PICES Working Group on North Pacific Climate Variability

by Emanuele Di Lorenzo, Shoshiro Minobe, and Michael Foreman

Motivations

In recent years much progress has been made in our understanding of the large-scale physical dynamics of Pacific climate variability and change. New modes of ocean and atmospheric variability over the Pacific have been recognised and shown to influence ecosystem processes. The PICES Working Group 27 on *North Pacific Climate Variability* (http://wg27.pices.int) was established during the inter-sessional Science Board meeting in April 2011 with the goal of "*developing essential understandings of the mechanisms of North Pacific climate variability and change that can better guide the formulation of process-based hypotheses underlying the links between ecosystem dynamics and physical climate.*"

Background

At the 2009 PICES Annual Meeting on Jeju Island, Korea (October 24–25), a 2-day workshop on "*Exploring the predictability and mechanisms of Pacific low-frequency variability beyond inter-annual time scales*" was co-convened by the authors of this article. The overall goal of the workshop was to review our current understanding of the dynamics underlying low-frequency fluctuations of the Pacific and isolate potential mechanisms and linkages (*e.g.*, tropics/extra-tropics coupling, ocean/atmosphere coupling and feedbacks in the western boundary current system) that can provide the basis for low-frequency predictability. This workshop was very well attended, and during the discussion a synthesis schematic (Fig. 1) was agreed on as a starting hypothesis to investigate the dynamics linking the dominant modes of Pacific climate variability. In this schematic there are two sets of dominant dynamics in the Pacific – the El Niño Southern Oscillation (canonical ENSO) with its connections to the Aleutian Low and the Pacific Decadal Oscillation (PDO) (red path on Fig. 1), and the Central Pacific Warming (CPW) El Niño with it connections to the North Pacific Oscillation (NPO) and the North Pacific Gyre Oscillation (NPGO) (blue path on Fig. 1). These two dominant systems are physically linked and connected through ENSO in the tropics.

How are the ocean and atmosphere climate modes of the Pacific useful to understand, quantify and predict ecosystem variability?

Ecosystem studies often conduct simple correlation analyses between one or two of the climate modes (*e.g.*, ENSO, PDO) and ecosystem changes as a way to establish a link between physics and biology. However, these types of correlative analyses ignore the process dynamics that link physics and biology. During the Jeju workshop, it was recognized that there are important gaps in our understanding of the physical processes and dynamics underlying the specific climate modes. This lack of knowledge makes it hard to isolate the mechanistic links between the physical variability associated with the climate modes and the ecosystem response. To this end, WG 27 will develop quantitative approaches to evaluate the role of these ocean/atmosphere modes in explaining physical and biogeochemical climate variability in the North Pacific (*e.g.*, sea surface temperature, ocean circulation, seasonal timing, nutrient fluxes, acidification, hypoxia, upwelling and mixing), and to link this physical and biogeochemical variability to changes in the marine ecosystem.

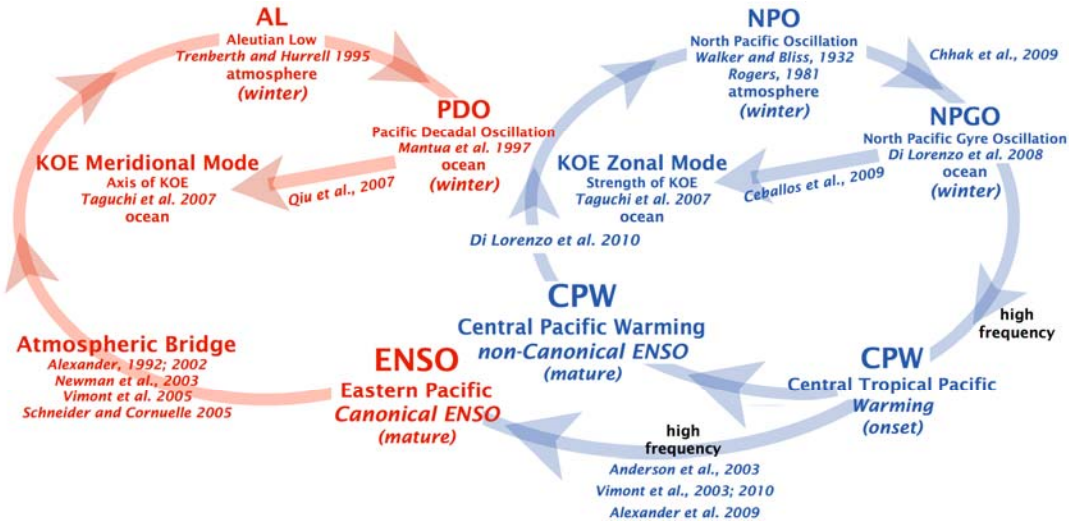

Fig. 1 Synthesis schematic of the dynamics linking the dominant ocean and atmosphere modes of Pacific climate variability.

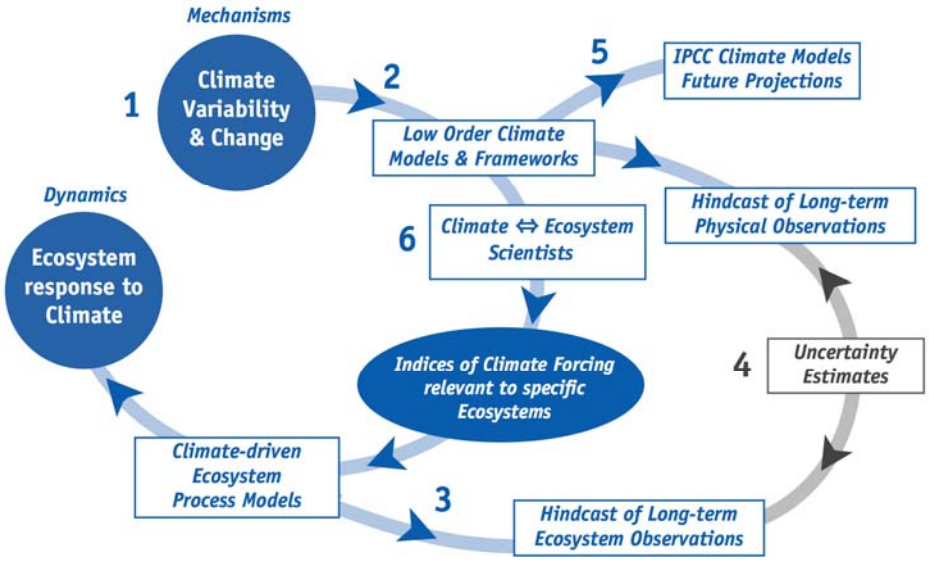

Fig. 2 WG 27 terms of reference schematics.

Terms of Reference (TOR)

The main objective of WG 27 is to improve our understanding of the mechanisms of Pacific climate variability and change to enable better diagnosing and predicting of the dynamics of marine ecosystem responses to climate forcing. In order to make the link between climate and ecosystem response, WG 27 will initially summarize the current understanding of the mechanisms of Pacific climate variability and change, and evaluate the strengths of the underlying hypotheses (*e.g.*, Fig. 1) with supporting evidence (TOR 1, Fig. 2). In particular, WG 27 will develop conceptual frameworks of Pacific climate variability and change, such as the schematic of Pacific climate variability (Fig. 1), which can serve as guidance to ecosystem scientists to better isolate and understand the essential physical processes that are relevant to specific ecosystem dynamics. Conceptual frameworks such as these will be synthesized in mathematical low-order process models of the climate system (TOR 2, Fig. 2). Low-order process models reduce the complex processes to their basic elements and dynamics and will be used to hindcast long-term physical observations. These low-order climate models will also serve as the basis for a scientific exchange between the climate and ecosystem scientists. Through this exchange, WG 27 will generate indices of climate forcing that are relevant to targeted ecosystem species in order to develop climate-driven ecosystem process models, which will be used to hindcast available long-term ecosystem observations (TOR 3, Fig. 2). This TOR 3 builds on the strengths of PICES, which provides an ideal community to use such quantitative models with long-term observations available from all PICES member countries. If these low-order process-based models of the ecosystem are successful in hindcasting available observations, we will be able to better isolate and quantify the dynamics of the ecosystem response to climate forcing (see Fig. 2).

The low-order climate models and the climate-driven ecosystem process models developed in TOR 2 and 3 will also be used statistically to provide uncertainty estimates of decadal variability in recent historical climate and ecosystem time series (TOR 4, Fig. 2). An important outcome of the development of the low-order climate models is that they provide improved metrics to test the mechanisms of climate variability and change in IPCC models (TOR 5, Fig. 2). The evaluation of the IPCC model is an activity that the PICES WG 20 on *Evaluations of Climate Change Projections* has conducted over the last three years. Although WG 27 will not directly evaluate the IPCC models, it will work in coordination with other PICES expert groups and FUTURE Advisory Panels to assist in evaluating those models and providing regional climate forecasts over the North Pacific.

The success of WG 27 relies on an active and efficient exchange between the climate and ecosystem scientists, which will allow the PICES community to understand and fill the gaps between what physical models can currently produce and what ecosystem scientists suggest are the important physical forcing factors required for predicting species and ecosystem responses to climate variability and change (TOR 6, Fig. 2).

Activities in 2011 and 2012

WG 27 has an ambitious working plan that will require coordination and planning among all group members, and with members of other PICES expert groups (*e.g.*, WG 28 on *Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors*), and joint activities with ICES. Although WG 27 had its first official business meeting only in October of 2011 (see below), several activities that advance WG 27 terms of reference have been planned for 2012. Below is a short overview.

Participants of the WG 27 meeting at PICES-2011 (Khabarovsk, Russia). Indicated by green, blue and red arrows are WG 27 Co-Chairmen and co-authors of this article, Drs. Shoshiro Minobe, Michael Foreman and Emanuele Di Lorenzo.

WG 27 had its first meeting on October 15, 2011, at the 2011 PICES Annual Meeting in Khabarovsk (Russia). Despite relatively short notice of this very first meeting, Working Group members showed their great enthusiasm, as 16 out of 19 members attended. After reviewing the terms of reference and the presentations from the members, it was decided that WG 27 would begin producing a simple mathematical framework or simple model to capture and quantify the known mechanisms of Pacific climate variability (Fig. 1), and that this model would be used to re-interpret an ecosystem dataset, such as the one used in Hare and Mantua (2000), in light of the recent advances in our understanding of Pacific climate variability. WG 27 will also establish a connection with the new PICES Section on *Climate Change Effects on Marine Ecosystems* (S-CCME) as a way to facilitate the exchange between ecosystem and climate scientists.

During the 2012 PICES Annual Meeting in Hiroshima (Japan), WG 27 will convene a Topic Session on "*Challenges in understanding Northern Hemisphere ocean climate variability and change*". Through collaboration between PICES, CLIVAR and ICES, this session invites contributions exploring important developments in the research field of North Pacific climate variability and change, including physical environmental variations and their predictability, teleconnection dynamics between oceanic basins, such as the Pacific and Atlantic Oceans, and linkages between physical conditions and marine ecosystems. The session also aims at bringing together climate and physical oceanography researchers with marine ecosystem scientists to share ideas about what physical parameters and processes are important in understanding and predicting the response of specific marine ecosystems to climate forcing.

In the summer of 2012, WG 27 is planning a 3-day workshop on "*Forecasting ecosystem indicators with climate-driven process models*", co-sponsored by U.S. GLOBEC, PICES and ICES, to be held in Friday Harbor (WA, U.S.A.). The goal of this workshop is to select a set of ecosystem indicators for both the North Pacific and North Atlantic large marine ecosystems and implement, through an interaction between physical/climate scientists and marine biologists, four examples of climate-driven process-based models that forecast ecosystem indicators. On Day 1, we will have a plenary session with review talks on (1) known physical mechanisms of variability in the North Pacific and North Atlantic, (2) the targeted ecosystem indicators, and (3) existing attempts to model the indicators. In the afternoon of Day 1 and the entire Day 2, four break-out groups will implement and test prototypes of climate-driven process models to hindcast and forecast the targeted indicators. On Day 3, the break-out groups will reconvene to present and discuss their findings, and plan future directions of research.

Dr. Emanuele (Manu) Di Lorenzo (edl@gatech.edu) is an Associate Professor at the School of Earth and Atmospheric Sciences, Georgia Institute of Technology, U.S.A. His research interests and experience span a wide range of topics from physical oceanography to ocean climate and marine ecosystems. More specific focus is on dynamics of basin and regional ocean circulation, inverse modeling, Pacific low-frequency variability, and impacts of large-scale climate variability on marine ecosystem dynamics. In PICES, he is Co-Chairman of the Working Group on North Pacific Climate Variability (WG 27) and a member of the FUTURE Advisory Panel on Climate, Oceanographic Variability and Ecosystems. He also serves on the U.S. Comparative Analysis of Marine Ecosystem Organization (CAMEO) Science Steering Committee.

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 Implementation Plan Writing Team for the PICES scientific program, FUTURE, and now co-chairs the Working Group on North Pacific Climate Variability (WG 27).

Dr. Michael (Mike) Foreman (mike.foreman@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences in Sidney, British Columbia. His primary research interests are coastal modelling and climate change. Mike is a former Chairman of the Physical Oceanography and Climate Committee and Co-Chairman of the Working Group on Evaluations of Climate Change Projections (WG 20). In addition to WG 27, is also a member of the new Working Group on Regional Climate Modeling (WG 29).