Implementation Plan for Phase 3 (2018-2020)
PICES-ICES Section on Climate Change Effects on Marine Ecosystems

Vision

ICES and PICES will become the leading international organizations providing science and advice related to the effects of climate change and variability on marine resources and ecosystems.

ICES and PICES will develop the scientific basis for evaluating the vulnerability, status and sustainability of marine systems under changing climate conditions. Collaborative research within ICES and PICES will facilitate the development, maintenance and evolution of a network of regional interdisciplinary research teams that will share research approaches on a global scale to foster laboratory, field and modelling activities that will provide data and understanding at the spatial and temporal scales needed to monitor, assess and project climate change impacts on marine ecosystems.

Background

In the spring of 2011, ICES and PICES agreed to jointly develop a Science Plan to establish a PICES-ICES Section on *Climate Change Effects on Marine Ecosystems* (S-CCME, S-CCME IP). This joint expert group is known as the Strategic Initiative on Climate Change Effects on Marine Ecosystems (SICCME) within ICES. As stated in the Science Plan the goal of S-CCME is to:

  i.   Define the research activities needed to understand, assess and project climate change impacts on marine ecosystems with sufficient spatial and temporal resolution to plan strategies for sustaining the delivery of ecosystem goods and services and the preservation of biodiversity. When possible predictions should include quantifying estimations of uncertainty.

  ii. Define and quantify the vulnerability of marine ecosystems to climate change, including the cumulative impacts and synergetic effects of climate and marine resource use.

  iii. Build global ocean prediction frameworks, through international collaborations and research, building on ICES and PICES monitoring programs.

The ICES and PICES co-chairs published the Science Plan and Implementation Plan (IP) for this initiative in 2013 (Hollowed *et al*., 2013, Report of the PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Fisheries, PICES Scientific Report No. 45, Appendix 4, S-CCME IP). The S-CCME IP was designed to provide a roadmap for a long-term effort within ICES and PICES, and should be considered a guide for future research that is responsive to the changes and new science that will emerge over time. A phased implementation approach was proposed within the S-CCME IP. ICES and PICES Governing Councils recognized that the specific activities of S-CCME may change overtime. However, three activities of the S-CCME IP were expected to continue: synthesis of existing knowledge, advancement of new science and methodology, and communication of research findings.

On March 5, 2017, S-CCME members met in Victoria, British Columbia, Canada to discuss plans for Phase 3 (2018–2020). A summary of this meeting and the primary findings and outcomes are provided below. Eighteen scientists from eight member nations participated (Table 1).

Workshop participants reviewed the relationship between S-CCME and the new ICES and PICES Strategic Plans. The group recognized that PICES and ICES share many of the same goals, and the S-CCME goals are well aligned with both Strategic Plans (Table 2). S-CCME is actively integrating human dimensions into its

projections to more holistically capture the interactions occurring in marine ecosystems within the social–ecological landscape. S-CCME is building models that address the complex and dynamic aspects of evolving scientific understanding and marine policy and management. This is a core need for both PICES and ICES.

Table 1. List of workshop participants, Victoria, British Columbia, March 5, 2017.

Name	Country	Organization
Kim Huston	Canada	Department of Fisheries and Oceans
Angelica Peña	Canada	Department of Fisheries and Oceans, Institute of Ocean Sciences
Jackie King	Canada	Department of Fisheries and Oceans, Pacific Biological Station
Alex Bychov	Canada	PICES Secretariat
Hal Batchelder	Canada	PICES Secretariat
Robin Brown	Canada	PICES Secretariat
William Chung	Canada	University of British Columbia
Wojciech Wawrzynski	Denmark	ICES Secretariat
Myron Peck	Germany	University of Hamburg
Shin-ichi Ito	Japan	University of Tokyo
Suam Kim	Korea	Pukyong University
Romeo Saldívar-Lucio	Mexico	Centro de Investigaciones Biológicas del Noroeste
Svein Sundby	Norway	Institute of Marine Research
Cisco Werner	USA	NOAA Fisheries
Alan Haynie	USA	NOAA Fisheries, Alaska Fisheries Science Center
Anne Hollowed	USA	NOAA Fisheries, Alaska Fisheries Science Center
Kirstin Holsman	USA	NOAA Fisheries, Alaska Fisheries Science Center
Matthew Baker	USA	North Pacific Research Board

Table 2. Comparison of S-CCME goals with strategic goals of ICES and PICES.

ICES	PICES	S-CCME
International policy delivery	Foster collaboration among scientists and other multinational organizations	✔ Delivery of publications to be considered by IPCC writing panels. Communication of results to inter-sectoral parties through an inclusive approach.
Building a foundation of science	Understand and quantify how marine ecosystems respond to natural forcing and human activities	✔ Model development: Integration of knowledge of biological responses into coupled bio-physical models with socio-ecological coupling.
Producing the information and advice decision – makers need	Advance methods and tools. Mare ecosystem predictability associated with climate-driven processes is the foundation for providing improved advice for science-driven ecosystem-based management.	✔ Soliciting and integrating stakeholder input to conduct climate change impact assessments under different management strategies within a multi-sector environment.
Underpinning advice through data information services	Provide relevant scientific information pertinent to North Pacific ecosystems that is timely and broadly accessible.	✔ Delivery of socio-ecological scenarios for use in evaluating the trade-offs in different management, emission, and socioeconomic pathways. These scenarios can be used by the scientific community for 2nd order research.
Develop an integrated, interdisciplinary understanding of the structure, dynamics, and resilience and response of marine ecosystems to change.	Understand the status and trends, vulnerability and resilience of marine ecosystems.	✔ Promote integrated, interdisciplinary modelling teams with a focus on climate change impacts.
Understand the relationship between human activities and marine ecosystems, estimate pressures and impacts, and develop science-based, sustainable pathways	Understand and quantify how marine ecosystems respond to natural forcing and human activities.	✔ Evaluate trade-offs in different representative fishing pathways for use in identifying robust management strategies and climate informed reference points.
Evaluate and advise on options for the sustainable use and protection of marine ecosystems		✔ Deliver robust management strategies and climate informed reference points.
Catalyze best practices in marine data management, and promote the formation of data nodes as a global resource	Disseminate broadly through high quality publications, web and other electronic media and through outreach materials.	✔ 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.

S-CCME activities since 2012 reveal an impressive suite of accomplishments:

- S-CCME sponsored or contributed to 22 intersessional workshops and symposia on climate change and marine ecosystems (Table 3).
- S-CCME members convened at least one topic/theme session at every PICES or ICES annual meeting.
- S-CCME members Anne Hollowed, Svein Sundby and Sukgeun Jung served the IPCC as lead authors, several S-CCME members served as contributing authors, and several S-CCME members served as reviewers for the 5th Assessment Report (AR5).
- S-CCME members Shin-ichi Ito, William Cheung and Manuel Barange were members of the scoping panel for the IPCC Special Report on oceans and the cryosphere. Anne Hollowed is a member of the scoping panel for AR6.
- S-CCME members Manuel Barange and Jacquelynne King served as convenors of the 3rd Symposium on Effects of Climate Change on the World's Oceans in Santos, Brazil. Anne Hollowed and Shin-ichi Ito are serving as symposium convenors for the 4th Symposium on Effects of Climate Change on the World's Ocean meeting which will be held in Washington DC, USA. SICCME members also served, or are currently serving, on the Scientific Steering Committees for these two symposia.
- Several research programs focused on climate change impacts on marine ecosystems are currently funded or funding is pending (Table 2) in most of the PICES and ICES regions (Figure 1).

Review of the progress to date shows that S-CCME is well on its way towards "*Building global ocean prediction frameworks through collaborations and research*." In Phases 1 and 2, S-CCME's workshops and topic/theme sessions provided forums for the discussion of emerging methods to project and evaluate the effects of climate change on marine ecosystems. These meetings presented an opportunity for scientists to discuss key sources of scenario, parameter and structural uncertainty in coupled end-to-end social–ecological models. These accomplishments are tangible evidence of the success of the S-CCME activities and illustrate that S-CCME has been successful in forging linkages with the IPCC.

Phase 3, 2018–2020:

In Phase 3 S-CCME will conduct activities similar to those described in Phase 1 and 2, namely:

a) Recognizing that S-CCME has advanced to the point where active climate research nodes exist in most member countries, S-CCME will take a more active role in providing forums for communication and coordination between national modeling teams (Figure 1).

b) S-CCME will continue to complete ecosystem projections and evaluate outcomes based on IPCC AR5 results and explore the new CIMP6 projections when they are released in 2019.

c) S-CCME will continue to expand core research activities needed to advance the global synthesis of climate change impacts on marine ecosystems. This will be used to assess research gaps.

d) S-CCME will continue to recommend suites of topic sessions and workshops that provide a forum for the synthesis of existing projections of climate change impacts on marine ecosystems (*e.g.*, contributions to the 4th Symposium on *Effects of Climate Change on the World's Oceans*).

e) S-CCME will recommend suites of topic sessions and workshops that provide a forum for the synthesis of climate change vulnerability assessments.

f) S-CCME will encourage a further integration between the Section on *Human Dimensions* [now Human Dimensions Committee] through joint theme or topic sessions and workshops (*e.g.*, contributions to the 4th Symposium on *Effects of Climate Change on the World's Oceans* and MSEAS Symposium)

g) Publication of climate change impacts and their effects on human societies and marine ecosystems should be timed to allow their consideration by the IPCC in the formation of the AR6 report (for 2021). This effort will facilitate international collaboration and provide a mechanism for communicating our current knowledge to stakeholders and the broader scientific community.
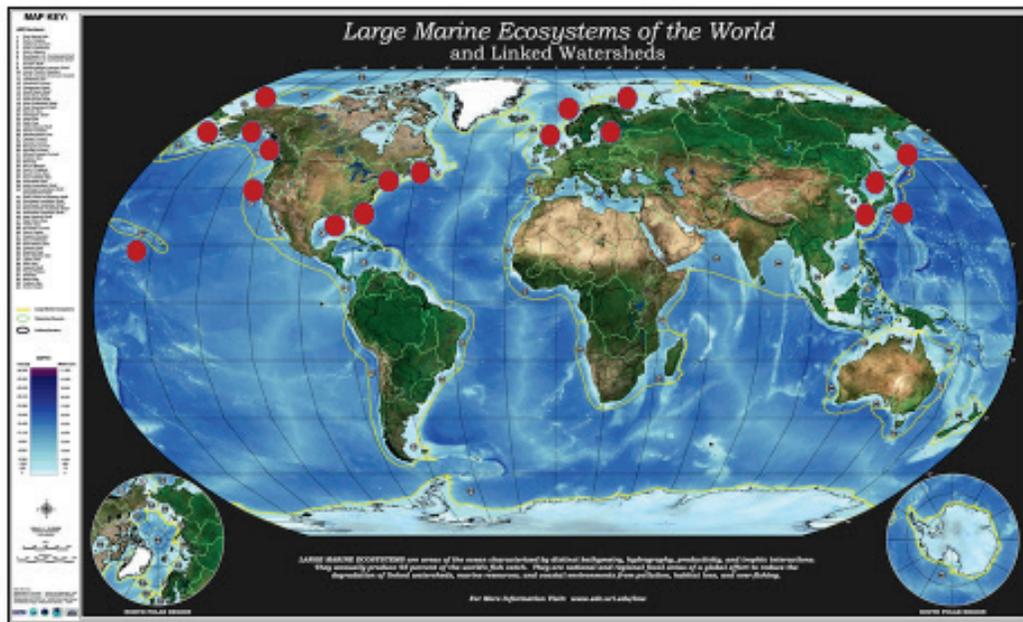
Figure 1. Large marine ecosystems of the world (solid red circles) with modelling approaches.

Workshop discussions included the following new research efforts for Phase 3.

1. Advanced science and methodology

    a. Help develop and align future scenarios to be used to explore the future cultural and social impacts of climate change on fisheries and fishery dependent communities.
    b. Work with national funding organizations to advance the mission of S-CCME
    c. Encourage and integrate S-CCME science with and between external climate assessment organizations.
    d. Promote the development of platforms that are flexible and can be used to streamline implementation of the projection modelling enterprise to facilitate the delivery of policy-relevant management advice.
    e. Promote innovation in coupled biophysical–social modelling through workshops and topic sessions. This activity would address things like the exploration of methodologies to explore the role of watersheds to ocean coupling and land–sea margins, uptake of nutrients and chemistry and other advancements in regional ocean modelling, and include bias corrections, ensemble modelling, scenarios, uncertainty, and post-normal science.
    f. Develop social science metrics jointly with PICES and ICES human dimension Committee/working groups.
    g. Explore issues of spatial resolution including two-way feedbacks between anthropogenic activities and global carbon budgets and innovations in the treatment of vertical fluxes on estimates of regional production.
    h. Improve our ability to project the synergistic impacts of climate-driven multiple stressors on marine ecosystems (linking with PICES WG 36 on *Common Ecosystem Reference Points*). Distil the most important drivers (*e.g.*, wind effects on nutrient delivery) impacting ocean systems.

    i.   Continue to advance new methods to assess and attribute climate variability (modes) from global climate change.

2. Communication and integration of science through international symposiums

    a.   Identify and recommend to ICES and PICES opportunities for joint (co-sponsored) activities with other organizations to advance the mission of S-CCME.

    b.   Training options – coursework

        i.   Call for proposals for applied work – geospatial modeling, size spectral models, EwE, Atlantis,

        ii.   Call for proposals for communicating research,

        iii.   Communicating climate impacts to the general public, NGOs and decision makers. Perhaps staged coincidentally with the release of AR6. Differences in impacts from terrestrial ecosystems and description of uncertainty,

        iv.   Training in communication of uncertainty. Distinguishing quantitative (likelihood) vs qualitative (evidence and agreement in the scientific communication) uncertainty.

    c.   Develop an external communication outreach strategy, including tools to identify products of greatest value to the public and decision makers. Expand the use of mass communication tools (e.g., pod-casts or documentaries) for education of the difficulties associated with conducting and modeling ocean systems. Perhaps engaging with the press as part of the 4th Symposium on *Effects of Climate Change on the World's Oceans*, *e.g.*, COMPASS.

    d.   Outreach – web-presence, *Effects of Climate Change on the World's Oceans* symposia; COP side meetings; workshops, *etc*.

    e.   Develop and maintain an internal and external communication strategy

        i.   Maintain website: metadata, archiving outputs, links to data delivery sites, perhaps through ClimeFish.

        ii.   S-CCME Co-Chairs will work with members to maintain relevant information (publications, logo, presentations, *etc*.)

        iii.   Encourage S-CCME members to contribute research products to a distributed database. S-CCME could establish protocols and data management policy for contributions to a shared database (explore FishMIP protocols, and Sea Around Us database).

3. Dedicated S-CCME Sessions for ICES and PICES annual meetings

In addition, S-CCME will strive to introduce training programs to support the scientists involved in providing strategic advice on climate change effects on marine ecosystems.

Conclusion

The goals and objectives of S-CCME are ambitious and will require that scientists within ICES and PICES engage in collaborative interdisciplinary research. The Implementation Plan illustrates how S-CCME will work within the ICES and PICES governance structures to accelerate advancements in our understanding of climate change effects on marine ecosystems. The plan outlines a suite of linked intersessional workshops, international symposia, and topic/theme sessions that will engage the collective knowledge and expertise of ICES and PICES scientists. By enlisting the minds and energy of scientists throughout the northern hemisphere, ICES and PICES will be able to deliver credible scientific advice regarding climate change effects on marine ecosystems in the near future.

Table 3. List of S-CCME-related climate modelling projects in northern hemisphere.

Project name	Category	Start Date	End Date	Lead PI(s)
Alaska Climate Integrated Modeling (ACLIM) Program	Management strategy evaluation - projection	9/1/2015	12/1/2017	Anne Hollowed and Kirstin Holsman
Operationalization of Alaska's Climate Integrated Modeling (ACLIM) program	Management strategy evaluation - projection	Pending	Pending	Anne Hollowed, Kirstin Holsman, Kerim Aydin
Understanding and predicting patterns in northeast Pacific groundfish species movement and spatial distribution in response to anomalously warm ocean conditions	Spatial shifts in distribution	7/1/2015	6/30/2018	Anne Hollowed, Phyllis Stabeno, Ned Cokelet, Wayne Palsson
Eastern Bering Sea Climate Vulnerability Assessment	Vulnerability assessment	12/14/2015	12/31/2017	Paul Spencer, Mark Nelson, Al Hermann, Anne Hollowed, Mike Sigler
Oceanographic monitoring in the Far-Eastern Seas	Retrospective	2007	On-going	Yury Zuenko, Alexander Figurkin, Vladimir Matveev, Elena Ustinova, Gennady Khen
Resilience and Adaptive Capacity of Arctic marine systems under a changing climate (RACArctic)	Retrospective/Outreach	6/1/2015	5/31/2018	Ken Drinkwater, Sei-Ichi Saitoh, Franz Mueter
Use of multispecies models to examine effects of fishery management strategies and climate on groundfish in the eastern Bering Sea	Management strategy evaluation - projection	2015	ongoing	Franz Mueter, Gordon Kruse
Climate Change and European Aquatic Resources (CERES)	Vulnerability assessment - Management strategy evaluation - projection	03/01/2016	02/29/2020	Myron Peck
Climate-driven Change in the Habitat Suitability of Marine Organisms (CLIMAR)	Spatial shifts in distribution	03/01/2017	02/29/2020	Myron Peck, Paolo Domenici, Daniel Fernandez, Patricio Manriquez
Oceanographic monitoring of the Northeast U.S. Continental Shelf	Climate indicators and early warning	1977	Ongoing	Paula Fratantoni et al
Evaluating Social-Ecological Vulnerability and Climate Adaptation Strategies for Northeast U.S. Fishing Communities	Vulnerability Assessment	12/14/2015	12/31/2017	Kathy Mills et al.

Robust Harvest Strategies for Responding to Climate-Induced Changes in Fish Productivity	Management strategy evaluation - projection	12/14/2015	12/31/2017	Jeremy Collie et al.
Climate Velocity Over the 21st Century and its Implications for Fisheries Management in the Northeast U.S.	Spatial shifts in distribution	12/14/2015	12/31/2017	Malign Pinsky et al.
A High-Resolution Physical-Biological Study of the Northeast U.S. Shelf: Past Variability and Future Change	Physical/chemical projections	12/14/2015	12/31/2017	Enrique Curchister et al.
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	Spatial shifts in distribution	12/14/2015	12/31/2017	Vince Saba et al.
Predicting Social Impacts of Climate Change in Fisheries	?	12/14/2015	12/31/2017	Steven Scyphers et al.
Species distribution modeling of Thorny Skate	Spatial shifts in distribution	10/1/2017	9/30/2017	Jon Hare et al.
"Blue Action: Arctic Impact on Weather and Climate" – Work package 5 "Developing and Valuing Climate Services"	Short-term projection modeling	12/1/2016	12/1/2020	Mark Payne
Using a Species Distribution Model coupled with a fisheries longline simulator to study CPUE standardization in relation to climate change	Spatial shifts in distribution	current	no end date	Michael Schirripa
Developing and testing indices of vulnerability to climate change for fishing communities	Vulnerability	pending		Kevin St. Martin, Jameal Samhouri
Modeling physics to fleet response to climate change for California fisheries	Human dimensions	pending		Michael Jacox
Vulnerability of fish and fisheries to climate change and ocean acidification	Vulnerability	pending		Isaac Kaplan
Climate change vulnerability assessment	Vulnerability	2014	2017	Karen Hunter

Cumulative impacts of climate change on life history events and production of Pacific salmon	Cumulative effects	2016	ongoing	Kim Hyatt
Vulnerability of fish and fisheries to climate change and ocean acidification	Vulnerability	2017	2021	Caihong Fu
Development of mitigation and adaptation technologies to climate change in the sectors of agriculture, forestry and fisheries II, "Evaluation of climate change impacts on fisheries and aquaculture"	Management strategy evaluation - projection	2002	2017	Shin-ichi Ito, Hideaki Kidokoro
Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX)	Physical/chemical projections	2015	2019	Shin-ichi Ito, Ichiro Yasuda
Program for Risk Information on Climate Change (SOUSEI)	Climate risk assessment	2012	2017	Michio Kawamiya, Masaaki Sumi
Integrated Climate Assessment – Risks, Uncertainties and Society (ICA-RUS)	Climate risk assessment	2012	2017	Yasuhiro Yamanaka, Shota Emori
Creating and evaluating indices of climate-induced changes in spatial distributions and predator-prey overlap for North Pacific fishery resources	Spatial shifts in distribution	2017	2019	Rebecca Selden, Steven Bograd, Kirstin Holsman, Malin Pinsky, Jameal Samhouri, Melissa Haltuch
Whale Watch - NOAA Westcoast	Short-term projection modeling	2017		Elliott Hazen and others?
Development and application of a climate enhanced multi-species stock assessment model for the Gulf of Alaska to evaluate alternative harvest strategies under climate change	Management strategy evaluation - projection	2017	2019	Kirstin Holsman, Martin Dorn, Ingrid Spies, Jim Ianelli, André Punt, Anne Hollowed, Kerim Aydin
Essential Fish Habitat projection under climate change	Spatial shifts in distribution	2016	2018	Kerim Aydin, Ivonne Ortiz, Chris Rooper, Al Hermann
Projecting climate impacts to the coastal zone in China	Physical/chemical projections	Ongoing		Qiang Liu et al. (Ocean University of China)