

## ICES/PICES Workshop on Global Assessment of the Implications of Climate Change on the Spatial Distribution of Fish and Fisheries

by Myron A. Peck, Anne B. Hollowed and Suam Kim

St. Petersburg, Russia, one of the most important gateways where the East meets the West, was the perfect venue for PICES and ICES scientists to come together for three days to discuss climate-driven changes in the spatial distribution of living marine resources. The Strategic Initiative (Section) on Climate Change Impacts on Marine Ecosystems workshop on changes in spatial distribution (WKSICCME-Spatial) took place on the island district of Vasileostrovskiy from May 22 to 24, 2013, and was attended by 67 scientists from 13 countries as well as representatives from ICES, PICES and the FAO (Fig. 1). The workshop, co-convened by Anne Hollowed (USA, PICES), Suam Kim (Korea, PICES) and Myron Peck (Germany, ICES), was held to foster the development and testing of analytical methods for detecting changes in distribution, assessing the skill of different modeling approaches, and quantifying uncertainty in projected climate-driven changes. Other important questions addressed were: How do we best design a global database of marine observations and what are the strategies used to

assess vulnerability (of resources and those that depend upon them) to shifts in distribution?

The workshop was organized around six theme sessions: (1) Analytical methods for detecting changes in spatial distribution, (2) Skill assessment and model inter-comparison, (3) Quantifying uncertainty, (4) Design specification for database of observations of distribution of living marine resources, (5) Vulnerability assessment, and (6) Communicating outcomes to inform decisions regarding management of living marine resources under changing climate. Each session had 1 or 2 keynote speakers (Fig. 2) and 3 breakout group leaders; the latter guided participants through a set of pre-defined discussion questions. The key points from each session were discussed in plenary, including consensus recommendation for future PICES/ICES activities on climate-driven changes in spatial distribution of living marine resources. The following provides a very brief overview of key discussion points and findings in each session.



Fig. 1 Group photo of participants of the ICES/PICES SICCME-Spatial workshop (top) as well as small breakout group discussions (bottom left and middle) A welcome address and wrap up summary of the workshop was provided by Anne Hollowed (bottom, right). Pictured in the bottom left photo (L to R: Chan Joo Jang (Korea), Michael Foreman (Canada) and William Sydeman (USA), Toru Suzuki (Japan), Naesun Park (Korea), John Stein (USA)); bottom middle photo (L to R: Anne Britt Sandø (Norway), Jinqiu Du (China) Lorna Teal (Netherlands), Myron Peck (Germany) and David Reid (Ireland)).



Ten of the 11 keynote speakers at the ICES/PICES SICCME-Spatial workshop. From the top to the bottom (L to R): Session 1, William Cheung (Canada), Franz Mueter (USA); Session 2, Shin-ichi Ito (Japan), Miranda Jones (UK); Session 3, Grégoire Certain (Norway), Tatiana Pavlova (Russia); Session 4, William Sydeman (USA); Session 5, Gretta Pecl (Australia), Cassandra de Young (FAO); Session 6, Motomitsu Takahashi (Japan), and – not pictured – John Pinnegar (UK).

In session 1, William Cheung (Canada) and Franz Mueter (USA) gave presentations on different approaches to detect changes in the spatial distribution of living marine resources. They highlighted the different challenges faced when examining global changes based upon fisheries-dependent data *versus* examining historical changes in specific ecosystems based upon survey data (*e.g.*, 42 taxa in the Bering Sea). Changes in distribution have been assessed using a variety of approaches tailored to fit the scale of the question. Workshop participants agreed that comparisons of different approaches within the same system are needed. Moreover, examples highlighted how responses at the center, leading and trailing edges of a species' distribution may vary due to different processes. There was consensus that fisheries oceanographic (process) studies (including tagging and behavioral studies) along with laboratory studies (including physiological experiments) are needed to verify proposed mechanisms. Not only documenting historical shifts but also understanding the underlying mechanisms will be critical for making robust projections of future changes.

In session 2, Miranda Jones (UK) and Shin-ichi Ito (Japan) illustrated different modelling approaches (bioclimate envelope models constructed for many species *versus* coupled biophysical-ecosystem, full life cycle modeling of one species) and methods they used to examine the skill of models to reproduce historical distributions. These two talks highlighted the diversity of biological modelling tools available within the community and the different approaches taken (from pattern matching to quantitative statistical analyses) to assess how well models “perform”. The breakout groups summarized previous efforts to examine the skill of a wide range of biological models applied around the globe (*e.g.*, what models have been used, where have they been applied, and how has model skill been appraised?). Discussions emphasized the close link between skill assessment and the *in situ* observations at appropriate temporal and spatial scales (*e.g.*, skill assessments of modelled responses at the base of the marine food web have been aided by the availability of satellite data, while those for upper trophic levels remain more challenging due to gaps in observations). There was consensus among workshop participants that it is important to identify life history bottlenecks to guide auxiliary surveys for model verification, and that the attribution of climate change impacts will be advanced by developing techniques to disentangle the effects of multiple drivers. To the extent practicable, participants suggested that biological modelers follow practices currently employed in climate modelling for evaluating hindcasts with contemporary observation. A key element includes assessing model skill in terms of both spatial and temporal patterns.

Within session 3, Tatiana Pavlova (Russia) provided an update on climate simulations and projections for Russia and its adjacent seas which featured variability in model projections of the seasonal changes in the extent of Arctic

Sea ice. This was followed by a presentation by Grégoire Certain (Norway) who provided an example of how to identify and address the cumulative error propagating through various steps of species distribution models (*e.g.*, from sampling error associated with the collection of species and environmental data, structural error associated with the formulation and selection of statistical models to examine those field data, the choice of climate model and ensembles of forecasts). Similar to session 2, workshop participants agreed that there is a need to identify regions where multiple modelling approaches have been developed and compare them after finding a “common currency”. Short-term projections (nowcasts) available in various locations provide an opportunity to test assumptions behind links in changes in species distribution and environmental factors but it was important that users were informed about the uncertainty of projections. For biological models, both within (sensitivity analysis) and between (ensemble) model comparisons are needed.

Session 4 addressed data needs to better understand and project climate-driven changes in species distribution. William Sydeman (USA) gave a presentation summarizing the process of building the National Center for Ecological Analysis and Synthesis (NCEAS) “MarClim” database. The end product was a database that included information from studies on 857 species and species-assemblages, representing 1735 observations of marine biological responses to climate change (see [www.nceas.ucsb.edu](http://www.nceas.ucsb.edu)). The talk highlighted both the results of the meta-analysis as well as the challenges of compiling data from a variety of different sources. Workshop participants agreed that there is 1) an urgent need for an aggregated database of fishery-independent and fishery-dependent data collected at a higher spatio-temporal resolution than existing databases, and that such a database 2) is best supported by national or international institutions with 3) continued engagement from data collection experts because of the complicated nature of individual datasets (*e.g.*, non-standard, gear, region, design specificity).

Session 5 took a broader view of climate impacts by discussing the vulnerability of species (and the human communities that rely on those species) to climate-driven changes in distribution. From a human communities standpoint, Cassandra De Young (FAO) presented the generic model developed by the IPCC to assist in understanding vulnerability to climate change as a function of 1) the sensitivity of a system to changes in climate, 2) the adaptive capacity of practices, processes, or structures that can moderate or offset damage or that allow exploitation of new opportunities, and 3) the exposure of the system to climatic hazards. She provided global, regional (tuna fishing and 8 small Pacific island nations) and local (coral reef fishing and 10 communities in Kenya) examples of vulnerability assessments. From a living marine resources perspective, Gretta Pecl (Australia) summarized efforts taken in southeastern Australia to classify 150

species of invertebrates and fish into various risk categories (from very sensitive to insensitive) based on the potential for climate-driven changes distribution, abundance, productivity, and phenology. She also presented details on the “Redmap” (Range Extension Database and Mapping) project ([www.redmap.org.au](http://www.redmap.org.au)), an online database and mapping resource allowing the public to submit observations (including photographs) of marine species occurring outside their known distribution (*i.e.*, species that may be undergoing range shifts). Workshop participants agreed that ICES and PICES are uniquely placed to provide vulnerability assessments of climate change impacts on living marine resources. Discussions centered on the various pros and cons of performing quantitative *versus* qualitative assessments and the need to apply vulnerability, statistical and dynamic simulation modelling to the same problem when possible.

In session 6, the presentation by Motomitsu Takahashi (Japan) discussed both qualitative and quantitative methods used to provide information needed by policy makers regarding historical and projected environmental status. The presentation summarized ongoing activities in PICES [Working Group 28](#) which focuses on the development of indicators to characterize the ecosystem responses to multiple stressors, including expert elicitation using stressors-habitats matrices. Based on published scientific reports, vulnerabilities were scored as spatial scale, frequency, functional impact, resistance, recovery time and certainty and identified most influential activities/stressors in the ecosystems. In a second talk, John Pinnegar (UK) reflected upon recent experience in the UK and European Union (EU) of communicating with policy makers, members of the public and the media using two key examples. The first example was a summary of the joint UK-Ireland Marine Climate Change Impacts Partnership (MCCIP) which was formed to transfer high quality evidence on marine climate change impacts from scientists to policy advisors and decision-makers. The 2010 Annual Report Card included contributions from 100+ scientists from 40 separate institutes. A very similar Annual Report Card was produced in 2009 by scientists in Australia and, together, these assessments have elicited considerable media interest all around the world. The presentation also summarized results from the EU CLAMER (Climate Change and Marine Ecosystem Research Results) project which hired a professional polling company to conduct a quantitative survey of 10,000 citizens within 10 European countries. The survey revealed that most European citizens obtain their information about marine climate change issues via television, but they do not necessarily trust this form of media. Scientific articles in journals were used less but were the most trusted, whereas newspapers and social-media websites were the least trusted. Workshop participants highlighted the importance of clearly communicating concise and reasonably accurate advice to managers. They agreed that there is a need to develop tools that include management strategy evaluations of the implications of policies and actions on the future

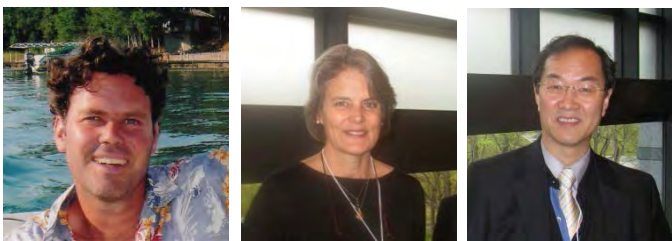
state of nature. When communicating with the public and/or policy advisors, clearly, a variety of fruitful pathways exist (from report cards and status reports to peer-reviewed publications) and evaluations that summarize suites of products for decision makers can be very effective.

Recommendations from the ICES/PICES WKSICCME-Spatial will improve methods used to assess regional and latitudinal differences in the vulnerability of species or species groups to climate change-induced shifts in ocean conditions. A series of manuscripts stemming from this workshop will form a special volume of a peer-reviewed journal, and it is hoped that a synthesis of climate-driven changes in distribution will be developed to inform future decisions regarding the governance and management of marine resources responding to changing ocean conditions.

The format of the workshop allowed ample time for discussion and debate and a considerable amount of information was exchanged within the three days. Despite the tight schedule and intense, small group discussions, workshop participants got the chance to enjoy the local sites (Fig. 3). The workshop conveners are grateful to our colleagues from the Pacific Research Institute of Fisheries and Oceanography (TINRO-Center, Vladivostok) and GOSNIORH (St. Petersburg) for taking care of all of the local arrangements (special thanks go to Ms. Tatiana Semenova, Ms. Ekaterina Kurilova and Dr. Andrey Pedchenko) as well as the PICES Secretariat for ensuring that the workshop ran smoothly. Further details regarding discussions and the keynote presentations can be found in the workshop report posted on both the ICES and [PICES](#) websites.



Fig. 3 Despite a very busy workshop schedule, participants still got to enjoy the waterfront and historical sites around St. Petersburg including an impromptu ICES-PICES-FAO bowling competition (luckily not pictured here); from left to right: Alan Haynie (USA), Cassandra de Young (FAO), Franz Mueter (USA), Myron Peck (Germany), Gretta Pecl (Australia), our helpful guide, Vladimir Kulik, Janet Nye (USA), and Mark Payne (Denmark).



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Dr. Anne B. Hollowed ([Anne.Hollowed@noaa.gov](mailto:Anne.Hollowed@noaa.gov)) is a Senior Scientist with the U.S. National Marine Fisheries Service's Alaska Fisheries Science Center. She conducts research on the effects of climate and ecosystem change on fish and fisheries and leads the Status of Stocks and Multispecies Assessment (SSMA) program (<http://www.afsc.noaa.gov/REFM/Stocks/default.php>). Anne serves as Co-Chairman of the joint PICES/ICES Section on Climate Change Effects on Marine Ecosystems. She is also a lead author of Chapter 28, Polar Regions, of the Working Group II contribution to the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Anne is an Affiliate Professor with the School of Fisheries and Aquatic Sciences at the University of Washington. She is a member of the NPFMC Scientific and Statistical Committee and the Weather, Climate and Fisheries task team of the Joint Committee for Agriculture and Meteorology (CAgM) and the Joint Technical Committee for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organization.

Dr. Suam Kim ([suamkim@pknu.ac.kr](mailto:suamkim@pknu.ac.kr)) received his B.Sc. (1976) and M.Sc. (1979) in Oceanography from Seoul National University and his Ph.D. (1987) in Fisheries Oceanography from the University of Washington. Currently, he is a Professor of the Pukyong National University, Busan, Korea. His areas of interest include fisheries ecology, especially recruitment variability focusing on early life histories of fish in relation to oceanic/climate changes. Suam has represented Korea in several international organizations and programs, such as PICES, GLOBEC, CCAMLR, IGBP, NPAFC and SCOR. He now serves as Co-Chairman of the joint PICES/ICES Section on Climate Change Effects on Marine Ecosystems.