Open session

Physical, economic and societal impacts of climate change: testing common scenarios of future impact

Conveners: Myron Peck (ICES), John Pinnegar (ICES), Anne Hollowed (PICES), Shin-ichi Ito (PICES)

The primary aim of this 'open session' was to: (1) present a roadmap of activities planned in the third phase (2018-2020) of the **ICES-PICES Strategic Initiative on Climate Change Impacts on Marine Ecosystems (SICCME)**; but also (2) to discuss progress with regard to modelling activities throughout the northern hemisphere, including general updates from both ICES and PICES partners; and (3) to discuss ongoing efforts to align political, social and economic scenarios that will be used alongside trajectories of future climate change being tested in various programs around the world.

The session was well attended (40+ participants), and began with a general introduction to SICCME, its ongoing plan of activities and how this fits with both the ICES and PICES Science Plans. This introduction was delivered by Anne Hollowed (NOAA). Anne reminded participants that over its lifetime SICCME has contributed to 23 workshops in 15 Countries, and 4 continents since 2012. The strategic initiative has promoted activities focusing on: (a) shifting spatial distributions; (b) projection methods; (c) biological responses; (d) societal responses; and (e) Integration methodology.

Looking forward, between **2018 and 2020 SICCME will endeavour to**:

- Accelerate the projection modelling capability within ICES and PICES, including integration of knowledge of biological responses into coupled bio-physical models with socio-ecological coupling.
- Develop socio-ecological scenarios to evaluate the trade-offs in different management, emission, and socioeconomic pathways.
- Evaluate trade-offs in different representative fishing pathways for use in identifying robust management strategies and climate informed reference points.
- Update, deliver and maintain projections of climate change impacts on marine ecosystems and marine resource dependent communities as a resource for the global research community.
- Solicit and integrate stakeholder input to conduct climate change impact assessments under different management strategies within a multi-sector environment.
- Deliver publications to be considered by IPCC writing panels.
- Engage in outreach and communication of results.

Myron Peck (University of Hamburg) provided an overview of outputs from the ICES-PICES sponsored **"Workshop on regional climate change vulnerability assessment for the large marine ecosystems of the northern hemisphere"** (WKSICCME-CVA) held on 19 - 21st July 2017, Copenhagen. This workshop brought together considerable experience in conducting CVAs on fisheries and aquaculture systems worldwide, including 23 global case-studies (North America, Australia, Europe, west Africa) encompassing both ecological and social vulnerability components. The variety of approaches (scale, framework, data requirements) were

compared and contrasted. Work is ongoing, and the final report will be submitted by 1st October. A review paper resulting from this workshop is now planned, as well as a follow-up meeting in Washington DC (in conjunction with 4th CCEWO conference).

Ten (6 minute) 'flash' presentations were then provided in the open session, outlining **progress with regard to climate change and fisheries modelling activities (modelling 'nodes') throughout the northern hemisphere** (Europe, Canada, eastern USA, western USA, Japan) and globally (FAO and FishMIP).

John Pinnegar (Cefas, UK) provided an overview of the European Union H2020 project 'CERES' (Climate change and European aquatic RESources). CERES considers climatic impacts (past and future) on both aquaculture and fisheries, it includes work-packages focussed on bio-physical modelling, biological responses and quantifying socio-economic consequences. In the first year of the project, significant progress has been made with regard to: (1) generating outputs from the NORWECOM model for the Barents/Norwegian Sea, POLCOMS-ERSEM for the northeast Atlantic and Mediterranean, RCO-SCOBI for the Baltic Sea and E-Hype for freshwater catchments in Europe; (2) development of socio-political storylines based on the IPCC 'Shared Socio-economic Pathways (SSP) approach; and (3) a review of fish and shellfish literature (500 studies) including laboratory and field studies across Europe.

Ken Drinkwater (IMR, Norway) provided an update on various Arctic programmes focussed on climate change, these included: (1) the Resilience and Adaptation to Climate Change in Arctic marine ecosystems (RACArctic) project, involving Japan, USA and Norway and funded by the Belmont Forum; (2) the IMBeR/Future Coasts Continental Margins working group; (3) the INTAROS: Integrated Arctic Observation System, led by the Nansen Center (Norway) and including 62 institutions in Europe, North America and Asia; and (4) the INTEROS project, that is part of that EU's H2020 Arctic Blue Growth intiative.

Alain Vézina (Fisheries & Oceans, Canada) described the DFO political mandate to "Use scientific evidence and the precautionary principle, and take into account climate change, when making decisions affecting fish stocks and ecosystem management." He also described the recently completed Aquatic Climate Change Adaptation Services Program in Canada, spanning 2011-2015, and costing $16.5 million. This program had three components: (1) assessment of climate change risks and vulnerabilities in four large basins, e.g. Pacific and Atlantic; (2) research to understand the impacts of climate change; and (3) research to create applied science to adapt to climate change. A series of new projects/initiatives will hopefully begin in late-2017 with the primary aims to: (a) continue and further-develop vulnerability assessments (VA) including social and economic vulnerability of dependent communities; (b) enhance understanding of changing ocean chemistry including ocean acidification and hypoxia; (c) improve ocean/climate modelling including seasonal forecasting abilities.

Jon Hare (NOAA Fisheries, NE USA) provided an overview the Northeast Regional Climate Action Plan issued in 2016. Six projects were funded by NOAA fisheries in this region in late 2015, with a 2-3 year duration and costing ~$5 million in total. These include:

- A high-resolution physical-biological study of the Northeast U.S. shelf: Past variability and future change - Curchitser et al. (Rutgers University) [theme session presentation A:332]
- Climate velocity over the 21st century and its implications for fisheries management in the Northeast U.S. - Pinsky et al. (Rutgers University)

- Indicators of habitat change affecting three key commercial species of the U.S. Northeast Shelf: A design to facilitate proactive management in the face of climate change – Saba et al. (NOAA Fisheries) [theme session presentation A:317]
- Robust harvest strategies for responding to climate induced changes in fish productivity - Collie et al. (University of Rhode Island) [theme session presentation A:403]
- Predicting social impacts of climate change in fisheries – Scyphers et al. (Northeastern University)
- Evaluating Social-Ecological Vulnerability and Climate Adaptation Strategies for Northeast U.S. Fishing Communities - Mills et al. (Gulf of Maine Research Institute) [theme session presentation A:582]

In 2017 a further 5 projects were commissioned in the Northeast Region, costing ~$5 million in total. These include:

- Development and evaluation of a seasonal-to-interannual statistical forecasting system for oceanographic conditions and living marine resources on the Northeast U.S. Shelf (Kwon et al. Woods Hole Oceanographic Institution)
- Climate induced habitat changes in commercial fish stocks (Bell et al. - The Nature Conservancy)
- Development of Robust Management Strategies for Northeast Groundfish Fisheries in a Changing Climate (Kerr et al. – Gulf of Maine Research Institute)
- Understanding climate impacts on American shad recovery, fisheries management, and influences of dams (Stich et al - State University of New York College at Oneonta)
- Climate-fisheries dynamics: Individual-based end-to-end sea scallop model with socioeconomic feedbacks (Davis et al. - Woods Hole Oceanographic Institution).

Kathy Mills (Gulf of Maine Research Institute) presented a summary of Vulnerability assessments for Northeast U.S. fishing communities, under the auspices of the Coastal and Ocean Climate Applications Program (within the 2015 overarching NOAA program described above). Much of this work had been previously reported at the ICES-PICES vulnerability workshop in June, but also in a separate contribution to the ICES ASC on Thursday afternoon (oral presentation A:582).

Michael Jacox (University of California Santa Cruz) provided a brief summary of new work in the in the California Current ecosystem, under the wide-ranging “Coastal and Ocean Climate Applications (COCA)” program. This project will develop an end-to-end framework to identify climate-resilient management strategies for the California Current Large Marine Ecosystem and evaluate the impacts of climate change on US-managed marine species and fishing communities. A separate COCA project will focus on seasonal and decadal forecast development for multi-species pelagic longline fisheries.

Alan Hayne (NOAA, Alaska Fisheries Science Centre) provided a quick update on the Alaska Climate Integrated Modeling (ACLIM) project. This project aims to determine: (a) How and when will the Bering Sea change? and (b) Can management adapt & minimize impacts of change? ACLIM employs a diverse ensemble of different modelling approaches, ranging from simple stock assessment models, to very complex socio-ecological models (such as ATLANTIS). Recent activities have focused on visualization tools to better communicate complex model outputs, and also the derivation of socio-economic storylines based on the IPPC Shared Socioeconomic Pathways (SSPs) and complimentary with those used in CERES (see above).

Shin-ichi Ito (University of Tokyo) provided an update on climate change related initiatives in Japan under the Ministry of Agriculture, Forestry and Fisheries (MAFF). He described a sequence of Japanese projects starting in 2002 focusing on climate change impacts on fisheries and aquaculture, the most recent of which (2013-2017) focusses explicitly on the development of mitigation and adaptation technologies. Analyses were described that make use of the eNEMURO bio-physical modelling framework, including future simulations for Pacific Saury. Other ongoing climate-related projects in Japan include: (a) OMIX (2015-2020) – that will include future simulations for walleye pollock, chub mackerel, jack mackerel; (b) ArCS (2015-2020) on Arctic biodiversity; (c) GRANTARCTIC (2017-2022) on Antarctic euphausiids, mesopelagics and sea birds etc.

Hassan Moustahfid (FAO, Italy) gave a presentation communicating that SICCME had been requested to help update Fisheries and Aquaculture Technical Paper. No. 530. (2009) on "Climate change implications for fisheries and aquaculture. Overview of current knowledge and responses". An initial workshop was held in Rome, 28-29 June 2017. John Pinnegar and Myron Peck (ICES) were requested to draft the section on 'North Atlantic and Atlantic-Arctic Fisheries', Anne Hollowed, Kirstin Holsman and Shin-ichi Ito (PICES) were requested to draft the section on 'North Pacific and Pacific-Arctic Fisheries'.

William Cheung (University of British Columbia) provided an update on the Fisheries and Marine Ecosystem Model Intercomparison project (FishMIP). FishMIP comprises a global network of >30 fisheries modellers. It aims to forecast the long-term impacts of climate change on fisheries and marine ecosystems at the global scale. An ensemble of (10) different modelling approaches are used. A long-term aspiration is to also make use of shared socioeconomic pathways (SSPs) based on human population growth and GDP etc. but this has not yet been attempted.

The open session concluded with a brief discussion regarding the need to coordinate efforts across the northern hemisphere to model future climate change impacts on fisheries. Participants also discussed potential suggestions for theme sessions at the ICES and PICES Annual Science Conferences in 2018. It was agreed that the primary activity for SICCME in 2018 will be the "Fourth International Symposium on the Effects of climate change on the world's oceans" (CCEWO) in Washington D.C. (4-8th June) with the support of IOC, FAO, PICES and ICES. Most of the participants in the open suggestion suggested that they will attend this event.