PICES Press

SUMMER 2016
VOL. 24, NO. 2

Newsletter of the North Pacific Marine Science Organization

The 2016 Inter-sessional Science Board meeting: A note from the Science Board Chairman

This year our Inter-sessional Science Board meeting (ISB-2016) was held in the historic city of Hangzhou, China, from May 30 to June 1, 2016, back to back with a rare inter-sessional Governing Council meeting,. I thank the Government of China for hosting these two meetings. The venue and local logistics were ably organized by the Second Institute of Oceanography, SOA, who also provided a tour of their Hangzhou labs on the second day of ISB-2016.

One of the first items on the Science Board meeting agenda was to look at the progress made to date by PICES' FUTURE (**F**orecasting and **U**nderstanding Trends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) Scientific Steering Committee (SSC). Earlier this spring the SSC held its second inter-sessional meeting (March 8–10, 2016) in La Jolla, USA, at NOAA's Southwest Fisheries Center, and the SSC Co-Chairs reported on the outcome of the meeting to Science Board at ISB-2016. The SSC has updated the FUTURE Implementation Plan to align with the current governance structure of the program and has identified priority areas for the next stage of implementation. It is anticipated that additional FUTURE-proposed expert groups will be established soon to help fill any remaining gaps in the program. As part of the 25th Anniversary of PICES and to further engage PICES participants in FUTURE, PICES' integrated science program will be showcased at PICES-2016 so please plan to attend and participate at this exciting event.

FUTURE SSC meeting, March 8–10, 2016, in La Jolla, USA. Seated, clockwise from top: Sinjae Yoo, Hiroaki Saito (SSC Co-Chair), Thomas Therriault, Robin Brown, Laura Richards, Steven Bograd (SSC Co-Chair), Sukyung Kang, Ian Perry, Jacquelynne King, Guangshui Na, Toyomitsu Horii; inset: via Skype, Emanuele Di Lorenzo and Harold (Hal) Batchelder. Missing from the photo is Oleg Katugin who was taking this picture.

In This Issue

ISSN 1195-2512

Science Board and Governing Council participants at ISB-2016, from left: Takashi Ikeda (Advisor, Governing Council, Japan), Noritsugu Takahashi (Governing Council, Japan), Kyung-Il Chang (POC), Rui Zheng (Advisor, Governing Council, China), Igor Shevchenko (representing Russia), Chul Park (PICES Vice-Chair), Elizabeth Logerwell (FIS), Lev Bocharov (Governing Council, Russia), Laura Richards (PICES Chair), John Stein (Governing Council, USA), Thomas Therriault (Science Board Chair), Harold (Hal) Batchelder (Deputy Executive Secretary), Jennifer Boldt (MONITOR),Toru Suzuki (TCODE), Robin Brown (Executive Secretary), Steven Bograd (FUTURE SSC), Shigeru Itakura (Governing Council, Japan), Chuanlin Huo (MEQ), Carmel Lowe (Governing Council, Canada), Hiroaki Saito (Science Board Chair-elect; FUTURE SSC), Jinqiu Du (Advisor, Governing Council, China). Angelica Peña (BIO) not present.

Top: A warm welcome to PICES Science Board and Governing Council provided by our hosts at the Second Institute of Oceanography, Hangzhou; bottom: Dr. Tao Bangyi introducing participant to SIO.

To coincide with PICES' 25th Anniversary, a revision of the PICES Strategic Plan was undertaken by the Study Group on *Revising the Strategic Plan*, and was shown to the ISB participants. Look for this document, with an exciting new look and new PICES logo on the PICES website soon.

As the extent of PICES' science increases, so does its need for strategic collaborations with other organizations. One of our longest and strongest partnerships is with the International Council for the Exploration of the Seas (ICES). ICES and PICES have collaborated both formally and informally on many activities over the past 25 years, including jointly sponsored symposia series such as the very successful 6th Zooplankton Production Symposium, which was held May 9–13, 2016 in Bergen, Norway. In addition, PICES co-sponsored the ICES MSEAS Symposium on "*Understanding marine socio-ecological systems: Including the human dimension in Integrated Ecosystem Assessments*" held May 30 – June 3, 2016 in Brest France (see the articles related to these symposia elsewhere in PICES Press), and don't forget the PICES/ICES Symposium on "*Drivers of small pelagic fish resources*", which will be held March 6–11, 2017 in Victoria, Canada (abstract submission is now open). After adopting a framework for Strategic Cooperation with the Northwest Pacific Action Plan (NOWPAP) at PICES-2015, PICES is continuing to strengthen its working relationship with our partner on environmental quality and to this end we were represented at the NOWPAP CEARAC Focal Point Meeting held April 7–8, 2016 in Toyama, Japan. Similarly, to further enhance our relationships with CLIVAR (Climate and Ocean – Variability, Predictability, and Change) PICES will be sending invited speakers to the CLIVAR Open Science Meeting September 15–23, 2016 in Qingdao, China.

At every ISB, Science Board reviews the theme of the Annual Meeting one year in advance. PICES-2017 will be hosted by Russia in Vladivostok and the theme will be "*Environmental changes in the North Pacific and impacts on biological resources and ecosystem services*". This Annual Meeting will recognize the ongoing changes occurring in the North Pacific, especially to resources that are important to coastal communities. To submit Topic Sessions or Workshops for PICES-2017 please visit the PICES submissions page.

Participants at the SG-NPESR3 workshop (posing in front of the PICES Secretariat). Back row, from left: Keith Criddle, Nicholas Bond, Harold (Hal) Batchelder, Sonia Batten, Jacquelynne King, Phillip Mundy (SG-NPESR3 Chair), Michael Foreman, Tony Koslow, Vladimir Kulik, Juan José Alava, Matthew Baker; front row, from left: Hiroya Sugisaki, Se-Jong Ju, Lisa Eisner, Thomas Therriault, Angelica Peña, Jennifer Boldt, Peter Chandler, Thomas Van Pelt.

Marine non-indigenous species continue to be an important issue for PICES member countries. In addition to PICES' ongoing ADRIFT (Assessing the Debris-Related Impact of Tsunami) project, funded by the Japanese Ministry of Environment, PICES was well represented at the 9th International Conference on Marine Bioinvasions held January 26–29, 2016 in Sydney, Australia. The Conference theme was "*Hulls, harbours and other invasion hotspots*" and a special Session was devoted to ADRIFT project outcomes (see the next article in PICES Press). ADRIFT project Co-Chair meetings were recently held in Tokyo, Japan (February 2016) and Vancouver, Canada (April 2016) to discuss scientific objectives and budget allocations for Year 3 projects. Recognizing the ongoing issue of marine non-indigenous species in the PICES region, Governing Council approved Science Board's recommendation at ISB-2016 to establish an Advisory Panel on *Marine Non-Indigenous Species*.

As one of PICES' high priority activities, the North Pacific Ecosystem Status Report is considered a flagship product of the Organization. At PICES-2014, SG-NPESR3 was established to outline a means to compile the third iteration of this document. The SG met just recently (June 28–30, 2016) at the Institute of Ocean Sciences in Sidney, Canada, to review candidate ecosystem time series observations (ETSOs), identify spatial gaps in ETSOs, and discuss methods for production, including what the third report might look like. An exciting new long-term approach to identify and use the ETSOs to characterize and understand changes in North Pacific marine ecosystems was developed by the workshop participants. Please watch for a special overview of this new approach at PICES-2016. To continue the groundwork of the SG, and actually develop NPESR3, a new Working Group on NPESR3 was also approved at ISB-2016.

Another PICES high priority activity is capacity building. This can occur via major symposia, such as the PICES/ICES Early Career Scientist Conference being planned for Busan, Korea in 2017, or it can take the form of PICES sponsorship or co-sponsorship of summer schools or training workshops such as the one on "*Freshwater discharge and coastal environments*" being planned for the late fall 2016 in Nagoya, Japan. PICES also provides funds that enable early career scientists (ECS) to travel to PICES meetings or PICES events such as the 9th International Conference on Marine Bioinvasions noted above that included 10 award recipients from PICES member countries.

Evening on West Lake, Hangzhou, China.

PICES-2016 is fast approaching. The theme of our 25th Annual Meeting in San Diego, USA, is "*25 Years of PICES: Celebrating the past, imagining the future*". For important dates regarding the meeting, see p. 39 and the Meeting website. I look forward to seeing you there where an exciting, diverse (and extremely full) agenda awaits!

Science Board Chairman
Thomas Therriault

PICES at the 9th International Conference on Marine Bioinvasions

by Thomas W. Therriault, Cathryn Clarke Murray, and Graeme Inglis

The 9th International Conference on Marine Bioinvasions (ICMB-IX) was held in Sydney, Australia from January 19–21, 2016. This conference was an outstanding success, with strong attendance from scientists, policy makers, decision makers, industry, students and educators. The meeting title, "*Hulls, harbours and other invasion hotspots*" and its location within walking distance of the iconic Sydney Harbour, reflected a focus on places of importance in marine invasion pathways – global locations that are the source of invasive species or that are severely affected by them. Further, sponsors for ICMB-IX included: Cawthon Institute, Centre of Excellence for Biosecurity Risk Analysis (CEBRA), New Zealand Ministry for Primary Industries, NSW Department of Primary Industries, North Pacific Marine Science Organization (PICES), and National Institute of Water & Atmospheric Research Ltd (NIWA); local hosts were the University of New South Wales and Sydney Institute of Marine Sciences (SIMS); and Co-Chairs were Professor Emma Johnson (University of New South Wales, Australia) and Dr. Graeme Inglis (National Institute of Water & Atmospheric Sciences Ltd (NIWA), New Zealand). Over the course of the meeting, delegates were treated to six stimulating and entertaining talks from invited plenary speakers and were able to choose from 33 sessions that included 127 oral and 34 poster presentations covering a range of bioinvasion topics. ICMB-IX was attended by 162 delegates from 19 countries, including four PICES member countries (Fig. 1).

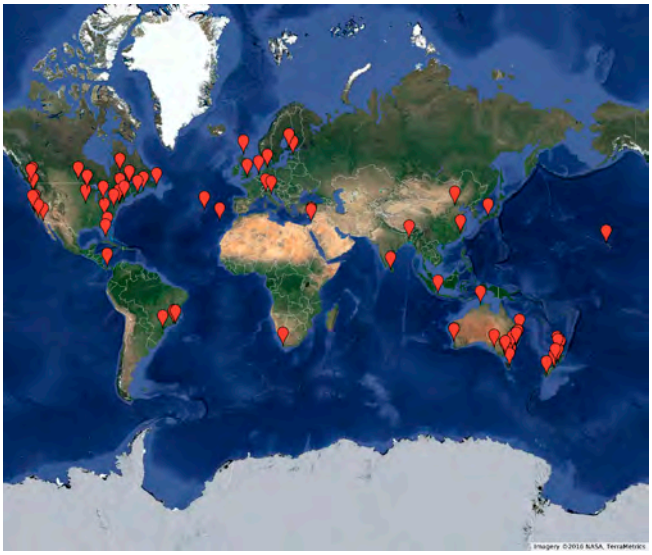


Fig. 1 ICMB-IX participants travelled to Sydney from all over the globe.

As with other PICES-supported events, the development of young researchers with an interest in marine bioinvasions is an important aim of the ICMB conference series. The conference allows them to place their own research into a global context, to network with other young researchers, to hear from leading scientists in their field and to interact with managers, policy makers and industry professionals. Contributions made by the sponsors of ICMB-IX allowed organizers to offer a reduced registration rate for students and early career scientists. PICES provided direct travel assistance to 10 young researchers from countries around the North Pacific allowing them to travel to Sydney (Fig 2). The outcome was that almost one third of the delegates at ICMB-IX were students (33) or ECSs (16). Collectively, they contributed 36 oral papers to the general session of the conference and 13 posters.

Fig. 2 PICES Early Career Scientist Travel Award recipients (one missing from the photo) with PICES Science Board Chairman and ICMB-IX Scientific Steering Committee member, Dr. Thomas Therriault.

In addition to the scheduled talks, a series of social events were planned to facilitate informal interactions. These included an icebreaker the night before the conference that kick-started discussions and a poster session that allowed presenters and attendees to mingle and learn about the latest findings in a relaxed atmosphere. Finally, at the conference's conclusion, delegates enjoyed a dinner cruise around Sydney Harbour (Fig. 3). Despite torrential rain and lightning this was a great success. The conference was, as is typical, very successful in bringing together the leading research in marine bioinvasions and eliciting productive discussion, new and continuing connections, and future collaborations.

Fig. 3 Top: The famous Sydney Opera House on the south shore of Sydney Harbour; middle: Government House, official residence of the Governor of New South Wales, also overlooking Sydney Harbour; bottom: Sydney Institute of Marine Science near the mouth of Sydney Harbour where participants were treated to a field trip during the conference.

Finally, the 10th International Conference on Marine Bioinvasions (ICMB-X) will be held in Puerto Madryn, Argentina, October 16–18, 2018. This represents the first time that ICMB will be convened in South America and it should be another exciting and stimulating meeting. Those working on marine invasions in the North Pacific should definitely pencil this into their calendars now!

PICES' ADRIFT project presentations

The devastating Tōhoku earthquake and tsunami in March 2011 cast a vast amount of debris from coastal ports and cities in Japan and sent it rafting across the Pacific Ocean. More than 300 species of invertebrates, algae, and fish from Japanese waters made an ocean journey of more than 5,000 km to wash up on the shores of the United States and Canada, primarily attached to, or within floating docks, boats, buoys and totes. The PICES ADRIFT (Assessing the Debris-Related Impact From Tsunami) project, funded by the Ministry of the Environment of Japan, has been tracking the movement of marine debris from the tsunami across the North Pacific, monitoring its landfall in the eastern Pacific, and assessing the risk of establishment by potentially invasive species. A special session at ICMB-IX entitled "*Tsunami Bioinvasion*" provided an update on the ADRIFT project outcomes and included the following presentations:

- Carlton, James; Chapman, John; Geller, Jonathan; Miller, Jessica; Ruiz, Gregory; Carlton, Deborah; and McCuller, Megan. *The invasion process model and the long-distance transoceanic dispersal of coastal marine organisms by Japanese tsunami marine debris*. Oral presentation.
- Clarke Murray, Cathryn; Therriault, Thomas; Wallace, Nancy; Maki, Hideaki; and Bychkov, Alexander. *Effects of marine debris caused by the Great Tsunami of 2011*. Poster presentation.
- Geller, Jonathan B.; Campbell, Tracy; Carlton, James T; Chapman, John W.; Heller, Philip; Miller, Jessica; and Ruiz, Gregory M. *DNA barcode and metagenetic approaches for monitoring and surveillance of marine invasive species in North American waters, with focus on 2011 Japanese Tsunami Marine Debris-associated species*. Oral presentation.
- Hansen, Gayle I.; Hanyuda, Takeaki; and Kawai, Hiroshi. *Marine Algae arriving on Japanese Tsunami Marine Debris (JTMD) and their invasion threat to the coasts of Oregon and Washington, USA*. Poster presentation.
- Miller, Jessica; Carlton, James; Chapman, John; Geller, Jonathan; and Ruiz, Gregory. *The mussel Mytilus galloprovincialis on Japanese Tsunami Marine Debris: A potential model species to characterize a novel transport vector*. Poster presentation.
- Ruiz, Gregory; Geller, Jonathan; Carlton, James; Chapman, John; Miller, Jessica; Di Maria, Ruth; Lohan, Katrina; and Barnard, Rebecca. *Japanese Tsunami Marine Debris: Potential transoceanic rafting of bivalve parasites and pathogens*. Oral presentation.

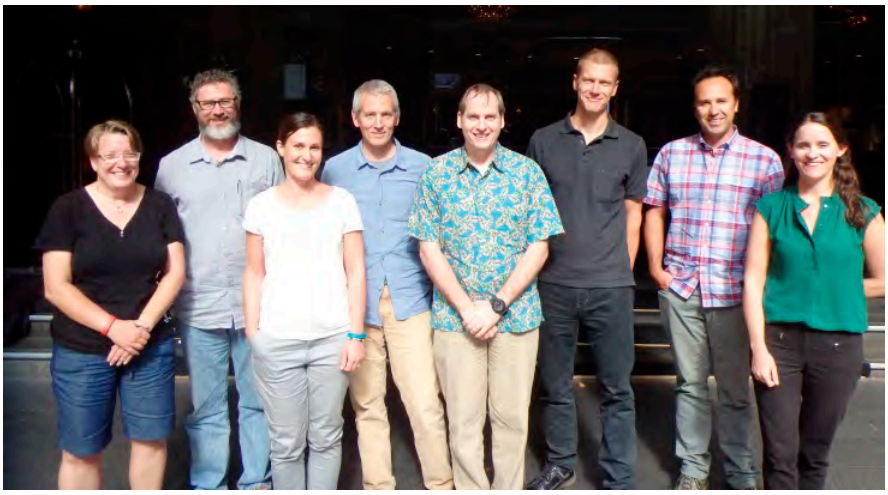


Fig. 3 Workshop attendees in Sydney, Australia, from left: Marnie Campbell (Australia/New Zealand), Chad Hewitt (Australia/New Zealand), Sonia Gorgola (Australia), Chris McKindsey (Canada), Tom Therriault (Canada), Oliver Floerl (New Zealand), Grant Hopkins (New Zealand), Cathryn Clarke Murray (PICES).

In addition to this special session, the PICES ADRIFT project took advantage of this conference's location in the southern hemisphere to host a special 1-day workshop (Fig. 3) related to assessing the risk of the tsunami vector prior to the conference. In order to evaluate the overall risk from tsunami debris, a vector risk assessment is being conducted and workshops are being used to gather expert opinion. The risk assessment incorporates data from the invasive species, surveillance and monitoring, and modeling research activities, described in previous PICES Press articles. The invasive species research will provide data on cumulative species richness, species richness per debris item, and abundance. The surveillance and monitoring research will provide estimates of the number of debris items that made landfall in each region. The modeling research will provide data on the likely voyage routes and voyage durations of debris items. Finally, life history and environmental matching data from the invasive species team will be used to estimate the likelihood of establishment of species on debris items. When combined, there will be an estimate of relative risk to each region from JTMD and the relative risk of different types of debris items.

Dr. Thomas Therriault (Thomas.Therriault@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada (DFO) at the Pacific Biological Station in Nanaimo, British Columbia. Tom is working on a number of aquatic invasive species research questions both within DFO and through the second Canadian Aquatic Invasive Species Network (CAISN II). He was the Principal Investigator for the Taxonomy Initiative of PICES Working Group 21 on Non-indigenous Aquatic Species that includes rapid assessment surveys for non-indigenous species. Within PICES, Tom serves as Chairman of Science Board.

Dr. Cathryn Clarke Murray (cmurray@pices.int) is a Visiting Scientist with PICES on the project "Effects of marine debris caused by the Great Tsunami of 2011", funded by the Ministry of the Environment of Japan. She is also Adjunct Professor in the Institute for Resources, Environment and Sustainability at the University of British Columbia. Cathryn has worked with WWF (World Wildlife Fund)-Canada on the cumulative effect of human activities, with Fisheries and Oceans Canada on ecological risk assessment, and studied the spread of invasive species on marine recreational boats.

Dr. Graeme Inglis (Graeme.Inglis@niwa.co.nz) leads the Marine Biosecurity research programme, which is a partnership involving the National Institute of Water and Atmosphere Research (NIWA), the Cawthron Institute, and the Ministry for Primary Industries. He is a member of the IUCN Invasive Species Specialist Group, a Technical Advisor to the GEF/UNDP/IMO Global Ballast Water Management Programme and sits on advisory panels for implementation of New Zealand's Biosecurity Science Strategy and MAF Biosecurity NZ's Biosecurity Surveillance Committee. Graeme's research is primarily on the design and implementation of marine pest surveillance, including early detection, baseline and delimiting surveys for unwanted marine organisms.

The ICES/PICES 6th International Zooplankton Production Symposium

by Astthor Gislason and Padmini Dalpadado

The 6th International Zooplankton Production Symposium (ZPS) was held in Bergen, Norway, from May 9–13, 2016, at a time when there was a nationwide hotel and restaurant strike in Norway. Despite the strike, the symposium ran smoothly, thanks to the efforts of conference hotel staff who did their utmost to make us feel very comfortable. The city of Bergen which is known to be quite "rainy" showed its best side with sunny and warm weather throughout the week. The ZPS brought together almost 400 scientists from 38 countries to debate and address a range of issues on zooplankton ecology. The theme of the symposium, "*New challenges in a changing ocean*", reflects that the focus was on the climate-induced changes in marine life and the research challenges we face due to these changes.

The major sponsors of the symposium were the International Council for the Exploration of the Sea (ICES), the North Pacific Marine Science Organization (PICES), the Institute of Marine Research (IMR) and the Norwegian Research Council (NRC) and several commercial sponsors. The symposium was co-convened by Atsushi Tsuda (PICES, Japan), Astthor Gislason (ICES, Iceland), and Padmini Dalpadado (ICES, Norway) who also chaired the Local Organizing Committee. Assisting these people were the other members of the Scientific Steering Committee, Se-Jong Ju (Republic of Korea), Desiree Tommasi (USA), Piotr Margonski (Poland) and Lidia Yebra (Spain) and coordinators from ICES (Adi Kellermann) and PICES (Hal Batchelder).

This conference was the sixth in a series of international symposia, sponsored by the ICES, and in most cases also by the PICES, dedicated to zooplankton research. The previous symposia were held in Copenhagen, Denmark (1961), Plymouth, UK (1994), Gijón, Spain (2003), Hiroshima, Japan (2007) and Pucón, Chile (2011). These symposia have proved to be excellent fora for bringing together scientists and experts from all over the world to present and discuss state-of-the art research on marine zooplankton and their role in the global ecosystem, as evidenced by the numerous publications derived from them. The 6th International Zooplankton Production Symposium was no exception, and the best contributions of the symposium will be published in a special volume of the *ICES Journal of Marine Science* in 2017.

Participants of the 6th International Zooplankton Production Symposium.

Clockwise, from top: ICES President, Dr. Cornelius Hammer, opening the symposium; PICES Science Board Chair, Dr. Thomas Therriault, welcoming participants to the symposium on behalf of PICES; Plenary speakers, Dr. Stein Kaartvedt, University of Norway and Dr. Hein Rune Skjoldal, Institute of Marine Research, Norway.

The meeting was attended by 387 persons from 38 countries and was thus the best attended ICES/PICES Zooplankton Production Symposium ever held. The 5-day symposium consisted of an opening session, plenary sessions, parallel theme sessions, workshops, poster presentations and a plenary summing up session.

The Opening Session took place on the morning of Monday May 9, 2016. The session started with a lovely and inspiring performance by the Bergen Cultural School saxophone quartet. This was followed by welcome and opening remarks by the ICES convener, Astthor Gislason, and short addresses by the Director of IMR, Sissel Rogne, the Mayor of Bergen, Marte Mjøs Persen, the Chair of PICES Science Board, Thomas Therriault, and ICES President, Cornelius Hammer, who declared the symposium as officially opened. The Opening Session ended with two excellent plenary talks by Norwegian scientists:

- *Calanus species in the Arctic Mediterranean: from life history to ecosystem dynamics*, by Hein Rune Skjoldal (Norway);
- *Echosounders: Non-intrusive observations of the pelagic*, by Stein Kaartvedt (Norway).

On the evening of the first day, the Institute of Marine Research (IMR) hosted a reception welcomed by the local convener, Padmini Dalpadado, with refreshments at the conference hotel. The reception offered a perfect opportunity for people to connect with new colleagues and renew existing relationships right at the beginning of the meeting. The welcome reception included a very nice musical performance by the Bjørgvin vocal choir.

In addition to the plenary talks given during the Opening Session, the ZPS included four other excellent plenary talks given in the mornings of Days 2 and 4:

- *Does climate change matter for zooplankton production in upwelling systems?* by Rubén Escribano (Chile);
- *Discovery of the new through scrutiny of the old: Odate collection and future of zooplankton monitoring in the global observation initiatives*, by Sanae Chiba (Japan);
- *Modeling Southern Ocean food webs – Approaches and challenges*, by Eileen Hoffman (USA);
- *On the adaptive potential of marine zooplankton to global change*, by Erica Goetze (USA).

Two Theme Sessions were run in parallel on Days 1, 2, 4 and 5 and included 117 oral presentations (14 invited talks) and 170 posters. The Theme Sessions were:

- S1: *Application of optical and acoustical methods in zooplankton studies*. Conveners: Mark Benfield (USA) and Ian H. McQuinn (Canada);
- S2: *Response of zooplankton communities to changing ocean climate*. Conveners: Todd O'Brien (USA) and Tone Falkenhaug (Norway);
- S3: *The diversity and role of macrozooplankton in marine ecosystems*. Conveners: Priscilla Licandro (UK), Stig Falk-Petersen (Norway), and Se-Jong Ju (Republic of Korea);

- S4: *Zooplankton diversity in the oceans by integrative morphological and molecular techniques*. Conveners: Ann Bucklin (USA) and Ryuji Machida (People's Republic of China);
- S5: *The role of microzooplankton in marine foodwebs*. Conveners: Albert Calbet (Spain) and Karen E. Selph (USA);
- S6: *Individual level responses of zooplankton to environmental variability and climate change*. Conveners: Eva Friis Møller (Denmark) and Pamela Hidalgo (Chile);
- S7: *Zooplankton in high-latitude ecosystems*. Conveners: Kim Bernard (USA) and Rolf Gradinger (Norway);
- S8: *New technologies and approaches in zooplankton trophic studies*. Conveners: Monika Winder (Sweden) and Antonio Bode (Spain).

The workshops were run concurrently in the morning on Day 3, and as the Theme Sessions, they included both oral and poster presentations, with 31 talks (5 invited) and 27 posters:

- W1: *Use of zooplankton indicators to characterize state of pelagic ecosystems*. Conveners: Alessandra Conversi (Italy), Hongsheng Bi (USA), and Sun Song (People's Republic of China)
- W2: *ICES/PICES cooperative research initiative: towards a global measurement of zooplankton production*. Conveners: Lidia Yebra (Spain) and Toru Kobari (Japan)
- W3: *Zooplankton as a potential harvestable resource*. Conveners: Webjørn Melle (Norway) and So Kawaguchi (Australia)
- W4: *Effects of microplastics on zooplankton*. Conveners: Elaine Fileman (UK) and Maiju Lehtiniemi (Finland)
- W5: *Zooplankton as the "to" in end-to-end models*. Conveners: Geir Huse (Norway) and Rubao Ji (USA)
- W6: *A hands-on Introduction to time series analysis, visualization, and inter-comparison of plankton survey data*. Instructor: Todd O'Brien (USA)
- W7: *Toward a taxonomically-comprehensive global reference database for DNA barcodes of marine zooplankton*. Conveners: Tone Falkenhaug (Norway) and Silke Laakmann (Germany)

Almost 200 posters were on display, and due to the high enrolment and the limited space, these were displayed in two afternoon sessions on Day 2 and Day 3, with approximately 100 on each day.

International scientific symposia, like the Zooplankton Production Symposia, allow scientists the opportunity to share knowledge and experiences between themselves and to communicate messages to the general public. However, they also offer an opportunity to establish cooperation and friendships among fellow scientists. And this may very well be one of the more important roles that they play. The social events of the symposium were excellently organized by the IMR Local Oganizing Committee led by Padmini Dalpadado and included the Welcome Reception on Day 1, evening poster sessions on Days 2 and 3, afternoon sightseeing trips on Day 3, and a symposium dinner on Day 4.

An excursion to Lysøen island, the home of the famous Norwegian musician, Ole Bull.

In the afternoon of May 11, 2016, participants took a break from the formal sessions for the exciting excursions. There were five options to choose from: an excursion to Lysøen island, the home of the famous Norwegian musician, Ole Bull; an excursion to the Coastal Museum in Øygarden with a visit to a fish farm; a walk in Bergen with a local guide; a guided tour in the KODE art museum, and a visit to Fløyen, the rooftop of Bergen. All the excursions were memorable and we were extremely lucky to have good sunny weather with temperatures of above 20º Celsius. The day ended with a poster session and refreshments.

During the conference, Per Flood exhibited a selection of his excellent photographs of zooplankton. The images really convey the incredible diversity and beauty of this group of marine organisms.

From Per Flood's exhibition of zooplankton images

In the Closing Ceremony, which began after the sessions on Friday 13, Hal Batchelder, Deputy Executive Secretary of PICES, offered a few summarizing remarks, pointing out the great success and the large attendance of the 6th Zooplankton Production Symposium, signifying its importance. This was followed by Piotr Margonski, the Chair of the Awards Committee, who described the difficult task given to the Committee of having to select among the many excellent presentations of early career scientists. The awards for best oral presentation were given to Michael Blackett (National Oceanography Centre Southampton and Sir Alister Hardy Foundation for Ocean Science, UK), for his talk on "*Biology and ecology of the siphonophore Muggiaea atlantica in the northeast Atlantic*", and Helena Hauss (GEOMAR, Germany) for her presentation titled "*Dead zone or oasis in the open ocean? Zooplankton distribution and migration in low-oxygen mode water eddies*". The best poster awards went to Ana Luisa Moran Ahern (Scripps Institution of Oceanography, USA), for her poster on "*Monitoring spawning activity in Cabo Pulmo National Park using molecular identification of fish eggs and larvae*", and Carolyn L. Faithfull (University of Hawaii, USA) for her poster titled "*Can nauplii use bacteria as a phosphorus or energy source?*".

Early career scientists who were sponsored by ICES and PICES.

Piotr Margonski, Chair of the Awards Committee, presenting awards to the early career scientists. Left to right: Carolyn L. Faithfull, Michael Blackett, Ana Luisa Moran Ahern and Helena Hauss with her boy on her shoulders. Hal Batchelder, who led the Closing Ceremony, is in the background.

A few glimpses from the symposium.

After the awards presentations, Michelle Jungbluth (USA) and Svein Sundby (Norway), presented a few closing scientific remarks, Michelle from her perspectives as an early career scientist and Svein as a senior one. The work of those who contributed most in the organizing and preparatory work was then acknowledged by Hal Batchelder, who officially closed the symposium.

Michelle Jungbluth and Svein Sundby who summarized the symposium results at the Closing Ceremony.

The Local Organizing Committee is very grateful to the staff at the ICES Secretariat (Vivian Piil, Celine Byrne, Mike Drew, Maria Lifentseva, Helle Falck, Henrik Larsen) who provided excellent professional assistance in the planning, development, coordination and smooth running of the symposium and to the IMR IT Department (Tommy Bogno Iversen, Christer Johannessen) who did an excellent job in running the session and workshop presentations very smoothly. Special thanks are also extended to Solveig Thuland and Åse Pedersen who assisted greatly with the local organizing at all stages and Ingunn Bakketeig, Maria Hauge and Hege Iren Svenson from the Public Relations and Communication Department at IMR for all the help received in preparation of the symposium poster, flyer and dissemination of the symposium announcement. Without the efforts of all these people, and the generous financial support from our sponsors, it would not have been possible to convene a symposium of such broad scope.

In summary, by all accounts the meeting was a great success, and the companionship and friendship between participants was clearly evident. We hope that what transpired at this symposium leads to new collaborations and endeavours among all of us who are devoted to study the fascinating world of zooplankton.

Dr. Astthor Gislason (astthor@hafro.is) is a zooplankton ecologist at the Marine Research Institute, Iceland. His research interests include seasonal dynamics, life history and long-term changes of zooplankton, and more recently the use of acoustics and in situ imaging systems (VPR) for assessing abundance and distribution of zooplankton. He is a member of the ICES Working Group of Zooplankton Ecology (WGZE).

Dr. Padmini Dalpadado (padmini.dalpadado@imr.no) is a zooplankton ecologist at the Institute of Marine Research, Bergen, Norway. Much of her research in recent years has been focused on climate effects on the Barents Sea ecosystem dynamics with special emphasis on predator-prey interactions between zooplankton and fish. She is a member of the ICES Working Group of Zooplankton Ecology (WGZE) and the Working Group on the Integrated Assessments of the Barents Sea (WGIBAR).

PICES/ICES Workshop on "*Use of zooplankton indicators to characterize state of pelagic ecosystems*"

by Alessandra Conversi, Hongsheng Bi and Kathryn Cook

Climate change and overfishing is causing changes in the distribution of marine organisms and shifts in ecosystem structure, affecting ecosystem productivity and overall health. Zooplankton are vital components of the pelagic food web and often show rapid response to changes in the marine environment and food web structure. To mitigate the intense pressure from climate change and overfishing and to ensure the sustainability of the marine ecosystem, there is an urgent need to characterize the state of the pelagic ecosystem. However, the complexity of marine ecosystems and nonlinear interactions among different ecosystem components makes it difficult to achieve this goal. A common practice is to develop various ecosystem indicators as proxies for key physical and biological processes and infer ecosystem status based on a suite of indicators. Zooplankton indicators are the essence of ecosystem indicators.

The workshop (W1) on "*Use of zooplankton indicators to characterize state of pelagic ecosystems*" aimed to address this topic. It took place on May 11, 2016, in Bergen, as part of the ICES/PICES 6th Zooplankton Production Symposium on "*New challenges in a changing ocean*". The overall goals of the workshop were to look at the function of zooplankton indicators as proxies for physical and biological processes, their use in ecosystem modelling, and their practical applications in marine policy. Additional goals, developed during the months preceding the workshop, included the writing of a review/opinion paper on zooplankton indicators, and the building of a network of people interested in the use and understanding of zooplankton indicators.

Within the symposium, 7 workshops ran simultaneously from 9:00am to 12:30pm. This workshop had high attendance, with approximately 80 scientists actively participating to the discussion. The workshop was organized with one invited talk and 7 additional talks, selected among several submitted abstracts (see the Symposium program), plus discussion time open to all participants (about 1 hr 20 min long), and a poster session (10 posters) in the evening.

This article reports the main findings of the workshop discussion.

- *Which zooplankton indicators?*

To identify proper indicators, a clear question – what one needs the indicators for – will facilitate the indicator selection process, as there will be different suites of indicators corresponding to different questions. Ideally, one should build a matrix of indicators *vs* questions/problems. It is also important to delineate the proper spatial and temporal scales for different indicators and questions, reflecting the complexity and nonlinearity in ecosystem structure and function.

Most zooplankton indicators are based on species composition (*e.g.*, richness and diversity), relative abundance (*e.g.*, results from multivariate statistics), species-level abundance (*e.g.*, cold water copepods *vs* warm water copepods), different functional groups (*e.g.*, predator *vs* prey), keystone species (*e.g.*, jellyfish, krill) and invasive species (*e.g.*, *Mnemiopsis*). Developing these indicators is not an easy task because enumerating zooplankton samples is laborious and time consuming. This is complicated by the fact that most indicators require time series data. However, there are some useful indicators that could be developed using modern technologies, *e.g.*, size spectra and food quality.

Size spectra give a simple measure of how size changes over season: the slope gradually gets steeper as the phytoplankton increase and then there is a major change as the zooplankton start to bloom. There was consensus that size information on its own does not give the full picture and taxonomic information is also necessary, *e.g.*, a change in size could have different effects on trophic transfers. Also, non-native species would not be picked up if they are the same size as the native species.

Food quality for higher trophic levels (C/N ratios, stable isotopes, *etc.*) were proposed as good indicators, which are relatively easy to measure. For example, copepods *vs* cladocerans could be an indicator of lipid levels.

Dr. Hongsheng Bi addressing Workshop 1 participants.

- *What constitutes "good" indicators?*

There was consensus that the indicator collection needs to be economical for it to last in time. For example, size spectra, food quality indicators and taxa that can be measured with automatic (optical, acoustic) systems are relatively easy to measure, and relatively economical. Systems can use ships of opportunity and provide detailed taxonomic information (*e.g.*, Continuous Plankton Recorder) without the cost of research ship time. However, the choice of simple/economic indicators, such as size spectra, could discourage funding of other monitoring, hence again raising the problem of duration *vs* completeness of a program. In any case, zooplankton monitoring needs to continue even after an assessment has concluded good status. In general, zooplankton indicators need to secure the overall understanding of ecosystem functioning and be able to dynamically capture its changes through time.

- *Zooplankton indicators around the world*

The indicator field is growing, especially as some countries are developing indicator-based monitoring systems, *e.g.*, the European Union's Marine Strategy Framework Directive requires all member states to set up a system of indicators of good environmental status and to monitor their waters. However, different countries are tackling the issue with different systems (*e.g.*, ecosystem status reports in the U.S. and Canada).

The discussion and the talks highlighted that there are a lot of groups developing different indicators in different regions, but communication between these groups is often lacking. If a network is formed (as proposed by the workshop conveners), it could start addressing the questions above and recommend indicators that can be applied across systems.

- *How "universal" are zooplankton indicators, in space and time? (and suggestions for future work)*

This area shows lots of uncertainty and will likely need more development in the near future.

It was noted that the role of a local indicator *vs* a global indicator is different, and that in different regions different drivers and species can respond to these in various ways.

There was discussion about how the currently used indicators perform under large ecological changes such as regime shifts. It was felt that many indices would work under "normal" interannual variability, but not during the altered variability seen when approaching a shift. Current zooplankton indicators on their own may not be enough to detect a major regime shift.

Overall, the variability and consistency over space/time of the zooplankton indicators are not well understood: it was suggested that a review paper with a space/time (Stommel) diagram of indicators would be very appropriate.



Dr. Alessandra Conversi (aconversi@ccmail.sunysb.edu) is a Senior Scientist at CNR-ISMAR-La Spezia, Italy. Her research interests are the impacts of climate change on the marine biota, including interdisciplinary connections between biological oceanography, physical oceanography, and climatology. In particular, Alessandra's research deals with retrospective analyses (decadal scale), and climate oscillations and zooplankton variability. Her most recent work focuses on marine regime shifts and non-linear relationships. Additional interests include marine policy, coastal management, and deep sea faunal variability.

Dr. Hongsheng Bi (hbi@cbl.umces.edu) is an Associate Professor at the University of Maryland, Center for Environmental Science at the Chesapeake Biological Laboratory, USA. His research interests are ocean–climate variability and ecosystem response, zooplankton community and population dynamics, and the application of satellite techniques in marine fisheries.

Dr. Kathryn Cook (Kathryn.Cook@gov.scot) is a researcher at the Marine Laboratory in Aberdeen, Scotland, UK. Her current work is mainly concerned with the analysis of zooplankton time-series data from the Marine Scotland long-term coastal monitoring sites to assess the status of the Scottish coastal zooplankton community, and their response to climate change. She has also been involved with the development of plankton indicators to assess Good Environmental Status, and experimental studies to assess sub-lethal effects of climate change on copepod physiology. Kathryn is a member of the ICES Working Group for Zooplankton Ecology and a chair invited member of the ICES Working Group on Integrated Morphological and Molecular Taxonomy.

PICES/ICES Workshop on "*ICES/PICES cooperative research initiative – Towards a global measurement of zooplankton production*"

by Toru Kobari and Lidia Yebra

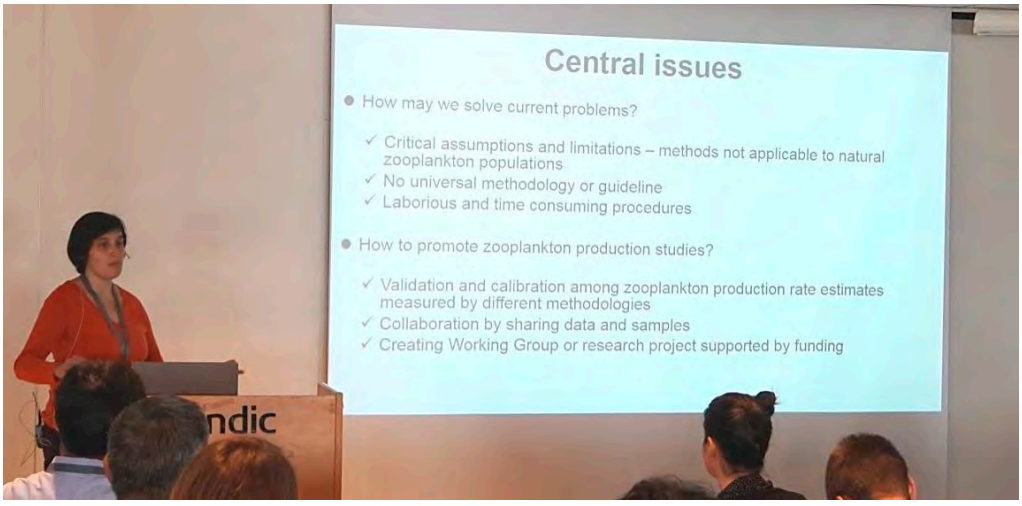
Approximately 20 zooplankton ecologists met March 11, 2016, to discuss zooplankton production methodologies and measurements at a half-day workshop during the ICES/PICES-sponsored 6th International Zooplankton Production Symposium in Bergen, Norway. We briefly summarize the presentations (one invited) and subsequent discussions of this workshop (W2) in this report. The workshop focused on contemporary methodologies and advances in estimating zooplankton production, with a goal of eventually providing a global assessment of zooplankton production. Workshop presentations included direct estimates of growth, empirical models and indirect biochemical indices of zooplankton production.

Dr. Lutz Postel presented an invited talk on estimating zooplankton production by applying P:B ratio to multiple times series data of biomass and abundance. He mentioned that empirical models of growth rates provide useful information on zooplankton productivity and proposed that empirical models on P:B ratio would give good estimates of zooplankton production. Dr. Koichi Ara estimated mesozooplankton production in Japanese coastal waters using abundances from microscopic counts, biomass indirectly estimated from length–weight equations and growth rates computed from an empirical model (*i.e.*, coupling different traditional methodologies). Alejandro Marrero, presented a poster that tested three zooplankton production models against direct measurements of growth in the marine mysid *Leptomysis lingvura* (Mysidacea, Crustacea). In her presentation, Dr. Karyn Suchy showed crustacean production estimates using chitobiase activity in Canadian coastal waters. She emphasized that this biochemical approach would overcome some disadvantages of traditional methods and provide high temporal and spatial data resolution using simple procedures and rapid measurements compared to traditional methods. Posters displayed by Dr. Toru Kobari and Dr. Lidia Yebra showed the application of biochemical methods like aminoacyl-tRNA synthetases (AARS) activity to estimate production of the zooplankton community in the field.

There were additional contributions demonstrating the utility of other direct and indirect methods to estimate zooplankton production. Unfortunately, due to the economic situation in Brazil, some authors could not attend and present their work at the workshop.

Before discussion, the major problems for zooplankton production assessment were summarized as follows:

- *How do we solve current problems?*
  - ✓ Critical assumptions and limitations: Methods not applicable to natural zooplankton,
  - ✓ No universal methodology or guideline,
  - ✓ Laborious and time consuming procedures.
- *How do we promote zooplankton production studies?*
  - ✓ Validation and calibration among zooplankton production rate estimates measured by different methodologies,
  - ✓ Collaboration by sharing data and samples,
  - ✓ Creating a Working Group or research project supported by funding.



Workshop 2 Co-Chair, Dr. Lidia Yebra, summarizing the central issues for zooplankton production assessment.

Since a previous PICES workshop on zooplankton production at the 2012 PICES Annual Meeting (see pp. 51–54 in Session Summaries-2012), some progress has been made by colleagues from ICES and PICES nations. Principal among these achievements is the organization of this workshop at the 6th International Zooplankton Production Symposium and the preparation of a review paper on biochemical methodologies for zooplankton production estimation for submission to a peer-reviewed journal.

It should be noted that these achievements had been accomplished without financial support, and therefore, progress towards a global measurement and assessment of zooplankton production has been slower than hoped for. We discussed different approaches that might be necessary for achieving more effective advances in the measurement and intercalibration of zooplankton production. For example, we discussed using multiple but small funding sources for our working group activities, rather than continuing unsuccessfully to approach major international science organizations like SCOR or EUROCEANS for greater resources. Collaborative research opportunities alongside summer schools that could include training courses on zooplankton ecology, and especially target the measurement of secondary production by zooplankton, could be an alternative approach.

During the workshop, we discussed the advantages and disadvantages of the current methodologies that are used to estimate zooplankton production of natural zooplankton populations or communities. More direct measurements on body mass would be recommended for those who use the traditional methods, such as incubations to estimate the "molt rate". These incubation methods are laborious and time-consuming and need special care to eliminate artifacts. Most biochemical approaches have relatively simple protocols and quick measurements, but they need to be calibrated against the direct rates they approximate. As confirmed at the earlier PICES workshop on zooplankton production, all participants realize that little attention and effort is being directed to community-based zooplankton production. Indeed, it is uncommon to propose sessions and workshops on zooplankton production methodologies and measurements even at the Zooplankton Production Symposium. Since zooplankton have key structural and functional roles in complex food webs, zooplankton production might be considered an integrated response of biogeochemical cycles and trophodynamics in marine ecosystems. Throughout the discussion, we confirmed that more quantitative evaluations like zooplankton production estimates are essential for understanding the response of marine ecosystems and trophic pathways in oceans that are rapidly changing. This is an issue of concern worldwide, and of particular focus for ICES and PICES in the North Atlantic and North Pacific, respectively.

A main outcome of W2 was the initiation of an international network of plankton ecologists interested or already involved in developing a cooperative research initiative with a goal to achieving a global assessment of zooplankton production. The prospective activities to be carried out by the group include:

1. Proposing a PICES Working Group on Zooplankton Production;
2. Producing reviews and guidance on the advantages and disadvantages of traditional and biochemical approaches for estimating zooplankton production;
3. Organizing international workshops and/or summer schools for intercomparison of zooplankton production methodologies and measurements using multiple small funding sources;
4. Expanding the cooperative network among ICES, PICES and southern hemisphere nations.

Dr. Toru Kobari is an Associate Professor on the Faculty of Fisheries of Kagoshima University, Kagoshima, Japan. His research focuses on the population dynamics, life cycles and feeding dynamics of marine copepods in the waters of the Northwest Pacific. He was a member of the PICES Oceanic Ecodynamics COmparison in the Subarctic Pacific (OECOS) project to compare the oceanic Gulf of Alaska in the eastern subarctic Pacific to the Oyashio region off Northern Japan in the western subarctic Pacific. Toru convened the Workshop on "Secondary production: Measurement methodology and its application on natural zooplankton community" at PICES-2012 in Hiroshima, Japan and co-convened W2 at the ICES/PICES 6th International Zooplankton Production Symposium. He is a chair-invited member of the ICES Working Group on Zooplankton Ecology.

Dr. Lidia Yebra is a researcher at the Spanish Institute of Oceanography in Málaga, Spain. Her interests include zooplankton physiology and ecology, and she developed methodologies to estimate production rates using biochemical approaches, such as the activity of the enzymes aminoacyl-tRNA synthetases (AARS). She was an invited speaker at the Workshop on "Secondary Production: Measurement methodology and its application on natural zooplankton community" at PICES-2012 in Hiroshima, Japan. She is a member of the ICES Working Group on Zooplankton Ecology and contributes to the ICES Zooplankton Status Report. She is also a member of the Scientific Steering Committee of the ICES/PICES 6th International Zooplankton Production Symposium, and co-convened W2.

PICES/ICES Workshop on "*Zooplankton as a potential harvestable resource*"

by So Kawaguchi and Webjørn Melle

A half-day workshop entitled "*Zooplankton as a potential harvestable resource*" was held May 11, 2016, during the ICES/PICES 6th International Zooplankton Production Symposium in Bergen, Norway.

The only current large-scale harvesting of zooplankton is for Antarctic krill (*Euphausia superba*), but recent advances in technology are allowing for more efficient fishery operation and high value products, which is now changing the dynamics of zooplankton fisheries. Increased demand for these products may open up new zooplankton fisheries in the near future. The management of these new fisheries requires scientific knowledge according to best practice. This workshop (W3) aimed to bring together the latest information on current and potential zooplankton fisheries, their future prospects, and discuss scientific contributions for improving our understanding of the ecosystem to help to improve management of the fisheries and the ecosystems.

At the workshop four talks on *Calanus finmarchicus*, and five talks on krill were presented.

Kurt Tande (Calanus AS), the invited speaker for this workshop, gave an opening talk on the development of harvesting, bioprocessing and utilization of *C. finmarchicus.* Current harvesting for *Calanus* is at a pilot scale but the oil from copepods is unique in the sense that it mostly contains wax esters, and that the market has a strong potential for the protein and the oil, with attractive biomedical effects relevant for public health. He also explained that the company is committed to the highest environmental standards in all aspects of its operations, and practices harvesting in a precautionary and sustainable manner.

Lise Langård described the Norwegian management plan for harvesting *C. finmarchicus*, explaining that an expansion of *C. finmarchicus* harvesting to a larger scale needs to be managed according to a sustainable and ecosystem-based management practice to ensure conservation of biodiversity and ecosystem functioning, which includes advice concerning regulatory measures to avoid harvesting on spawning grounds of commercially important fish stocks. She also explained that the management plan will have a precautionary catch limit and further "trigger levels" as a safeguard that cannot be exceeded until a more developed management strategy is established – a similar system being applied to the Antarctic krill fishery.

Two contributed talks on copepods were on modelling approaches:

- *An individual based modelling approach to harvesting of Calanus finmarchicus in the Norwegian Sea* (Cecilie Hansen *et al.*);
- *Comparing modelling results of highly resolved analogous Eularian/Lagrangian model setups of Calanoid copepod to study aggregation patterns* (Lionel Eisenhauer and Dag Slagstad).

So Kawaguchi presented on the Antarctic krill fishery, explaining that international interest in the krill fishery remains high, and the demand for krill products may grow. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is a pioneer for the ecosystem-based management of Antarctic krill, and needs to continue to take such an approach, including the development of a feedback management system to make sure the krill fishery develops in an orderly manner. Good science is essential for a successful ecosystem management regime through CCAMLR and a strong commitment by governments, industry, management, science and the operators is the key to successful management of the krill fishery.

Angus Atkinson reported on the impacts of rapid regional climate change on the population dynamics of Antarctic krill. He discussed the implications of major, climate-driven changes in krill dynamics for nutrient flows in the food web using the updated KRILLBASE (a circumpolar compilation of krill abundance and length frequency data).

The other three contributed papers on krill covered a range of topics including one on northern krill:

- *Utilising innovative fishing technology to address key questions on the biology of Antarctic krill* (Patti Virtue *et al.*);
- *Assessment of mortality of Antarctic krill (Euphausia superba) escaping from a trawl* (Bjørn A. Krafft *et al.*)
- *Ecosystem-based stock management of krill in the Gulf of St. Lawrence, Canada* (Gesche Winkler *et al.*).

After a series of presentations, we managed to spend some time for a lively and interesting discussion. Dialogue was initiated by asking the following few guiding questions:

- What are the commonalities and differences between the two fisheries?
- What are the lessons that we can learn from development of the Antarctic krill fishery?
- How can a sustainable zooplankton fishery develop into the future?

During the discussion the workshop noted that ecosystem-based management of the Antarctic krill fishery by

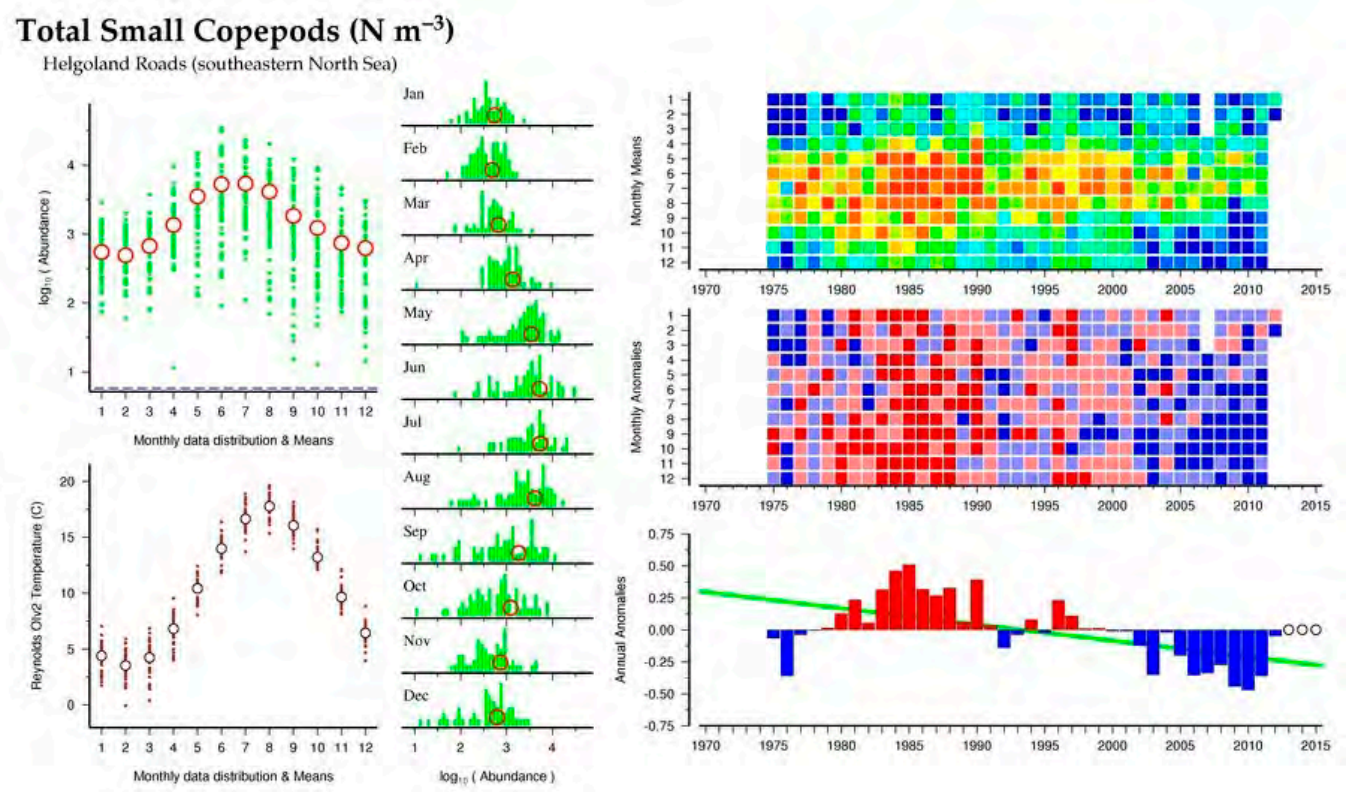
(Continued on page 20)

PICES/ICES Workshop on "*A hands-on introduction to time series analysis, visualization and inter-comparison of plankton survey data*"

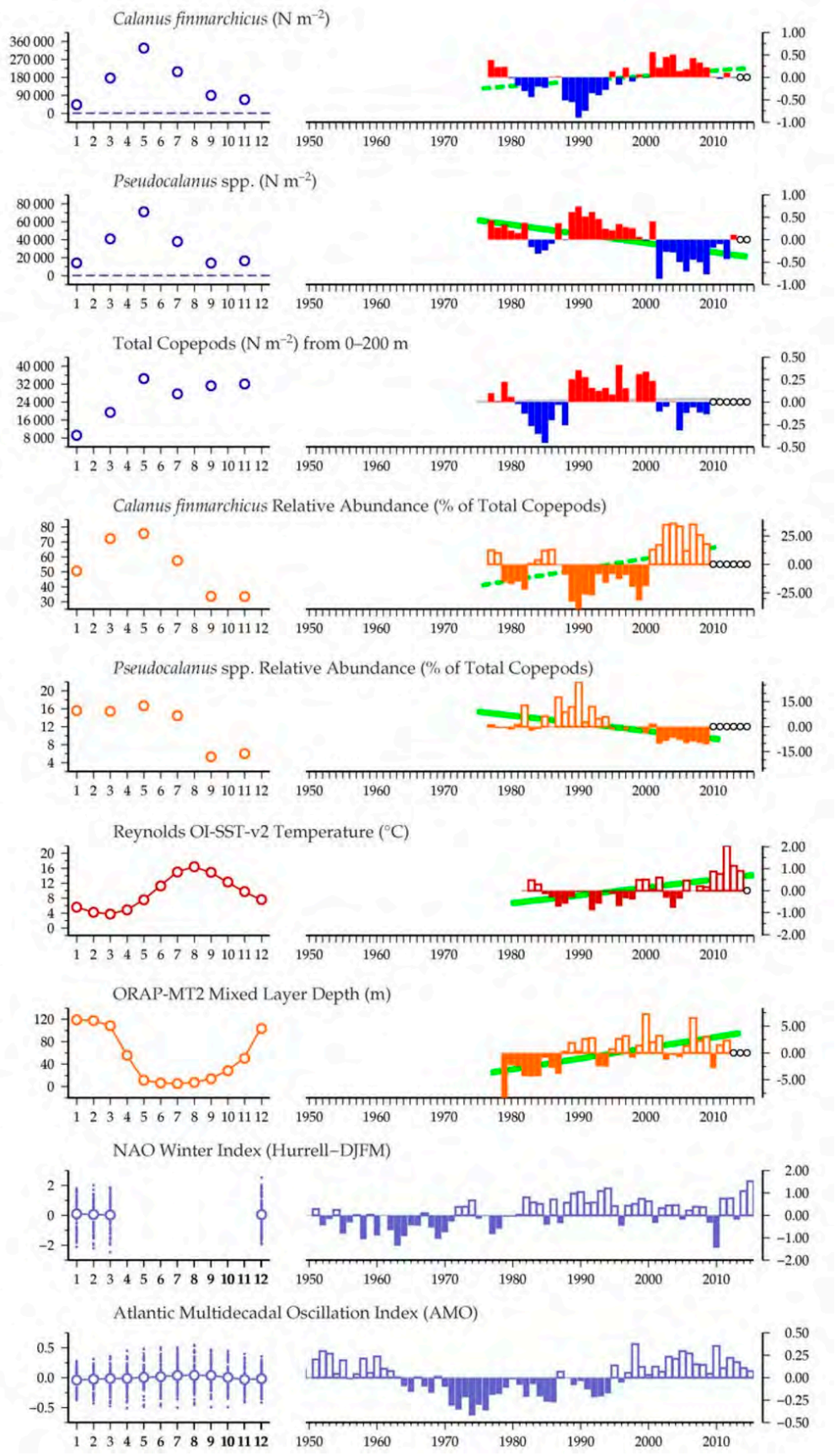
by Todd O'Brien

After ten years of working with plankton time series, a clear data trend was evident: Too many time series scientists have never seen their data outside of an Excel spreadsheet. Yes, a handful had access to expensive software packages or an R-savvy graduate student, but more often they did not have the software or programming skills needed to dig deeper into their data. This trend may soon reverse, however, thanks to COPEPOD's Interactive Time-series Explorer, also known as COPEPODITE.

This free time series exploration tool only requires a simple spreadsheet and a web browser, software that is already found on most computers. Once a user has labelled their data fields in the simple spreadsheet-based format, they can then upload and work with their data in COPEPODITE's online interface. First, the user specifies the geographic coordinates of their time series sampling site, so COPEPODITE can automatically add any regionally-relevant climate indices (*e.g.*, NAO, PDO, and multiple others) as well as satellite-based time series from the same region (*e.g.*, 30 years of SST data, 15 years of satellite chlorophyll data). During the data processing stage, COPEPODITE automatically bins and time-synchronizes the incoming data, for example, combining daily temperature data with weekly chlorophyll and monthly zooplankton data. The user then has a variety of analysis and visualization options to choose from that allows them to look at seasonality and interannual variability and trends both within variables and between variables. Simply put, COPEPODITE lets a user painlessly turn their spreadsheet of time-series data into a collection of graphical visualizations and analytical results, all done without expensive software or hours spent programming and debugging.



Example of a COPEPODITE exploratory plot showing seasonal and interannual patterns and trends within small copepod abundances at the Helgoland Roads time series (http://igmets.net/sites/?id=de-30201).



Example of a COPEPODITE multiple variable comparison plot showing seasonal and interannual trends across a variety of user-provided (top four panels) and COPEPODITE-added (bottom four panels) variables from the EcoMon Gulf of Maine time series (http://igmets.net/sites/?id=us-50101).

A half-day workshop (W6) held May 11, 2016, at the ICES/PICES 6th International Zooplankton Production Symposium in Bergen, Norway, used COPEPODITE to introduce the basics of time series analysis and visualization. A sample data set was provided for experimentation during the workshop and participants were encouraged to test the system with their own data. Part of the workshop included a live demonstration of processing a volunteer's own data set in front of the group. Very true to the reasons for the creation of COPEPODITE, this volunteer had never seen his data outside of Excel. Within minutes the data set was labelled, uploaded, and run through a variety of analyses and plots. The volunteer was thrilled to see results that displayed clear and ecologically-explainable differences in both seasonal patterns and interannual trends across the major species in the time series, all accomplished in a few minutes. In the end, the workshop was equally beneficial to COPEPODITE which now has a nice list of desired new features and options to be added over the next few months. This time series toolkit will continue to expand in its capabilities and throughout the user community, with plans for a follow-up workshop at the next International Zooplankton Production Symposium in ~2020.

COPEPODITE is available online at: http://www.st.nmfs.noaa.gov/copepodite.

Todd O'Brien (Todd.OBrien@noaa.gov) is the creator and developer of COPEPOD, the Coastal & Oceanic Plankton Ecology, Production, & Observation Database. This summer, Todd celebrates his 20th year with NOAA, a career that so far has involved creating and building a global plankton database (COPEPOD), its time series and spatial data side projects (COPEPODITE and NAUPLIUS), and providing the data analysis and visualization backbones behind multiple ICES, SCOR, and IOC-UNESCO time series working groups (e.g., IGMETS, WGZE, WGPME, WG125, WG137). Todd is the lead editor for the ICES Plankton Status Report series and the newly started IGMETS report series.

(Continued from page 17)

CCAMLR has been successful using the best available science, and provides a good model for the management of other zooplankton fisheries, including the *C. finmarchicus* fishery.

There were various views on the level of zooplankton harvesting that can be done in a sustainable manner. However, the important message arising from the participants was that zooplankton have a fundamental role in energy flow through the ecosystem, and we still do not know the extent of impact that removal of zooplankton has on the functioning of the ecosystems, and therefore an appropriate management scheme based on good science must be in place before the fishery expands.

Dr. So Kawaguchi (So.Kawaguchi@aad.gov.au) is a marine ecologist and Principal Research Scientist of the Australian Antarctic Division (AAD). So leads the Australian krill research program and manages the AAD krill research aquarium. His current research activity spans a range of topics on Antarctic krill biology and ecology, including studies into climate change impacts on krill. His research interest also extends to krill fishery management in the Southern Ocean.

Dr. Webjørn Melle (webjorn@imr.no) is a Research Scientist at the Institute of Marine Research, Norway. Webjørn's research interests are focused on the ecosystem of the Nordic Seas and he also works in the Arctic and Antarctic. He studies bottom-up and top-down regulated ecosystem processes induced by multiple stressors such as climate and fisheries, and his main interest is zooplankton, in particular, Calanus spp. Webjørn's also works with the mesopelagic community and its role in different North-Atlantic ecosystems. His special interests in these topics are reproduction of Calanus spp. and feeding and migration of pelagic planktivorous fish stocks.

PICES/ICES Workshop on "*Toward a taxonomically-comprehensive global reference database for DNA barcodes of marine zooplankton*"

by Silke Laakmann and Tone Falkenhaug

DNA barcoding is a useful tool for identification and discrimination of species across most taxonomic groups of marine zooplankton, using species-specific DNA sequences. DNA barcodes can also reveal cryptic, rare, and invasive species, link different life-cycle stages of a species, and – increasingly – characterize patterns of biodiversity based on environmental sequencing (also called high-throughput DNA sequencing, metabarcoding). A variety of genes have been used as DNA barcodes for the identifications of metazoan species, including most frequently mitochondrial cytochrome oxidase subunit I (COI), but also other mitochondrial (16S rDNA, COII) and whole or parts of nuclear genes (18S rDNA). With some exceptions, genes suited for discrimination of closely-related species typically provide very weak phylogenetic information at higher taxonomic levels. Hence, barcodes cannot be used to identify and classify species for which no barcode has been determined. In this sense, lack of a complete DNA barcode reference library is the most limiting factor for accurate and reliable discrimination and identification of zooplankton species. In particular, comprehensive databases are needed for metabarcoding efforts that seek to characterize species-level diversity of marine zooplankton assemblages and ecosystems.

On May 11, 2016, a workshop entitled "*Toward a taxonomically-comprehensive global reference database for DNA barcodes of marine zooplankton*", was held at the ICES/PICES 6th International Zooplankton Production Symposium in Bergen, Norway. The purpose of this workshop was to encourage wide-ranging discussions of the concept of a taxonomically-comprehensive, global DNA barcode reference database linking DNA sequences of zooplankton to accurately-identified specimens.

This workshop (W7), co-convened by the authors of this article, included one invited presentation and brief introductions to the seven posters associated with this workshop. The workshop was well attended, with 50 participants during the presentation session, and 30 people taking part in the discussions after the coffee break.

The main discussion topics were:

- What are the main limitations with available DNA barcode reference databases?
- Which gene(s) should be included in a barcode database?
- What metadata should be required for submission of DNA barcodes data to a reference database?
- How can accuracy of species identification be assured?
- Should taxonomic authorities be reviewed or rated in some way?

The workshop started with a presentation session where the speakers gave an introduction to current uses of DNA barcode databases, their benefits and limitations.

The invited speaker of this workshop, Dr. Ann Bucklin (University of Connecticut, USA), gave a motivational talk on "*The need for reference DNA barcode databases*". She pointed out that neither DNA barcodes nor molecular operational taxonomic units (MOTUs) can be matched to species or other recognized taxonomic units unless there is a reference sequence for that taxon and gene. Accurate and reliable species identification requires a match to reference sequence in the database based on a specimen identified by a taxonomic expert (Fig. 1). Although the COI gene has been sequenced for all major groups of marine zooplankton, only a small fraction of these sequences are accompanied with identified voucher specimens that allow identification of known species.

A research area well represented at the workshop was the application of metabarcoding to assess and monitor zooplankton diversity. Dr. Kasapidis Panagiotis (Hellenic Centre for Marine Research, Greece) presented the Mediterranean "MetaCopepod" project. In this project, a combination of DNA metabarcoding and image analysis was used, since some taxa were systematically over- or under-represented in the DNA metabarcoding analysis.

A DNA metabarcoding approach to profile macrobenthos and zooplankton biodiversity was given by Dr. Lisa Devriese (Institute for Agricultural and Fisheries Research, Belgium). The different steps in the development of a flexible DNA metabarcoding pipeline with best taxonomic resolution were outlined and she showed informative results on the relationship between read counts per species and the relative proportion of species in mixed samples.

Dr. Ryuji Machida presented the work by Shian-Lei Ho (Biodiversity Research Centre, Taiwan) on the integration of individual- and community-based transcriptomics on the planktonic gastropod *Hydromyles globulosus* of which very little genomic and genetic data are available in public DNA sequence databases. With their work the authors aimed at enhancing the functionality of a reference nucleotide database and describing basic characteristics of genes and transcripts.

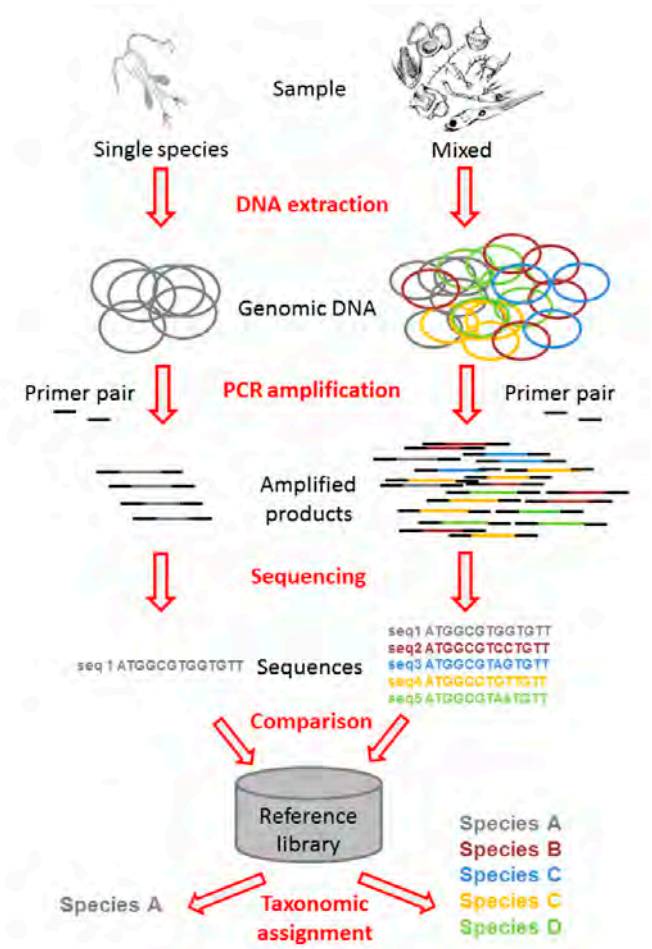


Fig. 1 Schematic representation of the molecular taxonomic analysis of a zooplankton sample using a single-species approach with prior morphological identification (left arrows) and mixed-sample analysis (i.e. metabarcoding; right arrows). From Corell and Rodriguez-Ezpeleta 2014, Rev. Invest. Mar., 21, 19–39. Lack of a complete DNA barcode reference library is the most limiting factor for accurate and reliable discrimination and identification of zooplankton species in metabarcoding.

Dr. Peter Wiebe (Woods Hole Oceanographic Institution, USA) reviewed The Biological and Chemical Oceanography Data Management Office (BCO-DMO), which is a data management system connecting related datasets and metadata, including genetic data. This system ensures that the chain of data treatment is preserved, and that the genetic data can be linked back to the specimen and associated metadata

Dr. Silke Laakmann presented the work of Inga Mohrbeck (German Center for Marine Biodiversity Research, Senckenberg am Meer, Germany) on the evaluation of DNA-based identifications of high-throughput sequencing and classical Sanger sequencing. In their work the authors established their own DNA reference library in order to link DNA sequences to identified species. This approach highlighted the need for a trustworthy and valid reference library in order to test these new molecular approaches for environmental sequencing.

The second part of the workshop was dedicated to a 1½-hour group discussion on the concept of a global DNA barcode reference library for zooplankton. The workshop participants discussed limitations and needs, and made recommendations with the aim to answer the following four main questions.

- *What are the main limitations with available DNA barcode reference databases?*

Dr. Endre Willassen (The Natural History Collections, University of Bergen, Norway) provided an overview of the limitations with available public reference barcode databases. When users are trying to match a barcode with a species, several problems may occur related to: (1) missing barcodes leading to problems with resolution (Table 1), (2) an erroneous identity tag *(i.e.*, misidentification of species, wrong taxonomy, amplification of non-target DNA), (3) unresolved taxonomy (*i.e.*, cryptic species), and (4) taxonomic disagreements. This calls for a critical revision of the taxonomies and genetic data available in databases, and encourages more integrative research and the investigation of more than only one gene.

Another limitation of the available reference databases is the discrepancy between hits in different databases. The workshop participants suggested a better exchange of data between the public reference databases in order to get consistent results when comparing with their own data. Such an exchange is not only desired for genetic data but also for taxonomy. A connection between DNA reference libraries and taxonomic databases such as the World Register of Marine Species (Worms) would enable more frequent (constant) updates of the taxonomy of the barcoded species.

- *Which gene(s) should be included in a barcode database?*

For the molecular identification of metazoan species, we need a marker which unites different qualities: Preferably the marker should (1) resolve on species level, (2) not be functional, (3) have universal primers for the amplification of the target gene in all the different zooplankton taxa, (4) have the adequate reading length to be analyzed by high-throughput sequencing techniques, and (5) be available for a variety of taxa and species in public reference libraries. The participants of the workshop had experiences with different genes or gene regions as DNA barcodes and the preferred markers were discussed with all their pros and cons. In general, COI is used as the metazoan DNA barcode and thus, databases like Barcode of Life Data Systems (BOLD) only include this gene fragment in their database. It was argued that at the current state of the art, COI is not useful to be applied in metabarcoding because of its long fragment length and missing universal primers. Alternatively, 16S rDNA and parts of 18S rDNA were discussed as suitable markers. Nevertheless, for some groups (*i.e.*, polychaetes) 16S rDNA shows a better resolution on species level compared

Table 1 *Missing data (few barcodes) in the DNA databases may cause problems when users are trying to match a barcode with a species. In this example, the isopod Ischnomesus bispinosus (Crustacea) showed a 70% match with a primate (the "Preuss's monkey) in the BOLD database (from the presentation by Endre Willassen).*

Order	Family	Genus	Species	Similarity (%)	Status
Primates	Cercopithecidae	Cercopithecus	*preussi insularis*	70.57	Published
Mesostigmata				70.16	Published
Lepidoptera	Pyralidae	Lepidomys	*sp. AZR-2012*	70.08	Published
Diptera				70.05	Private
Diptera	Agromyzidae	Ptochomyza	*asparagi*	70	Published
Diptera				69.89	Private
Diptera				69.84	Private
Diplostraca	Chydoridae	Graptoleberis	*testudinaria*	69.69	Early-Release
Diptera				69.68	Private
Diptera				69.63	Private
Diptera	Chironomidae			69.61	Published
Amphipoda	Phreatogammaridae	Phreatogammarus	*fragilis*	69.61	Early-Release
Diptera	Muscidae	Helina		69.59	Published
Diptera	Muscidae	Helina		69.59	Published
Diptera	Muscidae	Helina		69.56	Published
Diptera	Mycetophilidae	Phronia		69.54	Early-Release
Diptera	Muscidae	Helina		69.5	Published
Diptera	Mycetophilidae	Epicypta		69.49	Published

to COI, but species of other groups are missed in the analysis of 18S rDNA because this marker better resolves on genus rather than on species level (*i.e.*, species of the copepod *Pseudocalanus*). Disadvantages of 18S rDNA are the rare entries in public reference libraries and partly lack of resolution on species level. However, as discussed during the first topic, we have to investigate more than only one gene for every species.

- *What metadata should be required for submission of DNA barcodes data to a reference database?*

Metadata for DNA barcode entries are essential since they give important information on the identification and the sampling of the species. Nevertheless, this information is often missing in public reference libraries. The workshop participants agreed on the importance of metadata but have to face the problem in the realization of a standardized list of minimum metadata to be included in every DNA barcode record, and in particular to require people to submit metadata. It was suggested using the ICES Metadata Guidelines (provided by ICES Working Group on Zooplankton Ecology, WGZE) as a standard list of metadata, which should be complemented with genetic metadata. Another possibility to provide metadata would be to link public DNA reference libraries to the digital data management system used by different institutions and offices (*e.g.*, the BCO-DMO).

Specifically, metadata on species identifications and sampling locations were discussed. The morphological diagnostic characters used for species identification of each specimen are essential. Photographs of whole individuals, provided by some public databases, were criticized since they are not meaningful for identification. In order to emphasize the species characteristics, specimens often have to be dissected. In order to evaluate the genetic diversity within a species with a wide geographical distribution range, it is critical to include geographical coordinates of the sampling site as metadata.

- *Quality control: How can accuracy of species identification be assured?*

The workshop participants recommended combining morphological and genetic species identification, referred to as an integrated taxonomic approach. Here, the morphological identification of the specimen is the first and essential step and represents the quality control for the DNA barcode. To assure the accuracy of the morphological species identification, the community has to be provided with easily accessible information on species identification. As an example for this, Dr. Claudia Castellani (SAHFOS, UK) presented the initiative of updating and revising the ICES Identification Leaflets for Plankton. Next to the morphological characters, DNA barcodes will also be made available. These leaflets will be provided with a DOI number and will be linked to taxonomic and DNA reference libraries.

One essential problem in DNA reference libraries are entries with the wrong assignment of species names or insufficient genetic data. In order to evaluate the quality of a barcode it is of great importance to allow verification of the species identification process. In order to do so, each DNA barcode should be linked to a voucher specimen. For

(Continued on page 27)

MSEAS 2016—Understanding marine socio-ecological systems: Including the human dimension in Integrated Ecosystem Assessments

by Keith Criddle

The MSEAS (Understanding Marine Socio-Ecological Systems: Including the Human Dimension in Integrated Ecosystem Assessments) symposium will be remembered for outstanding presentations, scintillating dialogue among physical, biological, and social scientists, great food, and beautiful weather. By every measure, it was a success—a meeting to be remembered by all those fortunate to attend. The meeting, held May 30–June 3, 2016 in Brest, France, was organized by convened under the able leadership of Jason Link (USA), David C. Smith (Australia), and Olivier Thébaud (France) who served as local host and chaired the steering committee. MSEAS 2016 was organized by ICES, and co-sponsored by PICES, IFREMER NOAA, CSIRO, Université de Bretagne Occidentale, Centre for Marine Socioecology, Fisheries Research and Development Corporation, LabexMER, Université Européenne de Bretagne, Belmont Forum, Région Bretagne, Le Conseil Départemental 29, and Brest Métropole. Key papers from this symposium will be featured in an upcoming issue of the *ICES Journal of Marine Science*.

The objectives of the symposium were to advance understanding of marine social-ecological systems, to foster interdisciplinary discussions and collaborations, to identify challenges ahead and key areas for future research, to support the uptake of human dimensions in integrated assessments, and to further the development and uptake of Ecosystem-Based Management. The symposium was structured around six themes:

A. *Identifying needs for managing multiple ocean use sectors*: What information is needed to inform policy, management and industry developments?

B. *Coupled ecological, economic and social process understanding*: Can we build scenarios integrating ecological, economic and social dimensions?

C. *From data to indicators to reference points and performance evaluation*: How do we use available data to set reference points and assess policy performance?

D. *Participatory assessment processes*: What are the opportunities and challenges associated with participatory research?

E. *Governance and institutional frameworks*: Can governance systems promote greater integration of knowledge systems and ocean management?

F. *Case studies*: What lessons have we learned from practical research experience?

Keynote talks were presented by: Serge Garcia, UN FAO (*Fisheries from biological clockworks to socio-ecological systems and ecosystems services*), Jake Rice, DFO Canada (*Fisheries governance in an SES system: All things for all people or all things for all creatures?*), Beth Fulton, CSIRO (*What's easy and hard about modelling socioecological systems?*), Linwood Pendleton, LabexMER (*Indicators, indices, and essential variables; Oh my! A decidedly non-statistical take*), Edward Hugh Allison (PICES Keynote Speaker), University of Washington (*Adventures in integration: Unexpected insights for coastal and marine governance from interdisciplinary assessments*), Simon Levin, Princeton University (*Dealing with public goods and common-pool resources in marine ecosystems*), and Anthony Charles, Saint Mary's University (*Assessing and managing a multi-sectoral multi-objective ocean: Challenges for integration and participation*).

The meeting attracted over 230 attendees and 125 oral presentations were delivered. The PICES region was represented by 20 attendees, including 5 members of the Section on *Human Dimensions of Marine Systems* (S-HD).

Hirota Masahito, Juri Hori, and Grant Murray, members of S-HD, during a coffee break.

Left: Aoi Sugimoto, Juri Hori, and Masahito Hirota socializing between sessions. Right: S-HD members Robert Stephenson, and Keith Criddle participating in the MSEAS Young Researchers Workshop.

Presentations from PICES member countries were included in all the theme sessions, and talks by S-HD members covered four of the sessions:

- Keith Criddle (University of Alaska Fairbanks, USA), *La Machine Infernale—How the interplay of social, ecological, and environmental factors influences the observability and controllability of fishery social ecological systems* (Theme Session B);
- Keith Criddle (University of Alaska Fairbanks, USA), *Human dimension indicator data for North Pacific ecosystems* (Theme Session C);
- Juri Hori (Rikkyo University, Japan), *International comparison of human well-being structures and factors: a study of the PICES 6 countries* (Theme Session C);
- Masahito Hirota (Fisheries Research Agency, Japan), *Marine ecosystem health and human well-being (PICES MarWeb)—A good relationship between local communities and seafood diversity* (Theme Session D);
- Grant Murray (Duke University Marine Lab, USA), *Overview of the Marine Ecosystem Health and Human Well-being (MarWeb) project* (Theme Session B);
- Grant Murray (Duke University Marine Lab, USA), *What are we managing for: values and the Management of Marine Social-Ecological Systems* (Theme Session C);
- Robert Stephenson (Department of Fisheries and Oceans, Canada), *A framework for practical integration of ecological, economic, social and institutional aspects in integrated management* (Theme Session C);
- Robert Stephenson (Department of Fisheries and Oceans, Canada), *Practical steps toward integrating economic, social and institutional objectives and indicators in fisheries management* (Theme Session E).

The symposium provided a thorough representation of where we are and where we need to be headed in the study and management of marine ecosystems. Challenges faced by marine socio-ecological systems, including human dimensions in Integrated Ecosystem Assessments, are the lack of a common conceptual framework for model structure, differences in scale and scope, over-reliance on a quantitative approach and failure to develop models that mesh qualitative and quantitative methods. While reductionism is useful for exploring mechanisms and details, it is unlikely to be useful for identifying systemic solutions—there is a strong need to shift modeling effort towards a systems approach. To date, fisheries ecosystem models have often been conceptualized and developed by fisheries scientists who, after having developed their models, ask social scientists to apply a 'human dimensions' patina. To make more effective progress on IEA, scientists from a broader suite of disciplines need to be involved from the start rather than as an afterthought. While the theme of MSEAS 2016 was broad, most presentations focused on fisheries and aquaculture. Effective IEA will require better engagement with other sectors, such as transportation, energy, and tourism and the disciplines from whom they seek advice. Implementation of IEA and evaluation of alternative choices that balance competing uses of the marine system necessitate consideration of national and multinational governance mechanisms and will likely require innovative new mechanisms for addressing cross-jurisdictional uses.

Dr. Keith Criddle (keith.criddle@alaska.edu) is a bioeconomist at the Juneau Fisheries Center of the University of Alaska Fairbanks. His research explores the intersection between the natural sciences, economics, and public policy and is driven by an interest in the sustainable management of marine resources of the North Pacific. He directs graduate projects in bioeconomics, statistical inference, and policy analysis and teaches courses in resource and environmental economics, econometrics and time series analysis, operations research and decision theory, fisheries law, and policy analysis. In PICES, Keith co-chairs the Section on Human Dimensions of Marine Ecosystems and a member of the Study Group on Socio-Ecological-Environmental Systems. Keith was a member of the MSEAS Scientific Steering Committee, representing PICES.

The Little Green Bucket's 10,000 mile journey

by Nancy Treneman

The devastating earthquake and resulting tsunami that hit Honshu's northwestern shores in Japan on March 11, 2011, swept millions of tons of debris into the ocean. In this giant mega-mass of plastic, wood, foam and metal, there was a small green toy bucket. This bucket, with a child's name, grade, and school neatly written on the back, was carried away with the house containing it – the house of the Onoderas, in Minamisanriku-cho in Miyagi Prefecture.

Minamisanriku-cho, Miyagi Prefecture, Japan

Gold Beach, Oregon, USA

Crook Point, Oregon, USA.

On December 25, 2014, this little green bucket washed ashore at Crook Point, Oregon, 22 miles (35 kilometers) north of the California border.

I am a member of the Japanese Tsunami Marine Debris (JTMD) Team, and I survey the beaches of Oregon and Washington, collecting JTMD and the marine organisms on and inside it. Funded by the Japanese Ministry of the Environment (MoE) and coordinated by the North Pacific Marine Science Organization (PICES), the Team studies biofouling on JTMD as an activity of Assessing the Debris Related Impact From Tsunami (ADRIFT) project. My specialty is the wood boring clams (known as "shipworms") that burrow into JTMD wood.

On Christmas Day, 2014, my husband and I walked the beach to Crook Point, about 10 miles from our house. There, in the rocks, was a large grey plastic pallet with Japanese script, some broken pieces of crate, and a little green bucket, cracked along one side, also with Japanese writing, along the bottom and on the front, and exceedingly cute little green frogs labeled Kerokerokeroppi. I scraped bryozoans (tiny marine animals that colonize debris as it drifts at sea) off the pallet, and brought the bucket home for later examination.

I showed photos of the bucket's writing to a 5th grade student, who reads Japanese and Chinese, at our elementary school. He told me that the writing was the name and school of a student in 2nd grade. I kept the bucket in my growing collection of tsunami-related items, hoping that at some point I would be able to learn more about its owner.

The Little Green Bucket, photographed December 25, 2014 at Crook Point. Pretty cute!

In November 2015, at the Coastal and Estuarine Research Federation (CERF) Conference in Portland, Oregon, I had the pleasure of meeting Dr. Hideaki Maki, from Japan's National Institute for Environmental Studies who is involved in the ADRIFT project. I showed him photos of the bucket, and he felt that there was enough information on it to potentially determine the owner. Later that month he visited Minamisanriku and the elementary school Isatomae. The school administrators told him that Takuya Onodera, whose name was on the bucket, had graduated a few years ago, but that they knew a friend of Takuya's mother who would be able to connect Dr. Maki to Mrs. Onodera. Takuya was now 20 years old!

Nancy Treneman, Mrs. Onodera and her husband, and the Little Green Bucket. Photo courtesy of Hideaki Maki.

When Dr. Maki emailed me that he had found the bucket's owner, I was rather speechless (a rare state for me!). He indicated that the family would be very pleased to have the bucket returned. After traveling across the ocean, 5000 miles in 2½ years, it seemed rather impossible to simply put the bucket in the mail. I wanted to return this small memory to the place where it had started its journey, and personally present it back to the family.

PICES and the MoE helped to organize the trip to Minamisanriku-cho. The 9 people in our group represented three countries: Japan, Canada, and the USA. Getting to Minamisanruku-cho involved trains and a van, and as we traveled we were able to see the reconstruction efforts along the coast. On Friday afternoon, February 26, 2016, we arrived in Minamisanriku, first meeting with city officials, then visiting Mrs. Onodera's friend, and driving by the school.

It was almost dark when our van pulled up in the Onodera family driveway. We poured out and were warmly greeted by Mrs. Onodera and her husband. In a small, informal ceremony, she carefully unwrapped the Little Green Bucket, and a smile broke out on her face. Although she spoke in Japanese, I could easily tell she was saying, "Oh, Yes! This is it!" The second 5000 miles of the Little Green Bucket's journey was over. This small piece of plastic, a connection to her son's childhood, was back home, almost five years later.

Many people worked to make this happen. I am very grateful to Dr. Hideaki Maki for his dedication and for all of his superb work in organizing the visit to Minamisanriku and locating the Onodera family, to Mr. Jun Saegusa of MoE who accompanied us, to Dr. Jim Carlton, of Williams College and Mystic Seaport, the lead scientist for JTMD biofouling, who got me started on both shipworms and JTMD, and to all of the other people from PICES, Fisheries and Oceans Canada (DFO), NOAA and MoE who helped to arrange and participate in the trip. It was an amazing privilege to visit the tsunami zone, see the reconstruction efforts, and, most of all, meet the people who survived this catastrophe.

Nancy Treneman (ntreneman@gmail.com) lives on the Southern Oregon Coast, and is an independent field biologist. After receiving a Masters of Science from Oregon State University, she was science educator in the public schools for 28 years, working in various research programs during the summer. Her passion for the study of shipworms (Teredinidae) started while working with the Japanese Tsunami Marine Debris Team, collecting the construction beams rafting to Oregon shores from Japan. Since then, her interests have expanded to the study of shipworms of Hawaii and beyond. For the last 13 years she has conducted field research in the rocky intertidal community on microgastropods, nudibranchs, chitons, and marine algae.

(Continued from page 23)

this we need a voucher code for the specimen (*i.e.*, by group, species, net sample) and the name of the unique identifier. To prevent bad data, the scientific community is encouraged (1) to perform quality checks of their own data before submitting to public reference libraries, (2) to compare their own data to available sequences in the database (*i.e.*, by alignments or by analyzing phylogenetic trees), and (3) when identifying discrepancies, to contact the authors who submitted these data. These days, as the DNA barcode databases become more complete, it is easier to spot and identify untrustworthy sequences. In this context, the scientific community is encouraged to connect their personal reference libraries to public barcode databases.

One of the important central messages that emerged in both talks and discussions during the workshop is that continued integrative morphological–molecular taxonomic analysis is needed to produce a trustworthy taxonomically-comprehensive database of barcode sequences for all species of marine zooplankton. Such an integrated database allows us to make progress in novel molecular approaches towards a fast and accurate identification of zooplankton biodiversity.

(left) Dr. Silke Laakmann (slaakmann@senckenberg.de) is a marine ecologist at the German Center for Marine Biodiversity Research, Senckenberg am Meer, Germany. Her present postdoctoral research focusses on combining morphological, genetic and proteomic approaches for species identification and phylogenetic relationships, mainly on zooplankton organisms.

(Right) Dr. Tone Falkenhaug (tone.falkenhaug@imr.no) is a Research Scientist at the Institute of Marine Research, Norway. In her current research, she is using integrated morphological and molecular taxonomy to conduct an inventory of marine planktonic species of copepods and cladocerans in Norwegian waters (The COPCLAD project, Norwegian Taxonomy Initiative).

A community needs assessment for coastal Guatemala – Balancing ocean and human health

by Vera L. Trainer, Charles G. Trick and William P. Cochlan

Background

In collaboration with our colleagues at the Universidad de San Carlos de Guatemala, we have engaged in a series of conversations with community members from two villages along the Pacific coast of Guatemala – Las Lisas and Monterrico. Our goal was to identify the factors that influence the balance between sustainable human communities and productive marine ecosystems in Guatemala. Specifically, considering the on-going global changes in climate, and human social and economic conditions, the Marine Ecosystem Health and Well-Being (MarWeb) project objectives are two-fold: 1) to determine how marine ecosystems support human well-being; and 2) to identify how human communities support sustainable and productive marine ecosystems. This is a shift from the traditional role where people are exploiters of the ocean to one where people are integral components of resource sustainability and ecosystem health. This concept, called "Sato-umi" in Japanese, recognizes the well-balanced availability of various ecosystem services, together with effective management of coastal seas.

To address the project goal, on our initial visit in January 2014, our overarching question for the communities was simply, "What is your relationship with the sea?" The fishermen and fisherwomen of both villages responded that the sea is their life and while fishing is a struggle and challenging occupation, they wished to create a balanced and sustainable approach to fishing, both for themselves and for future generations. Collectively, they accepted responsibility for the dwindling fish stocks – and confided that they had participated in the overfishing of their estuaries and coastal waterways. In one community, the fishers felt that they were the "last fisherman" in Guatemala. The communal statements were clear and honest – and reflected a fear for the future. These were communities motivated to make a change, but felt that change would be limited, and were unsure how to proceed. These fishers conveyed a strong need for more understanding, and a demand for directed action from the PICES team of scientists. In other words, they were looking for someone to help them take the initiative steps to facilitate the needed changes to ensure economic and ecological sustainability.

The primary purpose of our second visit in February 2015 was to perform a Community Needs Assessment (CNA) on the communities of Las Lisas and Monterrico with the adjacent seas. A CNA is a systematic process for determining the 'needs' (*e.g.*, economic, nutritional, and social) and the definable 'goals' of a community. CNAs are performed before major actions are implemented as part of a strategic planning process. CNAs can assist in directing resources and energies into creating the desired future of a community and can be used to address needs, or 'gaps' between current conditions and desired conditions. For example, in response to the "last fisherman" statement – Did the community want to invest in rebuilding the fishing industry or in recreating the community, where fishing would be just a part of the mosaic of needed changes?

For the CNAs of Las Lisas and Monterrico, we conducted both surveys and directed interviews. We spent a day with the community members of each village and surveyed 20 families (Las Lisas) and 29 families (Monterrico) using a 'clicker technology' response system. The responses from family representatives were anonymous but after each question, the group response was made known to all the respondents. With follow-up discussions, the diversity of answers could be probed further, revealing a deeper understanding of the various answers to the initial question.

The questionnaire was comprised of 34 questions, with clickable answers. The questions in general fell into four probing areas: 1) questions to introduce the process so that the families could familiarize themselves with the clicker system and diminish any anxiety associated with the survey itself; 2) questions that helped delineate the demographics of the responder; 3) questions that probed the demand and accessibility of fish/protein supply; and 4) questions that examined the willingness of respondents to change their relationship with the resources of the sea.

The community of Las Lisas wishes to preserve their ocean resources for the next generation.


Left: The fishers of Monterrico; right: the children of Las Lisas.

From our discussions and answers to the survey, we considered the following:
The fishers view the future as a balance – the next generation of fishers must be a smaller group that is better educated in sustainable business practices. The communities also need to divert some of their fishing efforts to aquaculture activities. The fishers are already aware that a lower fishing intensity is necessary to allow the fish stocks to recover, but this is contrasted by the intense demand for fish. Already the canals and inter-coastal waterways are extremely overfished, and the resultant removal of young fish stocks prevents them from contributing to coastal fisheries recovery. Until the fishing pressures in the inter-coastal waters are significantly reduced, there will be little improvement in the coastal fisheries. The desire for an alternative to traditional fisheries – using aquaculture – is steadfast. However, because the Las Lisas community is remote and does not have access to a good road system, the pursuit of aquaculture for non-local sales will be a challenge. Whatever aquaculture is chosen, sustainability is key: these efforts must result in a sustainable operation, and must not create unsupportive environmental conditions that result in reduced ecosystem health.

Recommendations for the communities

During our third visit in February 2016, summaries of the CNAs were provided to both communities as an oral presentation, a summary booklet with photos and comments, and a comprehensive report. The latter included a full synthesis of the survey results, conclusions of the CNA and recommendations provided by the PICES team. These reports and summaries were given to the communities so they could see 'first hand' that their concerns were represented in the reports, and that they could be used to assist community leaders in writing proposals for future projects. Community leaders were encouraged to use the report as a tool to help secure funding for future eco-friendly development while carefully considering which opportunities best promoted both community economic and ecosystem health. A synthesis of the major recommendations from the report include:

1. A healthier lifestyle can be facilitated with opportunities for better education; sustainable, environmentally-friendly tourism; and environmentally-considerate aquaculture opportunities.
2. Protection of the lagoon waters is essential, as these waters are breeding grounds for many major economically valuable species.
3. Community-wide, coordinated eco-tourism and fishing trips for tourists can be implemented to create a more sustainable alternative to fishing for sustenance.
4. An alternative source of fish-based food supplies must be sought – such as through aquaculture.
5. The communities have a relationship with the Universidad de San Carlos de Guatemala and should work with the faculty and researchers to develop sustainable associations.

Las Lisas.

Reading the booklet summarizing the CNA survey results.

The way forward

As an integral part of our recommendations to the communities, we invited Mr. Max Baldetti, a Guatemala citizen and graduate of the Center for the Study of the Sea and Aquaculture at the Universidad de San Carlos de Guatemala, and the country's only certified adventure sport guide, to provide a series of lectures on sustainable tourism. He spoke about how Guatemala is a 'mega-diverse' country providing diverse opportunities for tourists to climb mountains and volcanoes, hike in the jungles, paddle on the rivers and mangroves, as well as engage in a variety of other potential activities. He mentioned that, "….when you enjoy the coastal environment, you give it value. When it has value, you wish to preserve it and it becomes sustainable." He spoke about his background in tourism and his experiences growing up in both the United States and Guatemala, in particular, his increased appreciation of the sea in the Monterrico region during in his boyhood. He strongly promoted the idea that tourism is not just for visitors, but improves life for the whole community by bringing in opportunities for education and income for community members – women, men, children – who all can be involved in tourist activities. Max stressed that that tourism can provide many opportunities for women who wish to participate, and that once tourist activities are developed and become sustainable, they can be shared with children to educate them about their native environment. He mentioned that the potential for enhancing tourism needed to be driven by a local desire to serve the entire community. Various efforts have been made to start tourist activities in coastal Guatemala, but mostly in isolation or by guides from Antigua or Guatemala City. Max suggested that the creation of sustainable, targeted tourist activities requiring local expertise would provide visitors with a richer, home-grown, more comprehensive experience. The result of such efforts would be that tourist agencies in the big cities would need the services of local guides and would then be motivated to promote tours that use local knowledge and expertise. Some examples of tours incorporating local knowledge included fishing trips followed by a cooking class in a local home, mangrove activities together with local arts and crafts, and local bird watching.

Max Baldetti discussing ecotourism with the people of Monterrico.

In another related part of the project, we have been working with the poor coastal community of La Barrona, near the Guatemalan border with El Salvador, to develop an oyster aquaculture operation that hopefully can be transferred to other coastal communities. *Crassiostrea gigas* and *C. cortesiensis*, have been cultivated in Guatemala as part of past research projects, but these species have not been used in aquaculture efforts in the natural environment. Through the MarWeb project, *C. gigas* seed was purchased from El Salvador, and the oysters were grown for 2–3 months in the shallow waters of the Pacific Naval Base San Jose Port Escuintla until they were large enough to survive the higher sediment load in the waters of the La Barrona estuary. There, the fishery cooperative at La Barrona has the legal rights to work in

Fishing in the estuary.

Meeting with the community members of La Barrona at the Naval Base.

the mangrove area and will continue to grow the oysters into maturity. A 3-year agreement with the Guatemala Navy to use a small area of the San Jose port facility for the oysters' initial growth phase will benefit the and will strengthen the relationship between the community and the Navy. This collaborative project with the Guatemala Navy, oyster aquaculture experts from the Universidad de San Carlos, and La Barrona, serves as a model for bringing an alternative food source to an impoverished community in a developing nation.

This MarWeb project partnership has opened avenues of collaboration among the local communities on the coast, the military – formerly alienated from academics and the public, and the University research community. Although the project duration is only 4 years, we hope that these partnerships will continue well into the future. In 2017, we will make a final trip to the communities to facilitate their communications with leaders of a United Nations Development Program (UNDP) project intended to support and expand the five Marine Protected Areas (MPAs) on the Pacific coast of Guatemala. This proposed trip by PICES team members is dependent on adequate funding from PICES and UNDP. We hope that the knowledge gained from these communities will help them strike a balance between economic success and preservation of the beauty and sustainability of the ocean.

Acknowledgements The authors wish to express their deep appreciation to Dr. Leonel Carrillo and Ms. Dora Carolina Marroquin of the Universidad de San Carlos de Guatemala who have dedicated much effort and logistical support to this project. In addition, we thank Mr. Julian Herndon, formerly of San Francisco State University and currently at NOAA's Pacific Marine Environmental Laboratory in Seattle, Washington, who provided excellent cultural and linguistic services for this project's success. We are grateful for their collaboration, friendship and professionalism. We thank the people of Las Lisas, Monterrico and La Barrona for sharing their knowledge and their time with us.

Dr. Vera Trainer (vera.l.trainer@noaa.gov) is a Supervisory Oceanographer with the Marine Biotoxin Program at the Northwest Fisheries Science Center, Seattle, USA. She is the Co-Chair of the PICES Section on Ecology of Harmful Algal Blooms in the North Pacific and is the President of the International Society for the Study of Harmful Algae (ISSHA). Her current research activities include refinement of analytical methods for both marine toxin and toxigenic species detection, assessment of environmental conditions that influence toxic bloom development, and characterizing the spatial extent of new toxins such as azaspiracids.

Dr. Charles Trick (trick@uwo.ca) is a Distinguished Research Professor for Ecosystem Health at Western University, London, Canada, a position that emphasizes the merging of science, health/medicine, social and psychological aspects of environmental programs. Since receiving his Ph.D. in Oceanography, Charlie has worked in a variety of different coastal and open ocean projects. He has recently completed a sustainability assessment of the Persian Gulf and continues his research in marine and freshwater harmful algal blooms. In PICES, he is a member of the Section on Ecology of Harmful Algal Blooms in the North Pacific.

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

GlobalHAB – A new initiative in the HAB community

GlobalHAB, the new international scientific programme on Harmful Algal Blooms (HABs) was launched this year. The first meeting of the newly formed GlobalHAB Scientific Steering Committee (SSC) was hosted at the Scottish Association for Marine Science (SAMS) in Oban, Scotland from 8 to 10 March 2016. GlobalHAB is an initiative under the auspices of the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission of UNESCO (IOC). GlobalHAB builds on the wealth of scientific results delivered through the recently completed Global Ecology and Oceanography of Harmful Algal Blooms (GEOHAB) programme (www.geohab.info).

The steering committee has representatives from across the globe (Fig 1): Elisa Berdalet (Chair, Spain), Neil Banas (UK), Michele Burford (Australia), Chris Gobler (USA), Bengt Karlson (Sweden), Raphael Kudela (USA), Po Teen Lim (Malaysia), Lincoln Mackenzie (New Zealand), Marina Montresor (Italy), and Kedong Yin (China). Liaisons from ICES (Eileen Bresnan), IPHAB (Gires Usup), PICES and ISSHA (Vera Trainer), and SAMS (Keith Davidson) participated in the meeting and are helping develop the GlobalHAB plans. Henrik Enevoldsen from IOC and Ed Urban from SCOR assisted the GlobalHAB SSC and provided input from sponsoring organizations.

In this first meeting, with a positive and active atmosphere, the participants defined the fundamental elements that will structure the GlobalHAB Science and Implementation Plan expected to be completed by June 2016.

The **mission** of this cutting-edge programme is *to improve understanding, prediction, management and mitigation of HABs in aquatic ecosystems*.

The scientific **goals** of GlobalHAB include:

- To address the scientific and societal challenges of HABs, including the environmental, human health and economic impacts, in a rapidly changing world.
- To involve participants from related fields of natural and social science, and link with other regional and international organizations, and initiatives relevant to HABs.
- To foster intercalibration among existing methods, as well as promote the development and adoption of new technologies.
- To promote training, capacity building and communication of knowledge about HABs to society.
- To serve as a liaison between the scientific community, stakeholders and policy makers, promoting science-based decision making.

A range of **implementation activities** was identified to be undertaken in the next three years and beyond. Namely, workshops and open science meetings will specifically address toxin-related challenges (detection methods, action mode, molecular basis), evaluate the impacts of aquaculture on HAB occurrences in different regions, and ascertain the potential climate change impacts on HABs occurrence in freshwater and marine ecosystems. Science/stakeholder forums will be organized to assess the potential socio-economic impacts of HAB occurrences and to engage the medical community to improve human health protection. GlobalHAB implementation will be conducted with new linkages with the existing international and regional initiatives including IPHAB, the ICES-IOC Working Group on HAB Dynamics, PICES Section on Ecology of Harmful Algal Blooms in the North Pacific, GOOS, the IOCCG/GEOHAB Ocean Colour & HAB working group, GEO and IAEA.

The GlobalHAB Science and Implementation Plan will be presented at the 17th International Conference on Harmful Algae in Florianopolis, Brazil in October 2016. This will be an extraordinary opportunity to involve the international community working on HABs with the new programme. As in its predecessor programme, GEOHAB, the international coordination approach to address the fundamental problem of HABs is the keystone of GlobalHAB.

Fig. 1 GlobalHAB Scientific Steering Committee (SSC).

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IMBER – Synthesis and the way forward

by Eileen E. Hofmann and Carol Robinson

The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project grew from a desire by the international marine science community to address the challenges of understanding the interactions and relationships between biogeochemical cycles and food webs across multiple space–time scales, and to quantify and predict marine system responses to natural and anthropogenic forcings. IMBER was initiated in 2005 as a joint project of the International Geosphere-Biosphere Programme (IGBP) and the Scientific Committee on Oceanic Research (SCOR) with the central goal to provide a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth system and human society. IMBER has its origins in previous IGBP–SCOR projects, the Joint Global Ocean Flux Study (JGOFS) and the Global Ocean Ecosystem Dynamics (GLOBEC) project, which highlighted knowledge gaps and limitations in the global research capacity for integrated approaches across multiple scales and key processes that were needed to understand global change effects on marine ecosystems.

During the past ten years (2005–2015), the IMBER goal has been pursued through science activities under four overarching and interlinked themes that consider key interactions in marine ecosystems, sensitivity to global change, feedbacks to the Earth system, and responses of society (Fig. 1). IMBER has addressed these themes through international coordination, networking and capacity building activities, regional programs, working groups, national contributions, endorsed projects, and integrative, project-wide activities (Fig. 2). In-depth regional and topical analyses and comprehensive comparisons of diverse marine ecosystems have provided new understanding about the potential effects of global environmental change on biogeochemical cycling, food web dynamics, and impacts and linkages to human systems at multiple scales. The focus of a global community of natural and social scientists on a specific research agenda facilitated these important advances (see Hofmann *et al*., 2016 for an overview).

The IMBER project is now undergoing a transition in parallel with changes and transitions in the global environmental research community. The IGBP ended operations in late 2015, following the ending of other international science coordination bodies, the International Human Dimension Programme, DIVERSITAS and the Earth System Science Partnership. These multiple organizations were replaced with a single overarching program, Future Earth, a 10-year international research initiative focused on providing the knowledge and support

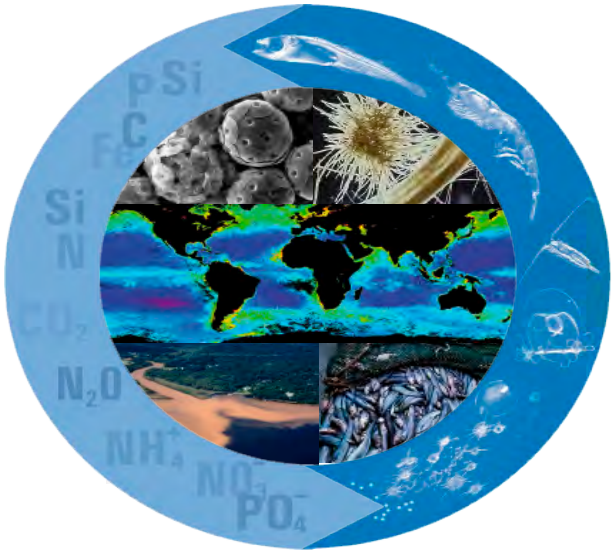

Fig. 1 Schematic of interacting science themes that guided the first decade of IMBER research (2005–2015) illustrating the linkages between food webs and biogeochemical cycles (Theme 1 key interactions, outer circle), marine organisms (such as calcifying and N_2 fixing phytoplankton) that respond to global change (Theme 2 sensitivity to global change, upper panel), a global chlorophyll distribution (Theme 3 feedbacks to the Earth system, middle panel), and human-marine interactions including fisheries (Theme 4 responses of societies, bottom panel).

to accelerate transformations to a sustainable world. The science plan and implementation strategy (SPIS) that guided IMBER for the past 10 years is ending, which provides the opportunity to reconsider IMBER's vision and goal in light of its accomplishments and research needs and directions for the future.

IMBER began the process of developing a new SPIS with its 2014 Open Science Conference (OSC). The OSC provided an opportunity for the marine science community to present key findings of IMBER-relevant research and promote integrated syntheses of IMBER research. It also gave a planned opportunity to solicit and discuss approaches for updating the IMBER research agenda to guide future research into marine biogeochemistry, ecosystem structure and functioning, the human dimensions of global marine change, and interactions between each of these. The outputs from the OSC, subsequent community-wide consultations, and inputs from partner organizations and national programs resulted in the development of a new IMBER SPIS to guide the next decade of research, and to provide the basis for IMBER to transition to becoming a core project of Future Earth and to continue as a research focus for SCOR.

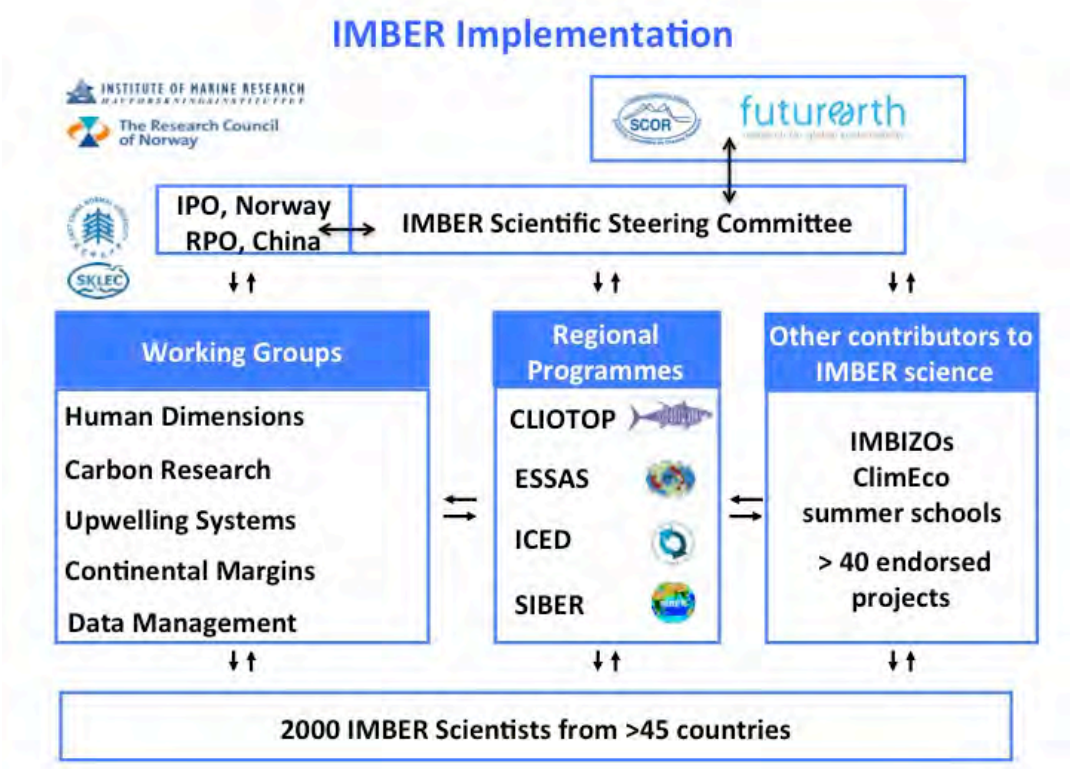

Fig. 2 IMBER project organization and implementation. Coordination of IMBER activities is through the International Project Office (IPO), the Regional Project Office (RPO) and the Scientific Steering Committee. IMBER science is implemented through working groups, regional programs, project-wide activities (IMBIZOs, ClimEco summer schools), and endorsed projects; all supported by an international community of scientists. The Carbon, Upwelling and Continental Margins working groups are jointly sponsored with the Surface Ocean–Lower Atmosphere (SOLAS) project, the Climate and Ocean: Variability, Predictability and Change (CLIVAR) project, and the Future Earth Coasts project, respectively. The regional programs are: CLimate Impacts on Oceanic Top Predators (CLIOTOP), Ecosystem Studies of Subarctic and Arctic Seas (ESSAS), Integrating Climate and Ecosystem Dynamics (ICED) in the Southern Ocean, and Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER).

The new IMBER SPIS recognizes that the evolution of marine ecosystems (including biogeochemical cycles and human systems) is linked to natural and anthropogenic drivers and stressors. This broadened the IMBER vision to focus on ocean sustainability under global change for the benefit of society. This vision is supported by a research goal for the next decade to: Understand, quantify and compare historic and present structure and functioning of linked ocean and human systems to predict their future structure and functioning and develop options for securing or transitioning towards ocean sustainability.

The integrated research agenda for the next decade supports this new vision and goal, and is based on three grand challenges that focus on climate variability, global change and human drivers and stressors, and innovation challenges that focus on new areas for IMBER where research is needed and where it is believed that major achievements can be made within 3–5 years (Fig. 3). The first grand challenge considers the state and variability of marine ecosystems, the impacts of natural variability and anthropogenic global change, and interactions across time and space scales. This grand challenge is further developed in the second that focuses on predictions and projections of ocean–human systems at multiple scales, which includes improving ecosystem models for scenario testing and evaluation, and includes considerations of maintenance of biodiversity and direct anthropogenic drivers such as fishing. The final grand challenge focuses on improving and achieving sustainable governance and recognizes the need to improve the science-policy-society interface and develop new linkages between marine and human systems, and includes "communicating relevant information and knowledge needed by society to secure sustainable, productive and healthy oceans". Implementation of the grand challenges in a 3- to 5-year time horizon is provided by the innovation challenges that consider metabolic diversity and evolution, global ocean observational and modeling networks, ecological feedbacks in the Earth system, and social science data for ocean management, decision-making and policy development.

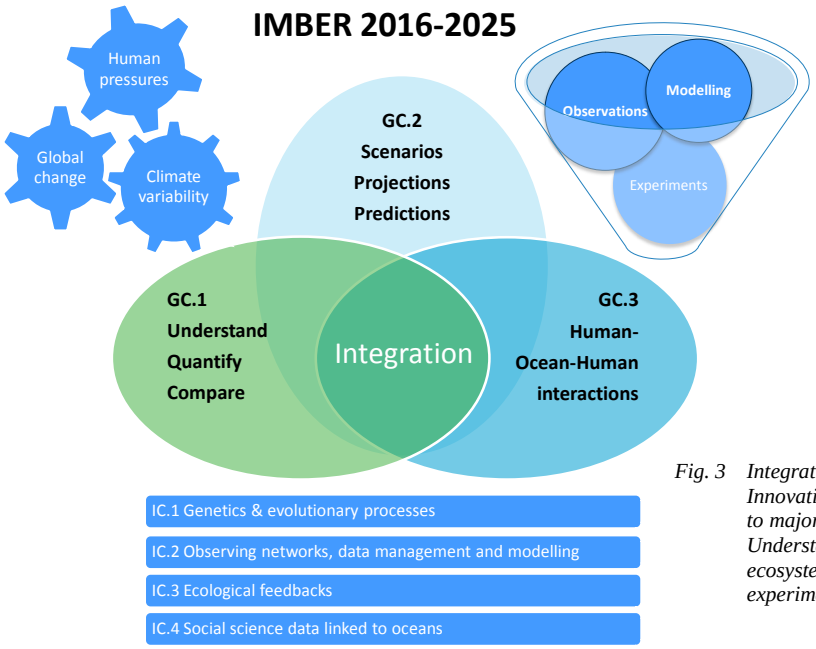

Fig. 3 Integrative structure of IMBER Grand Challenges (GC) and Innovative Challenges (IC). Marine ecosystems are responding to major pressures (upper left) that operate at a range of scales. Understanding, quantifying and predicting responses of marine ecosystems to these pressures requires integrated observational, experimental and modeling programs (upper right).

With its new SPIS, IMBER will maintain its strong commitment to basic, curiosity-driven science and expand into new areas of problem-driven, policy-relevant interdisciplinary research. The IMBER project is now evaluating its working group and regional program structure with a view towards better alignment with the new SPIS. As IMBER moves forward into a new decade of research, the project will maintain the legacy of IGBP, continue to contribute to the objectives of SCOR which focus on promoting international cooperation in planning and conducting oceanographic research, and solving methodological and conceptual problems that hinder research, and transition to a core project of Future Earth to contribute to their vision of supporting research which enables transformation to global sustainability and equitability. The IMBER SPIS is undergoing final review by SCOR and Future Earth and will be jointly published by both organizations in 2016.

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(Left) Dr. Eileen Hofmann (hofmann@ccpo.odu.edu) is a Professor in the Department of Ocean, Earth and Atmospheric Sciences and a member of the Center for Coastal Physical Oceanography, both at Old Dominion University, Norfolk, Virginia, USA. Her research interests are in the areas of physical–biological interactions in marine ecosystems, environmental control of marine diseases, descriptive physical oceanography, and mathematical modeling of marine ecosystems. She has worked in a variety of marine environments, most recently the continental shelf of the western Antarctic Peninsula, the Ross Sea, Delaware Bay, and the Middle Atlantic Bight. She is past Chair of the IMBER SSC.

(Right) Dr. Carol Robinson (carol.robinson@uea.ac.uk, @CarolRobinson8) is a microbial oceanographer at the University of East Anglia, Norwich, UK. Her research interests relate to the role of marine bacteria, phytoplankton and zooplankton in the global cycling of carbon and oxygen, and how this varies in space and time and with changing environmental conditions such as increasing nutrient supply, temperature and carbon dioxide and decreasing dissolved oxygen. This involves a combination of laboratory and field observations, remote sensing, numerical models and the use of water mass tracers (sulphur hexafluoride), gliders and time series datasets. Carol has been a member of the GEOTRACES and IMBER SSCs, and has received funding from UK SOLAS for a study of Eastern Boundary Upwelling Systems. She is the current Chair of the IMBER SSC.

GLODAPv2: Data synthesis product published at CDIAC

by Alex Kozyr, Toru Suzuki and Masao Ishii

The long awaited GLobal Ocean Data Analysis Project Version 2 (GLODAPv2) data base has been published at CDIAC and available at its website.

The GLODAPv2 data synthesis project is a cooperative effort of the international "GLODAPv2 Group" of scientists from Norway, The Netherlands, Germany, Spain, Sweden, Japan and the United States, and hundreds of sea-going scientists around the world. These scientists generated funding and dedicated time to collecting the data, and shared their data with the wider scientific community. Chief scientists and principal investigators for all parameters measured during each cruise are listed in the Cruise Summary Table (CST) at CDIAC.

The aim of GLODAPv2 was to unify the data in the first version of GLODAP (GLODAPv1.1) with the data from CARINA and PACIFICA, and any new data that were made available, and to fully re-evaluate all of these data to produce a global calibrated data product and mapped climatology.

GLODAPv2 includes data from all ocean areas of the globe. Data from 556 unique cruises were available fromGLODAPv1.1, CARINA and PACIFICA*, and data from 168 new cruises were added to the collection (Fig. 1).

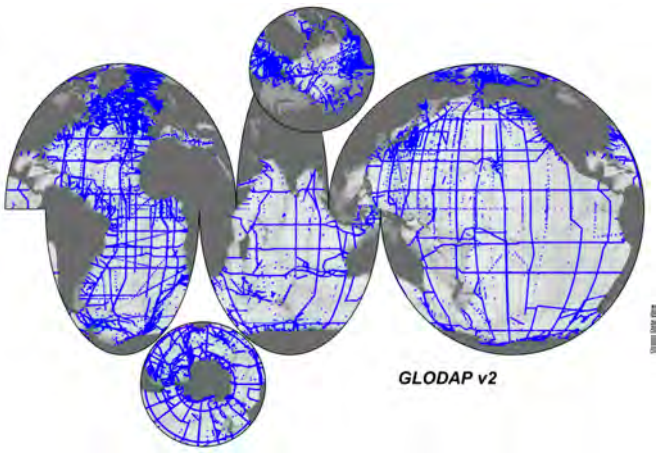

Fig. 1 GLODAPv2 station locations.

A secondary QC was performed to allow the identification of measurement biases in the data, and to correct for these in the GLODAPv2 product files. The secondary QC was carried out using crossover and inversion procedures as described by Johnson *et al*. (2001), Gouretski and Jancke (2001), Tanhua *et al*. (2010) and Lauvset and Tanhua (2015). Data for the following sea water constituents were subjected to secondary QC: Salinity, Oxygen, Nitrate, Silicate, Phosphate, TCO_2, total alkalinity, pH, CFC-11, CFC-12, CFC-113 and CCl_4. The secondary QC was carried out in a series of steps as described in detail by Olsen *et al*. (2016). All adjustments derived in GLODAPv1.1, CARINA and PACIFICA were re-evaluated within the context of the entire GLODAPv2 dataset and revised where necessary.

The results of the secondary QC are provided on a per cruise and parameter basis in the online Adjustment Table. Access to this table is also available via various links at the primary CDIAC GLODAPv2 web site. The secondary QC results are described in detail by Olsen *et al*. (2016).

The GLODAPv2 mapped product includes global fields at 1° resolution for TCO_2, alkalinity, pH, calcite and aragonite saturation state (Ω_{Ca}, Ω_{Ar}), phosphate, nitrate, silicate, oxygen, salinity and potential temperature on 33 pressure surfaces. These 33 pressure levels are numerically identical to the 33 depth levels used for the World Ocean Atlas 2009 and its past versions (Locarnini *et al*., 2010). The pixel center latitudes and longitudes run from –89.5 to 89.5ºN and from –179.5 to 179.5ºE, respectively (identical to the NODC grid). Each property map comes with an associated error map, giving the mapping error in the unit of the parameter in question. This mapping error does not include the measurement uncertainty. Lauvset *et al*. (2016) provides the full details of the approaches used for the mapping.

The numeric data package NDP-093 database consists of GLODAPv2 data synthesis product files, separated by oceans, the mapped climatology product, GLODAPv2 Cruise Summary Table (CST), original cruise data for all 724 cruises included in the database, and the GLODAPv2 Recommended Adjustments Table.

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* PACIFICA was an initiative of the PICES Section on *Carbon and Climate*. As a result of this effort, the northwest Pacific is one of the most data-dense regions in the GLODAPv2 database.

The GLODAPv2 database can be accessed via CDIAC-developed Web-Accessible Visualization and Extraction System (WAVES: http://cdiac3.ornl.gov/waves/glodapv2/). The architecture of this system is based on the following components: PHP engine, MySQL RDBMS, and map server. The PHP engine with DHTML and JavaScript (JQuery library) are used as the main tools for building interface, forming results pages and program interactions. The visualization for making cruise lines was made using tools developed by ORNL DAAC and is based on the ArcGIS server and Google map engine. The functionality allows researchers to subset datasets based on spatial and/or temporal conditions. At the same time it provides access to extensive metadata collections that accompany datasets and single cruise lines. The access to metadata is accomplished by using API for Mercury metadata search engine developed by ORNL ARM Data Archive.

The GLODAPv2 database is also available as an Ocean Data View (ODV) Collection at (Fig. 2).

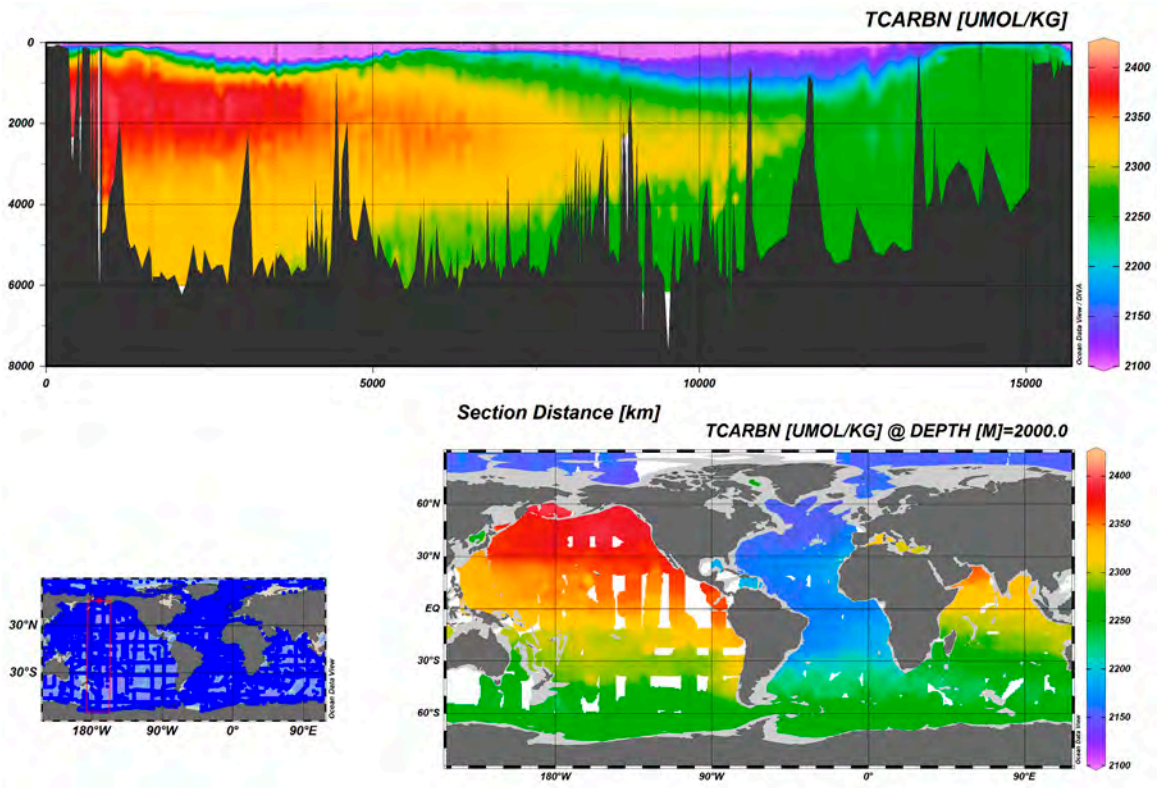

Fig. 2. Example of GLODAPv2 ODV Collection plots.

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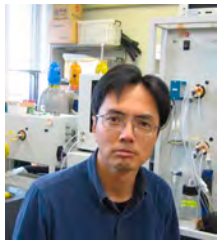


Dr. Alex Kozyr (kozyra@ornl.gov) is a Senior Research Scientist, and Oceanographic Data Analyst at the Carbon Dioxide Information Analysis Center (CDIAC), Environmental Sciences Division, Climate Change Science Institute of Oak Ridge National Laboratory, US Department of Energy. Since 1993 he has been working at CDIAC as the data manager for ocean carbon dioxide and other measurements from research ships, volunteer observing ships (VOS) or ships of opportunity (SOOP), moorings and time series measurements. Alex has been involved in the national and international data synthesis projects such as GLODAP, CARINA, PACIFICA, GLODAPv2, SOCAT and the LDEO pCO_2 Database. Alex has been involved in PICES since 1997, and is a member of the PICES Section on Carbon and Climate. Alex also is a member of Southern Ocean Observing System (SOOS) Data Management group, member of international advisory board of EU Fixed-point Open Ocean Observatories (FixO3) project.

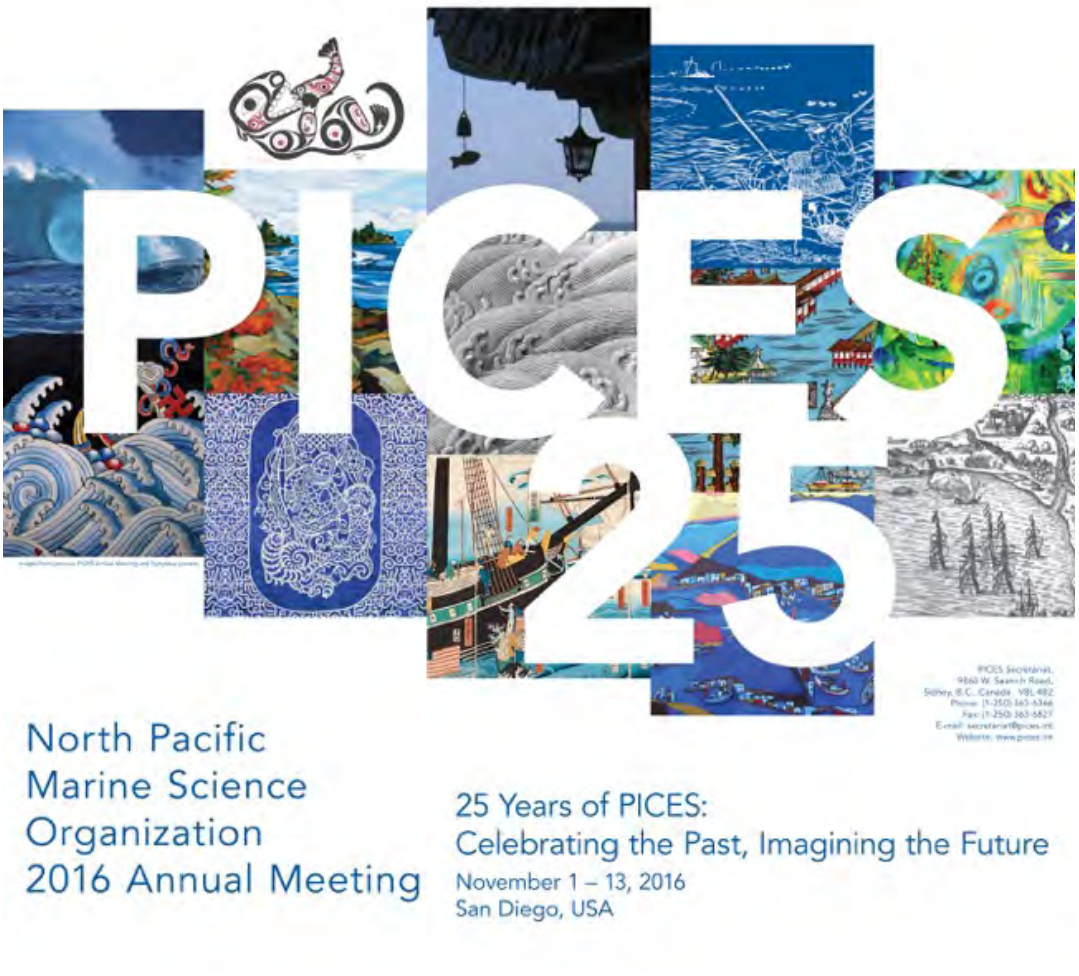
Dr. Toru Suzuki (suzuki@mirc.jha.jp) is the Deputy Director General of the Research Division at the Marine Information Research Center (MIRC), Japan Hydrographic Association. Toru received his PhD in Fisheries from Tokyo University of Fisheries (the present Tokyo University of Marine Science and Technology). Toru's background is physical oceanography, and he has worked in oceanographic and bathymetric data management and quality control in MIRC since 1997. Toru has attended PICES Annual Meetings since 1999. He is the Chairman of TCODE and has been a member of the Section on Carbon and Climate since 2005.

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

PICES calendar of upcoming events

IMBER ClimEco5 Summer School on "*Towards more resilient oceans: Predicting and projecting future changes in the ocean and their impacts on human societies*", August 10–17, 2016, Natal, Brazil (co-sponsored by PICES)
CLIVAR Open Science Conference on "*Charting the course for climate and research*", September 15–23, 2016, Qingdao, China (co-sponsored by PICES)
ICES Annual Science Conference, September 19–23, 2016, Riga, Latvia
UN-IHP Training Course on "*Coastal vulnerability and freshwater discharge*", November 27–December 10, 2016, Nagoya, Japan (co-sponsored by PICES)
PICES-2016, "*25 years of PICES: Celebrating the past, imagining the future*", November 1–13, 2016, San Diego, USA
DFO Symposium to Celebrate Station Papa's 60th Anniversary, November 29–30, 2016, Sidney, Canada (co-sponsored by PICES)
ICES/PICES/AMAP Workshop on "*Understanding the impacts and consequences of ocean acidification for commercial species and end-users*" December 5-9, 2016, Copenhagen, Denmark
PICES/ICES Symposium on "*Drivers of small pelagic fish resources*", March 6–11, 2017, Victoria, Canada
3rd PICES/ICES Conference for Early Career Scientists on "*Climate, oceans and society: Challenges and opportunities*", May 30–June 2, 2017, Korea
ESSAS Open Science Meeting on "*Moving in, out and across the Subarctic and Arctic marine ecosystems: shifting boundaries of water, ice, flora, fauna, people and institutions*", June 11–15, 2017, Tromsø, Norway (co-sponsored by PICES)

Important dates



- **S1: SCIENCE BOARD SYMPOSIUM**

25 years of PICES: Celebrating the past, imaging the future

- **S2: BIO/TCODE/FIS TOPIC SESSION**

Early life history stages as indicators and predictors of climate variability and ecosystem change

- **S3: MEQ TOPIC SESSION**

Source, transport and fate of hydrocarbons in the marine environment

Co-sponsored by the Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)

- **S4: FIS TOPIC SESSION**

Climate Variability, Climate Change and the Reproductive Ecology of Marine Populations

- **S5: BIO/MONITOR/MEQ TOPIC SESSION**

Understanding our changing oceans through species distributions and habitat models based on remotely sensed data

- **S6: POC/MEQ/MONITOR/BIO TOPIC SESSION**

What Factors make or break Trophic Linkages?

- **S7: POC/TCODE/MEQ TOPIC SESSION**

New stage of ocean acidification studies: Responses of oceanic ecosystem including fisheries resources

Co-sponsored by the International Council for the Exploration of the Sea (ICES)

- **S8: MoE/MEQ/TCODE Topic Session**

The effect of marine debris caused by the Great Tsunami of 2011
Co-sponsored by PICES MoE ADRIFT project

- **S9: FIS/TCODE Topic Session**

Resilience, transitions and adaptation in marine ecosystems under a changing climate
Co-sponsored by the International Council for the Exploration of the Sea (ICES)

- **S10: FUTURE Topic Session**

The Response of marine ecosystems to natural and anthropogenic forcing: Past, present and future

- **S11: POC Topic Session**

Advances in understanding and modeling of physical processes in the North Pacific in the past 25 years of PICES and future directions

- **S12: MONITOR/BIO/TCODE Topic Session**

Causes and consequences of 25 years of variability in ocean conditions on the ecosystems of the North Pacific

- **S13: MONITOR/TCODE Topic Session**

Understanding the changing coastal ocean: Advances and challenges in multi-parameter observations

- **W1: POC Workshop**

Acidification of the North Pacific Ocean: a basin-wide assessment

- **W2: MEQ Workshop**

Conditions promoting extreme *Pseudo-nitzschia* events in the eastern Pacific but not the western Pacific

- **W3: BIO Workshop**

Distributions of habitat-forming coral and sponge assemblages in the North Pacific Ocean and factors influencing their distributions

- **W4: FIS Workshop**

Methods relating oceanographic conditions to the distribution of highly migratory species
Co-sponsored by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)

- **W5: FIS Workshop**

Modeling effects of climate change on fish and fisheries

- **W6: BIO Workshop**

Consumption of North Pacific forage species by marine birds and mammals

- **W7: MONITOR Workshop**

Delivering quality multi-parameter data from the coastal ocean
Co-sponsored by Oceans Networks Canada

- **W8: POC Workshop**

Mesoscale and submesoscale processes in the North Pacific: history and new challenges

- **W9: POC Workshop**

The role of the northern Bering Sea in modulating Arctic environments: towards international interdisciplinary efforts
Co-sponsored by the North Pacific Research Board (NPRB)

- **W10: MEQ Workshop**

Distribution and risk analysis of radionuclides in the North Pacific

- **BIO, FIS, MEQ, POC, MONITOR, and S-HD contributed Poster Sessions**

meetings.pices.int/meetings/annual/2016/pices/scope

PICES Early Career Scientists

THEME 1: Climate effects on physical, chemical and biological processes

SESSION 1A
Climate change and the effects on the ocean

SESSION 1B
Cross-scale interactions and trends of climate change

SESSION 1C
Coastal dynamics: changes in sea level, geomorphology and ecosystems

THEME 2: Anthropogenic effects on the marine environment

SESSION 2A
Introduction of anthropogenic substances to the ocean and their impacts

SESSION 2B
Ecosystem-Based Management – Get the big picture

SESSION 2C
Evaluation of best management practices

THEME 3: Patterns and processes in marine ecosystems

SESSION 3A
Biodiversity and ecosystem functioning

SESSION 3B
Marine population dynamics and community ecology

SESSION 3C
Marine ecosystems and biogeochemical cycles

SESSION 3D
Ecological forecasting in marine ecosystems

Important Dates

SEPTEMBER 28, 2016

- Abstract submission
- CV and financial support application

Symposium Convenors

Hal Batchelder (PICES) and Wojciech Wawrzynski (ICES)

www.pices.int/ecs3

- PLENARY SESSIONS

- TOPIC SESSIONS

SESSION 1

Environmental control of spatio-temporal changes in population size, distribution and migration of small pelagic fish in the ecosystem context

SESSION 2

External drivers of change in early life history, growth and recruitment processes of small pelagic fish

SESSION 3

The role of small pelagic fish in food web dynamics between plankton and top predators

SESSION 4

Comparison of methods for assessment of small pelagic fish populations

SESSION 5

Future challenges for ecosystem-based management of highly variable fish populations

SESSION 6

Small pelagic fish and humans – social, economic and institutional dimensions

- POST-SYMPOSIUM CONCURRENT WORKSHOPS

Important Dates

MARCH 21, 2016

- Early registration
- Abstract submission
- Financial support application

JUNE 1, 2016

- Deadline for workshop proposal submissions

OCTOBER 1, 2016

- Closing date for early registration
- Closing date for abstract submission
- Closing date for financial support

DECEMBER 1, 2016

- Abstract acceptance notification
- Financial support grant notification

Symposium Convenors: Jürgen Alheit (ICES) and Yoshioki Oozeki (PICES)

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PEEC 2016 – A West Coast conference

by Mary Toews

Participants at PEEC 2016, February 27–28, 2016, Bamfield, Canada.

This year PICES supported the 37th annual Pacific Ecology and Evolution Conference (PEEC), which was once again held in the tiny inlet town of Bamfield, British Columbia, at the internationally acclaimed Bamfield Marine Sciences Centre. Geared towards early career scientists still completing their undergraduate and graduate studies, PEEC is a unique experience that allows for collaboration and networking for the up and coming class of ecology and evolution researchers. Without an audience of supervisors and professors, students have the opportunity to be the experts in their fields, and can present their first research findings, discuss novel or controversial results, practice talks, or test new theories in a supportive but stimulating environment. PEEC 2016 was unequivocally a great success, with 68 students attending from as far as Ontario and Quebec, enthusiastic contingents from Alberta and Interior BC, and many students from British Columbia's range of coastal campuses. The attendees included 21 undergraduate students, 3 recent graduates, 37 Masters students, 3 PhD students, one post-doctoral researcher, a research assistant, a lab manager, and a teaching assistant.

Thanks to the diverse group of attendees, we began Saturday with 27 twelve-minute presentations and 18 three-minute blitz talks, which highlighted the incredible diversity in ecology and evolution. These talks fell into six key themes:

1. *Species and environmental interactions*

This theme featured a diverse range of talks exploring the factors affecting species mortality, dispersal, distribution and survival, shedding light on what constitutes habitat selection – from fish to mammals to birds.

2. *Management and conservation*

Ecological research can guide and inform policy and management, while sometimes uncovering challenges for conservation. In this session we learned how marine mammal, terrestrial mammal, and burrowing owl distribution models can improve management, and examined the effectiveness of policy and management techniques.

3. *Community and ecosystem biology*

Here we explored how collecting data and making inferences on community and ecosystem-wide processes is a challenging endeavor, whether it is the cross-over between birds and streams, terrestrial and aquatic habitats, or diversity and colonization of bacterial, phytoplankton and algal communities.

4. *Humans and nature*

No discussion of ecology and evolution is complete without considering the omnipresence of humans. This session considered traditional ecological knowledge and local knowledge in conservation, how to manage ecosystems for the dual benefits of humans and nature, and how to limit our impact on the land and water which we use.

5. *Evolution and local adaptations:*

As highlighted by the PEEC 2016 dance theme, evolution can present strange and specific adaptations – from diet-driven sex changes to carapace spines, this session explored the role of stress, resiliency and biomechanics in adaptation.

6. *Species interactions and behaviour*

This session focused on how animals can demonstrate a range of behaviours which can be driven by genetics, species interactions, food preferences, human disturbances and even fear.

PEEC highlights.

The talks concluded in the early afternoon, and we emerged from the conference centre to sunny skies and unusually warm weather. Full of new knowledge and brimming with ecological enthusiasm, the majority of the group set off across the Bamfield Inlet to explore the fine sand and rocky sea stacks of Brady's Beach. This was invariably a highlight for many, as the West Coast beaches are a spectacular place to contemplate the beauty of ecology and evolution.

We were lucky to have two concurrent workshops this year, both very well attended after a relaxing walk along the beach. The first was a Research Derby put on by Dave Riddell and Jessica Brown of Ocean's Network Canada (ONC). Students were encouraged in the weeks leading up to the conference to explore the data available through ONC, and start devising their research ideas. During the workshop, they learned how to best utilize the wide range of ONC data, and collaborated with peers to develop their ideas into tangible research questions and hypotheses, practicing a critical but often overlooked scientific skill. To further entice students, ONC offered a scholarship prize for students who move forward with their research questions and present their findings at a future conference. The second event was a Storytelling workshop designed by Dr. Aerin Jacob, a postdoctoral researcher at the University of Victoria, and led by Jennifer Schine, a social scientist, artist and broadcaster. Jennifer highlighted the push for scientists to improve communication of their work, and engage the public in open, meaningful, and exciting ways. Students prepared stories – from their work, research, and play – ahead of time, and collaborated with Jennifer and each other to become more engaging and effective storytellers.

That evening, we mingled around 18 poster presentations, all of which provided for stimulating conversation. These spanned the range of themes from the talk sessions, and covered the ecology and evolution of everything from microbes, invertebrates, and fish to mammals, birds and plants. Next followed the highly anticipated costume dance, with this year's theme being "Weird and Tentatively Functional (WTF) Evolution." The PEEC attendees had not only delivered on their talks and posters earlier in the day, but brought their scientific knowledge to the dancefloor. Some memorable costumes which showcased the peculiarities of adaptations were a bird of paradise, a geoduck, several narwhals and anglerfish, and a pair of baboons. Accentuating the dance was a built-in-the-moment R Programming Language script which, with the help of a projector, decorated the walls with graphics.

The next morning, we sat back and enjoyed the much anticipated keynote talk. This year, our keynote speaker was Dr. Natalie Ban, an Assistant Professor leading the Marine Ethnoecology group at UVic. Her research is highly interdisciplinary, investigating both the ecological and social dimensions of conservation and land-use planning. It was an invaluable experience for early career scientists to gain insight from such a strong and passionate researcher, and to hear her thoughtful and optimistic advice for careers in ecology and conservation.

The 37-year history of PEEC is shrouded in mystery, and even the organizers each year have little idea of its origin, with only vague memories from older academic cohorts to guide speculation. Yet, each year PEEC occurs again, thanks to a small group of students who volunteer their time to plan and coordinate all aspects of the event, rotating each year between the University of Victoria, Simon Fraser University, and the University of British Columbia. PEEC 2016 was organized by Angela Fortune, Mary Toews, Angeleen Olsen, Devin Roberts, Laura Kennedy, Jessica Holden, Erin Hornell, Alessia Kockel, Alexandra Francis, Katie Davidson, Lauren Eckert, Gillian Harvey and Sandra Frey, all graduate students at the University of Victoria.

While the committee has an integral role in planning and running the conference, this event would not be possible without our dedicated sponsors, who each year help to greatly reduce student costs. On behalf of the all PEEC attendees, the PEEC 2016 committee would like to give special thanks to PICES, Oceans Network Canada and UBC Forestry as our Gold Sponsors, without whom the conference would not have been possible. We would also like to thank U of A Biology, The Canadian Society for Ecology and Evolution, UBC Biodiversity Centre, UBC Biology, UBC Botany, SFU Biology, and Ecofish Research as our Silver Sponsors, and the contributions of UVic Geography, The College of Applied Biology, Lady Rose Marine Services, SFU Faculty of Environmental Studies, UVic Biology, UVic Environmental Studies, and the Watershed Watch Salmon Society. We also received support in the form of donated gifts and prizes from a range of local and larger businesses, the full list of which can be found at www.peec.ca.

Mary Toews (toews.mary@gmail.com) is a MSc student in Fisheries Ecology at the Marine Conservation (Juanes) Lab, Department of Biology, University of Victoria. Her interests are the effect of the human footprint on large mammals, boreal forests, thresholds, landscape ecology, and cumulative effects management.

The Blob is gone but has morphed into a strongly positive PDO/SST pattern

by William Peterson, Nicholas Bond and Marie Robert

In the past three issues of PICES Press, we have reported on the status of the mass of warm water in the Gulf of Alaska, fondly referred to as "the Blob", that began to form in autumn 2013. This warm 'red' mass, like its cinematic namesake, subsequently grew and spread across much of the North Pacific and Bering Sea during spring and summer of 2014; sea surface temperature (SST) anomalies in excess of 4°C were observed commonly across the region. Coastal upwelling kept the Blob offshore of the California Current ecosystem throughout much of 2014 but in autumn 2014, a relaxation of upwelling winds allowed a slab of warm water to move eastward and occupy much of the continental shelf off eastern Alaska and the Pacific Northwest. Once this happened, the SST pattern associated with the Blob began to look more like a positive Pacific Decadal Oscillation (PDO) pattern. Indeed, by December 2014, the value of the PDO was + 2.51 (among the highest for any December); 16 months later, in April 2016, the PDO peaked at + 2.62. These two values are the 5th and 6th highest in the 115-year record.

It is interesting that the atmospheric conditions which resulted in the positive state of the PDO value in the winter of 2014/15 were decidedly different than those a year before. Specifically, the winter of 2014/15 featured a deeper than normal and southeast displaced Aleutian low and associated wind anomalies in the Northeast Pacific out of the southeast. This brought about air temperatures that were about 2°C warmer than normal over the region stretching from Baja California to the Gulf of Alaska. Similar atmospheric anomalies have been observed during previous El Niños, but in the case of 2014/15, only the central tropical Pacific was considerably warmer than normal. A strong El Niño did develop in the summer of 2015, with the precursor conditions in the Northeast Pacific potentially playing a significant role in that development. The winter of 2015/16 also featured a relatively deep Aleutian low, but without the usual displacement accompanying El Niño. The upshot was an enhanced storm track into the Pacific Northwest, another very mild winter for Alaska, and stronger than normal westerlies across the central North Pacific. This all supported the continuation of a positive state for the PDO, with especially warm water relative to seasonal norms in the coastal Gulf of Alaska and the southeastern Bering Sea in the spring of 2016.

The magnitude of the warm anomalies in the near surface waters of the Gulf of Alaska along Line P moderated late in 2015. On the other hand, the penetration of the relatively warm water to depths of 200 to 300 m during the last couple of years means there remains a large reservoir of extra heat in the region, as can be seen in Figure 1.

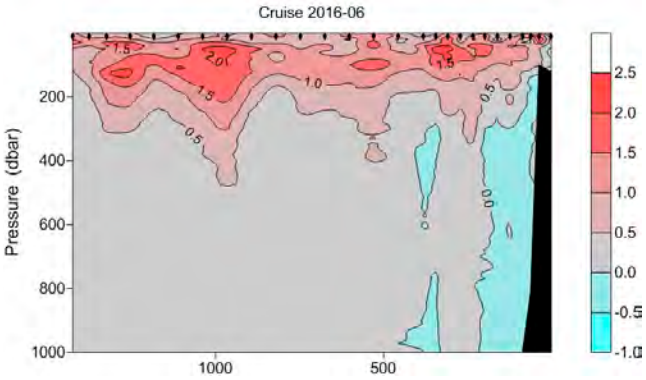

Fig. 1 Temperature Anomaly Field in June 2016 along Line P with respect to the 1956–1991 averages. (unprocessed data)

Since our last report to PICES Press (pp. 46–48, Vol. 24, No. 1), SST anomalies in outer shelf waters off Newport, Oregon have continued to be + 2°C (through May 2016) but such anomalies are expected with a positive PDO SST pattern (Fig. 2, top). However, what is unusual is that the anomaly of the number of copepod species found in zooplankton net tows continues to be very high, with 5 to 10 species greater than the 20-year monthly climatology (Fig. 2, bottom). The copepod biomass anomalies are still strongly negative for 'northern' species and strongly positive for 'southern' species which means that the lower trophic level of the ecosystem is still dominated by tropical and sub-tropical lipid-replete species. The same observations have been found from regular sampling in shelf waters off Vancouver Island by DFO scientists (Moira Galbraith, personal communication).

Many negative ecosystem and economic effects have resulted from poor ocean conditions associated with the Blob and subsequent positive PDO temperature patterns: in 2015, the California squid fishery shifted north to Monterey Bay and more northern ports and in 2016, squid were harvested and marketed off Oregon. In 2015 the whiting fishery in the northern California Current was among the worst on record and there are no signs of improvement in 2016. The Dungeness crab fishery (which is the most highly valued fishery in the Pacific Northwest) was closed in Washington and Oregon for 1½ months due to contamination by domoic acid caused by a harmful algal bloom (of the diatom *Pseudonitzschia*); the fishery remained closed for much of California through 2015. The pink shrimp harvest in 2015 was below average and in 2016, few large (marketable) shrimp are being found.

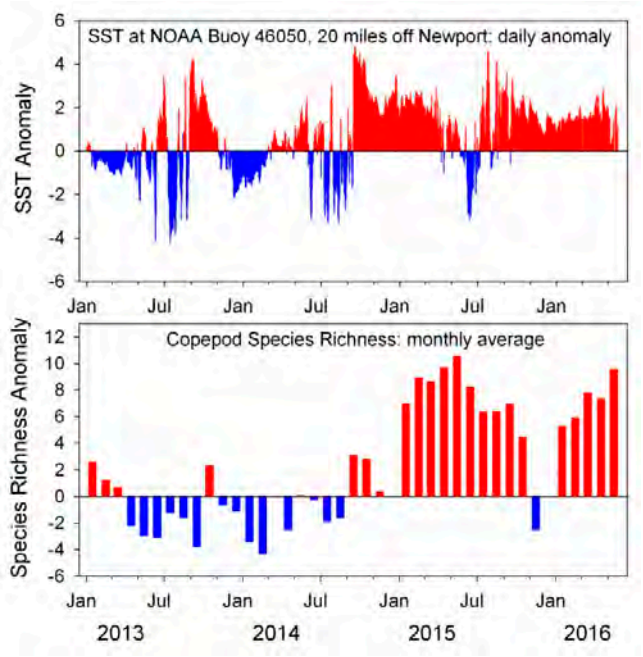

Fig. 2 Top: sea surface temperatures at a buoy 20 miles (32 km) off Newport, Oregon (44.6°N); bottom: copepod species richness anomaly at a long-term monitoring station located 5 miles (9 km) off Newport. Species richness values in 2015/16 are nearly double the values during previous El Niño/warm water events (1998, 2003–2006 and 2010). To view the entire 20-year time series of copepod species richness see PICES Press 24(1): 46–48.

The salmon harvest has suffered as well: coho salmon returns to the Puget Sound, Washington, and the coastal waters off Washington and Oregon were among the lowest on record, and most fish were significantly smaller than average. Sockeye salmon returns to Alaskan rivers were of average numbers but fish were about half the size as 'normal'. Similarly the runs to the Fraser River also declined. Oddly, a near-record number of adult sockeye returned to the Columbia River but once they neared Bonneville Dam (approximately 120 miles (193 km) upstream from the ocean), the mortality of adults increased dramatically due to extraordinarily high river temperatures: water temperatures were + 2°C warmer than at any past year. Adult salmon of all species returning to spawn in 2016 (and 2017) are not expected to do well either.

Hundreds of anecdotal observations of unusual reptile, fish, bird and mammal species were reported in the media (and can be found quickly through a web search) but perhaps the two most unusual records were of seven swordfish caught in a trawl off Newport in summer 2015, and the report of a yellow-bellied sea snake off Newport, in August 2015. This latter observation is significant because it places the sea snake on the order of 25 degrees of latitude north of its 'usual' range.

Finally, the PDO remains in a strongly positive phase and will almost certainly remain in a positive phase through the summer of 2016, given the anomalously high heat content of the eastern North Pacific (Fig. 3). Current simulations from a variety of climate models used for seasonal weather prediction are indicating that the waters along the west coast of North America will remain warm through 2016 even as a moderate La Niña develops, which is a rather unusual situation. Past research (Peterson *et al*. 2014; Fisher *et al*. 2015) has established that the lower trophic levels (copepods) will not transition to a cold water (and lipid-rich) community until 4–6 months after the PDO has changed to a negative phase. Thus, if the PDO remains positive through September 2016, we do not expect the return of lipid-rich food and favorable feeding conditions for pelagic fish until spring 2017 at the earliest. If the positive PDO persists through the winter of 2016/17, improvements in ocean conditions may not be seen until late 2017 or 2018.

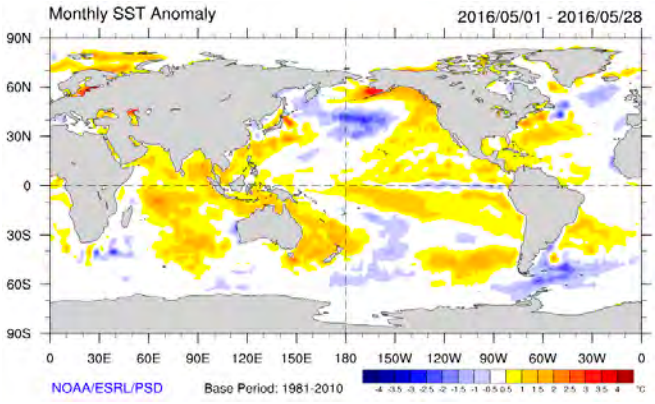

Fig. 3 SST anomaly for May 2016 illustrating a strongly positive PDO pattern.

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(Continued on page 50)

The state of the western North Pacific during the 2015/2016 cold season

by Takashi Yoshida

The western North Pacific during the 2015/2016 cold season was characterized by persistent above-average sea surface temperatures (SSTs) around 30°N (Fig. 1). A positive anomaly developed in December 2015 and persisted during the season.

The winter maximum sea ice extent in the Sea of Okhotsk was 1.16 million km^2 in late February, which was almost the same as the 30-year average of 1.17 million km^2. The seasonal maximum exhibits a long-term downward trend of 0.067 million km^2 per decade, which corresponds to 4.3% of the Sea of Okhotsk's total area (Figs. 2 and 3).

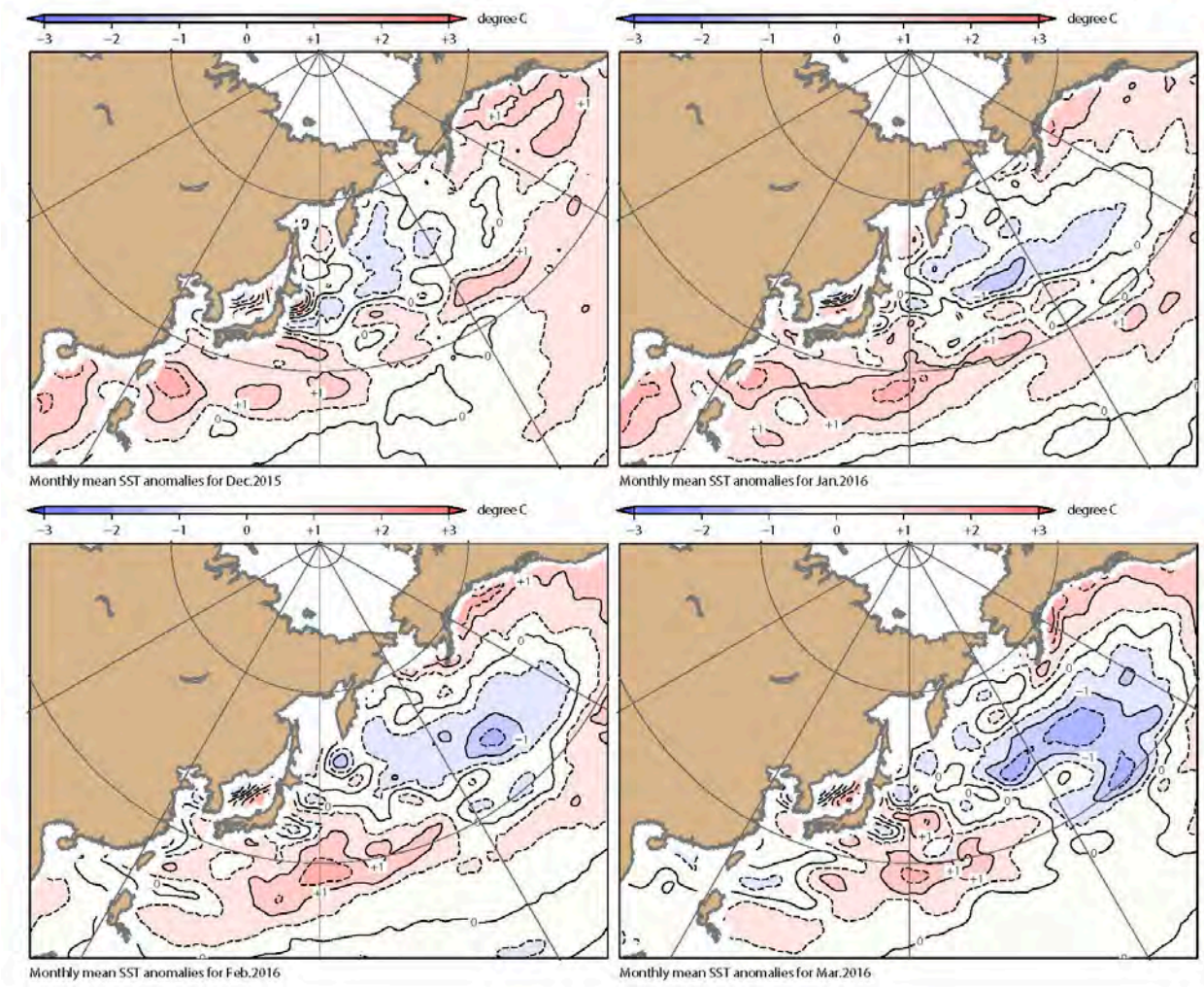

Fig. 1 Monthly mean sea surface temperature anomalies for December 2015 and January, February and March 2016. Monthly mean SSTs are based on JMA's COBE-SST (Centennial in situ Observation-Based Estimates of variability of SST and marine meteorological variables). Anomalies are deviations from the 1981–2010 climatology.

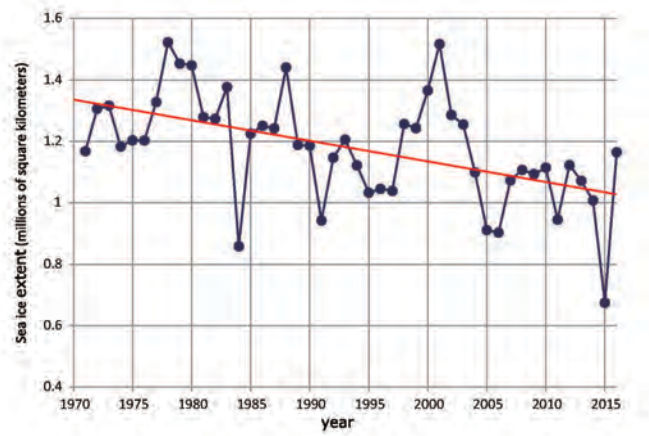

Fig. 2 Time-series representation of winter maximum sea ice extent values in the Sea of Okhotsk from 1971 to 2016. The red line represents the long-term linear trend.

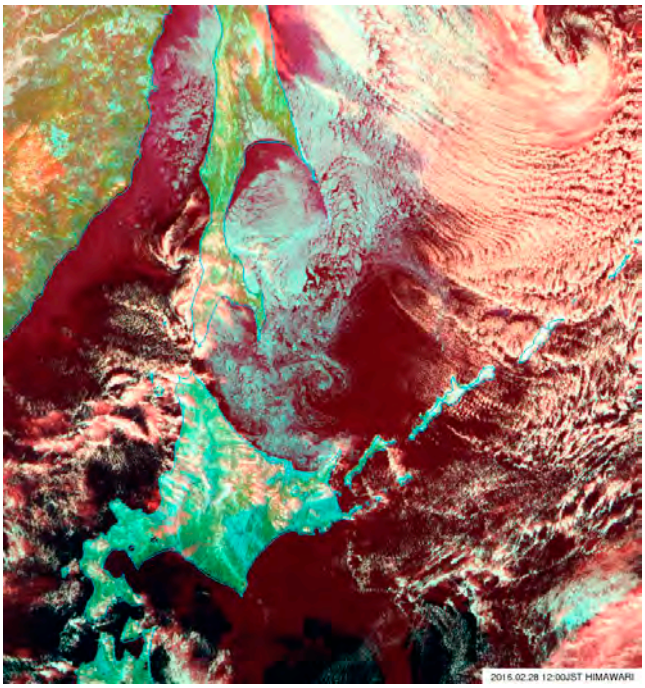

Fig. 3 Satellite image of sea ice in the southern part of the Sea of Okhotsk on February 28, 2016 captured by Himawari-8 geostationary meteorological satellite.

The Japan Meteorological Agency (JMA) has conducted oceanographic observations in the western North Pacific for more than 40 years to monitor the long-term variability of ocean-related changes. This work includes monitoring to highlight long-term trends of oceanic/atmospheric CO_2 concentrations and to determine pH in surface seawater from 3°N to 34°N along JMA's repeat hydrographic line at 137°E and 165°E. The record shows that mean growth rates for oceanic and atmospheric CO_2 concentrations along 137°E and 165°E in winter are 1.6–1.9 ppm/year and 1.8–2.0 ppm/year, respectively (Fig. 4).

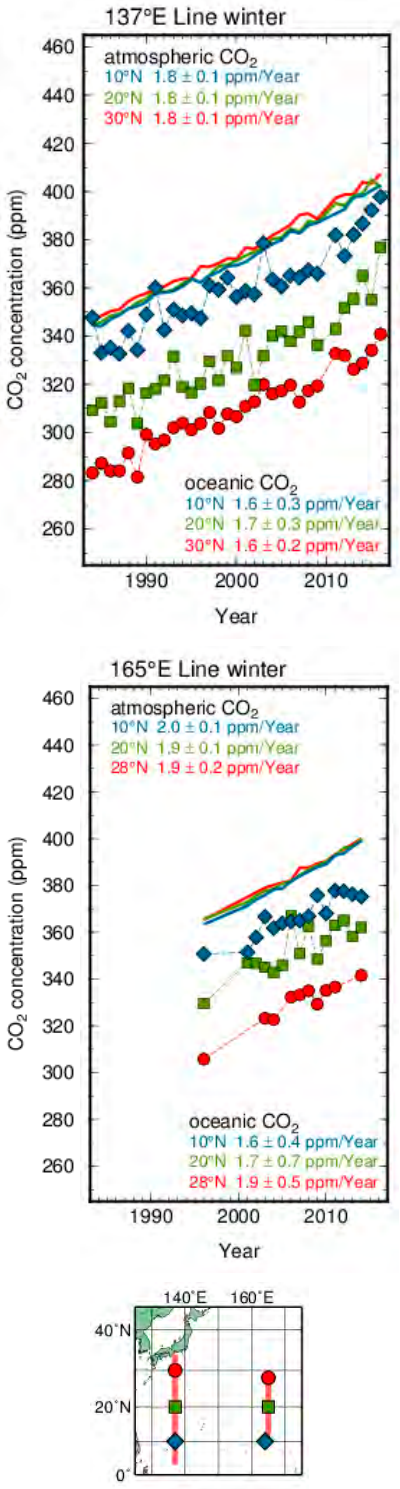

Fig. 4 Annual changes in oceanic (symbol and dashed-line) and atmospheric (solid line) CO_2 concentrations. Top panel: CO_2 concentrations at 10, 20, 30°N along 137°E. Middle panel: CO_2 concentrations at 10, 20, 28°N along 165°E. Bottom panel: JMA's repeat hydrographic line at 137°E and 165°E. The numbers in the figure indicate the rate of change with a 95% confidence interval.

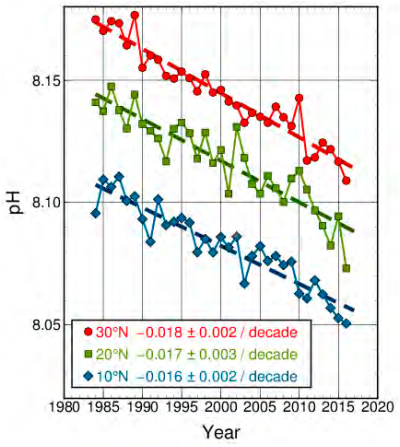

Fig. 5 Long-term trends of pH at 10, 20 and 30°N along 137°E. The numbers in the figure indicate the rate of change with a 95% confidence interval.

Values of pH in surface seawater show a clear long-term trend of decrease at rates of approximately 0.01 to 0.02 per decade at 10°N, 20°N and 30°N along 137°E in winter (Fig. 5).

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

(Continued from page 47)



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

Dr. Nicholas (Nick) Bond (nicholas.bond@noaa.gov) is a principal research scientist with the Joint Institute for the Study of the Atmosphere and Ocean (JISAO) of the University of Washington (UW) and also holds an appointment as an affiliate Associate Professor with the Department of Atmospheric Sciences at the UW. He is the State Climatologist for Washington. His research is on a broad range of topics with a focus on the weather and climate of the Pacific Northwest and the linkages between the climate and marine ecosystems of the North Pacific. He cheerfully admits to being a weather geek. He is the Chair of the PICES Study Group on Climate and Ecosystem Predictability.

Marie Robert (marie.robert@dfo-mpo.gc.ca) is a physical oceanographer with the Institute of Ocean Sciences of Fisheries and Oceans Canada, as well as coordinator of the Line P program. She leads each of the three cruises per year, and has responsibility for the products and future research of this program. Line P received the PICES Ocean Monitoring Service Award (POMA) in October 2010.

The Bering Sea: Current status and recent trends

by Lisa Eisner

Climate and oceanography

Unusually warm conditions prevailed on the eastern Bering Sea shelf from October 2015 through March 2016. This is illustrated with a time series of air temperatures at St. Paul (Fig. 1), which shows extended periods of above-normal temperatures interspersed with short periods of slightly to moderately below-normal temperatures. For virtually all of Alaska, it was the warmest October through March period in a historical record extending back to 1925. The Bristol Bay region, in particular, experienced air temperatures greater than 6° C above normal.

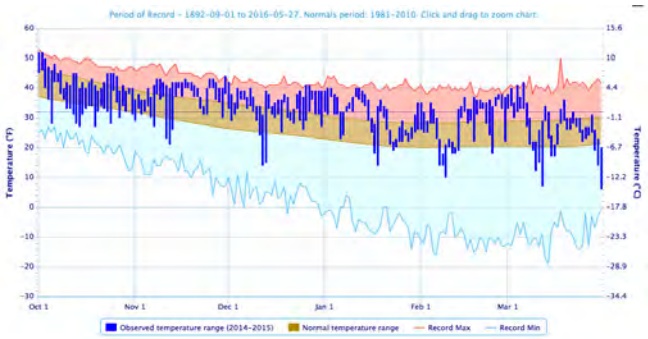

Fig. 1 Daily temperatures at St. Paul, Alaska (PASN) for October 2015 through March 2016. The blue bars indicate the range between minimum and maximum temperatures; the daily average and record minimum and maximum temperatures are also indicated. Figure courtesy of Dr. Nick Bond, PMEL.

The warm weather can be attributed to two factors: (1) relatively warm water on the Bering Sea shelf going into the cold season of 2015/16 and (2) a relatively high frequency of air masses of maritime rather than of continental or arctic origin. The latter situation is often associated with anomalously low sea level pressure (SLP) over the eastern Bering Sea, as was the case for the period of October 2015 through March 2016 (Fig. 2). This SLP distribution implies stormier than normal conditions for the southeastern Bering Sea shelf in an overall sense. In more quantitative terms, the mean wind speeds at St. Paul for the period were about 16% higher than normal (not shown). November 2015 was an especially stormy month. As mentioned in the previous edition of PICES Press (pp. 42–45, Vol. 24, No. 1), a strong El Niño developed in 2015. The deeper than normal Aleutian low that occurred during the winter of 2015/16 is consistent with that which has occurred with past El Niños. On the other hand, the greatest SLP anomaly is usually located southeast of the Alaska Peninsula rather than over the southeastern Bering Sea shelf, as observed in 2015/16.

The consensus of the climate models used for seasonal weather predictions is that a La Niña of moderate intensity will develop during the summer of 2016. While La Niña corresponds with cooler than normal temperatures for Alaska, the climate models are unanimous in projecting the maintenance of positive ocean temperature anomalies on the eastern Bering Sea shelf through the remainder of 2016, with lesser anomalies and greater uncertainty for the western Bering Sea.

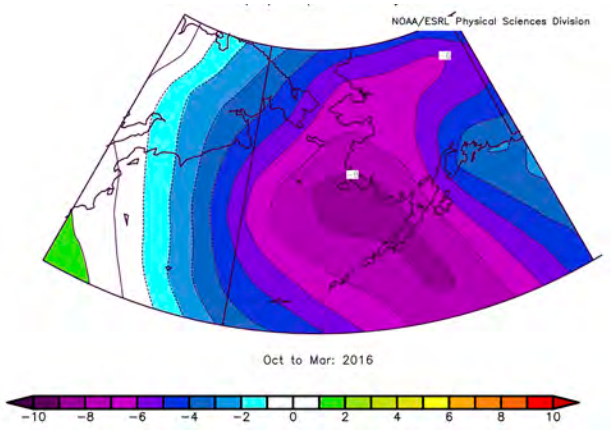

Fig. 2 NOAA mean sea level pressure (mb) anomaly (deviations from 1981–2010 climatology) for October 2015 to March 2016. Figure courtesy of Dr. Nick Bond, PMEL.

On the western Bering Sea shelf in summer 2015, the temperature was abnormally high in the entire water column, and the "cold pool" in bottom waters almost disappeared (Figs. 3 and 4). Cyclonic activity strengthened over the Russian Far-Eastern seas in autumn of 2015 that favored heat advection in the northern areas (Bering Sea). The winter of 2015/16 was relatively warm, but not as warm as the previous winter (Information obtained from the Russian national report to Advisory Panel for a *CREAMS/PICES Program in East Asian Marginal Seas*, 2016, unpublished).

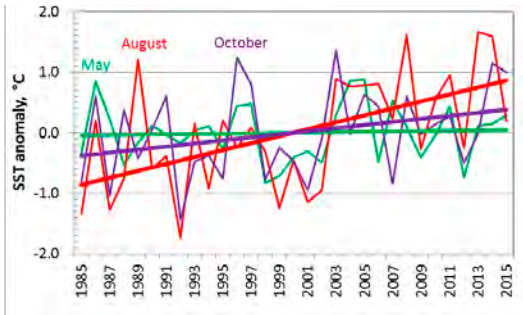

Fig. 3 Year-to-year SST fluctuations in the northwestern Bering Sea in May, August and October and SST trends in the same months (same colors). Trend inclination is highest for August. Figure courtesy of Dr. Gennady Khen, TINRO-Center, Russia.

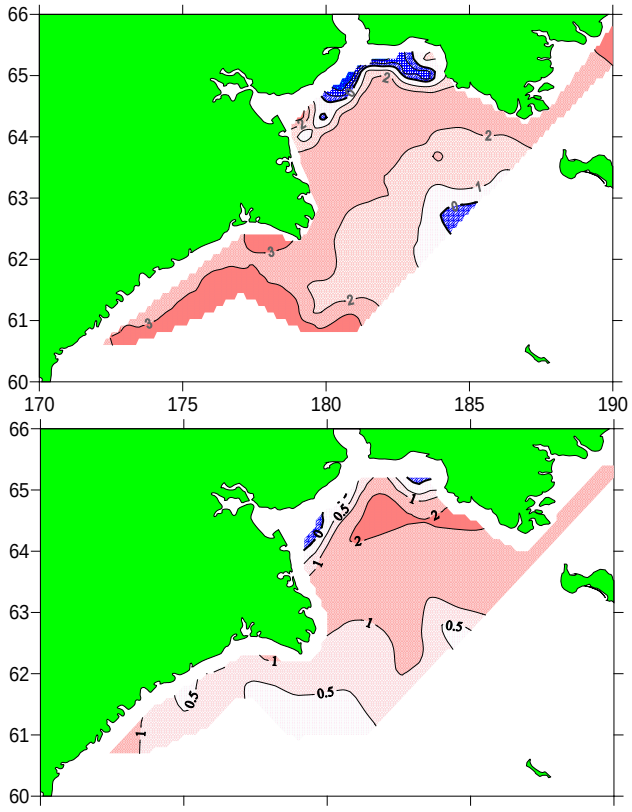

Fig. 4 Temperature at the bottom of the Anadyr Bay in summer 2015 (top panel) and its anomaly (bottom panel) (RV TINRO). Figure courtesy of Dr. Alexander Figurkin, TINRO-Center, Russia.

Ice seal survey

NOAA's Marine Mammal Laboratory's (MML) Polar Ecosystems Program (PEP) conducted an ice-seal research cruise in the central Bering Sea this spring (April 2–29, 2016) aboard the NOAA Ship *Oscar Dyson*. One of the primary objectives for the cruise was to deploy satellite-linked data recorders (SDRs) on ribbon and spotted seals; these seals are closely associated with sea ice during this time of year. The data collected by the SDRs, together with information collected during similar cruises since 2005, will provide information on the timing of hauling out (critical for calculating abundance estimates from aerial surveys), and dive behavior and seasonal movements (useful in identifying important habitat).

In all, scientists captured and sampled 13 spotted seals (2 adult males, 4 mother pup pairs, and 3 pups) and 10 ribbon seals (1 adult male, 1 adult female, 2 sub-adult males, 1 sub-adult female, 2 mother pup pairs and 1 pup). Seals were captured on ice floes with hand-held landing nets (Fig. 5a). In addition to instrumenting seals with SDRs (Fig. 5b, c), scientists also measured each seal (*i.e.*, length, girth and mass; Fig. 5d), and collected numerous tissue and fecal samples for studies of pathology, genetic population structure, blood chemistry, diet, contaminants, health, and condition. Many of the seals sampled were mother-pup pairs, dependent pups, or recently weaned pups (Fig. 5e) — a primary focus of this cruise, which was timed to coincide with the whelping, nursing, and maturation of pups. These samples will begin to form a reference database that can be used to assess the future impacts of climate disruption and loss of sea ice.

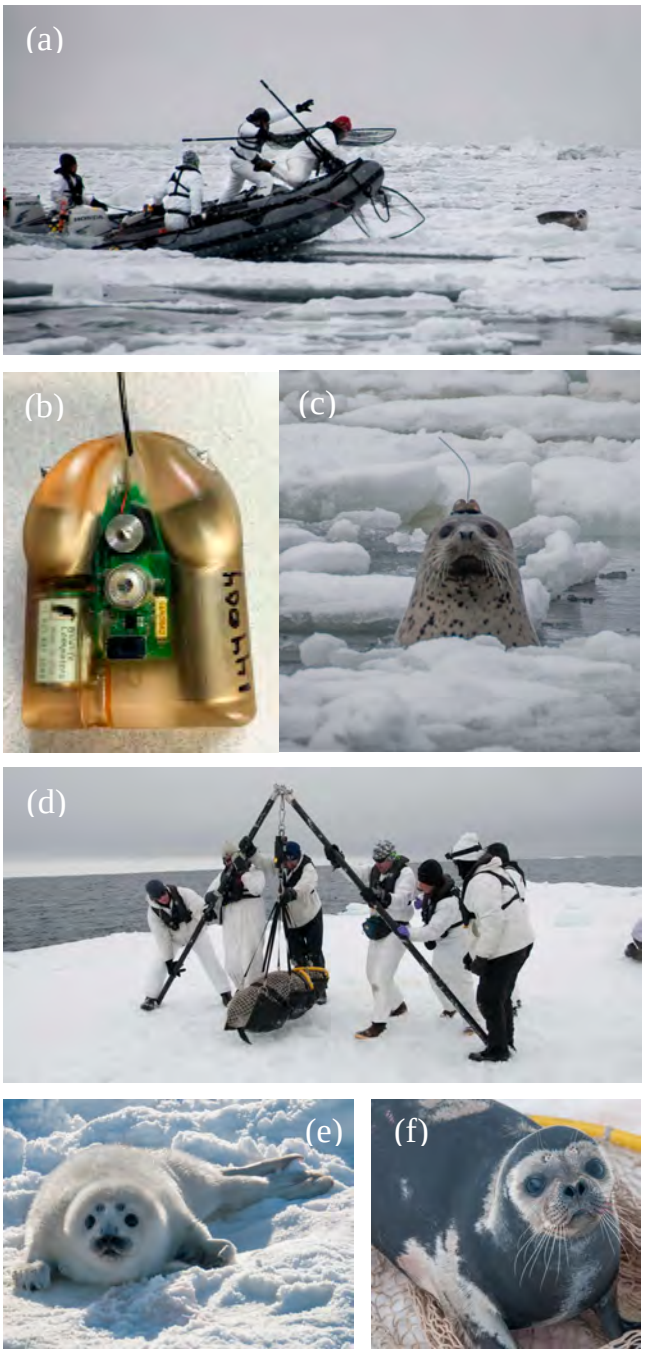

Fig. 5 (a) Preparing to capture a seal. (b) satellite-linked data recorder (SDR) on a spotted seal (c); (d) weighing a spotted sea, (e) ribbon seal pup, (f) young ribbon seal with large bald patches (dark colored areas). Photos by David Withrow, NOAA Fisheries. All research conducted and photos collected under the authority of MMPA Permit No. 19309.

Interestingly, all of the adult and sub-adult ribbon seals we captured this year have had skin lesions and/or bald patches (Fig. 5ft); one was almost entirely bald. It is possible that these seals are survivors of a significant disease outbreak in 2011. The tissue samples taken from these seals will help to answer that question.

High-resolution sampling in the eastern Bering Sea

This past May, the Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) group at NOAA Pacific Marine Environmental Laboratory (PMEL) completed field testing a newly acquired instrument, the Sea Sciences Acrobat (Fig. 6). Testing occurred during the spring 70-m isobath survey on the NOAA Ship *Oscar Dyson*. The Acrobat is a versatile and compact towed sampling platform equipped with a CTD, chlorophyll *a* fluorometer, scatterometer and nitrate sensor. The Acrobat makes high-resolution observations of the upper ocean, showing small-scale features that are not easily resolved with traditional shipboard sampling. Wings cause it to undulate from the surface down to 60 m making a complete vertical profile every 500–1000 m along track. Towed at 5–7 knots, it can cover more than 200 km in a day. Complementing the shipboard survey, the Acrobat was flown southward from the ice edge parallel to the 70-m isobath on the Bering Sea shelf (Fig. 7 top). The 45-km long section revealed a complex hydrographic structure near St. Matthew's Island: layers of surface meltwater, deeper winter water formed in autumn, and narrow, turbid intrusions of warm, salty water that likely formed on the flanks of the island (Fig. 7 bottom). The spring surface phytoplankton bloom was also captured, along with thin subsurface phytoplankton layers. The EcoFOCI group is already planning future deployments of the Acrobat, expanding their capability to monitor the physical, chemical and biological properties on the Bering Sea shelf.

Fig. 6 Acrobat retrieval from the stern of NOAA Ship Oscar Dyson. Photo by Lisa Eisner, NOAA Fisheries.

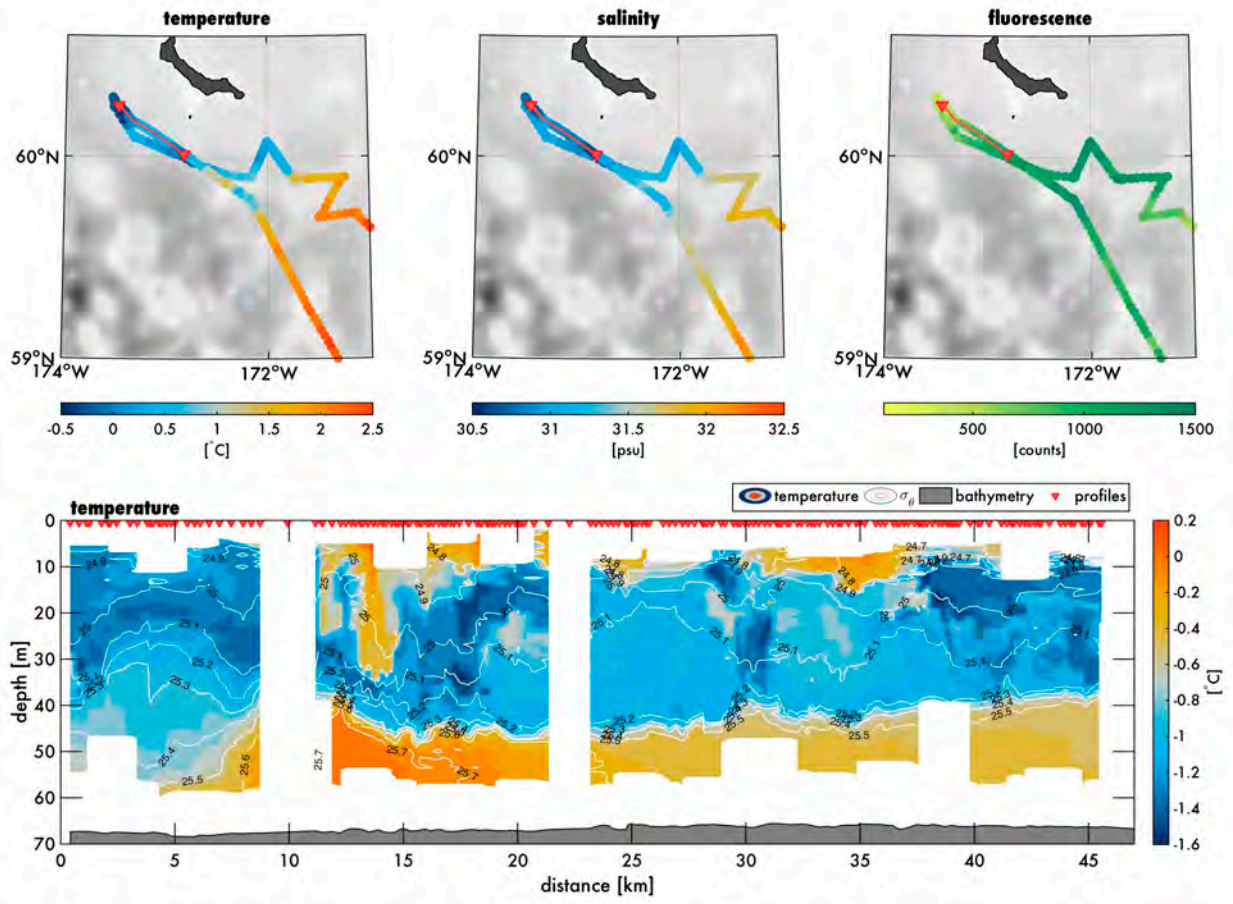

Fig. 7 Top: Surface shipboard along track data (temperature, salinity and chlorophyll a fluorescence) overlain by Acrobat track (in red); bottom: temperature slice overlain by density contours (sigma-theta) resolved from Acrobat profiles. Figure courtesy of Dr. Kim Martini, PMEL.

Upcoming or ongoing Bering Sea surveys

- Bottom-trawl groundfish and crab surveys, NOAA Alaska Fisheries Science Center (AFSC): **May 26 to August 3** aboard FVs *Alaska Night* and *Vesteraalen* (Annual Eastern Bering Sea Shelf Survey) and FV *Cape Flattery* (Biennial Upper Continental Slope Survey), **June 3 to August 12** aboard FVs *Alaska Provider* and *Sea Storm* (Biennial Aleutian Islands Survey) (Fig. 8);

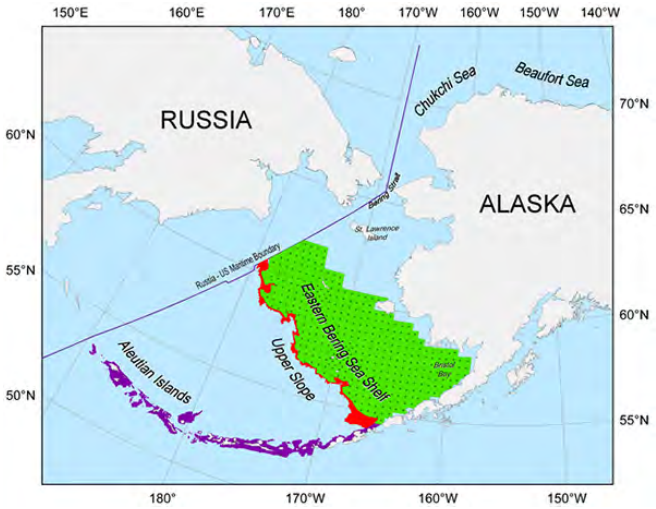

Fig. 8 Proposed areas for bottom-trawl surveys in the eastern Bering Sea and Aleutian Islands. Figure courtesy of Maggie Mooney-Seus, NOAA Fisheries.

- Biennial Acoustic-Trawl Survey for walleye pollock and euphausiids over the eastern Bering Sea shelf and Russian waters, **June 12 to August 17** aboard NOAA Ship *Oscar Dyson*. Participating Institutions include NOAA AFSC, Pacific Fisheries Research Institute (TINRO-Center), Stony Brook University, and the University of New Hampshire;
- Yukon Delta salmon studies, Emmonak, Alaska, NOAA AFSC, **May16 to July 31;**
- Pelagic fisheries, oceanography and zooplankton surveys: southeastern shelf, NOAA AFSC and PMEL, **August 22 to October 4** aboard NOAA Ship *Oscar Dyson*; northern shelf, NOAA AFSC, **August 23 to September 16** aboard the FV *Cape Flattery;*
- Distributed Biological Observatory (DBO) sites sampled for oceanography and zooplankton in the northern Bering Sea by NOAA AFSC in **September** on northern and southeastern pelagic fisheries and oceanography surveys (described above) and by Canada's Three Oceans in **July** aboard the RV *Sir Wilfred Laurier*. For details on DBO sites, see http://www.arctic.noaa.gov/dbo/

Upcoming Bering Sea meeting

PICES workshop (W9): "*The role of the northern Bering Sea in modulating arctic environments: towards international interdisciplinary efforts*", PICES-2016, November 3, 2016, San Diego, California.

Acknowledgements: Many thanks to the scientists who helped create this report: Dr. Nicholas Bond, Dr. Kim Martini, and Dr. Sue Moore at NOAA, PMEL; Dr. Michael Cameron and Maggie Mooney-Seus at NOAA, AFSC; Dr. Yury Zuenko at TINRO-Center.

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PICES Press
Produced and published by the PICES Secretariat
P.O. Box 6000
9860 West Saanich Road
Sidney, British Columbia V8L 4B2, Canada
E-mail: secretariat@pices.int
www.pices.int