

2010 Symposium on “Effects of Climate Change on Fish and Fisheries”

by Anne B. Hollowed, Manuel Barange, Shin-ichi Ito, Suam Kim, and Harald Loeng

The North Pacific Marine Science Organization (PICES), International Council for the Exploration of the Sea (ICES) and Food and Agriculture Organization (FAO) held an international symposium on “*Climate change effects on fish and fisheries: Forecasting impacts, assessing ecosystem responses and evaluating management strategies*” from April 26–29, 2010, in Sendai, Japan, with co-authors of this article serving as symposium convenors. Unfortunately, Drs. Manuel Barange (UK) and Harald Loeng (Norway), as well as Dr. Kenneth Drinkwater (Norway; theme session convenor), were unable to attend the meeting because of the eruption of Mount Eyjafjallajökull in Iceland. Three more (out of 23) theme session convenors were unable to participate due to unexpected illnesses. Even though these were notable absences, the symposium was still considered a grand success.

The symposium was the culmination of the planning and preparation of PICES and ICES. In recognition that climate change impacts on marine ecosystems will not be limited to one region of the globe, these two organizations formed in 2009 the first joint Working Group on *Forecasting Climate Change Impacts on Fish and Shellfish* (WG-FCCIFS). One of the priority tasks for WG-FCCIFS was to convene a symposium to provide a venue for the exchange of scientific information and the discussion of the issues and challenges related to predicting the future impacts of climate change on the world’s marine ecosystems. The symposium in Sendai was the product of this effort.

The symposium was designed to provide an opportunity for scientists and policymakers to discuss the potential impacts of climate change on marine ecosystems, and our use of the resources provided by these ecosystems. During the meeting, we considered strategies that society can take to be prepared for anticipated impacts on fish and fisheries. A key element was the desire to publish selected papers from the symposium, with sufficient time for them to be considered by review panels responsible for the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and by other review bodies, such as the Millennium Report of the United Nations Development Program.

The response to this symposium exceeded our expectations, with more than 350 abstracts submitted by scientists from over 40 countries. After the final tally, 337 scientists from 37 countries were in attendance. A total of 208 oral presentations and 105 posters were presented.

During the symposium, the global significance of the issues was highlighted in many discussions and presentations. It

was a great satisfaction for the convenors to see scientists from around the world debating the issues stemming from climate change impacts on marine ecosystems. Sound scientific advice on the expected impacts of climate change requires the international research community to work together in an interdisciplinary research setting to identify, forecast, and assess strategies to respond to the impacts of climate change on fish and fisheries. The symposium provided this type of interdisciplinary exchange of information.



President of the Fisheries Research Agency of Japan, Dr. Toshihiko Matsusato, preparing to register for the symposium.

The symposium was arranged around 10 theme sessions, with 6 workshops preceding the meeting (summary reports from 5 workshops are included elsewhere in this issue of PICES Press). These sessions and workshops encompassed a broad range of topics that provided a global perspective on climate change and the future of the world’s fish and fisheries.

Day 1 started with presentations by four plenary speakers: Drs. Kevin Trenberth (National Center for Atmospheric Research, U.S.A.), Akihiko Yatsu (Seikai National Fisheries Research Institute, Japan), Eddie Allison (WorldFish Center, Malaysia) and Ussif Rashid Sumaila (University of British Columbia, Canada).

The themes for Day 1 included:

- *Forecasting impacts: From climate to fish* (co-chaired by Kenneth Drinkwater, Harald Loeng, Franz Mueter, Carl O’Brien, Graham Philling and Yashuhiro Yamanaka);
- *Forecasting impacts: From fish to markets* (co-chaired by Manuel Barange, Jacquelynne King, Ian Perry and Adolf Kellermann);
- *Species-specific responses: Changes in growth, reproductive success, mortality, spatial distribution and adaptation* (co-chaired by Richard Beamish, Myron Peck and Motomitsu Takahashi).



Symposium in session.

The themes for Day 2 were:

- *Downscaling variables from global models* (co-chaired by Michael Foreman and Jason Holt);
- *Assessing ecosystem responses: Impacts on community structure, biodiversity, energy flow and carrying capacity* (co-chaired by Thomas Okey and Akihiko Yatsu);
- *Species-specific responses: Changes in growth, reproductive success, mortality, spatial distribution and adaptation* (continued from the previous day);

The themes for Day 3 focused on:

- *Comparing responses of climate variability among nearshore, shelf and oceanic regions* (co-chaired by Jurgen Alheit, Jae Bong Lee and Vladimir Radchenko);
- *Impacts on fisheries and coastal communities* (co-chaired by Eddie Allison, Keith Brander and Suam Kim);
- *Evaluating human responses, management strategies and economic implications* (co-chaired by Tarub Bahri, Kevern Cochrane and Jake Rice);
- *Contemporary and next generation climate and oceanographic models, technical advances and new approaches* (co-chaired by Jonathan Hare and Shin-ichi Ito).

The final half-day session on “Sustainable strategies in a warming climate” (co-chaired by Anne Hollowed and Michael Schirripa) was held in plenary. Dr. Steve Murawski provided a summary of first impressions from the symposium. He identified many issues for participants to consider (Fig. 1).

It is impossible to summarize all of the exciting outcomes and research findings that were revealed during the symposium in a short article for the PICES Press. Thus, Table 1 includes the selection of key outcomes from the plenary and theme sessions that provide a glimpse of the broad scope of issues discussed during the meeting.

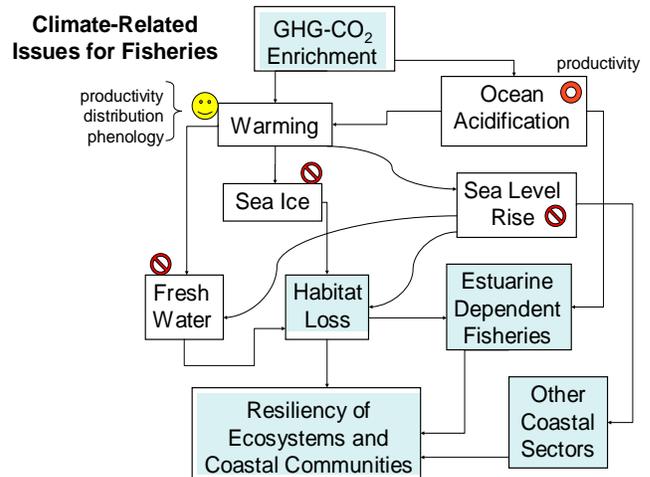


Fig. 1 Summary of climate-related issues for fisheries: smiling symbol indicates that substantial research is currently underway on this issue, open red circle indicates some research has been initiated on this subject, crossed red circles indicate that additional work is needed on this subject area (prepared by Dr. Steve Murawski).



Dr. Steve Murawski, Director of Scientific Programs and Chief Science Advisor for NOAA Fisheries, offering his impressions from the symposium.

Table 1. Summary of key outcomes from the symposium

1	Long-term ocean monitoring programs are needed to track and understand ecosystem and climate change as they occur.
2	Networks of shelf-seas ecosystem models have already been developed within several of the world's LMEs. These models provide a basis for examining structural uncertainty within shelf sea ecosystem models (Fig. 2).
3	Three sources of uncertainty in Global Ocean Models (GOMs) are under investigation: (1) parameter uncertainty, (2) structural uncertainty, and (3) scenario uncertainty. Parameter uncertainty is being addressed to some degree with sensitivity tests; structural uncertainty is being explored via comparison of different coupled physical-biological models; and scenario uncertainty related to greenhouse gas emissions and economics can only be dealt with by using ensemble model sets.
4	There are five approaches to predicting the effects of climate change on fish and fisheries: (a) conceptual predictions, (b) inferences from laboratory studies, (c) statistical downscaling from GOM to the regional scale; (d) dynamic downscaling to regional ocean models; (e) whole earth system models. Each approach has strengths and weaknesses.
5	Fisheries oceanography and laboratory studies are critical to integrating biological and oceanographic models, evaluating species environmental tolerances and adaptation, and tracking species responses to long-term ecosystem and climate change as it occurs.
6	Models that couple marine social and economic responses are needed to evaluate management strategies; however, few examples exist (Fig. 3).
7	Issues of food security and marine conservation may require new approaches to satisfy the growing demand for marine resources.
8	Two-way communication is needed between scientists and stakeholders to develop meaningful scenarios on human responses to the impact of ecosystem and climate change.

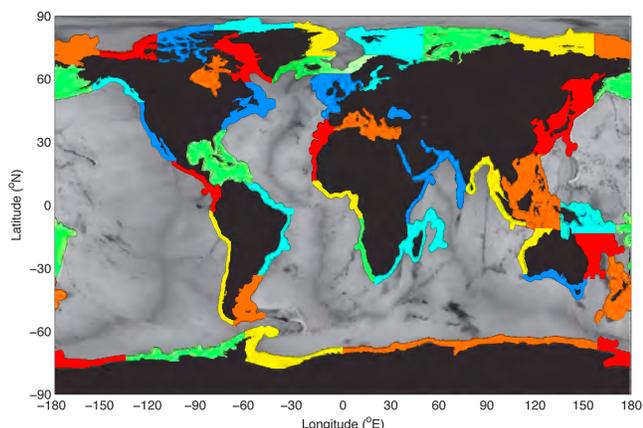


Fig. 2 The QUEST_FISH regional modeling domains (resolution 0.1 deg) defined by the 800 m contour plus 200 km of open ocean. The colors indicate that the models are regional and are only coupled through boundary conditions (Barange et al.; In: Ommer et al., Coping with climate change in marine socio-ecological systems. Blackwell FAR Series, in press).

The session on “Forecasting impacts: From climate to fish” consisted of 20 oral presentations and 19 posters, including invited talks by Drs. Kevin Trenberth, Akihiko Yatsu and Randall Peterman (Simon Fraser University, Canada). Dr. Trenberth provided an overview of the Earth’s climate system and presented unequivocal evidence that humans are warming the world’s atmosphere and oceans. He emphasized the importance of changes in the extremes rather than in mean climate states. Dr. Yatsu noted the need for interdisciplinary collaboration to incorporate the effects of climate forcing at different life stages when modeling impacts on marine fishes. Dr. Peterman

discussed the major sources of uncertainty when forecasting climate effects, highlighting the importance of structural model uncertainty, which can only be addressed by considering multiple alternative models. He emphasized that inadequate communication among scientists, decision makers, and stakeholders can be a potentially important and poorly understood source of uncertainty. A key contribution of this session was the review of a variety of frameworks and methodologies employed for forecasting the effects of climate change on fish and fisheries. The majority of papers generated quantitative forecasts of future productivity or distribution of selected species based on the output of one or more global circulation models (GCMs). Based on GCMs, the approaches can be divided into global-scale static models, global-scale dynamic models, dynamic downscaling approaches, and statistical downscaling approaches. Other approaches did not produce quantitative forecasts but aimed at predicting the likely direction of future changes under global warming based on understanding the mechanisms that relate productivity of key species to climate variability. The comparative approach was similarly employed to better understand the mechanisms that favor different species during warm and cold periods. Statistical time series analyses were used to better assess past variability in climate and biological populations as an aid in understanding future variability, but forecasting future responses based on past patterns of variability is fraught with difficulties. Finally, some presentations highlighted the importance of field and laboratory studies to help estimate vital rates for fishes, which are needed to elucidate and quantify important mechanisms and to support modeling efforts.

The session on “*Forecasting impacts: From fish to markets*” consisted of 8 oral presentations, including invited talks by Drs. Eddie Allison and Rashid Sumaila. A key outcome of this session was the recognition that climate–fish–people models are beginning to be constructed, but are still in their early stages. Simpler (statistical) models which identify present fishing habitats and use of these to project fishing locations with future climate conditions are more common, and were included as the bases in most of the presentations in this session. This type of model often uses simple parameters such as SST. Future developments are needed to incorporate at least oxygen and temperatures at depth. Models of societal responses have many uncertainties, including how information is transferred within communities, and how human behavior responds to changing pressures.

The session on “*Downscaling variables from global models*” consisted of 13 oral presentations and 1 poster, including invited talks by Drs. J. Icarus Allen (Plymouth Marine Laboratory, UK) and Muyin Wang (Joint Institute for the Study of Atmosphere and Ocean, University of Washington, U.S.A.). This session focused on the techniques for estimating and communicating uncertainty in forecasts. Dr. Wang presented a framework for selecting scenarios for the Arctic and showed the importance of using models that address seasonal changes. Dr. Allen reviewed the different sources of uncertainty in climate models and outlined methods for estimating these uncertainties. He decomposed uncertainty into three categories: parameter uncertainty, structural uncertainty, and scenario uncertainty. The first one can be addressed by series of sensitivity tests that alter parameter values through a reasonable range. The second refers to the specific nature of the model, particularly the biogeochemical component, and could be explored, for example, by coupling biological models with differing complexity to the same physical model and examining the range and accuracy of the results. In the context of climate projections, the third refers to uncertainties in greenhouse gas emissions and can only be dealt with by computing ensembles that cover a range of plausible states.

The session on “*Species-specific responses: Changes in growth, reproductive success, mortality, spatial distribution and adaptation*” consisted of 28 oral presentations and 40 posters, including invited talks by Drs. Hans-Otto Pörtner (Alfred-Wegener-Institute, Germany) and John Pinnegar (Centre for Environment, Fisheries, and Aquaculture Science, UK). This session focused on the response of key fish species and fisheries worldwide to climate change. Presentations documented historical, often long-term fluctuations in abundance and distribution, discussed processes underlying current changes, and/or projected future impacts in light of adaptive capacity using a number of approaches. The research utilized a variety of methodological approaches. Most studies included topics such as observed and/or projected changes in distribution

and/or productivity. A key outcome was the observation that quantitative evidence linking physiological responses to ecosystem change in various climate scenarios is scarce. Patterns identified in long-term field data or via macro-physiology and meta-analyses using various statistical tools are not sufficient to understand climate effects because the fundamental, underlying physical mechanisms are lacking. The session also revealed that additional research is needed to improve our understanding of the adaptive capacity of species to environmental change. Dr. Pörtner provided one example of the study type required. He reviewed the physiologically underpinnings that define tolerable marine habitats in fish and invertebrates, including expected cellular-level changes in metabolic scope via changes in oxygen and capacity-limited thermal tolerance. He also highlighted changes in ocean pH and the need to examine interactive effects of multiple stressors on vital rates.

The session on “*Assessing ecosystem responses: Impacts on community structure, biodiversity, energy flow and carrying capacity*” included 27 oral presentations and 15 posters. The invited speakers were Drs. Beth Fulton (CSIRO Marine and Atmospheric Research, Australia) and Jeffery Polovina (NOAA’s Pacific Island Fisheries Science Center, U.S.A.). This session addressed the challenges involved in assessing the effects of climate change on marine ecosystems. A key outcome was the recognition that ecosystem models have been developed for many of the shelf-sea systems around the globe, and this network of models provides a foundation for examining shifts in the boundaries and structure of marine ecosystems.

The session on “*Comparing responses to climate variability among nearshore, shelf and oceanic regions*” included 15 oral presentations and 14 posters. The invited speakers were Drs. Nicholas Dulvy (Simon Fraser University, Canada) and Svein Sundby (Institute of Marine Research, Norway). Unfortunately, Dr. Sundby was unable to attend due to the eruption of the volcano in Iceland. Dr. Dulvy discussed climate impacts on Caribbean coral reefs and North Sea fishes. He demonstrated that Caribbean coral reef cover is at an all time low, and that the associated collapse in architectural complexity has led to severe habitat loss for coral reef fishes and resulted in declines in fish abundance. Warming of the North Sea has affected fish distribution and has led to range extensions of southern and range contractions of northern species. This session provided several case studies, showing the implications of climate change on near shore and oceanic regions.

The session on “*Impacts on fisheries and coastal communities*” consisted of 13 oral presentations and 11 posters. The invited speakers were Drs. Ian Perry (Pacific Biological Station, Canada) and Tarub Bahri (Food and Agriculture Organization). Dr. Perry reviewed the bio-physical, as well as human, drivers of changes in marine social-ecological systems and noted that we need to promote capabilities for

observing, assessing, and adapting marine social-ecological systems to environmental changes to improve our ability to forecast the future impacts of climate change (Fig. 3).

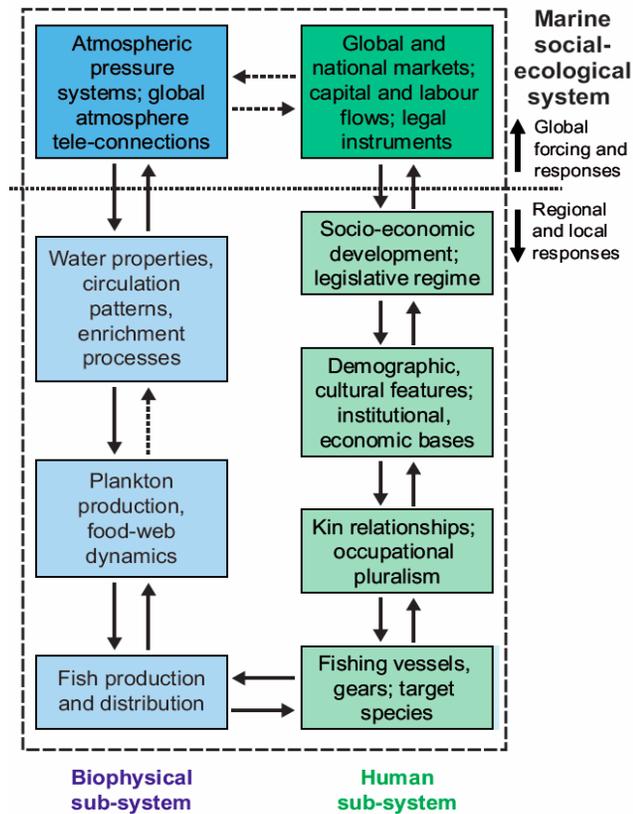


Fig. 3 Coupled marine social-ecological systems (Perry et al., 2010; In: Barange et al., *Marine ecosystems and global change*. OUP).

The session on “Evaluating human responses, management strategies and economic implications” included 13 oral presentations and 7 posters. The invited speakers were Drs. Johann Bell (Secretariat of the Pacific Community, New Caledonia) and Bonnie McCay (Rutgers University, U.S.A.). This session addressed a broad spectrum of studies that demonstrated how communities were influenced and adapted to change in the ecosystem. An important theme in many talks was underlined by Dr. McCay that despite rhetoric, people have not been treated as truly part of marine ecosystems in much research and policy.

The session on “Contemporary and next generation climate and oceanographic models, technical advances and new approaches” consisted of 13 oral presentations and 6 posters, including invited talks by Drs. Anand Gnanadesikan (NOAA’s Geophysical Fluid Dynamics Laboratory, U.S.A.) and Michio Kawamiya (JAMSTEC’s Frontier Research Center for Global Change, Japan). Dr. Kawamiya outlined the IPCC AR5 modeling plan and challenges to reduce uncertainty of future prediction, which arises from the initial condition, by applying data assimilation for the ocean part of the climate models. Dr. Gnanadesikan

showed, as an example, a state-of-the-art earth system modeling which covers from climate to biochemical systems. This session provided an overview of the new modeling approaches currently under development and many of the presentations pointed out the difficulty of evaluation of complex state-of-the-art models. Continuing efforts to develop observational networks were emphasized.

The session on “Sustainable strategies in a warming climate” consisted of 9 oral presentations and 1 poster, including invited talks by Drs. Éva Plagányi (CSIRO Marine and Atmospheric Research, Australia) and Chang- Ik Zhang (Pukyong National University, Korea). This session focused on examples of management strategies that could be applied to sustain fisheries under a changing climate and techniques for assessing and forecasting the performance of harvest policies under changing climate. A key outcome was the need for two-way communication between scientists and stakeholders to develop meaningful scenarios on human responses to the impact of ecosystem and climate change.

The poster session, held over 2 evenings in the beautiful Sakura Hall, generated a lot of interest and resulted in many fruitful interactions.



Bottom left to right: Drs. Chang-Ik Zhang, Brian Rothschild and Takashige Sugimoto.



Early career scientists, (top left) Jörn Schmidt (Germany), (top right) Mega Laksmi Syamsuddin (Indonesia), (bottom left) Felipe Hurtado-Ferro (Columbia) accepting best poster award certificates from the symposium convenors; (bottom right) Dr. Yasuhiro Yamanaka accepting a certificate for Taketo Hashioka (Japan).

Posters, prepared by early career scientists, were evaluated during the symposium for excellence, and the recipients of these awards were:

- Jörn O. Schmidt (IFM-GEOMAR, Germany) for his paper on “*The rise and fall of snake pipefish (Entelurus aequoreus L.) off North Scotland*”;
- Taketo Hashioka (JAMSTEC, Japan) for his paper on “*Potential impact of global warming on North Pacific spring blooms projected by an eddy-permitting 3-D ocean ecosystem model*”;
- Mega Laksmi Syamsuddin (Hokkaido University, Japan/Indonesia) for her paper on “*Regional climate change impacts on bigeye tuna (Thunnus obesus) catch in the Indonesian Seas*”;
- Felipe Hurtado-Ferro (University of Tokyo, Japan/Columbia) for his paper titled “*Could management react to a changing climate? The case of the Japanese small pelagic fishes*”.

During the symposium, a press interview booth was set up and selected experts had an opportunity to directly communicate their findings and thoughts at daily press conferences with the regional and national media (press and TV) on how climate change affects fish and fisheries. For the press

conferences, an English/Japanese brochure was prepared which included summaries of the experts’ presentations and selected figures. This brochure helped to encourage the communication with the public. An enlarged poster of the brochure pages was also displayed at the booth. The symposium was covered on two TV media outlets and by six newspapers.

On the day after the symposium, Drs. Anne Hollowed, Shin-ichi Ito and Akihiko Yatsu reported on the outcomes from the symposium at a public seminar held at the Sendai City Information and Industrial Plaza located next to the Sendai Station. A 4-page Japanese leaflet which contained a brief summary of the symposium was provided to the attendees. This leaflet was also distributed to policy-makers, members of Japan Fisheries Cooperatives and Japan Fisheries Industry Cooperatives.

The symposium was made possible by the hard work of the local organizers and professionals at the PICES and ICES Secretariats, by the hospitality of the people of Sendai, and by the generous financial support from our sponsors. In addition to primary international (PICES, ICES and FAO) and local (Fisheries Research Agency of Japan and Hokkaido



Drs. Akinori Takasuka (top), Michio Kawamiya (middle) and Icarus Allen (bottom) briefing reporters on science matters at a daily press conference conducted by Japanese media.



Grouped, left to right: Drs. Akihiko Yatsu, Anne Hollowed and Shin-ichi Ito describing the outcomes of the symposium to the audience at a public seminar, with moderator, Dr. Katsumi Yokouchi (far left), looking on.

University Global Center of Excellence Program) sponsors, the following agencies and organizations made financial contributions to the symposium:

- Fisheries and Oceans Canada (DFO)
- Integrated Climate System Analysis and Prediction, Germany (CLISAP)
- Intergovernmental Oceanographic Commission (IOC)
- International Pacific Halibut Commission (IPHC)
- Japan Society for the Promotion of Science (JSPS)
- Korea Ocean Research and Development Institute (KORDI)
- Australia National Climate Change Adaptation Research Facility (NCCARF)
- Japan National Institute of Environmental Studies (NIES)
- National Marine Fisheries Service of NOAA (NMFS)
- North Pacific Anadromous Fish Commission (NPAFC)
- North Pacific Research Board (NPRB)
- Pacific Salmon Foundation (PSF)
- Scientific Committee on Oceanic Research (SCOR)
- Sendai Tourism and Convention Bureau (STCB)
- World Bank (WB)



Without the funds these organizations provided, it would have been impossible to achieve the aim of convening a symposium of global scope. These funds allowed the support of 67 early career scientists and scientists from developing countries.

Immediately after the symposium, WG-FCCIFS members met to develop a report that will summarize the outcomes of the symposium. This report will be finalized over the summer and presented to ICES and PICES this fall. At this meeting, an agreement was reached to propose a Theme Session, tentatively titled “Climate change effects on fisheries: Physics-fish-markets”, to be convened at the Second PICES/ICES/IOC Symposium on “Effects of climate change on the world’s oceans”. This symposium will be held from May 14–18, 2012, in Yeosu (Korea), as one of the official events related to the World Ocean Expo-2012. If accepted, we will strive to ensure that the PICES and ICES communities remain engaged in studies on the effects of climate change on fish and fisheries well into the future.



Dr. Anne Hollowed (Anne.Hollowed@noaa.gov) is a Senior Scientist with the U.S. National Marine Fisheries Service's Alaska Fisheries Science Center. She conducts research on the effects of climate and ecosystem change on fish and fisheries and leads the Status of Stocks and Multispecies Assessment (SSMA) program (<http://www.afsc.noaa.gov/REFM/Stocks/default.php>). Anne serves as Co-Chairman of the ICES/PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish. 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 Fisheries and the Environment (FATE) Steering Committee.



Dr. Manuel Barange (m.barange@pml.ac.uk) is Director of Science at the Plymouth Marine Laboratory (UK), and Chairman of the Scientific Committee of the International Council for the Exploration of the Sea (ICES). His research interests are on the assessment of climate and anthropogenic impacts on marine ecosystems and their services, and on the interactions between natural and social sciences in fisheries, ecosystems and climate change. Manuel is the Principal Investigator of the QUEST_Fish research programme (<http://web.pml.ac.uk/quest-fish/default.htm>), and is particularly involved in the development of bioeconomic models of global fishmeal and fish oil, investigating the dual exposure of marine-based commodities to global environmental change and market developments. Until recently, he was Director of the International Project Office of the IOC-SCOR-IGBP core project GLOBEC (Global Ocean Ecosystem Dynamics). Manuel co-chairs the ICES/PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish and is a founding member of the Global Partnership for Climate, Fisheries and Aquaculture (PaCFA).



Dr. Shin-ichi Ito (goito@affrc.go.jp) is Chief Scientist of the Physical Oceanography Section at the Tohoku National Fisheries Research Institute of the Fisheries Research Agency of Japan. Shin-ichi completed his graduate work in physical oceanography at Hokkaido University and became an observational physical oceanographer at the institute. His main field is the Oyashio Current and the mixed water region. He has deployed more than 30 moorings and is handling a water glider. His research includes development of a fish growth model coupled to the lower trophic level ecosystem model NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography. For Including Saury and Herring). Shin-ichi co-chairs the ESSAS (Ecosystem Studies of Sub-Arctic Seas) Working Group on Modeling Ecosystem Response. Within PICES, he serves on the Physical Oceanography and Climate Committee (POC), FUTURE Advisory Panel on Status, Outlooks, Forecasts, and Engagement (SOFE-AP), and ICES/PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish.



Dr. Suam Kim (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. In PICES, he serves as Co-Chairman of the ICES/PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish.



Dr. Harald Loeng (harald.loeng@imr.no) has been at the Institute of Marine Science, Norway, since 1976 and has been involved mainly in projects related to physical oceanographic processes in the Northern Seas, and relations between climate and fish population parameters. Presently, Harald is responsible for the "Management and research programme on the Norwegian Sea ecosystem". He has been involved in several national and international organizations and committees. He just left the position as Chairman of the Norwegian National Polar Research Committee. Harald has been Vice-Chairman and Chairman of the Arctic Ocean Science Board and is the Norwegian member of the European Polar Board under the European Science Foundation where he is a member of the Executive Committee. Within ICES, he is chairing both the Hydrography and Oceanography Committees. He was Chairman of the Consultative Committee (2005–2008) and presently is Co-Chairman of the ICES/PICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish.