Working Group 27 on *North Pacific Climate Variability and Change*

The 2012 business meeting of the Working Group on *North Pacific Climate Variability and Change* (WG 27) was held October 12, 2012 in Hiroshima, Japan, under the chairmanship of Drs. Shoshiro Minobe (Japan), Emanuele Di Lorenzo (USA), and Michael Foreman (Canada). The meeting was well attended (*WG 27 Endnote 1*) by the members and by two graduate students (Yohei Takano and Andrew Davis) who gave talks at the PICES POC Paper Session and POC-sponsored Topic Session (S3). Unfortunately, Korean and Chinese members did not attend.

AGENDA ITEMS 2 and 3
Meeting agenda and science activities

Most of the meeting time (see *WG 27 Endnote 2*) was spent providing overviews of members' research relevant to the WG 27 terms of reference and to identifying new areas of research and joint activities that are ready for more collaboration among the members. At the end of the discussion three main themes of joint research where isolated:

1. Process modeling of large-scale ecosystem processes

During 2011 and 2012, WG 27 worked to organize large-scale datasets to update the dominant modes of biological variability in the North Pacific (*e.g.*, Dr. Nathan Mantua's talk in Topic Session S3 reported on those efforts). During 2012 we also initiated statistical analyses of the biological dominant modes and their links to climate forcing. We now plan for 2013 to develop process models that enable us to diagnose the temporal variability of the biological dominant biological modes and identify the important large-scale climate forcing functions.

Preliminary discussion with ecosystem scientists also took place to address the issue of how climate forcing may impact bio-geographic distributions important to marine (*e.g.*, fish) populations. Some contact with PICES scientists outside WG 27 provided the basis to initiate new joint research in trying to isolate bio-geographical distribution changes driven by climate forcing. (WG 27 and other PICES members directly involved: S. Minobe, E. Di Lorenzo, J. King, Y. Zuenko, S. Chiba, J. Keister, F. Mueter)

2. Mesoscale eddy dynamics, climate and ecosystems

Another scientific theme that raised significant interest among the members was understanding how climate may impact changes in the mesoscale dynamics and their associated transport processes. As a way forward, the group identified three research priorities: (A) diagnose the large-scale forcing dynamics controlling regional eddy statistics, (B) evaluate changes in the forcing dynamics predicted by IPCC climate models, and (C) link changes in eddy statistics to ecosystem processes. Some WG members showed interesting results on how climate forcing affects changes in mesoscale eddies in the California Current and Gulf of Alaska. (WG 27 members directly involved: E. Di Lorenzo, A. Davis (non-PICES member), B. Taguchi, T. Mochizuki).

3. Controls and mechanics of oxygen variability

Several members of WG 27 are currently working on understanding the dynamics controlling Pacific oxygen variability and its impacts on biogeochemical cycles. After reviewing these results, members of WG 27 will lay out a joint plan for 2013 to undertake the following tasks: (A) understand O_2 statistics by combining observations and ocean models, (B) identify the different scale-dependent regional controls on O_2 variability, and (C) develop process models to hindcast and forecast regional O_2. These activities are likely to lead to high impact scientific results and high profile publications. (WG 27 members directly involved: T. Ito, Y. Takano (non-PICES member), S. Bograd, T. Mochizuki. E. Curchister, S. Minobe and E. Di Lorenzo)

AGENDA ITEM 4
Developing synergies between PICES and CLIVAR

In the current CLIVAR Science Plan, one of the major four programs supervised by WCRP (World Climate Research Programme), which will end in 2013, is devoted to physical climate variability including the ocean. Thus, CLIVAR's focus on the ocean is mostly limited to what can be important in the atmosphere, leading to most of CLIVAR endorsed programs in the tropics and ignoring a number of processes important in marine ecosystem and biogeochemical cycles.

The new CLIVAR has been asked by WCRP to collaborate on research on green oceanography, especially with IMBER. WG 27 Co-Chair, Dr. Minobe, FUTURE's AP-COVE Chair, Dr. Hiroaki Saito, and Dr. Toshio Suga attended the 7th CLIVAR Pacific Panel meeting, April 28–29 in Noumea, New Caledonia. At this meeting they proposed that new CLIVAR should widen its scope to include marine biophysical interactions. The essence of this proposal was transferred to joint CLIVAR SSG-IMBER SSC meeting on June 13, La Paz, Mexico. The proposition was well received and the new CLIVAR Science Plan draft mentions Marine Biophysical Interactions and Dynamics of Upwelling Systems. Of course, inclusion of this is not solely due to our efforts, but the fact that the schematics produced by Dr. Minobe is used by CLIVAR SSG Co-chair, Martin Visbeck, for WCRP JSC-33 Bejing, China, in 18 July 2012, indicates that our proposal played a role.

Collaboration with CLIVAR still poses some issues because the CLIVAR Pacific Panel has been working on the tropical Pacific with a little spatial overlap with the primary region of interest to PICES. Thus, further continuous efforts from PICES are necessary. For the next step, we propose to have a joint workshop between PICES and CLIVAR Pacific Panel, with travel support for two PICES members to the workshop.

2013 CLIVAR/PICES joint workshop

The details of the workshop [later developed as a theme session on "*Biophysical interactions*" Dr. Shoshiro Minobe (Japan) as a PICES Convenor] will be held at an international symposium on "*Boundary Current dynamics: Its connection with open-ocean, coastal processes, biophysical interactions and responses to global climate change*", July 8–13, 2013, in Li Jiang, China. The following topic questions will include: What roles do western boundary currents play in biogeochemical cycles and marine ecosystems? What processes are important? How variability and change of the western boundary current influence the biogeochemical cycles and marine ecosystems. PICES endorsed the proposal and the joint session is currently being organized.

AGENDA ITEM 5
2012 ECOFOR Workshop

A jointly sponsored GLOBEC/PICES/ICES Workshop on "*Forecasting ecosystem indicators with process-based models*" (ECOFOR) took place in Friday Harbor (WA) on September 9–12, 2012. The ECOFOR workshop was attended by 28 climate and marine ecosystem scientists. The discussions were very energetic with rich scientific exchanges.

The goal of the workshop and the activities that are following within WG 27 is to move beyond the simple correlation analyses between physical and biological variability, and to identify key processes that enable us to succinctly and quantifiably model the mechanisms underlying the relationships observed in physical-biological datasets, both in the North Pacific and North Atlantic. The process models developed for this goal include as few degrees of freedom as possible (not full complexity) to sufficiently capture and test specific mechanisms of the ecosystem response to climate forcing and of the internal population dynamics. The process models are developed and tested within statistically based frameworks (*e.g.*, Bayesian hierarchical models, linear inverse models, *etc*.) that allow formal quantification of the uncertainties in historical reconstructions and future predictions of targeted ecosystem variables. Ten examples of diagnostic and predictive ecosystem process models of different degrees of complexity were presented and discussed at the workshop, and are available in the workshop report and website http://wg27.pices.int/ecofor.

These types of ecosystem process models complement full-ecosystem complex models (*e.g.*, End-To-End, Atlantis, ROMS-NPZD-NEMURO, IBM) by (1) directly testing the understanding and (2) quantifying the role of specific mechanisms underlying the physical-biological linkages. Although process models by definition do not include a complete description of ecosystem function and cannot account for the multi-dimensional interactions, they avoid magnifying uncertainty stemming from processes that are not well understood and modeled in full-ecosystem complex models.

Developing hindcast and forecast ecosystem process-based models

The goals here are to: (1) maintain and improve the collaboration and exchange between marine ecosystem scientists, physical oceanographers, and climate scientists. This dialog is the foundation for developing better and new hypotheses linking ecosystem response to climate forcing. (2) Identify and develop targeted observational and modeling datasets that are required to test the new hypotheses using the process models.

Recommendations to PICES and ICES

Discussions at the workshop led to the following recommendations:

1. *ECOFOR II*. Most of the workshop participants felt that there was a need for more time to continue the discussion. All the participants supported the idea of holding a second workshop, ECOFOR II, in 2013. Given that promoting and continuing this interdisciplinary exchange has been identified as one of the priorities in the executive summary of this workshop, and is most relevant to the activities of PICES and ICES, we recommend the two organizations support ECOFOR II through PICES WG 27 (within PICES) and by extending the mandate of WKECOFOR (within ICES).

2. *PICES Workshop 2013 and ICES Theme Session*. In order to support the main priorities isolated in the executive summary, WG 27 recommended to support an ICES theme session and a PICES workshop proposal (*WG 27 Endnote 3*) to be held at the ICES Annual Science Conference and PICES Annual Meeting in 2013, respectively, and both entitled: "*Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and "data dreams" for the future*".

This workshop addresses directly the terms of references of WG 27 (ToRs: 2, 3, 4, 6, 7, and 8; http://wg27.pices.int/tors.html) and ICES-WKECOFOR, and builds on the results from the co-sponsored GLOBEC/PICES/ICES workshop on "*Forecasting ecosystem indicators with process-based models*" (http://wg27.pices.int/ecofor) held at Friday Harbor Labs in September 2012.

These two proposals were submitted and both were accepted. They have the same focus and title in order to be able to collect inputs from both the PICES and ICES scientists on this topic.

3. *Climate forcing indicators repository*. A major challenge towards developing and testing new hypotheses of the physical-biological linkages is the need to (1) identify/develop targeted observational and modeling datasets that can be used with process models and (2) better understand the regional physical forcing dynamics associated with the large-scale climate variability and change. To this end we recommend the development of a web-based repository of relevant climate forcing indices (from observations and models) along with a comprehensive explanation of their regional impacts and dynamics. This activity is already ongoing within PICES WG 27 but may also be considered within ICES for the activities of the new joint ICES/PICES Strategic Initiative on Climate Change and Marine Ecosystems (SICCME; in PICES, it is referred to as a Section (S-CCME).

ECOFOR website, publications and PICES Press newsletter

All the material and documents of the ECOFOR workshop have been organized on the workshop website http://wg27.pices.int/ecofor/. The website also contains the presentation files and summary for each of the presenters. The website is hosted on the PICES WG 27 website (http://wg27.pices.int). We plan to keep the

ECOFOR website active and updated while we continue to engage in the post-workshop activities outlined below. A publication of the [workshop summary](#) can be found in PICES Press (2013, Vol. 21, No. 1) newsletter.

AGENDA ITEM 6
Review of Terms of Reference

1. Summarize the current understanding of mechanisms of Pacific climate variability and change, and evaluate the strengths of the underlying hypotheses with supporting evidence. (Members involved: Di Lorenzo, Taguchi, Ustinova, Minobe)

2. Develop conceptual frameworks and low-order models of North Pacific climate variability and change, which can be used by climate researchers to investigate the mechanisms of those variations and by ecosystem scientists to explore hypotheses linking ecosystem dynamics and physical climate. (Members involved: Xiaopei Lin, Soon Il, Sang-Wook, Di Lorenzo, Minobe)

3. In conjunction with ecosystem scientists, coordinate the development and implementation of process-based models, which include important processes in simple forms, to hindcast the variability of available long-term biological time series. (Members involved: Foreman, Guimei, Bograd, Ito, (Hollowed), Di Lorenzo, Curchister)

4. Develop a method to identify and provide uncertainty estimates of decadal variability in recent historical climate and ecosystem time series. (Members involved: Minobe)

5. Provide improved metrics to test the mechanisms of climate variability and change in IPCC models, and in coordination with other PICES working groups and FUTURE Advisory Panels, assist in evaluating those models and providing regional climate forecasts over the North Pacific. (Members involved: Di Lorenzo, Yeh, Jang, Guimei, Pavlova, Bograd, Mochizuki)

6. 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. (Members involved: Foreman, Guimei, Bograd, Ito, (Hollowed), Di Lorenzo, Curchitser)

7. Maintain linkages with, and summarize the results from National and International programs/projects such as CLIVAR, IMBER, US CAMEO, ESSAS, Japanese Hot Spot in the Climate System, POMAL, CREAMS EAST-I, POBEX, and others. (Most members are heavily involved in these organizations)

8. Convene workshops and sessions to evaluate and compare results and maintain an awareness of state-of-the-art advances outside the PICES community.

9. Publish a final report summarizing results.

WG-27 Endnote 1

WG 27 participation list

<u>Members</u>

Steven Bograd (USA)
Patrick Cummins (Canada)
Enrique Curchitser (USA)
Emanuele Di Lorenzo (USA, Co-Chairman)
Michael Foreman (Canada, Co-Chairman)
Shin-ichi Ito (Japan)
Taka Ito (USA)
Jacquelynne King (Canada)
Takashi Mochizuki (Japan)
Shoshiro Minobe (Japan, Co-Chairman)
Bunmei Taguchi (Japan)
Elena Ustinova (Russia)
Yury Zuenko (Russia)

WG-27 Endnote 2

WG 27 meeting agenda

1. Welcome and introductions
2. Meeting agenda
3. Science activities
4. Developing synergies between PICES and CLIVAR
5. 2012 ECOFOR Workshop
6. Review of Terms of Reference

WG-27 Endnote 3
Proposal for 1-day Workshop on *"Identifying mechanisms linking physical climate and ecosystem change: Observed indices, hypothesized processes, and "data dreams" for the future"* at PICES-2013

Climate variability and change in the ocean is now recognized as a significant driver of marine ecosystem response, from primary production to zooplankton composition, and through the trophic chain to fish, marine mammals and other top predators. Past studies have often relied upon existing datasets to draw correlative conclusions (associated with indices and discovered time-lags in the system) regarding the possible mechanisms that may control these linkages. In this workshop, we seek to identify and model key processes that enable us to succinctly and quantifiably explain the mechanisms underlying the correlative relationships in physical-biological datasets, both in the North Pacific and North Atlantic. The description and modeling of these key processes may (a) involve few or several variables (but not full complexity), (b) use dynamical (e.g. eddy-resolving ocean models, NPZ, IBM, etc.) or statistically based methods (e.g. Bayesian, linear inverse models, etc.), (c) explain variability in low or high tropic levels (although we seek to emphasize secondary and higher producers), and (d) include uncertainty estimation. We also solicit ideas and hypotheses concerning new mechanisms of physical-biological linkages that can only be tested by establishing novel long-term observational strategies, where the harvest of understanding will eventually be reaped by future generations of ocean scientists, as well as by developing creative modeling datasets, where ecosystem complexities can be effectively unraveled. The workshop format will be a mixture of talks and group discussions that aim at enriching the exchange of ideas and concepts between physical and biological

ocean scientists. The ultimate goal is to deliver (1) a set of new hypotheses of the mechanisms of marine ecosystem response to climate forcing, and (2) a description of the observational and modeling datasets required to test these hypotheses using process models.

Sponsoring Committees/Program: POC/BIO/MONITOR/FUTURE

Co-conveners: Emanuele Di Lorenzo (COVE-AP/WG 27; USA), Arthur Miller (USA), Ryan Rykaczewski (USA), Shoshiro Minobe (WG 27; Japan), Kazuaki Takadoro (Japan), Jacquelynne King (WG 27; Canada), Marc Hufnagl (ICES, Germany)

Invited Speakers: Jügen Alheit (Germany) and Carolina Parada (Chile)