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FUTURE and the FUTURE Open Science Meeting — The future of FUTURE

by Harold (Hal) Batchelder

FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) is the second integrative science program implemented by PICES. The first science program of PICES, the Climate Change and Carrying Capacity (CCCC) program, had a goal of increasing understanding of climate influences on marine ecosystems, especially as climate might impact the carrying capacity of the North Pacific to support fish resources. The goals of FUTURE go beyond understanding climate effects to understanding how marine ecosystems in the North Pacific respond to climate change *and human activities*, to *forecast ecosystem status* based on a contemporary knowledge of how nature functions, and to *communicate new insights* to its members, governments, stakeholders and the public. This is a much broader mandate than that expected from the CCCC program. It also includes new, and in some cases, unfamiliar or difficult aspects such as developing useful (*e.g.*, skillful, with uncertainty estimates) climate–ecosystem products and engaging with non-scientific stakeholders to determine what products are useful and desired, and how to deliver those to receptive audiences.

The leadership of PICES, while very satisfied with the scientific productivity of the CCCC integrative program, felt there was a disconnect between the program and the six standing committees of PICES, which are oriented along the disciplines or technical needs of the Organization. Thus, there was a desire to better integrate the activities of FUTURE into the committees. This was done by tasking the leadership of FUTURE to the PICES Science Board, which includes as its members the chairman of each committee. Science Board receives advice from three Advisory Panels (AP) that make up FUTURE, whose chairs are also members of Science Board: AP-COVE: *Climate Ocean Variability and Ecosystems*, AP-AICE: *Anthropogenic Influences on Coastal Ecosystems*, and AP-SOFE: *Status, Outlooks, Forecasts and Engagement*.

New expert groups would be proposed, and if approved by Council, established to work on new tasks that require specific expertise or focused effort. Since the start of FUTURE in October 2009, six new working groups, two sections and five study groups have been created to specifically address scientific issues relevant to FUTURE.

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The new working groups established specifically to address components of FUTURE are: WG 26, *Jellyfish Blooms around the North Pacific Rim: Causes and Consequences*; WG 27, *North Pacific Climate Variability and Change*; WG 28, *Development of Ecosystem Indicators to Characterize Responses to Multiple Stressors*; WG 29, *Regional Climate Modeling*; WG 30, *Assessment of Marine Environmental Quality of Radiation around the North Pacific*; and WG 31, *Emerging Topics in Marine Pollution*. These working groups have clearly defined terms of reference, and are expected to complete their tasks usually within three, or exceptionally four, years. The two new Sections on *Climate Change Effects on Marine Ecosystems* (S-CCME) and *Human Dimensions of Marine Systems* (S-HD), created to advance FUTURE objectives, are expected to continue during the entire program. The Study Groups on *Socio-Ecological-Environmental Systems* (SG-SEES) and *Biodiversity Conservation* (SG-BC) were approved by Governing Council at PICES-2013. A common result from study groups is the recommendation of a longer term group, usually a working group, to pursue the problem over multiple years. SG-SEES will develop an integrated Social-Ecological-Environmental model case study of hypoxia and acidification in a coastal ocean and recommend a suitable focus region. SG-BC will review drivers of biodiversity change in the North Pacific, identify new approaches for advancing biodiversity-base research in the North Pacific, review past biodiversity research and identify potential collaborations and the potential to provide evidence-based advice for informing diversity conservation and management. Both new study groups will meet at PICES-2014 in Yeosu, Korea.

A workshop to develop a FUTURE "roadmap" was held in May 2012 to provide higher level coordination of the various expert groups that are contributing to furthering the FUTURE objectives. A roadmap (basically sufficient information to get from where we were two years ago to where we want to be in 2019, when FUTURE will be 10 years old) was developed. What emerged from this meeting was more a timeline than a map, but it did provide indications of what new expert groups might be needed and what FUTURE activities would occur. Included in the roadmap were:

- Products (new science knowledge, status reports, forecasts and outlooks, outreach and engagement),
- Expert group contributions and future needs, and
- Events (*e.g*., symposia, workshops).

Roadmaps with these "landmarks" are updated about twice a year and can be viewed at http://pices.int/members/scientific_programs/FUTURE/FUTURE-roadmap.aspx.

Also at this workshop, PICES expert groups described products that might emerge from the FUTURE activities within the next 2–3 years, which is about at the time that this article is being written. It was recognized at the meeting that products should be driven by demand from stakeholders, which were (a) not represented at the workshop, and (b) have not yet been surveyed or asked to specify their needs. Products available within a few years were judged to be sufficiently close that they were likely to appear during FUTURE but still provide time to identify receptive audiences (outside of the scientific community). PICES took an adaptive approach to focus on products that will be ready for communication soon, and to identify and contact potential users to begin dialog to make products relevant to their needs. Fifteen "potential" FUTURE products were listed in a PICES Press (Vol. 20, No. 2, pp. 5–8) article about the ISB-2012 meeting and roadmap workshop. While many are actively being worked on, or perhaps are ready, none have, to this writer's knowledge, actually been delivered to non-scientist stakeholders. Another recommendation that emerged from the roadmap workshop was to hold a FUTURE Open Science Meeting in the spring of 2014. This meeting was to serve many purposes, but I will mention only two here. First, to showcase (and dare I say, celebrate) the breadth and depth of FUTURE-related science that has been accomplished and second, to provide an opportunity for self assessment and external critique of the FUTURE program goals, progress and structure. The convenors of most of the scientific sessions and workshops have written summaries for this newsletter, which I personally thank them for their efforts on organizing, convening and summarizing these sessions/workshops. As to the assessment and critique, I will leave that to the FUTURE Evaluation Team.

Dr. Hal Batchelder (hbatch@pices.int) is the Deputy Executive Secretary of PICES (since February 2014). Prior to assuming that position he was a Professor in the College of Earth, Ocean and Atmospheric Sciences (CEOAS) at Oregon State University. Hal has contributed to PICES in diverse ways previously: Co-chairman of the Climate Change and Carrying Capacity integrative science program and Science Board member; member of several study groups and working groups; member of AP-SOFE; and U.S. delegate to the PICES Governing Council. His research specialization is biological oceanography and ocean ecology, with emphasis on zooplankton population and community ecology, and the coupling of ecological processes to ocean physics using numerical models. Recent interests have included design of Marine Protected Areas, and the changing incidence of hypoxia on the U.S. west coast and its potential impacts on shelf organisms.

2014 Inter-sessional Science Board Meeting: A note from the new Science Board Chairman

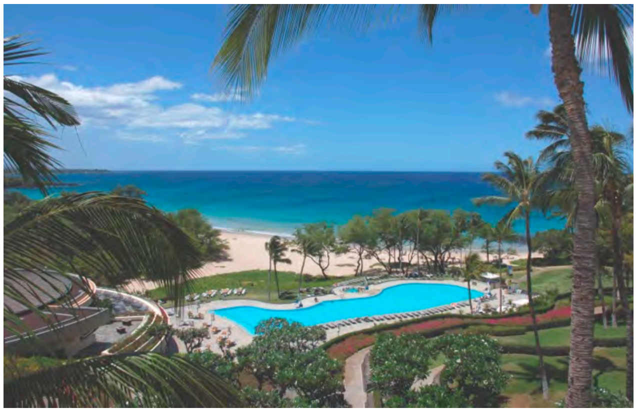
In recent years it has become a tradition to have the PICES inter-sessional Science Board (ISB) meeting in conjunction with another meeting or workshop. This year was no exception as we met April 19–21 right on the heels of the PICES FUTURE Open Science Meeting (OSM) which was held on the Kohala Coast on the Big Island of Hawaii. FUTURE (**F**orecasting and **U**nderstanding **T**rends, **U**ncertainty and **R**esponses of North Pacific Marine **E**cosystems) is the second integrative science program of PICES. Planning for the OSM had been in the works for about 2 years, and the meeting was a tremendous success as you will see from the session and workshop summaries in the following pages. In addition, since the OSM was planned around the mid-point of the FUTURE program, Science Board decided it would be an opportune time to review progress, identify gaps, and set the course for the last half of this decade-long program. Science Board, which also functions as the Scientific Steering Committee (SSC) for FUTURE, established an Evaluation Team that consisted of some scientists involved in FUTURE and others knowing little about the program, to conduct a review and provide an assessment and recommendations to PICES. The Evaluation Team report and comments from the PICES standing committees and FUTURE Advisory Panels will soon be available on the PICES website. The Team did an exceptional job and although they found progress was great in many areas, there were other parts of FUTURE where progress was lagging, and where extra attention and refocusing is needed. Science Board will discuss the report over the summer and will engage the broader PICES community about possible changes in FUTURE during a day-long meeting on Sunday, October 19 at PICES-2014 in Yeosu, Korea. I encourage all PICES attendees to participate in this meeting, since FUTURE is identified as a high priority activity of the Organization. Please plan to arrive in Yeosu in time to contribute to this important discussion. ISB-2014 was my first official meeting as Science Board Chairman after taking over from Sinjae Yoo following PICES-2013 in Nanaimo, Canada.

FUTURE Evaluation Team members (from left): Jake Rice, Jackie King, Julie Hall, Manuel Barange, Bill Peterson, and Shin-ichi Ito.

Participants of the ISB-2014 meeting (from left): Chuanlin Huo (MEQ), Phillip Mundy (AP-SOFE), Enrique Curchitser (Governing Council), Adi Kellermann (ICES), Michael Foreman (POC), Tom Therriault (Science Board Chairman), Hal Batchelder (PICES Deputy Executive Secretary), John Stein (Governing Council), Alex Bychkov, (PICES Executive Secretary), Hiroaki Saito (Science Board Vice-Chairman), Steven Bograd (MONITOR), Angelica Peña (BIO), Chul Park (PICES Vice-Chairman), Ken Mori (F&A), Libby Logerwell (FIS), Jennifer Boldt (MONITOR), Hideaki Maki (MOE, Japan), Igor Shevchenko (representing Russia), Toru Suzuki (TCODE), Karin Baba (Japan), Laura Richards (PICES Chairman), Robin Brown (Governing Council), Guangshui Na (WG 31).

However, I was not the only one with a new leadership role as this was also the first Science Board meeting for Jennifer Boldt (Technical Committee on Monitoring), Angelica Peña (Biological Oceanography Committee), and Steven Bograd (FUTURE Advisory Panel on *Anthropogenic Influences on Coastal Ecosystems*) who now has my old job. Also, Hiroaki Saito was unanimously approved as Science Board Vice-Chairman, and so I welcome Hiroaki in this new capacity.

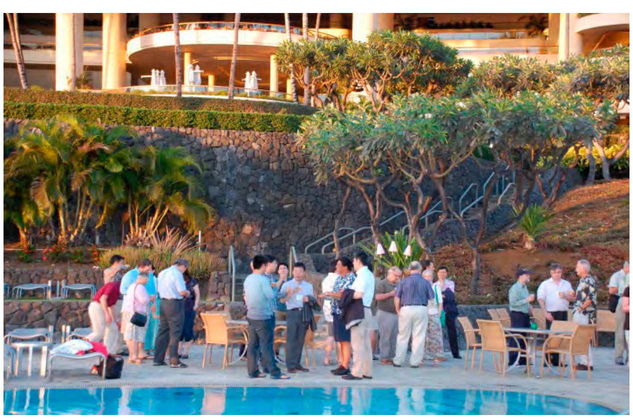
As the science that PICES conducts and fosters enlarges in scope, so too does the need for strategic (and technical) collaboration with other organizations. PICES and ICES have a shared interest in Northern Hemisphere marine science issues and established a framework for strategic cooperation (approved in 2011), joint working groups, and have convened a number of jointly sponsored symposia, workshops, and topic/theme sessions. At ISB-2014 we discussed two joint PICES/ICES symposia, the 6th Zooplankton Production Symposium which continues an extremely productive series and a proposal for a Symposium on small pelagic fish tentatively entitled "*Drivers of dynamics of small pelagic fish resources*" that will revisit this very important topic that has once again emerged at the global research level. Both will take place in 2016 and details on both of these events will be posted online as they become available. Also, PICES and ICES will be very busy with the 3rd Climate Change Symposium next year in Santos, Brazil. PICES and ICES in the coming year will review their framework for strategic cooperation to ensure emerging research topics are included, something that was intended in the original framework. As you may recall from previous updates in PICES Press (see Vol. 20, No. 1, p. 13) these types of frameworks have been used to identify other organizations/programs where increased collaboration would be a mutual benefit. PICES Science Board approved a similar framework for collaboration with the North Pacific Anadromous Fish Commission (NPAFC) following a recommendation from a Study Group established to develop the framework. Another organization with overlapping interests and geographical extent with PICES is NOWPAP (Northwest Pacific Action Plan) which is a Regional Seas Program of the United Nations Environment Program (UNEP). China, Japan, Korea and Russia are members of both organizations. NOWPAP and PICES have a long history of cooperative efforts. A joint Study Group was recommended by Science Board and approved by Governing Council in early July to explore strategic cooperation with NOWPAP. The Study Group will begin work this summer by correspondence and have a face-to-face meeting in Yeosu in October. These are but a few examples of PICES collaboration – as the depth and breadth of PICES science continues to grow, so does our need (and desire) to work with others in the scientific community.



Views from the Hapuna Beach Prince Hotel where the FUTURE Open Science Meeting and ISB-2014 were held.

Capacity attendance at the FUTURE OSM in April.

Former Science Board Chairman, Dr. Sinjae Yoo, presenting an overview of FUTURE.



Conversations carried over from the OSM rooms to poolside.

This will ensure a vibrant and responsive organization with expertise in many areas of North Pacific marine science.

ISB-2014 provided an opportunity for Science Board to discuss a new project recently funded by the Japanese Ministry of the Environment (MOE) on the effects of tsunami debris, including invasive species, on the coasts of North America and Hawaii. This new project will be centered on three themes: modeling debris transport; surveillance and monitoring; and aquatic invasive species. The project Co-Chairmen are Hideaki Maki (Japan), Nancy Wallace (USA), and myself. These Co-Chairmen represent different research areas and will be supported by a Project Science Team comprised of Hiroshi Kawai and Atsuhiko Isobae (Japan); Jim Carlton and Amy McFadden (USA); and Robin Brown (Canada). This group will have a strategic planning meeting this summer (bringing together some colleagues from the Working Group on *Non-indigenous Aquatic Species* (WG 21). The project is already underway so please watch for updates in future issues of PICES Press.

Science Board also discussed the nominees for both the Wooster and POMA awards but as you know, these will not be announced until Yeosu. However, I would like to take this opportunity to remind the PICES community about these annual awards; consider nominating your collaborators/colleagues in future iterations. There is a tremendous amount of high-quality research and monitoring being conducted within PICES and those who stand out should be recognized.

PICES-2015 will be hosted by China in Qingdao (previously held there in 1995 and 2002). The theme description "*Change and sustainability of the North Pacific*" was finalized shortly after ISB-2014. The PICES-2015 website is open (http://pices.int/meetings/annual/PICES-2015/2015-theme.aspx) for submission of topic sessions and workshops. This new system which we have used for the past few years has greatly improved the efficiency in evaluating and ranking submitted workshops and topic sessions. Deadline for submissions is August 18.

We've been very busy as an organization and have an excellent program developed for PICES-2014 in Yeosu. I look forward to seeing you at the meeting where the theme is "*Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future*".

Thomas Therriault
Science Board Chairman

More attractive science ecosystem design for FUTURE and beyond: A personal view from a researcher in a peripheral field

by Shoshiro Minobe

The central topic of the PICES FUTURE science program is ecosystems, and interestingly, the importance of the term "ecosystem" has rapidly increased during the last half-decade in the business world, particularly in the information technology (IT) field, where it has a quite different meaning from that used in PICES. In a simplified view, an *IT ecosystem* is an interaction system among IT vendors (*e.g*., Apple or Google), third-party software developers and service providers (hereinafter, providers), users, and investors. If an ecosystem is attractive, a larger number of providers will join it with the help of investors, which in turn provides better and more desirable "apps" (software applications) or services than in other ecosystems. Such an ecosystem attracts a larger number of users, and this movement further drives more providers and investors to join the ecosystem. It should be apparent that ecosystem development in business involves positive feedback—the so-called snowball effect—and therefore, a good design for an ecosystem is crucial for its continuing development.

Similarly, we can argue that science organizations and projects such as PICES and FUTURE have their own ecosystems. In a simplified form, a *science ecosystem* consists of a science organization or project and its internal researchers (providers); external researchers and other stakeholders (users); and the funding agencies and home institutes of researchers that provide research funds (investors). The IT ecosystem metaphor is useful when considering science ecosystems because of several important points of commonality. First, providers and researchers can choose which ecosystems to join. For an IT/science ecosystem, most providers and researchers can move relatively freely among ecosystems. This mobility may be the most important difference between IT/science ecosystems and biological ecosystems. In biological ecosystems, species do not have the freedom to select an ecosystem. Second, IT vendors and science organizations cannot directly control the behavior of providers and researchers, respectively, because the former does not directly pay the latter. Of course, there are some noteworthy differences between science and IT ecosystems. In a science ecosystem, money used for research comes from investors and not from users; in an IT ecosystem, in contrast, the role of investors is relatively small because users pay the providers for apps and services. Despite the difference in the relation of users to money, users of science and IT ecosystems play a common and important role. Users in an IT ecosystem evaluate the services and products by buying them, while users in a science ecosystem evaluate science papers and products (*e.g*., models and data sets) produced by internal researchers by reviewing and citing papers and by reviewing research proposals.

By making this analogy between science ecosystems and IT ecosystems, it becomes apparent that the design of science ecosystems is a crucial factor in attracting researchers and facilitating their work. A primary strategy commonly used by science organizations and projects is to determine some direction, such as by setting important research topics and establishing working groups, and then hope that researchers actually work along those directions by obtaining funding from the usual funding agencies of each country and the institute's internal research budget. This strategy works when two conditions are met: (1) researchers are motivated to do research in those directions; and (2) the researchers can obtain funding for conducting the actual research.

I will begin with the first condition. What kind of research topic is motivating to researchers? This can be an overly broad question, and so I would like to pose a more specific question that would be appropriate for multidisciplinary organizations and projects such as FUTURE: Is a researcher motivated more strongly by a research topic for which one can play a leading role, or by a topic for which one plays a secondary or smaller role? If researchers need to spend substantial time and money on a topic, then I believe that researchers will want a leading role. Such leading activities give a researcher career achievements and publications, which influence future evaluations from peers, improve the ability to secure funding, and can ultimately determine the trajectory of a career. Of course, sometimes it is desirable to play a secondary role. Personally, I have enjoyed being a co-author of ecosystem papers, contributing by analyzing physical climate data to elucidate linkages in the ecosystem data provided by marine ecosystem researchers. For me, such experiences are wonderful and bring a broader perspective, but my devotion to them cannot be equally compared with studies in which I play a leading role.

There is an asymmetry among disciplines in opportunities to assume a leading role according to the goals of specific disciplines. Typically, for multidisciplinary studies that involve ecosystem researchers and physical researchers, the main goals are in the domain of marine ecosystems, and thus physical researchers play only a secondary or service role. Collaborative research between physical researchers and biological researchers thus entails a collaboration in which physical researchers assist the ecosystem researchers in their goals. This *assist-goal asymmetry* needs to be clearly recognized if a good research ecosystem design is to be achieved. Furthermore, for such collaborations, physical researchers have to be invited to join, that is, this is a *passive collaboration* for the physical researchers. An uninvited physical researcher has nothing to do but wait. To motivate those researchers whose role is to assist in reaching an overarching goal, it is important to set visible *intermediate goals*, such as specific research topic questions on which the researchers *actively* play leading roles and do not need to wait to be invited. Intermediate goals must be adequate for publishing scientific papers and developing research proposals for researchers who work toward these goals. Such intermediate goals are more necessary for the peripheral disciplines than for the central disciplines in a research ecosystem because the primary goals are usually squarely within the central disciplines. By working on those intermediate goals, the peripheral discipline researchers (here, physical researchers) can contribute to the achievement of the overall goals for the project actively.

Let us now discuss point (2): How can science organizations and projects help to increase the chances of obtaining funding? This is important because "no funding" often means "no research," especially for researchers who have to depend on outside funding. From the above discussion on the leading and assistive roles, it is apparent that science organizations or projects must establish intermediate goals for a peripheral discipline, if they want researchers in those peripheral disciplines to contribute to the overarching goals with funding they can use for those goals. Without intermediate goals, peripheral researchers cannot write their own funding proposals. Another important point is to increase funding opportunities; science organizations and projects must advertise and sell their science to *users*. If users such as external researchers are impressed by the research direction and results, then this will cause a favorable evaluation of the direction in the science community. Additionally, external researchers may act as reviewers of funding proposals. In some countries, it is also important to attract the attention of funding agencies.

In order to sell science to outsiders, the science must be packaged in a concise, marketable form, widely advertised to broad users, and perhaps at the same time strategically targeted to users with specific needs for the products being developed. For example, long or complex documents can be difficult for outsiders to read. This difficulty is compounded in countries where English is not the native language. Researchers and funding managers in such countries, whose reading speed is much slower in English than in their mother tongue, will be reluctant to read superfluous English documents. Therefore, the direction of the science must be summarized in a short, memorable form, such as a title or short question. Once the science is packaged in a saleable form, then the science organization or project should advertise widely to users by multiple methods, such as the web, brochures, and sessions or town hall meetings at major conferences. In addition to increasing the likelihood of funding, selling a topic to a broader audience is attractive even for internal researchers because such promotion can increase the impact of the researcher's studies.

A natural question at this point is whether PICES does a good job of marketing its science to users. The answer depends on the discipline. FUTURE is targeted to marine ecosystems, and so it is reasonable that the influence is greater in marine ecosystem studies than in physical oceanography and climate research, to which my own experience is limited. I would imagine that questions listed in the FUTURE Science Plan may be useful for funding proposals in marine ecosystem studies. Unfortunately, it is difficult for me to use the FUTURE Science Plan and Implementation Plan in my own funding proposals, which will be reviewed by physical oceanographers or meteorologists in a Japanese funding system similar to that of the United States' National Science Foundation. This difficulty is associated with the lack of intermediate goals in physical disciplines, as discussed above. The advertisement of the FUTURE Science Plan to the broader research community is not bad, but there is room for further improvement. For example, the World Climate Research Program's ocean-related core project CLIVAR (Climate and Oceans: Variability, Predictability and Change) advertises their science to external scientists in a number of major science conferences such as the American Geophysical Union (AGU) fall meeting, the American Meteorological Society annual meeting, and the Ocean Sciences Meeting. CLIVAR also provides an impressive web page describing their research themes, which are called research foci, and a beautiful brochure. In fact, I noticed a research focus of regional sea-level rise that seemed likely to have a good chance of getting funding, even though I have not been actually involved in it. A funding proposal that I wrote in association with that focus successfully received modest four-year funding.

In summary, thinking in terms of ecosystems for science organizations and projects is useful. It is necessary to provide topics that motivate researchers in multiple disciplines to actively engage in the science of an organization or a project, and this may require setting intermediate goals for peripheral disciplines so that researchers in those disciplines do not have to passively wait to be invited to participate. From a funding perspective, intermediate goals for those disciplines can provide a *niche* in which peripheral science species can survive.

I should accept responsibility for the lack of intermediate goals suitable for physical researchers to tackle in the FUTURE Science Plan because I served as a writing team member of the plan. At that time, I tried to include some activities in the area of physical oceanography that would be of benefit to marine ecosystem science, but I failed to convince the other team members. This was partly because of my lack of experience and my difficulty with English. However, another factor may be that at the time of writing the FUTURE Science Plan, ecosystem thinking was not as common as it is today. The Science Plan was published in February 2008, but IT ecosystem thinking became much more obviously important after the launch of Apple's App Store in July 2008.

Although the halfway point has been passed in the FUTURE program, it may still be useful to discuss the science ecosystem for FUTURE and beyond. In future projects, it is important to establish intermediate goals for physical disciplines by identifying *topics of common interest* between physical oceanography and marine ecosystems. For example, mesoscale eddies and submesoscale phenomena, which are receiving increasing attention, are candidates for such topics, as are other phenomena such as upwelling. Upwellings, including those that occur in eddies and within the western boundary currents, are a central topic of CLIVAR's research focus "Marine biophysical interaction and dynamics of upwelling systems." These processes are important in determining nutrient supply to the euphotic layer, and thus important in biological production. Upwellings also influence coastal hypoxia and bring corrosive, acidified water to the shelf in some regions. It may be difficult to fully include ecosystem thinking in the implementation of the ongoing FUTURE program with respect to intermediate goals, but it may still be possible to add some flavors, especially for advertisements. It should be useful to have FUTURE sessions or town hall meetings at major science meetings such as the AGU fall meeting or the Ocean Sciences Meeting. This would allow us to sell our science to a wider audience. There are likely to be other, better ideas that I have not considered to grow a rich and productive ecosystem in which the various disciplines of PICES can thrive.

Acknowledgements

I appreciate all of my PICES colleagues who I have talked with throughout my career. In particular, the PICES Secretariat and Dr. Hiroaki Saito, who invited me to join the FUTURE science writing team, Drs. Mike Foreman and Hal Batchelder for constructive comments and editing, Drs. Shin-ichi Ito and Emanuele Di Lorenzo for helpful comments. Here, my aim was to offer criticism that is constructive not negative; however, if this report offends anyone, I apologize in advance. PICES is a wonderful organization and I owe a lot to it, but I believe that PICES can become even more attractive for researchers in all marine science disciplines and thereby become more important in the global science arena.

Dr. Shoshiro Minobe (minobe@mail.sci.hokudai.ac.jp) is a Professor at the Graduate School of Sciences, Hokkaido University in Sapporo, Japan. His overall interest is to understand the ocean's role in the earth's climate system, and he is working on decadal climate variability over the North Pacific, ocean–atmosphere interactions, and recently, biogeochemistry data analysis. Shoshiro was a member of the Science Plan Writing Team for the PICES scientific program, FUTURE, and now co-chairs the Working Group on North Pacific Climate Variability (WG 27).

OSM Session on "*Identifying multiple pressures and system responses in North Pacific marine ecosystems*"

by Ian Perry

Marine ecosystems of the North Pacific, both coastal and offshore, are impacted by multiple pressures, such as increased temperature, change in iron supply, harmful algal bloom events, invasive species, hypoxia/eutrophication and ocean acidification. These multiple pressures can act synergistically to change ecosystem structure, function and dynamics in unexpected ways that differ from single pressure responses. It is also likely that pressures and responses will vary geographically. A key objective of the PICES FUTURE science program is the identification and characterization of these pressures to facilitate comparative studies of North Pacific ecosystem responses to multiple stressors and how these systems might change in the future. This session had two primary objectives: 1) identify key stressors and pressures on North Pacific marine ecosystems, including comparisons as to how these stressors/pressures may differ in importance in different systems and how they may be changing in time; and 2) identify ecosystem responses to these multiple stressors and pressures. Objective 2 includes understanding how natural and human perturbations may cascade through ecosystems, and whether there may be amplifiers or buffers which modify the effects of perturbations on marine systems. The overall goal of this session was to contribute to the work of PICES Working Group 28 on *Developing Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors* and to obtain an overview of the pressures being experienced by North Pacific marine ecosystems and their impacts on the marine ecosystems of the North Pacific.

In total, 15 papers were presented in session S1, plus one by Isabelle Rombouts in a plenary session (Fig. 1). All presentations demonstrated that multiple stressors are common, and that single stressors are rare (*e.g*., Fig. 2). Literature analyses of multiple stressors usually list between 25 to 50 multiple stressors (Working Group 28 has been working with an integrated list of about 20 stressors for its comparative studies). Several presentations by Working Group 28 members (Takahashi *et al*., Martone *et al*., Kulik, Samhouri *et al*., Zador and Renner, Perry *et al*.) provided descriptions of multiple stressors in North Pacific marine ecosystems. The presentation by Perry *et al*. concluded that the scientific community is beginning to understand issues of sensitivity and exposure of habitats to multiple stressors (Fig. 3), but there is also consensus that a lot of questions remain. Early analyses from Working Group 28 suggest that there are more stressors, and greater impacts, in coastal than offshore areas. However, comparative studies also suggest there may be a shorter list of important stressors at regional scales. In analysis of scenarios of cumulative impacts along the coast of British Columbia, Canada, Clarke-Murray *et al*. found climate change impacts overwhelmed all other stressors.

Fig. 1 Plenary speaker, Dr. Isabelle Rombouts addressing the audience.

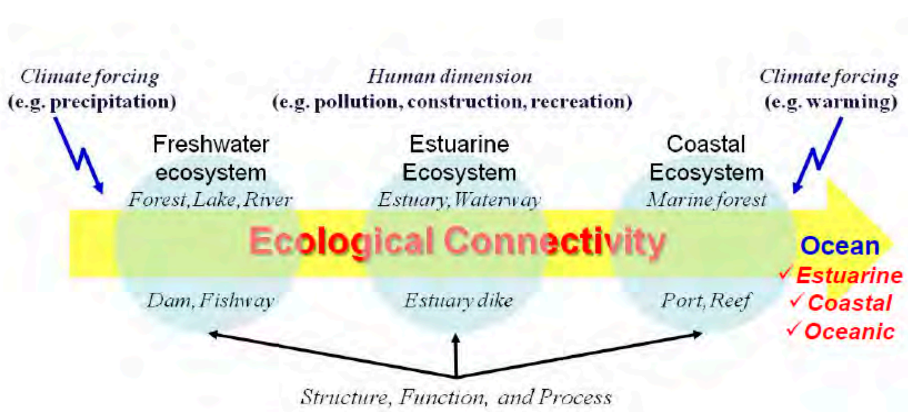


Fig. 2 Example of multiple and cumulative stressors along an ecological gradient from freshwater to marine systems. From Won et al.

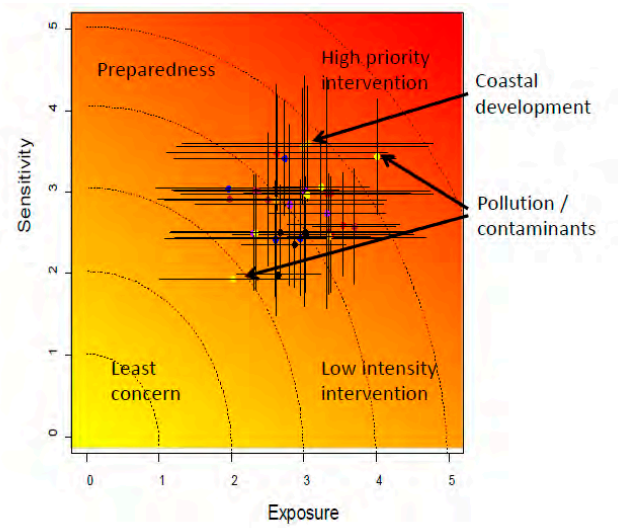


Fig. 3 Example of a risk plot (Exposure by Sensitivity) of multiple stressors (20 stressors by 22 habitats) for the Strait of Georgia, Canada. Color coding represents degrees of inferred relative risk. Horizontal and vertical bars represent uncertainties derived across multiple experts. From Perry et al.

Several presentations discussed options for developing ecosystem indicators to characterise ecosystem responses to multiple stressors. Boldt *et al*. outlined a number of requirements for such indicators. These include the need to define strategic goals and ecological or management objectives for these indicators, and the need for a suite of integrative indicators that would cover key components and gradients at the appropriate spatial scales. It was also recognised that mechanistic approaches can give insights into how pressures are likely to interact and how impacts may become observable. The synthesis of indicator status across multiple trophic levels may reveal broad-scale changes in the environment that may have important biological and management implications. For example, upper trophic level organisms such as seabirds and halibut may serve as integrative indicators that can provide near-real time cues of environmental state (Zador and Renner presentation).

Multiple stressors might interact in additive, synergistic, or antagonistic ways. An analysis of interaction type from 171 studies that manipulated 2 or more stressors found that 26% identified additive interactions, which are most commonly used in model studies of stressor interactions, but that 36% and 38% of the studies identified synergistic or antagonistic interactions, respectively (Crain *et al*. 2008, Ecology Letters). Examples presented during this session included the paper by Jung, who concluded that intensive fishing activities by Korean trawlers could have aggravated the potential resilience of the filefish stock, causing it to collapse when the climate changed; and the paper by Polovina and Woodworth-Jefcoats, who concluded that top-down responses in the Central North Pacific ecosystem means that fishing and potentially bottom-up climate impacts are likely to have stronger negative impacts on the larger fishes than on smaller fishes, causing the ecosystem size structure to shift towards smaller sizes. Their study, based on two ecosystem models, indicated that impacts from bottom-up stressors could range from moderate (–20%) to severe (–60%) depending on changes in phytoplankton. Del Raye and Weng identified a need for physiological models that use aerobic scope for activity to understand interactions between temperature and O_2 at discrete pCO_2.

Based on the presentations and discussions, the session reached the following conclusions:

- Ecosystem responses to multiple stressors are non-uniform: a suite of indicators is best to capture a diversity of ecosystem responses.
- Because a diversity of ecosystem responses is expected, it is essential to clarify which types of ecosystem changes matter to a pre-specified group of people.
- Interactions between multiple stressors more often appear to be non-additive (synergistic or antagonistic); there is the need to understand how predicted ecosystem responses vary with different assumptions about interactions between stressors (noting, however, that there is no substitute for data).
- Climate and fishing provide good examples of how interactions between stressors can act non-additively in some cases and additively in others to change the dynamics of exploited fish populations.

Different approaches may be needed for situations with different degrees of complexity. For example, data-driven evaluations are obviously to be preferred for situations where data are available (in space, time, and types of variables). Expert opinion may be necessary when the focus is on broad spatial scales, although care should be taken to verify these opinions with data or other experts when possible.

Acknowledgements

I would like to thank the other S1 co-convenors, Vladimir Kulik, Rebecca Martone, Jameal Samhouri and Motomitsu Takahashi for their contributions in organizing and chairing this session.

Dr. Ian Perry (Ian.Perry@dfo-mpo.gc.ca) is a research scientist with Fisheries and Oceans Canada at the Pacific Biological Station in Nanaimo, British Columbia. His research includes the structure and function of marine ecosystems and the development of ecosystem approaches to management of these systems.

OSM Session on "*Regional climate modeling in the North Pacific*"

by Enrique Curchitser and Chan Joo Jang

A session exploring regional climate modeling in the North Pacific was convened on April 15, 2014, at the FUTURE Open Science Meeting (on the Big Island of Hawaii) to report progress made towards the goals of the FUTURE science program. Session S2 was an opportunity for members of the PICES Working Group on *Regional Climate Modeling* (WG 29) to summarize their activities and develop links to other FUTURE efforts.

The topic of regional climate models has generated interest in the PICES community since it recognizes the need to both explore the implications of the global IPCC-class models for PICES member countries and assess state-of-the-science techniques for downscaling global models. Regional downscaling—effectively running models with higher spatial resolution in target areas—of global models is a means of representing climate on time and space scales more appropriate for socio-economic and coastal ocean studies. WG 29 has been focusing on ocean processes and the implications to marine ecosystems.

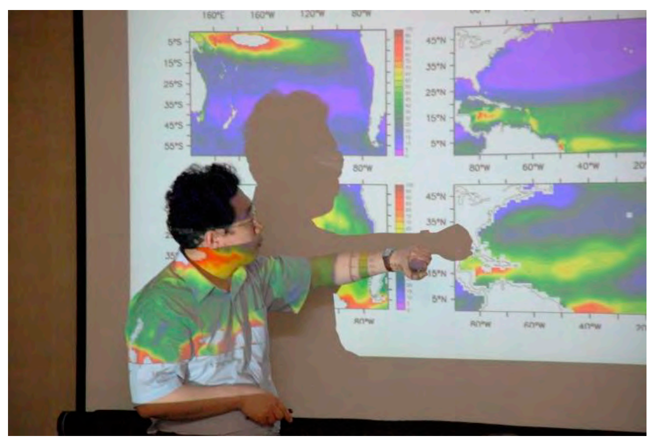
The session was co-convened by Drs. Enrique Curchitser (Rutgers University, USA) and Chan Joo Chang (KIOST, Korea) and had three invited speakers, Drs. Michael Foreman (Institute of Ocean Sciences, Canada), Arthur Miller (Scripps Institution of Oceanography, USA) and Takashi Mochizuki (JAMSTEC, Japan) and a total of 11 contributed papers. In the first invited presentation, given at the plenary session, Dr. Foreman described new techniques for downscaling climate projections for coastal, coupled physical–biological studies. The technique relies on bias correction of winds from global-scale future projections based on seasonal historical patterns. He demonstrated an application of this technique to the coast of British Columbia where both wind magnitude and direction are crucial to determining the patterns of coastal circulation.

Co-Convenor, Dr. Chan Joo Jang (KIOST, Korea), introducing the list of presentations for the theme session.

Dr. Miller presented results from a coupled ocean–atmosphere regional model of the Kuroshio Extension region, which is characterized by energetic oceanic eddies and fronts. He explored mechanisms for air–sea coupling of high-resolution components and highlighted the important role of the ocean in forcing the atmosphere on regional scales.

Dr. Mochizuki discussed the role of internal model variability to future projections using global models, in particular for the coming decades. He concluded that accurate initial and boundary conditions are essential for developing reliable decadal-scale climate projections.

Other abstracts in the session considered diverse topics and approaches: downscaled projections of future climate in the California Current (Dr. Francisco Werner); the role of model resolution on the air–sea CO_2 exchange (Dr. Jerome Fiechter *et al.*); regional biogeochemical downscaling in coastal British Columbia (Dr. Angelica Peña *et al.*); ensemble regional predictions in the Bering Sea (Dr. Albert Hermann *et al.*); dynamical downscaling of global models in the western Pacific (Dr. Chan Joo Jang); the role of a wave mixing parameterization in improving projections (Dr. Fangli Qiao) and a look at a global 1/10° model.



Dr. Fangli Qiao (First Institute of Oceanography, State Oceanic Administration, China) comparing mixed layer depths of two different oceans with and without wave effects.

Overall, the presentations can be categorized into three main topics: 1) additional value (*e.g.*, addressing known biases, coastal currents, *etc*.) derived from regional climate models, 2) regional projections of future climate and 3) applications of regional downscaling to ecosystem studies.

The main topic during the open discussion period focused on the question of what resolution is desirable in regional studies. The participants noted that the answer may depend

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OSM Session on "*Challenges in communicating science and engaging the public*"

by Phillip R. Mundy and Harold P. Batchelder

The FUTURE OSM session on the afternoon of April 15, 2014, was organized by the Advisory Panel on *Status, Outlooks, Forecasts and Engagement* (AP-SOFE) to showcase examples of the FUTURE goal of engaging human societies by providing useful products on ecosystem change. SOFE has found that such products are typically delivered by a four-step process that consists of 1) identifying climate driven ecosystem services, 2) defining processes and relationships between climate and ecosystem services, 3) developing products based on the relationships, and 4) developing timely and reliable communication with stakeholders. Stakeholders are the target audience for whom the products are intended. Stakeholders are, by and large, people who make decisions regarding human uses of living marine resources (LMR) and the habitats on which the LMR depend. These stakeholders function at various levels of resource use and regulation, from the top government policy-makers who prescribe the principles on which resources are to be regulated, through the managers who apply the regulations, to the individuals who work within the regulations in the course of earning a living. To take some examples, stakeholders are individual fisherman who need to know where and when to fish for particular species, or fishery managers who need to inform harvest decisions that result in the long-term sustainability of those species. Other examples of decision-makers in need of climate-change products include those who regulate sensitive coastal habitats and the policy-makers who develop the regulations governing human activities in coastal zones. Regardless of the specific human activities that depend on LMR, and regardless of differences in national approaches, all stakeholders need trustworthy information about how climate drives the ocean-provided services with which they are concerned, which in turn requires effective communication at all levels.

Effective communication is the common theme that unites the eight presentations and the preceding keynote address of Session S3 on "*Challenges in communicating science and engaging the public*". The keynote address and two other talks provided examples of *communicating effectively* with stakeholders to understand the products necessary to deal with climate driven resources (Peterson *et al*., Ito and Yamada, Orsi and Mundy). Three of the talks were concerned with building consensus among stakeholders through *effective communication* using diverse methods of reaching common understandings (Seino, Barbeaux and Lee, Volk *et al*.). In the realm of human dimensions, two of the talks dealt with *communicating effectively* through understanding the diversity of values and motivations among stakeholders (Yagi *et al*., Kurilova). Using models to integrate the complex suite of environmental drivers of natural resources to *effectively communicate* the consequences of climate change on LMR was addressed by one talk (Zhang *et al*.).

The keynote talk of Bill Peterson (USA) in the morning plenary session, "*A case study from the northern California Current*", illustrated SOFE's four-step process for producing useful products on climate driven LMR. Improvements in salmon management have been achieved by communicating more precise estimates of the numbers of salmon available to the fisheries. Increases in precision have been made possible by considering ocean conditions in the first summer of ocean entry, including hydrography and forage base from a long-term set of observations (now 19 years). Outlooks (the O in SOFE), or qualitative forecasts of coho and spring Chinook salmon adult abundance, and corresponding quantitative forecasts (the F in SOFE) have been developed based on a multivariate suite of ocean and ecological indicators. Simple-to-understand qualitative aids to communication include "stoplight charts" with green indicating favorable, yellow intermediate, and red unfavorable conditions of a particular input indicator. Years with many favorable (green lights) should be ocean entry years that favor survival of salmon, and predictions might indicate high returns of coho the following year, and of Chinook in two years. These aids are quantitatively supported on the web site with descriptions of the indicator and why it is related to salmon survival—usually described mechanistically as top-down or bottom-up linkages in the marine food web.

S3 Plenary speaker, Dr. William Peterson, speaking on the three pillars of SOFE related to providing management advice on Columbia River salmon.

Communication of the qualitative and quantitative information is through oral presentations to the public and managers. Uptake of the approach has been mixed, with some audiences very receptive, while others are reticent to alter the existing practices to salmon return forecasting, even in light of evidence that the approach may be more reliable, and because of a concern that the underlying data supporting the approach are produced by a research program rather than on an ongoing permanently funded operational basis.

Emphasizing the points made in Peterson's keynote, Orsi and Mundy (both USA; presented by Joseph Orsi) and Ito and Yamada (Japan) also illustrated by example the four-step process of SOFE in direct application to fishery management. Orsi and Mundy use data types and methods identical to those of Peterson over longer periods of time, applying physical and biological oceanographic observations to provide qualitative and quantitative forecasts that enhance fishery management capabilities. Orsi reported on his research resulting in a pink salmon abundance forecast for southeast Alaska that has been issued for eleven years (since 2004) based on a fisheries oceanography study that started in 1998 (17 years). The unprecedented precision of the annual pink salmon forecast has enabled the fishing industry to better prepare for the large fluctuations in annual abundance typical of pink salmon fisheries. Both Peterson and Orsi and Mundy identify approaches based on ocean sampling of the early marine life cycle stage of salmon to enable fishery management with more precise forecasts of abundance in the subsequent fisheries. Orsi also described Mundy's use of a long time series (52 years) of physical and biological observations to pinpoint the timing of marine exit of Chinook salmon, which allows fishery managers to estimate the abundance of the Chinook returns using data from the freshwater fisheries. Both Peterson and Orsi and Mundy communicate the uncertainty associated with quantitative harvest forecasts using simple qualitative rankings, various kinds of meetings, and via the web.

Dr. Shin-ichi Ito describing the information needs of the set net fishery.

Using an approach similar to that of Peterson *et al*. and Orsi and Mundy, Ito and Yamada (Japan) used ocean data to enable coastal fisheries in the area most impacted by the 2011 Great East Japan Earthquake and tsunami. Demonstrating the tightly environmentally dependent nature of these fisheries, the tsunami severely damaged fishery production by destroying vessels and gear and the harbors and aquaculture facilities on which production depends. Set net fisheries, especially those targeting salmon, are key fishing industries in coastal villages of northeastern Japan. Illustrating SOFE's four-step process, the problem was identified as environmentally damaged fisheries, the solution was to apply advanced technologies to recover the former marine harvest capacity, the approach was to build monitoring based on the needs of fisherman for ocean data, and the problem was solved by communicating to the fishers the information in real-time from sensors using phone apps and the web. Identified key data sets for the set net fishery were current velocity, wave height and direction, and wind velocity and direction. High current velocities can submerge the trap making recovery difficult and enabling escapement of trapped fish, and data on waves and winds is used to plan recoveries of gear. Prior to the tsunami, most implemented monitoring was for temperature (and mostly for aquaculture needs), but aquaculture and fishers are able to get temperature data from other sources, whereas current velocities are not readily available elsewhere. Conversations with the stakeholders identified a previously unknown priority to set net fishers, which could be met in deploying replacement monitoring systems. Peterson, Orsi and Mundy and Ito and Yamada provided compelling real-world examples of the value of the types of scientist-stakeholder engagement for which SOFE was established.

An important aspect of effective communication is building consensus among stakeholders using diverse methods to reach common understandings. Presentations by Seino, Barbeaux and Lee, and Volk *et al.* provided examples of this critical aspect of SOFE's four-step process for developing useful products to inform stakeholders about climate change. Seino (Japan) introduced the topic by describing how several international conventions and treaties, such as the Convention on Biological Diversity, and international trends, such as in coastal and wetland conservation, have enabled new multi-sectorial environmental conservation and restoration frameworks in Japan. Seino noted that domestic coastal environmental issues have become very complicated, and social sectors are demanding more integrated approaches to management and increased communications across sectors. Seacoast habitats, especially rocky shores, are of immense cultural and aesthetic value in Japan. For example rocky coastal areas are the workplace of highly respected and iconic elderly women who gather seaweed and harvest shellfish. Communication between managers and their constituents is important in shaping the evolution of coastal policy in Japan. Building consensus among stakeholders was highlighted by Volk *et al*. (USA), who described the exhaustive process and intricate organizational framework that was essential to effectively communicate with diverse stakeholders who were concerned about inequities of regional harvest patterns of chum and sockeye salmon in the fisheries of Western Alaska. The Western Alaska Salmon Stock Identification Program (WASSIP) was implemented to inform participants regarding the origin of salmon in commercial and subsistence salmon fisheries. Residents of western Alaska were very concerned that fisheries in other parts of Alaska were removing so many salmon that their opportunity to harvest was precluded. WASSIP used accepted genetic methods to identify the origins of salmon in the contested areas, thereby gaining widespread trust among regional interests. The key to success at resolving the disputes was effective communication with stakeholders about the fundamentals of sampling design and statistical analysis protocols. The common understandings achieved on the reliability of sampling and statistical methods of analysis satisfied stakeholder concerns to the extent that the results were accepted as a basis for agreement. Consensus building between managers and harvesters was further illustrated by Barbeaux (USA), who described joint USA-Korea cooperative research projects using Korean managed fisheries. The research was intended not only to collect data for fisheries management, but also to foster communication and broaden stakeholder engagement in fisheries research. Consensus was achieved by developing a trusted common data base, as was also the key to success on the studies described by Seino and Volk *et al*. The respected common database was built by providing relatively inexpensive temperature loggers on fishing gear (headropes of commercial trawlers; red snow crab pots; and soon commercial longliners and purse seines). Opportunistic acoustic data archiving to hard drives was collected to describe animal density, depth and seasonal distribution. Lessons learned from the consensus-building exercise are that fisherman and stakeholders in Korea and USA are eager to participate in cooperative monitoring/ research, that stakeholders develop greater trust in science when engaged in data collection, and that the resulting consensus improves communication. In addition, formulating and communicating clear and reasonable objectives for researchers and participating stakeholders is essential to successful participatory science, as is developing realistic expectations among fishers and managers. Cultural differences matter. For instance, in Korea, small mistakes are more likely to discourage stakeholder cooperation, whereas in the USA, such missteps are considered learning opportunities that contribute to the successful evolution of consensus building projects.

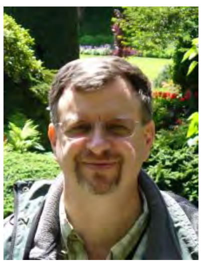
In the realm of human dimensions, the session established the principle that communicating effectively requires understanding the diversity of values and motivations among stakeholders (Yagi *et al*., Kurilova). Yagi (Japan) contrasted the results of a socioeconomic survey of coastal and inland communities in Japan regarding the importance of marine ecosystem services and its influence on human behavior. He identified three factors important in regulating behaviors with regard to marine ecosystem services: essential benefits (supporting services of the Millenium Ecosystem Assessment [MA]), indirect benefits (analogous to regulating and provisioning services of MA), and cultural benefits (corresponding to cultural benefits of MA). For people in both coastal and inland areas, cultural benefits were most linked to behavioral intentions, including funding marine conservation—even more so than essential benefits. Cultural benefits, moreover, were the only significant influence in inland regions. Conversely, essential benefits also influenced behavior in coastal populations. The survey results suggest that enhancement of cultural benefits will most impact future marine conservation efforts. Reinforcing the importance of understanding the values and motivations of stakeholders, Kurilova (Russia) described that the mechanism of communication in remote coastal Russian communities depends on the strong regional cultural differences of small ethnic communities, which often have unique local concerns. Her conclusion was that the message and method of communication depends on the audience; therefore, understanding the diversity of values and motivations among stakeholders that directly determine the level of satisfaction from ecosystem services is essential to effective communications.

Models are a powerful means of effectively communicating the consequences of climate change on living marine resources and the human uses of those resources. Zhang (Korea) described the current status of Integrated Fisheries Risk Analysis Method for Ecosystems (IFRAME) as a framework supporting ecosystem approach for fishing. He reviewed the ecosystem effects of fishing, which in addition to harvest mortality (the direct effect), have indirect, perhaps undesirable side effects of bycatch, habitat modification or destruction, and biological interactions. IFRAME involves assessment of ecosystem structure and risk, forecasting structure and risk, and evaluating and implementing management. The implementation is iterative, with feedbacks from management on assessment and forecasting. New to IFRAME is the use of semi-quantitative or qualitative analysis when knowledge level of the ecological systems is low. Zhang showed examples of how IFRAME methods contribute to FUTURE objectives and questions, how AICE and COVE could contribute to the assessments, forecasting and management aspects, and how SOFE should be used to disseminate outlooks and forecasts from IFRAME, and solicit feedback from management strategies.

Dr. Phil Mundy, one of the co-convenors of S3, addressing the audience.

Each of the nine presentations described above illustrates successful application of SOFE's four-step process for fulfilling the FUTURE premise that it is possible to deliver useful and timely products on climate driven ecosystem change to resource stakeholders. The validity of this premise was a cornerstone of the rationale for creating the PICES FUTURE program. The session has provided extensive examples that validate the fundamental FUTURE premise. A potential stumbling block for extending the application of the FUTURE premise is the daunting nature of the data collection efforts necessary to build the long time series of observations that underpinned the examples of success presented in this session. Moving toward full operational status will require secure long-term funding to continue the observational framework that enables forecasts and outlooks of the type described in this session.

Dr. Phillip Mundy (Phil.mundy@noaa.gov) is Director of Auke Bay Laboratories (ABL), Juneau, Alaska. As a division of NOAA's Alaska Fisheries Science Center, ABL collects observations on the physical and biological properties of the Gulf of Alaska, Bering, Chukchi and Beaufort Seas to provide information for management of living marine resources. Phil received his Ph.D. in Fisheries Science from the University of Washington. He served on the faculty of Old Dominion University and the University of Alaska Fairbanks. He has served as a scientific advisor to the North Pacific Fishery Management Council and the Pacific Salmon Commission. Phil was a charter member of the North Pacific Research Board who contributed to developing the Bering Sea Integrated Ecosystem Research Program. His most compelling current interest is implementing the ecosystem approach to management in the Arctic, which he pursues as a U.S. delegate to the Arctic Council. In PICES, he serves as Chairman of the Advisory Panel on Status, Outlooks, Forecasts, and Engagement and Advisory Panel on the Continuous Plankton Recorder Survey in the North Pacific, and is a member of Science Board and MONITOR.



Dr. Hal Batchelder (hbatch@pices.int) is the Deputy Executive Secretary of PICES (since February 2014). Prior to assuming that position he was a Professor in the College of Earth, Ocean and Atmospheric Sciences (CEOAS) at Oregon State University. Hal has contributed to PICES in diverse ways previously: Co-chairman of the Climate Change and Carrying Capacity integrative science program and Science Board member; member of several study groups and working groups; member of AP-SOFE; and U.S. delegate to the PICES Governing Council. His research specialization is biological oceanography and ocean ecology, with emphasis on zooplankton population and community ecology, and the coupling of ecological processes to ocean physics using numerical models. Recent interests have included design of Marine Protected Areas, and the changing incidence of hypoxia on the U.S. west coast and its potential impacts on shelf organisms.

(Continued from page 11)

on the region and dynamics of interest. Furthermore, it may be necessary to adjust model resolution after an initial exploratory investigation. Another topic during the discussion was on the need and future of ensemble modeling in regional settings and the unique challenges that could emerge. Of note was the conversation on the expected number of ensemble members and the need for multi-model ensembles. Finally, the participants discussed the topic of bias propagation from global to regional models and from physics to biogeochemistry. The discussion focused on ways to identify and quantify model biases in the different model components.

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

Dr. Jang Joo Chan (cjjang@kiost.ac) has been a Principal Research Scientist in the Ocean Circulation and Climate Research Division of the Korea Institute of Ocean Science and Technology since 2011. His research interests include analysis and modeling of climate change in the North Pacific Ocean, focusing on Korean waters, circulation–ecosystem couple modeling, and turbulence modeling. He is a member of the PICES Physical Oceanography and Climate Committee, Working Group 27 on Climate Variability and Change in the North Pacific and co-chairs Working Group 29 on Regional Climate Models.

OSM Sessions on "*Ecosystem status, trends, and forecasts*" and "*Ecosystem resilience and vulnerability*"

by Thomas Therriault and Hiroaki Saito

Marine ecosystems are constantly changing. Therefore, researchers need to develop and to communicate information on ecosystem status, trends, and forecasts to ensure that sound management and policy decisions are made for the benefit of the societies that depend on them. Ecosystem indicators are one way to communicate such information, but the selection of the most appropriate indicators can prove challenging, especially given an increasingly complex array of audiences. It is likely that different indicators will be needed where the scale of ecosystem responses to different stressors must be reconciled with the scale of the perturbation (*e.g.*, coastal *versus* oceanic). Forecasting ecosystem change demands good understanding of how multiple stressors affect ecosystem structure and function. A key element of the FUTURE program is the ability to convey to diverse audiences, in each of the PICES member countries, ecosystem status, trends and forecasts. Session S4 on "*Ecosystem status, trends and forecasts*" explored current and proposed ecosystem status and trend indicators, including some already in use in the North Pacific Ecosystem Status Reports, and attempted to identify metrics required in support of ecosystem forecasts.

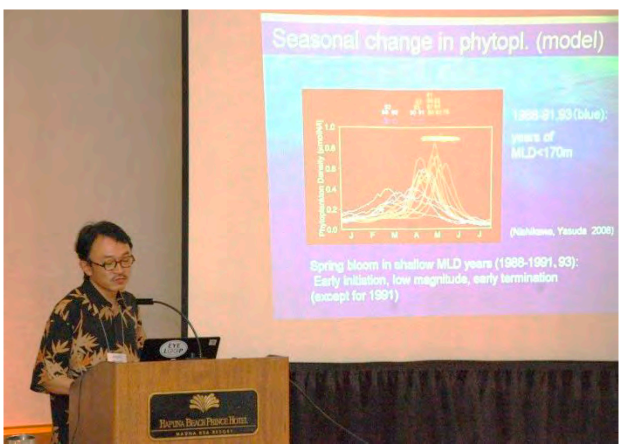
The plenary speaker, Dr. Deborah Steinberg, did an excellent job setting the stage for this topic session by giving a talk entitled "*Ecosystem comparison of trends in zooplankton community structure and role in biogeochemical cycling*". She presented an overview of the status of spatial variation in zooplankton biomass and implications for the biological pump that can be characterized by community structure. She then highlighted patterns of eutrophic and oligotrophic regions and provided links to climate indices or sea ice dynamics. With respect to trends, she used subtropical monitoring sites (BATS and HOT) to show that with increased warming, the biological pump is changing. Lastly, she argued the importance of understanding the mechanisms responsible for change as well as documenting changes in status and trend.

In the breakout session there were talks by Drs. Sanae Chiba and Sonia Batten that demonstrated how long-term zooplankton data sets could be analysed to find trends and patterns with respect to distribution. Dr. Chiba showed that the diversity index was correlated with the Kuroshio Extension Current strength (1960–1988), but that this relationship broke down during the oceanographic regime shift that followed this period. Dr. Batten explained how various indices obtained from Continuous Plankton Recorder (CPR) samples, such as the phytoplankton colour index, total diatom biomass, timing of the spring diatom bloom, warm-water copepod abundance, *etc*., could indicate ecosystem regime shifts. Talks by Drs. Douding Lu and Ichiro Imai assessed the trends and status of harmful algal blooms (HABs) by means of retrospective analysis of HAB data sets. Dr. Lu showed how increasing HAB events in Chinese coastal waters were related to increasing anthropogenic activity, such as eutrophication, ballast water, or aquaculture. Similarly, Dr. Imai demonstrated how new water quality regulations reduced eutrophication, improved water quality in the Seto Inland Sea, Japan, and decreased the number of HAB events. The session also had talks about status, trends, and forecasts for higher trophic levels. Dr. Jongjun Tian suggested an ecological indicator as an early warning signal for forecasting the future (current) regime shift. He was able to demonstrate how fish assemblage data were used to detect five past regime shifts (1911, 1934, 1963, 1975 and

S4 plenary speaker, Dr. Deborah Steinberg, addressing session participants on ecosystem cross-comparisons of zooplankton communities.

S4 speaker, Dr. Ichiro Imai, discussing long-term trends of red tides and toxic blooms in the Seto Inland Sea of Japan.

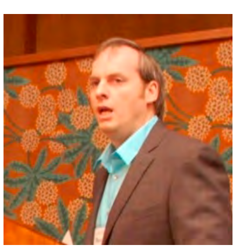
1988) and that these coincided with shifts in sea surface temperature and a climate index. Dr. Jon Brodziak used a striped marlin dataset to introduce participants to a new "steepness" index which can quantify population resilience, and be used to set biological reference points, such as maximum sustainable yield. Drs. Haruka Nishikawa and Suam Kim talked about ways to develop fishery forecasts for commercial target species (neon flying squid, Pacific flying squid) under global warming scenarios. Lastly, Dr. Hiroaki Saito's talk provided a nice summary of the session by considering mechanisms of fish species alternation in the western North Pacific which were induced by changes in the wind field in the central-eastern North Pacific. He pointed out the weaknesses of fisheries as a modern industry, *i.e.*, unplanned high variability, and that forecasting future changes in marine ecosystem and fisheries production is likely the most effective way to mitigate intrinsic weaknesses in modern fisheries. Clearly our understanding of the mechanisms creating observed ecosystem variation is still limited. Much remains to be done to "understand the mechanisms behind status and trends" and to "forecast future states", as these are essential science contributions to society.



Dr. Hiroaki Saito providing the final talk of Session S4.

S6 plenary speaker, Dr. Beth Fulton, chatting with Robin Brown during coffee break.

Marine ecosystems around the globe are affected by numerous natural and anthropogenic stressors. The interactions among stressors are incredibly complex and proving difficult to understand. Ultimately, these stressors will change ecosystem structure and function. This can lead to changes in ecosystem stability and productivity, and impact the societies that depend on them. One of the central themes of the FUTURE Science Plan focuses on ecosystem resiliency and vulnerability to natural and anthropogenic stressors and poses the question how ecosystems around the North Pacific might change in the future. Thus, the ability to understand how resilient marine ecosystems are and to characterize the degree to which ecosystems are vulnerable to change via multiple stressors is critical to advancing the FUTURE program. Session S6 on "*Ecosystem resilience and vulnerability*" attracted only a single submitted oral presentation, perhaps indicating the difficulty in quantifying resilience and vulnerability in marine systems with diverse stressors. Because of this problem, there has been little attention devoted to these issues to date in PICES. Dr. Beth Fulton explored resilience in a plenary talk titled "*Exactly how resilient are ecosystems?*".



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

Dr. Hiroaki Saito (hsaito@aori.u-tokyo.ac.jp) is an Associate Professor at the Atmosphere and Ocean Research Institute, the University of Tokyo. He has a broad range of interests but his focus lies in the role of marine organisms in food-web dynamics and biogeochemical cycles. He is one of the establishing members of the A-line monitoring programme for the western North Pacific. He was a core member of the SEEDS I, II and SERIES Fe fertilization experiments, led the DEEP (2002 2007), SUPRFISH (2007–2012) projects, and is leading the SKED project (2011–2021). He has also been involved in IMBER, and was Chairman of IMBER-Japan from 2004–2008. In PICES, Hiroaki has been a member of several expert groups. He is currently a member of the BIO Committee and SG-SC-NP, is Chairman of the FUTURE AP-COVE, and is Vice-Chairman of Science Board.

OSM Session on *"Strategies for ecosystem management in a changing climate"*

by Anne B. Hollowed, Suam Kim and Manuel Barange

The co-authors of this summary co-convened Session S7 on "*Strategies for ecosystem management in a changing climate*" held April 17, 2014, as part of the PICES FUTURE Open Science Meeting. The session was co-sponsored by the ICES-PICES Strategic Initiative (Section) on *Climate Change Effects on Marine Ecosystems*.

Overview

The session explored the complex issue of implementing an ecosystem approach to management under changing climate conditions. Climate change is expected to impact the distribution and abundance of fish and shellfish through direct and indirect pathways. The temporal signature of these changes will be dominated by long-term trends and thus may require new approaches to setting biological reference points for single species management. Projection models indicate that climate change may alter the species composition within an ecosystem which, in turn, could change the structure and function of the system. New approaches may be needed to address the complex issues of defining biological and ecosystem reference points under uncertain future states of nature. For fished stocks that are projected to decline under changing climate conditions, it is unclear when or if additional precautionary approaches would sustain the populations or the fishery that depends on them.

Objectives

Participants in this session presented papers that addressed the research theme noted above by: A) exploring implementations of an ecosystem approach to management under projected climate change; B) proposing techniques that identified how uncertainty in climate and biological responses could be incorporated into biological or ecosystem reference points; C) evaluating the performance of proposed strategies under changing climate conditions; and D) defining the precautionary approach under a changing climate.

Summary

Scott Large gave the keynote talk for this session on behalf of Jason Link. The presentation, entitled "S*olutions for marine ecosystem-based management in a changing climate*", focused on Objective "A" above and identified what changes to the current approach for defining and implementing an ecosystem approach to management will be needed to adapt to changing ecosystem conditions. The speaker recommended that the "climate savvy" ecosystem approach will include vulnerability and risk assessments, enhanced data collection, next generation modeling, and skill assessments to evaluate projection performance.

The session included 10 oral presentations. The first three talks focused on Objective "A". Samuel Pooley presented several examples from the Hawaii region of how marine ecosystems could mediate the relationship between people and nature. Jake Rice discussed the information that is really needed to inform adaptation strategies to climate change. His talk considered the question of: How well does the supply of science advice meet the demand for policy support? He noted that scientists attempting to project future climate change impacts on marine ecosystems should consider the impacts of extreme events rather than focusing solely on average conditions. Biological Envelope Modeling will not be applicable to all fisheries management issues, as such projections are primarily for use for large-scale fisheries targeting mobile species. He advocated more place-based forecasts of fish communities. Manuel Barange discussed how climate impacts on fisheries production differentially affect fisheries-dependent communities.

Dr. Jake Rice (Canada) discussing adaptation strategies to climate change.

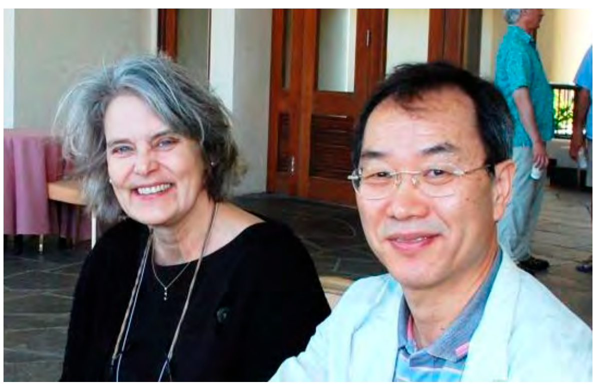
Dr. Manuel Barange (UK) discussing climate change impacts on fisheries production.

Manuel Barange, Jake Rice and Myron Peck (back to camera) talking about adaptation strategies during break?

Five talks focused on Objective "B". Paul Spencer discussed techniques for evaluating the implications of climate-induced shifts in spatial distributions on predator–prey interactions. Jacquelynne King reviewed several management approaches employed for northeast Pacific fish stocks that incorporated climate variability and change. Kirstin Holsman, presenting on behalf of Kerim Aydin, discussed a full end-to-end model that has been developed for the Bering Sea. Anne Hollowed, on behalf of Sukyung Kang and Nicholas Bond, presented results of projected production of Korean chub mackerel under past and future climate climate conditions. Tim Essington discussed the benefits of conducting meta-analyses as a technique for understanding key factors underlying fish responses to climate change.

Two talks focused on Objective "C". Kirstin Holsman presented a multispecies modeling approach that incorporates climate effects on bioenergetics. This model is formulated to allow the analyst to explore the trade-offs of different management strategies through a management strategy evaluation. Anne Hollowed and Cody Szuwalski are working on the difficult task of defining a suite of potential strategic responses that managers and stakeholders might consider in the future. None of the talks specifically dealt with Objective "D".

Acknowledgements *The Session convenors would like to thank the keynote speaker and session participants for active discussions.*



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Dr. Manuel Barange (m.barange@pml.ac.uk) is the Deputy Chief Executive and Director of Science at the Plymouth Marine Laboratory (UK). He was Director of the International Project Office of the IOC-SCOR-IGBP core project GLOBEC from 1999–2010 and Chairman of the Scientific Committee of the International Council for the Exploration of the Sea (ICES) from 2010–2013. Manuel's expertise includes physical/biological interactions, climate and anthropogenic impacts on marine ecosystems, fish ecology, behaviour and trophodynamics, and fisheries assessment and management. In recent years, he has increasingly focused his research on the impacts of climate change and economic globalization on marine-based commodities, and on the interactions between natural and social sciences in fisheries, ecosystems and climate change, in both the developed and developing world. He co-chairs the ICES/PICES Strategic Initiative (Section) on Climate Change Effects on Marine Ecosystems and is a founding member of the Global Partnership for Climate, Fisheries and Aquaculture (PaCFA).

OSM Workshop on "*Top predators as indicators of climate change: Statistical techniques, challenges and opportunities*"

by Elliott Hazen, Rob Suryan, Takashi Yamamoto and Steven Bograd

Top predators such as fish, turtles, marine mammals, and seabirds integrate multiple lower trophic level processes and can also exert top-down control of marine food webs. Climate change and variability affect the timing and productivity of pelagic ecosystems. This variability is integrated into the life histories of top predators, potentially affecting their breeding patterns, migration strategies, diets, and ultimately, fitness and reproductive success. Pan-Pacific data about top predators are generated by surveys, animal tracking studies, dietary analyses, and measurements of reproductive performance. Environmental and climate data can be synthesized and compared to ecosystem responses in many locations. To incorporate top predators into our understanding of climate change impacts on marine ecosystems and to support the objectives of FUTURE, the PICES Advisory Panel on *Marine Birds and Mammals* (AP-MBM) with joint support from IMBER's regional program, CLIOTOP (Climate Impacts on Oceanic Top Predators), convened this workshop to examine how top predators have responded, and are predicted to respond, to climatic variability and long term change.

The primary goal of this workshop (W1) was to review existing examples of observed and predicted top predator responses to climate change and variability in the North Pacific. More specifically, we had a number of goals that came to light via talks and workshop discussions:

- Identify existing top predator, ecological, and oceanographic datasets that can be used to examine response to climate variability and change;
- Review statistical techniques that can be used to differentiate top predator response from climate variability and change;
- Identify sentinel species and life history characteristics that may best reveal responses to physical and biological changes;
- Discuss synthetic approaches, beyond single measurement types, that are needed to understand how climate variability and change is integrated by top predator behavior, distribution, abundance, and demography;
- Prepare a statement outlining the need for enhanced sampling for top predator response to the predicted 2014–2015 El Niño event;
- Outline and write a review paper on a framework for assessing climate response in North Pacific top predators
- Realize the goal of an interdisciplinary, North Pacific-wide funding proposal to synthesize top predator datasets relative to potential climate change effects;
- Continue these efforts in collaboration with CLIOTOP and IMBER at the 3rd PICES/ICES Symposium on the "*Effects of climate change on the world's oceans*" in 2015.

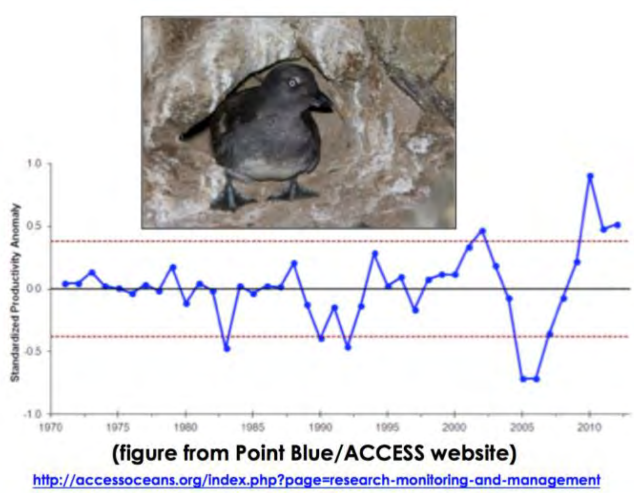
With the primary goal of FUTURE, "*To understand and forecast responses of North Pacific marine ecosystems to climate change and human activities at basin and regional scales, and to broadly communicate this scientific information to members, governments, resource managers, stakeholders and the public*", top predators are particularly useful given their integration across the physical environment and multiple trophic levels, making their responses a metric of ecosystem change. Also, there is strong public interest in many top predators, making outreach and engagement easier than for other ecosystem components. Furthermore, a wide variety of data has been collected on top predators, including multiple responses (behavior, distribution, fitness) to climatic events (*e.g.*, El Niños) that may give us insight to future long-term changes.

Participants of the top predators workshop.

There were 22 participants in the workshop. The workshop included 4 invited talks, 7 contributed talks, and 2 hours of discussion. The talks were organized largely by species groups, starting with fish predictions as a function of climate change and finishing with baleen whales.

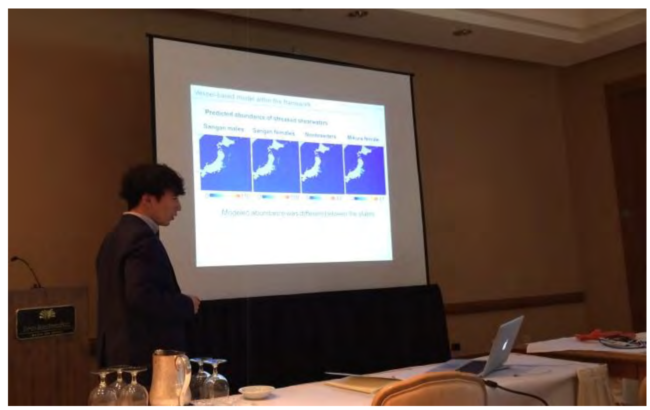
The presentation by M. Gadea Pérez-Andújar (University of Hawaii, USA) reviewed tagging results and vertical movement of deep-water sharks relative to the oxygen minimum zone (OMZ). By comparing species with different movement patterns (deep water activity within the OMZ), we may be able to understand how different species are likely to respond to more prevalent encounters with low oxygen waters. Rachael Orben (University of California Santa Cruz, USA) discussed winter movements of black-legged kittiwake from the Pribilof Islands to the sub-arctic North Pacific across three winter seasons. She found higher use of the Bering Sea during the El Niño conditions of 2009/10 and that individuals traveled farther, flew more, and used more area in La Niña conditions in 2010/11. Stable isotopes also showed greater individual variability in carbon isotopes in 2010/11, suggesting a use of a broader geographic area and/or prey base in this year.

William Sydeman (Farallon Institute for Advanced Ecosystem Research, USA) gave an invited presentation on challenges and opportunities for assessment and attribution of climate impacts on North Pacific seabirds. A meta-analysis revealed that increased temperatures had mixed effects on North Pacific seabirds, highlighting the need for more detailed examination of climate change mechanisms and responses. Additional important points were that we need more data and climate projections on mid-trophic forage species that greatly influence these top predators, and that we will likely need both mechanistic numerical models combined with statistical models to begin teasing apart the effects of climate variability from change.



Increased variability in Cassin's auklet breeding success in recent years. From W. Sydeman's presentation.

This invited talk was followed by two more seabird presentations from Takashi Yamamoto (University of Hokkaido, Japan) and Rob Suryan (Oregon State University, USA). Yamamoto's presentation examined both tracking data and shipboard sighting surveys of shearwaters in the Northwest Pacific. He used generalized additive models to partition sightings data into likely colony origination and sex, and also to predict changes in sea distribution with increased temperatures up to 4°C. Suryan used a 10-year time series to assess changes in common murre chick stable isotope signatures and diets as a function of local- and basin-scale environmental forcing. Specifically, he found a strong relationship between murre nitrogen isotope ratios and local upwelling intensity, suggesting possible trophic level shifts associated with upwelling regimes. It is unclear whether this represents a change in the length of the food chain or change in nitrogen values at the base of the food web. In contrast, carbon was most strongly associated with basin-scale indices of water mass transport impacting nutrient sources.



Takashi Yamamoto discussing streaked shearwater habitat use in the Northwest Pacific.

Chandra Goetsch (University of California Santa Cruz, USA) presented results on northern elephant seal foraging behavior changes and diet switching during the 2010 Central Pacific El Niño. Female elephant seals show extreme fidelity to their migrations, so changes in diet are likely a function of prey densities or selectivity by foraging elephant seals. Diet estimates from fatty acid analysis differed between ENSO states (negative, neutral, and positive) with positive, or El Niño, conditions being significantly different from neutral and negative (La Niña) conditions. Future analyses will examine specific remotely sensed oceanographic conditions which may be driving the behavioral and diet changes observed.

Our second invited speaker, Jeffrey Polovina (NOAA Pacific Islands Fisheries Science Center, USA), spoke about climate impacts on Hawaiian monk seals and loggerhead sea turtles relative to changes in the North Pacific Transition Zone (NPTZ). One of the strongest messages highlighted the complexity in predicting climate change effects on top predators, and why tagging studies are critical to assess impacts on these species. Specifically, models predicting a northward migration of the NPTZ may not have a large effect on sea turtles if the Kuroshio Extension and Bifurcation also migrate northward ensuring that the "highways" are still aligned with increased productivity. Furthermore, central place foragers, like monk seals, that are tied to land may no longer be able to reach critical foraging habitat after northward movement of the NPTZ, which likely will create population level effects.

Our third invited speaker, Kevin Weng (University of Hawaii, USA) gave a presentation on fish futures and how species are likely to adapt and respond to climate change. His talk discussed physiological responses to climate change and the potential interplay among CO_2, O_2 and temperature on fitness. Kevin discussed the use of end-to-end (E2E) ecosystem models such as SEAPODYM and APECOSM that are predicting climate change effects on distribution and abundance of top predatory fish. Furthermore, the point was made that we need to seek integrative funding calls to complete the research necessary to understand top predator responses to climate variability and change. Kevin also discussed the role of CLIOTOP and highlighted potential joint interests between the FUTURE and CLIOTOP programs on observing and predicting the effects of climate on top predators.

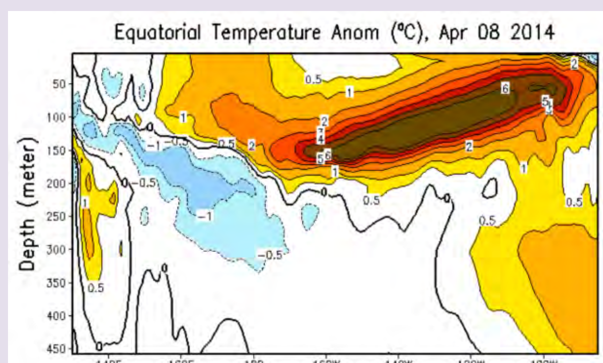
Brianna Witteveen (University Alaska Kodiak, USA) talked about the Gulf Apex Predator-Prey (GAP) integrated research project which is documenting spatial and temporal patterns in habitat use and consumption estimates of top predators in the ecosystem around Kodiak Island. These integrative surveys measured physical oceanography and lower trophic level species (zooplankton and fish) up to top predator sightings. Multi-scale data including aerial surveys, stable isotopes, and individual tracking data were also collected and can be used collectively to examine ecological changes in baleen whales since 1997.

Our final presentation was by Kathy Kuletz (U.S. Fish and Wildlife, USA) who provided an overview of available at-sea survey data for the subarctic and arctic North Pacific. A suite of studies are underway examining spatial shifts in seabird species and likely population changes such as for northern fulmars. Sightings data on seabirds are being linked to prey and oceanographic data. Long-term datasets and synthetic studies like these highlight the importance of understanding both responses to climate variability (*e.g.*, extreme climatic events) but also long-term (20+ years) trends in top predator distribution and abundance.

Summary and conclusions from the Workshop

There were several key takeaway messages from the workshop discussion: 1) A need to define the term "indicator" particularly for top predators; 2) A need to identify the mechanistic processes necessary to understand and attribute climate effects to top predator ecology and demography; 3) The importance and need for the synthesis and analysis of existing data, particularly in extreme years; and 4) a need to identify life history characteristics and metrics that are inherent to sentinel species. As part of these discussions, we came up with a suite of tasks mentioned in the objectives above that we hope to accomplish as part of AP-MBM, FUTURE, and CLIOTOP upcoming activities.

Box 1. Climate predictions for 2014 suggest that a strong El Niño – potentially similar in magnitude to the strongest previously recorded ENSO events – is developing in the tropical Pacific that may have large ecosystem effects throughout the North Pacific. Based on discussions from our PICES FUTURE workshop, we emphasize the importance of data collection to monitor the ecosystem response to the impending El Niño. Specifically, 1) ensure existing sampling and monitoring programs on physical and biological oceanography, forage species, and top predators are continued, 2) implement additional sampling to test key mechanistic hypotheses of ecosystem change that were generated during prior ENSO events, and 3) obligate sufficient funding to compile and analyze data with respect to previous El Niño events (1982–3/1997–8). Given the broad-reaching effects of El Niño events on ocean ecosystems, data collection and analyses should be coordinated throughout PICES member countries. Understanding the response of ecosystems to extreme climate events is critical to understanding how ecosystems may respond in the future under projected climate change scenarios. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_disc_apr2014/ensodisc.html.



First, our use of the term "indicators" refers to sentinel species that reflect (indicate) the impact of climate change on upper trophic level species and may serve to highlight or even lead certain biophysical processes that particularly impact upper trophic level species. Inclusion of sentinel species in FUTURE, therefore, fulfills a critical objective of assessing ecosystem impacts of climate change. The use of sentinel species to be early "indicators" of climate change is most appropriate in situations where information obtained from them is not being collected otherwise (*e.g.*, top predators can be indicators of prey species such as the abundance of Pacific sand lance, *Ammodytes hexapterus*, which is difficult to sample using traditional fisheries methods).

Second, understanding mechanisms (for example, PICES-2011 Topic Session S2, convened by Alheit, Hazen, Katugin, Suryan, Watanuki, Yasuda, 2011; Marine Ecology Progress Series Theme Section 487: 176–304, 2013) of how sentinel species are affected by climate change is critical to modeling ecosystem impacts to upper trophic levels. This effort will require a combination of statistical, numerical, and energy flow modeling approaches to identify mechanisms. The group also acknowledged that understanding all mechanisms is unrealistic given the suite of variables integrated by top predators, but identifying a few dominant mechanisms is realistic and should be a goal in the future. Particular life history traits may cause various top predators to respond differently to climate change such as a) central place forager *vs*. migratory species, b) trophic position in the food web, c) specialist *vs*. generalist foragers, d) air breather *vs*. gilled organism. Consideration of these traits have important implications when testing response mechanisms. We proposed that a subset of the workshop participants develop a review paper that examines the framework needed and mechanisms involved to understand responses of top predators to climate change.

Third, there is still much to be learned by compiling and analyzing existing datasets, particularly in response to extreme climatic events. This is critical for learning from past events, but also for targeting future research to fill knowledge gaps. It is essential to request adequate funds for data synthesis in future funding of field data collection.

Fourth, and perhaps most importantly, there was much discussion about understanding climate variability, particularly extreme years and the top predator response to these events. There is a suite of potential responses (*e.g.*, spatial shifts, temporal shifts, dietary changes, fitness and demographic change). Furthermore, with a potentially extreme El Niño event developing in the second half of 2014 (see Box 1), there is an urgent need to understand ecosystem responses to this event. We have written a statement for distribution among the PICES community stating the importance of continued measurements and, where possible, additional data collection. We foresee the need to collaborate across PICES committees to identify physical, biological, top predator, and ecosystem data needs to measure the response of the North Pacific to climatic extremes.

Acknowledgements *We thank the speakers for taking the time to travel to attend the workshop, summarizing and sharing their data, and contributing to a fruitful discussion. We would especially like to thank those individuals who contributed additional time to analyze new datasets specifically for this workshop. We thank the BIO and POC Committees, Science Board and the PICES Secretariat for supporting the workshop and for providing travel funds for our invited speakers. We also thank CLIOTOP for co-sponsoring an invited speaker for the session.*

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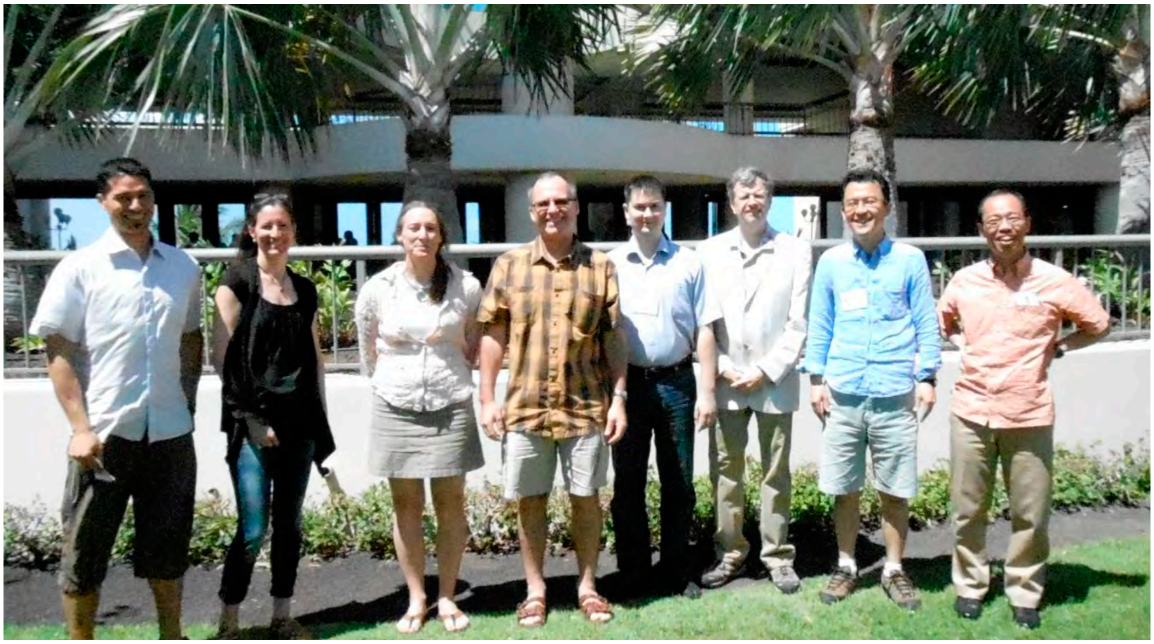
Dr. Steven Bograd (steven.bograd@noaa.gov) is a physical oceanographer (with Elliott Hazen) at NOAA's Southwest Fisheries Science Center, Environmental Research Division, in Pacific Grove, California. Steven is currently involved in a number of research projects studying climate variability and its impacts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

Dr. Takashi Yamamoto (taka.y@nipr.ac.jp) is a postdoctoral fellow of Arctic Environment Research Center at National Institute of Polar Research (working at Hokkaido University) in Japan. His research specialty is the spatial ecology of top predators, especially seabirds. Recently his research interests include behavioural and morphological adaptations of animals to local marine environment, and also understanding the factors influencing species distribution and predicting species response to climate-related changes using habitat modelling techniques.

Dr. Rob Suryan (rob.suryan@oregonstate.edu) is an Associate Professor - Senior Research in the Department of Fisheries and Wildlife at Oregon State University. His research focuses on marine ecosystem processes and their effect on foraging, reproduction, and population dynamics of mid to upper trophic-level predators and human-resource interactions.

OSM Workshop on "*Bridging the divide between models and decision-making: The role of uncertainty in the uptake of forecasts by decision makers*"

by Edward J. Gregr



Convenors and invited speakers (left to right): Kai M.A. Chan (Canada), Lee Failing (invited speaker, Compass Resource Management Ltd., Canada), Georgina A. Gibson (invited speaker, International Arctic Research Center, University of Alaska Fairbanks), Edward J. Gregr (Canada), Vladimir Kulik (Russia), Hal Batchelder (PICES Secretariat), Motomitsu Takahashi (Japan), Shin-ichi Ito (Japan), Missing: Naesun Park (Korea), Ian Perry (Canada), Jameal Samhouri (USA).

The FUTURE science program recognizes the need to more directly address uncertainty in products such as ocean climate forecasts, and to improve how the knowledge produced by PICES is disseminated. In a series of presentations and discussions, our workshop (W2), held April 14, 2014, examined both the nature of uncertainty in model systems, and how uncertainties can be included in the decision making process. The workshop was well attended, with broad representation from PICES member countries. We identified a number of opportunities for the PICES community to improve how uncertainty is characterized, and to highlight several advantages that would emerge from tailoring model outputs, including uncertainties, for diverse audiences.

Understanding uncertainty

The first step in addressing uncertainty is to understand its source. Gregr and Chan (in review) consider three classes (Data, Scope, and Process) of uncertainty based on the assumptions necessary at various steps in the model design process. Assumptions about data relate to uncertainties about things such as sampling bias, representativeness, and the overall relevance of the data to the study under consideration. Decisions about model scope (*e.g*., specification of spatial, temporal, and compositional extents) are central to model design and contain uncertainties about model boundaries and resolution, among other things. Once model data and scope are defined, decisions and assumptions about process must be made, for example, which ecosystem components interact and the nature of these interactions, some of which are also uncertain.

For the purposes of communication and decision-making, Gregr and Chan added two additional classes of assumptions, Communication and Relevance (Table 1). Assumptions around communication obscure uncertainties related to things such as language and disciplinary epistemology. Perhaps most importantly, the relevance of ecosystem model results to decision-making is often assumed to be quite high by model developers. However, this is far from certain, and evidence suggests that it is often quite low (Failing, this workshop). This class of assumptions thus relates to uncertainties about indicator selection and the context relevance. In many cases, comprehensive treatments of model uncertainties are not necessarily desirable (or tractable). However, Gregr and Chan argue that a more explicit recognition and discussion of model assumptions is necessary for improving our understanding and communication of model results, and the associated uncertainties.

Table 1 Assumption classes and the associated types of uncertainty.

Assumption class	Uncertainty
Data	Observational
Scope	Design uncertainty
Structure	
Process	Parameter estimation
	Natural variation
	Inherent randomness
Communication	Ambiguity
	Under-specification
	Vagueness
Relevance	Context dependence
	Relativism

Representing uncertainty

Several presentations illustrated methods for examining model uncertainties. Invited speaker, Georgina Gibson (USA), discussed the role of assumptions in the development of lower trophic level (LTL) ecosystem models. Describing how the complexity of model structure and parameterization can increase quickly, she emphasized the associated need for assumptions to manage this. She demonstrated how to use sensitivity analysis to identify critical parameters, but noted that the large computational demands limit the extent to which it can be applied. Gibson and Spitz (2011) used a one-dimensional lower trophic level model to examine a suite of 135 biological and 8 environmental factors, and ranked these factors according to their influence on model outputs. Although the approach identified parameters deserving closer scrutiny, similar analysis has not been applied to 2- or 3-dimensional models because of the computational limitations, leaving important parameters untested.

Exploring the parameter uncertainties in such simulation models is typically handled using established Monte Carlo methods. However, knowing the range over which to sample parameters is critical to such efforts. Unfortunately, such ranges (which are necessary to parameterize theoretical, mechanistic models) are not always known, and thus represent important design assumptions. Similarly, initial or starting conditions for models may be unknown, which can have a significant effect on the trajectory of model predictions (Gibson and Spitz 2011).

Rowenna Gryba (Canada) examined assumptions about the relevance and utility of data, and how this influences the evaluation of habitat suitability in models of North Pacific Right whales. Standard cross-validation approaches to evaluating models of habitat suitability are sensitive to potential biases in the data. Analytical methods typically assume unbiased data, but analyses often contain implicit, potentially false assumptions about the relevance or suitability of such data, which may contain geographic or seasonal sampling biases. Gryba also considered conceptual assumptions implicit in such models, where, for example, it is often assumed that mammal sightings are correlated with high prey concentrations. She showed how this conceptual assumption is testable using independent data on prey distributions, thus providing insights into the uncertainty associated with this key habitat modeling assumption.

The challenge of coupling models was discussed by Shin-Ichi Ito (Japan), who presented the results of a fisheries production model for Pacific saury forced using sea surface temperature predictions from 12 different global climate models developed by the Intergovernmental Panel on Climate Change (IPCC). While a number of correlations were found, uncertainty in fish growth projections were dominated by uncertainties in the physical forcing. This emphasizes the need for appropriate scaling methods when moving from global to regional study areas. Ito suggested that to effectively couple models across scales, more attention needs to be paid to key processes at the interfaces. For example, zooplankton dynamics play a key role in saury abundance. Thus, it is critical to appropriately capture the relationships between physics and zooplankton, and between zooplankton and higher trophic levels (HTLs). Given that HTLs typically respond to multiple drivers operating at different scales (*e.g*., Palacios *et al*. 2013), a better understanding is needed about how HTLs respond to short-term forecasts.

The need to understand such processes and their interactions was nicely illustrated by Bill Peterson (USA), who showed how the correlation between the Pacific Decadal Oscillation (PDO) and Chinook salmon ocean survival, which had shown a robust negative correlation for 15 years, suddenly failed dramatically in 2011. The causal relationship appears mediated by copepods, which provide an index of the lipid richness at the base of the food chain. This 'lipid rich copepod index' is, in turn, correlated with Chinook survival. However, the decoupling of the relationship highlights new uncertainties about the scale and process of the presumed mechanism. Once again, this emphasizes the need to understand the process, though even so, surprises should be expected. For HTL models in particular, the need to transition from correlative to mechanistic model frameworks is increasingly relevant (Palacios *et al*. 2013).

Decision making and communication

Lee Failing (Canada), our second invited speaker, provided an important perspective on the role of research and uncertainty in decision making. Failing noted that while many frameworks exist to support integrated management, the process of actually making decisions and managing the risks arising from uncertainty are rarely emphasized. Rather, the decision-making components are often presented as *post-hoc* interactions with the principal science represented in prominent detail (*e.g.*, Figure 1). Treating decision-making as an afterthought introduces many implicit and likely false assumptions about the role of science in the decision-making process. Such perspectives are grounded in the information deficit model of science communication, an approach that is increasingly understood to be false (see http://en.wikipedia.org/wiki/Information_deficit_model). Only a small portion of science as currently practiced is typically salient to decision makers. To improve the relevance of science to policy and decision making, Failing emphasized the transformative power that comes from "making the decision" the goal of the scientific effort and analysis. This leads to immediate identification of what is important, and informs where science could best contribute to the process. The salience of such contributions would be greatest if they helped inform the trade-offs faced by decision-makers and their stakeholders.

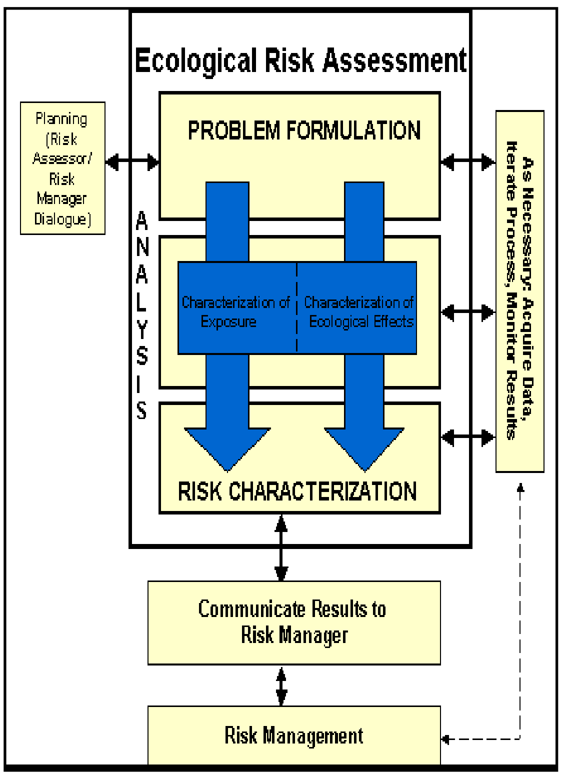


Fig. 1 Example risk assessment framework emphasizing (red oval, added) the implied post-hoc role for the decision making process.

This leads to the question of science communication, and Kai Chan (Canada) argued that this is as much a question of targeting as it is of understanding the science and the inherent uncertainties. Through various examples, Chan emphasized the need to focus on the complete decision scenario to identify what really matters and, equally important, what is at risk. From the perspective of the FUTURE program, this means identifying relevant metrics and understanding the distribution of inputs and outputs. It also means being explicit about unquantified assumptions to help understand the associated risk. And perhaps most importantly, it means recognizing that there is no single audience or stakeholder, but rather a diversity of interests for whom different metrics and presentation methods may be required. Targeting – identifying what matters, and how it is best measured, for each decision scenario – will be key to effectively communicating FUTURE products beyond the PICES scientific community.

Challenges and opportunities

In addition to the presentations, we devoted considerable time to discussion, including a joint session with the participants of workshop W3 on "*Climate change and ecosystem-based management of living marine resources: appraising and advancing key modeling tools*". The joint session acknowledged that the fundamental challenge for the modeling community is to identify what resonates with decision makers. Given the diversity of management and policy decisions that are regularly made, this emphasizes the need to develop communication strategies that can adapt effectively to diverse audiences. Decision makers would like to reduce risk and reduce surprises. This would presumably simplify the trade-offs inherent in policy and management decisions.

The role of reliable ecosystem forecasts in reducing risk and producing fewer surprises is recognized, although the risk of such forecasts being wrong and surprising decision makers will need to be carefully managed. Integrating data from regional Ocean Observing Systems, focusing on short-term forecasts, and predicting the responses of HTLs are essential components of such ecosystem forecast systems. The increasing risks faced by decision makers due to climate uncertainty provide an opportunity to advocate for ocean climate forecast services at regional scales, emphasizing that their utility for managing risk is as high as traditional short-term weather forecasts.

Uncertainties related to closure terms (*i.e.*, the parameters required to represent aspects not included in the model), model structure, and the downscaling of global models will continue to present challenges to the development of such short-term forecasts. Ensemble modeling is increasingly providing an opportunity to address the cumulative uncertainty in highly complex models, allowing the assessment of robustness (Knutti and Sedláček 2013). To demonstrate their relevance, a key performance challenge for such short-term forecasts is to achieve not only statistical accuracy, but to reasonably predict the phase (*i.e.*, timing) of climatic events. This will be best approached through regional models, which have already met with some success, such as the prediction of hypoxia events (Siedlecki *et al.* 2014). Accurate predictions of phase changes is critical (although emphatically not sufficient) for forecasting the HTL indicators important for many stakeholder groups.

(Continued on page 34)

OSM Workshop on "*Climate change and ecosystem-based management of living marine resources: Appraising and advancing key modeling tools*"

by Tim Essington, Anne B. Hollowed and Myron A. Peck

The workshop (W3), co-sponsored by the ICES/PICES Strategic Initiative (Section) on the *Impacts of Climate Change on Marine Ecosystems* (SICCME/S-CCME), was convened by the co-authors of this summary on April 14, 2014, as part of the PICES FUTURE Open Science Meeting. Ten scientists representing 6 nations participated in the meeting.

Overview

Climate variability and climate change interact with other pressures to affect the productivity and dynamics of marine ecosystems. Managers charged with the stewardship of sustainable living marine resources are challenged to deal with the consequences of this variability, and better tools are needed to inform them. The workshop was convened to discuss state-of-the-art tools for: (1) calculating biological reference points under changing climate conditions that recognize that equilibrium states no longer apply; (2) assessing the relative ecological and economic costs and tradeoffs of different ecosystem-based management scenarios, and (3) estimating the vulnerability and stability of ecosystems (and their key components) required to make informed, ecosystem-based fisheries management decisions. The workshop was intended to provide a critical review of modeling tools available for fisheries management needs and to understand what advancements are required to address climate-driven changes in ecosystem dynamics.

Objectives

The three main objectives were to discuss state-of-the-art tools for:

1. Calculating biological reference points under changing climate conditions that recognize that equilibrium states no longer apply,
2. Assessing the relative ecological and economic costs and tradeoffs of different ecosystem-based management scenarios, and
3. Estimating the vulnerability and stability of ecosystems (and their key components) required to inform ecosystem-based fisheries management.

Summary

Two invited speakers provided a strong conceptual backdrop on the current status and important avenues for future progress in state-of-the-art ecosystem modeling. In the first talk, Icarus Allen (PML, UK) presented an overview of the current state of lower trophic level (LTL) models with emphasis on examining links between physics, biogeochemistry and the production of phytoplankton and zooplankton. He compared the pathways utilized to represent food web connections within LTL models highlighting the fact that these are fairly rigid and different pathways. Many of these nutrient-phytoplankton-zooplankton-detritus (NPZD) models were never designed to represent zooplankton dynamics, although many are being utilized to estimate biomass and productivity of that component. An important advancement of these LTL models includes more mechanistic (physiological-based) representation of life history and trait-based approaches allowing evolution and adaptation to environmental conditions to take place (and emergent properties of communities), and more widespread inclusion and increased complexity in representing benthic processes. Modular models with flexible components are needed. Furthermore, the talk stressed the importance of broad-scale patterns (consistent features of groups which are independent of habitat characteristics) that allow one to better validate models.

In the second invited talk, Beth Fulton (CSIRO, Australia) provided an overview of her experience constructing complex (parameter-rich) end-to-end models and ongoing improvements in model structure and parameterization that help represent real-world complexity. Her talk stressed how ecosystems are moving targets with respect to the features of key components. One example was the inability to examine temporal development in fish groups without explicitly accounting for fishery-induced changes in size during the early portion of the time series and both fishery effects and climate-induced changes. She also highlighted the importance of exploring scenarios in end-to-end models that include consideration of the full extent of (potentially surprising) human responses within multiple interacting sectors. When used in this manner, it is possible to assess the importance of various attributes of ecosystems (such as the presence or absence of adaptation of key species to change). Her work with these complex models also highlighted the importance of collecting new information on key groups such as mesopelagic fish and forage species, which are a rarely studied but possibly are a critically important component in many marine food webs. Understanding and modeling the adaptive capacity of both biological (food web components) and social systems are important challenges that need to be overcome.

Alan Haynie (NOAA NMFS, USA) provided a (recorded) talk introducing FishSET, a spatial economics toolbox to better incorporate fisher behavior into fisheries management and ecosystem modeling. The model attempts to understand how fishers respond to various aspects such as fish or fuel prices, changes in habitat and the environment, bycatch regulations, catch shares, and marine reserves or other closures. This location-choice model uses various types of available data to evaluate what factors explain where vessels fish (and related questions). The fishing area is chosen as a function of key economic indicators such as expected catch/revenue in the area, travel costs (fuel, time, wages, the opportunity cost of not using the boat elsewhere) and vessel characteristics (*e.g*., horsepower), as well as biological and environmental characteristics of areas. FishSET is a stand-alone Matlab application and the presentation outlined the 7 primary features of the model. An upcoming pilot project in the Northeast/Mid-Atlantic will examine the interactions between fishers and potential wind energy projects.

In the final talk, Myron Peck (University of Hamburg, Germany) briefly introduced the EU VECTORS program which is attempting to examine the ecological and economic costs and tradeoffs of changes in the distribution and productivity of outbreak forming species (such as jellyfish) and alien invasive species. Three European regional seas are in focus (North Sea, Mediterranean Sea, and Baltic Sea). This presentation summarized efforts to build consistent future scenarios that allow one to not only incorporate physical and biological changes projected under different greenhouse gas emission scenarios but also the key economic (fish price, fuel price, gear investment, *etc*.) and policy decisions regarding spatial utilization of ocean habitats (from fisheries, renewable energy, conservation, *etc*.). An important take-home message was that future policy mechanisms may be as important as potential climate-driven changes in the distribution of fish stocks. The talk also summarized how distributional changes, as detected using different approaches (bioclimate envelop models, dynamic energy budget models) under common scenarios, were being assessed using a spatially explicit bio-economic model (FishRent).

A wide ranging discussion followed these talks which was facilitated by a 1-hour combined session with workshop W2 focusing on communicating science and effective stakeholder engagement. Key findings from the workshop were:

- Models should be flexible to accommodate shifting selectivity, growth, natural mortality, and availability. Zooplankton and mesopelagic species, as well as the adaptive capacity of food web components need to be better represented.
- Fisher choice models provide insight into functional responses which will be critical to use within end-to-end models of marine systems, which include management evaluation frameworks. Stock assessment and fisheries scientists should partner to conduct retrospective studies of fisher responses to changing conditions.
- Setting biological reference points without knowing the trajectory to a new equilibrium state will be challenging. Management evaluation frameworks are needed to identify robust harvest strategies.
- Projections of the effects of climate change on future fish and fisheries must consider also the responses of fishers and managers. Developing future scenarios must be done in conjunction with stakeholders. A set of candidate alternative futures is needed to set the stage for discussion of scenarios.

Acknowledgements

The workshop convenors thank the invited speakers and workshop participants for active discussions. Issues were highlighted that can be taken up by ICES/PICES S(I)CCME via inter-sessional work.

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Dr. Myron A. Peck (myron.peck@uni-hamburg.de) is an Associate Professor of Biological Oceanography at the University of Hamburg, Institute of Hydrobiology and Fisheries Science (Hamburg, Germany). He has a broad range of research interests related to physical and biological processes governing marine and estuarine species and food webs, including coupling species life history and physiology and translating that knowledge to models to advance predictive capacity.

OSM Workshop on an *"Ecosystem projection model inter-comparison and assessment of climate change impacts on global fish and fisheries"*

by Anne B. Hollowed, Kirstin Holsman and Kerim Aydin

Introduction

Climate change is a global issue affecting marine ecosystems and species that span multiple international boundaries, and is one of the most universal challenges facing fisheries scientists and managers around the world. To address these challenges scientists have developed modeling approaches and management tools to project future impacts. This task mandates international collaboration to develop approaches that can be implemented across multiple, large marine ecosystems worldwide. Keeping pace with a rapidly changing climate also requires fisheries management tools that can accurately and efficiently inform best solutions in an uncertain future and evaluate tradeoffs associated with alternative carbon management strategies, yet implementation of such management lags behind climate-driven changes to species and ecosystems. As part of the on-going activities of the PICES/ICES Section on *Climate Change Effects on Marine Ecosystems* (S-CCME, also known as the Strategic Initiative on Climate Change Effects on Marine Ecosystems), Anne B. Hollowed (AFSC NOAA), Kerim Aydin (AFSC NOAA), and Kirstin Holsman (JISAO/AFSC) co-convened a workshop on April 12–13, 2014, at the FUTURE Open Science Meeting (OSM). The workshop was funded by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) as a project within its International Science Program. Twenty nine scientists, representing seven nations, participated in the meeting.

The goal of this workshop was to discuss options for interfacing fisheries and ecosystem models with next generation Earth System Models (ESMs). Several marine ecosystem modeling approaches have been advanced to project the impacts of climate-driven changes on marine ecosystems and to identify sustainable harvest practices for ecosystems impacted by climate change[1][2]. Each of these approaches has inherent strengths and weaknesses, depending on which fisheries management questions are being considered[3]. Increasingly, fishery and ecosystem modelers recognize that a global network of models is needed for a world-wide synthesis of climate change effects on marine ecosystems and the global food supply. A necessary first step towards this goal is an assessment of the relationship between model complexity, efficiency, predictive skill, and the computational costs of increased ecological realism in models, which can be used to identify the suite of candidate models for the global network [4][5]. This assessment requires guidance on how the fisheries science community and the global climate modeling community interface their models and exchange data.

The workshop brought together earth system modelers, oceanographers, fisheries stock assessment scientists, and ecosystem modelers to discuss the current and near-term future status of ESMs and their potential contributions to projecting climate change impacts on living marine resources, providing much-needed information for sustainable fisheries management in the future. Increases in computing power and storage have facilitated refinements in the spatial and temporal scale of climate models[6] and ESMs have been developed that incorporate terrestrial and oceanic biosphere processes. Conceivably, ESM outputs could be used to project climate change impacts on the distribution and abundance of phytoplankton and zooplankton in marine systems[7], eliminating the need for dynamic downscaling of global climate projections to regional circulation models. However, because ESMs may not appropriately capture important oceanographic features (*e.g.*, regional upwelling zones, coastal eddies, or benthic processes) the appeal of such a unified, global approach must be weighed carefully against the advantages of regionally tailored marine ecosystem modeling frameworks.

Specific objectives for the workshop included:

Obj. 1 Identify the optimal means of combining global ESMs, high resolution regional modeling frameworks (RMFs), and ecosystem models of varying complexity to provide robust assessments of climate change impacts on living marine resources and their habitat.

Obj. 2 Coordinate international efforts to assess biological and societal impacts of climate-driven changes to future marine resources.

The 1½ day workshop (W4) consisted of a mix of oral presentations and group discussions. On day 1, Anne Hollowed gave a brief opening address and described the expectations for the workshop. She explained that participants would focus on three tasks: (1) review the current state of climate and ecosystem models for each region; (2) identify inter- and intra-region comparisons and objective questions, specifically, identify focal regions/ marine systems, available data, and a subset of existing models for initial analyses; and (3) identify a list of collaborators, individual tasks relative to comparative analyses phase A or B (see Fig. 1), specific timelines and benchmarks, and budgetary/funding requirements for completing model inter-comparisons.

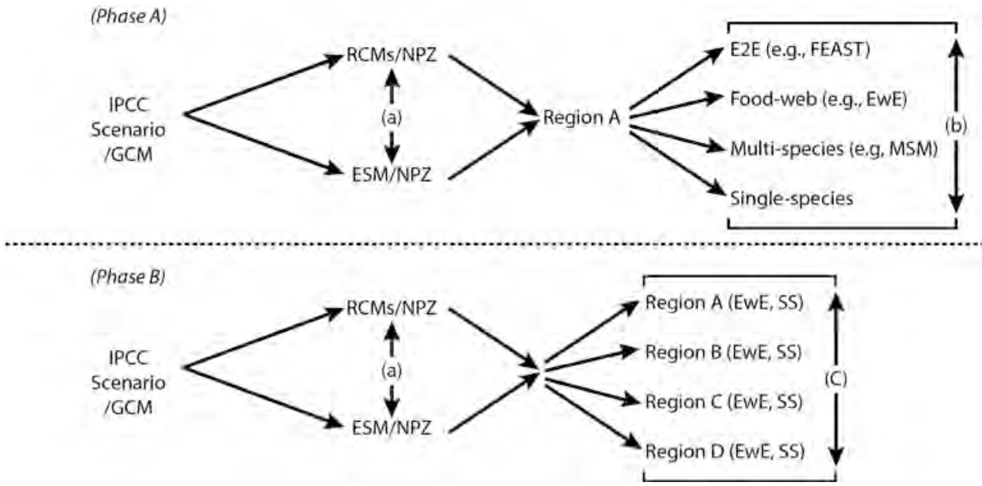

Fig. 1 Two-phase framework for model inter-comparisons (order of phases depends on available models and data), using the eastern Bering Sea (AK, USA) as an example. a) Comparative results from coupled regional climate models and nutrient phytoplankton zooplankton models (RCMs/NPZ) and Earth System Models (ESM); b) intra-regional comparison of model results to identify best models for application in c) inter-regional comparisons. Proposed regional models are for illustrative purposes only and will depend on existing models for each region. E2E: end-to-end models; EWE: Ecopath with Ecosim; MSM: multi-species stock assessment; SS: single-species stock assessment.

Task 1 was accomplished through 16 oral presentations during the first day. The first four speakers discussed existing work on global climate models and earth system models. The spatial distribution of global climate models and earth system models varies. Charles Stock reviewed the types of models currently developed or under development at the Geophysical Fluid Dynamics Laboratory in the U.S. Enrique Curchitser discussed ongoing collaborations between Rutgers University and the National Center for Atmospheric Research (NCAR) and presented several examples where models developed by the climate modeling community have been used to project changes in habitat quality and quantity (*e.g.*, polar bear habitat in the Arctic and spatial extent of future coral reef bleaching). Scientists at Rutgers and NCAR are partnering to develop high resolution coupled models (the Community Earth System Model, CESM) of the California Current ecosystem. Icarus Allen described the United Kingdom Earth System Modeling Project (UKESM). Members of this project are developing suites of models at different spatial and temporal resolutions that will contribute to the sixth Climate Model Intercomparison Project 6 (CMIP6) effort. Scientists are exploring outcomes from nutrient, phytoplankton and zooplankton models with different levels of complexity. The inter-comparison will attempt to have common computing platforms, common physics, common forcing, and common initial conditions. New models with 1/10 degree spatial resolution of the physical models are being tested in the UK. Michio Kawamiya discussed the status and future of Japanese climate models. Japanese scientists are testing new models in preparation for CMIP6 that will include improved spatial resolution (vertical and horizontal) and enhanced complexity of the nutrient, phytoplankton and zooplankton components of the models. Nesting models at different spatial scales provide improved ability to resolve fine-scale physical features in waters off the coast of Japan.

The next suite of modelers presented results of efforts to force regional marine ecosystem models with boundary conditions from climate models. Beth Fulton described the on-going research in Australia to project the implications of decadal variability and climate change on marine ecosystems. Australian modelers are also striving to improve the biological realism and spatial resolution of models. She introduced an existing effort to develop a Fish Model Intercomparison (FISH-MIP) and an Intersectoral Impact Model Intercomparison (ISI-MIP). Workshop participants recognized that the goals of FISH-MIP and ISI-MIP are similar to S-CCME and therefore, participants will pursue possible future collaborations with these groups. Michael Foreman provided an overview of the current status and future plans for ocean ecosystem modeling in Canada. He noted that efforts are underway to improve the spatial resolution and biological realism of the ocean models. Recent retrospective comparisons showed that current regional circulation models were not reproducing offshore upwelling and downwelling winds and seasonal transitions correctly so additional work is needed. In addition, Canadian scientists are developing a high-resolution regional model for the high Arctic. Al Hermann discussed a regional ocean model for the southeastern Bering Sea that was first developed as part of the GLOBEC program and has been improved as part of the BEST-BSIERP Bering Sea Project. This model reproduces known physical features with reasonable accuracy and preliminary projections through 2040 are now available for use in fisheries models.

Afternoon presenters continued to discuss the status of regional ocean model experiments. Shin-ichi Ito noted that several models have been developed to project climate impacts on Japanese fish distribution and abundance. The complexity of the nutrient-phytoplankton-zooplankton components of these models differed substantially.

Projections through 2100 are available for some species (*e.g.*, Pacific saury and sardine). William Cheung presented a global assessment of the catch potential of fisheries in the future based on available climate model outputs. Kirstin Holsman gave a talk on behalf of Kerim Aydin who was unable to attend the meeting. Aydin's model extends the coupled bio-physical model described by Hermann to include fish and fishers. The model tracks local environmental conditions, and fish movement emerges as a property of energetic demands, prey availability and predation. Retrospective runs of the model are able to reproduce the general spatial pattern of key ecosystem components. Projections should be available within the next 6 months. Melissa Haltuch and Kirstin Holsman provided an overview of available methods for projecting future abundance of key species using climate-enhanced single species or multispecies models. Using approaches similar to Cheung's dynamic bioclimatic window approach, Elliott Hazen estimated the impact of future climate change on the availability of suitable habitat for several top predators. Pheobe Woodworth-Jencoats compared projections based on an ecosystem model (Ecopath with Ecosim) and a size spectrum modeling approach. She found similarities in model outputs at lower trophic levels but important differences between the two modeling approaches for larger predators. This finding provided insight into the range of possible projected future outcomes. The last speaker of the day was Nicholas Bond who discussed a relatively new effort to develop short-term now-casts of climate. These now-casts can be utilized to estimate uncertainty in short-term model projections.

Discussion

In most regions increases in computing power and storage have facilitated refinements in the spatial and temporal scale of climate models[6], and ESMs have been developed that incorporate terrestrial and oceanic biosphere processes. Conceivably, ESM outputs could be used to project climate change impacts on the distribution and abundance of phytoplankton and zooplankton in marine systems[7], eliminating the need for dynamic downscaling of global climate projections to regional circulation models. However, because ESMs do not yet appropriately capture important small-scale oceanographic features (*e.g.*, regional upwelling zones, coastal eddies, or benthic processes), in the near-term the use of ESMs in a unified, global approach should (minimally) be coupled with regionally-tailored marine ecosystem modeling frameworks.

Definitions

The workshop participants held a lengthy discussion regarding terminology for this experiment. Our experiment differs substantially from the Coupled Model Inter-comparison Phase 5 used to support the most recent Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5. In our experiment, estimates of higher tropic level responses to climate will be derived from different scenarios regarding regional ocean conditions. To the extent practicable, investigators will strive to utilize a common suite of representative concentration pathways (RCPs) and a common suite of GCMs (Global Climate Models) or ESMs. However, the methods used to downscale these global boundary conditions to derive regional ocean conditions will differ between modeling approaches. Thus, disparate projected impacts of climate change on higher trophic levels will partially reflect different mechanisms incorporated into the models utilized by the modeling teams. We anticipate that the models will span a wide range of mechanistic complexity ranging from minimally realistic approaches to fully coupled end-to-end ecosystem models (Fig. 1). Thus, our proposed experiment will not represent a true model inter-comparison, wherein the conditions are held constant to the extent practicable and the structural aspects of the model are evaluated. The comparison will be an evaluation of the projected higher trophic level responses to regional ecosystems change caused by a common suite of climate forcing scenarios.

The participants discussed a variety of issues related to evaluating model performance. They considered the approach often used in the stock assessment community, where analysts develop a simulated system with known properties and then evaluate their model's ability to correctly identify the properties of the system. In the context of the proposed experiment, analysts would have to develop a simulated ocean and lower trophic level system with known properties as a test-bed for evaluating model performance. While this is a useful idea, the feasibility of analysts developing a simulated ocean was deemed too difficult at this time. The group recommended that the modeling framework should include retrospective runs and short-term predictions as potential diagnostics on model performance and agreed that the goal of this experiment was not to judge the models but to compare the projected scenarios of higher trophic level response across a range of models.

The group recognized that defining the framework to conduct this experiment is a very high priority as it sets the stage for each of the modeling teams. Workshop participants will work off-line to develop this framework. Details of the modeling framework can be discussed during the S-CCME meetings at ICES' Annual Science Conference and at PICES-2014. The group will propose a workshop to be held in 2015 to re-convene the group to finalize the framework.

Results of a subsequent workshop (see the workshop on "*Climate change and ecosystem-based management of living marine resources*") provided substantial evidence that assumptions regarding the response of fishers to changes in the distribution and abundance of target species are important and must be incorporated into the framework of the experiment. Participants in that workshop recommended that a range of possible fisher responses should be considered and thus, the framework for the proposed upper trophic level projection experiment should also describe how to treat this issue.

Discussion questions

1. Are ESMs ready to be implemented for use in forcing regional ecosystem models?

The group agreed that the current practice of using ocean and atmospheric conditions derived from GCMs can be extended to utilize outputs from ESMs. Between now and 2021, the spatial resolution of global climate models (GCMs) and ESMs are likely to be reduced to 0.25–0.1 degree. Initial runs of ESMs at 0.1 degree resolution reveal the models are capable of resolving finer-scale ocean current features, including eddies and upwelling. Atmospheric and physical features derived from these models can continue to be used as boundary conditions for regional ocean circulation models. There is wide diversity of opinion whether, or how, nutrient, phytoplankton and zooplankton outputs from ESMs should be used as boundary conditions for regional models. There are presently no biological feedbacks between the regional models and ESMs.

Some outputs from climate models are available to the scientific community. However, the temporal resolution of the output from some models is coarse and information from vertical layers is not always available. The regional modeling community should develop a request of key outputs with consistent spatial and temporal resolutions needed from global models to adequately force regional models.

The group noted that several organizations around the globe have initiated model inter-comparison projects including:

a) The Coupled Model Intercomparison Project Phase 5 that formed the basis for the most recent IPCC report;
b) The Arctic Model Intercomparison Project;
c) The Geoengineering Model Intercomparison Project;
d) The Atmospheric Model Intercomparison Project;
e) The Carbon–Land model Intercomparison Project;
f) The Inter-Sectoral Impact Model Intercomparison Project (ISI–MIP) which has a sub-component dealing with marine ecosystems and fisheries (FISH-MIP);
g) In 2009, PICES initiated a Marine Ecosystem Model Intercomparison Project (MEMIP) to examine regional zooplankton productivity. Extensions of this effort could contribute to the proposed project focused on fish and fisheries;
h) The international MARine Ecosystem Model Inter-comparison Project (MAREMIP), which is an ecosystem model inter-comparison focusing on hindcasting phyto-plankton concentrations as measured by ocean color;
i) At the same time as these formal inter-comparison projects, biological ensemble modeling has been conducted using projections from multiple GCMs on a single model[8] and one GCM using multiple biological models[9], showing the potential benefits of critically examining the outputs of biological models with structural differences.

The group recommended that the proposed PICES and ICES initiative to compare projections of future fish and fisheries using different models could contribute to the FISH-MIP effort.

2. Do existing higher trophic level models use a common set of the most recent IPCC projections?

Yes and No. While regional teams are using forcing from models that have implemented the IPCC emissions scenarios, they do not all use the same specific (or ensemble) GCM or ESM for downscaling RCMs. Regional ocean circulation modelers often work with modeling teams in closest proximity to their laboratories. There are several advantages to this including ease of access to experts for discussions and a general sense of comfort that the ESM modeling teams are familiar with the local physical and environmental features of the region. In a few cases, regional modeling teams have evaluated GCM or ESM modeling performance relative to reproducing important features of a regional ocean. Model selection is based on performance. For example the Bering Sea modeling team used the MIROC, CGCM3 and the ECHOG models. Likewise, the Japanese regional modeling teams plan to work with modeling teams from the Geophysical Fluid Dynamics Laboratory and the Hadley Center as well as their local modeling nodes.

The regional modeling teams had a mixed track record with respect to access and utilization of the most current version of GCM and ESM models. In several regions the regional ocean circulation models were being forced with models developed for AR4 rather than the more recent CMIP5 models. This time-lag needs to be addressed to ensure that regional ocean model projections are based on the best available science.

3. How should IPCC scenarios be selected (e.g., a specific emission scenario, multiple, etc.)?

Multiple model scenarios are needed to reflect the full range of possible future conditions. As noted above, a framework for implementing multi-model higher trophic level projections will be needed. Time did not permit a full discussion of this framework.

4. Is (or will) the quality and spatial resolution of phytoplankton and zooplankton output from ESMs be of sufficient quality to use as boundary conditions for regional models or as indices for stock projection models?

Unclear. The methodology for coupling biological responses derived from ESMs and regional models has not been fully developed. A few starting steps have been taken, and these make clear that dealing with differences in scale and the resolution of processes in the different models raises scientific issues that need careful handling to avoid the introduction of artifacts when shifting from one scale to another.

5. What is the state of coupled RCMs/NPZ models?

See [Workshop 4 presentations](). Multiple regions have begun or are already using coupled RCMs/NPZ models.

6. How sensitive are NPZ models to structural assumptions (i.e., boxes)? Should we try to standardize this across regions?

Models are sensitive to their formulations, but it would not be advisable to insist upon a common modeling platform to be used universally, as system-specific idiosyncrasies are required for making robust projections of the dynamics of different ecosystems. Trying to develop and implement a universal model would likely require resources and data sets in excess of what is currently available.

7. What are the most confident outputs from NPZ and ecosystem models (e.g., biomass, abundance, shifts in distribution, upper trophic consumers or lower trophic level biota [e.g., phyto- or zooplankton])?

While there is agreement that the general patterns produced by NPZ models are capturing system dynamics, the absolute values remain uncertain. Zooplankton dynamics are perhaps the weakest terms at present, with phytoplankton much more reliable. This is, in part, because of how the zooplankton are currently represented, and also because there are significant gaps in available data, which become increasingly spatially and seasonally heterogeneous with higher trophic levels, particularly in key processes such as the partitioning of mortality across different sources of natural mortality. This is important because zooplankton are a key trophic link between the plankton communities and fish communities (*via* larval, juvenile fish age classes and planktivorous species). Many subtle features of ecosystem evolution are currently missed and a review of what works where and why would be a valuable exercise, though it may be contingent on the original motivation for the development of the initial models.

8. What are the strengths and weakness of simplifying assumptions for higher trophic level projection?

While individual modeling teams have a strong appreciation of the shortcomings of their own model representations, they are not well known outside these expert user groups. This is, in part, because it would be a significant undertaking to document these features. The proposed intermodel comparison, suitably documented, would be a useful step forward in disseminating this information in a tangible and tractable way.

General timelines

- *April 2014:* Workshop 1 at the FUTURE Open Science Meeting, Hawaii;
- *May–December 2014:* Design a framework for comparing within region multi-model projections;
- *March 2015:* Workshop 2 to be held in 2015 (Proposals to be submitted to ICES, PICES and NOAA);
- *2015–2016:* Complete Phase 1 comparison of multi-model projections for selected regions;
- *Summer 2016:* Submit (Phase 1) results to target journal;
- *March 2016:* Workshop 3 – review frameworks for comparing between region multi-model projections for selected species groups;
- *2016–2017:* Complete Phase 2 comparison of region multi-model projections for selected species;
- *2019:* submit Phase 2 results to target journal;
- *December 2020:* Published results for use in next IPCC assessment.



See Dr. Anne Hollowed's bio in the previous article.

Dr. Kirstin Holsman (kirstin.holsman@noaa.gov) is a research scientist with the University of Washington Joint Institute for the Study of the Atmosphere and Ocean. In collaboration with colleagues at the Alaska Fisheries Science Center (NOAA Fisheries), her current work is focused on developing quantitative methods for ecosystem-based approaches to management and methods to assess and manage for climate-change impacts on fish and fisheries. In particular, her research includes climate specific multi-species stock-assessment models for the Bering Sea (AK, USA), Integrated Ecosystem Assessments, bioenergetics and food-web models, and field studies of multi-trophic effects of fishery and aquaculture interactions with marine and estuarine ecosystems.

Dr. Kerim Aydin (Kerim.Aydin@noaa.gov) is the program leader of the Resource Ecology and Ecosystem Modeling Program at the Alaska Fisheries Science Center. His current research is focused on modeling predator/prey interactions, both from an individual behavioral standpoint and from a population (food web model).

References

1. Plagányi, É.E. *et al*. 2011. Modelling climate-change effects on Australian and Pacific aquatic ecosystems: a review of analytical tools and management implications. Mar. Fresh. Res. 62(9): 1132–1147.
2. Stock, C.A. *et al.* 2011. On the use of IPCC-class models to assess the impact of climate on living marine resources. Prog. Oceanogr. 88: 1–27.
3. Hollowed. A. B. *et al.* 2013. Trade-offs associated with different modeling approaches for assessment of fish and shellfish responses to climate change. Climatic Change 119(1): 111–129.
4. Link, J.S. *et al.* 2012. Dealing with uncertainty in ecosystem models: The paradox of use for living marine resource management. Prog. Oceanogr. 102: 102–114.
5. Planque, B. *et al.* 2011. Uncertainties in projecting spatial distributions of marine populations. ICES J. Mar. Sci. 68(6): 1045–1050.
6. Delworth, T.L. *et al.* 2012. Simulated climate and climate change in the GFDL CM2.5 high-resolution coupled climate model. J. Climate 25(8): doi:10.1175/JCLI-D-11-00316.1
7. Rykaczewski, R. and J. P. Dunne. 2010. Enhanced nutrient supply to the California Current ecosystem with global warming and increased stratification in an earth system model. Geophys. Res. Lett. 37: L21606.
8. Niiranen, S. *et al.* 2013. Combined effects of global climate change and regional ecosystem drivers on an exploited marine food web. Global Change Biol. 19(11): 3327–3342,
9. Gaardmark, A. *et al*. 2013. Biological ensemble modelling to evaluate potential futures of living marine resources. Ecol. Appl. 23: 742–754.

(Continued from page 26)

Other opportunities are emerging due to the consequences of a changing ocean. As ecosystem boundaries shift, baselines on which stock assessment data are based will begin to expose the assumption of spatial stationarity. This provides an opportunity for fisheries scientists to reconsider how the science underpinning management decisions is conducted, and perhaps refocus it more directly on the decision and the risks to stocks in a more unpredictable ocean. This is particularly salient in light of recent research suggesting ocean conditions play a much stronger role in recruitment than previously believed (Szuwalski *et al*. 2014), re-enforcing the need for reliable ocean forecast systems.

The take-home message for FUTURE from the workshop is that broader uptake of our knowledge products will require clearly articulating the decision context to which they contribute. The extent to which we can explicitly inform the risks in the choices facing managers and policy makers will influence the uptake of our science into decision making. Casting our uncertainties as risks, and targeting these results at the appropriate audiences, will further increase our contribution to evidence-based decision making. Finally, by considering how we can contribute to decisions that will be made in the future, the ocean science community has an opportunity to move from a reactive, crisis-management role to proactive leadership where best available science provides timely, salient, and sound advice to support ocean management decisions.

References

Gibson, GA and YH Spitz. 2011. Impacts of biological parameterization, initial conditions, and environmental forcing on parameter sensitivity and uncertainty in a marine ecosystem model for the Bering Sea. Journal of Marine Systems 88: 214–231.

Gregr, EJ and KMA Chan KMA. 2014. Leaps of Faith: How implicit assumptions compromise the utility of ecosystem models for decision-making. BioScience. In review.

Knutti, R. and J. Sedláčcek. 2013. Robustness and uncertainties in the new CMIP5 climate model projections. Nature Climate Change 3, 369-–373.

Palacios, DM, MF Baumgartner, KL Laidre, and EJ Gregr. 2013. Beyond correlation: integrating environmentally and behaviourally mediated processes in models of marine mammal distributions. Endangered Species Research 22: 191–203. doi: 10.3354/esr00558

Seidlecki, SA, A Hermann, N Bond, S Alin, and R Feely. 2014. Hypoxia and ocean acidification of the coastal waters of the Pacific Northwest: evaluation of seasonal predictions of hypoxia and pH. Presentation at the 2014 Ocean Sciences Meeting, Honolulu, HI.

Szuwalski, CS, KA Vert-Pre, AE Punt, TA Branch, and R Hilborn. 2014. Examining common assumptions about recruitment: a meta-analysis of recruitment dynamics for worldwide marine fisheries. Fish and Fisheries 1467-2979. doi.org/10.1111/faf.12083.

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ICES Symposium on the "*Ecological basis of risk analysis for marine ecosystems*"

by Alexei Orlov

Fig. 1 Participants of the ICES symposium "Ecological Basis of Risk Analysis for Marine Ecosystems", June 2–4, 2014, at the Art Factory in Porvoo, Finland.

The world's marine ecosystems are facing an increasing number of challenges. Fishing intensity is high, and there are several other threats such as possible oil spills from drilling and transportation, climate change, eutrophication, and risks associated with aquaculture. The aggregate analysis of multiple interacting risk factors is a challenging task for scientists. While risk assessment methods are well established in scientific disciplines like finance, health, and insurance, they are less established in resource management and climate change.

About 80 scientists from 18 countries (Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, Norway, Philippines, Spain, Sweden, Switzerland, Russia, United Kingdom, and USA) gathered near the bank of the Porvoo River in the famous old city of Porvoo, Finland, from June 2–4, 2014, for a symposium on the "*Ecological basis of risk analysis for marine ecosystems*" (Fig. 1).

The ICES symposium was co-sponsored by PICES, the EU Seventh Framework Programme (FP7), Year of the Gulf of Finland 2014, The Federation of Finnish Learned Societies, Maa-ja vesitekniikan tuki ry, and Finnish Cultural Foundation and was convened by Professor Sakari Kuikka (ICES/Finland), Dr. Tony Smith (ICES/Australia) and Dr. Alexei Orlov (PICES/Russian Federation) (Fig. 2).

The aim of the symposium was to support ICES' strategic goal to evaluate the uncertainties related to the sustainability of marine-related industries and production of integrated advice to decision makers. Further, it was to enhance co-operation between ICES and other bodies relevant to risk-based management of marine activities, and to broaden the diversity of scientists participating in these activities. In providing scientific advice, one of the main tasks of ICES advisory and scientific activities is to assess risks and incorporate risk analyses in an integrated and scientifically justified way and to successfully communicate these to scientists in other fields, to managers and to a wider audience. This allows identification of potential risks and leads to better opportunities to manage or control these risks.

The symposium was organized around six overarching themes:

- Fisheries management under uncertainty,
- Decision modelling in fisheries management,
- Probabilistic fish stock assessment,
- Oil spill and eutrophication risk analysis,
- Environmental risk assessment for marine areas,
- Risk analysis in aquaculture.

Fig. 2 Two of the symposium convenors: (top) Prof. Sakari Kuikka, (bottom) Dr. Alexei Orlov.

The symposium (Fig. 3) was opened with a "welcome and opening" speech by the Vice-Rector of the University of Helsinki, Prof. Pertti Panula. This was followed by a presentation by the Vice-Chairman of the ICES Advisory Committee (ACOM), Dr. Carmen Fernandez (Germany), who spoke on Bayesian solutions to ICES responsibilities. The keynote talk by Prof. Samu Mäntyniemi (University of Helsinki), described a Bayesian approach to fisheries stock assessment used in the EU project ECOKNOWS (Effective Use of Ecosystem and Biological Knowledge in Fisheries). Despite their growing popularity, many of the Bayesian stock assessments have only partially followed the logic of Bayesian reasoning. The most notable deviation has been the idea borrowed from statistical data analysis, according to which all the model parameters should be statistically identifiable based on the observed data at hand. This has led to the practice of using different model structures, depending on the amount of data available. A goal of the ECOKNOWS project was to develop a Bayesian stock assessment modelling framework which allows for biologically credible population dynamics and is able to quantify the uncertainty arising from the usual confounding of the model parameters. The General Population Dynamics Model (GPDM) was designed to have a modular structure which describes the essential features of population dynamics. The population can be structured by one or more attributes. For example, age-growth and length-species structures can be specified. The transition of the population from one time step to the next is defined as a probability distribution. This distribution is derived from the assumption that individual fish are correlated due to schooling behavior or patchiness in the environment. Tailoring the GPDM to an assessment problem requires a thorough search for existing information. An important part of the project was to develop ways to formulate the information found from literature, databases and experts into prior probability distributions that describe how well the biology of the population is known. Once the alternative model structures and prior distributions for parameters have been specified, the Bayesian approach is to update these beliefs in light of observed assessment data. Usually, the data are not very informative about most of the parameters but can provide new insights about parameter combinations that pose a difficult computational challenge.

Session 1. Fisheries management under uncertainty. This session dealt with uncertainties from a range of sources that contribute to difficult management processes. Presenters tried to answer the following questions related to data-poor stocks, climate-dependent productivity, complex systems with high numbers of target and bycatch species, and social behaviour by fishers, consumers and policy makers: How can modellers and managers express risks in understandable and practically implementable ways? How can management strategies be developed that are robust to these sources of uncertainty? How can the acceptability of risks be determined in consistent processes? What can be learned from other disciplines applying risk analysis methods?

There was a wide range of presentations regarding analysis of risk assessment for fisheries management that involves various sources of data (life history, environment, ecology, economy, climate, *etc*.). Different methodical approaches, software and databases used in current fisheries management under data-limited conditions were considered and discussed.

Session 2. Decision modelling in fisheries management. This session focused on the following questions: Modelling stocks is an essential component of fisheries management but are models explicitly addressing the decision-making processes used by fisheries managers? How can we integrate ecological, social, economic and institutional aspects? Which variables are relevant for stakeholders? How are model outputs displayed so that management problems and options can be efficiently visualised to support decisions? How may we treat tradeoffs? How do models provide feedback on past decisions? To what extent can fisheries models learn and partially automate decision-making? Are there financial instruments that can deal effectively with ecological risk?

Fig. 3 The symposium in session.

The keynote presentation was given by a member of the ECOKNOWS Scientific Advisory Board, Dr. Robert Stephenson, (Canadian Fisheries Research Network). The ECOKNOWS project represents a major initiative in the challenge of improving fisheries assessment methods by integrating new sources of biological knowledge and the study of the ecological basis for risk analysis for marine ecosystems. An attempt has been made to put the ECOKNOWS experience in context by looking at the developments and progress related to this theme over the past 30 years, and by looking forward at outstanding questions and issues. Looking back, it is instructive to compare the themes and methods of this meeting with those, for example, of the 1998 Symposium on "*Confronting uncertainty in the evaluation and implementation of fisheries-management systems*" (ICES Journal of Marine Science 56:6, 1999). Looking forward, it is important to consider how to address the challenges of evolving domestic and international policies, the move to 'ecosystem' and 'integrated' management, increasing market (and general public) pressure for certification of sustainability, and the need to obtain and maintain 'social license'. The evolving landscape of fishery evaluation and management demands has increased participation in management processes and shared stewardship responsibility, and must adapt to changes in both the ecosystem and in public perception. Additionally, it is important to consider fisheries with other activities in more comprehensive evaluations that can support management decisions in an integrated context. Outstanding research priorities include: (1) more holistic evaluations that take into account the full suite of ecological, social, economic and institutional objectives related to management; (2) methods to support management trade-offs among diverse objectives and activities, and (3) methods that will allow consideration of the cumulative impacts of multiple activities.

Other presentations considered and discussed various examples of decision models with the use of different approaches under different conditions.

Session 3. Probabilistic fish stock assessment. The key questions of this session were: Fisheries assessment now normally include uncertainty as an integral part of the modelling approach, but how consistently is uncertainty applied in the many parameters of complex models, or in the structure of the model itself? While there is an intuitive expectation that reducing uncertainty is desirable, how can priorities be set and the value of reducing relevant individual uncertainties be judged? Are uncertainties on ecological and socio-economic parameters treated the same or differently? Do the assessment models learn from all sources of information effectively?

The session was kicked off with keynote presentation by Dr. Tony Smith (CSIRO, Australia) entitled "*Add a little spice to your life*". Much like cooking, the art of modelling is knowing when to add that little bit of extra spice. The number of foodweb and end-to-end models are growing in number and coverage of the global oceans. While they are an informative means of exploring system dynamics they are not an appropriate risk assessment tool for many applications (such as tactical stock assessments). Nevertheless, experience with such models and other multi-species methods is providing insights into what kinds of ecological idiosyncrasies can undermine the performance of population dynamics with static parameters. Environmental drivers, habitat dependencies, critical predator or prey linkages can shape population trajectories by creating bottlenecks at key points in a stock's life history. In addition, shifting environmental regimes and ecosystem status highlight the importance of considering non-stationary parameters – not just for recruitment, but also size and natural mortality rates. Not all of these additional concerns will always be relevant, this is not a call for more complexity "just in case". Instead, it is a simple reminder that good model practice is to periodically revise what are key processes, links and feedbacks that need to be considered for the case in point, to check the assumptions. This is something that is being more widely recognized as new hybrid and intermediate model types proliferate and ocean ecosystems change around us. As with any discipline in its early steps, however, a lot can be learnt from sharing lessons to date. Other presentations dealt with various examples of probabilistic stock assessments based on various methods, models, and approaches.

Session 4. Oil spill and eutrophication risk analysis. This session addressed the questions: How are pollution and eutrophication risk analyses formulated? How the risks caused by transportation of oil are linked to ecosystem health? How are exposure and response impacts quantified? How can management at multiple points along an exposure pathway be focused on localized events and endpoints? How are pollution risks built into broader fisheries, coastal and ocean use management models that include multiple, potentially competing, uses of ecosystems? What kinds of advisory and stakeholder groups are needed to link environmental and fisheries risk together?

The session consisted of five presentations by Finnish and German scientists and focused mainly on modelling of oil spills in the Baltic and North Seas under various conditions.

Session 5. Environmental risk assessment for marine areas. This session tried to answer the questions: To what extent are environmental risk assessments in marine areas different from terrestrial systems? How are acceptable endpoints determined in these complex systems? How can the outputs of fishery risk assessments be incorporated into wider marine ecosystem risk assessments?

Eight presentations by scientists from the USA and Europe tried to review current approaches of evaluating environmental risk assessment for various ecosystem components using different tools (marine spatial planning, statistical models, *etc*.).

Session 6. Risk analysis in aquaculture. Production from aquaculture is rapidly overtaking capture fisheries. Simple harvest optimization has been applied to aquaculture modelling but as production becomes more intensive and global, aquaculture must be managed with the expectation of risk. Moreover, aquaculture creates risk for ecosystems. Risks to external (pollution, diseases and parasites, genetic introgression, escapees) and internal (diseases, parasites, genetic deterioration) effects of aquaculture need to be included in aquaculture models. This session was expected to answer two questions: Can general risk models be applied to integrate the range of threats aquaculture faces? How the risks could be incorporated in spatial planning? Unfortunately, these questions did not receive sufficient scientific attention, and the session was cancelled. There was a single poster, dealing with aquaculture-environment interactions in Canada.

The poster session consisted of a dozen of posters that focused on various aspects of risk assessments analysis for marine living resources.

The final event of the symposium was a discussion led by Dr. Robert Stephenson who stimulated participants to formulate key issues that were considered during symposium and those that were missed (Fig. 4). A special issue in the ICES Journal of Marine Sciences has been set to publish the results presented at this symposium.

Fig. 4 Final discussion convened by Dr. Robert Stephenson (Canada).

The steering committee of the symposium included Tapani Pakarinen (Finland), Konstantinos Stergiou (Greece), John Mumford (UK), Robert Stephenson (Canada), Atso Romakkaniemi (Finland), Kirsi Hoviniemi (Finland), Sakari Kuikka (Finland), Tony Smith (Australia), and Alexei Orlov (Russia).

Dr. Alexei Orlov (orlov@vniro.ru) is Principal Scientist at the Laboratory of Sea Fishes of the Russian Far East, Russian Federal Research Institute of Fisheries and Oceanography (VNIRO), Moscow, Russian Federation. He maintains broad interests in taxonomy, zoogeography, distribution, general biology and stock assessment of demersal and deepwater fishes, mostly of the North Pacific and partly of the North Atlantic. Alexei has worked in VNIRO for 28 years on a variety of commercial and bycatch groundfish species with special interest related to elasmobranchs, lampreys and grenadiers. He is the author of over 550 scientific and popular science publications, including abstracts of conferences, monographs, and chapters. Alexei is the member of Moscow Naturalists Society, European Ichthyological Society, Russian Hydrobiological Society, American Fisheries Society, Asian Fisheries Society, Fisheries Society of British Isles, Ichthyological Society of Japan, and Russian Geographic Society. He serves as Executive Editor-in-Chief for the Journal of Ichthyology, Associated Editor for Acta Ichthyologica et Piscatoria and is a member of the Editorial Boards of the Russian journals Izvestiya TINRO, Trudy VNIRO, and Vestnik AGTU Fisheries. In PICES he is a member of the BIO Committee.

Human dimensions in the Russian Federation – Effectiveness of ecosystem governance related to fishing

by Ekaterina Kurilova

Effective ecosystem governance is based on a balance between ecosystem sustainability, water bioresources conservation and at the same time economic, cultural, and spiritual satisfaction of the community. To maintain this balance requires an integrated understanding of how ecosystem changes affect human social systems, and how humans impact ecosystems.

Such things as expectations, needs and satisfaction level from ecosystem services of human communities should be taken into consideration. Social status and distance of communities from the ocean are just two of the important factors related to ecosystem services values.

One of the main difficulties is how to evaluate community expectations and demands from ecosystem services in large countries like the Russian Federation where different communities have various expectations and historical-cultural experiences.

The Russian Far East coast is mostly occupied by small cities and settlements, with the majority of the population in these settlements engaged in fisheries. These people and small ethnic groups historically consider the ocean and its products as a source for provision and survival, as fishing is an essential part of people's daily life. Conversely, people residing in big cities far from the coast are generally more concerned, and value more the tendencies in the economy, such as the development of the fishing industry, and coastal recreational and cultural services. People with higher education level have higher expectations. However, both coastal and inland communities are dependent upon conservation of marine biodiversity and an opportunity to obtain marine ecosystem products.

Fishermen in Aldoma Bay (photo courtesy of Okhotsk laboratory).

Main concepts of the fisheries legislation system in the Russian Federation

Water bioresources (*e.g.*, harvestable biomass) are regarded as a basic component of human well-being. Therefore, fisheries regulation is produced with the recognition that natural resources are an essential component and the basis of human activities and at the same time as an object of private ownership. Priority is given to the conservation and rational use of water bioresources. Thus, water bioresources can be used if human activity (harvest of living marine resources) does not damage the environment and water bioresources status.

The principle and practice of the fisheries regulation system in the Russian Federation is *to invite representatives of coastal communities and fisheries associations* to participate in the decision-making process if the decision might influence the status of water bioresources. Needs of the local and native population in the areas, where subsistance fishing is the means of securing the necessities of life, is taken into consideration. It is a priority to provide the natives with access to water bioresources fishing.

Fisheries legislation

Fisheries legislation system is rather complicated in the Russian Federation. Fisheries in the country is mainly regulated by federal fisheries legislation (laws) describing the general regulation. All the laws of the Russian Federation that regulate fishing activities in the Russian EEZ comply with international legislative acts and agreements, in particular, the UN Convention on the Law of the Sea (December 10, 1982), relating to the conservation and management of straddling (transboundary) fish stocks and highly migratory fish stocks.

All fishery regulation laws are published in the media and available to all citizens. The central administrative authority for fisheries management in the Russian Federation is the Federal Agency for Fisheries. Its main functions are: governmental control and supervision in fields of fisheries and conservation of marine biological resources in the inland waters of the Russian Federation (with the exception of inland marine waters), state supervision of merchant shipping in terms of ensuring the navigation safety of fishing vessels in the fishing areas, public services and management of the state property in the fields of fisheries, monitoring, sustainable usage, studies, conservation, and reproduction of aquatic biological resources and their habitats, as well as aquaculture (fish farming), processing of fish and other aquatic biological resources, production operations aboard the fishing fleet and seaports within the marine terminals for fishing vessels servicing.

On the basis of the Federal laws the subject executive bodies can issue legal texts on fisheries regulation and water bioresources conservation. At the regional level legislative councils may pass their own laws regulating relations between local authorities and fishing companies. However, regional laws and their provisions are developed in accordance with the Federal law on fisheries.

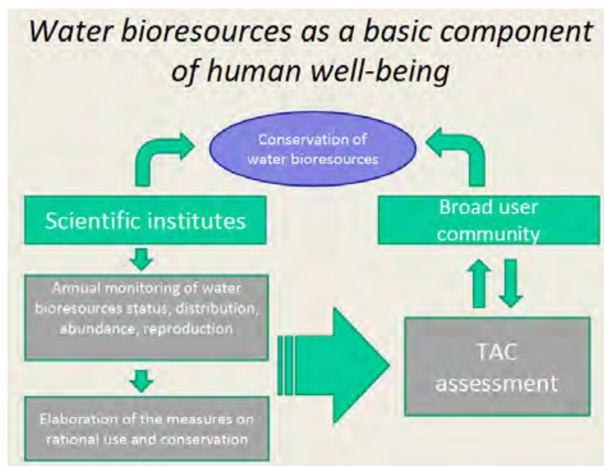
Detailed information on fishing gear requirements, fishing restrictions concerning spawning periods and special conservation areas are presented in Fishing Regulation documents issued for each fisheries basin. There are eight fisheries basins in the Russian Federation whose boundaries include watersheds located on the land territories of several regions – republics, oblasts, krais, *etc*. ("oblast" and "krai" are analogs of the term "state"), adjacent territorial and inner marine waters, and EEZ areas. The Baikal fisheries basin includes freshwater bodies only. Fishing Regulation documents are elaborated in accordance with a particular fisheries basin peculiarities, taking into account the needs of the local populations. This document is also approved by the Federal Government, but its content is discussed at the Fishery Research Councils of the subjects of Russian Federation. Amendments to this document can be proposed by any citizen. They are collected by the branches of Federal Agency for Fisheries and discussed by the scientific research organizations and state authorities. These amendments are approved by the science councils of the territory institutes and Russian Federal Research Institute of Fisheries and Oceanography. After the amendments have been approved by these Councils, the Federal Government issues the Fishing Regulation Document. The primary aim of this document is conservation and management of water bioresources.

Fishery Research Councils (FRC) are established for each fisheries basin. Their main task is to elaborate the recommendations and proposals on conservation and rational use of the water bioresources. These councils are composed of the representatives of federal executive bodies, executive bodies of the subjects of Russian Federation, scientific research organizations, Fishery Basin Institutions for the conservation and restoration, and representatives of non-governmental organizations, including small ethnic communities of the North, Siberia and the Far East. Decisions of the Council are advisory. Management of the FRC facilitates the transparency of decision-making in the field of fishery regulation, amendments to the fishery legislation and development of broader discussions.

TAC determination

Total allowable catch (TAC) volume distribution is estimated in accordance with ecological, social and economic factors. Two year forecasts and TAC are applied to the most valuable commercial water bioresources. For under-caught and little used species, so-called Permissible Catch is developed. However, some important fisheries, such as salmon, do not have a TAC estimate. The reason is that salmon returns are difficult to predict and often require adjustment of the catch depending on actual run returns. Increase or change in a TAC requires a series of formal procedures which may take up to several months. For salmon runs, the correction in allowed capture may need to be approved in a matter of days, before the massive run of salmon ends. Thus, it was decided to apply "Permissible Catch" regulation to salmon fisheries.

Information enabling total allowable catch volume estimation is developed by scientific research organizations, which conduct annual monitoring of water bioresources status. The evidence is discussed at organized public meetings with representatives of the community, fisheries associations and authorities. After being approved, the evidentiary materials are passed to the State Expert Commission for ecological examination. The Federal Agency for Fisheries then prepares the order on TAC followed by the order on quota allocation by different fisheries types.



Engagement of communities into developing total allowable catch (TAC) levels of water bioresources, which include marine fisheries. (from a presentation by the author in S3 at the FUTURE OSM, April 2014).

Quota allocation

Salmon quotas are allocated among the companies with agreements for fishery plots (for 20 years). The catch volume (%) of quota allocated to the company in the previous years and economic indicators (such as taxes) are also taken into account. The catch share of the quota depends on the fishery plots. Allocation is made by the regional Commissions on regulation of harvesting the anadromous fish, which are composed of the representatives of fisheries enforcement organizations, fisheries associations, research institutes, and territorial administration officers. Preference is given to companies that have proved successful in the past, as well as providing more jobs for local people.

Fishery plot allocations used to be provided for a 10 year period; now they are provided for 20 years. Fishery plots are allocated by the results of an auction. Applicants pay a fee, which remains in the budget of the region. In addition to considering a company's financial contribution, priority depends also on the performance characteristics of the company – employment of the local population, fishery capacity, bid size and development of the quotas allocated to the company for the past 4 years. If a specific fishery plot has not been used by a company for two years, or the quota was less than 50% fulfilled, the government has the right to revoke the contract and put it up for auction.

This system encourages sustainable use of biological resources, because the company which has been allocated a fishery plot for 20 years is interested in the long-term sustainability of the fishery in this plot, compliance with environmental legislation, and developing positive outcomes of the company in order to continue getting quotas and fishery plots. However, in this approach to quota allocation, a new user (company) without a work history has almost no chance of getting commercial quotas. The system is designed to limit the number of users.

For salmonids, there are no fishing areas in offshore sea, only in the fresh and inshore waters. Auctions are used to allocate quotas on marine and fresh water species to which TAC is applied. The main criteria considered in allocating quotas are the history of the company, especially the amount of quota developed in the past. For non-anadromous species to which Permissible Catch rules apply, quotas are allocated by the State Commission according by applications, but they cannot exceed the Permissible Catch (volume). At reaching of the Permissible Catch limit, fishing is closed or catch limits may be increased.

Fish transportation near Plosky Cape. (Photo courtesy of Okhotsk laboratory.)

Fisheries

Fishing can be produced only for species whose catch is not prohibited. All species in general have allowable fishing, except species which are protected (e.g., species in the International Union for Conservation of Nature (IUCN) and Russian Red lists). The list of species for commercial and coastal fishing is elaborated by the federal executive body. The same legislative body adopts the list of the valuable and the most valuable species. Special permission (or license) issued in accordance with Fishing Regulation is generally needed to harvest fish (with the exception for recreational fishing by rod but not for all species, plots and periods). The license contains the list of allowed species and catch volume for fishing. Red list species, or species not allowed for catch (*e.g*., sturgeons), when captured in bycatch must be released. The following types of fisheries are distinguished.

Commercial fisheries
It is a business activity on water bioresources fishing, processing, transportation, conservation and fish production. Fish products are to be delivered to the seaports in the Russian Federation or other ports defined by the Russian Federation Government. Allocation of quota shares is given to companies that historically fulfilled their prior quota agreements.

Coastal fisheries
Coastal fisheries can be conducted on the fishery plots. It differs from the commercial fisheries by the coastal regional authorities' involvement in the fishery management including establishment of fishery areas and list of species for catch trans-shipment, landings and at-sea processing.

Fisheries for scientific and research purposes
This type of fishery has the purpose of study and conservation of water bioresources. Scientific research organizations are allocated fishing quota on the basis of annual research plans. A special license is needed. The catch volume is determined in accordance with needs for a research purpose. All water bioresources caught by a scientific organization are to be used only for scientific purposes and should be released afterwards. If water bioresources are used for bioanalysis, they must be ground up afterwards. If scientific research is conducted on the vessel, fish production process is prohibited. Fisheries conducted for scientific and research purposes are regulated by the Federal laws.

Fisheries for educational and cultural purposes
This type of fishery has the purpose of education and cultural activity. Research and educational organizations are allocated fishing quota on the basis of annual educational plans. The catch volume is determined in accordance with needs for these purposes. Water bioresources are to be used for educational purposes, such

as for displays at zoo exhibits and aquaparks. Fishery for educational and cultural purposes is regulated by the Federal laws.

Fisheries for reproduction and naturalization purposes
This type of fishery has the purpose of water bioresources conservation, aquaculture development, reproduction and naturalization. Fishing quotas are distributed in accordance with needs for these particular purposes on the basis of programs on artificial reproduction and naturalization activity.

Recreational and sport fisheries
Citizens are allowed to fish for free if it is not under the restrictions in accordance with Fishing Regulation Document. Captured organisms can either be released or not. Special permission is needed to fish in a water reservoir located on private property. Some areas are given to entrepreneurs or organizations in order to organize a sport fishing there. Recreational and sport fishing in some areas operated by entrepreneurs or organizations require paid licenses.

Fisheries as the means of securing the necessities of life of native small ethnic communities
Members of small ethnic communities may fish without a license or allocated fisheries plot as a means of securing the necessities of life.

Conservation and management measures

State monitoring is a system of regular observations on status, distribution, abundance, reproduction, fishery and conservation of water bioresources. Fisheries and conservation are important components of these observations. The data obtained during the monitoring are applied to the assessment of biological status and abundance of water bioresources, and for elaboration of the measures on rational use and conservation of water bioresources, including elaboration of the fishery restrictions.

Monitoring of water bioresources and fishing vessels is done by the Center for Fishery Monitoring and Communications, which collects, analyzes, stores and transmits data on location of fishing and research vessels (both Russian and foreign), provides satellite positioning control of fishing vessels, and submits information to federal authorities.

Russia has no state integrated programs based on social and economic studies directly related to marine ecosystem management, such as IFRAME (Korea) or IEA (USA) and PNCIMA (Canada). Scientific research fisheries institutes in Russia estimate the potential loss of economic value of ecosystem resources as a result of anthropogenic activity (*e.g.*, construction of seaports, bridges, pipelines, *etc.*). Integrated analysis is needed to better understand social-cultural and economical issues of society and how these can be used to implement more effective management of marine ecosystem resources.

There is not a long history in the Russian Federation of conducting social surveys as a means of a obtaining socio-economic data. In the last years the number of websites where you can express your opinion is increasing. An online survey of Russian residents using a site popular with fisherman (www.fishnews.ru) was conducted to inquire about key fisheries management and ecosystem issues. The results of the online survey of Russian residents indicated concern about the effectiveness of fisheries, including unlawful poaching of fish, and difficulty getting legally captured fish to markets and sold. Additional fish marketing might be suggested, as well as improvements in access to potential customers for fish.

Conclusions

The fisheries regulation system in the Russian Federation has many advantages, but also some disadvantages. The most obvious advantage is the combination of fish quotas, catch shares and 20 year fishery area allocations. This process provides favorable conditions for investments into the fishery sector and encourages quota users to be more responsible in relation to water bioresources and environmental legislation, because they are interested in long-term cooperation and sustainable fish resources in the allocated plots. At the same time, fishery sector on the most valuable commercial species are effectively closed (limited entry) to companies without a prior and long fishery history, as the past performance at meeting quota levels is one of the most important considerations in a quota distribution auction on TAC species. Users without a fishery history are welcome to participate in non-anadromous fisheries that are managed using the Permissible Catch criterion.

Aquaculture of marine species has not been properly regulated in the country and therefore was not very popular. Russia was not one of the top 15 producers of the 38 million tonnes of aquaculture fish in 2012 (SOFIA-2014, The State of World Fisheries and Aquaculture report). Not long ago, the Law on Aquaculture in the Russian Federation was established, and is expected to become the basis for aquaculture development in the country.

A disadvantage of the fishery legislation system in the Russian Federation is the rather complicated procedure for amending the law; that requires too much time for decision-making. It is almost impossible to alter TAC, for example, because of the complexity of the TAC approval process. That is why salmonid species were included in the Permissible Catch regulation. It was done for better fishery regulation of these commercially valuable species. Fisheries Regulation Documents that are issued for the eight fisheries basins lack flexibility. For instance, there is no mechanism to temporarily suspend implemented legislative acts.

While flexibility in management is a concern at the basin level, there are some examples of effective local fishing

(Continued on page 48)

Microbial Culture Collection at the National Institute for Environmental Studies, Tsukuba, Japan

by Masanobu Kawachi and Mary-Hélène Noël

MCC-NIES team (from left to right): Ishimoto (Charales curator), Yumoto (curator, DNA), Mori (curator, cryopreservation), Kawachi (head), Matsui (assistant curator), Noël (curator, projects), Niitsuma (assistant curator, DNA), Sato (curator, flow cytometry), Shimura (Post-Doc, cyanobacteria), Fujii (secretary).

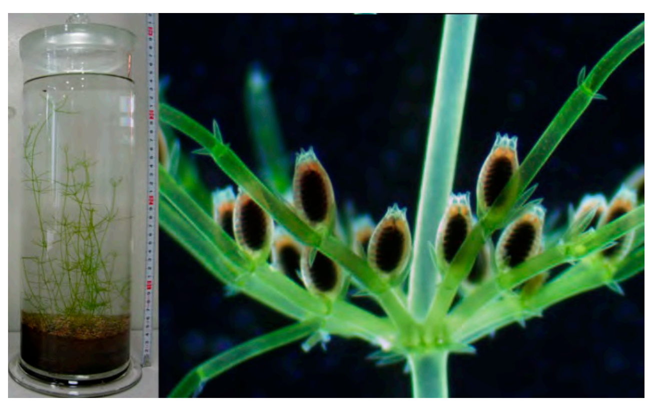
History and characteristics of the MCC-NIES collection

The Microbial Culture Collection at the National Institute for Environmental Studies (MCC-NIES), located in Tsukuba, Japan, was founded as an "environmental study-oriented" culture collection in 1983 when eutrophication of lakes and rivers, and air and water pollution were severe in Japan. The MCC-NIES started with *ca*. 250 strains mainly of red-tide-forming algae (*Chattonella antiqua* and *Heterosigma akashiwo*) and water-bloom-forming cyanobacteria (*Microcystis aeruginosa*). Although the MCC-NIES is still characterized by such types of strains, the collection now holds almost all eukaryotic lineages and a diversity of cyanobacteria, too. At present the collection includes 18 phyla, 51 classes, 354 genera, 718 species and 2,356 strains.

Most of the MCC-NIES strains have been directly deposited by researchers, but some have been deposited from exchanges with other collections. Around 80% of the MCC-NIES strains were originally sourced from Japan, giving the collection a high level of specificity.

This is also the only culture collection holding major endangered macroalgae. The collection, which started *ex situ* conservation of endangered algae in Japan, has been in operation since the mid-1990s. In the list of endangered Japanese wildlife (the red list) compiled by the Ministry of Environment of Japan in 2007, 116 taxa (species and varieties) of algae are listed as extinct, extinct in the wild, or as endangered in Japan. At present, the MCC-NIES holds *ca*. 300 strains of these endangered algae, including *Charales* and freshwater red algae. The collection is partially supported by the Time Capsule Project conducted by the Ministry of Environment of Japan since 2002.

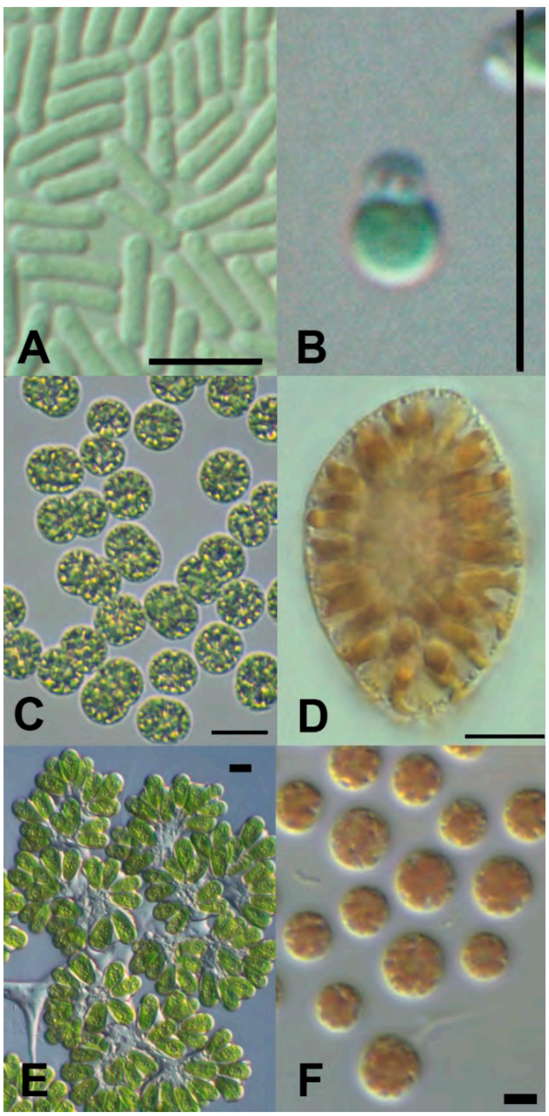
In 2002, the MCC-NIES was selected as the core repository for algae in the National BioResource Project (NBRP) conducted by the Ministry of Education, Culture, Sports, Science and Technology of Japan (NBRP: http://www.nbrp.jp). In this framework, more than 200 strains of *Microcystis* and *Anabaena*, collected from representative eutrophic lakes all over Japan, were deposited by the National Science Museum along with phylogenetically diverse strains of microalgae and protozoa deposited by the University of Tsukuba. In addition, more than 300 strains of cyanobacteria and eukaryotic microalgae maintained at the IAM Collection (University of Tokyo) were transferred to the MCC-NIES up until the end of FY 2006, when the IAM Collection was closed.



Charales strains maintained in MCC-NIES.

The collection includes:

- Evolutionarily important species such as *Mesostigma viride* (NIES-296) and charophytes (NIES-1601);
- Experimental materials that have been well-studied in genomic, genetic, molecular, and physiological terms, such as *Cyanidioschyzon merolae* (NIES-1332/10D), *Chlamydomonas reinhardtii* (NIES-2235/C-9), and *Thermosynechococcus elongatus* (NIES-2133/BP-1);
- Ecologically significant species such as *Prochlorococcus marinus* (NIES-2086) and *Micromonas pusilla* (NIES-1411);
- Harmful algal species such as *Microcystis aeruginosa* (NIES-44) and *Chattonella marina* (NIES-3);
- Commercially useful strains such as *Botryococcus braunii* (NIES-836), *Porphyridium* (NIES-1035) and *Chlorella vulgaris* (NIES-227).

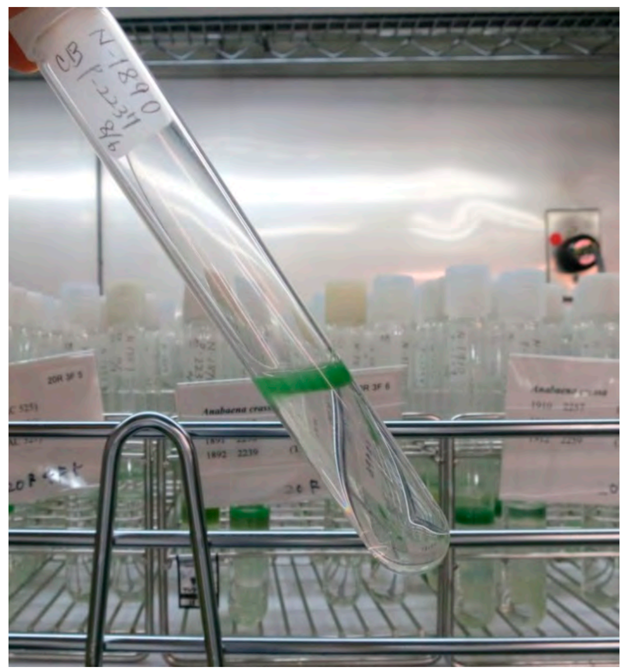


A. *Thermosynechococcus* (NIES-2133), B. *Cyanidioschyzon* (NIES-1332), C. *Microcystis* (NIES-44), D. *Chattonella* (NIES-3), E. *Botryococcus* (NIES-836), F. *Porphyridium* (NIES-1035). Scale bar = 10 μm.

Since the start of the collection, the Committee for Evaluating Microbial Culture Strains has evaluated the NIES strains upon deposition based on a set of criteria. At present, the Committee includes nine researchers at NIES and six supervisors outside NIES. In addition, since 2002 the MCC-NIES has been supervised by the Steering Committee of the NBRP Algae.

Maintenance of strains

About 3/4 of the NIES strains (~ 2,000 strains) are maintained by subculturing under optimal and/or sub-optimal conditions, mostly ranging from 5 to 25°C (37 or 45°C for thermophilic strains) and with a 4 to 50 μmol·m^{-2}·s^{-1} photon flux density in a 12-h-light:12-h-dark light regime.



Test tube of Anabaena.

The strains are serially transferred at 10-day to 6-month intervals. Specially designed software for the collection allows a flexible gestion of the daily transfers. Maintenance conditions differ with each algal strain and are individually indicated in the catalogue of strains on our web site.

To prevent the loss of strains during maintenance by subculturing, we conduct weekly growth checks. Once a year, we also check axenic strains for the absence of bacteria by using several bacterial check media.

The remaining strains—about 600 including most of the cyanobacterial strains and some of the green and red algal strains—are cryopreserved only, in the vapor phase of liquid nitrogen.

Upper: Subculture of strains in liquid or agar media. Lower: Cryo-preserved strains in liquid nitrogen tanks.

Scientific names and phylogeny

The scientific names of the NIES strains are given primarily by the depositors. However, we have used DNA sequencing (mostly of the 18S rRNA gene) to re-evaluate the strains for which DNA sequence data have not yet been reported. As a result, we have changed the scientific names of the misidentified strains, although we have left their former names as "Formerly identified as." We have also added "Re-identified at NIES by DNA sequencing" in "Identified by" and, if the original scientific names of these strains were appropriate, we have simply indicated "Confirmed at NIES by DNA sequencing", with gene names and accession numbers in "Gene data." We are still re-evaluating the remaining strains.

MCC-NIES services

Most of the strains are available for education, research and development in accordance with the "Agreement for distribution". The MCC-NIES also provides genomic DNA for worldwide distribution.

Packaging for worldwide distribution of culture strains.

Technical advice and follow-up of the distributed strains are provided to customers. Usual time for delivery of an ordered strain is 10 days as most of the strains are maintained under active growth. For strains kept as cryopreserved samples, the delay is longer since the MCC-NIES first return the culture to active growth before shipping it.

The MCC-NIES accepts the deposit of strains that are environmentally important, as well as those for basic and applied studies. The collection also accepts the deposition of strain types of cyanobacteria and specimen types of eukaryotic microalgae as frozen samples.

Useful information relating to the DNA barcodes, photosynthetic pigments, morphology and other relevant literature are provided for each strain at our web site. The MCC-NIES collection welcomes joint research and collaborations; please contact us at mcc@nies.go.jp. Japanese, English and French are the available languages for any communication with the collection.

A culture collection is "team work", each step being important for the final state of the cultures (from washing, media preparation to sub-culturing, *etc*.). We take care of the culture strains as much as possible and hope to share our passion for microalgae.

Dr. Masanobu Kawachi (kawach9i@nies.go.jp) is a microalgae taxonomist working at the National Institute for Environmental Studies based at Tsukuba, Japan. Since 2012, he has been the head of the Microbial Culture Collection. As a Ph.D. student, Masanobu revealed the food capturing role of the haptonema for the haptophyte Chrysochromulina. He spent 6 months at an Antartica research base, and travelled worldwide to collect microalgae samples from various environments. With co-workers he is involved in the discovery of a new class, the Pinguiophyceae, having specific fatty acid content. Taxonomic revision of Chattonella and toxic cyanobacteria are among the fields of research he is working on. He is currently participating in several research projects: on coral symbionts with global warming concerns, picoplankton diversity with the environmental DNA analysis, and biofuel production from microalgae.

Dr. Mary-Hélène Noël (noel.mary-helene@nies.go.jp) came to the National Institute for Environmental Studies in 1996 as a Post-Doc right after her Ph.D. graduation from the University of Paris XII, CNRS 386 / E.N.S. With a background in marine biogeochemistry, she spent the first 4 years at the Water and Soil Division of NIES, then started to work on the coccolithophorid life cycle at the Biological Division and MCC-NIES. Her participation to the culture collection consists of recovering the strains with growth troubles, adapting strains, and providing advice to customers internationally. She is also involved in research projects on marine picoplankton diversity and life cycle studies.

The Bering Sea: Current status and recent trends

by Lisa Eisner

Climate and oceanography

Overall, the eastern Bering Sea shelf experienced much different weather during the past cold season of 2013–14. Specifically, it was 1–2°C warmer than normal for the period of October 2013 through March 2014 compared with the relatively cold temperatures that have prevailed since 2007. The past cold season included anomalously high sea level pressure (SLP) from eastern Siberia across the Gulf of Alaska (Fig. 1). The consequence for the mean winds was weak anomalies from the north along the shelf-break between the Bering Sea shelf and the deep basin, and weak anomalies from the south near the west coast of mainland Alaska.

The warm weather can be attributed mostly to relatively warm and moist air over the Bering Sea shelf. This warm air was due to a ridge of anomalously high geopotential heights aloft, centered over the Gulf of Alaska and extending into mainland Alaska. These conditions produced greater downward longwave radiation fluxes than normal over the Bering Sea shelf and Alaska. The result was a reduced rate of cooling of the ocean over the shelf, and less tendency for the development of extremely cold air masses over Alaska, the usual source of the lower-atmospheric flow for the Bering Sea shelf.

The only prominent and multi-day cold snaps at St. Paul, for example, were during mid-February and mid-March 2014 (Fig. 2). The latter event occurred at a time when the sea ice extended to near the Pribilof Islands. The maximum extent of the sea ice was considerably less, and the retreat of the ice edge to the north was earlier than during the heavy ice years of the recent past. This meant an early onset of warming in the spring of 2014; by mid-May, sea surface temperatures on the central and southern portion of the shelf were 1–1.5°C above normal.

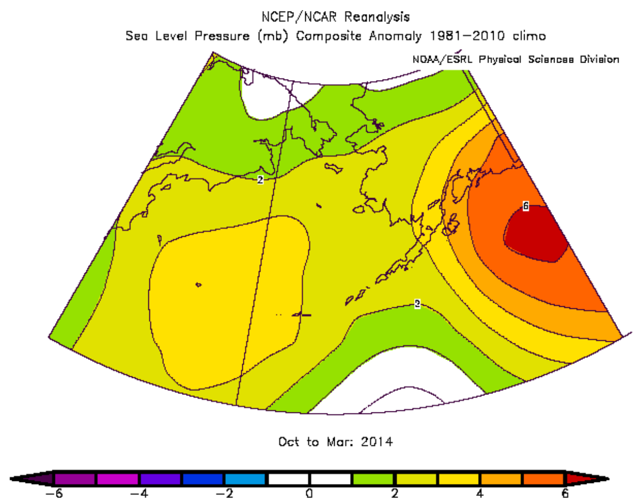


Fig. 1 NOAA sea level pressure (mb) composite anomaly (deviations from 1981–2010 climatology) for October 2013–March 2014. Figure courtesy of N. Bond.

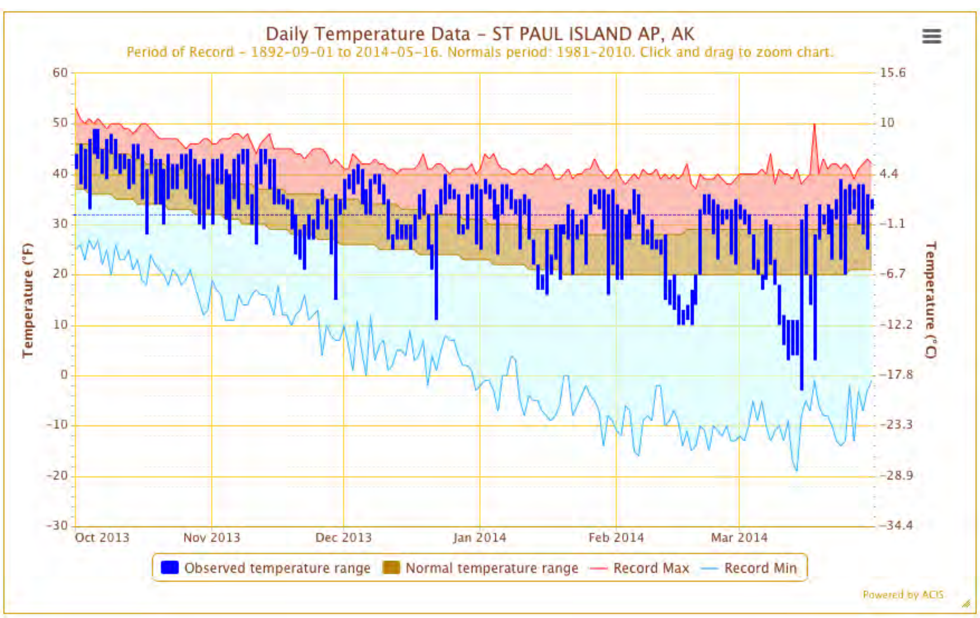


Fig. 2 Daily air temperature (°F) at St. Paul Island October 2013–March 2014. The reddish and aqua lines at the top and bottom, respectively, refer to the all time high and low temperatures for each date; the tan lines in the center refer to the average daily high and low temperatures for each date. The period of record is 1892 to present. Figure courtesy of N. Bond.

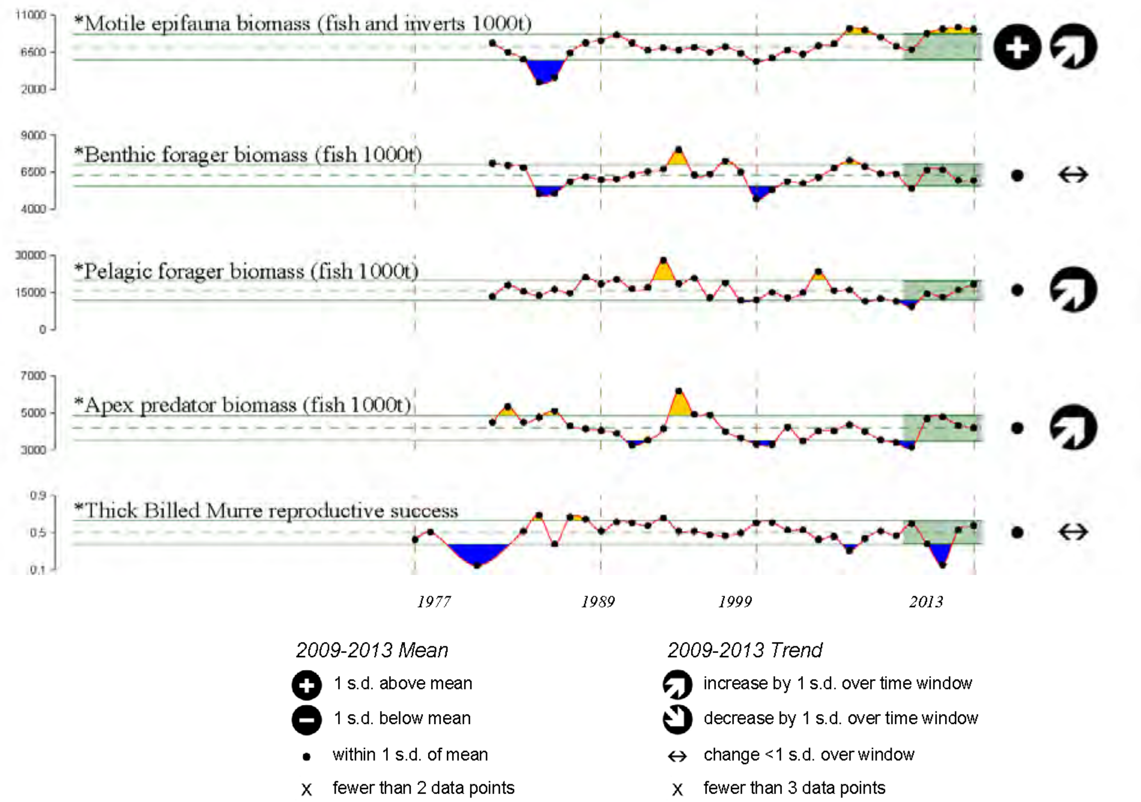


*Fig. 3 Eastern Bering Sea ecosystem assessment indicators. * indicates time series updated in 2013.*

Eastern Bering Sea ecosystem considerations

Highlights from the 2013 eastern Bering Sea ecosystem considerations chapter (Fig. 3) compiled by the Alaska Fisheries Science Center (AFSC) indicate that survey biomass of motile epifauna has been above its long-term mean since 2010 and fairly stable since the early 1990s. However, the trend of the last 30 years shows a decrease in crustaceans (especially commercial crabs) and a long-term increase in echinoderms, including brittle stars, sea stars, and sea urchins. It is not known if this reflects changes in survey methodology rather than actual trends. Survey biomass of benthic foragers has remained stable since 1982, with interannual variability driven by short-term fluctuations in yellow fin and rock sole abundance. In contrast, survey biomass of pelagic foragers has increased steadily since 2009 and is currently above its 30-year mean. While this is primarily driven by the increase in walleye pollock from its historical low in 2009, it also reflects increases in capelin from 2009–2013, perhaps due to cold conditions prevalent in recent years. The springtime larval drift patterns for 2013, based on Ocean Surface Current Simulations (OSCURS) model time series runs, do not appear to be consistent with years of good recruitment for winter-spawning flatfish such as northern rock sole, arrowtooth flounder and flathead sole.

Fish apex predator survey biomass is currently near its 30-year mean. The increase since 2009 back towards the mean is driven primarily by the increase in Pacific cod from low levels in the early 2000s. Arrowtooth flounder, while still above its long-term mean, has declined nearly 50% from the early 2000s, although this may be due to a distributional shift in response to colder water over the last few years rather than a population decline. Thick-billed murre reproductive success on St. George Island was above average in 2013, suggesting that foraging conditions were favorable for piscivorous seabirds.

Jellyfish, primarily *Chrysaora melanaster*, remained abundant in the summer 2013 surveys, although catch per unit effort (CPUE) was down slightly from 2012. The years 2009–2013 continue a trend of higher abundance, relative to the years 2001–2008 when catch rates of jellyfish were low. For additional information on ecosystem indicators, see http://access.afsc.noaa.gov/reem/ecoweb/index.php.

Eastern Bering Sea spring mooring survey

The spring mooring survey conducted by the Pacific Marine Environmental Laboratory (PMEL) and AFSC Fisheries Oceanography Coordinated Investigations (FOCI) occurred May 6–17, 2014, onboard the R/V *Oscar Dyson*. Oceanographic variables and zooplankton were sampled around Unimak Pass, along the 70 m isobath, off the shelf and over Bering Canyon. Six moorings were deployed in the southeastern Bering Sea. Since 2014 may be a warm year, additional analyses (primary productivity experiments and microzooplankton identification) were done to better understand the effects of a warming climate on lower trophic levels. Preliminary observations suggest that zooplankton, jellyfish and icthyoplankton were patchily distributed along the 70 m isobath.

Photo from spring mooring cruise, courtesy of K. Martini.

Recent and future 2014 Bering Sea fisheries oceanography surveys

Surveys in 2014 include:

- Eastern Bering Sea Spring Ichthyoplankton, AFSC, R/V *Oscar Dyson*, May 20–June 8;
- Eastern Bering Sea Bottom Trawl, AFSC, F/Vs *Vesteraalen* and *Alaska Knight*, June 1–August 11;
- Aleutian Islands Bottom Trawl, AFSC, F/Vs *Sea Storm* and *Alaska Provider,* June 5–August 15;
- Eastern Bering Sea Pollock Echo Integration Trawl (EIT), AFSC, R/V *Oscar Dyson*, June 12–August 13;
- Western Bering Sea Pollock Trawl-Acoustic, TINRO, Russia, R/V *TINRO*, August 10–September 4;
- Bering Arctic Subarctic Integrated Survey (BASIS), southeastern Bering Sea fisheries oceanography, AFSC and PMEL, R/V *Dyson*, August 17–October 14;
- North Bering Sea Pelagic Trawl, Alaska Department of Fish and Game and AFSC, F/V *Alaskan Endeavor*, August 31–September 24.

2014 will be the first year without a western Bering Sea salmon survey by TINRO, Russia.

Upcoming meetings

Meetings in the second half of 2014 and early 2015 of interest to scientists working in the Bering Sea include:

- PICES-2014, October 17–26, 2014, Yeosu, Korea;
- 9th International Flatfish Symposium, November 9–14, 2014, Cle Elum, WA, USA;
- Alaska Marine Science Symposium, January 2015, Anchorage, AK, USA;
- 3rd PICES/ICES/IOC Symposium on "*Effects of Climate Change on the World's Oceans*", March 23–27, 2015, Santos City, Brazil.

Acknowledgements *Many thanks to the following scientists who helped create this report: Dr. Nicholas Bond (NOAA, PMEL), Colleen Harpold (NOAA, AFSC), Dr. Carol Ladd (NOAA, PMEL), Dr. Kim Martini (NOAA, PMEL), Dr. Olga Temnykh (TINRO, Russia), and Dr. Stephani Zador (NOAA, AFSC).*

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

(Continued from page 42)

regulation policy being implemented. For much of the coastal populations in the Okhotsk Sea area, fishing, especially on herring in coastal areas, is the only source of income. Heavy ice conditions in coastal areas in 2008 prevented access to the traditional and regulated fishing grounds, and herring catches plummeted. Only the estuarine regions were sufficiently ice free to catch spawning herring, but these regions under existing regulations were not open to herring fishing. Through the joint effort of local communities, scientists and government, the regulations were changed to permit herring to be fished in the estuary since 2009, restoring basic income to local residents.

Ekaterina P. Kurilova (katy_k07@mail.ru) is a linguist and an assistant director in the Khabarovsk branch of TINRO-Center, Russian Federation. She works in an administrative department and deals with international cooperation of the Institute. Her particular interests focus on intercultural communication aspects, as well as the process of communication in general. She studies the problem of influencing public opinion via mass media, communicating science and social impacts of fisheries management in Russia. Since 2012, she has been a member of the PICES Section on Human Dimensions of Marine Systems.

The state of the western North Pacific in the second half of 2013

by Takashi Yoshida

The western North Pacific in the second half of 2013 was characterized by a significantly warm summer. In the North Pacific, remarkably positive sea surface temperature (SST) anomalies were seen over a large area north of 30°N in summer. During July and August, the North Pacific High was enhanced to the south of Japan and extended to eastern China and western Japan. The enhancement brought significantly positive SST anomalies in the seas around the Northeast Asian countries, especially in August (Fig. 1).

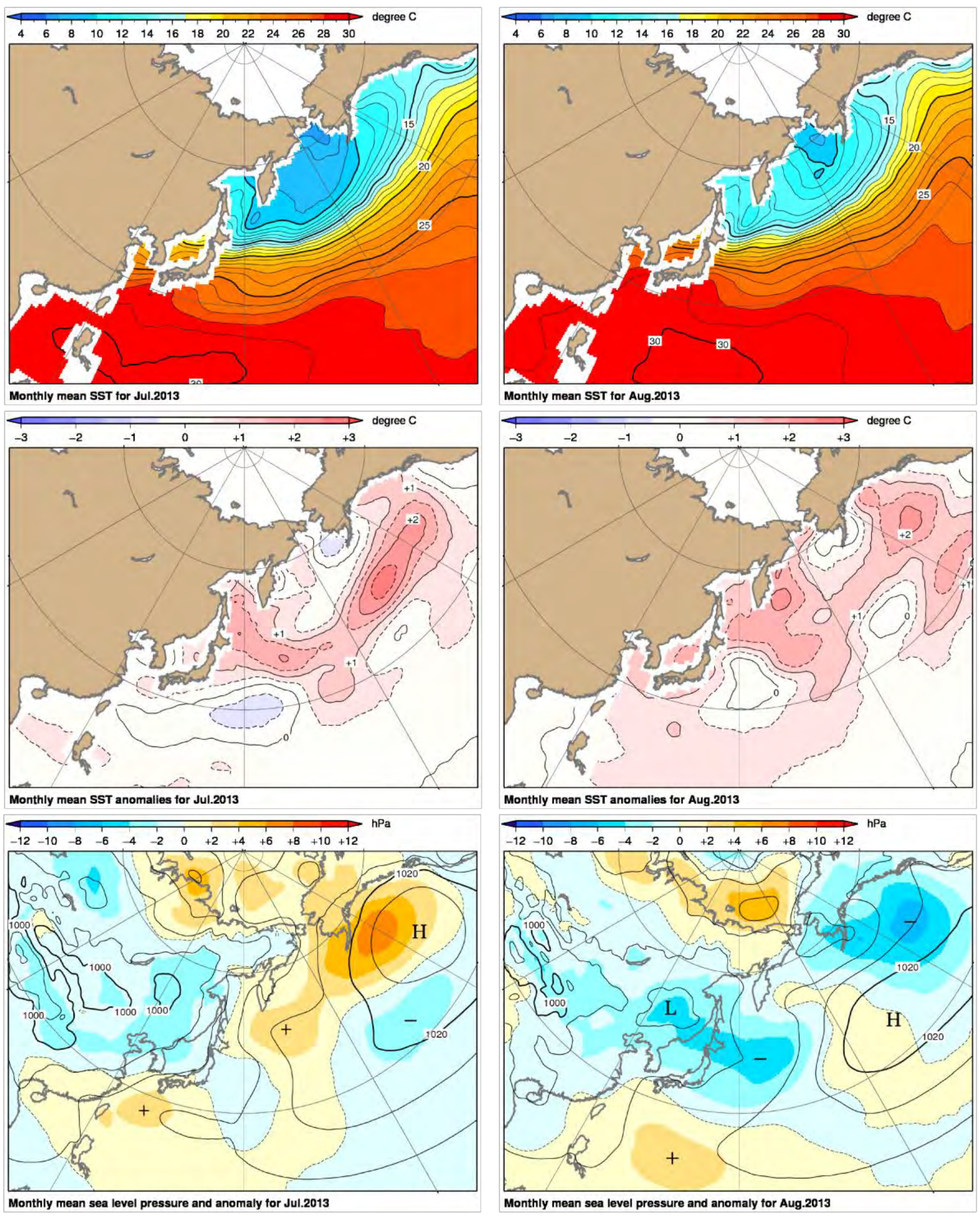


Fig. 1 Monthly mean sea surface temperature (upper), SST anomalies (middle) and sea level pressure (SLP) anomalies (bottom) for July and August 2013. Monthly mean SSTs and SLPs are based on JMA's COBE-SST (Centennial in situ Observation-Based Estimates of variability of SST and marine meteorological variables) and JRA-55 (Japanese 55-year Reanalysis), respectively. Anomalies are deviations from 1981–2010 climatology.

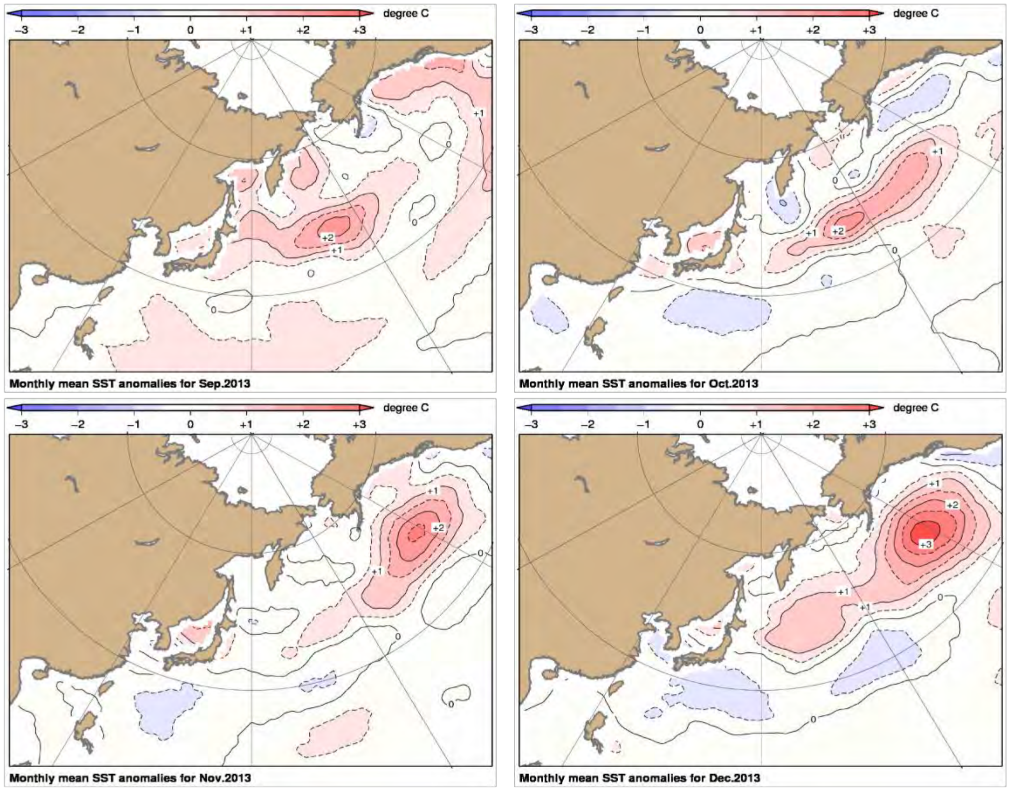


Fig.2 Monthly mean SST anomalies from September to December 2013.

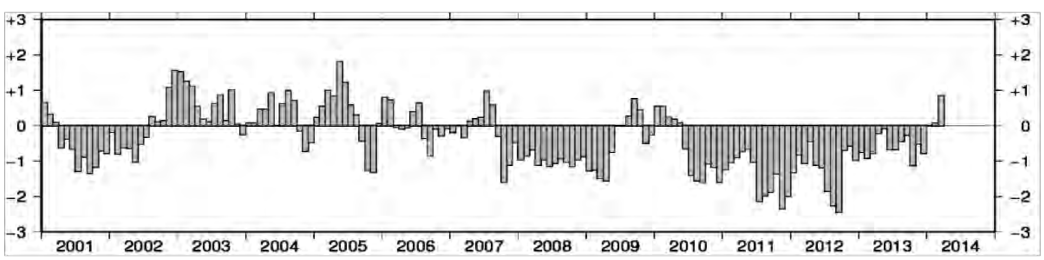
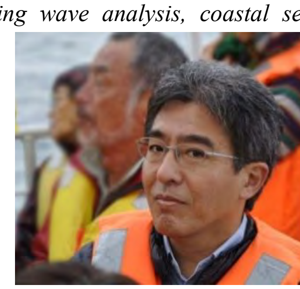


Fig.3 Time series of Pacific Decadal Oscillation (PDO) index from January 2001 to March 2014.

Several impacts of the significant warm climate on fisheries and aquatic life were reported. In the Okhotsk Sea, coastal fishermen experienced unusual yellowtail catches in their salmon fixed nets from August to October. Fishermen also experienced unusual bluefin tuna catches in the Oyashio region, the sea southeast of Hokkaido, usually occupied by cold subarctic waters where tuna have been rarely caught. Warmer water temperatures delayed the southwest migration of Pacific saury, causing its short supply in early September. Slower growth of oysters in several Japanese oyster farms and coral bleaching in Okinawa were observed in these months, which are also considered to be impacts of the warm episode.

The Pacific Decadal Oscillation (PDO), which had positive and negative SST anomalies in the central and eastern parts of the North Pacific, respectively, was in the negative phase throughout almost the whole year, although the pattern was slightly obscure from summer to autumn 2013 (Fig. 2). The PDO is an SST anomaly pattern of Pacific climate variability that shifts phases on an inter-decadal time scale usually covering more than 10 years. Recently (since mid-2010), the negative phase of the PDO with positive SST anomalies in the central part of the North Pacific has been occurring frequently (Fig. 3).

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



Unusual warming in the Gulf of Alaska

by Howard Freeland and Frank Whitney

In March 2014 there was something very unusual occurring in the Northeast (NE) Pacific that might have substantial consequences for biota in the Gulf of Alaska and southward into the subtropics. A quick examination of the Reynolds sea surface temperature (SST) data set shows considerably higher than normal temperatures in early 2014. Each month since November 1981, these data have been published by NOAA/NCEP (ftp://ftp.emc.ncep.noaa.gov/cmb/sst/oimonth_v2/) and represent the best estimate of the SST in the global oceans (see also Reynolds *et al*., 2007). A January mean state, including a field of standard deviations, for the N.E. Pacific was computed by averaging the SST fields for all Januaries from 1982 to 2013 inclusive. An anomaly field was then computed for January 2014 by subtracting the mean state and normalising by the field of standard deviations. Similar calculations were done for February 2014.

In January 2014 (Fig. 1a), we see SST departures of 4.5 standard deviations or ~3°C from the long-term mean, centered on 42°N 148°W. The anomaly field covers a large region of the N.E. Pacific in January 2014 and (not shown) a similar area in February, though the peak anomalies are slightly smaller. The black dots show the nominal locations of the stations comprising Line-P, for later reference. The authors of this article have never seen deviations from normal of 4.5 standard deviations before, despite extensive work with the Line-P data set. The warming event first appeared in November 2013, becoming strongest in January (Fig. 1a), and lasting into February 2014.

Something as extraordinary as a 4.5-sigma deviation requires corroboration, and for that purpose we examined Argo data, which are not ingested by the Reynolds data sets. The reason for this exclusion is that Argo floats sample during their ascent phase, and the CTD pump is turned off at a pressure of 4 decibars to avoid pumping surface films into the conductivity cell. In Figure 1b Argo data were interpolated to Ocean Station Papa (50°N and 145°W) and averaged over all Januaries from the start of the Argo program in the Gulf of Alaska in 2002 to the present time. The temperature, salinity and density (σ_t) are colored red, green and black, respectively, and the horizontal lines indicate the mean values computed from 2002 through 2013. The final point shows the recently observed values for January 2014, and the annotations indicate the value as a mean plus anomaly in standard deviations. The Argo data verify the very large temperature departures seen in Figure 1a, with an anomaly of 4.4 standard deviations from the mean in temperature, and similar large deviations in salinity. We note that high temperature anomalies coupled with low salinity anomalies both act to reduce density. Hence we see very large anomalies in surface density that must act to impede mixing near Station Papa, and likely over the entire region of SST anomaly.

To complete the description of the physical field, Figure 1c shows the distribution along Line-P of the temperature anomaly fields in January 2014. The temperature field has been computed using objective analysis to interpolate from all Argo profiles available in a 10-day window centred on the 15th day of January, and using a Gaussian covariance function with an *e*-folding scale of 400 km (see Bretherton *et al*., 1976, for a description of the methods). The mean state used to compute the temperature anomalies is from Marie Robert (Robert, 1994), which used all observations from 1956 to 1991. The section in Figure 1c shows the very strong warming and demonstrates that the event is primarily restricted to the upper 100 metres of the water column with possibly slight warming in deeper waters. The equivalent plot for salinity (not shown) has a similar behaviour with little influence below the top 100 metres.

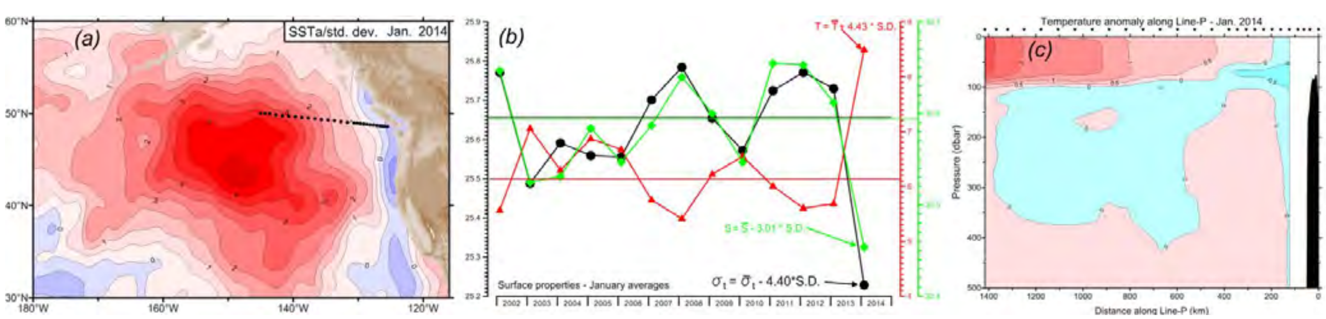


Fig. 1 Temperature and salinity in the N.E. Pacific in January 2014. Panel (a) shows the January 2014 SST anomalies (in standard deviations) from the 1982–2013 Reynolds NOAA/NCEP mean January state. Panel (b) shows January temperature (red), salinity (green) and density (σ_t; black) departures from the 2002–2013 mean state (horizontal lines) at Ocean Station Papa. Panel (c) shows temperature anomalies (°C) contoured versus depth and distance along Line-P in January 2014.

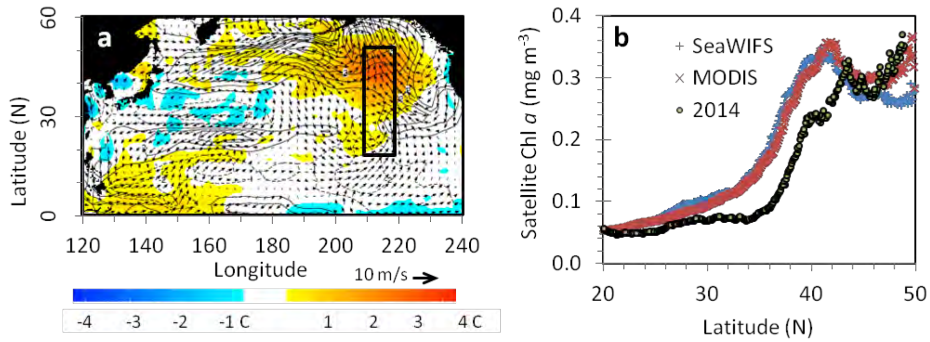


Fig.2 (a) Sea surface temperature (SST) and 1000 mbar wind anomalies for January 2014 in the North Pacific Ocean. SST anomaly (color bar) and wind speed (arrow) scales are shown at bottom; plots are generated by the International Research Institute for Climate and Society, Columbia University, NY on their website http://iridl.ldeo.columbia.edu using data from the NCEP/NCAR Reanalysis and the NOAA OISSTv2 dataset (Kalnay et al., 1996; Reynolds et al., 2007). The black rectangle outlines the region assessed in Panel b. (b)Average SeaWiFS and MODIS chlorophyll a for January, as well as January 2014 MODIS chlorophyll, are plotted against latitude for the region between 140–150°W (data from the Giovanni online data system, developed and maintained by the NASA GES DISC).

Wind anomalies (Fig. 2a) show the cause of the warm anomalies in the ocean's surface layer to be an unusual flow from the south as the North Pacific high pressure cell expanded northward. This pattern disrupted the path of the westerly winds that cross the subarctic Pacific, winds that normally transport nutrients from the subarctic North Pacific into the subtropics during winter (Ayers and Lozier, 2010; Whitney *et al*., 2013). In most years, a winter region of high productivity is created by this Ekman transport which reaches as far south as 30–32°N in the N.E. Pacific (Bograd *et al*., 2004). Named the Transition Zone Chlorophyll Front (TZCF), it is an important feeding area for migratory fish and seabirds (Block *et al*., 2011).

Without nutrients from the subarctic, the productivity of subtropical waters must decline. To assess impacts of the warm anomaly on ocean productivity, satellite chlorophyll between 140 and 150°W was averaged in 2 degree bins between 20 and 50°N. South of the warm anomaly between 22 and 40°N, January chlorophyll *a* was well below the SeaWiFS (1998–2010) and MODIS (2003–2014) averages in 2014 (Fig. 2b). Consequently, the TZCF (identified as 0.2 mg chl m^{-3}) was located 240 km north of its average location over the previous 16 years. Between 30–40°N, surface chlorophyll dropped to 60% of the average values. Top predators may be able to locate the chlorophyll front since they are accustomed to travelling great distances in their search for prey. However, weakened nutrient transport from the subarctic into the subtropics this past winter will dramatically reduce the productivity of the eastern subtropics over an area of ~17,000 km^2 (20° Longitude × 240 km northward displacement of the TZCF). One possible outcome might be a northward shift of the albacore tuna fishery in 2014.

References

Ayers, J. M., and M. S. Lozier (2010), Physical controls on the seasonal migration of the North Pacific transition zone chlorophyll front. *J. Geophys. Res. 115*, C05001, doi:10.1029/2009JC005596.

Block, B.A. *et al*. (2011), Tracking apex marine predator movements in a dynamic ocean. *Nature 475*, 86–90, doi:10.1038/nature10082.

Bograd, S. J. *et al*. (2004), On the seasonal and interannual migrations of the transition zone chlorophyll front, *Geophys. Res. Lett*., *31*, L17204, doi:10.1029/2004GL020637.

Bretherton, F. P., R. E. Davis, and C. B. Fandry (1976), A technique for objective analysis and design of oceanic experiments. *Deep-Sea Res*., *23*, 559–582.

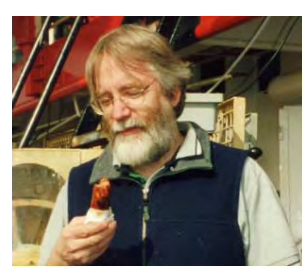
Kalnay, E. *et al*. (1996), The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Amer. Meteor. Soc., 77*, 437–471.

Reynolds, R. W. *et al*. (2007), Daily high-resolution blended analyses for sea surface temperature. *J. Climate*, *20*, 5473–5496.

Robert, M. 1994. A study of El Niño events along the British Columbia coast. Department of Atmospheric and Oceanic Sciences, McGill University, M.Sc. thesis.

Whitney, F. A., S. Bograd, and T. Ono (2013), Nutrient enrichment of the subarctic Pacific Ocean pycnocline. *Geophys. Res. Lett. 40*, 1–6, doi:10.1002/grl.50439.

Dr. Howard Freeland (Howard.Freeland@dfo-mpo.gc.ca) is a scientist emeritus at the Institute of Ocean Sciences. Despite his retirement, he maintains a keen interest in the Argo program and ocean climate change. (In this picture he is seen launching yet another Argo float.)



Frank Whitney (whitneyf@shaw.ca) retired from Fisheries and Oceans Canada in 2006. He has remained interested in chemical processes impacting the productivity of the ocean, whether it is nutrient supply to surface waters or hypoxia at depth. Recent papers (J. Oceanogr. 67: 481–492; GRL 40: 1–6) summarized some of the trends he and colleagues observed over a span of 25 years or more in the subarctic Pacific. (In this photo, Frank is studying a common type of tube worm that barbecues quite nicely onboard ship.)

Obituary – Dr. Toshiro Saino

by Sanae Chiba

A few months have quickly passed since we lost our colleague, friend and mentor, Dr. Toshiro Saino. He passed away on April 17th in Yokohama, Japan, just one week after the cherry blossom season ended. In Buddhism, one must complete a seven-week journey to reach the Heavens after he/she has left this side of the world. Every week, a task is given, such as crossing the river by paying special coins to the boatman (so we put a special traveler's burial clothes on him/her with those coins in its wallet). The fifth week is the climax, when one must pass the qualification interview with the Emperor of Hell. I imagine how Saino-san took that interview, and am sure he could outcompete the Emperor in debate quite confidently. Now I can see him enjoying discussions with past famous scientists in history far up there, of course sipping Heaven's best whiskey, sake or whatever…. I just cannot help but imagine it that way.

Saino-san was probably most familiar to the recent PICES community as the Co-Chair of the Section on *Carbon and Climate*. He was Japan's leading biogeochemist and ocean color scientist who had been promoting a number of domestic and international programs in these areas. He was a member of the JGOFS Scientific Steering Committee starting in the 1990s and served on its Executive Committee until the program ended in the mid-2000s. Starting his science career with studies of nitrogen fixation physiology of *Trichodesmium* in the late 1970s at the University of Tokyo, he made important contributions on a wide range of subjects concerning the ocean nitrogen cycle, such as development of a stable isotope technique for measuring nitrogen fixation in the sea and methods for estimating nitrate and new production from remote sensing. More recently, he launched the project for development of an ocean productivity profiling buoy system, aiming to make possible the semi-real time observation of primary productivity. After moving from Nagoya University to JAMSTEC in 2008, he led time-series observation projects using the profiling buoy system, with one deployed in the subarctic and the other in the subtropical western North Pacific.

Testing the Ocean Productivity Profiling System.

I personally came to know Saino-san when I was a graduate student of the Tokyo University of Fisheries. When I applied for a Postdoc position at JAMSTEC, he was one of the interviewers at that very scary, serious interview session. I successfully got the post and Saino-san became my boss, who was dignified but very approachable. We worked together on the retrospective analysis of long-term ecosystem change over the North Pacific by collecting and re-analyzing historical plankton samples and data such as the Odate Collection that the Fisheries Research Agency possessed. He was an advocate for the Odate Project, by which our understanding of marine ecosystem responses in the western North Pacific to climatic forcing, such as the Pacific Decadal Oscillation, was greatly improved.

Group photo of the Section on Carbon and Climate meeting at PICES-2011 in Khabarovsk, Russia. Left to right: Dong-Jin Kang, Jim Christian (S-CC Co-Chairman), Pavel Tishchenko, Alex Kozyr, Toshiro Saino (S-CC Co-Chairman), Toru Suzuki, Akihiko Murata and Minhai Dai.

Saino-san with Drs. Shuichi Watanabe and Toru Suzuki at PICES-2002.

Saino-san earning the name "in-Saino", with Alex Kozyr and Alex Bychkov during a JGOFS N. Pacific Synthesis Group meeting, 2003.

Saino-san and Fei Chai enjoying dinner with wine, and watching the sunset on a Maine lake, 2006.

Invited speakers, Drs. Toshiro Saino and Michael Behrenfeld, PICES-2007.

Saino-san always expanded his scientific interests toward new perspectives and methods whenever he found it challenging. He was a fully internationally active oceanographer who conducted his projects in the global context, loved to work with international colleagues, and encouraged others to go global, as ocean science is global. That is why he had so many good friends all over the world. Throughout his professor career at the University of Tokyo and Nagoya University, he played a role as a mentor of many capable young scientists, among which were excellent overseas students who are now world leading oceanographers. It was really impressive that there were so many messages of condolence from overseas at his funeral. I must also mention that he was a supporter of women scientists in Japan, where the ceiling is often visible rather than just made of glass.

Besides science, I should write here about his lovable character. He had a large collection of rhinoceros goods in his office because he related its Japanese name "sai" to himself. On celebration of Saino-san's Japanese Oceanographic Society Award, one of us even tried to find a gift of a rhino crystal figure in the flagship shop of Swarovski in Vienna where he attended the EGU meeting. He insisted that he desperately needed a rhino, and ended up having thoroughly confused the shop clerk who suggested an elephant and other animals because they had no rhino products and did not understand why it must be a rhino. That anecdote always makes me smile. Saino-san was known as a great host at his home BBQ parties. Yet not so many know that he was a highly skilled Kendo (Japanese fencing) player; the 4th grade is only given to, well, "Samurai-level" competitors. Indeed, he was a Samurai while he was fighting with cancer, brave and positive, and worked hard as always even in such bad condition. Also, he was a scientist, who thoughtfully did the research, critically analyzed the symptoms, and tried new treatments. We believed he could have pulled through.

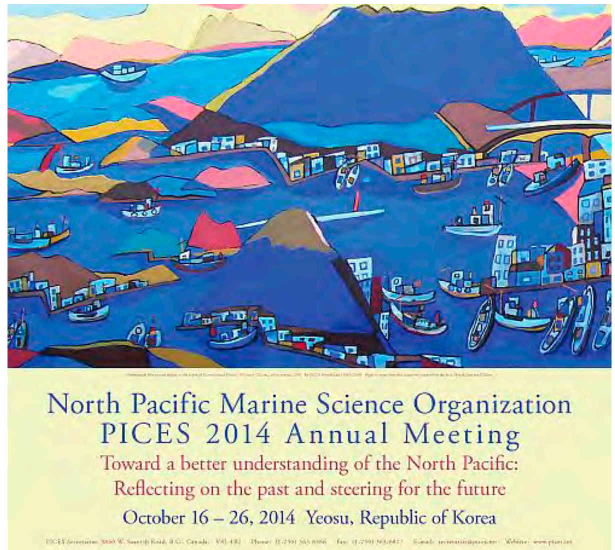
Saino-san leaves behind his wife Fumiko Saino, a daughter, two sons and two grandchildren. And a third grandchild is expected soon. Saino-san has left us, but he sowed a lot of seeds of ocean scientists over the world. I end this obituary with my favorite quote of Oscar Wilde,

> *"To live is the rarest thing in the world, most people just exist, that is all."*

Saino-san lived.

I thank Drs. Jim Christian, Joaquim Goes, Takashi Ishimaru, Toru Suzuki and Fei Chai, who shared information and photos for this article.

Program of topic sessions and workshops at PICES-2014

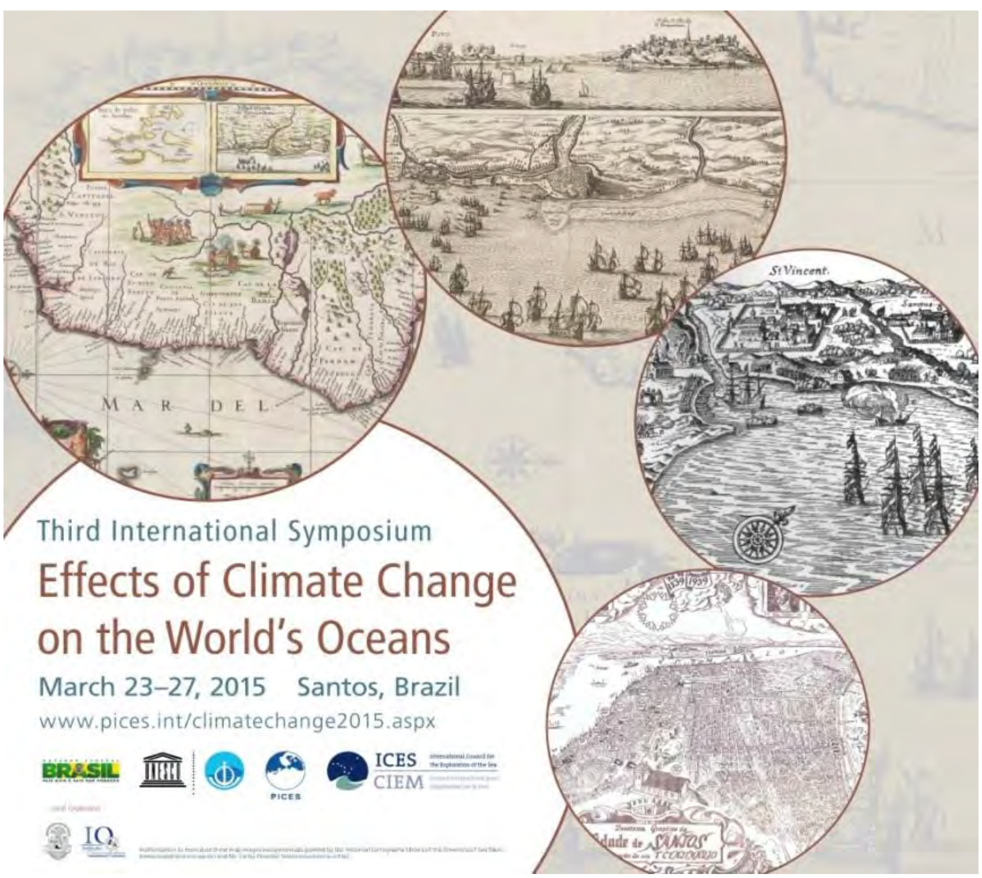


- **Science Board Symposium (S1):** Toward a better understanding of the North Pacific: Reflecting on the past and steering for the future
- **BIO Topic Session (S2):** Strengths and limitations of habitat modeling: Techniques, data sources, and predictive capabilities
- **BIO/MEQ Topic Session (S3):** Tipping points: defining reference points for ecological indicators of multiple stressors in coastal and marine ecosystem
  Co-sponsored by the International Council for the Exploration of the Sea (ICES) and Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)
- **BIO/MONITOR/TCODE Topic Session (S4):** Use of long time series of plankton to inform decisions in management and policy concerning climate, ecosystems and fisheries
- **FIS Topic Session (S5):** Ecosystem considerations in fishery management of cod and other important demersal species
  Co-sponsored by the International Council for the Exploration of the Sea (ICES)
- **FIS/FUTURE Topic Session (S6):** Climate change impacts on spatial distributions of marine fish and shellfish
- **FIS/TCODE/FUTURE Topic Session (S7):** Recent assessments of climate change impacts on marine ecosystems
  Co-sponsored by the International Council for the Exploration of the Sea (ICES) and Intergovernmental Panel on Climate Change (IPCC)
- **MEQ Topic Session (S8):** Marine debris in the Ocean: Sources, transport, fate and effects of macro- and micro-plastics
  Co-sponsored by the Group of Experts on Scientific Aspects of Marine Pollution (GESAMP), International Council for the Exploration of the Sea (ICES) and the Northwest Pacific Action Plan (NOWPAP)
- **POC/MONITOR Topic Session (S9):** Variability in advection and its biological consequences for Subarctic and Arctic ecosystems
  Co-sponsored by the International Council for the Exploration of the Sea (ICES)
- **POC/TCODE/FUTURE Topic Session (S10):** Regional climate modeling in the North Pacific
- **MarWeB Topic Session (S11):** Ecological and human social analyses and issues relating to Integrated Multi Trophic Aquaculture
- **BIO, FIS, MEQ, POC contributed paper sessions**
- **FIS Workshop (W1):** Dynamics of pelagic fish in the North Pacific under climate change
  Co-sponsored by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC)
- **FIS Workshop (W2):** Linkages between the winter distribution of Pacific salmon and their marine ecosystems and how this might be altered with climate change
  Co-sponsored by the North Pacific Anadromous Fish Commission (NPAFC)
- **MEQ Workshop (W3):** Mitigation of harmful algal blooms: Novel approaches to a decades long problem affecting the viability of natural and aquaculture fisheries
- **MONITOR Workshop (W4):** Networking ocean observatories around the North Pacific Ocean
  Co-sponsored by Ocean Networks Canada
- **POC Workshop (W5):** SOLAS into the Future: Designing the next phase of the Surface Ocean-Lower Atmosphere Study within the context of the Future Earth Program
  Co-sponsored by Surface Ocean Low Atmosphere Study (SOLAS)

3rd International Symposium on "*Effects of climate change on the world's oceans*"

Twelve scientific sessions and six workshops will take place at the 3rd International Symposium on the "*Effects of climate change on the world's oceans*", to be held March 23–27, 2015 in Santos, Brazil. This meeting continues a series of climate change focused meetings (2008: Gijón, Spain; 2012: Yeosu, Korea) coordinated by the International Council for the Exploration of the Sea (ICES), the North Pacific Marine Science Organization (PICES) and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO). **Deadline for early registration rates and abstract submission is October 31, 2014.** Details about the meeting are available at www.pices.int/climatechange2015.aspx. Selected papers (oral and poster) from the symposium will be included in a special issue of the *ICES Journal of Marine Science* (www.ices.dk/products/icesjournal.asp) scheduled for publication in 2016. In addition, it is anticipated that selected sessions and workshops will develop their own proposals for special volumes. Below, two of the symposium convenors have expressed the importance of this meeting and why you should attend:

Jacquelynne King (PICES): As a natural scientist that provides scientific advice for marine resource management, climate change impacts on the oceans is a personal interest. These impacts have been evident in my own research, from warming trends in sea surface temperature time series to changes in fish community composition. Along the Pacific coast of Canada, these observed changes have had major consequences for the coastal communities and stakeholders that utilize marine ecosystem services: both as lost resources and as opportunities for new resources. Sustainable management of marine resources in the face of climate change requires quantification of uncertainty and risk in our climate, ocean and ecosystem modeling and forecasts. This symposium continues to build on the latest developments and innovations in these fields and bridges to the human dimensions of climate change impacts, with a focus on coastal communities, management objectives and governance adaptation. It will be an integrated forum for physical, natural and social scientists from around the world, providing the opportunity to present research on a suite of climate change pressures and system responses including advection, nutrient transport, ocean acidification, carbon pumps, phenology, biodiversity, resilience, and evolutionary adaptation. It is a unique opportunity to advance, discuss and debate the scientific understandings of climate change effects on marine systems in conjunction with the forethought to the societal implications of reliance on those systems' services.



Luis Valdés (IOC): Since its creation, the IOC-UNESCO has played a pivotal role in the development of oceanography at an international level providing mechanisms to guide and complement ongoing research by nation states. At the IOC we are convinced that climate change is not only a challenging scientific issue that has developed a corpus of observations, models and hypothesis on possible consequences affecting critical processes for the functioning of Earth's ecology, but also has had a dragging effect in other disciplines that have modified the approaches to classical topics such as risk analyses, socio-economics, ethics and politics, energy, natural resources management, geo-engineering and even evolution, which are now addressed under a different perspective. The scientific debate has moved very fast from observations to impacts and from impacts to discussion on potential mechanisms to mitigate and adapt to this new reality. This was likely in accordance to the fact that there was, and still is, an urgent need for actions to minimise the impacts of global warming, and obviously the decisions must be based on credible scientific knowledge. The debate on climate change needs input from science as one of the essential elements, and symposia like this, that bring together experts from different disciplines to exchange observations, results, models and ideas are crucial to consolidate our understanding and knowledge at a global scale.

This 3rd International Symposium on the "*Effects of climate change on the world's oceans*" aims to deliver new insights into the ways in which climate change and variability is affecting marine ecosystems, especially in Latin America and the Southern Hemisphere, reduce the scientific uncertainty behind environmental change and provide a solid basis for future comparisons and research.

Join us in Brazil next March!

PICES Interns

We are pleased to announce that Ms. Anna Skvortsova joined the Secretariat in July as the 2014 PICES Intern. Anna was born and raised in Vladivostok in the Russian Far East. She graduated from the Far East State University in 2004 and was immediately employed by the Pacific Scientific Research Fisheries Centre (TINRO-Centre). She has worked at the International Department and was engaged in preparation of the PICES Annual Meetings held in Vladivostok in 2005 and in Khabarovsk in 2011. Anna was in charge of coordination and implementation of international cooperation based on bilateral agreements between the Russian Federation and the Republic of Korea, People's Democratic Republic of Korea, and People's Republic of China. She enjoys travelling, spending spare time with her close and dear people, attending the francophone meetings supported by *Alliance Francaise* and participating in meetings of the Young Entrepreneurs Center. She has a great interest in embroidery, baking and dancing.

We extend our sincere appreciation to Mr. Keyseok Choe, who completed his term as PICES intern with the Secretariat in June 2014 and who has returned to Korea where he is now working as Supervisor of the General Affairs Team at the East Sea Research Institute of the Korea Institute of Ocean Science and Technology (KIOST). Keyseok was of valuable assistance in day-to-day activities at the office as well as helping with activities at PICES-2013, the FUTURE Open Science Meeting, and the 2014 PICES Summer School. We wish the best for Keyseok in his career.

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