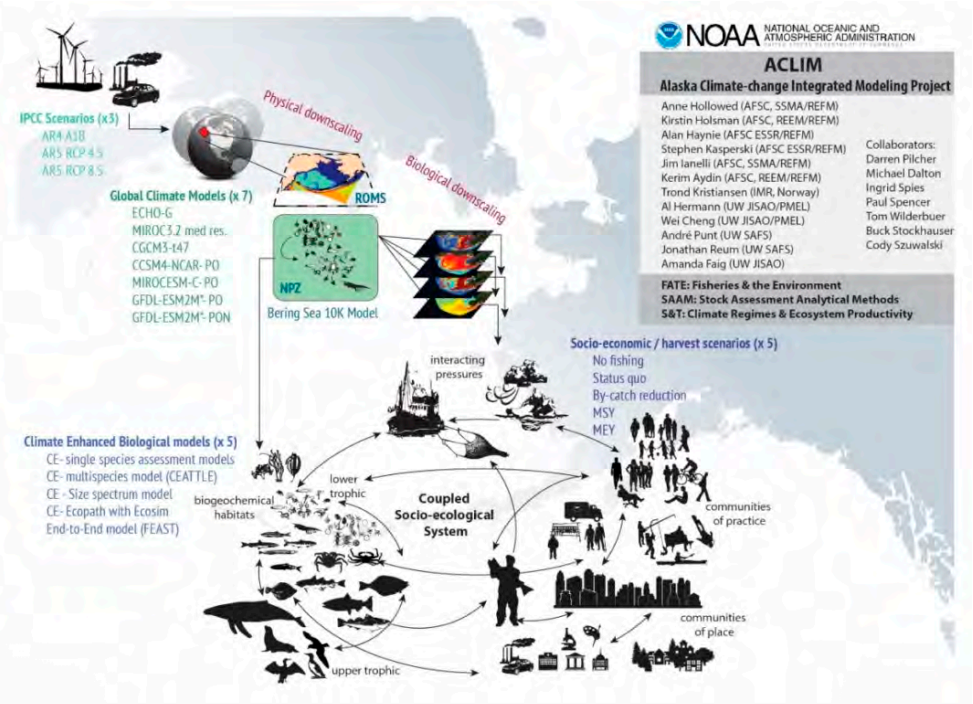


Fig. 3 Schematic of the modeling framework for Alaska Climate-change integrated Modeling (ACLIM).

ecological systems: including the human dimension in Integrated Ecosystem Assessments." The workshop had three primary goals: a) Identify the socioeconomic data and features of the suite of representative future fishing and ecosystem scenarios identified in the S-CCME inter-sessional workshop of August 2015 (see PICES Press Vol. 24 No. 1, pp. 20–23) that could be employed for use in evaluating climate change effects on fish and fisheries, b) Identify how fisheries management policies will interact with climate change and identify how researchers can best evaluate what management tools are most likely to be resilient to climate change effects on fisheries, and c) Identify suites of bioeconomic and spatially explicit models of fishery behavior that can be used to project the implications different climate models on commercially important marine fish stocks in the northern hemisphere. Approximately 35 researchers from biological, economic, and other social science backgrounds participated. Efforts are on-going to write several papers that address the above goals and to standardize scenarios which will be used in regional projects.

Dr. Haynie also described a related workshop held in Seattle as part of the ACLIM Project. In addition to working to integrate ACLIM economic and biological models, the workshop focused on developing management scenarios that would map to the IPCC-shared SSPs. The group is working to complete North Pacific scenarios by the end of 2017.

Regional status reports and updates

Participants were allowed time to provide a short update of the status of climate change research in their country. Reports included presentations from Drs. Jacqueline King (Canada), Xiujuan Shan (China), Suam Kim (Korea), Shin-ichi Ito (Japan), Yury Zuenko (Russia), Elliott Hazen (USA), and Kenneth Drinkwater (Norway).

Discussion

The workshop participants held an open discussion session on best practices for model selection. They discussed the pros and cons associated with different selection options. They also identified two inter-sessional activities for 2017. S-CCME's first meeting will occur on March 5, 2017 in Victoria, British Columbia, Canada. The focus of this workshop will be to review and update the S-CCME/SICCME Implementation Plan. This activity will ensure that S-CCME/SICCME remains on the cutting edge of research efforts focused on projecting the impacts of climate change on marine ecosystems and the communities that depend on them. The second meeting will be a 3-day workshop from July 19–21, 2017 at ICES headquarters (Copenhagen, Denmark). This workshop will provide a forum for the discussion of climate vulnerability assessments. The main goals will be to:

a) Compare and contrast various vulnerability assessment approaches used for fisheries and aquaculture, including their strengths and weaknesses;
b) Discuss opportunities for comparative studies, looking at the relative vulnerability of species in different Large Marine Ecosystems (LMEs);
c) Discuss best practices for extending vulnerability assessments of marine fish and invertebrates to vulnerability of coastal communities and identify a suite of representative concentration pathways for use in vulnerability assessments in the northern hemisphere;
d) Identify opportunities for operationalizing vulnerability assessment methods to enable updates (e.g., release of CMIP6 scenarios) and automating exposure assessments;
e) Draft short statements on climate change impacts and vulnerability for regional ecosystem overviews produced at ICES and potentially other organizations.

Summary

Climate change research is occurring in many regions across the North Pacific and North Atlantic oceans. Preliminary projections of the implications of climate change on ocean ecosystems within the PICES and ICES regions should be completed for most regions by 2018.

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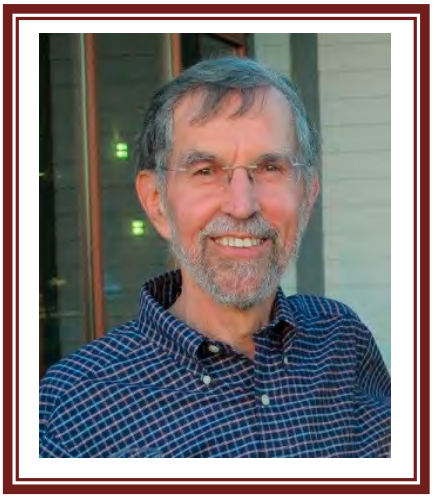
Dr. Anne B. Hollowed (Anne.Hollowed@noaa.gov) is a Senior Scientist with the U.S. National Marine Fisheries Service's Alaska Fisheries Science Center. She conducts research on the effects of climate and ecosystem change on fish and fisheries and leads the Status of Stocks and Multispecies Assessment (SSMA) program. Anne is an Affiliate Professor with the School of Aquatic and Fisheries Sciences at the University of Washington. She is a member of the NPFMC Scientific and Statistical Committee and the Weather, Climate and Fisheries Task Team of the Joint Committee for Agriculture and Meteorology (CAgM) and the Joint Technical Committee for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organization. Anne serves as Co-Chair of the joint PICES/ICES Section on Climate Change Effects on Marine Ecosystems. She was the recipient of the Wooster Award presented at PICES-2015.

Dr. Shin-ichi Ito (goito@aori.u-tokyo.ac.jp) is a Professor at the University of Tokyo. His fields and topics of research range from physical to fisheries oceanography. He co-chairs the joint PICES/ICES Section on Climate Change Effects on Marine Ecosystems (S-CCME) and is a member of POC. He is also a member of the NEMURO-mafia in PICES.

Dr. John Pinnegar (john.pinnegar@cefas.co.uk) is the Director of the Cefas Marine Climate Change Centre. He was appointed UK representative (2013) on the ICES Science Committee (SCICOM). He is honorary secretary of the Fisheries Society of the British Isles and honorary lecturer in the School of Environmental Sciences at the University of East Anglia (2002–present). John is the ICES Co-Chair of the joint ICES/PICES Strategic Initiative (Section) on Climate Change Effects on Marine Ecosystems.

In memoriam
Professor Emeritus Paul J. Harrison, Fellow of the Royal Society of Canada (FRSC)



It is with great sadness that we announce the passing of our colleague Paul J. Harrison on 17 December 2016, after a brief illness. Paul joined the Department of Oceanography at the University of British Columbia in 1975 after completing his Ph.D. at the University of Washington. He soon built an internationally recognized program in Biological Oceanography, which trained 45 graduate students, 15 postdoctoral scholars and countless undergraduates, many of whom went on to be leaders in academia, government and industry. He published >300 refereed scientific papers (nearly 50 in the last 5 years), authored "The Bible" of seaweed physiology and ecology, and is one of the most highly cited scholars in his discipline. Despite being the recipient of many awards, including being elected to the Royal Society of Canada, Paul was a humble individual that was always willing to put the achievements of others above his own. He was also an exceptional educator, and was the first recipient of UBC's Graduate Teaching Award. In 2002, he left UBC to become the Director of the Graduate Program in Atmospheric and Marine Science at the Hong Kong University of Science and Technology. Paul returned to the Earth, Ocean and Atmospheric Sciences Department at UBC as Professor Emeritus in 2010, where he remained as active as ever.

Paul was also very active in PICES. He was an Invited Speaker at the Science Board Symposium at the 1997 PICES Annual Meeting in Pusan, Korea. He represented Canada on the BIO Committee from 1997–2003 and served on Working Group (WG 15) on E*cology of Harmful Algal Blooms in the North Pacific* and the Advisory Panel on *Iron Fertilization Experiment*. In addition to authoring or co-authoring numerous papers on phytoplankton–biochemistry in the North Pacific, Paul served as Guest Co-Editor for the Special Issues on The Joint Global Flux Study (Canada) in the NE Subarctic Pacific (1999, Deep-Sea Research II 46), North Pacific Biogeochemical Processes (2004, Deep-Sea Research II 49) and Subarctic Ecosystem Response to Iron Enrichment Study (2006, Deep-Sea Research II 53).

A celebration of Paul's life is planned in March.

Workshop W9, "*The role of the northern Bering Sea in modulating arctic environments: Towards international interdisciplinary efforts*"

by Lisa Eisner, Kirill Kivva and Matthew Baker

Despite the fact the Bering Sea is outside the Arctic Ocean, in many ways it behaves as an Arctic sea and is an important link between the Arctic and the Pacific. The northern Bering Sea (NBS) influences the state of the southern Chukchi Sea ecosystem as well as the functioning of many other Arctic regions, including the central Arctic. The Pacific Arctic Region has received considerable attention during the past few years: RUSsian-American Long-term Census of the Arctic (RUSALCA) annual cruises and publications; Adaptation Actions for the Changing Arctic AMAP Report part C, and the Pacific Arctic Region synthesis (Grebmeier and Maslowski, Eds., 2014). Yet, the scientific efforts in the Northern Bering–Southern Chukchi Sea region are mostly conducted at the national level. At some degree, they are not jointly coordinated.

The goal of this workshop was to bring together researchers representing multiple national and international institutions and multiple scientific disciplines (*e.g.*, physical oceanography, chemical oceanography, biological oceanography, fisheries) to share data, share knowledge, build collaborations and conduct outreach. We encouraged attendance by scientists interested in:

1) physical oceanography and chemical fluxes,
2) plankton distribution and ecology,
3) fisheries and ecosystem dynamics, and
4) modeling efforts across the NBS region.

Between 15 and 25 people attended W9 (held on November 3 at PICES-2016 in San Diego, California, USA). Ten presentations (see the PICES-2016 website) were made (five in morning and five in afternoon), followed by morning and afternoon discussion periods.

Short descriptions of presentations

The workshop consisted of three invited 30-minute talks and seven contributed 20-minute talks, summarized here in order of presentation. One poster was also included, "*Seasonal dynamics of dissolved inorganic nutrient in the Bering Sea*" by Kirill Kivva who received Best Poster Award by an early career scientist for POC-sponsored workshops and sessions.

Seth Danielson (invited) from the College of Fisheries and Ocean Sciences (CFOS) at the University of Alaska Fairbanks (UAF) assessed the role of "*Currents and water mass structure in and near the Gulf of Anadyr*". He addressed the primary flow patterns in the NBS, baroclinic currents in the Gulf of Anadyr, when and where water mass modification occurs and how recent years compare to past decades. Key points include: there has been excellent CTD coverage across the entire NBS in since 2000; mean thermohaline fields reflect the important regional drivers: Pacific–Arctic pressure head, Anadyr Current, river discharges, winter freezing and these data provide insight to the locations and roles of advection and mixing; recent thermal conditions appear to be outside the envelope (higher) of nearly the entire last century (Fig. 1).

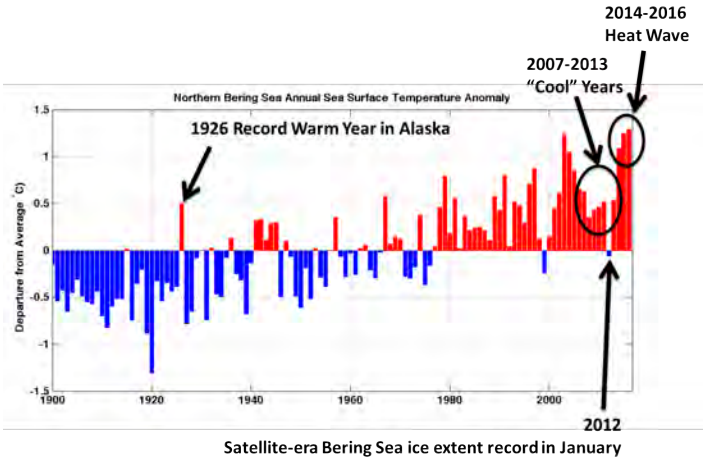


Fig. 1 Northern Bering Sea 1900–2016 annual SST anomaly. Figure courtesy of Seth Danielson, UAF.

Alexander Zavolokin (invited) from the North Pacific Fisheries Commission (NPFC) presented on the "*Impact of oceanographic fluctuations on the northwestern Bering Sea ecosystem*". His talk described the impacts of a change in water circulation for 2007–2011 that likely resulted in lower water inflow to the north. This change affected the distribution and abundance of highly migratory fish and might have caused biomass fluctuations of squids and mesopelagic fish. There were no pronounced changes in total zooplankton biomass in the western Bering Sea, but there was an increase in biomass of the cold water hyperiid amphipod *Themisto libellula* and a decrease in the small copepod *Oithona similis*. Finally, after the shift in water circulation, the intensity of trophic flows between different nekton species and zooplankton changed, while total food consumption by nekton remained at a similar level (2003–2006 compared to 2007–2010) (Fig. 2).

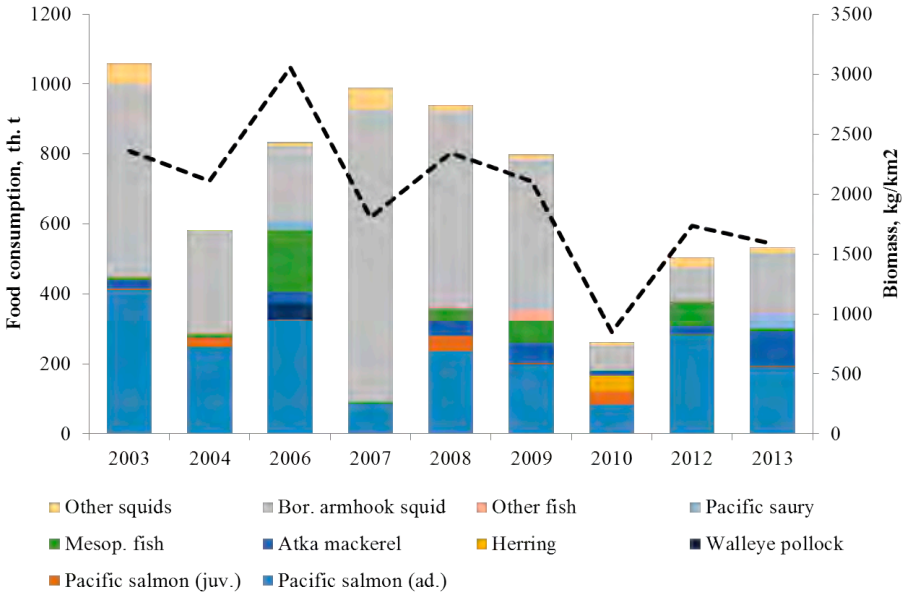


Fig. 2 Food consumption by nekton in the northwestern Bering Sea. Figure courtesy of Alexander Zavolokin, North Pacific Fisheries Commission.

Ellen Yasumiishi from the NOAA Alaska Fisheries Science Center (AFSC) discussed "*Climate related changes in abundance and range shifts of fish and jellyfish in the eastern Bering Sea, 2002–2015*." Main findings include: in warm years, capelin were distributed farther north and juvenile sockeye salmon were distributed farther north and west, and there was no difference in the distribution of herring or jellyfish in warm and cold years (Fig. 3); herring and juvenile sockeye salmon abundances increased with summer warming; and jellyfish biomass was negatively correlated with sea surface temperature (SST) at a 2-year lag (t-2).

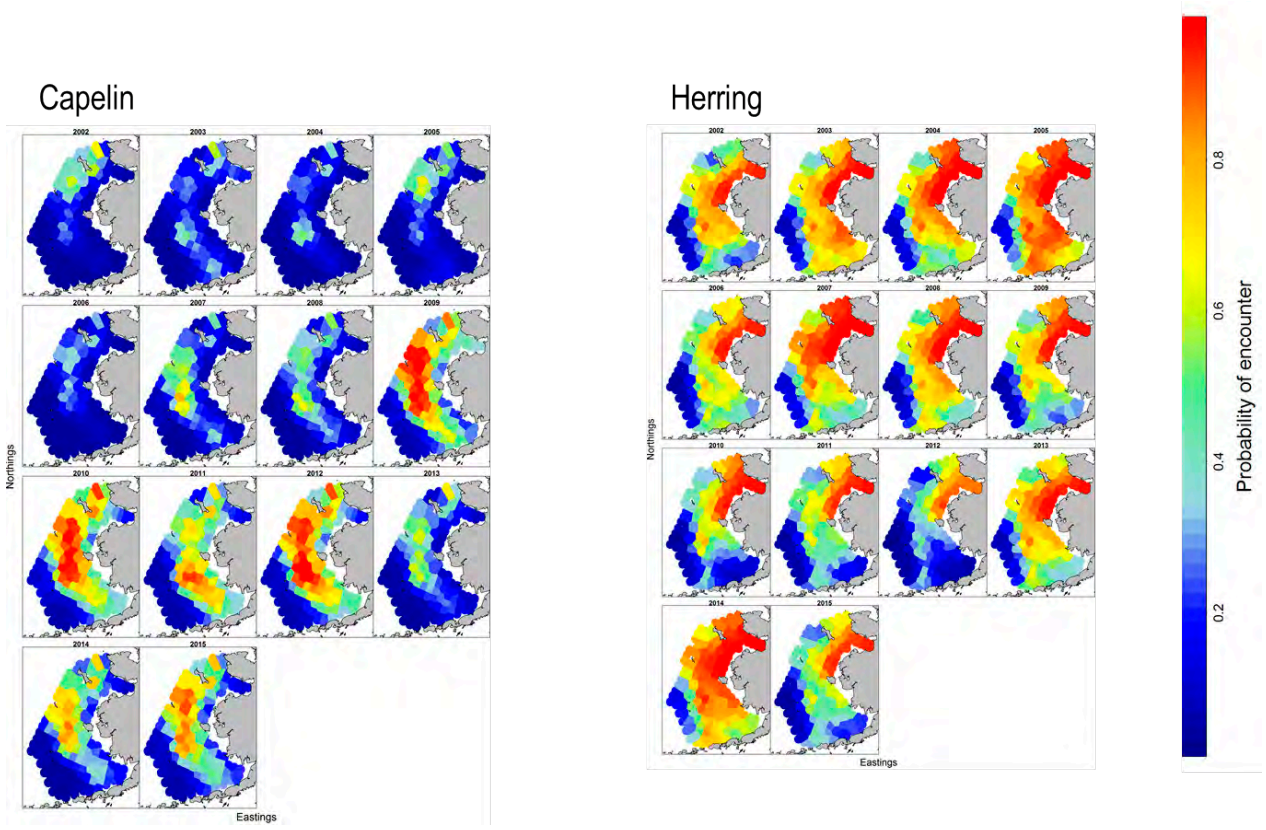


Fig. 3 Modeled probability of capture of capelin and herring for years 2002–2015 in the eastern Bering Sea. Warm years: 2002–2005 and 2014–2015; cold years: 2007–2012. Figure courtesy of Ellen Yasumiishi, AFSC NOAA.

Yury Zuenko from the Pacific Research Fisheries Center (TINRO-Center) reported on "*Environmentally driven variability of zooplankton composition in the northwestern Bering Sea and its influence on the pollock fishery*". This talk concluded that temperature and salinity conditions in the Navarin area from summer to fall depend on direction of advection controlled by the size and position of the Lawrence Cold Pool (very cold portion (< 0°C) of the Bering Sea cold pool situated southwest of St. Lawrence Island), determined by the severity of the preceding winter. For example, a strong along-slope current is formed after a relatively warm winter and provides heightened temperature and salinity. Environmental conditions favorable for high abundance of zooplankton in this area occur after both cold and warm winters, *e.g.*, high abundances can be seen in relatively cold years within warm periods or in relatively warm years within cold periods. Transport of euphausiids by currents from the Green Belt to the Navarin area is crucially important for pollock feeding. High annual landings of pollock in the Navarin area are possible only in years when pollock are able to continue feeding into fall (preying mostly on euphausiids) (Fig. 4).

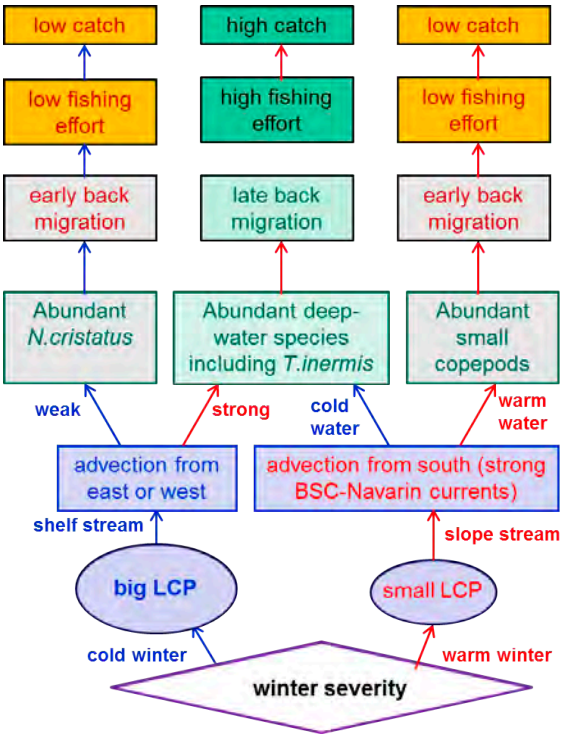


Fig. 4 Scheme of pollock fishery conditions development in the Navarin area, Bering Sea. LCP indicates Lawrence Cold Pool. Figure courtesy of Yury Zuenko, TINRO-Center.

Lisa Eisner from NOAA AFSC spoke on "*Spatial variations in late summer chlorophyll a and zooplankton distributions in the northeastern Bering Sea*". She concluded that between warm (2003–2005) and cold climate stanzas (2007–2012) changes in temperature, ice, chlorophyll *a* (Chl-*a*) and zooplankton composition are greater in the south than the north, although changes in the north are still significant for some regions. There is lower Chl-*a*, lower zooplankton biomass and more gelatinous zooplankton in the north than the south. High Chl-*a* and high abundance of large zooplankton occur in south Bering Strait and there is a negative relationship of Chl-*a* to temperature, unlike in the south Bering Sea. There are abrupt gradients in zooplankton composition from the north Bering Sea to the Chukchi Sea, related to water mass and latitude, with northward transport important.

Gennady Khen's (invited, TINRO-Center), presentation was given by Kirill Kivva who described "*Summer water masses and fish communities in the northwestern Bering and western Chukchi Seas in 2003–2010*". The study area was classified into six water masses: Anadyr + Alaska Coastal Water (ACW), Diluted Gulf Water, Siberian Coastal Water, Bering Summer Water (BSW), Remnant Pacific Winter Water, and Newly Ventilated Winter Water. The Navarin (Anadyr) current (formed in spring due to changes in wind direction) is the main pathway for transport of relatively warm and salty BSW into the Arctic. Main aggregations of Pacific salmon, walleye pollock, Pacific cod, and Pacific herring in the Gulf of Anadyr occurred in ACW. In the Chukchi Sea (mainly within ACW), only mature chum, sockeye, and Chinook salmon were caught. In cold and normal years, Arctic cod feed near the Bering Strait within ACW, while in warm years, they move north and westward into BSW (Fig. 5).

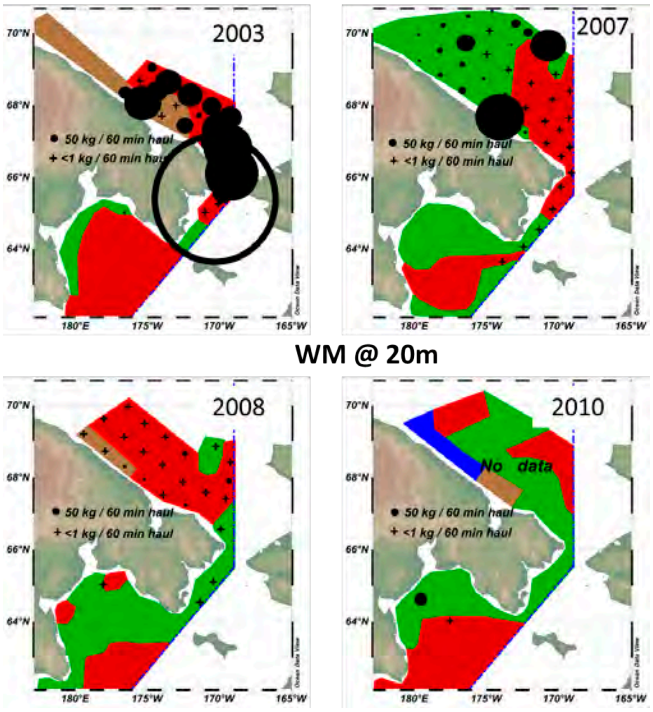


Fig. 5 Distribution of Arctic cod overlain on water mass. Red indicates ACW, green BSW, brown Siberian Coastal Water and blue Remnant Pacific Winter Water. Figure courtesy of Gennady Khen, TINRO-Center.

Jared Weems (student speaker) from UAF talked about the "*Early life history ecology of larval and juvenile blue king crabs in the US Subarctic*". Two study questions were posed: Are Pribilof Island blue king crab juveniles a bottleneck in stock recruitment processes? Will blue king crab populations contract with climate change? Preliminary results evaluated juvenile crab abundance and essential habitat; research is ongoing.

Ed Farley from NOAA AFSC presented on "*Defining critical periods for Yukon River Chinook salmon*" which focused on objectives to: extend an integrated ecosystem model into the NBS, develop annual indices (1970–2012) of size-selective mortality for Yukon River Chinook salmon during the first summer at sea (using models and data), identify key processes/mechanisms that affect the growth rate of salmon during critical periods, and test key processes/mechanisms in forecast models.

Al Herman from the Joint Institute for the Study of the Atmosphere and Ocean (JISAO), University of Washington examined the "*Statistical downscaling of global projections to the Bering Sea based on an ensemble of regional model output*". Twelve downscaling runs of global projections have been completed (one model run for bottom temperature is shown in Figure 6); a multivariate method yields promising results and analysis is underway; there are differences across modes derived from different IPCC models, especially for zooplankton; and there are hints at a negative relationship between SST and Chl-*a* in the NBS.

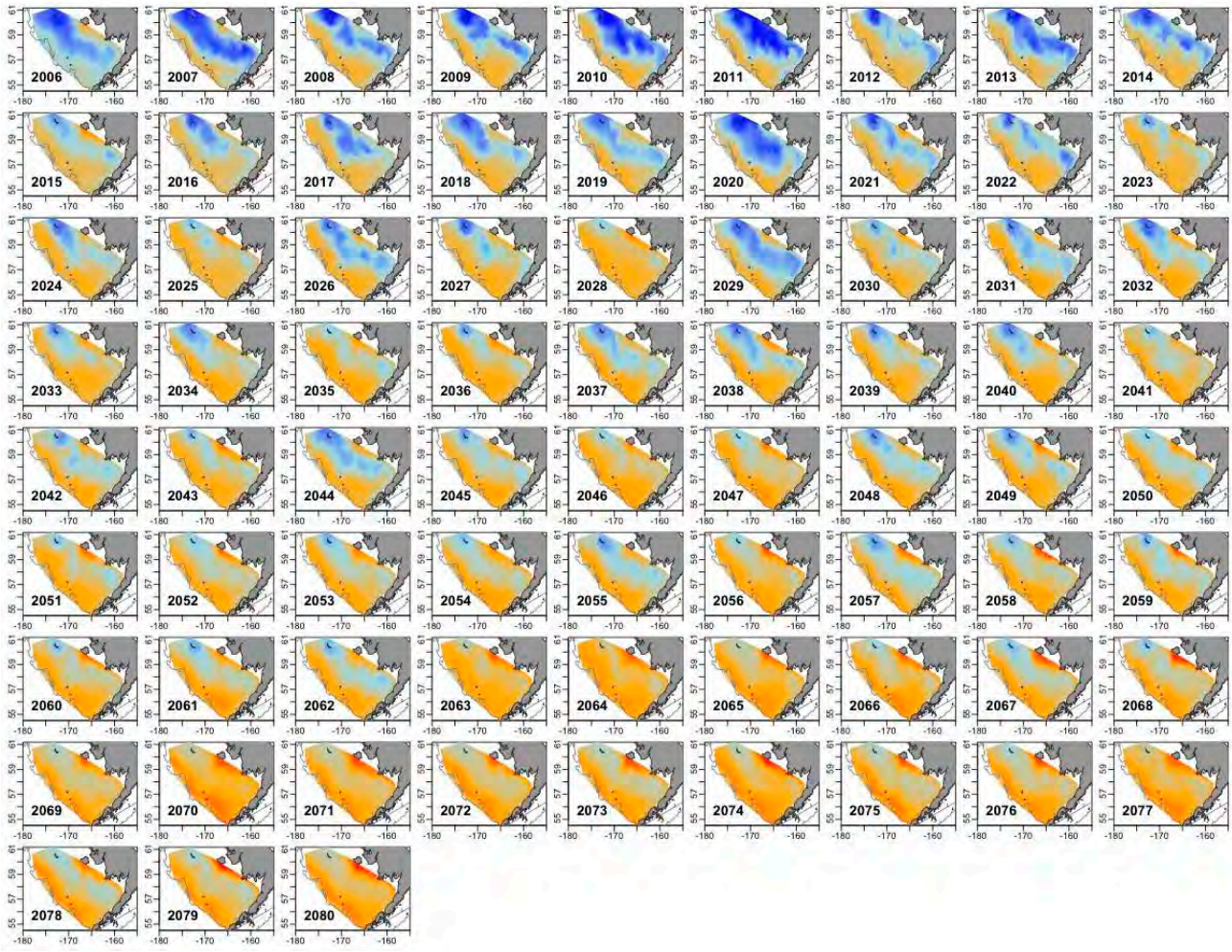


Fig. 6 One future realization of bottom temperature for the eastern Bering Sea. Figure courtesy of Al Hermann, JISAO UW.

Matthew Baker from the North Pacific Research Board (NPRB) examined "*Opportunities for data sharing in the northern Bering Sea – Research and data to support international and interdisciplinary analyses*", providing an overview of current and future research efforts in the Pacific Arctic, including national research efforts, international research programs (*e.g.*, NPAFC, RUSALCA), and new efforts (*e.g.*, NPRB Arctic Integrated Ecosystem Research Program). He also reviewed existing ecological time series observations and the potential new mechanisms for data sharing and exchange to understand processes, structure, and interactions in the northern Bering Sea and associated ecosystems.

(continued on page 29)

A symposium to mark the 60th anniversary of Station Papa/Line P

by Tetjana Ross and Andrew Ross

What does it take to build an oceanographic time series capable of distinguishing climate change from decadal variability in the Northeast Pacific Ocean; a time series that is the envy of many nations and has formed the backbone of paradigm-changing process studies? What must be done to increase the value of this time series in the future? These and many other questions were discussed at the recent PICES co-sponsored symposium marking the 60th anniversary of the Station Papa/Line P ocean monitoring program. The other co-sponsors were Fisheries and Oceans Canada (DFO) and Ocean Networks Canada.

The 2-day symposium, held on November 29–30, 2016 at the Institute of Ocean Sciences (IOS) in Sidney, BC, Canada, bought together about 80 people, including government scientists and academics from the United States, Japan, and across Canada. The event kicked off on the evening of November 28 with a public lecture, "*The North Pacific: Our ocean is changing and why we should care*" by Dr. Ken Denman at the Shaw Centre of the Salish Sea. This proved so popular that about 40 people (including some symposium attendees) had to be turned away at the door; even the standing-only area was filled!

During each day of the symposium, long poster sessions were framed with invited plenary lectures to set the theme. These long, late-morning breaks to view posters worked very well and stimulated lots of discussion, some of which continued in plenary. The theme of the first day was "*Celebrating accomplishments*", where speakers reviewed many of the Line P program's successes in assessing climate change in the Northeast Pacific and acting as a springboard for process studies. The theme of the second day was "*Looking forward*", where plenary speakers with an international perspective sparked reflection on how Line P complements and interacts with other oceanographic time series. This was supported by many shorter talks and posters presenting the vision for new work along Line P.

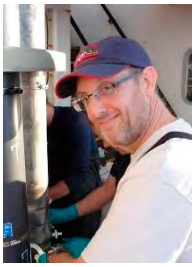
The Line P time series comprises a chain of oceanographic stations stretching from Vancouver Island to 50°N, 145°W in the Alaskan Gyre. At 60 years (and counting) this is one of the few ocean time series of sufficient quality and duration to be useful in examining long-term climate change and variability in the ocean. As such, the Line P program is the envy of oceanographers in other parts of the world. These include scientists like invited speaker Dr. William Large (US National Center for Atmospheric Research) who commented that the upper ocean at Station Papa was better known by the mid-1990s than the Southern Ocean is today, making Line P a natural ocean laboratory in which marine ecology and biogeochemistry, climate change and variability can be successfully studied.

Dr. Roberta Hamme at her poster during the Poster Session.

Dr. Meghan Cronin (US National Oceanographic and Atmospheric Administration), another invited speaker, paid tribute to the foresight of DFO scientists at IOS in first seizing the opportunity to make oceanographic measurements from operational weather ships and then seeing the value in creating and maintaining long-term time series of oceanographic measurements to support future ocean and climate research. Finally, during her introductory remarks, Dr. Carmel Lowe (DFO Pacific Regional Director of Science) mentioned being approached at the 2016 PICES Annual Meeting in San Diego by a delegation of Korean scientists, who asked her how Canada was able to establish and sustain such a successful ocean monitoring program, to which she replied that the three key aspects are: 1) the vision and dedication of individuals, 2) communicating the value of the work, and 3) partnerships. This symposium provided a venue to advance all three. For more information on the symposium see https://www.waterproperties.ca/linep/STPAPA60symposium/.

Participants of the Station Papa/Line P Symposium.

Dr. Tetjana Ross (tetjana.ross@dfo-mpo.gc.ca) is a Research Scientist for Fisheries and Oceans Canada based at the Institute of Ocean Sciences in Sidney BC, Canada. She is an ocean physicist who develops new ways to observe the ocean – from observing ocean mixing using sound to taking photographs of zooplankton in turbulence. Nowadays, she rarely goes to sea, sending robots out to do the work for her: both gliders and Argo floats (i.e. she currently leading the Pacific component of DFO's Argo and glider programs). In PICES she is member of the Technical Committee on Monitoring.



Dr. Andrew Ross (Andrew.Ross@dfo-mpo.gc.ca) is a Research Scientist and Section Head of Ocean Ecology and Biogeochemistry at the Fisheries and Oceans Canada Institute of Ocean Sciences (DFO-IOS) in Sidney BC, Canada. He develops and uses analytical methods to study the speciation, distribution and bioavailability of trace metals in the ocean and the biochemical responses of marine organisms to stress and disease. He is a member of the IOC-UNESCO time series working group IGMETS and holds an adjunct appointment in Biochemistry and Microbiology at the University of Victoria, Canada.

(Workshop W9 continued from page 27)

Discussion issues

During the morning discussion period, potential topics of interest for international collaboration included research on physical oceanography, biological oceanography and productivity, and fish and invertebrate ecology. In the afternoon, workshop participants discussed potential ways to encourage interdisciplinary and international collaboration and data sharing and dissemination. The Co-convenors suggested that a second workshop be held at PICES-2017 in Vladivostok, Russia to engage more scientists working in the northwestern Bering Sea. This suggestion was met with approval by participants.

Recommendation

A follow-up workshop is recommended at PICES-2017 to promote synthesis and understanding of physical and biological interactions in the northern Bering Sea and international efforts towards data sharing, active research and increased collaboration at the international level. All scientists interested in these topics are welcome to attend.

Kirill Kivva (kirill.kivva@gmail.com) is a Researcher at the Russian Federal Research Institute of Fisheries and Oceanography (VNIRO). His main scientific area is nutrient dynamics and primary productivity assessment in the Bering Sea. He also contributed to the North Pole research operations and several scientific cruises to the North Pacific and Arctic oceans in 2008–2015.

Dr. Matthew Baker (Matthew.Baker@nprb.org) is the Science Director at the North Pacific Research Board and lecturer at the University of Washington Friday Harbor Laboratories. His research focuses on forage fish dynamics, habitat mapping and model development, and using analyses of biophysical interactions to parameterize multispecies models. Matt serves on the Steering Committee of the Arctic Integrated Ecosystem Research Program in the northern Bering and Chukchi Seas. He formerly worked at the NOAA Alaska Fisheries Science Center and was a researcher in the NPRB/NSF Bering Sea Project.

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 eastern Bering Sea and Chukchi Sea research programs.

To the interface and beyond: Results and legacy of SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces

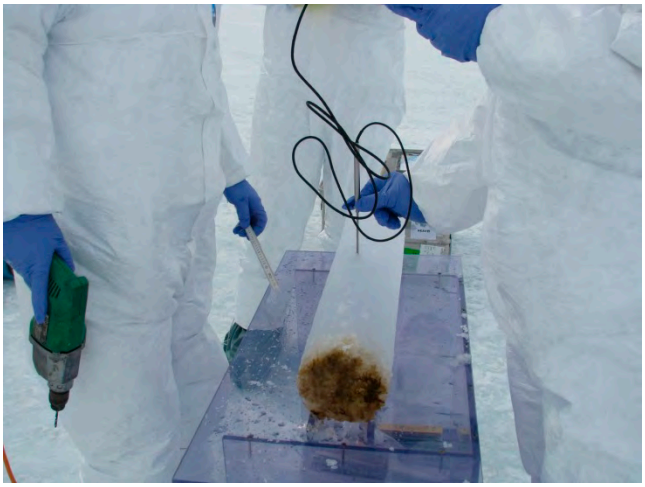
by Lisa A. Miller

This is a story that began with the Fram Expedition of 1893–96. Well, perhaps it's not necessary to go back that far. Instead, let's start in 2009, when a group of people interested in sea ice convened a session at the Open Science Conference of the Surface Ocean–Lower Atmosphere Study (SOLAS) in Barcelona, Spain. At that time, the new field of sea-ice biogeochemistry was exploding. Scientists working at both poles had discovered that sea ice contained extremely high concentrations of dimethyl sulfide (DMS), that inexplicably large quantities of CO_2 were moving in and out of the ice, and that changing sea-ice structure, as well as distributions, was impacting polar primary productivity. It had become clear that sea ice plays a much larger role in the biogeochemical cycles of climatically important compounds than had previously been thought. However, at the same time, we were painfully aware that the global community did not have the capacity to effectively study biogeochemical processes occurring within the ice. Thus in Barcelona, the idea was hatched to form an international working group focussed on sea-ice biogeochemistry, and with additional support from the European Union, through a COST Action 735 workshop held in Amsterdam in April of 2011, a successful working group proposal was prepared for the Scientific Committee for Oceanographic Research (SCOR).

The original SCOR Working Group 140 on Biogeochemical Exchange Processes at Sea-Ice Interfaces (BEPSII) included 10 full members, myself as a PICES-supported associate, and 26 other associate members. Over the subsequent four years, the mailing list expanded to include nearly 100 interested scientists. The Working Group was organized around three task groups focussed on what we felt were the most critical problems facing the community:

1. ***Methodologies and intercomparisons*** This task group published a treatise on the methods used to study sea-ice biogeochemistry, including best practices and recommendations for future method development (Miller *et al*., 2015). We also designed intercalibration experiments and facilitated their opportunistic implementation during field expeditions.
2. ***Data*** The primary goals were to compile existing data sets and develop standardized protocols for recording and archiving sea-ice biogeochemical data. Data compilations were completed for chlorophyll (Meiners *et al*., 2012) and iron (Lannuzel *et al*., 2016), and efforts are still underway for inorganic carbon, nutrients, and particulate organic carbon. We also developed standardized data sheets for documenting sea-ice biogeochemical parameters.
3. ***Modelling*** In a concerted effort to facilitate the productive exchange of information and ideas between observationalists and modellers (Steiner *et al*., 2016), this task group has published a series of articles documenting what is and is not known about biogeochemical processes occurring in sea ice and their relevance on regional and global scales (Vancoppenolle *et al*., 2012; Bowman, 2016; Grimm *et al*., 2016; Moreau *et al*., 2016).

Many of these reviews, as well as a number of papers on the results of specific experiments, expeditions, and model implementations are being published in a BEPSII special issue of the journal *Elementa: Science of the Anthropocene*.



Characterizing the sea ice off Cape Evans, Southern Ocean, November 2012. Photo credit: F. Fripiat.

As SCOR Working Group 140 was winding down, it became clear that the group was not ready to disband. Quite to the contrary, we found that once we had figured out how to resolve our methodological inconsistences, document our data properly, and actually talk to each other, we were ready to tackle some real scientific questions together. Therefore, with encouragement from both SOLAS and the Climate and Cryosphere program (CliC), BEPSII has evolved into a larger, long-lived consortium that will continue working together to understand the role of sea-ice biogeochemistry in the global system, including building capacity in the scientific community and developing new approaches. The first meeting of this expanded BEPSII consortium coincided with the final meeting of SCOR Working Group 140 in Paris during March 2016. In addition to our SOLAS and CliC sponsorship, BEPSII is now also supported by the

Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC). In addition, SCOR has approved a new working group dedicated specifically to intercalibration experiments for sea-ice biogeochemical methods (Measuring Essential Climate Variables in Sea Ice, ECV-ice).

Going forward, the goals of the expanded BEPSII consortium are to:

- Develop dedicated, consistent methodologies for sea-ice biogeochemical research;
- Establish effective sea-ice biogeochemical data archiving approaches and databases;
- Foster ecological process studies to determine their impact on biogeochemical cycles;
- Foster technological developments towards large-scale, autonomous, and high-frequency sampling of sea-ice biogeochemical parameters;
- Improve the representation and evaluation of sea-ice biogeochemistry in regional and Earth System numerical models;
- Synthesize and integrate observational and modeling efforts; and
- Continually revise and renew scientific foci, teams, and objectives.

These goals are organized among four task groups:

1. *Methodologies and data collation* (leads: Klaus Meiners, Klaus.Meiners@aad.gov.au and Lisa Miller, lisa.miller@dfo-mpo.gc.ca);
2. *Modelling and observational process studies* (leads: Hauke Flores, Hauke.Flores@awi.de, and Nadja Steiner, nadja.steiner@canada.ca);
3. *Syntheses and outlook* (leads: Delphine Lannuzel, Delphine.Lannuzel@utas.edu.au, and Martin Vancoppenolle, martin.vancoppenolle@locean-ipsl.upmc.fr); and
4. *Outreach* (leads: Bruno Delille, Bruno.Delille@ulg.ac.be and Letizia Tedesco, Letizia.Tedesco@ymparisto.fi).

Anyone interested in participating in BEPSII is encouraged to contact the relevant task group leaders or the BEPSII Chairs, Jacqueline Stefels (j.stefels@rug.nl) and Nadja Steiner (nadja.steiner@canada.ca).

The next BEPSII meeting will be held in La Jolla, California, on April 3–5, 2017. For up-to-date information, see the BEPSII website or follow us on Twitter (@BEPSII_seaice).

Participants of the final SCOR Working Group 140 meeting in Paris, March 16-18, 2015. Co-Chairs: Jacqueline Stefels and Nadja Steiner (front row, third and forth from left); PICES associate, Lisa Miller, middle row, wearing red jacket.

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(continued on page 35)

Webcam monitoring and modeling of Japanese tsunami marine debris washed ashore on the western coast of the North America

by Atsuhiko Isobe, Shin'ichio Kako, Tomoya Kataoka, Shinsuke Iwasaki, Charlie Plybon and Thomas A. Murphy

Introduction

According to an estimate by the Ministry of the Environment (MoE) of Japan (https://www.env.go.jp/en/focus/docs/files/20120901-57.pdf), about 5 million tons of Japanese tsunami marine debris (JTMD) flowed into the North Pacific on March 11, 2011. Part of this JTMD (estimated at 1.5 million tons) remained afloat, is still drifting in the North Pacific, and thus, there remain concerns about this debris reaching the Pacific Islands and North American coasts, even at the present time. Attention is especially focused on coastal Japanese species carried by JTMD because these invasive species could damage the indigenous marine ecosystem: see the website of the PICES/MoE project on Assessing the Debris-Related Impact of Tsunami project (ADRIFT).

However, it is a difficult task to estimate the abundance of JTMD (hence, invasive species) washed ashore. To date, there have been no published studies investigating temporal variations of marine debris abundance on beaches along the western U.S. and Canadian coasts over a period longer than one year (including seasonality), and with a monitoring interval shorter than a week. Consequently, there is no way of knowing "critical factors" governing the temporal variations of debris abundance on these beaches. In the present study, we installed a webcam system (Kako *et al.*, 2010; Kataoka *et al.*, 2012) on a beach on the western U.S. coast to hourly monitor marine debris abundance over a 1-year period. Using this record, we attempted to develop a numerical model to estimate the abundance of the JTMD washed ashore on the western U.S. and Canadian coasts. This is a brief preliminary report by the ADRIFT webcam team, and several peer-reviewed papers (Iwasaki *et al.*, in prep; Kako *et al.*, in prep; Kataoka *et al.*, in prep) are expected to be published in the near future.

Webcam system

We installed a webcam overlooking a beach directly facing the North Pacific in Newport, Oregon (Fig. 1). The webcam was set up to sequentially and automatically take photographs of a part of the beach on which marine debris, including driftwood and anthropogenic debris, were littered. Photographs were taken every 60 minutes during the day (10 times from 9:00 am to 6:00 pm Pacific Standard Time) from April 3, 2015 to the present (still ongoing). Hereinafter, "the abundance of marine debris" was evaluated by visually counting the number of objects on the beach from photographs. A single photograph was selected from 10 photographs taken on each day with the aim of identifying as much marine debris as possible during the daytime. Thereafter, the observer counted the number of marine debris objects, regardless of their sizes.

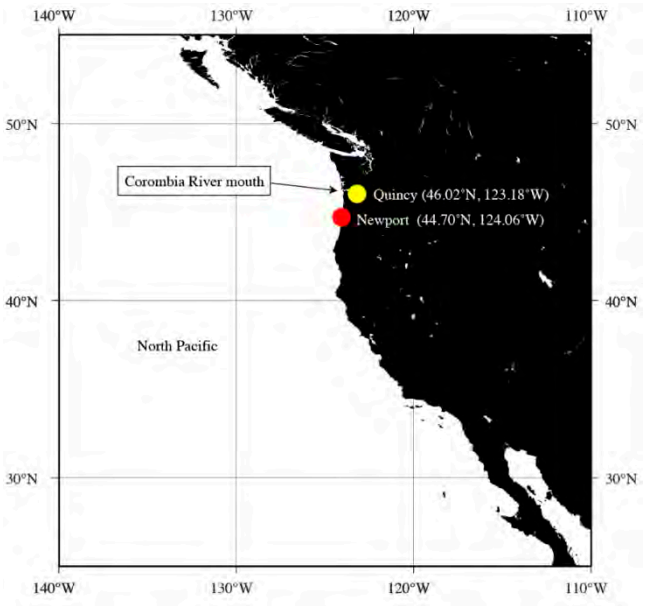

Fig. 1 Location of Newport where the webcam system was installed.

The temporal variation of the number of marine debris objects counted on the beach was compared with that of satellite-derived wind data to investigate the potential cause(s) of the variation. We used a global gridded wind vector dataset constructed by applying an optimum interpolation method (Kako *et al.*, 2011) to the Level 2.0 Advanced Scatterometer (ASCAT) wind product (Verspeek *et al.*, 2009).

Temporal variation of debris abundance: possible causes

First, it seems likely that the meridional wind component was responsible for the seasonal (summer to winter) increase of the debris abundance. In fact, the seasonal increase was revealed when southerly winds prevailed because of the development of the Aleutian low over the North Pacific (compare the two linear trends between September to March in Figure 2a). Looking landward at the coast, the seasonal increase of the marine debris during the southerly winds suggests that debris abundance is dependent on the occurrence of coastal upwelling/ downwelling and their associated cross-shore Ekman flows. In fact, it is well known that coastal upwelling (downwelling) occurs along the western U.S. coast, especially during the summer (winter) (Duxbury *et al.*, 2002). When the southerly

(downwelling-favorable) winds prevail, it is likely that the onshore-ward Ekman transport carries marine debris toward the coast, and that the debris littered on the beach increases thereafter. Meanwhile, the beach litter decreases when drifting marine debris is prevented from approaching the coast because of the offshore-ward Ekman transport induced by the northerly (upwelling-favorable) winds.

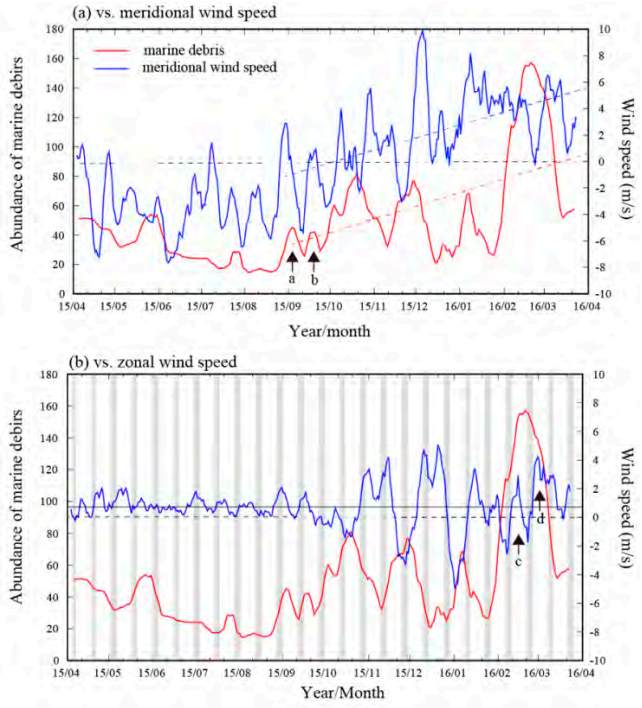

Fig. 2 Comparison of marine debris abundance with wind speed components (7-day running mean). Debris abundance (red curves) is depicted with (a) the meridional wind speed and (b) zonal wind speed, respectively. The red (blue) dashed line in (a) indicates the linear trend of marine debris abundance (meridional wind speed) from September to March. Gray bars in panel (b) indicate the period of the spring tides.

Second, the sub-monthly fluctuations of debris abundance (Fig. 2) superimposed on the seasonal increase seem to be related to those that appeared in the zonal wind component, especially in the latter half of the study period (from mid- to end of October; Fig. 2b). It is interesting that the marine debris decreased when the westerly (onshore-ward) winds prevailed in winter. One may consider that the debris abundance varied in a non-intuitive manner because onshore-ward winds were likely to carry floating objects onto the beach due to wind-induced surface currents and leeway drift. It should be noted that the minimal abundance in the latter half of the study appeared when westerly winds prevailed at spring tides (gray bars in Fig. 2b). Therefore, it is reasonable to consider that the wind setup resulted in the re-drifting of debris during the westerly (onshore-ward) winds at spring tides (particularly at flood tide). The photograph of the beach on December 11, 2015, when the westerly winds prevailed at the first spring tide, shows that the high-tide line moved landward over the entire beach (Fig. 3, middle). Thus, it is likely that the seawater occupying the entire beach mostly "swept away" the marine debris (Fig. 3, bottom), which had been accumulated on the beach until the occurrence of the wind setup (Fig. 3, top).

Fig. 3 Photographs of the day before (December 9, 2015), during which (December 11), and after (December 13) the westerly winds prevailed at the spring tide. The change in the ground formation just below the webcam was the result of a land slide which occurred during a storm on December 11.

Numerical modeling of JTMD

A straightforward model is constructed to validate whether or not the above-mentioned two critical factors (coastal upwelling/downwelling, and wind setup) determine the variation of marine debris abundance on the beach. We assumed that the marine debris abundance (N) on the beach depends on the meridional (V) and zonal (U) wind directions at grid cell nearest to Newport. The abundance increases by one when southerly winds occur (N = N + 1 at

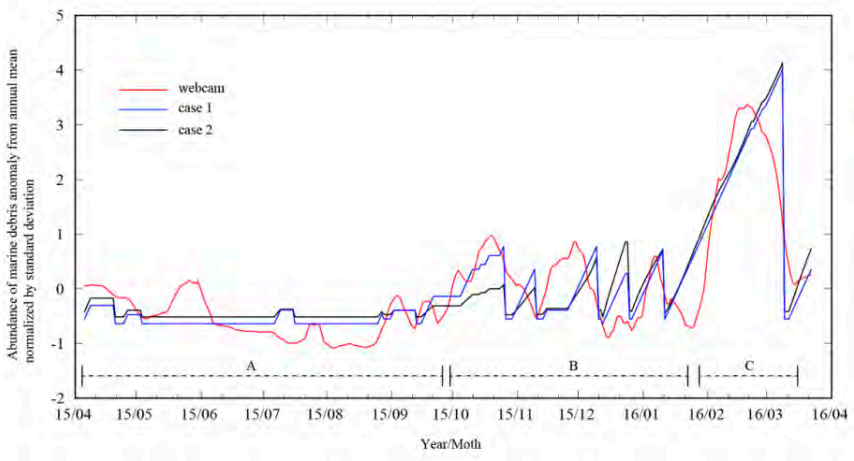

Fig. 4 Time series of abundance of the webcam-observed (red curve) and modeled (blue curve) marine debris. Case 2 (black curve) was not used in this report; Kako et al. (in prep).

V > 0; coastal downwelling), while the debris abundance on the beach vanishes when the onshore-ward wind speed becomes higher than its temporal average at spring tides (N → 0 at U > average over the entire period; wind setup). In spite of its simplicity, the model does a reasonable job of reproducing the abundance of marine debris on the beach (Fig. 4). The correlation coefficient between the webcam observation and the model run is 0.85, significant at the 99% confidence level. Because the above model is free of locality available only for the Newport beach, and because the coastal upwelling/downwelling as well as the wind setup at spring tides occur anywhere over the western coasts, it is anticipated that the model is commonly capable of reproducing marine debris abundance on various beaches along the western U.S. and Canadian coasts.

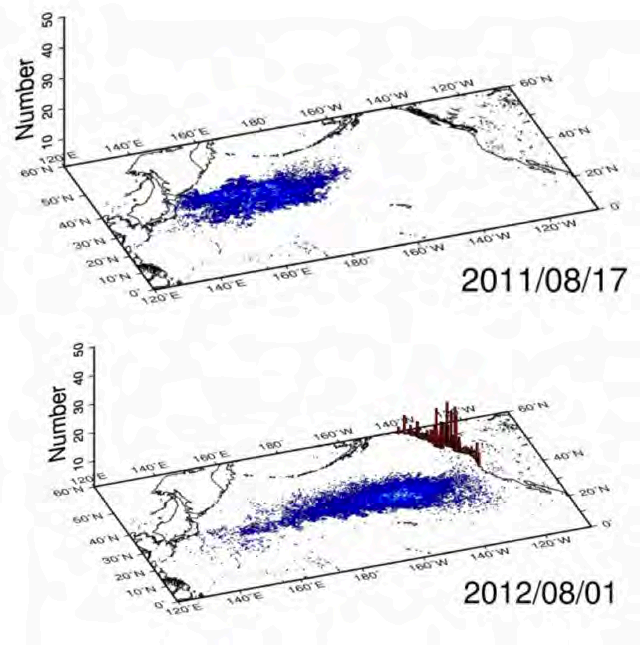

Fig. 5 Two snapshots of the particle tracking model (PTM) combined with the sub-model.

Our idea is to combine the above "sub-model" with a particle tracking model (PTM), reproducing JTMD motion in the North Pacific. The sub-model gives the criterion whether modeled particles approaching coasts are washed ashore on the land grid cell, and whether they return to the oceanic domain from the land. The satellite-derived winds on the oceanic grid cells neighboring the land boundary were used for the criterion in the sub-model. The PTM uses surface ocean currents provided by the HYbrid Coordinate Ocean Model (HYCOM), and Advanced Scatterometer (ASCAT) winds are used for both the PTM and sub-model. Fifty thousand particles were released off the Sanriku coast, Japan, on March 11, 2011, and thereafter a 5-year computation was conducted. The advantage of combining the sub-model with the conventional PTM is demonstrated in Figure 5, where the abundance of particles washed ashore as well as particles carried in the ocean was computed.

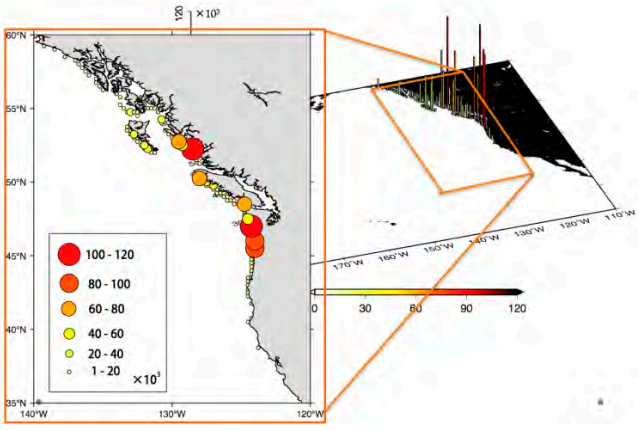

Fig. 6 Particle abundance integrated over 5-year computational period. Particle numbers washed ashore on the beach grid cells are represented by the bar height, and are also represented by circle diameters in the enlarged map in the left panel.

In summary, the abundance integrated over five years (Fig. 6) states that the JTMD (hence, invasive species) has not washed ashore homogeneously on western U.S. and Canadian beaches. Indeed, JTMD has been found from northern California to Alaska. It is, suggested however, that a large amount of JTMD may have been washed ashore in a relatively narrow area (<1000 km) around Vancouver Island, which might act as a "gate" for invasive spices carried by JTMD.

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Dr. Atsuhiko Isobe (aisobe@riam.kyushu-u.ac.jp) is a Professor at the Research Institute for Applied Mechanics at Kyushu University in Fukuoka, Japan. His research interests include ocean dynamics in coastal and shelf waters, atmosphere-ocean interaction, and marine debris.

Dr. Shin'ichiro Kako (kako@oce.kagoshima-u.ac.jp) is a Research Associate at the Graduate School of Science and Technology, Department of Ocean Civil Engineering, Kagoshima University in Kagoshima, Japan. His research interests include remote sensing, air-sea interaction, and marine debris.

Dr. Tomoya Kataoka (tkata@rs.tus.ac.jp) is an Assistant Professor at Tokyo University of Science in Chiba, Japan. His research interests include ocean dynamics in coastal waters, and marine debris.

Dr. Shinsuke Iwasaki (iwasaki@riam.kyushu-u.ac.jp) is a Research Associate at the Research Institute for Applied Mechanics at Kyushu University in Fukuoka, Japan. His research interests include atmosphere-ocean interaction, and marine debris.

Charlie Plybon (cplybon@surfrider.org) is the Oregon Policy Manager for the Surfrider Foundation. He works directly with a state-wide network of volunteers that conducts ongoing beach cleanups and engages in a variety of marine debris, coastal and ocean protection issues.

Thomas Murphy (ThomasMurphy@live.com) is a research technician at Oregon State University's Hatfield Marine Science Center and is a graduate of the University of Miami. He has been involved in maintenance of monitoring equipment as well as collection and cataloging of tsunami debris items for the Oregon Coast.

(BEPSII continued from page 31)

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Dr. Lisa Miller is a climate geochemist with Fisheries and Oceans Canada and a member of the PICES Section on Carbon and Climate. She studies air–sea exchange of carbon dioxide and other climatically-active substances, including the roles of sea ice and the sea-surface microlayer. She was on the scientific steering committee of the Surface Ocean–Lower Atmosphere Study from 2011 to 2016 and is currently on the BEPSII Steering Committee.

Mapping patterns of marine debris in the main Hawaiian Islands using aerial imagery and spatial analysis

by Kirsten Moy, Brian Neilson, Anne Rosinski, Amber Meadows, Miguel Castrence and Stephen Ambagis

Background

On March 11, 2011, the Great East Japan Earthquake and tsunami brought devastation upon the lives of thousands and swept millions of tons of debris into the Pacific Ocean. Soon after, a sudden influx of marine debris began to appear on North American coastlines and by September 2012, the first confirmed piece of Japanese Tsunami Marine Debris (JTMD) was reported in the Main Hawaiian Islands (MHI).

Hawaii is uniquely situated in close proximity to the North Pacific Subtropical Gyre (Howell *et al*., 2012) and the Subtropical Convergence Zone (Ribic *et al*., 2012), which concentrates marine debris and delivers the highest reported debris accumulations in the U.S. Pacific Coast (2012). Marine debris poses a substantial risk to Hawaii both environmentally and economically. It can break and smother entire reef ecosystems (Asoh *et al*., 2004), entangle and drown marine mammals (Henderson, 2001), seabirds and sea turtles (Nelms *et al*., 2016; Wilcox *et al*., 2015), and presents an insidious chemical threat, through ingestion, at all levels of the marine food web (Teuten *et al*., 2009). It is, therefore, of the utmost importance that the state be well informed regarding marine debris on its shores in order to manage this threat.

Over the past four years, the State of Hawaii Department of Land and Natural Resources (DLNR), together with local nonprofits, communities, businesses, and the National Oceanic and Atmospheric Administration (NOAA), tracked and reported over 500 distinct items of suspected JTMD origins and removed countless tons of other marine debris. However, the state had yet to complete a comprehensive survey of marine debris during this period of unusually high debris loads, so the project leaders from DLNR's Division of Aquatic Resources (DAR) developed a plan to use high-resolution aerial imagery, provided by Resource Mapping Hawaii, to map and detect marine debris along state coastlines. DLNR, Resource Mapping Hawaii, and Hawaii Coral Reef Initiative (HCRI) endeavored to create the state's first complete baseline of debris in 2015 with the financial support of the Japan Gift Fund to the Pacific Coast states, administered by NOAA's Marine Debris Program, and of the Ministry of the Environment of Japan via PICES.

Collecting and processing the aerial imagery

The aerial surveys were conducted from a Cessna 206 aircraft over the coastlines of Niihau, Kauai, Oahu, Molokai, Lanai, Maui, Kahoolawe, and Hawaii (Fig. 1). Flights were completed over the course of one to three trips per island between August and November 2015. Imagery was collected in the shortest timeframe possible so that any comparison between islands would have minimal bias due to seasonal variations in debris loads.

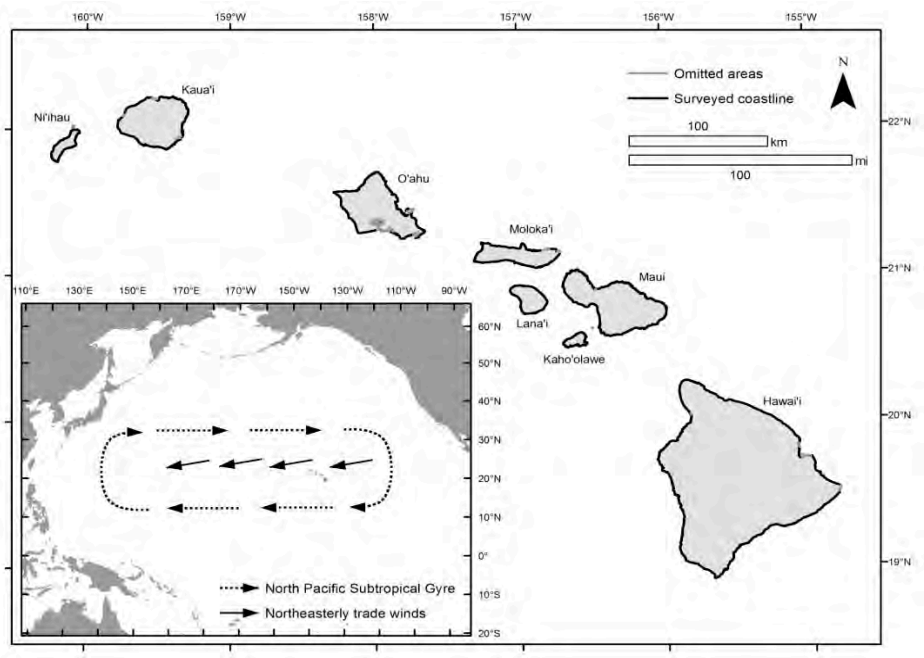

Fig. 1 Site map of the main Hawaiian Islands showing the survey area (main) and location with respect to the North Pacific Subtropical Gyre (inset). The sections of bold coastal outline indicate surveyed areas.

Fig. 2 A swath of Kaua'i coastline in ArcGIS and the data table of the identified dots of debris (left), with a zoomed screenshot of identified marine debris with numbers on Kamilo Point, Hawaii Island (right).

The imagery was captured using a three-camera array, taking photos every 0.7 seconds and flying 85 knots at a target altitude of 2,000 ft. The resulting resolution of the imagery was 2 cm per pixel and a swath width of 200–300 m. Small areas of coastline were omitted from the analysis where flight restrictions applied, such as airspace over military installments and airports. Custom photogrammetry software was used to create orthorectified image mosaics at 5-m horizontal accuracy for analysis in ArcGIS (Fig. 2).

Imagery analysis to detect debris

The imagery was manually interpreted, and every distinct object of marine debris was identified by category (plastic, buoys, floats, net, line, tires, foam, metal, wood, cloth, vessel, and inconclusive) and by size class (Very Small [< 0.5 m^2], Small [0.5–1.0 m^2], Medium [1.0–2.0 m^2], or Large [> 2.0 m^2]). The coordinates were recorded as well in order to assign each item to a distinct 1.6-km segment for the purpose of mapping marine debris concentrations. Segments were rated based on the count of debris items, and both island- and state-wide comparison maps were created to illustrate "hotspot" accumulations, or areas of high marine debris loads (Fig. 3). For state-wide comparison, all segments were regrouped into 8-km lengths to improve the visual interpretability of the state-wide accumulation map at the required scale.

Highlights from the analysis

The analysis yielded seven key findings:

(1) 20,658 debris items were identified state-wide;
(2) Niihau had the greatest distribution of debris: 38% of the state-wide total. All other islands had under 14%, and Oahu the least at 5%;
(3) 76% ± 7.1% of all debris occurred on windward (East and North-facing) shores;
(4) Plastics, including buoys, floats, net, and line, were the most common debris type and accounted for 80% of all debris;
(5) 86% of debris state-wide was under 0.5 m^2;
(6) Aerial surveys and *in situ* observations confirmed 27 abandoned and derelict vessels in the state;
(7) Four confirmed JTMD vessels were identified in the analysis, and another six suspected JTMD vessels were located, but were not present for *in situ* confirmation.

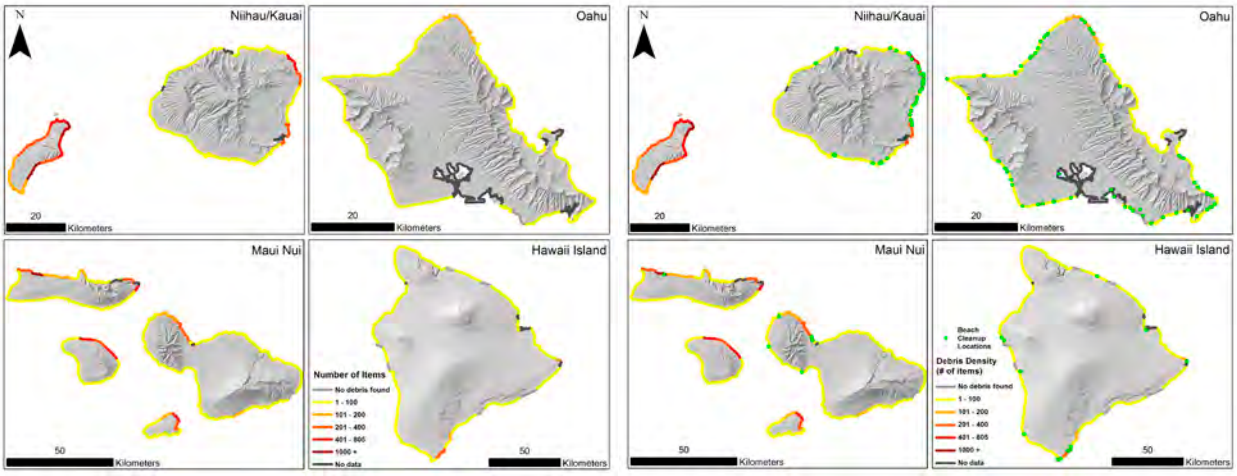

Fig. 3 Density and distribution of debris on the main Hawaiian Islands showing marine debris "hotspots," or segments with 100 or more items (left) and an adjusted map of marine debris beach cleanup events that occurred within 365 days of the aerial surveys in the main Hawaiian Islands. No cleanup data was submitted for groups operating primarily on Lanai, Kahoolawe, Molokai and Niihau.

The amount of debris on Hawaii's beaches varied among the eight islands but none more significantly than Niihau, which had more than twice the debris on its shorelines than any other island. This may be due to its unique position in the northern extent of the MHI, its offshore currents and wind exposure, and the absence of cleanup efforts on its beaches, which are privately owned and closed to the public. Hawaii Island also had a high amount of debris at its southern windward tip, Kamilo Point, which has a reputation as a hotspot of debris accumulation.

Fig. 4 JTMD vessels detected in the aerial imagery (top) and their corresponding in situ photo (bottom).

High-resolution aerial imagery allowed our analysts to detect debris as small as a detergent bottle, but anything smaller than that was difficult to categorize. Despite smaller size-classes being increasingly harder to see, the distribution of debris is significantly greater in this smallest grouping of less than 0.5 m^2. Given this trend, it is very likely that the amount of debris in the MHI is underestimated in this study.

Plastics were the most common debris type on all eight MHI, which is consistent with other efforts to categorize debris types (Gregory and Ryan 1997; Martin and Sobral 2011; Moret-Ferguson *et al*. 2010). Since our analysis was unable to categorize very small items, the proportion of plastics compared to other debris types is also likely underestimated.

Impact of coastal beach cleanups

It is important to acknowledge that during this assessment, beach cleanup data were not factored into the analysis, though beach cleanups do occur year-round, with some groups removing more than a metric ton of debris in one event. Twenty of the nonprofits and agencies that conduct regular cleanups contributed their removal data to the project (Fig. 3), but there was only one instance of a cleanup occurring the day before our flyovers. Two weeks prior to survey dates, 16 cleanups were conducted, but only four altered the segment rating from our initial analysis and do not significantly change the ratios or relative abundance between islands.

However, within one year prior to the survey dates, 68 segments were targeted by cleanup groups; removals ranged from a few fishing nets to truckloads of miscellaneous debris. Without knowledge of the rate of debris deposition in those segments, it is impossible to say what impact these cleanups have on overall shoreline densities. Nevertheless, it is worth noting that well over 30,000 man-hours of beach removals contributed to more than 70 metric tons of debris being removed from the coastlines in the past year.

Japanese tsunami marine debris

JTMD is recognizable by a set of shared characteristics, with more than 60 confirmed JTMD items reported to NOAA and reviewed by the Government of Japan, or may be distinguished from other debris by biofouling or Japanese writing. The aerial imagery in our study was unable to capture biofouling or Japanese letters, but large items like vessels were distinguishable from other abandoned and derelict vessels (ADVs) in most cases. JTMD vessels have similar shape, size, and coloring (Fig. 4). As of 2016, in Hawaii alone there are 17 confirmed JTMD ADVs and 16 pending confirmation with the Japanese Consulate. Each year since 2012, four to six vessels are reported to the state. The aerial surveys detected ten in just one round of flights. However, by the time vessel locations were revisited, six of the ten vessels were no longer on shore where our team had seen them in the imagery. Our analysis and *in situ* observations demonstrated that the aerial imagery process can potentially double the detection of JTMD ADVs, and that response and removal are time-sensitive.

JTMD is reported to NOAA via email at its marine debris reporting address, disasterdebris@NOAA.gov; in Hawaii, reports are received through the DLNR (808) 587-0400 or DLNR.marine.debris@hawaii.gov.

Conclusion

This high-resolution aerial imagery analysis is the first comprehensive survey of the MHI for marine debris, and it proved to be a useful method for detecting all points of debris on the coastline at a moment in time. The positional and categorical accuracy of the analysis helps managers, researchers, and marine debris cleanup groups to better understand and characterize marine debris accumulations in Hawaii. There is an ongoing problem with plastic debris, both consumer and fishery-based, that needs to be addressed both at the removal and prevention level. Furthermore, our marine debris accumulation mapping confirms the concentration of hotspots along the windward shores of the islands. This information is useful for prioritizing marine debris cleanups, and this study inspired the creation of a multi-partner collaboration to map cleanup efforts in the state, an ongoing endeavor scheduled to debut

in 2017. The project has published its imagery online for public access and created an online resource to further summarize the study's findings: http://arcg.is/29tjSqk.

Acknowledgements: The authors of this study would like to acknowledge the support and generosity of the North Pacific Marine Science Organization (PICES) and the Ministry of the Environment of Japan for funding this project along with contributions from the Japanese Gift Fund provided by the State of Hawai'i Department of Land and Natural Resources (DLNR). Furthermore, the authors thank the Marine Debris Program of NOAA, the Social Science Research Institute, Hawaii Coral Reef Initiative of the University of Hawai'i (UH), Manoa, DLNR's Division of Boating and Ocean Recreation, Land Division, and Division of Aquatic Resources for providing essential feedback and guidance. Particular thanks to Charissa Minato, Pamela Fujii and Kristine Davidson from HCRI for their support, to Meagan Putts, and to the UH undergraduate GIS analysts Stephanie Kung, Alexi Meltel, Andy Omori, Sarah Wieble and Nathan Oh for their long hours and hard work.

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Kirsten Moy (kmoy@hawaii.edu) joined the project as the Marine Debris Coordinator at DLNR's DAR. She continues working in marine debris under the newly-formed Hawaii Environmental Coastal Coalition and is the serving Chair of the Research Hui for the Hawaii Marine Debris Action Plan with NOAA.

Brian Neilson (brian.j.neilson@hawaii.gov) is the Aquatic Invasive Species Program Lead for DLNR and works to prevent and manage aquatic invasive species threats throughout the Hawaiian Islands including marine debris. He worked closely with PICES in developing the Hawaii Marine Debris Mapping Project. In addition, his work focuses on restoring and monitoring Hawaii's coral reefs.

Anne Rosinski (anneer@hawaii.edu) leads research-focused projects supporting the restoration and management of coral reefs for the Hawaiian Coral Reef Initiative (HCRI). She is also currently a PhD student at the University of Hawaii at Manoa in the Marine Biology Graduate Program, developing restoration strategies for Hawaii's corals.

Amber Meadows works with the HCRI on various projects that focus on the conservation of Hawaii's marine resources. Her current projects involve mapping of marine managed areas and day-use moorings, as well as working with the Makai Watch program to strengthen community involvement.

Miguel Castrence (miguel@remaphawaii.com) is the Pacific Operations Manager for Resource Mapping Hawaii. He specializes in GIS and remote sensing from satellite, aerial and unmanned systems for resource management.

Stephen Ambagis (stephen@remaphawaii.com) is the CEO and pilot of Resource Mapping Hawaii and has over 10 years of experience in landscape ecology, GIS and remote sensing. He has worked on a wide variety of international development, natural resource management and conservation projects in Africa, Asia, and the Americas.

New leadership in PICES

Governing Council

At PICES-2016, Dr. Chul Park (Korea) was elected Chair of PICES and Dr. John Stein (USA) was elected Vice-Chair. PICES is grateful to Dr. Laura Richards for her dedicated service as Chair of the Organization since October 2012.

Chul Park was born in a small town in the southern part of the Korean peninsula in 1956, as the youngest child of a relatively big family with five sisters and one brother. Since his mom kept him away from wheels and water, he had never had a chance to visit the beach until the age of 19. He lived in a rural area until the age of 12 with his parents. Later, he moved to Seoul with his youngest sister to obtain a better education.

In 1974, Chul entered Seoul National University (SNU) where he studied Oceanography. Completing his compulsory service in the army for 27 months, he received his B.Sc. degree in 1980, and M.Sc. in 1982 at SNU and Ph.D. in 1987 at Texas A&M University. His thesis was on the fine scale patchiness of zooplankton, a statistical approach.

Returning Korea in 1988, Chul joined the Chungnam National University (CNU), where he presently teaches. During Chul's early career, he participated in the Antarctic Cruise in 1988, 1989 and 1990 for the Antarctic Marine Living Resources program of the National Marine Fisheries Services (USA). In 1991, he spent one year as a post-doc working in Dr. Michael Landry's lab at the University of Hawaii, Manoa. Since then, he has been working on zooplankton ecology in relatively small bays in the western part of the Korean peninsula, focusing especially on seasonal patterns of distribution, measurement of egg production, respiration, *etc*.

In 2004, Chul moved temporarily to the National Fisheries Research and Development Institute (NFRDI, now National Institute of Fisheries Science, NIFS), and served as the Head of the Marine Environment Division, which prompted him get involved in PICES administration as Korean national delegate to Governing Council (GC) and the Finance and Administration Committee (F&A), representing the scientific community. Returning to CNU, he served as Dean of College of Natural Sciences (2006–2008) and joined GC again in 2009. He also served as the President of the Korean Society of Oceanography for two years, 2010–2011, during which he initiated the support for early career scientists to attend PICES Annual Meetings. He is also a member of Group of Experts for UN World Ocean Assessment.

In his private life, Chul is a devoted and happy family man. His wife Hyunsoon provides support to her beloved husband. They have two sons, Juweon and Jaehyun (both married), and one granddaughter. He presently lives in Barcelona and will return to Korea in July 2017.

Finance and Administration Committee

At PICES-2016, Dr. Carmel Lowe (Canada) was elected Chair of the Finance and Administration Committee (F&A), replacing Dr. John Stein who takes over the position of Vice-Chair of Governing Council. PICES thanks Dr. Stein (USA) for his dedicated service as Chair of F&A since October 2012.

Carmel Lowe was born and raised in Ireland. She obtained B.Sc. and M.Sc. degrees in Geoscience from University College Galway and a Ph.D. in Geophysics from Trinity College. In 1988, she moved to Canada for a post-doctoral appointment at Carleton University in Ottawa and subsequently took a position as a Research Scientist with the

federal government's Department of Natural Resources in 1990. Over the following 24 years she developed extensive experience in the design, development, management, and delivery of scientific research programs that addressed Canada's priorities related to responsible resource development and public safety in its onshore and offshore territories. Ready for a change, in July 2014 she took an appointment as the Pacific Regional Director of Science at Canada's Department of Fisheries and Oceans and the Canadian Coast Guard. In this role she manages an approximately 500 strong team of scientific and technical personnel to deliver the science knowledge and products required to support effective decision-making with respect to Canada's aquatic resources and habitats.

Carmel is one of two Canadian delegates on the PICES Governing Council. She is currently President of the North Pacific Anadromous Fish Commission and Chair of the Pacific Salmon Commission's Committee on Scientific Co-operation. She has broad interests in the outdoors and when not working, enjoys running, hiking, biking, skiing and kayaking.

Science Board

At PICES-2015, Dr. Hiroaki Saito (Japan) became Chair-elect of Science Board and, following PICES-2016 in San Diego, USA, he assumed the position of Science Board Chair. PICES appreciates Dr. Thomas Therriault's dedicated service to Science Board since 2010 as Vice-Chair, Chair-elect, and Chair. Dr. Therriault will continue to contribute to activities of the Organization as a member of the Marine Environmental Quality Committee.

Dr. Hiroaki Saito is a professor at the Atmosphere and Ocean Research Institute (AORI), the University of Tokyo. He was born in Fukushima, Japan. In his childhood, paddy fields, apple groves and rivers jumping with fish were 5 to 10 minutes by bicycle from his home. He enjoyed catching fish, crayfish, butterflies, and above all, beetles. During holidays, he often went to the country where his grandparents lived. Exploring the forests alone for feather-full nests, ambushing migrating golden-ringed dragonflies with an insect net, or encountering pale-green rat snakes were the most exciting events for him.

During his third year at the Tohoku University, Hiroaki listened to a course of lectures on oceanography from Prof. Satoshi Nishizawa. Hiroaki was so attracted to the unique atmosphere of authentic culturati created by Prof. Nishizawa, and to the novel, tough approach of his lectures that he changed his mind about being a business person and decided to study biological oceanography. In Nishizawa's laboratory, Hiroaki was a youngest member among many post-docs and graduate students, and here he learned how to practice sincere scientific objectivity through discussions and debates with senior members.

After receiving his B.Sc. and Ph.D. in Agriculture from the Tohoku University, Hiroaki started his scientific career at the Fisheries Research Agency's Hokkaido National Fisheries Research Institute in Kushiro as a research scientist to study the biology and ecology of copepods and their roles in fish population dynamics. After his Hokkaido period, interrupted for a year by a stay at the Danish Institute for Fisheries Research as a guest scientist, Hiroaki moved the FRA's Tohoku National Fisheries Research Institute (TNFRI) in Shiogama, where he led the Ecosystem Dynamics Group. In 2014, he moved to the University of Tokyo at the Department of Marine Ecosystem Dynamics, AORI. From 2016, he is a professor at the Center for International Collaboration, AORI.

Hiroaki's background is zooplankton biology and ecology, but his interests are broad, ranging from viruses to whales, to understand the processes and variation mechanisms of the marine ecosystem and biogeochemical cycles. Hiroaki is one of the establishing members of the A-line monitoring programme and has been serving this line for over 20 years. He is very proud that this programme received the 2013 PICES Ocean Monitoring Service Award (POMA).

Hiroaki led several multi-disciplinary projects such as DEEP (Deep Sea Ecosystem Exploitation Programme, 2002–2007), SUPRFISH (Studies on Prediction and Application of Fish Species Alternation, 2007–2012), and SKED (Study of Kuroshio Ecosystem Dynamics for Sustainable Fisheries 2011–2021). All these projects are designed to understand ecosystem dynamics and promote the wise use of ecosystem services. He was also a core member of a series of mesoscale iron fertilization experiments in the subarctic Pacific: Subarctic Pacific Iron Experiment for Ecosystem Dynamics Study (SEEDS-I and SEEDS-II) and Subarctic Ecosystem Response to Iron Enrichment Study (SERIES), which were recommended by the PICES Advisory Panel on *Iron*

Fertilization Experiment in the Subarctic Pacific Ocean. Now, he is a core member of interdisciplinary project NEOPS (New Ocean Paradigm on Its Biogeochemistry, Ecosystem and Sustainable Use) which largely overlaps with the goals of PICES' FUTURE and the International Council for Science's Future Earth.

Hiroaki began his association with PICES in 1994, attending the Third PICES Annual Meeting in Nemuro, Japan. Later, he served as a member of the MODEL Task Team, Advisory Panel on *Iron Fertilization Experiment in the Subarctic Pacific Ocean* and Working Group on *Iron Supply and its Impact on Biogeochemistry and Ecosystems in the North Pacific Ocean*. He has contributed to FUTURE from its planning phase, as a member of the Study Group on *Future Integrative Scientific Program(s)* and the FUTURE Science Plan Writing Team, and co-led the FUTURE Implementation Plan Writing Team. After FUTURE was formed, he served as Chair the FUTURE Advisory Panel on *Climate, Oceanographic Variability and Ecosystems* and a Co-Chair of the FUTURE SSC. From 2013, he served as Vice-Chair of Science Board.

On March 11, 2011, a devastating earthquake (magnitude 9.0) occurred off the coast of Tohoku triggering a powerful tsunami that attacked the Tohoku region. The tsunami also knocked out the Fukushima Daiichi atomic power plant, which resulted in a large area in Fukushima and surrounding waters to be contaminated by released radioactivity. Some of Hiroaki's relatives were forced to abandon their houses. The incident had a great impact on him. He is now more serious than ever on the role of science and scientists for society and human well-being. He believes it is the duty of scientists in the Anthropocene to fulfill society's request to answer the questions of FUTURE. From his long career in PICES, and of leading science programs, Hiroaki is convinced that PICES is a great platform for scientists to discuss and exchange ideas, especially for interdisciplinary issues. He is looking forward to serving as Science Board Chair and working with PICES scientists to help solve important marine science issues which are essential not only for science but also for society.

FUTURE Scientific Steering Committee

At PICES-2016, Dr. Sukyung Kang (Korea) was elected Co-Chair of the FUTURE Scientific Steering Committee, replacing Dr. Hiroaki Saito. PICES thanks Dr. Saito for his dedicated service as Co-Chair of the FUTURE SSC since October 2014.

Dr. Sukyung Kang is a Senior Scientist of the Fisheries Resources Management Division at the National Institute of Fisheries Science (NIFS) in Korea. She was born in Busan, the city of beautiful seas and beaches. When she was a kindergartener, her mother bought her a collection of National Geography books full of marine life. She loved the books so much and read them until they had worn out. Since then, her interest in marine life has awakened.

In 1988, the first Korea Antarctic Research Program team conducted a survey in the vicinity of King Sejong Station and the Antarctic King Sejong Station was inaugurated. Sukyung decided to study oceanography after watching the news on TV and dreamed of visiting King Sejong Station. She went to Pusan National University to study oceanography and studied biological oceanography in her Master's program.

After graduating her Master's program in 1995, Sukyung had a chance to work at the Polar Research Center of Korea Ocean Research and Development Institute (now Korea Polar Research Institute; KOPRI) as a research scientist. She had conducted marine and oceanographic studies on marine living resources in the Antarctic and the Korean adjacent waters for 5 years. She finally joined the Korea's Antarctic cruise as a biological researcher during the austral summer of 1996 and really enjoyed her research life there. However, she had always hoped to gain a deeper knowledge of the changes in fishery resources and eventually made up her mind to leave this job and go back to school to fulfill her desire for scholarship. Sukyung received a Ph.D. in fisheries oceanography from Pukyong National University in 2004. During her doctorate, she carried out chemical analysis (stable isotope and trace element) of otoliths for stock identification and environmental characteristics of the North Pacific chum salmon. In a presentation based on her research output, she was awarded a Best Presentation at the Science Board Symposium at 11th PICES Annual Meeting in 2002.

As soon as Sukyung finished her degree, she luckily got a job at NIFS (previous name National Fisheries Research and Development Institute). At NIFS, her first workplace was the salmon research center. Sukyung has worked on a long-term

ecosystem change by using historically collected chum salmon samples such as scale/data sets for 5 years. While working there, she attended the North Pacific Anadromous Fish Commission (NPAFC) meeting as a commissioner of Korea, and discussed the catch, cause of variability of Pacific salmon and salmon policies. In 2009 she was transferred to the Busan headquarter of NIFS and has been working on prediction of marine fisheries resources under climatic changes in Korean waters by using ichthyoplankton, fishing data sets, *etc*. Sukyung is still interested in salmon studies. Her current paper on trace element signatures in salmon otoliths was selected as the 2015 Best Paper by the Korean Society of Oceanography (KSO). During her research career, Sukyung has been involved in several international organizations/projects such as PICES, NPAFC, Yellow Sea LME, APEC, *etc*. However, since her first attendance at a PICES Annual Meeting, in 1997, PICES has always been her favorite international organization. PICES gives her the opportunity to work closely with experts from other countries around the North Pacific and to become friends with them.

Sukyung has broad interests from sports to arts and loves conversation with many people on a variety of topics. Her favorite sport is baseball. Since she grew up in Busan, which has often been referred as the 'Baseball Capital of Korea', she enjoys going to the ballpark in Busan with her friends. She is also fond of various cultural performances such as musicals, ballets, and concerts. Her life's motto is to enjoy her work and develop together in harmony with the people around her.

Biological Oceanography Committee

At PICES-2016, Dr. Se-Jong Ju (Korea) was elected Chair of the Biological Oceanography Committee (BIO) and Dr. Debora Iglesias-Rodriguez (USA) was elected as Vice-Chair, replacing Dr. Se-Jong Ju. PICES thanks Dr. Angelica Peña (Canada) for her dedicated service as Chair of BIO since October 2013. Dr. Peña will continue to contribute to activities of the Organization as a member of BIO and joint PICES/ICES Working Group (WG 33) on Climate Change and Biologically-driven Ocean Carbon Sequestration.

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 being an oceanographer at that time. During his sophomore year in university, his future changed when he met a brilliant and hardworking new faculty member, Prof. Yong-Chul Park, who is a chemical oceanographer. From that point, his passion to study oceanography became stronger. In 1988, he completed his Master's 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 three years.

Se-Jong then started his Ph.D. studies at the University of Maryland. 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 U.S. 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* and Working Group (WG 37) on *Zooplankton Production Methodologies, Applications and Measurements in PICES Regions*.

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.

Physical Oceanography and Climate Committee

At PICES-2016, Dr. Emanuele Di Lorenzo (USA) was elected Chair of the Physical Oceanography and Climate Committee (POC), replacing Dr. Kyung-Il Chang (Korea) who stepped down after two terms as Chair. Dr. Yury Zuenko (Russia) takes up the positon of Vice-Chair, replacing Dr. Michael Foreman (Canada), who held that position for two terms. PICES is grateful to Dr. Chang and to Dr. Foreman for their dedicated service to POC. Dr. Foreman will continue serving as a member of POC. He is also a member of the joint PICES/ICES Section (Initiative) on Climate Change Effects on Marine Ecosystems.

Dr. Emanuele Di Lorenzo is a Professor of Ocean and Climate Dynamics and Director of the Program in Ocean & Science and Engineering at the Georgia Institute of Technology, USA. He received his Ph.D. in oceanography at the Scripps Institution of Oceanography in 2003. His research interests and experience span a wide range of topics from physical oceanography to ocean climate and marine ecosystems (www.oces.us). He has led several international science efforts to understand the role of climate forcing on Pacific ecosystems within PICES and the GLOBEC program (e.g. wg27.pices.int, www.pobex.org), and currently serves on the Science Steering Committees of U.S. CLIVAR and PICES FUTURE.

He is also a passionate beginner woodworker, a hobby he picked up a few years ago, and a proud father of four small children – climate scientists in the making.

Technical Committee on Data Exchange

At PICES-2016, Dr. Joon-Soo Lee (Korea) was elected Chair of the Technical Committee on Data Exchange (TCODE), replacing Dr. Toru Suzuki who has held the position for two terms, since 2010. Mr. Peter Chandler (Canada) replaces Dr. Hernan Garcia (USA) as Vice-Chair. PICES is grateful to Dr. Suzuki and Dr. Garcia for their dedicated service to TCODE. They will continue serving as members of TCODE. Dr. Suzuki is also a member of the Section on Carbon and Climate.

Section on Marine Birds and Mammals

At PICES-2016, Dr. Patrick O'Hara (Canada) was elected Co-Chair of the Section on Marine Birds and Mammals (S-MBM). He replaces Dr. Rolf Ream (USA) who stepped down from the position. PICES thanks Dr. Ream for his service as S-MBM Co-Chair. He will continue serving as a member of S-MBM.

Dr. Patrick O'Hara grew up in the big cities of Ontario and Quebec and dreamed of the day he would be able to move to a coast on one of the three oceans that surround Canada. As soon as he graduated from high school Patrick moved to British Columbia to start his undergraduate degree as a dual major in marine zoology and oceanography at the University of British Columbia (Vancouver, Canada). As he progressed, he veered away from oceanography and swung towards the zoology side of things, writing a thesis on predator–prey interactions in the intertidal zone. After graduation, he worked for a number of years as a sea-going technician for the Oceanography Department at UBC, and then spent three years working and traveling throughout the Americas (getting as far as Peru). Although some of this work involved plant surveys in the cloud forests of the Andes, Patrick never really strayed too far from the oceans. While working on butterflies in Ecuador, he found out about an opportunity to work on a Ph.D. at Simon Fraser University (Vancouver, Canada) on shorebirds during the winter in Panamanian

mangrove systems, so he headed back to Canada to start. He successfully defended his Ph.D. in 2002 and shortly afterward started a post-doc focusing on oil discharges from ships and impacts on marine birds. To do this, Patrick had to understand a lot more about seabird distributions at sea and the oceanography that drives these distributions, which closes the loop – apparently, everything appears to lead back to oceanography, so Patrick had better just get used to it.

Currently, Patrick is a conservation scientist with the Canadian Wildlife Service working out of the Institute of Ocean Sciences (Sidney, British Columbia, Canada). At the Institute he collaborates with oceanographers and hydrographers, and often contributes to projects managed or led by Fisheries and Oceans Canada. Most of the projects Patrick is working on have direct conservation applications, ranging from impacts on marine bird and mammals from pollution (oil, plastics, noise), fisheries bycatch, ship-strike, and marine noise pollution to developing recovery plans for marine species at risk. Lately, his attention has been captured by meso-scale eddies that form off the west coast of Canada and Alaska, and how these eddies affect abundance and distribution of marine birds and their prey. As well, Patrick has begun developing a Canadian national research working group within Environment and Climate Change Canada and Fisheries and Oceans Canada that focuses on modeling distributions of marine birds and mammals based on at-sea survey data. He also regularly co-convenes a wildlife impact session at the annual AMOP (Arctic and Marine Oilspill Program - http://ec.gc.ca/amop/) conference.

Patrick first attended a PICES Annual Meeting in 2004, Honolulu, Hawaii, while he was a post-doc with the University of Victoria. When the Annual Meeting rotated to Canada (Nanaimo, British Columbia) in 2013, Patrick first participated in AP-MBM (now S-MBM), when he became a Canadian representative. Patrick has been an active member of the AP-MBM, and has participated in AP-MBM meetings and activities (workshops and topic sessions) every year since 2013. He looks forward to serving PICES and working with the members of S-MBM.

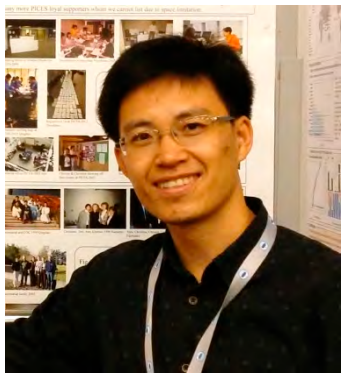
PICES Interns

We are pleased to announce that Mr. Minho Kang joined the Secretariat as a PICES intern in September 2016. A fast learner, he assisted the Secretariat in preparing for the PICES Annual Meeting in San Diego, USA, where many of you had the opportunity to meet him during registration.

Minho Kang grew up on the sunshine coast of Busan in the Republic of Korea and loves the lifestyle in that coastal city. Prior to joining the PICES Secretariat, Minho did an internship at the North Pacific Anadromous Fish Commission from 2015 to 2016 and worked as an international scientific observer for the National Fisheries Research and Development Institute in Korea in 2010 and 2015.

Minho graduated from Pukyong National University with a M.Sc. in 2007. His research topic was "*Genetic Stock Identification (GSI) of chum salmon in the western Bering Sea, 2004*". In 2008, he joined the Evolution and Ecology Program at the International Institute for Applied Systems Analysis, Austria, to study probabilistic maturation reaction norms of Korean chum salmon.

During his Master's program, Minho worked in the Graduate School of Oceanography program at the University of Rhode Island in 2011 conducting GSI studies of chum salmon, plastic responses of chum salmon growth according to environmental changes, multispecies biomass dynamics models including species interactions (predation and competition), and other statistical applications to commercially important fish populations. During his leisure time, Minho likes to spend time exploring the outdoors, especially beautiful beaches.



We express our sincere appreciation to Dr. Jinwen Liu, who completed his term as PICES intern with the Secretariat in July 2016 and returned to the Third Institute of Oceanography (TIO), State Oceanic Administration of China (SOA) to resume his duties there. Ever ready, with a smile, to provide assistance in Secretariat activities, it was a pleasure to have Jinwen in the office. We wish him the best in his career at TIO, and look forward to seeing him involved in future PICES events.

The Bering Sea: Current status and recent trends

by Lisa Eisner

Climate and oceanography

The marine heat wave in the Bering Sea that began in 2014 continued through the interval of April–September 2016. A map of the sea surface temperature (SST) anomaly distribution for the interval (Fig. 1) shows that it was especially warm (anomalies exceeding +3°C) on the southeastern Bering Sea shelf. The warm water was not just at the surface but rather, extended through the entire water column, with depth-averaged temperatures at Mooring 2 reaching a maximum in a record extending back to 1995 (the previous record was in 2015) (Fig. 2). Remarkably, the vertically-integrated heat content at the end of the winter of 2016 was comparable to that during cold summers, such as 1999. This heat can be attributed in large part to the warm winter of 2015–16, and its record low sea ice. One important consequence is that the "cold pool (deep temperature < 2°C)" in the middle shelf domain was virtually absent south of about 61°N. For the second year in a row, the extreme warmth during summer 2016 on the Bering Sea shelf was not so much due to enhanced summer heating but rather due to pre-existing positive temperature anomalies, especially at depth.

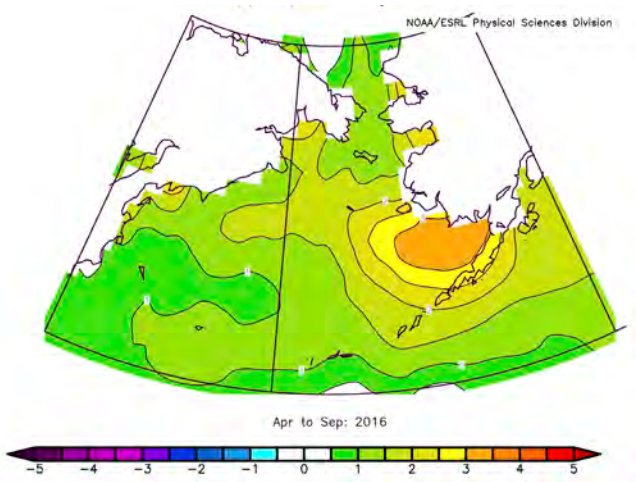


Fig. 1 Mean SST (°C) anomalies (deviations from 1981–2010 climatology) for April to September 2016. Figure courtesy of Nick Bond, PMEL.

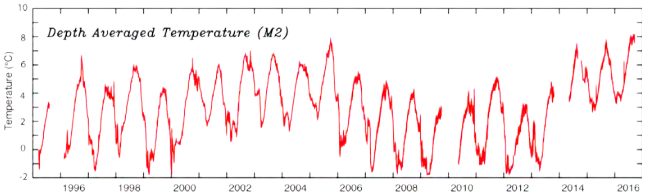


Fig. 2 Depth averaged temperature (°C) at the Mooring 2 site (56.87°N, 164.05°W) in the southeastern Bering Sea. Figure courtesy of Phyllis Stabeno, PMEL.

The atmospheric forcing during the spring and summer of 2016 was fairly typical in terms of the six-month average, as illustrated in the mean sea level pressure (SLP) anomaly map (Fig. 3). This map indicates slightly lower SLP than normal near the Aleutian Islands, which was a result of a relatively deep and southeast displaced Aleutian low during the spring of 2016. The positive SLP anomalies in the northwestern portion of the Bering Sea were associated with relatively high SLP during the summer months of July through September. It appears that the combination of high SLP and warm SST was accompanied by slightly suppressed cloudiness over the Bering Sea in the summer of 2016.

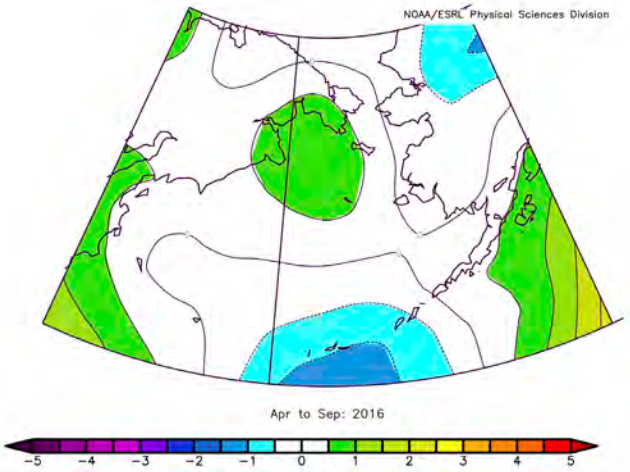


Fig. 3 Mean sea level pressure (mb) anomalies for April to September 2016. Figure courtesy of Nick Bond, PMEL.

The conditions that occurred in the Bering Sea during the spring and summer of 2016 can be placed in a longer-term climate context. Towards this end, a time series of mean air temperatures at St. Paul, Alaska, in the Pribilof Islands for April through September from 1950–2016 is plotted in Figure 4. This record shows that 2016 was indeed an extreme year, with a mean air temperature considerably greater than that during the previously warmest year of 1979. It turns out that the variability in air temperature at St. Paul closely tracks that of the regional SST; the April–September SST during 2016 for the eastern Bering Sea shelf as a whole also set a record by about 1°C (not shown). Time series of both air temperature and SST reveal that 2016 represented a short-term climate event on top of a baseline featuring an overall warming trend. It remains to be seen how long the current marine heat wave will persist into 2017 and perhaps beyond.

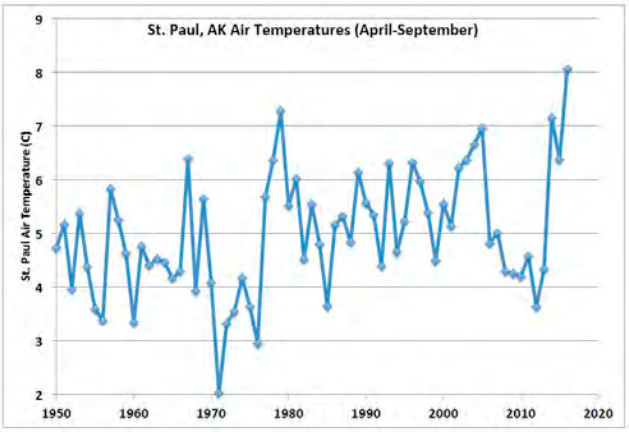


Fig. 4 Mean air temperatures (°C) at St. Paul, Alaska for April–September from 1950–2016. Figure courtesy of Nick Bond, PMEL.

Zooplankton abundance in the southeastern Bering Sea

The NOAA Ecosystem and Fisheries-Oceanography Coordinated Investigations group (EcoFOCI) at the Alaska Fisheries Science Center (AFSC) conduct at-sea rapid assessments to provide a near real time index of zooplankton abundance. In 2016, abundance in the southeastern Bering Sea was dominated by small copepods < 2 mm (*Acartia* spp., *Oithona* spp., and *Pseudocalanus* spp.) (Fig. 5). Large copepods (> 2 mm) were observed during the May/June survey and these were mostly late stage *Calanus* spp. They largely disappeared during the late summer surveys and small copepod abundance peaked. In early fall, some late stage *Calanus* spp. were observed but their numbers were 50% less than that observed in spring, and similar to those observed during the prior warm period 2003–2005 in August/September (Eisner *et al*., 2014, 2016). The warm conditions that persisted throughout the year resulted in the zooplankton being dominated by smaller sized species. This likely impacted age-0 walleye pollock which lacked large, lipid-rich copepod prey in the fall.

Seabird die-off in the Pribilof Islands

From October 17, 2016, onward, staff with the Aleut Community of St. Paul Island Tribal Government Ecosystem Conservation Office (ACSPI ECO) counted nearly 300 beached seabird carcasses on the beaches of St. Paul (Figs. 6 and 7). The carcasses were mostly tufted puffins, but horned puffins, murres, and recently, crested auklets were also found. The current encounter rate of tufted puffin carcasses (carcasses/kilometer) in October–November was more than 350 times the normal rate based on surveys conducted at St. Paul over the past 10 years (2006–2015) per the Coastal Observation and Seabird Survey Team (COASST) and ACSPI ECO. An estimated 6,000 tufted puffins and over 30,000 horned puffins breed at the Pribilof Islands. When the breeding season is over, the birds overwinter in the North Pacific until the following spring. The large number of puffins near the Pribilof Islands at this time of the year is unusual and likely includes birds from other breeding colonies. Because only a fraction of birds that die at sea will become beached, and even fewer are counted before removal by scavengers, the appearance of this many fresh dead seabirds (adults and juveniles) raises serious concern.

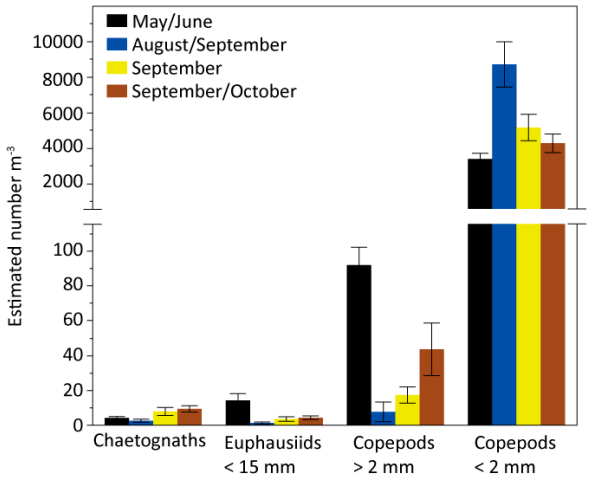


Fig. 5 Estimated zooplankton abundance (number m^3) for four research surveys (May–October) in the southeastern Bering Sea 2016. Zooplankton were classified into four categories: Chaetognaths (arrow worms), small euphausiids < 15 mm (juvenile krill), large copepods > 2 mm (primarily Calanus *spp.), and small copepods < 2 mm (primarily* Acartia *spp.,* Oithona *spp., and* Pseudocalanus *spp. Error bars represent standard error of the mean. Figure courtesy of David Kimmel, AFSC.*

Fig. 6 Carcasses of tufted puffins found on beaches of St. Paul Island, Alaska. Photo courtesy of COASST St. Paul.

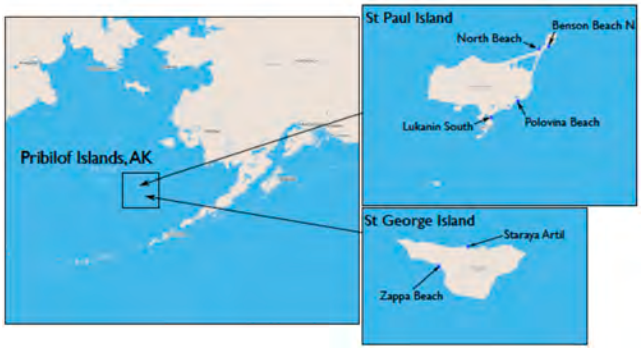


Fig. 7 Map of beaches on the Pribilof Islands where carcasses were found. Map courtesy of Lauren Divine, Aleut Community of St. Paul Island.

The U.S. Geological Survey National Wildlife Health Center (NWHC) in Madison, Wisconsin, performed necropsies to determine cause of death of eight of the Pribilof beached puffins and five crested auklets. All puffins and auklets showed severe emaciation characterized by severe atrophy of muscles of the breast and thighs, and complete absence of body fat. Presently, no pathogenic bacteria, viruses, or parasites have been identified in either species necropsied and the current cause of death of seabirds at St. Paul Island appears to be starvation. These results are similar to common murres examined during the 2015–2016 Gulf of Alaska seabird die-off, where 100,000s of murres were estimated to have starved state-wide. The causes of the seabird starvation, both of murres and puffins, is unknown but may be linked to changes in prey distribution or abundance (see *Zooplankton abundance* section) due to high SST (see *Climate and oceanography* section). Abnormally high SST were recorded in the Bering, Beaufort and Chukchi seas in October 2016, as well as record low levels of Arctic sea ice extent.

Carcasses are no longer being encountered at the peak rates observed during October–November 2016. ACSPI ECO staff are continuing to monitor the beaches in St. Paul and assist researchers and resource managers with communication and outreach efforts.

Walleye pollock and Pacific cod survey estimates

The NOAA, AFSC, 2016 eastern Bering Sea shelf bottom trawl survey estimates of abundance and biomass for walleye pollock and Pacific cod decreased compared to 2015. Abundance decreased for pollock by 22% (11.0 to 8.5 billion) and for Pacific cod by 33% (986 to 661 million). Decreases in biomass were 23% (6.4 to 4.9 million metric tons (mmt)) for pollock and 11% (1.1 to 1 mmt) for Pacific cod. Although lower compared to 2015, the 2016 estimates were still slightly above or near the long-term survey means for 1987–2015. Pollock catch rates were generally highest in the northwestern half of the shelf and near the central Alaska Peninsula, but were relatively low in the southwestern shelf and in the vicinity of the U.S.–Russia Maritime Boundary. Pacific cod catch rates were highest in the northern half of the inner and middle shelves and in Bristol Bay near the Alaska Peninsula.

Profiling mooring in the southeastern Bering Sea

As part of NOAA PMEL's Innovative Technology for Arctic Exploration (ITAE) program, this past summer a 1.5-m EcoFOCI oceanographic mooring near the M2 site (56.87°N, -164.06°W) was deployed on May 10, 2016 and recovered in September (Fig. 8). This was the second year of deployment for this mooring. It is equipped with a novel radiometer package that has the ability to gather climate quality measurements and can differentiate between direct and diffuse solar irradiance. Additional meteorological sensors measure winds, air temperature, relative humidity, and estimate cloud coverage. Below the surface is another emerging technology, the Prawler (Profiling Crawler). The Prawler is a new-generation autonomous platform that harnesses wave energy to ratchet along the mooring line with shore-based command and control. It is equipped with temperature, salinity and oxygen sensors. Preliminary 2016 data show a detailed time series of deepening chlorophyll during the spring bloom, and seasonal changes in oxygen (Fig. 9).

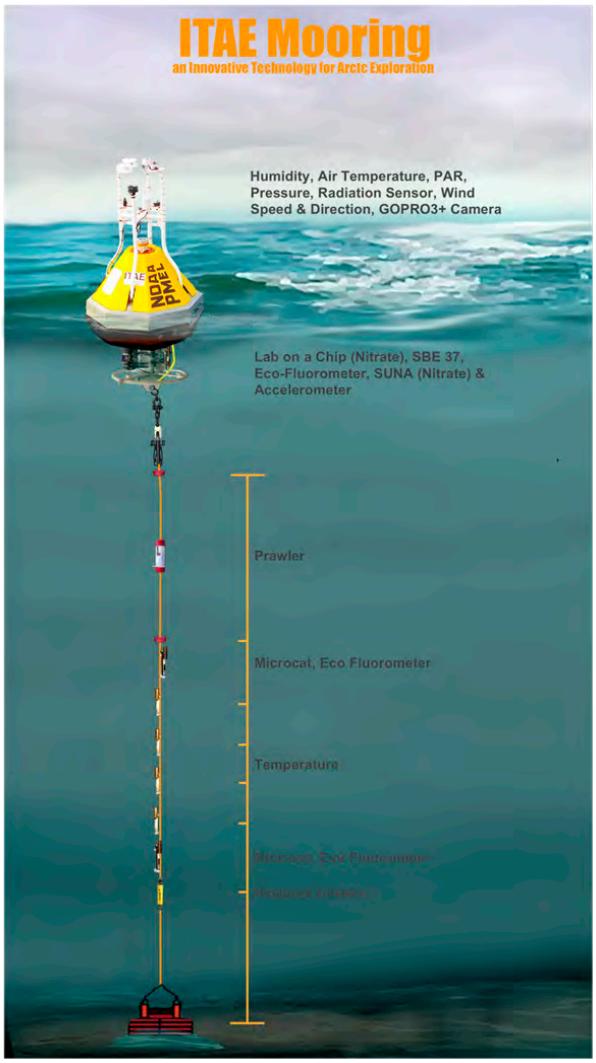


Fig 8 Schematic of the ITAE mooring surface and subsurface sensors. Figure courtesy of Heather Tabisola, PMEL.

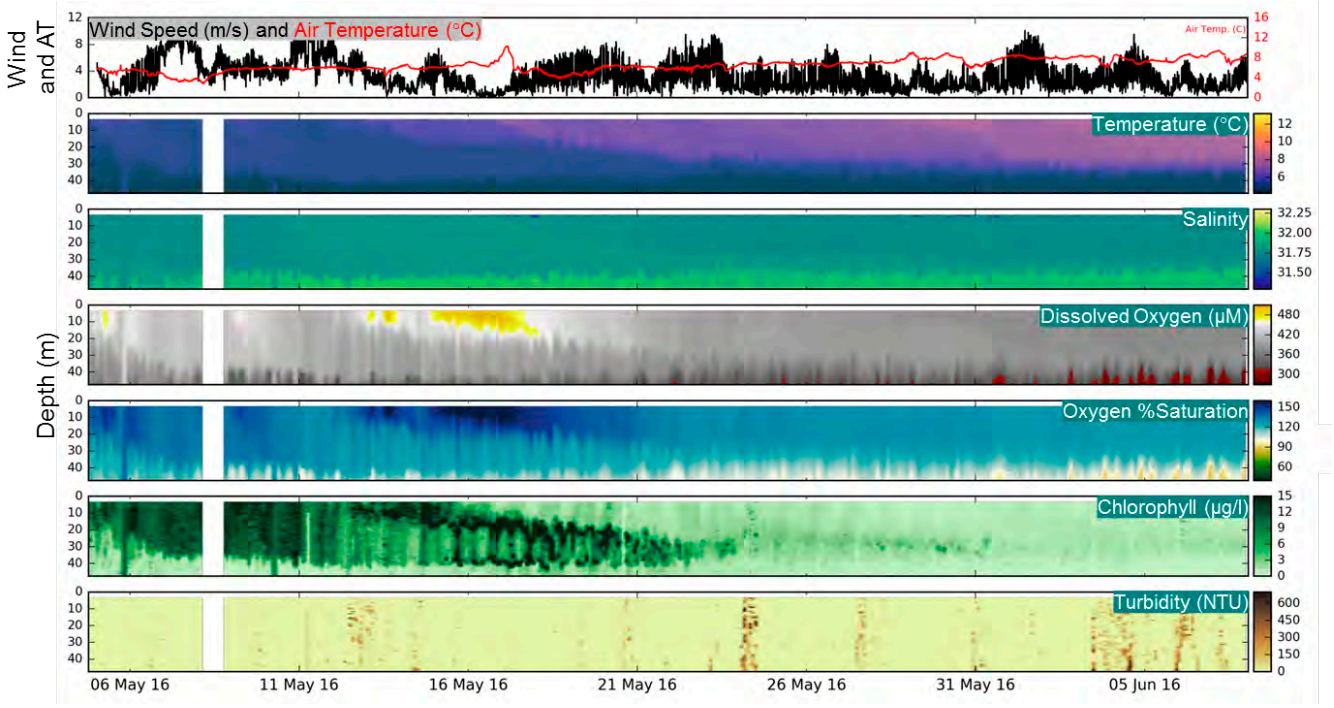


Fig. 9 Atmospheric and water column Prawler data collected from the ITAE mooring in the southeastern Bering Sea during spring (May to early June) 2016. Figure courtesy of Shaun Bell, PMEL.

Upcoming Bering Sea surveys

- PMEL and AFSC, NOAA will deploy moorings and conduct oceanography and plankton surveys on board the NOAA Ship *Oscar Dyson* on the southeastern shelf during late April/early May 2017.
- PMEL and AFSC will lead another mission to the Bering Sea to further field test integration of Saildrone research technologies. This mission will be accompanied by a carbon-focused mission in the Chukchi Sea. Expected launch date is mid-July 2017.

Upcoming Bering Sea meetings

- Alaska Marine Science Symposium, Anchorage Alaska, January 23–27, 2017.
- 31st Lowell Wakefield Fisheries Symposium: *Impacts of a changing environment on the dynamics of high-latitude fish and fisheries*, Anchorage Alaska, May 9–12, 2017.
- Pacific Seabird Group 44th Annual Meeting: *Sound to Sea: Marine Birds Across the Seascape*, Tacoma, Washington, February 22–25, 2017.

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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 eastern Bering Sea and Chukchi Sea research programs.

The state of the western North Pacific during the 2016 warm season

by Takashi Yoshida

The western North Pacific during the 2016 warm season was characterized by positive sea surface temperature (SST) anomalies in almost the entire region except along 30ºN where negative anomalies were observed. The positive anomaly was remarkable in August and September in the sea east of Japan where it reached over +3ºC. In the sea south of Japan, positive SST anomalies above +1ºC were observed (Fig. 1).

Ocean acidification in the western North Pacific Ocean is a particular concern because it limits the ocean's capacity of CO_2 uptake from the atmosphere and affects marine ecosystems. The average global surface seawater pH has decreased by 0.1 due to ocean uptake of anthropogenic CO_2 since the beginning of the industrial era (IPCC, 2013). The CO_2 absorbed by the ocean has been transported into the ocean interior through ocean circulation and biological processes, and has caused ocean acidification in the interior as well as in the surface layer. Figure 2 shows the long-term trends of pH in the ocean interior between 25.0 and 26.9 σ_θ along 137°E and 165°E. It shows decreasing trends of 0.002 to 0.031 per decade, with higher rates in the northern than the southern subtropics due to greater accumulation of anthropogenic CO_2 in the former. 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/oa_in/oceanacidification_interior_en.html.

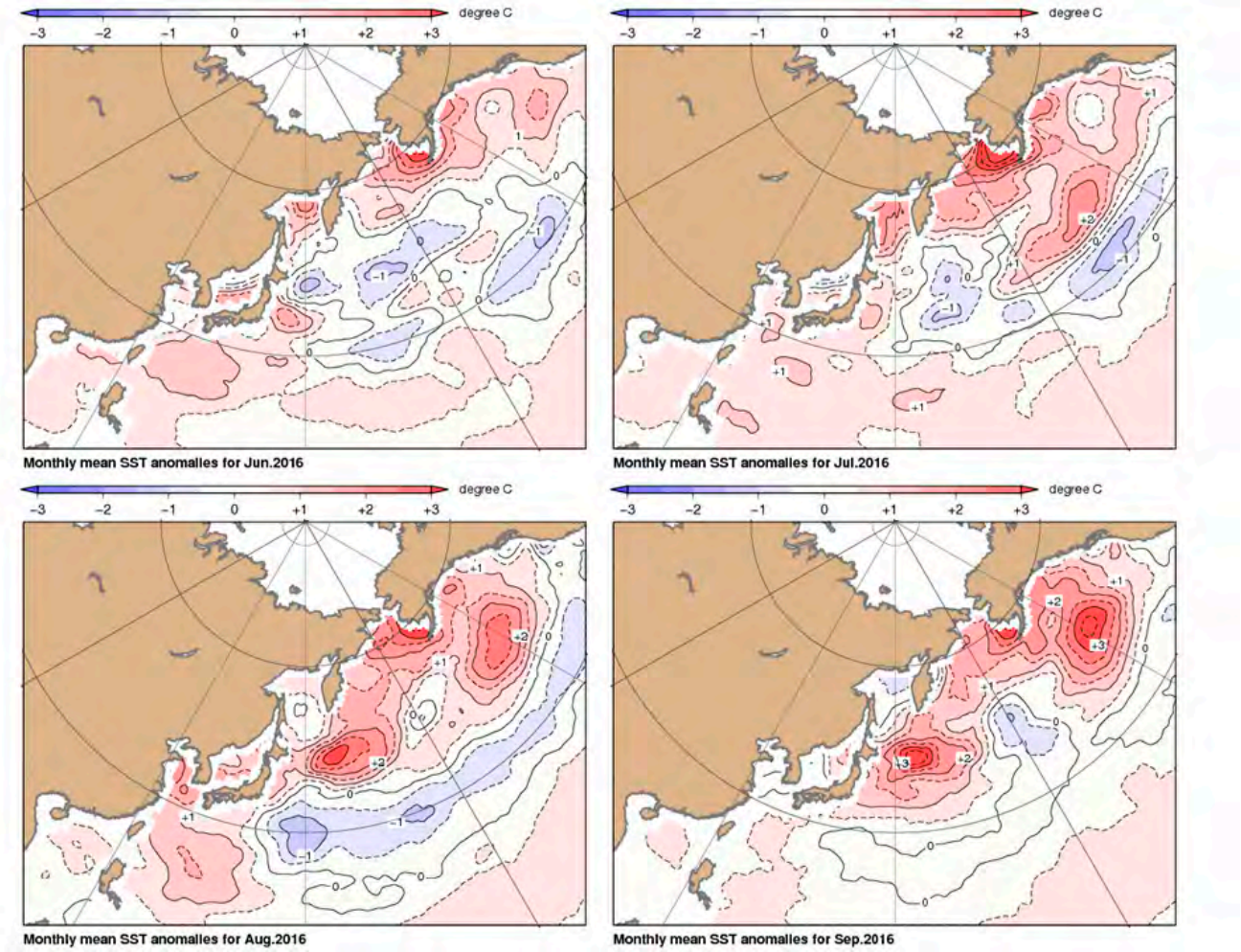

Fig. 1 Monthly mean sea surface temperature (SST) anomalies for June, July, August and September 2016. Monthly mean SSTs are based on JMA's COBE-SST (Centennial in situ Observation-Based Estimates of variability of SST and marine meteorological variables). Anomalies are deviations from the 1981–2010 climatology.

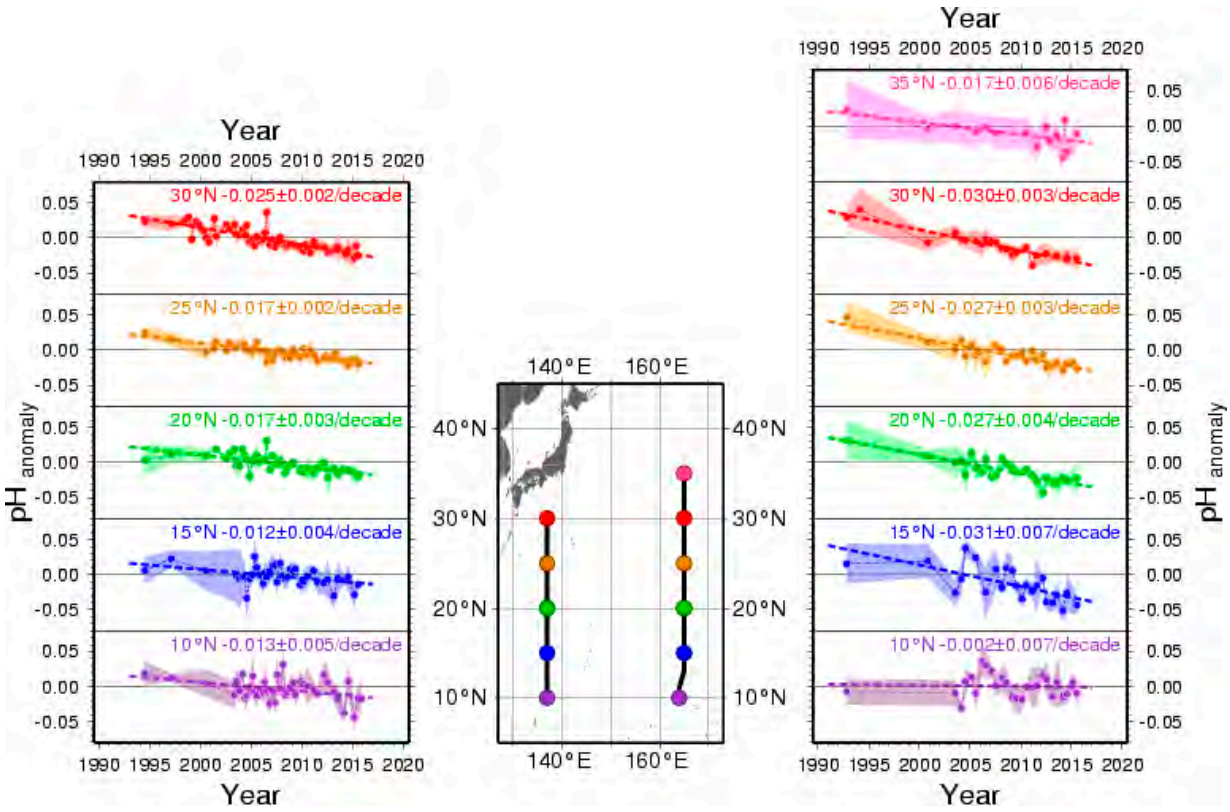

Fig. 2 Long-term trends of pH in ocean interior between 25.0 and 26.9 σ_θ (a depth range of about 150~800 m) along 137°E (left) and 165°E (right). Plots show pH anomalies from the normal (average for the period from 1991 to 2010) at each latitude. The shaded areas and bold dashed lines represent the standard deviation range (±1σ) and the long-term trend, respectively. The numbers indicate rates of change at each latitude. The ± symbols indicate a 95% confidence interval.

Reference

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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 the Working Group (WG 6) on Subarctic Gyre and contributed Western Pacific assessments to PICES Press previously in the 1990s.

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