US GLOBEC Transitions

New projects continue to explore the links between climate and ecosystems

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As the US GLOBEC programme completes its final, pan-regional synthesis phase, new projects are emerging that will continue research efforts in the areas linking climate change and ecosystems. This article describes two such efforts that have an emphasis on modelling of coupled systems.

Attendants at the CAMEO meeting in Santa Cruz, CA, USA. From left to right: Top row: Alec McCall, Tony Koslow, Kenny Rose, Dave Checkley, Jerome Fiechter, Miguel Bernal, Chris Edwards, Enrique Curchitser and Juergen Alheit. Bottom row: Hiroshi Kuroda, Akinori Takasuka, Shin-ichi Ito, Salvador Lluch-Cota, Bern Megrey and Kate Hedstrom.

The first is an NSF and NOAA joint venture under the Comparative Analysis of Marine Ecosystem Organization (CAMEO; http://cameo.noaa.gov) programme entitled "Mechanisms for low-frequency variability of forage fish: A comparative analysis of North Pacific sardine systems". This is an international collaborative effort between scientists in the US, Mexico, Japan and Canada. The aim of this effort is to improve our understanding of the physical, biogeochemical, and biological mechanisms that cause low frequency fluctuations in small pelagic fish abundance, and their potential responses to climate change. A significant part of this effort is the development of an end-to-end, physics-to-fish-to-fishers model to investigate the effects of both climate and fishing on marine ecosystems in two regions of the North Pacific Ocean (the California and the Oyashio/Kuroshio Current systems). The project aims to demonstrate the utility of end-to-end modelling and the power of the comparative approach for understanding bottom-up and top-down controls on fish populations.

A first meeting for the project was held at the NOAA Southwest Fisheries Science Center in Santa Cruz, California in December 2009. The meeting assembled physical and biological modelers as well as fish ecologists specializing on the sardine and anchovy systems of the North Pacific. The main goal of the meeting was to bring together these modelling and observational scientists, and to devise a strategy for studying the observed low frequency fluctuations in these fish populations using the modelling tools under development. The particular approach of this effort is to couple a general circulation model with a lower trophic level community-based model together with a multi-species, full life cycle individual-based model (IBM) for the upper trophic levels. The IBM explicitly models the growth, mortality, reproduction and movement of the target fish species. A significant portion of the time was devoted to a detailed description of the model mechanics complemented by a description of the natural history and ecology of the systems. A second meeting for the group is planned for the end of 2010.

A second emerging effort, recently funded by the National Science Foundation, has at its core a multi-scale ocean model consisting of the Regional Ocean Modelling System

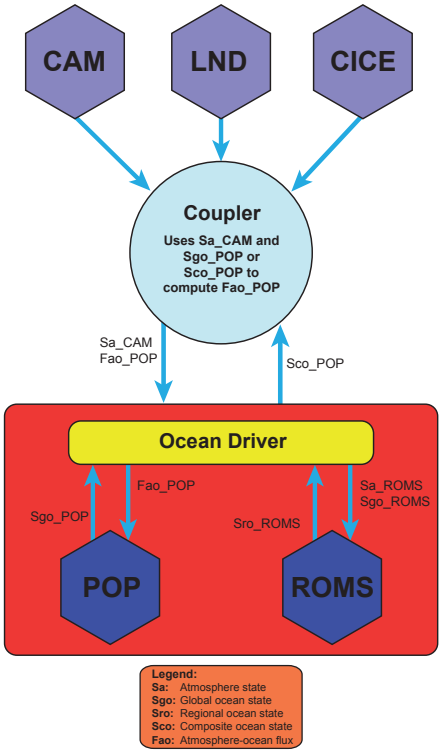

Figure 1. Schematic of the multi-scale CCSM. The original ocean module (POP) has been replaced by a composite POP/ROMS module that is controlled by a newly designed ocean driver. The Ocean driver passes fluxes and state variables to the respective oceans, controls the communications between the global and regional oceans (boundary conditions) and also assembles the output of the two oceans (e.g., SST's) that are then passed to the coupler for the computation of the fluxes to the atmosphere (CAM), Land (LND/CLM) and sea ice (CICE/CSIM) modules of the climate model.

(ROMS), a widely used regional ocean model, coupled to the Community Climate System Model (CCSM) developed and maintained at the National Center for Atmospheric Research. The project entitled "Assessing the role of eastern boundary upwelling regions and their ecosystems on climate variability using a fully coupled model" is a collaboration between Rutgers University, the National Center for Atmospheric Research, the University of Maine, the University of California at Santa Cruz and the University of Alaska at Fairbanks. Novel computational developments provide the ability to selectively increase the resolution of the ocean component of the global CCSM in desired regions while maintaining a two-way coupling between the ocean and the atmosphere (Fig. 1). These features will permit carrying out climate-scale simulations while resolving oceanic features, such as upwelling fronts, that are important for biological activity. In particular, this project will look at the physical and biological mechanisms affecting the CO_2 air-sea exchange and export in eastern boundary currents and the climate variability of these regions in the present, and under future scenarios. One of the goals of the project is to not only downscale climate to regional domains, but also to study the effects of up-scaling features that can only be resolved with locally high resolution on the global climate system.

Though these two projects are by no means an exhaustive list of projects or approaches to coupled bio-physical modelling, they are illustrative of some of the directions being pursued.