Report of the APN workshop on "Climate interactions and marine ecosystems"

Francisco E. Werner, Bernard A. Megrey and Kenneth A. Rose

A workshop on "Climate interactions and marine ecosystems" was held from October 10-13, 2004, in Honolulu, Hawaii. In attendance were scientists from Canada, the People's Republic of China, the Republic of Korea, Russia, and the United States (Fig. 1). Funding for the workshop was provided by the Asia-Pacific Network for Global Change Research (APN; http://www.apn.gr.jp/) through the award "Effects of climate on the structure and function of marine food-webs and implications for marine fish production in the North Pacific Ocean and marginal seas". Additional support for some of the workshop participants was provided by PICES and GLOBEC. The workshop took place roughly midway through the APN award, and as such the goals of the workshop were to assess achievements of the working team to date and to develop plans for the remaining six months of the project.

The project's overall hypothesis is that global climate change can alter both the structure and function of the marine ecosystem, causing changes in energy cycling, plankton composition and dynamics, and ultimately fish production. The objectives of the project include:

- to use a common marine food-web and fisheries bioenergetics modeling approach, along with long-term area-specific oceanographic and fisheries data sets, to understand the propagation of climate change effects up the marine food-web;
- to quantify its effects on energy cycling and fish growth and production in distinct geographic regions in the North Pacific; and
- to initiate a discussion of how these results can be integrated into the decision and policy making process by fisheries and resource managers.

Fig. 1 APN workshop participants. Back row: Matt Foster (U.S.A.), Shin-ichi Ito (Japan), Skip McKinnell (PICES), Alexander Leonov (Russia), Bernard Megrey (U.S.A.), Chang Ik Zhang (Korea), Jacob Schweigert (Canada), Douglas Hay (Canada), David Eslinger (U.S.A.). Front row: Harold Batchelder (PICES, CCCC), Wei Hao (China), Irina Ishmukova (Russia), Michio Kishi (Japan), Kenneth Rose (U.S.A.), Francisco Werner (U.S.A.).

Using NEMURO.FISH as a modeling framework (*PICES Scientific Report* No. 20, pp. 77-176), we focused on selected sites of the North Pacific shelf and continental margin regions. With Pacific herring as the initial target fish species, the workshop sub-hypotheses and resulting action items to be undertaken over the remaining months of the project can be summarized as follows.

Hypothesis 1: geographic variations in fish growth can be explained by differences in environmental conditions and resulting differences in lower trophic conditions.

To address this hypothesis the workshop participants:

- identified locations where data sets are available for calibration of lower trophic levels (LTLs);
- cross-referenced the LTL target list with locations that may have data on Pacific herring, sardines, anchovy, mackerel and other potential target species;
- developed a strategy for analysis of these data via a coupled LTL and fish model to address the hypothesis on geographic variability; and
- agreed to compile the available datasets with final site and target species selection to be determined depending on the quality of the various data sets.

Hypothesis 2: synchronous (or asynchronous) changes in herring growth rates across locations may be accounted for by basin-wide decadal-scale changes in environmental conditions.

The workshop participants were updated on the recent efforts of the PICES Study Group on *Fisheries and Ecosystem Responses to Recent Regime Shifts* (FERRRS). In particular, our hypothesis was reinforced by FERRRS' formal recommendation that regime shifts be considered as a concept for inclusion in ecological and management practices. With full-basin scale solutions as targets for the study of regime shifts in the longer term, an agreed target for the next six months is to implement and study the response of point LTL and coupled LTL-fish models at selected sites in the North Pacific both before and after periods associated with "regime shifts". This will allow for a measure of the possible sensitivity of the models' biological parameters to the pre- and post-regime shift conditions.

Hypothesis 3: future climate/global change scenarios may affect fish production through changes in structure of the lower trophic levels.

The study of this hypothesis requires a three-dimensional basin-scale approach that, beyond simple sensitivity studies, may fall beyond the present six-month goals of the project. Preliminary results of a basin-scale approach were presented at the PICES Thirteenth Annual Meeting (following the APN workshop) and suggested that simulations of future climate change scenarios may be available in one to two years' time. At this stage however, and guided by the basin-scale model results and other sources such as the IPCC reports, it was agreed that exploratory tests could be conducted by changing bulk parameters in the point model.

An example of calibrating NEMURO.FISH to the region off the west coast of Vancouver Island (WVCI), British Columbia is given in Figures 2 and 3. First, the lower trophic level (LTL) model without fishes was calibrated to primary and secondary production data from the region (Fig. 2). Once the LTL was calibrated, then fishes were added and dynamically linked to the prey resource provided by the LTL in such a way that consumption by fishes appeared as a mortality term for the prey species. Parameters of the fish bioenergetic model were calibrated to observed Pacific herring data. These data indicate that total biomass ranges from 2-5 g wet weight/m^2 (Fig. 3, upper panel), that a 10 year-old herring is about 200 g wet weight (Fig. 3, middle panel), and that size-at-age data, expressed in g wet weight from the model compare well to observed growth and size data (Fig. 3, lower panel). Workshop participants will be actively searching for useable data sets with which to perform similar calibrations of NEMURO.FISH to other regions of interest around the Pacific Rim. We can then effectively examine large-scale ecosystem response to climate change or regime shifts once the calibrated versions of the model are in place.

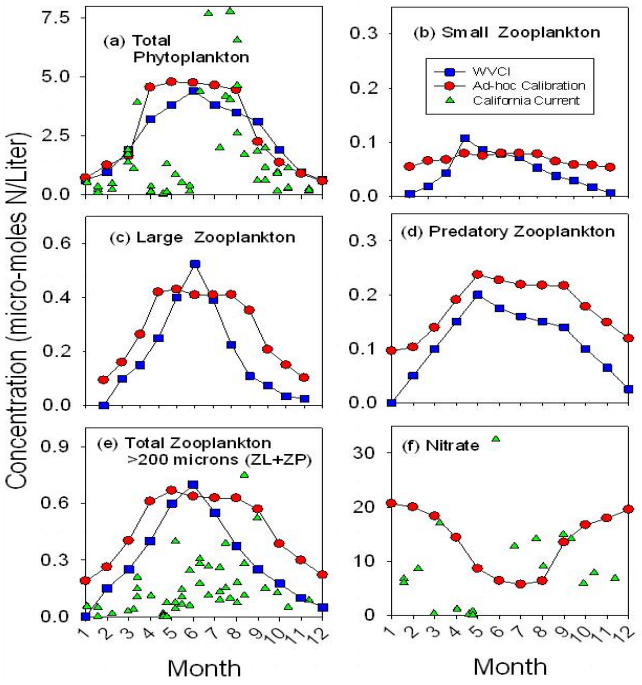

Fig. 2 Idealized coastal data set for WVCI (blue squares), field data reported for the California Current (green triangles), and model predictions from the ad-hoc calibration (red circles). Figure from Rose et al. *2004 (submitted to* Ecological Modeling*). Data from the California Current reported in Wang 1998 (Ph.D. Dissertation, University of South Alabama, Mobile) and Wainwright* et al. *(submitted to* Ecological Modeling*). Data for WVCI were assembled from a variety of sources: chlorophyll data from Richard Thomson (Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, B.C.), and zooplankton data from Stephen Romaine via the Institute of Ocean Sciences' Zooplankton Database and Donald McQueen (Aquatic Ecosystem Associates, Nanaimo, B.C.). Much of the zooplankton data reported by David Mackas* (Can. J. Fish. Aquat. Sci. *49: 903-921). WVCI calibration data was not available for nitrate. California Current data was available for total phytoplankton, total zooplankton (greater than 200 microns), and nitrate.*

The workshop's success was not only in being able to address the above scientific hypotheses, the workshop also yielded significant results and insights in the area of management – in particular as related to the communication of the present models' results to the managers – and in the area of capacity sharing.

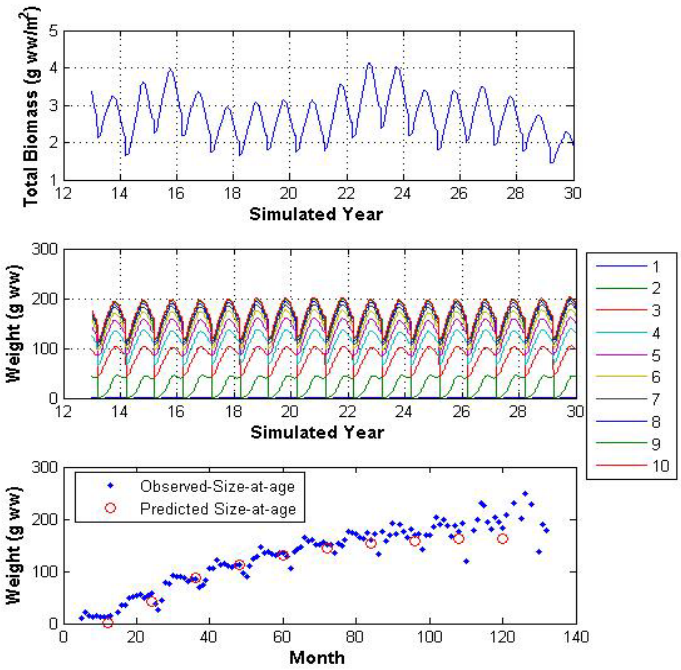

Fig. 3 Results from the calibration NEMURO.FISH to Pacific herring data (simulating 10 year classes) from the west coast of Vancouver Island, B.C. Figure from Megrey et al. 2004 (submitted to Ecological Modeling*).*

Links to management: The discussions of the relevance of the present model products to management led to the following observations: *(i)* correlations between size-at-age and fish biomass (and their fluctuations) exist; *(ii)* providing information on the size-at-age of the target fish species is a useful indicator of population health; and *(iii)* size-at-age allows us to better understand fish mortality in the context of bottom up (fishing independent) factors.

Capacity sharing: The exchange of information among the workshop participants resulted in collective gains in the following areas: *(i)* preliminary model codes were explained and distributed; *(ii)* novel quantitative methods to study model sensitivity were discussed and adopted as part of the group's approach to studies in the coming months; and *(iii)* new fish target species (*e.g.*, anchovy, sardines, etc.) were identified for future consideration and the associated data is to be made available.

Future communications: A portal will be set up to allow for ease of access of model code, data products and written material. The site will also serve as a repository of archival material.

Dr. Francisco Werner (cisco@unc.edu) is a Professor and Chairman of the Marine Sciences Department at the University of North Carolina at Chapel Hill, U.S.A., and also chairs the GLOBEC Scientific Steering Committee and the PICES MODEL Task Team. Originally from Venezuela, Cisco completed his graduate work in physical oceanography at the University of Washington in Seattle. His research includes the development of circulation of coastal ocean models and their coupling to trophodynamic inidvidual-based models of planktonic and early life stages of marine organisms.

Dr. Bernard Megrey (Bern.Megrey@noaa.gov) is a Research Fisheries Biologist with NOAA's Alaska Fisheries Science Center where he has worked since 1982. As the lead investigator for recruitment modeling studies for FOCI, he has over 20 years of experience studying dynamics of exploited North Pacific fish populations, relationships of environment to recruitment variability, and application of computer technology to fisheries research and natural resource management. His recent research has focused on developing indices of ecosystems status and health, building simulation models of marine ecosystems, and performing comparative analyses of system level characteristics of similar marine ecosystems. Bernie is a member of the PICES MODEL Task Team.

*Dr. Kenneth Rose (*karose@lsu.edu*) is a Professor with a joint appointment in the Coastal Fisheries Insitute and the Department of Oceanography and Coastal Sciences at Louisiana State University. Kenny joined the faculty of Louisiana State Unviversity in 1998, after 11 years as a research scientist at Oak Ridge National Laboratory. Kenny's research interests focus on the development and application of quantitative methods to aquatic ecosystems and fish population and community dynamics. Recent projects have centered on using individual-based and matrix projection models for fisheries management and for linking habitat quality and quantity with population health and sustainability.*