

## 2019 Inter-sessional Science Board Meeting: Notes from the Science Board Chair

Six months after the PICES 2018 Annual Meeting was held in Yokohama, the members of PICES Science Board returned to the city for the 17th inter-sessional meeting (ISB-2019; from April 18–20, 2019). It was too late in spring for the famous cherry blossom season, but the SB members were refreshed by pleasant spring breezes after their flights to Japan and enjoyed the atmosphere of Yokohama covered by fresh greenery and flowers. Dr. Hiroaki Saito, Science Board Chair, declared the opening of ISB-2019 with a welcome speech to the members and guests and acknowledgment for the warm hospitality of the local organizers, Fisheries Agency and Japan Fisheries Research and Education Agency. SB also welcomed new members, SB Chair-elect, Dr. Vera Trainer, and MEQ Committee Chair, Dr. Guangshui Na. Dr. Mitsutaku Makino, Vice-Chair of the Human Dimensions Committee, attended on behalf of HD Chair Dr. Keith Criddle. MONITOR Committee Chair, Dr. Jennifer Boldt, attended through video conferencing.

At meeting the Chairs of the five Science and two Technical Committees reported on progress and planned activities of their respective expert groups since PICES-2018. The Marine Environmental Quality (MEQ) Committee reported the status of the recently formed Working Group on *Indicators of Marine Plastic Pollution* (WG 42). Plastic pollution has emerged as a major environmental concern all over the world and timely preparation of scientific knowledge is needed before society can tackle this issue. In PICES-2019, the WG will hold a topic session on plastic pollution in collaboration with the United Nations Environment Programme

Northwest Pacific Action Plan (UNEP NOWPAP). WG 42 is being led by Co-Chairs, Dr. Chengjun Sun (China) and Dr. Jennifer Lynch (USA).

In conjunction with ISB-2019, two other PICES expert groups held meetings in Yokohama. One was the FUTURE Program Scientific Steering Committee (FUTURE SSC; Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems), which met prior to ISB-2019, on April 15–17. As a high priority activity of PICES, the FUTURE SSC has met inter-sessionally for the past four years as well as during PICES Annual Meetings in order to maintain momentum of this key activity. Major items discussed or undertaken at the meeting were: 1) the status of a FUTURE review paper which focuses on a Social-Ecological-Environmental System (SEES) framework that enhances an understanding



*Spring blooms in Yokohama.*

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ISB-2019 in session.

of processes ranging from climate through ecosystems to human societies (submitted to *Frontiers in Marine Science*), 2) how to give this flagship program more prominence on the [PICES website](#), 3) the creation of a short video describing the goals and approaches being used by FUTURE, also to be featured on the website, and 4) how should PICES and FUTURE collaborate with other organizations on delivering useful information about the North Pacific for the United Nations Decade of Ocean Science for Sustainable Development (see page 24). More details on each of these can be found in the article by the FUTURE Co-Chairs on page 5.

The second expert group, Working Group on the third *North Pacific Ecosystem Status Report* (WG 35/WG-NPESR3), met from April 18–21. WG-NPESR3 was established in 2016 for the purpose of collecting and synthesizing 14 regional environmental time series observations (ETSOs) in the North Pacific for publication in a new web-based format (as opposed to the previous two NPESRs which were in book form). The synthesis will cover the time period from 2009–2016 (give or take). At the request of Science Board, the Co-Chairs of the WG (Mr. Peter Chandler (Canada) and Dr. Sinjae Yoo (Korea)) were able to take a brief time away from their meeting (as both meetings were going on at the same time) to give a real-time report on the status of the ETSO collections and progress on drafting a synthesis paper, and web-based 14 individual regional chapters, a climate chapter, and a human dimensions chapter. Last year, an Editorial Board of eight PICES scientists not involved in the drafting of the NPESR documents was established to provide review and feedback on the synthesis publication and regional chapters of NPESR. Progress has been made on most of the chapters, but the results will not be available until the PICES-2019 meeting or shortly thereafter. Publication of NPESR3 may be useful for scientists and decision makers both inside and outside of PICES to understand the status and trend of the North Pacific marine ecosystem. It may also be very relevant to activities of the UN Ocean Decade program.

In 2016, the United Nations proclaimed a Decade of Ocean Science for Sustainable Development (2021–2030). It is now in its preparation phase (2018–2020) to design the scientific and public activities led by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. We believe that PICES is a key scientific organization that will collaborate with the IOC to contribute to the Ocean Decade. Science Board clearly shared consensus that the Ocean Decade is a great opportunity for marine scientists to do science and contribute to society by disseminating scientific knowledge about the Pacific Ocean. PICES will contribute to the Ocean Decade through PICES Annual Meetings, symposia, publications, capacity building and public events. IOC-UNESCO and PICES will co-sponsor a Regional Planning Workshop (July 31–August 2, 2019) in Tokyo. PICES is contributing to this workshop by identifying key PICES scientists to co-convene specific theme topics and by supporting the travel of these leaders and other participants to the [meeting](#). Based on the report from the FUTURE SSC, Science Board recognized that one of the potential contributions to the Ocean Decade by PICES could be through its FUTURE program, or the subsequent integrated science program after FUTURE ends. Science Board will revisit how to effectively collaborate with IOC on Pacific Ocean issues of the Ocean Decade at PICES-2019.

PICES science interests have expanded in recent years. A relatively new Human Dimensions Committee (initiated in 2016) links natural science and social issues, and the number of social scientists attending PICES Annual Meetings is increasing year over year. A new Study Group on *Impacts of Mariculture on Coastal Ecosystems* (SG-IMCE, 2018) is expected to reactivate significant new scientific activity related to aquaculture, which is important for food supply, marine ecosystems and marine planning. Recent collaborations with international organization such as ICES and several RFMOs (Regional Fisheries Management Organizations) has led PICES to establish joint expert groups such as the Section on *Climate Change Effects on Marine Ecosystems* (S-CCME; with ICES) WG 34 on *Ocean Conditions and the Distribution and Productivity of Highly Migratory Fish* (with ISC), WG 39 on *an Integrated Ecosystem Assessment for the Central Arctic Ocean* (with PAME and ICES), and WG 40 on *Climate and Ecosystem Predictability* (in collaboration with CLIVAR), and. As a result, the number of topic sessions and workshops to be held at PICES Annual Meetings is increasing as are also the number of business meetings. At PICES-2019, we will have 20 topic sessions during the Monday-to-Friday (October 21–25) main meeting, and 19 workshops and 28 business meetings earlier (October 16–20)! It will be the busiest Annual Meeting PICES has experienced. It is a gratifying situation because it means that PICES is examining issues of interest to the community. On the other hand, the rapid expansion of sessions, workshops and business meetings at the Annual Meeting creates financial issues for members of the





Science Board meeting participants, back row, from left: Joon-Soo Lee (TCODE), Motomitsu Takahashi (representing Japan), Sukyung Kang (FUTURE SSC), Harold (Hal) Batchelder (Deputy Executive Secretary), Steven Bograd (FUTURE SSC), Xianshi Jin (FIS), Mitsutaku Makino (HD), Igor Shevchenko (representing Russia), Emanuele di Lorenzo (POC); front row, from left: Jennifer Boldt (MONITOR) participating via WebEx, Saeseul Kim (observer, Korea), Chul Park (PICES Chair), Vera Trainer (Science Board Chair-elect), Hiroaki Saito (Science Board Chair), Carmel Lowe (Governing Council, Canada), Se-Jong Ju (BIO), Guangshui Na (MEQ).

Contracting Parties, and restricts the amount of travel funding available to support invited speakers and early career scientists. Also, the longer duration of the Annual Meeting may mean that many scientists can only attend a subset of the full meeting. In recent years, we have received feedback from attendees that the meeting is too long and the schedule is too full (*i.e.*, too many concurrent sessions). It is unfortunate if a scientist has to miss the opportunity to share ideas with others because they are attending another concurrent session. This year was a challenge to fit all of the activities into the main portion of the schedule. Science Board will discuss this issue on how many topic sessions and workshops can reasonably be accommodated in the schedule for future years.

Recruitment of early career scientists into PICES is essential for the progress of the Organization. Since its establishment, PICES has encouraged early career scientists and students to participate in PICES Annual Meetings by providing travel support, early career scientist awards, internship, *etc.* Activities such as training courses and summer schools are high priority items of PICES capacity building (CB). The Working Group (WG 37) on *Zooplankton Production Methodologies, Applications and Measurements in PICES Regions* held a practical workshop in 2018 in collaboration with Yokohama National University, Japan, and is planning a Phase II practical workshop at the Hakai Institute (Canada) just before PICES-2019. WG 37 is also collaborating with the Advisory Panel on *North Pacific Coastal Ocean Observing Systems* to provide a spring training course at Kagoshima University, Japan, in 2020. It was rewarding to Science Board to hear such positive and enthusiastic comments from the trainees of the practical course held in 2018. Science Board acknowledges and thanks WG 37 and volunteer lecturers of the past CB activity and future one. It is my hope that CB trainees become more interested in

marine sciences and regard PICES as a useful organization to develop their career.

As mentioned at the beginning of this article, Dr. Boldt of the MONITOR Committee participated throughout the 3-day Science Board meeting via the internet from British Columbia, Canada, even though there was a 16 hour time-difference. This is only one of many examples of the enthusiastic dedication of the Science Board members. As Science Board Chair, I sincerely acknowledge their tremendous efforts, dedication and contribution to steering PICES science activities.

The next PICES Annual Meeting (PICES-2019, October 16–27) will return to Victoria, British Columbia, Canada, the place where the first Annual Meeting was held, in 1992. The theme is *Connecting Science and Communities in the Changing North Pacific*. PICES-2019 will focus on the effect of human activities have on the North Pacific marine ecosystem and the contribution of science to society through effective communication to the public. We anticipate excellent presentations and posters, exciting discussions and also beautiful autumn scenery of Vancouver Island. I am looking forward to seeing all of you in Victoria!



Hiroaki Saito  
Science Board Chair

## 2019 Pacific Ecology and Evolution Conference

by Kat Nikolich

Thanks to the generosity of our sponsors, the 40<sup>th</sup> Annual Pacific Ecology and Evolution Conference (PEEC 2019) was able to bring together over 80 undergraduate and graduate students from 12 different universities and institutions across Canada. The event took place at the Bamfield Marine Sciences Centre (BMSC), against a stunning backdrop of the wild and remote town of Bamfield, BC. After gathering in Port Alberni and riding aboard the historic MV *Frances Barkley* to Bamfield, attendees and guests were put up in style and fed hearty meals by our hosts at BMSC. The conference officially began with a warm welcome by Huu-ay-aht First Nation elder Robert Dennis, and ended with a keynote address by the University of Victoria's Dr. Natalie Ban on the importance of people in ecological research. The conference featured 69 submitted talks from students and post-docs, including formal twelve-minute talks, three-minute speed talks, and posters.



Students browsing posters, discussing research, and taking a breather at the casual evening poster reception. Everything is made slightly quirkier by the no-shoes-inside rule in the Rix Centre.

Oral presentations were grouped into six themes:

- 1) **Marine Ecology**, in which presenters focused mainly on issues of marine habitat quality and spatial subsidies in a variety of environments from tropical reefs to west coast mudflats.
- 2) **Animal Behaviour**, which spanned life history traits and taxa from reproductive behaviour in fish to calling behaviour in whales to grazing behaviour in snails.
- 3) **Organismal Biology, Physiology, & Evolution**, in which presenters worked to link traits in marine animals and plants to their evolutionary and biological functions.
- 4) **Fisheries & Aquaculture**, representing work in wild-catch fisheries, shellfish aquaculture, and historical fishery management techniques.

- 5) **Terrestrial Ecology**, where the non-marine species had their time! Presenters spoke on a variety of taxa including reptiles, amphibians, mammals, and birds.
- 6) **Salmon Biology**, in which students working on one of the hottest topics in west coast marine ecology discussed acoustics and disease in relation to wild salmon populations in BC.



(Top) Students so enraptured by Elder Robert Dennis' territory welcome that they're ignoring the stunning west-facing view from the windows of BMSC's Rix Centre. (Bottom) BMSC staff members let students in on the technicalities, tricks, and foibles of running a field research station at the Supporting Research: the Faces Behind Your Paperwork panel.

As a Gold-level Sponsor of PEEC 2019, PICES was recognized as a host of the evening poster reception, which is a chance to debrief from the day of talks and network informally while engaging with poster presenters. Other highlights of the conference included workshops presented by Dr. Mauricio Carrasquilla from Ocean Networks Canada (ONC), in which students learned how to utilize ONC's open-access database, and a panel discussion by BMSC

(continued on page 6)



## Highlights from the FUTURE SSC's 5<sup>th</sup> inter-sessional meeting

by Steven Bograd and Sukyung Kang

The FUTURE Scientific Steering Committee (SSC) held its 5<sup>th</sup> inter-sessional meeting since 2014. FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems) is PICES' second integrative science program, which was launched at PICES-2009. This year's meeting took place April 15–17, 2019 in Yokohama, Japan. The 3-day affair was led by Steven Bograd and Sukyung Kang who are the Co-Chairs of the FUTURE SSC. The meeting was attended by 10 SSC members, with another member calling in, and two representatives from the PICES Secretariat.



Participants of the 5<sup>th</sup> inter-sessional meeting of the FUTURE Scientific Steering Committee, April 2018 in Yokohama, Japan. Back row, from left: Emanuele Di Lorenzo (USA), Steven Bograd (FUTURE SSC Co-Chair/USA), Thomas Therriault (Canada), Mitsutaku Makino (Japan), Harold (Hal) Batchelder (PICES Deputy Executive Secretary), Sinjae Yoo (Korea), Hiroaki Saito (Science Board Chair), Vyacheslav Lobanov (Russia). Front row, from left: Ryan Rykaczewski (USA), Ian Perry (Canada), Sukyung Kang (FUTURE SSC Co-Chair/Korea), Guangshui Na (China).

### Review of 2018-19 activities

The first task of the SSC was to review our activities since our last meeting at PICES-2018, which was also held in Yokohama, Japan. A key accomplishment of the past year was the completion of a synthesis paper that describes the Social-Ecological-Environmental (SEES) framework that the FUTURE SSC has implemented, and demonstrates the framework's utility by providing customized schematics and narrative outlines for four case studies: (a) species alternation in the western Pacific, (b) ecosystem impacts of an extreme warming event in the northeast Pacific, (c) jellyfish blooms in the western Pacific, and (d) warming and distributional shifts of migratory species in the North Pacific. The synthesis paper is currently under review in the journal *Frontiers of Marine Science* and is expected to be published this summer. The SSC also undertook a discussion

of additional case studies that reflect important issues in the North Pacific and that are amenable to our SEES framework. One potential case study is the investigation of basin-scale, extra-tropical impacts of the El Niño–Southern Oscillation, which would benefit from a joint collaboration amongst the working groups (WG) that FUTURE SSC parents or co-parents: WG 36 (*Common Ecosystem Reference Points across PICES Member Countries*), WG 40 (*Climate and Ecosystem Predictability*), and WG 41 (*Marine Ecosystem Services*).

Other FUTURE business included reviewing changes that have been implemented on the PICES website to improve communication and outreach on the FUTURE science program, and identifying additional material that should be posted, including a FUTURE video (see below).

### FUTURE outreach

A key task of our inter-sessional meeting was to develop outreach strategies for the FUTURE science program. The most important of these is the production of a video, which would have the SSC members describing the objectives and structure of FUTURE and the SEES framework it has implemented. SSC member Manu Di Lorenzo led the production of the video, which was completed at the meeting and will soon be available on the PICES website. As a further approach to outreach, the SSC prepared a two-page document describing the FUTURE program that will be printed in the PICES-2019 program book.



FUTURE SSC members filming the FUTURE video. Sukyung Kang's turn to be interviewed.

### FUTURE plans

An important part of the meeting was a broad discussion about the future of the FUTURE program and, more generally, integrative science within PICES. This discussion was motivated by a new Term of Reference that Science Board added for the FUTURE SSC at PICES-2018: 'Provide recommendations to Science Board on options for implementing PICES integrative science'. The general

consensus of the SSC was that, with the development of the SEES framework, FUTURE currently has momentum and is making significant progress towards its objectives. We felt that this was not a good time to initiate a new integrative science program, which would take significant time and effort to develop, but instead to maintain the FUTURE program, perhaps with some re-focusing to reflect new developments within the international marine science community. In particular, we envision a partnership between FUTURE, and PICES more generally, and the United Nations Sustainable Development Goals, with FUTURE providing leadership in implementing and coordinating activities of the UN Decade of the Ocean (2021-2030) in the North Pacific sector. In general, while it is critical for FUTURE to provide trans-disciplinary linkages and synthesis, it is important for PICES to maintain traditional disciplinary work. The SSC also discussed ways to

encourage more active engagement of early career scientists, including a competition to propose new SEES case studies, which would be rewarded with a travel grant to PICES-2020.

Finally, the FUTURE SSC prepared an Action Plan for the coming year, which includes: (a) finalizing and distributing a FUTURE Product Matrix; (b) facilitating new case study development with WGs-36, 40, and 41; (c) assuring the dissemination of FUTURE outreach products; (d) preparing an early career scientist proposal for implementation of the SEES framework; (e) participating in planning for the UN Decade of the Ocean; (f) revising the FUTURE Science Plan to reflect a focus on the SEES approach and engagement with the UN Sustainable Development Goals; (g) preparing for PICES-2019; and (e) planning for a proposed FUTURE Open Science Meeting to be held in 2021.



*Dr. Sukyung Kang (sukyungkang@korea.kr) is a Senior Scientist of the Fisheries Resources Management Division at the National Institute of Fisheries Science (NIFS) in Busan, Korea. After receiving her Ph.D. in fisheries oceanography from Pukyong National University in 2004, Sukyung began working in salmon research at NIFS. She currently works on the prediction of marine fisheries resources under climatic changes in Korean waters using ichthyoplankton and fishing data sets. Sukyung has been involved in several international organizations/projects besides PICES, such as NPAFC, Yellow Sea LME, and APEC. In PICES, she is a member of Science Board, Fishery Science Committee, and the Section Climate Change Effects on Marine Ecosystems. She co-chairs the FUTURE Scientific Steering Committee with Steven Bograd.*



*Dr. Steven Bograd (steven.bograd@noaa.gov) is a Physical Oceanographer at NOAA's Southwest Fisheries Science Center, Environmental Research Division, in Monterey, California. Steven is currently involved in a number of research projects studying climate variability and its impacts on the marine ecosystems of the North Pacific Ocean, and is Editor-in-Chief of Fisheries Oceanography. Steven has been active in PICES for many years, and is a member of Science Board, the Physical Oceanography Committee, and WG 35 on the Third North Pacific Ecosystem Status Report. He co-chairs the FUTURE Scientific Steering Committee with Sukyung Kang.*

*(continued from page 4)*

staff, who shared with students the work that goes into supporting researchers and science education (and also dispensed some amusing anecdotes of life in a remote community). In addition to the structured activities, this annual conference serves as a forum where students can

present and discuss their ideas with peers, meet future colleagues and collaborators, and reflect on their research in a casual, low-pressure setting. We were pleased to include PICES in our list of sponsors, and look forward to another successful conference next year.



*A group photo of all our attendees and guests right before boarding the ferry back to the 'real world' at the end of the weekend.*



*Kat Nikolich (katrinan@uvic.ca) is a PhD student in the Fisheries, Ecology and Marine Conservation Lab at the University of Victoria, supervised by Dr. Francis Juanes. Kat's research interests center around using bioacoustics and measurements of underwater sound as tools to answer important conservation questions. She is currently conducting her thesis research on the impacts of anthropogenic underwater noise on at-risk marine fish populations in Canada, including Pacific rockfish and Atlantic cod.*



## Working together at the 4<sup>th</sup> GOA-ON International Workshop

by Daniela Turk

### What is GOA-ON?

The Global Ocean Acidification Observing Network (GOA-ON; [www.goa-on.org](http://www.goa-on.org)) is an international collaborative effort to document the status and progress of ocean acidification (OA) in marine environments, to understand the drivers and impacts of OA on marine ecosystems, and to provide spatially and temporally resolved biogeochemical data necessary to optimize OA modelling. GOA-ON held its first workshop in 2012 and rapidly grew to a network of over 600 members from 94 countries. To facilitate coordination, collaboration, and sharing of OA monitoring expertise, the scientists have formed Regional Hubs in Latin America (LAOCA), the Mediterranean, North America, North East Atlantic, Africa, Pacific Islands and Territories, and Western Pacific. Recently, GOA-ON established an interactive data portal that provides locations of a wide range of observing platforms around the world (moorings, research cruises, and fixed time series stations) collecting OA variables, access to and visualization of OA data, and data synthesis products.

### Why is GOA-ON relevant to PICES?

GOA-ON is closely linked with other international research programs and intergovernmental organizations, e.g., Intergovernmental Oceanographic Commission of UNESCO (<http://www.ioc-unesco.org>), International Ocean Carbon Coordination Project (IOCCP; <http://www.ioccp.org>), and the International Atomic Energy Agency (IAEA) Ocean Acidification International Coordination Centre (OA-ICC; <https://www.iaea.org/services/oa-icc>). It addresses research topics and data that are of high interest and/or overlap with PICES research. Geographically, the implementation of activities in the area of the North Pacific is facilitated by two GOA-ON Regional Hubs: 1) North America Hub serving Canada, USA, and Mexico, and 2) Western Pacific Hub facilitated by the IOC Sub-Commission for the Western

Pacific (WESTPAC; <http://iocwestpac.org>). PICES scientists are involved in Regional Hubs and participate in joint events with co-sponsorship from PICES.

### The 4<sup>th</sup> GOA-ON International Workshop

From April 14–17, 2019, GOA-ON held its 4<sup>th</sup> International workshop in Hangzhou, China, one of the most renowned and prosperous cities in China, at the beautiful venue by West Lake, a UNESCO World Heritage site. The workshop was hosted by the State Key Laboratory of Satellite Ocean Environment Dynamics (SOED, <http://www.soed.org.cn>) and the Second Institute of Oceanography (SIO; <http://www.sio.org.cn>), Ministry of Natural Resources. It was co-chaired by Fei Chai (SIO, China and Univ. of Maine, USA), Jan Newton (Univ. of Washington, USA), and Minhan Dai (Xiamen Univ., China) and organized by a supreme team of organizers and volunteers led by Samuel Wang (SOED, China), with the support from session chairs, and program representatives Libby Jewett (NOAA), Kirsten Isensee and Katherina Schoo (IOC-UNESCO), Maciej Telszewski (GOOS), Kim Currie (IOCCP), and Lina Hansson and Marine Lebrec (IAEA/OA-ICC). PICES was one of the co-sponsors contributing to travel awards for participants.

*"We came to meet old friends and make new friends."*  
Fei Chai



Workshop co-chairs and organizers Fei Chai, Jan Newton, Samuel Wang, and Minhan Dai. Photo credit: GOA-ON2019.



Workshop participants. Photo credit: GOA-ON2019.

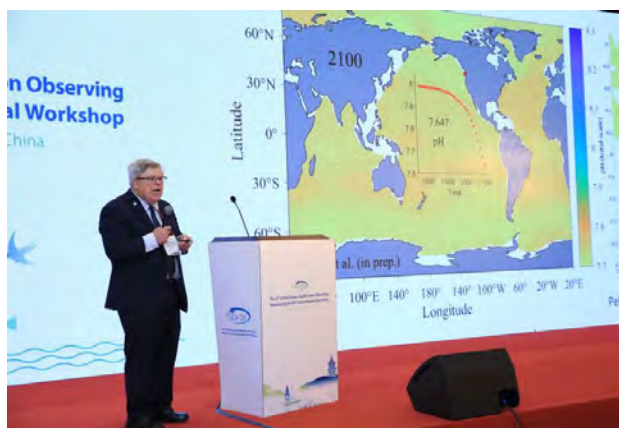
There were 270 participants at the workshop from 62 countries, including representatives from all PICES member countries discussing emerging research on OA. Thanks to the gracious support from sponsors, and GOA-ON vision and its efforts in capacity building, there was an impressive attendance by developing countries (*e.g.*, Brazil, Cameroon, Colombia, Ecuador, Egypt, Fiji, Lebanon, Mauritius, Philippines, and others) with appropriate gender balance and participation of early career scientists.

The workshop focused on four main themes:

- 1) Monitoring OA in multi-stressor environments,
- 2) Studying biological responses,
- 3) Advancing OA modelling,
- 4) Meeting the information needs of stakeholders.

These themes were addressed through three days of plenary talks, break-out presentations, discussions, and poster sessions. There were more than 90 oral presentations from the open and coastal ocean around the world. Only a few examples from each of the themes are mentioned here.

The *OA and multi-stressor* theme kicked off with a keynote talk by the world's top OA scientist and one of the GOA-ON founders, Richard Feely (USA). A tribute was given to his work and outstanding contributions to the field of OA. Some of the other presentations were very well received such as the presentation by Jianfang Chen (China) on enhanced hypoxia and OA off the Changjiang estuary, by Paula Judith Rojas-Higuera (Colombia) on OA and warming of the global ocean and Colombian coastal environment, and by Chen-Tung Arthur Chen (Chinese Taipei) on the sour and anoxic future of the Sea of Japan. These studies emphasized the importance and challenges of addressing the cumulative effect of multiple environmental stressors such as warming, deoxygenation, and pollution that have the potential to significantly modify the OA impact on marine ecosystems. The cumulative effects are often nonlinear, difficult to predict, and require integration of multidisciplinary data.



Keynote talk "Observing OA in open-ocean and coastal waters" by Richard Feely. Photo credit: GOA-ON2019.

Keynote speaker Dalin Shi (China) opened the *Biological responses* session and further suggested that recent manipulation experiments on both laboratory isolates and natural assemblages have already begun to reveal that multi-environmental stressors can considerably modulate the response of marine phytoplankton to OA, and such a response can be algal species-specific. In addition, Sam Dupont (Sweden) presented findings on the delayed development and change of sea urchin larvae morphology when exposed to OA, Nina Bednaršek (USA) showed that megalopae of the Dungeness crab are already dissolving under present-day natural pH gradients, and Carla Edworthy (South Africa) presented preliminary results that suggest the oxygen consumption of *Diplodus capensis*, a common coastal fish species, appeared to be unaffected by pH as low as 7.2 although the fish in the low pH treatment were less active. It is widely appreciated that understanding and predicting the net effect of multifaceted environmental changes on various marine ecosystems and organisms is still a challenge and should take into consideration regionally distinct multi-stressors in examining the impacts of OA.



Early career scientist Carla Edworthy (South Africa). Photo credit: GOA-ON2019.

In order to optimize computational models of OA, there is an urgent need to enhance such observational data on associated biogeochemistry and biology, particularly in the context of multiple stressors with a view to generating societally relevant forecasts and projections. The *OA modelling* session opened with a keynote talk by Andrew Lenton (Australia) focused on regional and global models of physical–biogeochemical coupling processes related to OA and associated ecosystem responses. Plenary speaker Samantha Siedlecki (USA) presented on a seasonal forecast of hypoxia and OA in Washington and Oregon waters, and Jianping Gan (Hong Kong, China) described a coupled physics–biogeochemistry modelling study in a multi-scale South China Sea system, followed by many other modelling presentations, posters, and discussions. The session emphasized the need to develop a world-wide predictive capability for ocean biogeochemistry and ecosystems on time scales ranging from days to seasons to decades to better monitor and forecast changes relevant to resource management and to assure their integration with data from ocean observing platforms.





Modellers Andrew Lenton (Australia) and Samantha Siedlecki (USA). Photo credit: GOA-ON2019.

The data and findings on OA and ecosystem responses from both observations and models ideally translate into *information to meet the needs of stakeholders*. This session, convened by Libby Jewett (USA) and Kirsten Isensee (France), discussed how such information is currently used and how GOA-ON might improve access to information and products needed by global-to-local decision makers, whether they be delegates to the UN Framework Convention on Climate Change (UNFCCC), the 2030 Agenda or oyster growers along the coast. Some of the examples included a keynote address delivered by Richard Bellerby (Norway/China), Tsuneo Ono's (Japan) presentation on a PICES Special Publication on OA and deoxygenation in the North Pacific Ocean, and Rueben Makomere's (Australia) report on multi-scale governance for regulating OA response strategies. I had great pleasure to present our recent study on the detection of long-term OA trends against background variability and to provide recommendations on how this information can help scientists and decision makers design and implement OA monitoring systems in the next decade. Three co-authors (Dwight Gledhill, Aleck Wang and Wei-Jun Cai (USA)) also attended and gave talks at the workshop.



Stakeholder Sheila Kong Mukwele (The Ministry of External Relations, Cameroon) addressing the involvement of regional diplomatic organizations in Africa. Photo credit: GOA-ON2019.

The workshop included a day with two special events, one of which was aimed at creating a dialogue between scientists and the aquaculture industry, and another one focused on the use of satellite remote sensing software (SatCO2).

#### ***A mini-workshop to improve industry–science responses to multi-stressors impacts on aquaculture***

Changing environmental conditions, such as decreasing seawater pH and dissolved oxygen, and increasing seawater temperature and harmful algae blooms (HABs) pose increasing threats to commercially exploited species with

potentially catastrophic losses to the aquaculture industry in the future. China accounts for nearly 70% of the world aquaculture production and has established various coastal observation and monitoring capabilities to gather environmental and biological data. However, application of this information to address the common coastal management issues, such as aquaculture, remains a gap between science research and industrial practice. This mini-workshop, convened by Weiwei You and Samuel Wang (China) offered a platform to engage aquaculture stakeholders in dialogue with scientists, identify what data and information aquaculture operators need in their daily practices, discuss ways for scientist to provide this data and information to stakeholders and work toward innovative solutions to support management and mitigation strategies.



Aquaculture industry representative Qingshu Cheng (China). Photo credit: GOA-ON2019.

#### ***The ocean carbon from space (SatCO2)/joint training workshop***

The SatCO2 training workshop was led by Yan Bai (China) and featured a presentation on current research efforts using satellite remote sensing to increase understanding of the ocean carbon cycle, the introduction of the 4th version of SatCO2 software and online database from SOED, hands-on training with technical assistance, and discussion. SatCO2 provides a unique 3D visualization of multi-source remote sensing data, time series analysis, and interactive analysis between remote sensing, *in situ* data and model simulations. Such analysis can significantly advance our understanding of multiple stressors. The software can be downloaded free of charge at [www.SatCO2.com](http://www.SatCO2.com).



Satellite remote sensing expert Yan Bai (SOED/SIO, China). Photo credit: GOA-ON2019.

Capacity building and scientific mentorship is a major component of GOA-ON's mission. One example is Pier2Peer, a scientific mentorship program that matches senior researchers with early career scientists to facilitate an

exchange of expertise and to provide a platform for international collaborations.

*“The GOA-ON workshop was a fascinating experience to network with scientists who shared a diverse range of OA projects world-wide.”*  
*Roshan Ramessur*



Left: Reuben Makomere (Australia), Pier2Peer contact Alicia Cheripka (USA), and Roshan Ramessur (Mauritius). Right: Patricia Castillo-Bricelo’s (Ecuador) take-home message that international technical support is key to developing OA research in developing countries. Photo credit: GOA-ON2019.

### Strengthening PICES links with GOA-ON

With the rapid increase in observation assets and data in the North Pacific, and the growing number of associated scientists and stakeholders combined with scattered funding sources, there is great opportunity and need for PICES coordination with other networks, such as GOA-ON to maximize efficiency and minimize duplication. Some possible ways include:

- 1) Travel support for attendance at international and regional meetings;
- 2) A proposal to GOA-ON for a PICES representative to serve on the Executive Council, which already includes representatives from other relevant international and intergovernmental bodies (IOC-UNESCO, IAEA, the International Ocean Carbon Coordination Project (IOCCP) and Global Ocean Observing System (GOOS));
- 3) Coordination of activities in the North Pacific with the GOA-ON North America Hub serving Canada, USA, and Mexico, and Western Pacific Hub under IOC-WESTPAC;
- 4) Joint capacity building activities;
- 5) Identification of assets in the North Pacific and contribution to the GOA-ON Data Portal, and development of additional products to support decision making;



GOA-ON Data Portal (<http://portal.goa-on.org/Explorer>) – Stationary and mobile platforms in the North Pacific.

- 6) Propose/secure funding from the member states to establish a program on the cumulative environmental effect on North Pacific Ocean ecosystems, and contribute to the UN Decade of Ocean Science for Sustainable Development (2021–2030) and UN Sustainable Development Goals (SDG) 14.3 target (2030 Agenda).

*“My perception of a complex interplay between multiple stressors. We try to observe and take snapshots, but mainly we are still in the dark”.*  
*Daniela Turk*



The workshop City Tour to a light show in Hangzhou Urban Balcony.

**Acknowledgments:** I am very grateful to PICES and the National Oceanic and Atmospheric Administration (NOAA), the workshop co-chairs and organizers, and my co-authors (Hongjie, Xiping, Dwight, Aleck, Liqing and Wei-Jun) for their kind support, Samuel Wang for his helpful comments on this article, and to the local hosts for wonderful hospitality. Thank you!

More information on the workshop can be found at <http://goa-on2019.com/en/>.



*Dr. Daniela Turk (daniela.turkca@gmail.com) is a senior Science Manager/Research Scientist with substantial experience in multidisciplinary research programs in oceanographic and climate science. She has held positions as a manager, coordinator and scientist in various national and international research programs/projects including Climate and Ocean – Variability, Predictability, and Change (CLIVAR) of the World Climate Research Programme (WCRP) in the UK, EuroCLIMATE and TOPOEurope at the European Science Foundation (ESF) in France, Surface Ocean-Lower Atmosphere Study (SOLAS), Ocean Tracking Network (OTN), and Canada Excellence Research Chair (CERC) in Ocean Science and Technology in Canada. She has a background in ocean biogeochemistry with a focus on ocean acidification and carbon cycle. She holds a PhD in Biological Oceanography from Dalhousie University, Nova Scotia, Canada and Engineering degree in Geodesy from the University of Ljubljana, Slovenia.*



## Scientific dialogue between the ocean and the atmosphere

by Jessica Gier, Li Li and Esther Rickert



Photo credit: Esther Rickert

The Surface Ocean-Lower Atmosphere Study (SOLAS) held its 7th Open Science Conference from April 21–25, 2019 in Sapporo, Japan – a cosmopolitan city at the wild end of Japan. A committee of 31 people, hailing from 17 countries, came together to organize SOLAS’s hallmark science conference, which welcomed 190 attendees from 30 countries to share their research and knowledge of SOLAS science. The conference participants were treated to the arrival of the cherry blossoms in northern Japan, a truly unforgettable experience.

Hokkaido provided the perfect backdrop for the Open Science Conference, located at a nexus of air–sea exchange research of both global and local significance. The northern coast of Hokkaido is the lowest latitude at which sea ice forms. It also borders the Sea of Okhotsk, the

primary ventilation site for the North Pacific Ocean. To the west, lies a temperate marginal sea that has been a site of extensive SOLAS research into how the human system interacts with air-sea exchange processes. And of course, to the east, the North Pacific Ocean, itself, where High Nitrate-Low Chlorophyll waters meet atmospheric dust and nutrient deposition, with periodic perturbation by typhoons.

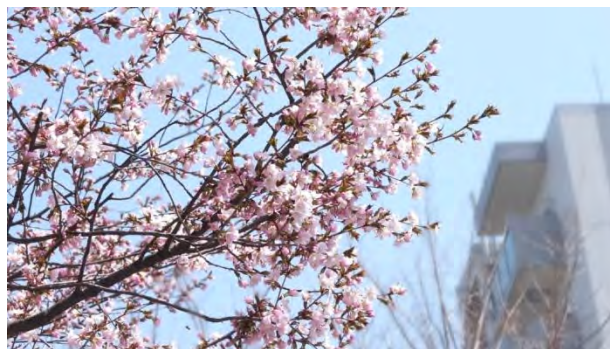
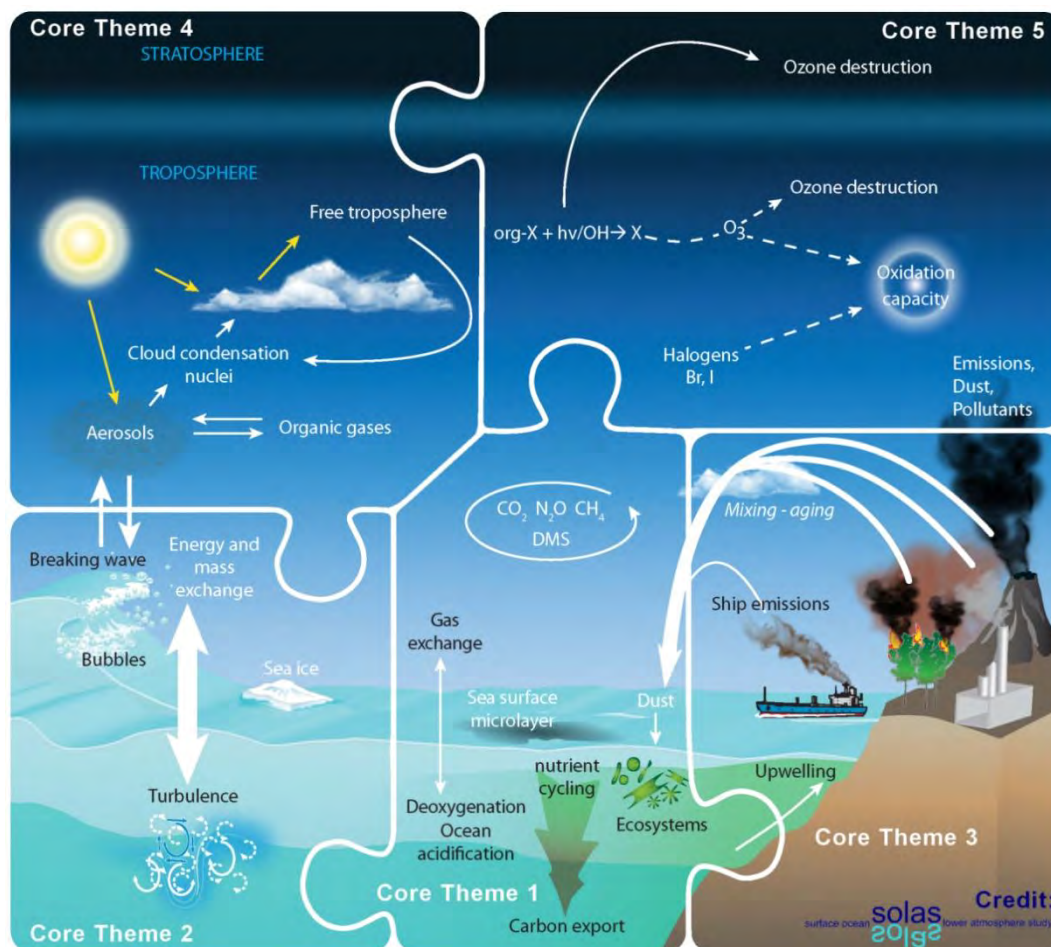


Photo credit: Jessica Gier

SOLAS is an international community whose research explores the interactions between the ocean and atmosphere through physical, chemical, and biological processes at the air-sea interface. A bottom-up organisation, SOLAS has been connecting researchers around the world from across these disciplines since 2004. The [SOLAS International Project Office](#), which is based at the GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany, with a nodal office in Xiamen, China, is responsible for coordinating the Global Research Project and was instrumental in organising the conference.



Participants at the SOLAS Open Science Conference 2019 in Sapporo, Japan. Picture credit: Aiko Murayama



The five Core Themes of the SOLAS 2015-2025 Science Plan and Organisation (<https://www.solas-int.org/about/solas.html>).

The five core themes and three cross-cutting themes outlined in the current [SOLAS Science Plan 2015-2025](#) were covered by plenary lectures. These were complemented by poster session for each of the Themes in the afternoons, as well as discussion sessions which provided an opportunity for the community to identify new frontiers to explore. The outcomes and reports of these discussion sessions will be published in the upcoming issue of the SOLAS Event Report which will be announced in the [SOLAS e-news](#).

**Core theme one**, “Greenhouse gases and the oceans,” featured a keynote lecture from Siv Lauvset, from the Norwegian Research Centre (NORCE), Norway, on the role of humans and the ocean in the carbon cycle.

**Core theme two**, “Air–sea interface and fluxes of mass and energy,” was dedicated to oceanic and atmospheric processes, driven for instance by waves, bubbles or surfactants, which influence the transfer of mass and energy between the ocean and atmosphere. Daiki Nomura of the University of Hokkaido, Japan, introduced this theme with his talk on gas exchange in ice-covered oceans.

**Core theme three**, “Atmospheric deposition and ocean biogeochemistry,” explores the impact of particles of continental origin which enter the ocean from the atmosphere. These particles can be from natural processes, such as dust or volcanic eruptions, or human activities, such as the burning of fossil fuels and biomass or agriculture. The keynote for this session was given by Ying Chen, from Fudan University, China. Her talk focused on the impact of nitrogen and trace metals received from the atmosphere on marine phytoplankton.

**Core theme four** focused on the interconnections between aerosols, clouds, and marine ecosystems and how these components form a system as a whole. Jonathan Abbatt of the University of Toronto, Canada, gave the keynote talk on how the ocean, aerosols, and clouds are connected in the summertime Canadian Arctic.

**Core theme five** is dedicated to ocean emissions of aerosols and reactive gases and how they impact atmospheric chemistry. Anoop Mahajan, from the Indian Institute of Tropical Meteorology, India, and one of the latest additions to the SOLAS Scientific Steering



Committee, introduced this theme. His talk provided a look through time at how the ocean regulates atmospheric chemistry.

In addition to the five core themes outlined above, the SOLAS Open Science Conference also dedicated sessions to three cross-cutting themes.

The **cross-cutting theme on Integrated Topics** is dedicated to oceanic systems where integrated studies are required and urgent. These are regional, high sensitivity, and high-priority systems, such as for instance the upwelling systems, sea ice, and coastal waters. The keynote talk for this theme was given by Marcela Cornejo, Pontificia Universidad Católica de Valparaíso, Chile, and focused on changes in the nitrous oxide in the Humboldt Current System.

Andrew Lenton, from the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, introduced the **cross-cutting theme on Geoenvironment**, which highlighted climate intervention approaches, including observational research and model predictions, as well as their environmental and societal impacts.

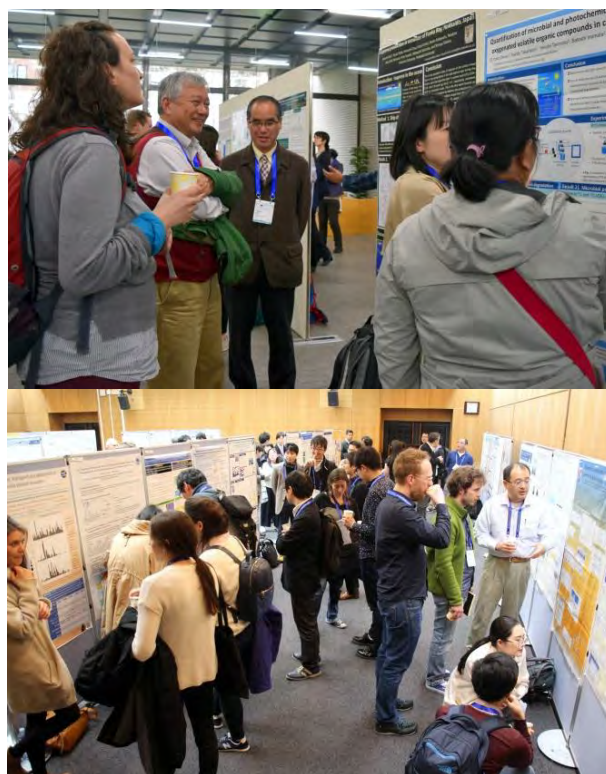
The **cross-cutting theme on Science and Society** focuses on SOLAS research with social relevance and on activities which have a direct impact on society, such as air quality, human health, ship emissions, marine resources, and climate regulation. The keynote talk by Kathryn Mengerink, from the Waitt Institute, USA, discussed the relevance of SOLAS research to marine spatial planning and science-based decision-making.

In addition to the main conference, an Early-Career Scientists Day and a Geoenvironment Workshop were organised, both of which were held the day before the conference. More information about the ECSD can be found on page 14.

The day-long Geoenvironment Workshop, led by Philip Boyd of the Institute of Marine and Antarctic Studies at the University of Tasmania, Australia, and Cliff Law of the National Institute of Water and Atmospheric Research, New Zealand, brought together observationalists, modellers, and legal experts working on the interactions between the ocean and the atmosphere. The workshop discussed how the air-sea research community can help inform the decision-making process in climate intervention. Last year, SOLAS published a [Position Statement on Geoenvironment](#), and has set itself the task of investigating the scientific basis of many carbon dioxide removal and solar radiation management techniques, such as iron fertilisation, alkalinity addition or increasing surface ocean reflectivity.

The next international SOLAS Open Science Conference is scheduled for 2022.

(continued on page 21)



Poster sessions. Photo credit: Jessica Gier



Cliff Law and Philip Boyd introduce the Geoenvironment Workshop. Picture credit: Jessica Gier

After the conference, the 17 members of the [International SOLAS Scientific Steering Committee](#) met for three days to discuss current research issues and their implementation. For example, on the subject of [Science and Society](#), SOLAS intends to focus more intensively on how new regulations of ship emissions impact ocean biogeochemistry and how plastics at the ocean surface contribute to the release of volatile organic and greenhouse gases. In September 2019, SOLAS will support the [Shipping and the Environment II](#) conference in Gothenburg, Sweden.

## SOLAS Early-Career Scientist Day

by Sohiko Kameyama, Yoko Iwamoto and Martine Lizzote



Group photo. (Photo credit: Y. Iwamoto)

The SOLAS Open Science Conference was held from April 21– 25, 2019 in Sapporo, Hokkaido, Japan. Before the main conference, an Early-Career Scientists Day (ECSD) was organised on 21 April, 2019. The ECSD was planned by the ECSD committee composed of Dr. Sohiko Kameyama (Hokkaido University, Japan), Dr. Yoko Iwamoto (Hiroshima University, Japan), and Dr. Martine Lizotte (Laval University, Canada). It brought together 25 doctoral students and postdoctoral researchers from 15 countries to network, discuss, and share their respective research. At the registration desk in the morning, souvenirs that had been specially designed for the ECSD were offered to the participants (Photo 1).



Photo 1: Presents designed for the ECSD participants. (Photo credit: Y. Iwamoto)

After the welcoming introduction, Dr. Anoop Mahajan (Indian Institute of Tropical Meteorology, India) gave a

lecture entitled “*Making science ‘cool’*” which delved into the reasons why science needs to remain fun and accessible from the point of view of connections between scientist and society. Afterwards, Mr. Namba Naoki (Hokkaido University, Japan), who has been involved in knowledge mobilization of research activities within the public at large, gave a talk on the importance of “*Writing about your research for a non-academic audience*”. During the lecture, participants actively engaged and asked questions of the lecturers (Photo 2).



Photo 2: Lecture by Dr. Anoop Mahajan (Indian Institute of Tropical Meteorology, India). (Photo credit: Y. Iwamoto)

Following the lectures, each early career scientist presented their research during three-minute talks which were accompanied by two-minute Q&A, and Early-Career peer evaluations. As a result, the best three talks were given awards during the conference banquet (Photo 3). Prizes were awarded to Dr. Hannah Horowitz (University of Washington, USA) for “*Where does mercury in fish come from?*”, Ms. Stephanie Schneider (University of Toronto,



Canada) for “*Heterogeneous oxidation of the surface microlayer with ozone*”, and Dr. Pat Wongpan (Hokkaido University, Japan) for “*Using under-ice spectra to determine land-fast ice algal biomass in Lake Saroma, Japan*”, along with special trophies created by Hokkaido glass crafts (Photo 4). After the three-minute competition, the Early-Career Scientists went on a field trip to Lake Shikotsu, a caldera lake created by a volcanic eruption that remains ice-free throughout the year despite its northern latitude (Photo 5). The day was calm and sunny, and the participants enjoyed the glass boat outing and the walk around the lake. After the excursion, the participants returned to Sapporo and the ECSD ended with the SOLAS Open Science Conference Ice-Breaker.



Photo 3: The three winners of the Early-Career Scientists Day three-minute talks receiving their prizes from Mitsuo Uematsu. From left to right: Pat Wongpan, Stephanie Schneider, and Hannah Horowitz. (Photo credit: K. Gier)



Photo 4. ECSD awards created by Hokkaido glass crafts. (Photo credit: S. Kameyama)



Photo 5: Field trip to Lake Shikotsu. (Photo credit: Y. Iwamoto)

The entire activities during the ECSD were made possible through the financial support of PICES. The organizing committee would like to thank PICES for its patronage and for providing the SOLAS Early-Career Scientists with an unforgettable experience.



Dr. Sohiko Kameyama ([skameyama@ees.hokudai.ac.jp](mailto:skameyama@ees.hokudai.ac.jp)) is working on marine chemistry and analytical chemistry, especially focusing on trace gas behavior in the air-sea boundary. He obtained his PhD at Hokkaido University, Japan, in 2007, and then worked as a postdoctoral researcher in the National Institute for Environmental Studies, Japan. He returned to Hokkaido University as an assistant professor in 2010, and was promoted an associate professor in 2015. His research is based on oceanic observations and he recently participated in research cruises in the Arctic Ocean to investigate the distribution and cycle of the biogenic trace gases.



Dr. Yoko Iwamoto ([y-iwamoto@hiroshima-u.ac.jp](mailto:y-iwamoto@hiroshima-u.ac.jp)) is a biogeochemist, who carried out her PhD at the University of Tokyo, Japan, in 2009. Her research investigates the biogeochemical cycles between ocean and atmosphere via aerosols. After working as a postdoctoral researcher at Nagoya University and Kanazawa University, Japan, and as assistant professor at Tokyo University of Science, Japan, since February 2017 she works at Hiroshima University, Japan. She has participated in many research cruises especially in the North Pacific, and is engaged in research on marine atmospheric aerosols.



Dr. Martine Lizotte ([Martine.Lizotte@qo.ulaval.ca](mailto:Martine.Lizotte@qo.ulaval.ca)) obtained a PhD at Laval University, Canada, investigating the oceanic cycling of dimethylsulfide (DMS). Since 2010, she has been working on the impacts of various environmental stressors (ocean acidification, iron depletion, light, warming) on the biogeochemistry of DMS under the auspices of the Canadian Research Chair on Ocean Biogeochemistry and Climate. She more recently joined the team of the Canadian Excellence Research Chair in Remote Sensing of Canada's New Arctic Frontier. Her involvement in Arctic-focused research programs and networks such as Arctic SOLAS, ArcticNet, NETCARE, Takuvik, and Sentinel North, has led to a deeper understanding of the interactions between oceans and the atmosphere, including the impacts of climate change on the production of DMS within the hydrosphere/cryosphere nexus at high latitude.

## **The PICES–MAFF-sponsored Project on “Building capacity for coastal monitoring by local small-scale fishers” (FishGIS): Incorporating community-based research principles**

*by Naoki Tojo, Takaaki Mori and Charles Trick*

Zora Neale Hurston, the famed author and anthropologist stated: “Research is formalized curiosity. It is poking and prying with a purpose” (Hurston, 1942). Most members of PICES–scientists, resource managers, national scientific decision-makers would probably agree with the statement, but most would have difficulty in defining the use of the word “purpose” in the quote. For most of us, “purpose” is the transformation of ideas into information, then to knowledge, and for many individuals in PICES, taking this knowledge and passing it along to decision makers. This pattern has served us well for decades.

In this day and age, many of the pressing problems that face us are not this simple, and thus we cannot follow the general teachings of the generations before us (even when it has a very successful track record). As environmental issues are now claiming the health and wellness of society, we have a new master—the affected communities, and for many projects, we must alter our research strategies in ways that are not natural in our scientific progression. The “purpose” is not to serve managers and decision makers. The “purpose” is to serve communities—and by doing so, enlighten decision-makers with the one (or many) path(s) of action. Accepting the altered research “purpose” is not a simple transition and requires a very non-traditional approach. No two studies are alike. Many projects are reflective or narratives or case studies—not based on first principles. Each path starts with understanding “community-based participatory research” (CBPR).

Several projects under the PICES umbrella are community-centric studies. Here, we discuss the PICES project on “Building capacity for coastal monitoring by local small-scale fishers” (FishGIS). The project is funded by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan, through the Fisheries Agency of Japan (JFA), from the Official Development Assistance (ODA) Fund. The official goal of FishGIS is “to enhance the capacity of local small-scale fishers to monitor coastal ecosystems and coastal fisheries in Pacific Rim developing countries”. To improve capacity, we have introduced several smart-phone driven technical surveillance apps/approaches that record water turbidity, fish catch, and water quality (plastics, for example). These technological approaches were provided to the communities along with training and opportunities to contribute to the assessment of changes in local fishing grounds over time. Details will be formalized soon as the project is entering the final phase of the three-year study. The word “study” here is a bit misleading as the goal is not

to gather data but to transform the communities into “sentries of their own economy” and it follows that their voice will now be heard when environmental concerns arrive. The power is based within the community, not with the scientists flying in to clarify the day.

In the FishGIS project, three groups are full participants. They are the participating fishers and aquaculture farmers, the broader family-oriented community, and the community of government managers. We recognized, based on previous PICES-MAFF projects (*e.g.*, MarWeB’s investigation into “sato umi” and “Improving aquaculture, marine ecosystems and human well-being: A social-ecological systems approach” in Indonesia and Guatemala); <https://meetings.pices.int/projects/MarWeB>) that strict adherence to the principles of CBPR was essential to achieve our goals (and to get ethical approval to work with communities to problem-solve environmental situations). For strong historical reasons, there are many “outlines” for what CBPR entails. One of the most comprehensive and accurate CBPR assessments is that of Viswanathan *et al.* (2004).

CBPR is a strategy where scientists, researchers, or observers enter into a relationship with a community long before any work has been attempted or considered. The aim is to create a shared knowledge base on a problem, the approach, and the solutions long before attempts are made to “study” the problem. From our experience, the first question that will be shared is, “Is there a problem?” Sometimes researchers stake out defined “stakeholders” but we find this a flawed approach since stakeholders are often “egocentric” managers of problems (“What’s in it for them?”). Instead, we seek out relationship managers who have a broader perspective of the problem–solution–effects (“How will my life be better?”). Here are our FishGIS communities and their stories.

In February of this year, several members of the FishGIS In February of this year, several members of the FishGIS Project Science Team (Mitsutaku Makino and Mark Wells, co-chairs; Shion Takemura, Joon-Soo Lee, Chang-an Xu, Naoki Tojo, Vera L. Trainer, and Charles Trick) were joined with two grad students, Takaaki Mori, one is the authors of this article and from Hokkaido University visited Indonesia to finalize the selection of additional case study sites, test the updated tools used in the 2018 workshop (see Takemura *et al.*’s article, page 16 in [PICES Press, Vol. 27, No. 1](#)), speak with the local communities to evaluate the



potential for a longer-term project vision, and to collect additional information about the local fisheries and socio-economic conditions. This was the third visit to Indonesia by the PICES Team for the FishGIS project. The Team went to Jakarta, then Pelabuhan Ratu, southwestern Java (Fig. 1) and two communities associated with economically vibrant fishing ports: Karangantu (of Banten) and Ratu (Fig. 2).



Fig. 1 PST and community members from the 3<sup>rd</sup> visit by the PICES Team to Pelabuhan Ratu.

For each community, four phases were predefined to train stakeholders for undertaking sustainable smartphone monitoring in Indonesia:

1. Training of fishers (defined here as including both wild- and aquaculture-based fisheries) to use the smartphone-based GIS-system to obtain and document fish landings and locations;
2. Training of fishers in use of the supplied HydroColor smartphone application to monitor and estimate water quality characteristics (primarily the level of chlorophyll in the surface waters).
3. Training of prominent community members in sample collection and analysis of phytoplankton community structure (with emphasis on key taxa associated with toxin production). Here they use individual inexpensive portable microscopes from Foldscope Instruments. They also use their smartphones to document the taxa of interest for confirmation by experts;
4. Instructing the BPPT staff and scientists on calibrating the HydroColor application to enable automated determination of chlorophyll concentrations, and verification of data on suspended sediments and turbidity measurements.



Fig. 2 Locations of the port communities, Karangantu and Ratu, where the PICES Team visited February 3–8, 2019. (Maps are modified from Google LLC, 2019).

**Enhancement of community-driven sustainability**

Earlier workshops trained community members on how to gather information with their smartphones. In the February 2019 visit, the purpose was to engage the community in understanding how the measurements they were taking would help in creating sustainable fisheries. But first, the community members needed to appreciate the complexity of creating sustainable fisheries. During our visit to the selected communities with BPPT colleagues, young BPPT staff members, advised by the PICES Team, first talked with the locals about their livelihood and the sustainability of local fishing grounds, and what their visions were for future fishing. They then asked the fishers to participate in a “game experiment” to learn decision-making and management skills towards sustainable fishing.

Key to the success of the discussion and the success of the project was to create an understanding of “sustainable fisheries.” This may be in our common vernacular, but the concept is less global than we may appreciate.

We challenged this question on the second PST visit to Indonesia when we integrated the PICES-developed FishGIS technology into the four selected communities (Muara Gembong and Indramayu, the Karangantu Port of Banten and Pelabuhan Ratu). Working with our in-country collaborator, BPPT, we performed a community-decision exercise that introduces “sustainability” to the discussion with the community. This “Fisheries Sustainability” game pits the decisions of one stakeholder group against another. While each group may “manage” the fishers, each does so in a stakeholder-specific understanding of rules. First, the fishers chose the number of fishes to catch based on

information about the size of the fishery stock and then removed this number from an opaque bag containing the entire “stock”. The initial game outcome showed a rapid depletion of the stock by overfishing, to the surprise and dismay of the fishers. However, they then quickly learned to transition their decision-making towards a more communal fishing strategy leading to a “sustainable” fishery. The take-home message, appreciated by all members of the fisheries community present, was that the monitoring efforts by the fishers using the FishGIS apps improved the understanding of the resource limitation and leads to a better appreciation and discussion of sustainability. (A good summary of the “fish sustainability” game can be found at the Marine Stewardship Council website. <https://www.msc.org/for-teachers/teach-learn-about-ocean-sustainability/games-and-activities>.)

**Building approaches to “Citizen Science”**

Since the beginning of the project in 2017, FishGIS has taken a “Citizen Science” approach, with IT technology, using smartphones (Fig. 3). Data and information about fishing targets, fishing vessels, fishing gear, algal blooms, and turbidity of water have been collected using smartphones by local fishers and coastal residents with aquaculture farms. The information is then assembled in a common server from individual smartphones with GPS information and synthesized data are projected onto the GIS platform of mobile devices with an Internet connection. Fishers and other community members can participate directly in the monitoring activities, and can interactively find their own inputs to the database using their smartphones.

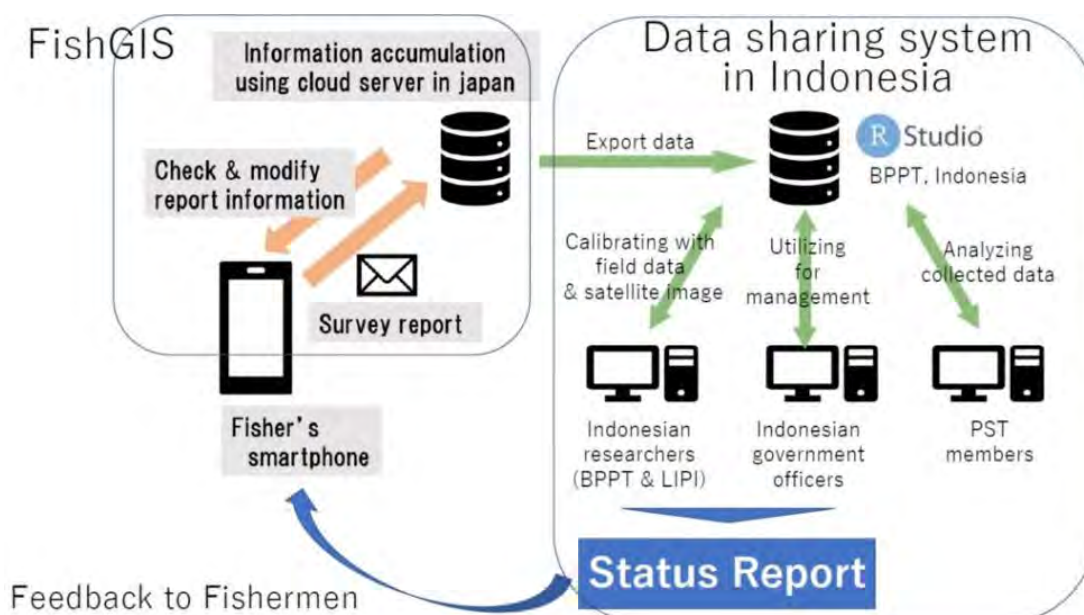


Fig. 3 Schematic of monitoring system for the FishGIS project. Eventually, the data server and reside in Indonesia and will be managed by Indonesians.



“Community participation” has two major connotations in this type of research-oriented project. First, the community participatory in sampling allows a cost-effective means to collect data. Many individuals can collect data simultaneously within the region. Second, the involvement of fishers and other community members in the project allows them to take responsibility for their activities (building project ownership and capacity improvement in the human dimension in the development).

There were some scientific concerns about the data collected by locals having the other purposes of visiting and using the sites, for example, the spatial coverages of the sampled data. On the other hand, it is also essential to track the information in specific fishing grounds from an applied scientific perspective. Data qualities may not be where/what status surveyors belong but be the matter of the training and attitude of surveyors in both the researcher’s survey and citizen science monitoring activity. Spatial dynamics in the efforts and fishing grounds may also be necessary. More importantly, a citizen science approach may allow people who need or want to know the biological and ecological targets and associated issues to connect with others who are collecting the data. From the perspective of a developmental assistant, “ownership” in project activities and responsibilities in the monitoring are precious to solve problems and to participants attain the sustainable developmental goals.

#### ***Extracting knowledge through conversation and sharing***

Takaaki Mori, who assisted in the field work of the FishGIS project, recalled his surprise during the December 2018 mission to Pabean Ilir village in Indramaya. *“Though we expected to document many types of fish, I was astonished that there were more than 25 species in the*

*catch each day.”* The diversity of species in their catch was one of the improvements the locals noticed as they became adept in using the project tools (Fig. 4). Mori also noted that what fishes were targeted fishes depended on the location of the communities, and which fish we bi-catch or fish of opportunity. For the locals whose livelihoods depend on fishing are, the categorization of the fishing targets should be simple and distinguishable for their monitoring operation, but it also should be ecologically meaningful. With the assistance of locals and managers, PICES team has been improving the selectable fish category for reporting through smartphones.

*“It was also a surprise to see how enthusiastic the locals were for participatory monitoring. They were passionate. The changing surroundings, especially the hard rains in the rainy season that disturb their fishing activities with their small boats, and financial hardships in their reality motivated them to find what they could do for their sustainable livelihood. Having information has been very important for their knowledge.”*

The technology of the FishGIS apps is a work in progress. Many of the initial concerns of the members of the Pabean Ilir village (Fig. 5), dealt with the use and structure of the languages of the interface. The app interface was translated into Bahasa Indonesia, the national language, for local users (termed “IKAN GIS”). Oversimplified selection of fishes of the interface was confusing to the local fishes and the traditional names were replaced with regional, common titles. This was a significant change as the local users reported that they felt “ownership” of the data they collected because they now understood the relationship between “catch,” “abundance,” and “resource.” The semantic match is a critical step in the community’s approach to sustainability.



Fig. 4 Diversity of species in the catch in Pabean Ilir village in a single day. More than 20 species were identified in the catch in every day.



PABEAN ILIR

Fig.5 Pabean Ilir village. Maps are modified from Google LLC (2019).



Fig. 6 Snapshots from the technical workshops with locals in Pabean Ilir village. These workshops were held in both the field and in common meeting places for locals with voluntarily participated residents

Workshops were held in the village on December 11 and 13 (Fig. 6). For example, uses of the project tools such as the FishGIS interface, HydroColor application and portable microscopes were reviewed with villagers in the meetings and field trainings. Site visits, observations of target species and fishing activities and field experiments from socio-economic perspective were made in the intervals of the technical workshops.

Locals that participated in these workshops, expressed the following feelings:

*“We hope to see the future with what we have learned in both some years later and generations later, with the project tools.”*

*“We also hope that improvements are made in the tools and systems by experts, continuously! ...work hard!”*

Not only information from the villages but also the comments of villagers have been collected and discussed in the PICES team after the visits and have been reflected to the technical improvement of the project and dissemination activities.

**Working with reality and wills toward futures**

After the first two years of interactions the PST recognized that the community members are discussing “sustainability” more than just fishing. As “sustainability” is a complex concept the local community members are having a difficulty maintain an appreciation of the long-term in On the other hand, the team also began to understand the difficulty faced by the locals; such as limited available technologies (e.g., types of smartphone) and limited resources (capital, time) to invest in monitoring activities. According to locals, changes in the environment,



especially the changes in rain regimes and pollution are inhibiting their fishing activities and livelihoods in recent years.

Over the next year, the FishGIS project faces the new phase—handing over the management to the local BPPT fisheries managers, ensuring quality control of the data, and supporting community access to the data and fish inventory information.

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*Mr. Takaaki Mori (takasawa0625@gmail.com) is a graduate student (M.S. candidate) in the Graduate School of Fisheries Sciences, Hokkaido University of Japan. He studies developmental fisheries, especially in the area of coastal community development and is involved in the FishGIS project as a student assistant.*

*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. In PICES, he is a member of the Section on Ecology of Harmful Algal Blooms in the North Pacific and a member of the Project Science Team in FishGIS.*

(continued from page 13)



*Dr. Jessica Gier (jgier@geomar.de) is a marine biogeochemist, who did her Master of Science in Biological Oceanography at GEOMAR Helmholtz Center for Ocean Research Kiel, Germany, and at the Ocean University of China in Qingdao, China. She carried out her Ph.D. at GEOMAR as a member of the interdisciplinary research project SFB 754, participating in research cruises in the Pacific, the Atlantic, and the Baltic Sea. Her work encompassed benthic nitrogen cycling in oxygen minimum zones. She joined the SOLAS International Project Office (IPO) as Project Officer at the beginning of 2017, and since April 2018 she has been the IPO Executive Director.*



*Dr. Li Li (lili34@xmu.edu.cn) is a marine ecologist and biologist, who obtained her Master of Philosophy degree from Xiamen University, China, on global distribution of virioplankton. She received her Ph.D. from the City University of Hong Kong on drug screening with transgenic fish. Li Li is a scuba diver with diving experience in many countries and voluntary working experiences in a non-governmental organisation. Li Li joined the SOLAS International Project Office (IPO) as Project Officer in September 2017 and is based in the SOLAS nodal office at the State Key Laboratory of Marine Environmental Science (MEL) of Xiamen University, China.*



*Dr. Esther Rickert (erickert@geomar.de) is a marine ecologist, who obtained her diploma of biology from the University of Kiel, Germany. She did her Ph.D. in the field of chemical ecology at GEOMAR Helmholtz Center for Ocean Research Kiel, Germany. After her Ph.D., Esther worked as a postdoc and scientific project coordinator on a remote sensing project located at the Research and Technology Centre (FTZ) of the Kiel University operating on the interface between applied ecological research and the implementation of government policies. Esther joined the SOLAS International Project Office (IPO) at GEOMAR as Project Officer in September 2018. In addition to her position at SOLAS Esther works as project manager at GEOMAR coordinating the collaborative REEBUS project - Role of Eddies in the Carbon Pump of Eastern Boundary Upwelling Systems.*

## Future Oceans2 IMBeR Open Science Conference: Thoughts and perspectives from early career attendees

*by Irene D. Alabia, Xin Guo, Patricia Angkiriwang and Andrés Beita-Jiménez*

The [2019 IMBeR Open Science Conference](#) was held in Brest, France on June 17–21, 2019. The week-long meeting covered a wide range of topics and workshops across natural science and social science disciplines, offered excellent opportunities to orient attendees with the advances in multidisciplinary research, and strengthened international research networks for future collaboration. The conference was attended by 752 participants across various research fields, of whom 367 were students or early career researchers.



*Early career scientists receiving travel support from the North Pacific Marine Science Organization (PICES). Left to right: Andrés Beita-Jiménez (Canada), Irene D. Alabia (Japan), Xin Guo (China), and Patricia Angkiriwang (Canada).*

On June 16, the day preceding the main conference, IMBeR hosted an Early Career Researcher Day which provided interesting talks and activities and created a welcoming environment for networking. Main events included

discussions with experts and early career scientists on building successful careers in marine science as well as non-academic careers, and were both encouraging and inspiring. There was also a training session on developing infographics for publications and other forms of science communication, a useful skill to better communicate our science to a broader community.

During the main conference, parallel sessions started with plenary talks gearing towards the overarching grand challenges of the meeting on (1) understanding and quantifying the state and variability of marine ecosystems; (2) improving scenarios, predictions, and projections of future ocean–human systems at multiple scales; and (3) improving and achieving sustainable ocean governance.

The parallel sessions around these themes included oral and poster presentations on recent inter- and transdisciplinary marine studies, traversing across the spectrum of natural and social sciences. They presented information on what we know so far about the structure and states of the marine ecosystems, while highlighting the research gaps that need further and urgent attention.

The conference was a unique opportunity not only to share our research and to keep ourselves up to date with the work that is being done in our study area, but also to broaden our horizons on how marine science is evolving towards interdisciplinarity. The plenary talks and sessions discussed a wide range of topics that scientists should consider in order to meet the demands of a changing ocean, from methods to improve the study of the biophysics of the ocean to the importance of integrating social science principles into our work.



*Expert panel discussions on building successful careers in marine science (left) and alternative successful career pathways (right) for early career marine researchers during the Early Career Researcher Day.*





Talks by (a) Irene D. Alabia; (b) Xin Guo; (c) Patricia Angkiriwang; and (d) Andrés Beita-Jiménez.

As early career researchers, we also appreciated the conference's emphasis on knowing how our science fits into a larger societal context: whether it be implications for communities and society (e.g., equity, nutrition, justice), how it fits in history (e.g., colonialism, mercantilism, military incentives) or how it is communicated to the public and decision-makers in order to have better ocean governance. We hope that all these discussions will stick with us and help us improve our contribution to the science

and management of the oceans.

Finally, we are extremely grateful for the opportunity to meet many scientists and create meaningful connections. In both academic and social events, we had the opportunity to engage in conversations with fellow early career scientists as well as established researchers, creating connections that may perhaps lead to more opportunities and collaborations in the future.



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*Patricia Angkiriwang (p.angkiriwang@oceans.ubc.ca) is an M.Sc. student at the University of British Columbia, located on Musqueam territory in Vancouver, Canada. She is currently working on a collaborative project with Tla'amin First Nation on the future of fish and food security, using participatory and transdisciplinary modelling approaches.*

*Andrés Beita-Jiménez (andres.beita-jimenez@mi.mun.ca) is an M.Sc. student at the Fisheries and Marine Institute, Memorial University of Newfoundland, Canada. His research interests are on quantitative assessment and management of marine resources. He is currently studying the life history variability of northern shrimp populations in Atlantic Canada and factors associated with it. Originally, Andrés is from Costa Rica, where he graduated with a B.Sc. in Biology from the University of Costa Rica working on ecology and management of fish on coral reef ecosystems.*

## First Global Planning Meeting for the United Nations Decade of Ocean Science for Sustainable Development (2021–2030)

by Robin Brown



*First Global Planning Meeting of the UN Decade of Ocean Science for Sustainable Development, May 13–15, 2019. Photo credit: Leif Bolding.*

In December 2017 the United Nations General Assembly (UNGA) declared the UN Decade of Ocean Science for Sustainable Development (2021–2030) (the Ocean Decade) to support efforts to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework that will ensure ocean science can fully support countries in the achievement of the 2030 Agenda Sustainable Development Goals (and more particularly SDG 14) and will contribute to UN processes.

The UN General Assembly tasked the Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO) to coordinate the Decade's preparatory process (2018–2020), inviting the global ocean community to jointly prepare an implementation plan for the Decade in ocean science and technology to deliver, together, the *Ocean We Need for the Future We Want*. This Implementation Plan will be submitted for approval to the 75<sup>th</sup> session of the UN General Assembly in autumn 2020. This is an aggressive and challenging schedule for a global program. The IOC has endorsed The Decade Roadmap (<https://en.unesco.org/ocean-decade/resources>) as a guide for the steps and processes needed to develop the Implementation Plan of the Decade, and formulates a preliminary set of globally defined objectives and research and development (R&D) Priority Areas.

PICES has supported the Ocean Decade concept from the beginning. This was an easy decision because the objectives of the Ocean Decade are so closely aligned with the purpose of PICES as defined in the Convention:

- i. To promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources, including but not necessarily limited to research with respect to the ocean environment and its interactions with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna and ecosystems, its uses and resources, and impacts upon it from human activities;
- ii. To promote the collection and exchange of information and data related to marine scientific research in the area concerned.

The first Global Planning Meeting was held from May 13–15, 2019 at the National Museum of Denmark, Copenhagen. This meeting was the first forum for international, interdisciplinary and multi-stakeholder dialogues to contribute to the Preparation Phase of the Decade. The specific objectives of the Global Planning Meeting were to:

1. Identify the science questions, including additional R&D priorities that need to be tackled in order to meet the societal outcomes that the Decade aims to achieve by 2030,
2. Elaborate plans to address these science questions, including potential programs, partnerships and resources,
3. Address cross-cutting priorities that are crucial to success of the Decade, such as capacity development and marine technology transfer, financing and partnerships, data and information sharing and knowledge exchange and communication, and



4. Connect with key stakeholders to build ambition and amplify engagement with the entire ocean community to prepare for the Decade.

The intended outputs of the meeting are to inform the preparation phase of the Decade and the development of the implementation and resource mobilization plan by identifying:

- i. The research priorities and the related capacity-development needs as well as possible synergies with the Decade strategic objectives,
- ii. The contribution of existing ocean research and capacity-development communities of actions, workings groups, networks or programmes that are under development or planned (as well as their timeline) and how these can respond to the Decade priorities and objectives as well as knowledge gaps,
- iii. Consultations around themes addressing one or more core areas of work of the Decade, for example, ocean observation, ocean data, ocean literacy, to be organized beyond this global meeting depending on the interest of various communities and partners, and
- iv. Opportunities for investment and resource mobilization for the Decade.



Mr. Peter Thomson, United Nations Secretary-General Special Envoy for the Ocean (left) and Dr. Vladimir Ryabinin (right), Executive Secretary of IOC-UNESCO after opening the 1<sup>st</sup> Global Planning Meeting.

The meeting was attended by more than 240 participants from a range of disciplines and communities, including ocean science and technology, ocean policy and sustainable development, business and industry, NGOs and civil society, and donors and foundations. Each PICES nation was represented, along with representatives of many of our partner organizations, including IOC, FAO, ICES, SCOR, IMBeR, SOLAS, Future Earth, WESTPAC and GESAMP. There was a very wide range of discussion on the breadth of issues associated with the Ocean Decade. I was particularly appreciative of the remarks of His Excellency Peter Thomson, United Nations Secretary-General Special Envoy for the Ocean, who described the urgency of ocean sustainability issues and the critical role that science must play in their resolution. I (and many others) were struck by Jane Lubchenko's particularly effective "pitch" for developing a new

social contract for ocean science, one in which science serves society and is embedded in society. The vision for the future is a world where citizens and policy makers embrace science and know how to use it to make decisions, and where there is enhanced enthusiastic support for science because the direct value of it is evident. She went on to say that to achieve this vision there is a need to change the narrative we have for the ocean, since narratives frame our thinking and influence our values. She described three such narratives:

1. **"The ocean is too big to fail"**. It is too vast to be significantly impacted by human activities. While this has been a dominant narrative for centuries, we have clear evidence that this is not the case.
2. **"The ocean is too big to fix"**. The problems are too big and vested interests make efforts meaningless. Prof. Lubchenko argued that this was not true, but that some parties might accept this because it is a justification for doing nothing. She cautioned against allowing this narrative to propagate.
3. **"The ocean is too big to ignore"**. This new narrative acknowledges that challenges are unprecedented and complex but not insurmountable, and that new science carried out through new partnerships and taking advantage of advances in technology and innovation will be able to address these challenges. We need to highlight those successful science-based efforts at restoration that give us hope that we can heal the ocean and solve multiple other problems at the same time such as food security, climate impact change, and equity.

The breadth of the meeting and participants was truly impressive. I did feel that the "fish and fishing sector" was very weakly represented, given their significant role in ocean sustainability problems. This is a stark contrast to some other meetings and venues, where the oceans are thought to provide little of value other than a place to keep fish before you catch them. This made for some interesting discussions. I was a bit disappointed that I could not see significant progress towards a clearly articulated set of research priorities for the Ocean Decade Science Plan, but I admit to being an impatient person. A more balanced view is that the Workshop was a good start to "kick off" the global planning for the Ocean Decade.

The next phase in the planning for the Ocean Decade includes a series of Regional Planning Workshops. PICES is working with IOC-WESTPAC and the Government of Japan on such a Workshop to take place in Tokyo July 31–August 2, 2019. The PICES Chairman (Prof. Chul Park), Science Board Chairman (Prof. Hiroaki Saito) and Executive Secretary (Mr. Robin Brown) are actively involved in the planning. In addition, key PICES scientists will attend. You can expect to hear more about this Workshop at PICES-2019.



Mr. Robin Brown (Robin.Brown@pices.int) is Executive Secretary of the North Pacific Marine Science Organization (PICES). When not traveling to far-off places to represent PICES, he can be found taking care of business at the PICES Secretariat in Sidney, Canada.

## In memoriam: Dr. Olga Nikolaevna Lukyanova



Sadly, PICES and the wider scientific community lost an eminent marine scientist from TINRO (Pacific Branch of the Russian Research Institute of Fisheries and Oceanography), Dr. Olga Nikolaevna Lukyanova, who passed away on January 19, 2019 after a battle with cancer.

Olga was born in a small village in the Primorye Region but grew up in Vladivostok. There, she developed a love for the natural world, and living close to the sea, took an early interest in marine life. After graduating from high school in 1974, Olga entered the faculty of science at the Far Eastern State University, Vladivostok, where she graduated with honors in the biology program in 1979. After graduation, she worked at the Institute of Marine Biology, Far East Branch, Russian Academy of Sciences, from 1979 to 1998, where she studied the physiological responses of marine organisms to environmental factors. This direction in her scientific career turned out to be a very good choice because soon, based on the results of her research, Olga defended her PhD thesis on “*Mechanisms of cadmium, zinc and lead accumulation for some species of invertebrates in the Japan Sea*” (in 1986), and then her dissertation on “*Molecular biomarkers for state of marine organisms in conditions of anthropogenic pollution*” for the degree of Doctor of Biological Sciences (in 1994). After her defense, Olga was ready to try a different path, and so took up teaching activities from 1998 to 2003 where she taught at the

Department of Chemistry, Biology and Applied Ecology of the Far Eastern State Academy of Economics and Management. However, her taste for scientific research brought her back to the Research Institute, this time at TINRO. From 2003, she was a Senior Researcher in the Laboratory of Applied Ecology and Toxicology at TINRO, and since 2015 (after the reorganization of this laboratory) – in the environmental monitoring sector of the Laboratory of Field Oceanography, all the while still continuing to teach – but at the Department of Ecology of the Far Eastern Federal University (formerly known as Far Eastern State University) as a Professor. The main theme of Olga Lukyanova’s scientific studies at TINRO was still the influence of anthropogenic environmental factors on the marine biota, which she explored using advanced methods, in particular the molecular biomarker method. Her work was in demand, and she actively published her results both in Russia and abroad, in total over 100 articles in scientific journals and several monographs. Until recent days, she was a member of the Editorial Boards of the scientific journals *Izvestia TINRO* and *Fisheries*.

In addition to her numerous publications, Olga Lukyanova’s studies became widely known and even popular in the scientific community because of her regular presentations at domestic and international conferences, symposiums, and seminars. Olga attended her first PICES Annual Meeting in 2002 in Qingdao, China, where she gave a talk on “*Molecular biomarkers in the marine organisms of various trophic levels influenced by human impacts*”. Obviously, PICES made an impression on her because from 2004 onwards (except for two years), she never missed a Meeting. Olga got immersed quickly in PICES activities. In 2005, she became an active member of the Marine Environmental Quality Committee and Section on *Harmful Algal Blooms in the North Pacific*. Later, she was also a member of two Study Groups (*Human Dimensions* and *Marine Pollutants*), Section on *Human Dimensions of Marine Systems*, Working Group (WG 28) on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*, and Co-Chair of the Working Group (WG 31) on *Emerging Topics in Marine Pollution*. In addition, Olga co-convoked a



*PICES-2006 – Observing a S-HAB lab demonstration; PICES-2007 – into the Halloween spirit during the host country’s (Canada) sport event, curling; PICES-2009 – enjoying a glass of wine with Dr. Lev Bocharov at the Chairman’s Reception; PICES-2011 – convening a pollutants workshop; PICES-2015 – attending a topic session on pollution.*



number of Topic Sessions and Workshops as well as presenting numerous papers related to marine environmental quality, bioindicators in ecosystem monitoring, and marine ecosystem services. She was also active in scientific cooperation with NOWPAP, providing expertise at POMRAC (Pollution Monitoring Regional Activity Centre) Focal Point Meetings and workshops.



Co-chairing the WG 31 meeting with Dr. Peter Ross at PICES-2014 (top), with PhD student, Vasily Tsugankov, at PICES-2011 (bottom).

Olga Lukyanova paid great attention to the training of scientific personnel. She supervised and graduated five PhD students, and encouraged them to become involved with PICES through Annual Meetings. She was a member of three dissertation councils: on marine biology at the Far Eastern Branch of the Academy of Sciences of Russia, on ecology at the Far Eastern Federal University and on marine biological resources at TINRO.

Olga Lukyanova left a noticeable mark in science, primarily in ecology, where she, as a biologist, contributed to the advancement of knowledge showing that human influence has an impact not only on hydrochemical processes, but also on biochemical processes in living organisms, and therefore biochemical indicators can be representative of environmental pollution.

A few of Olga Lukyanova's main publications are:

- Lukyanova O.N., Tsygankov V.Yu. 2017. Marine Ecotoxicology (study guide). Vladivostok: FEFU.
- Lukyanova O.N., Tsygankov V.Y., Boyarova M.D., Kristoforova N.K. 2015. Pacific salmon as a vector in the transfer of persistent organic pollutants in the ocean. *Russian Journal of Ichthyology*, 55, № 3, 425–429.
- Lukyanova O.N., Cherkashin S.A., Simokon M.V. 2012. Review of the modern ecological state of Peter the Great Bay. *Bulletin of the Far Eastern Branch of the Russian Academy of Sciences*, 162, № 2, 55–63.
- Lukyanova O.N., Ireykina S.A., Chernyaev A.P., Vazhova A.S., Boyarova, M.D. 2010. Ecotoxicological assessment of several estuarine zones in the south of Primorsky krai. *Russian Journal of Marine Biology*, 36, № 7, 489–496.
- Lukyanova O.N. 2006. Molecular biomarkers of energy metabolism in mussels under anthropogenic pollution of Peter the Great Bay, the Sea of Japan. *Russian Journal of Ecology*, 37, № 3, 205–209.
- Lukyanova O.N. 2003. Molecular biomarkers in the environmental monitoring of marine ecosystems. *Izvestia TINRO*, 133, 271–281
- Lukyanova O.N., Gorchakova N.K. 2003. Ecology (textbook). Far Eastern State Economic University, Vladivostok.

*This article was prepared by Dr. Lidia Kovekovdova, D.Sc., Analytical Center, TINRO and Dr. Yury Zuenko, Fisheries Oceanography, TINRO.*



MEQ Committee meeting participants, PICES-2018.

## Topic sessions and workshops at PICES-2019



- **S1: Science Board Symposium**  
**Connecting science and communities in a changing North Pacific**
- **S2: POC Topic Session**  
**Marine heatwaves in the North Pacific: Predictions and impacts in coastal regions**
- **S3: POC/MEQ/BIO Topic Session**  
**Coastal ocean modelling in the North Pacific**
- **S4: HD Topic Session**  
**The impacts of marine transportation and their cumulative effects on coastal communities and ecosystems**
- **S5: POC/BIO/FIS/FUTURE Topic Session**  
**Trends in ocean and coastal ecosystems and their services and its future**
- **S6: FUTURE Topic Session**  
**Identifying thresholds and potential leading indicators of ecosystem change: The role of ecosystem indicators in ecosystem-based management**
- **S7: MEQ Topic Session**  
**Environmental indicators of plastic pollution in the North Pacific**  
*Co-sponsored by the Northwest Pacific Action Plan ([NOWPAP](#))*
- **S8: FIS/BIO/POC Topic Session**  
**Creating more effective Integrated Ecosystem Assessments (IEAs) in PICES countries**  
*Co-sponsored by the International Council for the Exploration of the Sea ([ICES](#))*
- **S9: MONITOR Topic Session**  
**Coastal Ocean Observing Systems, Essential Biological Variables and community-based monitoring**
- **S10: MEQ Topic Session**  
**Linking changes in climate, nutrient distribution, phytoplankton ecology, and production of algal exudates in the North Pacific**
- **S11: FIS/POC/BIO/HD Topic Session**  
**Incorporating ecosystem variability and climate change into fisheries management: Progress and challenges for EBFM in the 21st century**
- **S12: POC/BIO Topic Session**  
**Impacts of meso-/submeso-scale processes on heat/material transport and on marine ecosystems**
- **S13: BIO Topic Session**  
**Implications of prey consumption by marine birds, mammals, and fish in the North Pacific**
- **S14: HD/FIS Topic Session**  
**Integrating economic and social objectives in marine resource management**
- **S15: POC/FUTURE Topic Session**  
**Advances in North Pacific marine ecosystem prediction**
- **BIO, FIS, HD, MEQ, POC Contributed Paper Sessions and a General Poster Session**



- **W1: FUTURE Workshop**

**Learn to effectively communicate your science**

- **W2: MONITOR/FIS Workshop**

**Integrating biological research, fisheries science and management of Pacific halibut and other widely distributed fish species across the North Pacific in the face of climate and environmental variability**

*Co-sponsored by the International Pacific Halibut Commission ([IPHC](#))*

- **W3: FIS Workshop**

**Let's play the GAME! (to achieve sustainable fisheries development in the PICES regions)**

- **W4: POC/BIO/FIS Workshop**

**Circulation, biogeochemistry, ecosystem, and fisheries of the western North Pacific marginal seas: Past and future of CREAMS (Circulation Research of East Asian Marginal Seas)**

- **W5: BIO Workshop**

**Celebrating two decades of North Pacific CPR sampling, and future directions**

*Co-sponsored by the CPR Survey, Marine Biological Association ([CPR Survey](#), [MBA](#))*

- **W6: HD Workshop**

**Assessing Marine Ecosystem Services: A comparative view across the North Pacific**

- **W7: SB Workshop**

**PICES contribution to Central Arctic Ocean (CAO) ecosystem assessment (Third)**

- **W8: BIO Workshop**

**Synthesis of bio-acoustics programs for monitoring zooplankton and fisheries in the North Pacific**

*Co-sponsored by [Ocean Networks Canada](#)*

- **W9: MONITOR/MEQ Workshop**

**Monitoring non-indigenous species in PICES member countries: Towards best practices**

- **W10: BIO Workshop**

**PICES/ICES collaborative research initiative: Toward regional to global measurements and comparisons of zooplankton production using existing data sets**

- **W11: FIS Workshop**

**PICES/NPFC collaborative research: The influence of environmental changes on the potential for species distribution shifts and population dynamics of Pacific saury**

- **W12: BIO Workshop**

**Potential food competition between top predators and fisheries in the North Pacific**

- **W13: FUTURE Workshop**

**Common ecosystem reference points**

- **W14: BIO Workshop**

**New frontiers: The application of molecular approaches in marine ecology and fisheries science**

- **W15: Workshop**

**Application of machine learning to ecosystem change issues in the North Pacific**

- **W16: FIS Workshop**

**Developing a collaborative, integrated ecosystem survey program to determine climate/ocean mechanisms affecting the productivity and distribution of salmon and associated pelagic fishes across the North Pacific Ocean**

*Co-sponsored by the North Pacific Anadromous Fish Commission ([NPAFC](#)) & North Pacific Fisheries Commission ([NPFC](#))*

- **W17: BIO Workshop**

**Scoping an IEA of the Northern Bering-Chukchi Seas LME**

- **W18: MEQ Workshop**

**GlobalHAB: Evaluating, reducing and mitigating the cost of Harmful Algal Blooms: A compendium of case studies**

*Co-sponsored by [SCOR](#), [ISSHA](#), [NOWPAP](#), [Greig Seafood Ltd.](#), [IOC](#), [GlobalHAB](#), [ASXAL Insurance](#), [FAO](#)*

- **W19: MEQ Workshop**

**The impacts of mariculture to coastal ecosystems**

## International Symposium Shellfish - Resources and Invaders of the North

November 5-7, 2019  
Tromsø, Norway

PICES will co-sponsor a symposium, titled *Shellfish – Resources and Invaders of the North*, with the International Council for the Exploration of the Sea (ICES) and the Northwest Atlantic Fisheries Organization (NAFO). The symposium will be held during November 5–7, 2019 in Tromsø, Norway. Convenors are Professor Gordon Kruse, University of Alaska Fairbanks, USA (PICES), Dr. Carsten Hvingel, Institute of Marine Research, Norway (ICES) and Dr. Bernard Sainte-Marie, DFO, Canada (NAFO).

The goal of this symposium is to discuss the role of cold-water shellfish both as a harvestable resource and as important ecosystem players in northern hemisphere cold marine ecosystem. There is a strong interest in both the North Pacific and the North Atlantic for shellfish resources, their population dynamics and their management, especially under changing environmental conditions. Specifically, the symposium seeks to address the following questions:

- How do we exploit them sustainably?
- Can we explain the recent changes in distribution and population dynamics for example shrimp and snow crab, and what should be the management responses?
- What are the ecological effects of invasive species, and should they be controlled by excessive harvests or managed for sustainability?
- The ecosystem effects of the boom and bust of large shellfish populations are potentially massive; can these impacts be quantified?

To address these questions, the symposium will consist of five theme sessions:

1. Shellfish in new and changing environments
2. Assessment and population dynamics of shellfish
3. New ways of harvesting shellfish
4. Managing shellfish fisheries
5. The grand shellfish discussion session

The 3-day symposium will consist of plenary sessions and poster presentations. Sessions will include invited and contributed papers. Contributed papers will be selected for oral and poster presentations. The **deadline for abstract submissions is August 15, 2019**. Accepted written contributions will be published in the ICES Journal of Marine Science. The **deadline for manuscript submissions is February 8, 2020**. **Deadline for Early-bird registration is July 15, 2019. Final registration is October 31, 2019**. A limited amount of funding is available to early career scientists to help support travel, which will be handled by the ICES Secretariat.

For details, see the symposium website:

<https://www.ices.dk/news-and-events/symposia/shellfish/Pages/default.aspx>

For questions, contact the PICES co-convenor, Prof. Gordon Kruse ([Gordon.Kruse@alaska.edu](mailto:Gordon.Kruse@alaska.edu))





## The Northeast Pacific: Current status and recent trends

by Tetjana Ross, Charles Hannah and Frank Whitney

Since 2014, when the research community in the Northeast Pacific first took notice of the sustained anomalously high sea surface temperatures that was nicknamed the “Blob”, a lot of attention has been paid to this particular marine heatwave. Both in terms of understanding why it occurred (e.g., Bond *et al.*, 2015; Di Lorenzo and Mantua, 2016) but also its impacts (e.g., Whitney 2015; Cavole *et al.*, 2016; McCabe *et al.*, 2016).

While that particular marine heatwave was extreme, marine heatwaves are becoming more common (Oliver *et al.*, 2018) and, both last month (Fig. 1c) and over the past 6 months (Fig. 1a), sea surface temperatures have been above average in the Northeast Pacific.

Since the time when the Blob was first noted and named (Bond *et al.*, 2015), a new classification and naming scheme for marine heatwaves has been proposed (Hobday *et al.*, 2018). In this scheme, marine heatwaves are considered Category I (moderate) if the anomalies (relative to the climatological seasonal cycle) exceed the 90<sup>th</sup> percentile, Category II (strong) if they exceed 2 times this increment, and so on through Categories III (3×; severe) and IV (4×; extreme). Of all the example marine heatwaves discussed in

Hobday *et al.* (2018), the Blob was the longest (711 days), but not the most intense (the Blob reached Category III, but not IV like the Western Australia marine heatwave of 2011). They also recommend only naming an event once it reaches at least Category II and to use a name that indicates both the geographic location and the year which it reaches its maximum intensity. Note that marine cold waves are neglected in this analysis, but could be equally well represented under the proposed classification scheme.

When this classification scheme is applied to near real-time sea surface temperature (SST) data (Fig. 2), we can see that much of the Northeast Pacific was experiencing a Category I or II marine heatwave as of June 12, 2019.

Additionally, by focusing in on one pixel on the map above (choosing, for example the approximate center of the 2014–2015 marine heatwave: 47°N, 138°W), we can see that over the NOAA Extended SST v4 timeseries, the number of marine heatwaves has increased, both in number and intensity (Fig. 3). Note that while in an area average sense the Blob only reached Category III (Hobday *et al.*, 2018), at its center it reached Category IV on two occasions during 2014–2015 (rightmost bar in Fig. 3).

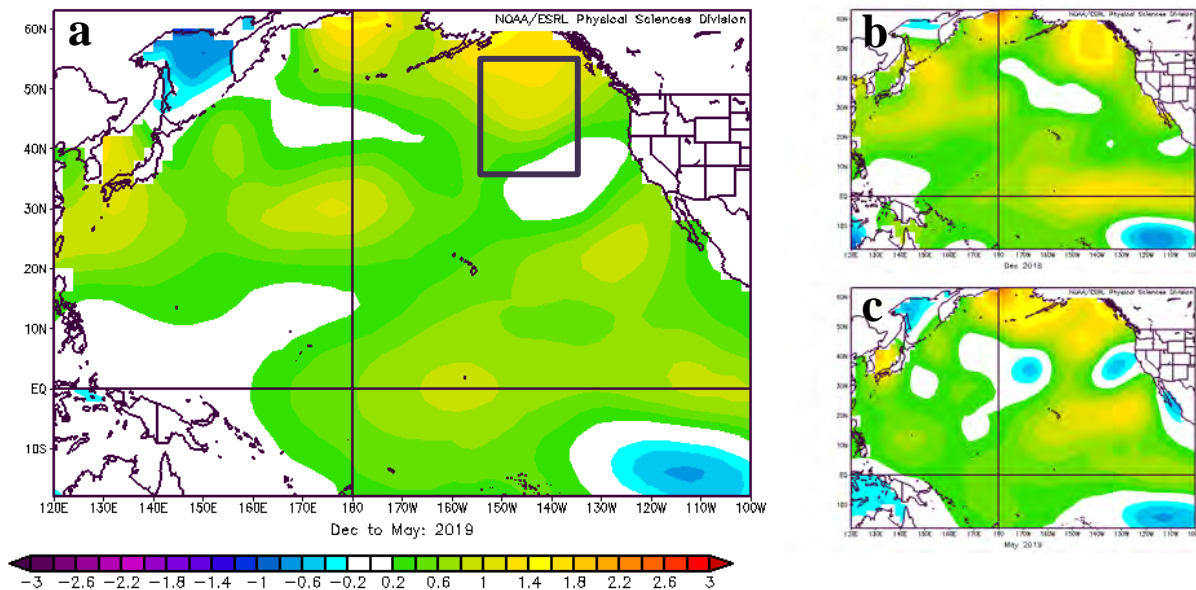


Fig. 1 Maps of temperature anomalies in the Pacific Ocean for (panel a) December 2018–May 2019, (panel b) December 2018 and (panel c) May 2019. The colour bar on the bottom, showing the temperature anomaly in °C, applies to all panels. The brown rectangle indicates the area averaged over in Figure 4. Source: NOAA Extended SST v4 <http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl>.

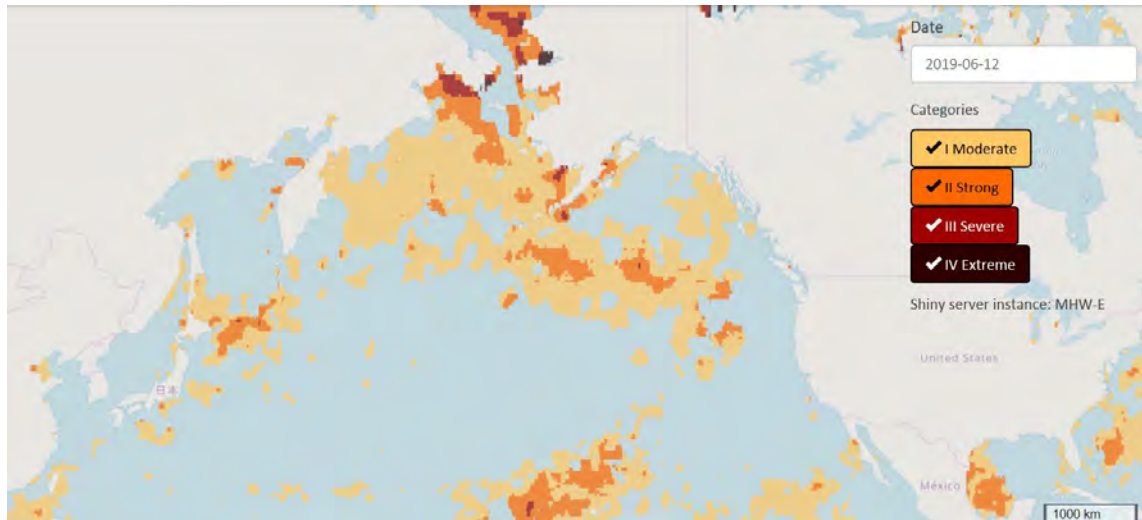


Fig. 2 Maps of marine heatwave categories calculated from sea surface temperature anomaly data from the same NOAA Extended SST v4 dataset shown in Figure 1. The marine heatwave conditions for June 12, 2019 are shown. Source: Marine heatwave tracker website: <http://www.marineheatwaves.org/tracker.html>.

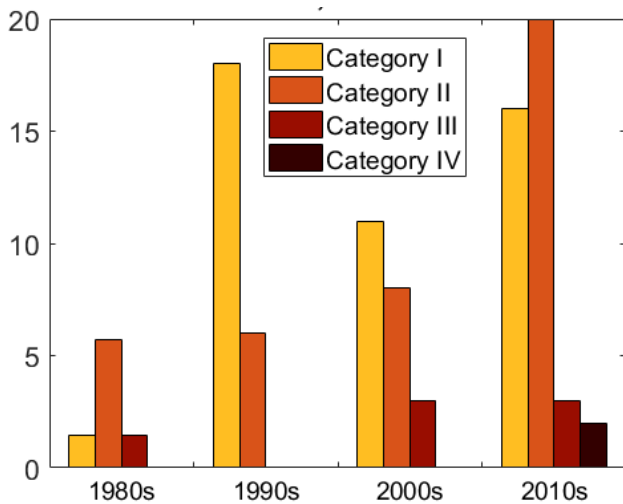


Fig. 3 Frequency of the maximum categories of 93 separate marine heatwave events at the location 47°N, 138°W grouped by decade. Note that the frequencies in the 1980s were increased by a factor of 1.43 to account for the missing 3 years. Source: Marine heatwave tracker website: <http://www.marineheatwaves.org/tracker.html>.

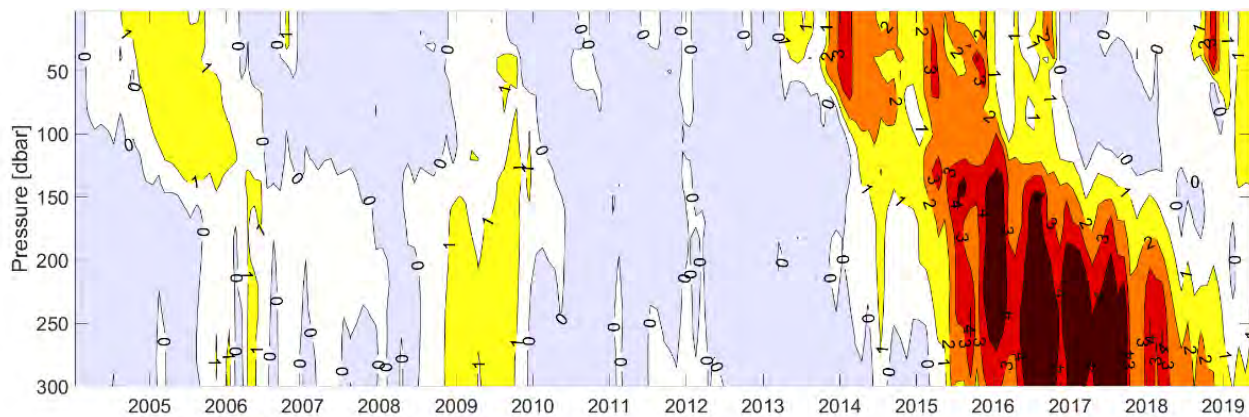


Fig. 4 False colour plot of temperature anomalies as observed by Argo floats in the Northeast Pacific. The anomalies are coloured based on their categorization in the Hobday et al. (2018) scheme (the light blue colour indicates cooler than average temperatures). To create the time series, the Roemmich and Gilson (2009) gridded Argo temperature dataset were spatially-averaged over 35–55°N and 135–155°W (box shown in Fig. 1a), anomalies calculated at each monthly time step by subtracting the 2004–2013 seasonally-corrected mean and then scaled to intensity (Hobday et al., 2016) by dividing by the 2004–2013 seasonally-corrected 90<sup>th</sup> percentile increment.



It might also be useful to apply this categorization scheme to the sustained deep temperature anomalies in the Northeast Pacific reported on in the last two PICES Press updates for this region (Ross *et al.*, 2018; 2019), as can be seen in Figure 4. This analysis, which is limited because it uses the Argo-based climatology of only 9 years of data prior to the arrival of the Blob (2004–2012, inclusive), agrees with the SST analysis presented above (Figs. 2 and 3) and in Hobday *et al.* (2018). The Blob was a sustained marine heatwave that reached Category 3. The more recent heatwave, late fall 2018, was much shorter, but was intense enough to merit naming. However, what is most remarkable is the subsurface temperature anomalies in 2016 and 2017. These would be classified as a Category IV anomaly – even when averaged over a large section of the Northeast Pacific (35–55°N, 135–155°W). Note, however, that while the intensity is very high below 150 dbar, this is because the variability was historically smaller. The absolute anomalies between 200 and 300 dbar were less than 0.4°C, while the surface anomalies exceeded 1.5°C.

**Acknowledgements:** The Argo data were collected and made freely available by the [International Argo Program](#) and the national programs that contribute to it. The Argo Program is part of the Global Ocean Observing System.

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## The Bering Sea: Current status and recent trends

by Lisa Eisner

### Climate and oceanography

In an overall sense, the Bering Sea had warmer than normal weather during the period October 2018 through March 2019. This was especially the case for the northern Bering Sea into the Chukchi Sea during the 6-month period, with surface temperature anomalies of about 5°C (Fig. 1).

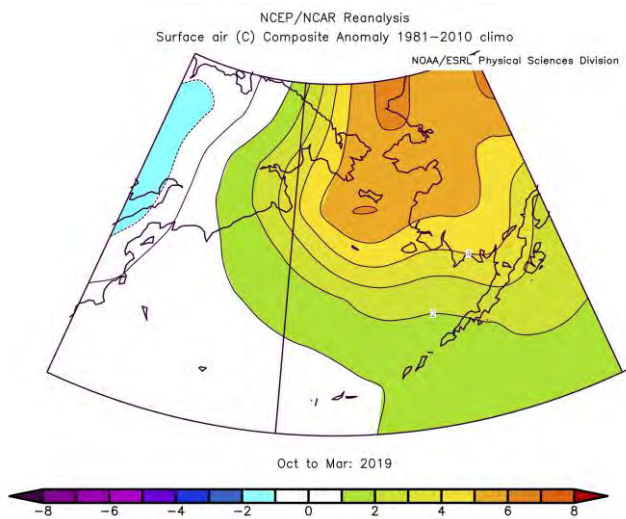


Fig. 1 Mean surface air temperature anomalies (°C) from the NCEP/NCAR Reanalysis for October 2018 through March 2019. Figure courtesy of Nick Bond, NOAA Pacific Marine Environmental Lab (PMEL).

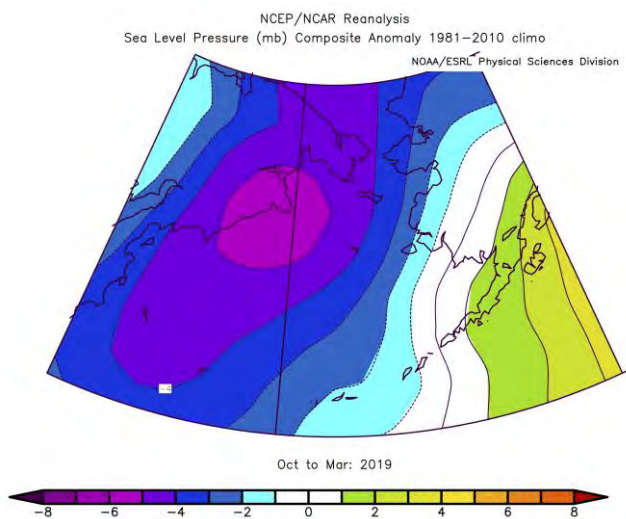


Fig. 2 Mean sea level pressure (SLP) anomalies (mb) from the NCEP/NCAR Reanalysis for October 2018 through March 2019. Figure courtesy of Nick Bond, NOAA, PMEL.

This pattern was remarkably similar to that of the previous year (October 2017 through March 2018), with the more recent fall/winter being somewhat less extreme. The two periods featured similar atmospheric circulation patterns with lower than normal sea level pressure (SLP) to the west and higher than normal pressure over the Gulf of Alaska (Fig. 2), resulting in wind anomalies from the south. The magnitudes of these mean wind anomalies ranged from 2 to 3.5 m s<sup>-1</sup> over the eastern Bering Sea shelf during October 2018 through March 2019, less than the year before, but still substantial relative to the usual anomalies, which are typically 1–2 m s<sup>-1</sup> in magnitude.

The seasonal mean temperature and wind anomalies illustrated above are not the entire story; the six-month period included substantial sub-seasonal variability. In particular, strong winds from the north accompanied by relatively low air temperatures and the rapid development of sea ice occurred in the northern Bering Sea during roughly the last 3 weeks of December 2018. That interval was followed by a sudden reversal to milder weather that prevailed for most of the remainder of winter. This was notably the case during the month of February 2019, which included wind anomalies from the south exceeding 10 m s<sup>-1</sup> in the central Bering Sea, and air temperature anomalies of astounding magnitudes (~12°C) along the west coast of Alaska. This is usually a time of year with increasing ice extent on the Bering Sea shelf, but not during 2019.

It is interesting that 2017–2018 and 2018–2019 had similar atmospheric circulation anomalies in light of the state of El Niño-Southern Oscillation (ENSO) during the two years. A weak Aleutian Low, with higher than normal SLP south and east of the Aleutian Islands, generally accompanies La Niña, as was present during the fall and winter of 2017–2018. But a similar distribution of anomalous SLP materialized during 2018–2019, despite the presence of El Niño. The latter event was only of weak-moderate intensity. Nevertheless, the global-scale teleconnection pattern accompanying it, namely related to the seasonal mean weather for the North Pacific and North America, little resembled that associated with previous tropical Pacific events of its nature.

The spring of 2019 was marked by a reversal in the SLP anomaly pattern in the region of interest (Fig. 3). Modestly higher than normal SLP was present over the western Bering Sea during the period of April 1 through June 13, 2019, implying suppressed storminess and cloud cover over the western and central Bering Sea. This feature probably served to help maintain the higher than normal sea surface temperatures in the Bering Sea that have been the rule for the last 5–6 years. The climate models used for seasonal weather predictions are suggesting elevated odds of higher than normal pressure over the Bering Sea during the upcoming summer, particularly



during the months of August and September 2019 (not shown). These models have limited skill at predicting atmospheric circulation anomalies during the summer, but if they are correct, upper ocean temperatures on the eastern Bering Sea shelf are apt to be considerably warmer than normal into fall 2019.

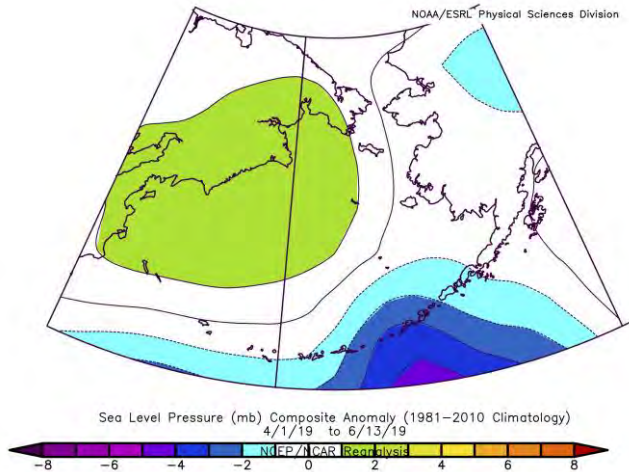


Fig. 3 Mean sea level pressure (SLP) anomalies (mb) from the NCEP/NCAR Reanalysis for 1 April through 13 June 2019. Figure courtesy of Nick Bond, NOAA, PMEL.

**Sea ice extent**

For the second year in a row, sea ice extent was drastically reduced by late winter 2018–2019 (Fig. 4). Extent was average from November through January, then decreased in

February in part due to winds from the south (described above), similar to winter 2017–2018.

Satellite images from March/April 2019 showed the reduced sea ice extent in the northern Bering Sea (Fig. 5). The low sea extent ice may be detrimental to organisms and people for which sea ice is a resource, with warming and changes in sea ice the subject of ongoing fisheries and oceanography surveys by several countries.

**Preview of ecosystem and economic conditions**

The NOAA Alaska Integrated Ecosystem Assessment (IEA) Program held a 2-day workshop at the Alaska Fisheries Science Center (AFSC) in Seattle Washington, June 6–7, 2019. Over 40 regional experts met to exchange information on early physical, biological, and economic conditions to inform the fall fisheries stock assessment cycle. The main objective was to identify any areas of concern or unusual conditions that may be relevant to stock and ecosystem assessments. These warning signals will be tracked through the summer field season. Those that continue to be of concern will be presented to the North Pacific Fisheries Management Council in October, when they begin to review the science supporting the annual groundfish stock assessments. The early warning and final ecosystem assessments will be included in the ecosystem status reports of the eastern Bering Sea, which will be available publicly December 2019. This workshop was a great success with annual meetings planned for the future.

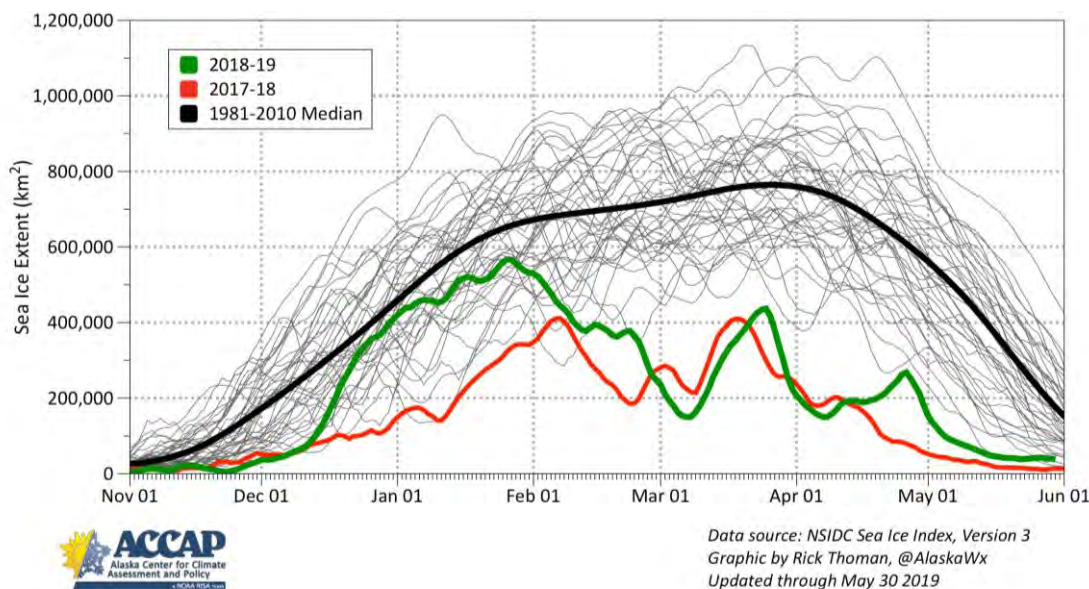


Fig. 4 Bering Sea daily sea ice extent for winter 2018–2019 (green), and winter 2017–2018 (red) compared to prior winters, 1978–1979 to present. Area includes the eastern and western Bering Sea.

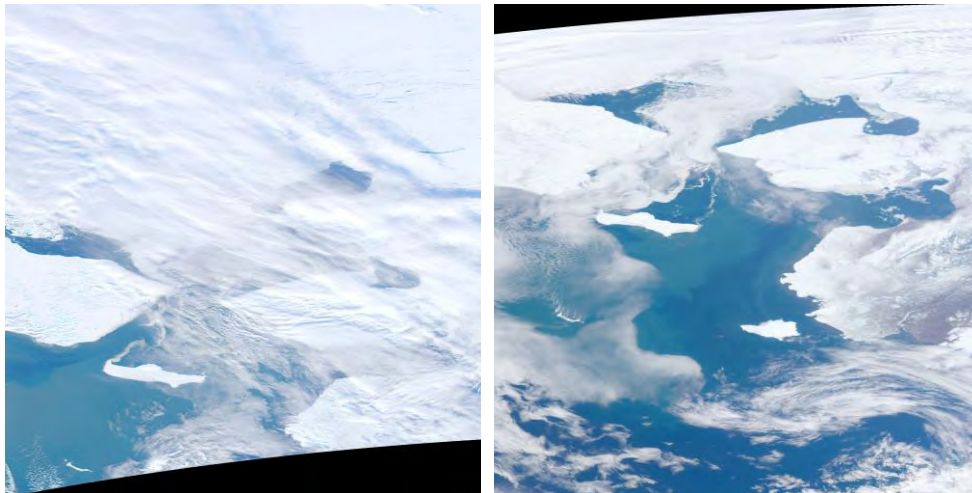


Fig. 5 True color images of the northern Bering Sea and Bering Strait on March 2 (left) and April 1 (right), 2019. Images courtesy of Toru Hirawake, Hokkaido University, Japan.

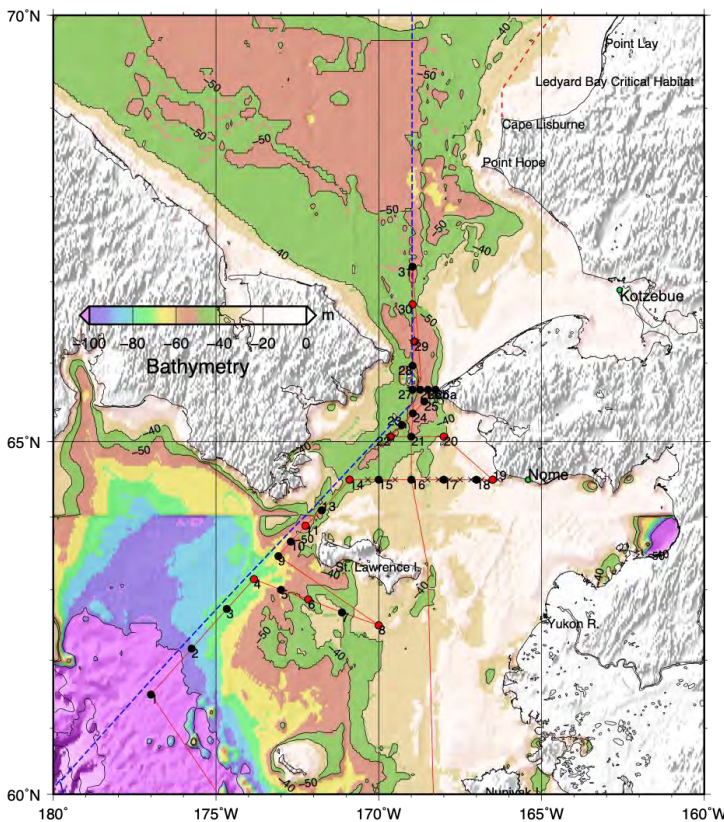


Fig. 6 Map of sampling stations in July 2018. Black and red circles show routine and biological stations, respectively. Cross shows XCTD station (along stations 14 to 19). Figure courtesy of Toru Hirawake, Hokkaido University, Japan.

**2018 summer survey in the northern Bering and Chukchi seas**

T/S *Oshoro-maru*, Faculty of Fisheries Sciences, Hokkaido University, carried out oceanographic and ecosystem surveys in the northern Bering and southern Chukchi seas in July 2018 with support from the Arctic Challenge for Sustainability (ArCS) project (Fig. 6). CTD, XCTD (Expendable Conductivity/Temperature/Depth), ADCP, water sampling, optical measurements, retrieval of

mooring (sediment trap), plankton sampling, benthos sampling, sighting survey of seabirds and mammals, and fish sampling with kite-trawl and MOHT net were conducted.

Scientists observed several unusual phenomena during the cruise, which may be similar to findings on other cruises in 2018. Bottom water at stations south of St. Lawrence Island was warmer than that in the past. Chlorophyll concentrations for the Anadyr water in the Bering Strait were very low. While large abundances of walleye pollock and Pacific cod were found in the northern Bering Sea, Arctic cod almost disappeared from the surveyed area.

**2019 summer and fall surveys in Bering and Chukchi seas**

- PMEL and AFSC, NOAA will conduct mooring work, and oceanography and plankton sampling on board the NOAA Ship *Oscar Dyson*, September.
- AFSC, NOAA will conduct bottom trawl surveys to monitor commercial fish and shellfish stocks in the eastern and northern Bering Sea, May–September.
- AFSC, NOAA will conduct forage fish and oceanography surveys in the northern Bering Sea, August/September.

Arctic Integrated Ecosystem Surveys will be conducted by AFSC, NOAA along with national and international partners as well as Alaska Native communities. Oceanography, plankton and fisheries data will be collected onboard the R/V *Ocean Starr*, August–September. Scientists will use these data to document the current environmental state of the U.S. High Arctic and examine any biological and ecological responses to the changing environment.

(continued on page 39)



## The western North Pacific during the 2018/2019 cold season

by Takafumi Umeda

The western North Pacific was characterized by positive anomalies of sea surface temperatures (SSTs) to the east of

Japan, especially along the Kuroshio Extension, throughout the 2018/2019 cold season (Fig. 1).

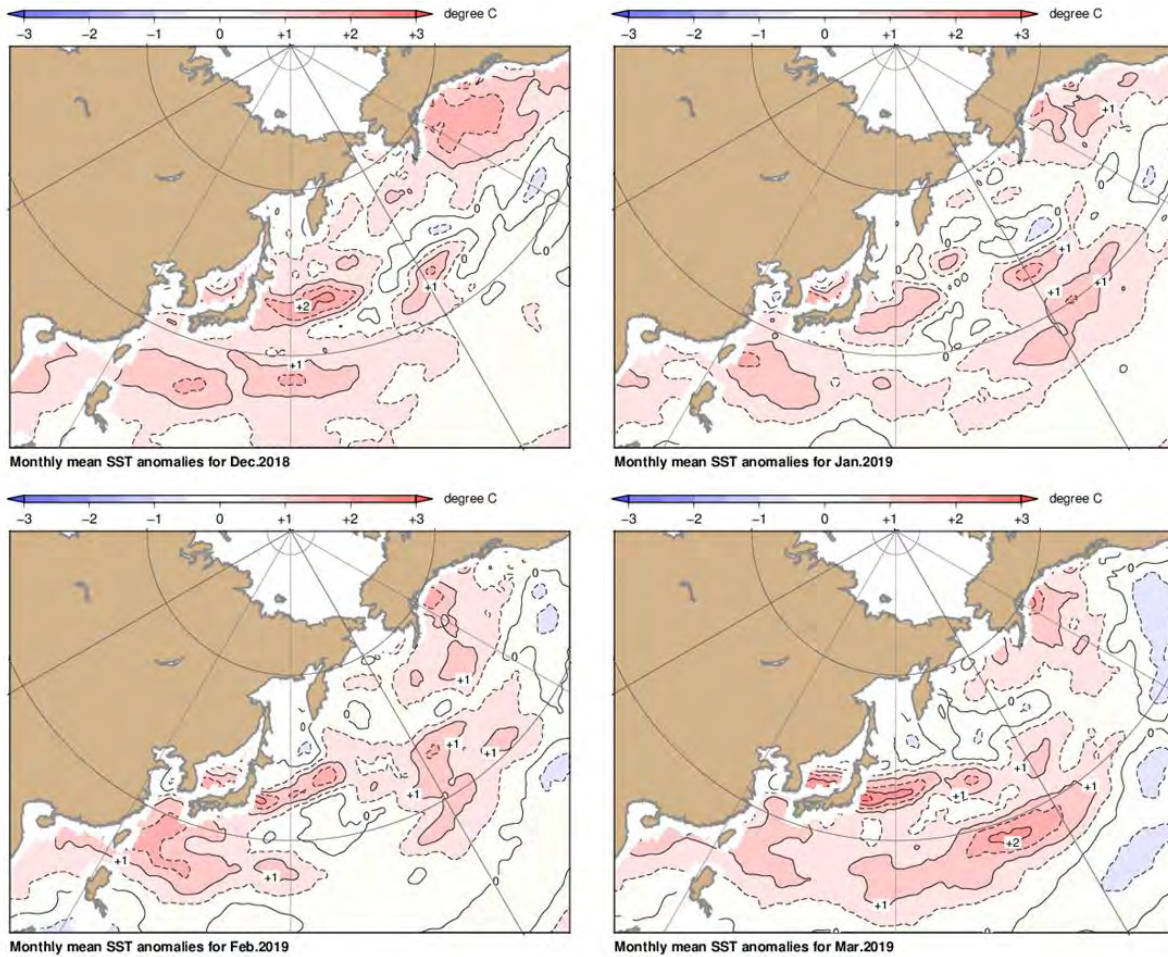


Fig. 1 Monthly mean sea surface temperature anomalies from December 2018 to March 2019. Monthly mean SSTs are based on JMA’s COBE-SST (centennial in-situ observation-based estimates of variability for SST and marine meteorological variables). Anomalies are deviations from the 1981–2010 climatology.

The winter maximum sea ice extent in the Sea of Okhotsk was 1.20 million km<sup>2</sup> in early March, which was very similar to the 30-year average of 1.17 million km<sup>2</sup>. The seasonal maximum exhibits a long-term decreasing trend of 0.062 million km<sup>2</sup> per decade, which corresponds to 3.9% of the Sea of Okhotsk’s total area (Fig. 2).

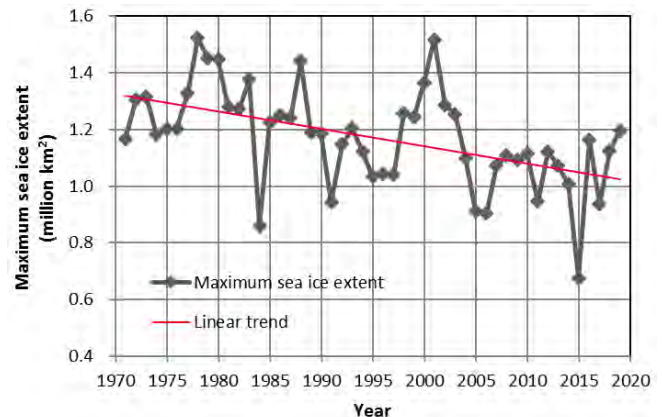


Fig. 2 Time series of winter maximum sea ice extent in the Sea of Okhotsk from 1971 to 2019. The red line denotes the long-term linear trend.

**The third-longest period of Kuroshio large-meander event on record**

As previously reported in PICES Press (Vol. 26, No. 2 and Vol. 27, No. 1), the Kuroshio has followed a large meander (LM) path since the summer of 2017. As of April 2019 the period of meander event had continued for a year and nine months, which is the third longest since records began in 1965 (Fig. 3 and Table 1).

Table 1 Historical Kuroshio large-meander periods since 1965.

Period	Duration
Aug. 1975 – Mar. 1980	4 years, 8 months
Nov. 1981 – May 1984	2 years, 7 months
Dec. 1986 – July 1988	1 year, 8 months
Dec. 1989 – Dec. 1990	1 year, 1 month
July 2004 – Aug. 2005	1 year, 2 months
Aug. 2017 – Ongoing	1 year, 9 months (as of April 2019)

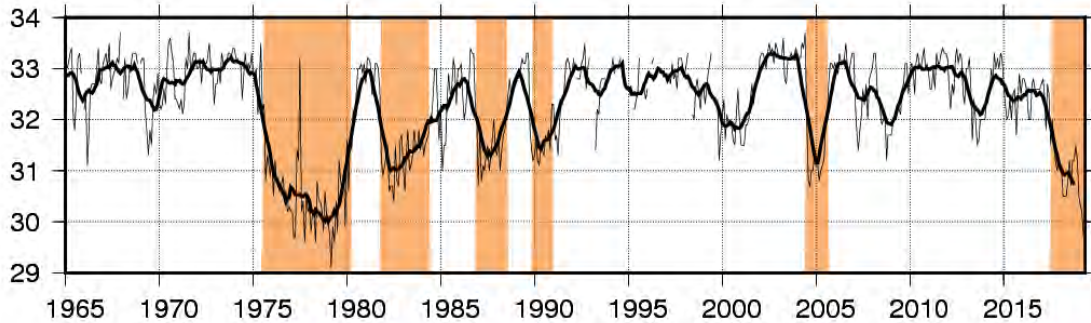


Fig. 3 Time-series representation of the southernmost latitude of the Kuroshio path south of Japan (136–140°E). Shading indicates periods of Kuroshio large-meander events, the thin line indicates monthly values, and the thick line indicates 13-month running means. Kuroshio large-meanders are defined as being south of 32°N.

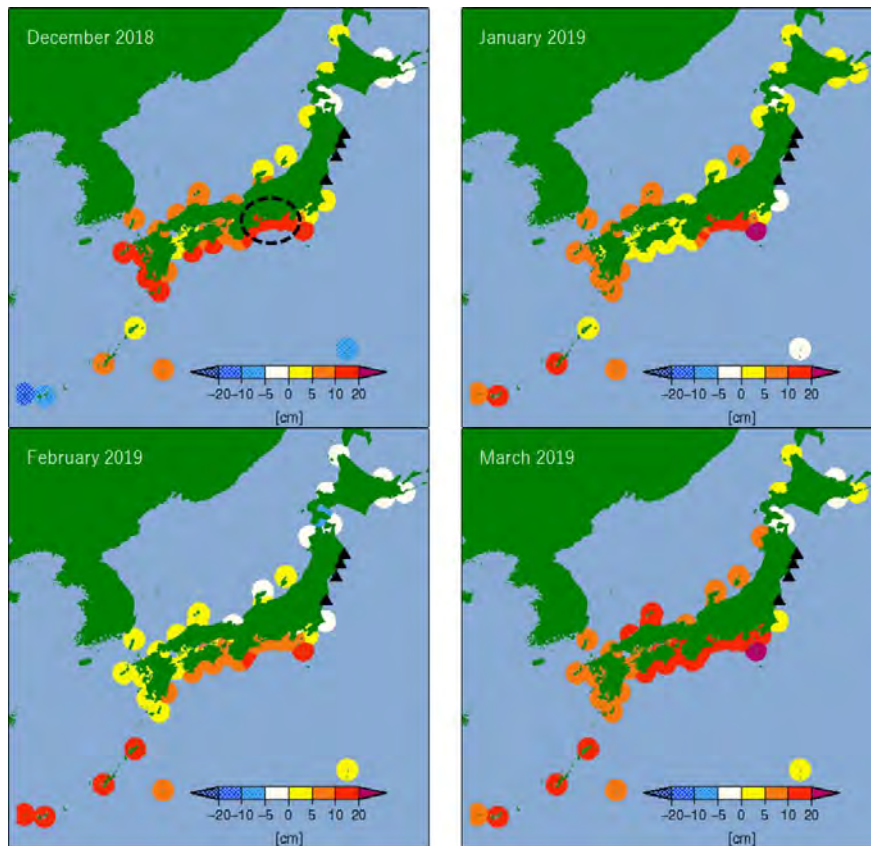


Fig.4 Monthly mean sea level anomalies from December 2018 to March 2019. Anomalies are deviations from the previous five-year mean. Black triangles indicate unused tide stations due to the influence of the 2011 Great East Japan Earthquake. The dashed oval in the top-left panel shows the coast of the Tokai region.



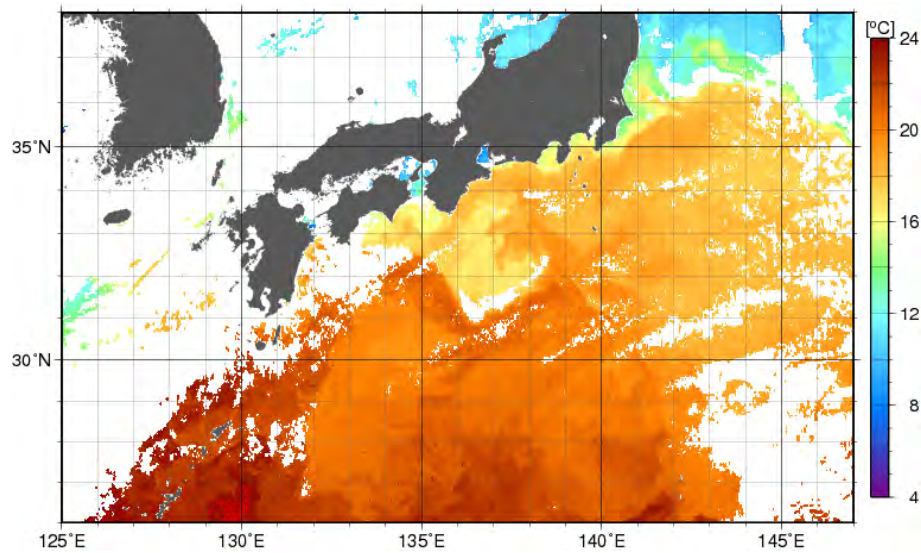


Fig. 5 Composite of sea surface temperatures for February 3, 2019 (00–11 UTC) as observed by Himawari-8.

Kuroshio LM events have implications on sea levels along the southern coast of Japan as well as fishing grounds and the shipping economy. Sea levels around the Tokai region from December 2018 to March 2019 were higher than

normal (compared to the mean for the previous five years) (Fig. 4). Frequent warm-water intrusion events from the Kuroshio during this period, as illustrated in Figure 5, are considered to have contributed to these higher sea levels.



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(continued from page 36)

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