The Second Marine Ecosystem Model Inter-comparison Workshop

by Bernard Megrey, Harold Batchelder and Shin-ichi Ito

The objective of the PICES Marine Ecosystem Model Inter-comparison Project (MEMIP) is to compare the performance of various lower trophic level (LTL) marine ecosystem simulation models (Fig. 1) at predicting the abundance and distribution of coastal zooplankton functional groups. Models with high performance (*i.e*., models that show good agreement between model predictions and observational data) will be used to examine the future state of marine ecosystems, especially their responses to global climate change. Model comparisons at multiple locations will provide information on the spatial-temporal robustness of particular model structures and parameterizations. It will also help estimate the uncertainty and robustness of predictions when we examine the future responses of coastal marine ecosystems to global climate change.

The first MEMIP workshop was held at PICES-2008 in Dalian, China. The second workshop was convened on October 24–25 at PICES-2009 in Jeju, Korea. Twenty-six participants attended the meeting. The first day opened with a brief introduction by Bernard Megrey (U.S.A.) who summarized the accomplishments made in 2008 and set the goals of the workshop. Invited presentations were given by Yvette Spitz (U.S.A.), Angelica Peña (Canada) and Naoki Yoshie (Japan). Yasuhiro Yamanaka (Japan) presented an update on the goals and progress of the European MARine Ecosystem Model Intercomparison Project (MAREMIP), which is an ecosystem model inter-comparison focusing on hindcasting phytoplankton concentrations as measured by the ocean color SeaWiFS and MODIS sensors (http://lgmacweb.env.uea.ac.uk/maremip/index.shtml). The

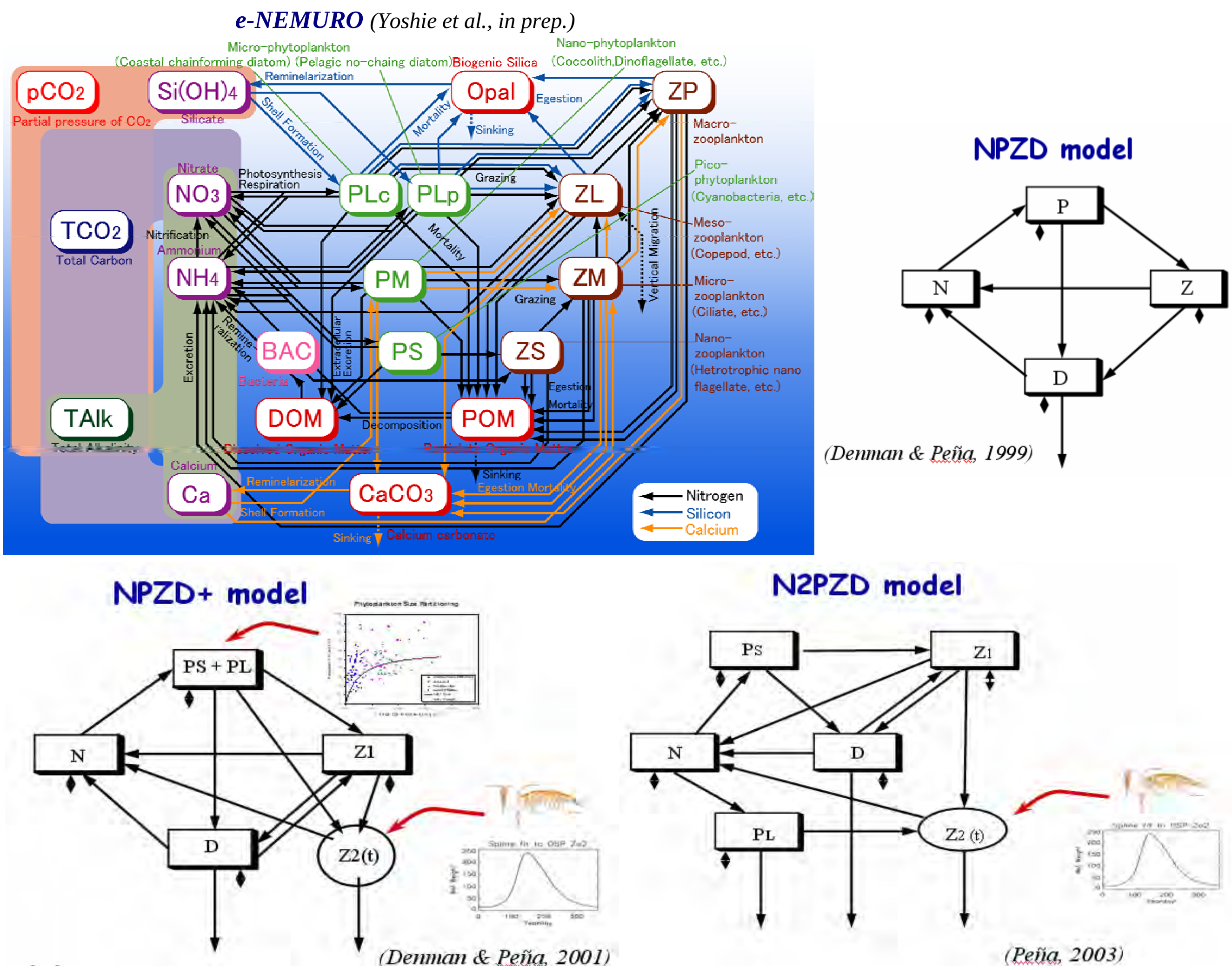

Fig. 1 Alternate representations of lower trophic level marine ecosystem models of various complexity.

Fig. 2 Maps showing the location of the three MEMIP test bed locations: the A-line off Hokkaido Island, Japan (left), the Gulf of Alaska (GAK) line off Seward Peninsula, northern Gulf of Alaska (middle), and the Newport Hydrographic (NH) line, off Oregon, U.S.A. (right).

goals of MAREMIP and MEMIP seemed complementary and not redundant or duplicative.

Three test bed locations that represented a good spatial contrast across the basin were identified for the North Pacific (Fig. 2). These locations also have exceptional data sets which allow the calibration and validation of marine ecosystem model applications. The model chosen to apply to the test locations will be a 2-dimensional Regional Ocean Modeling System (ROMS) model (transects from the nearshore to stations far from shore, and by depth) coupled with a marine ecosystem model. It was decided that this would best describe coastal upwelling regions which have strong cross-shelf gradients in nutrient supply, primary production and grazer responses. The 2-D ROMS model will not include the influence of alongshore (or 3-D) horizontal advection. The physical model framework is a compromise between what can be accomplished computationally—short of the implementation of a full 3-D ROMS model at each test bed location. The main question for the comparison is "which model representation of the lower trophic levels is the most general (*i.e.*, portable) to multiple locations within the North Pacific basin".

At the workshop, presentations were also made on the physical and biological characteristics and availability of data for all three test bed locations: for the A-line by Shin-ichi Ito (Japan), and for the GAK line and NH line by Hal Batchelder (U.S.A.). Both presentations used a predefined rubric for comparing the characteristics of the test bed locations with respect to physics, biology and available data. The difference between MEMIP and MAREMIP and other ecosystem model inter-comparison projects, such as Friedrichs *et al.* (*J. Geophys. Res.*, 2007, Vol. 112; doi: 10.1029/2006JC003852), the Ocean Carbon-cycle Model Inter-comparison Project (http://www.ipsl.jussieu.fr/OCMIP/), the Coupled Carbon Cycle Climate Model Inter-comparison Project (http://c4mip.lsce.ipsl.fr/ background.html), and the Ecosystem Model-Data Inter-comparison (http://gaim.unh.edu/Structure/Intercomparison/EMDI/index.html) is that MEMIP focuses on the consequences to secondary (zooplankton) production in coastal marine ecosystems, which is very important to the production of commercial and protected species (*e.g.*, shellfish, finfish, marine mammals). Earlier, ecosystem studies primarily focused on the response of primary producers to different marine ecosystem applications.

Extensive discussions revolved around procedures to conduct controlled execution of the ecological models at the three test locations and issues related to configuring the 2-D ROMS model for each location. Participants also discussed at length the goal of MEMIP and concluded that an assessment and comparison of the generality (portability) of several state-of-the-art ecosystem models would constitute a significant contribution to the goals of the PICES FUTURE integrative science program, and to marine pelagic ecology more generally.

There are several unique aspects of MEMIP. These include: 1) specifically looking at coastal regions of the North Pacific; 2) using zooplankton abundance and distribution as the metric of model skill; 3) providing a direct food-web link to upper trophic levels, and using model investigations as a tool to evaluate the ability of the various models to hindcast biomasses and distributions of zooplankton, in addition to nutrients and phytoplankton chlorophyll. The products of the comparison will contribute to the estimation of the uncertainty and limits of forecasting. In this context, MEMIP will contribute to FUTURE.

A current version of the ROMS model code was retrieved from the ROMS distribution site, and six marine ecosystem models of varying complexity were selected for the comparison. A list of tasks was prepared and several workshop participants agreed to take responsibility of the various identified tasks. The "active team" of this project (*i.e.*, those who agreed to volunteer their time) includes: Hal Batchelder, Shin-ichi Ito, Bernard Megrey, Yvette Spitz, Angelica Peña, Guimei Liu (China) and Naoki Yoshie. Each individual will assume responsibility for executing the marine ecosystem model to a specific test bed location and/or using a specific lower trophic level ecosystem model. A timeline was established for the completion of specific tasks and to maintain progress toward achieving the goal of MEMIP. Most of the work will occur between PICES Annual Meetings.

A proposal was prepared to hold a follow-up 2-day workshop immediately prior to the 2010 PICES Annual Meeting in Portland, U.S.A. This third workshop will be technical hands-on, and focus on parameterizing, executing and calibrating three test bed versions of biogeochemical LTL marine ecosystem models. Three to six ecosystem models will be run for each location. Specific ecosystem models (*i.e.*, NPZD, NEMURO and CoSINE) will be executed. Some ecosystem models will be tuned to hindcast data from a specific region and be tested by application to the other two North Pacific test beds. An important aspect of MEMIP is that the physical model for each test bed location will be a fixed scenario simulation, so that comparisons of ecosystem model to data, or model to model, will eliminate variability due to differently tuned physical models. Model skill will be assessed quantitatively.

In summary, MEMIP will conduct technical hands-on workshops, apply a consistent biophysical marine ecosystem model to multiple North Pacific locations, use multiple LTL ecosystem model representations, utilize a consistent ocean physics model (using a 2-D version of ROMS) at each site, use early 2000's forcing (2001–2003 in each site), provide qualitative and quantitative skill assessment concerning the models' ability to represent *in situ* data, identify mechanisms that are important controls on the level and variability of secondary production at each test bed site, and bound the levels of uncertainty in model predictions by calculating ensemble statistics. The models will be used to identify processes that are important in controlling secondary production, zooplankton biomass and variability, to bound the levels of uncertainty in model predictions, and to identify processes that are particularly sensitive to change and thereby susceptible to potential future climate variability and change. The products of the comparison will contribute to FUTURE by estimating the uncertainty and the limits of forecasting.

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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. His research involves studying the dynamics of exploited North Pacific fish populations, relationships of the environment to recruitment variability, climate impacts on marine ecosystem production, and application of computer technology to fisheries research and natural resource management. He is Co-Chairman of the ESSAS (Ecosystem Studies of Sub-Arctic Seas) Working Group on Modeling Ecosystem Response, former Co-Chairman of the PICES MODEL Task Team, and current Chairman of the PICES Technical Committee for Data Exchange (TCODE).

Dr. Harold (Hal) Batchelder (hbatchelder@coas.oregonstate.edu) is a professor of oceanography at Oregon State University. He has been the Executive Director of the U.S. GLOBEC Northeast Pacific Regional Coordinating Office since 1998. Earlier in the 1990s, Hal served for 6 years as the Scientific Director of the National U.S. GLOBEC Steering Committee Office. In PICES, he is a member of the Status, Outlooks, Forecasts and Engagement (SOFE) Advisory Panel of the Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems (FUTURE) integrative science program. Prior to that, he was Co-Chairman of the PICES Climate Change and Carrying Capacity Program. He is a zooplankton ecologist and population dynamicist, who spends more time working with models than with living (or even recently deceased) marine critters. His research uses both Lagrangian and Eulerian type models to examine the interactions of plankton populations and physical flow fields.

Dr. Shin-ichi Ito (goito@affrc.go.jp) is Chief Scientist of the Physical Oceanography Section in FRA's (Fisheries Research Agency of Japan) Tohoku National Fisheries Research Institute. Shin-ichi completed his graduate work in Theoretical Physical Oceanography at Hokkaido University and converted to an observational physical oceanographer in FRA. His research includes the development of a fish growth model coupled to the lower-trophic-level ecosystem model NEMURO.FISH (North Pacific Ecosystem Model for Understanding Regional Oceanography For including Saury and Herring). He is Co-Chairman of the ESSAS Working Group on Modeling Ecosystem Response. Within PICES, he was Co-Chairman of the MODEL Task Team and serves now as a member of the Physical Oceanography and Climate Committee (POC), FUTURE SOFE Advisory Panel and joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish (WGFCCIFS).