Coastal Ocean Advances in Shelf Transport (COAST)

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A cooperative effort between scientists at Oregon State University, the University of North Carolina and the Lamont-Doherty Earth Observatory is investigating cross-shelf transport processes in the wind-driven system off Oregon. Since our first field effort is scheduled for 2001, we have spent much of this year doing continued ocean circulation, ecosystem and atmospheric modeling, analyzing existing data sets and preparing instrumentation for use during next spring and summer. In order to optimize sampling during 2001, we have been analyzing data from the 1999 NOPP-sponsored and 2000 GLOBEC-sponsored field programs off Oregon. In addition, a comparison between satellite scatterometer measured winds and atmospheric model winds has been very enlightening regarding the temporal and spatial scales of the atmospheric forcing off the northwest coast.

We have successfully scheduled two research vessels for both a May-June early-upwelling study and an August mature-upwelling study. Scientists aboard the R/V Wecoma will conduct high-spatial resolution mapping in coordination with those on the R/V Thomas Thompson who will conduct vertical profiling of physical and biological parameters. A test cruise for a new fiber-optic tow cable system which will allow high-data rate instruments (e.g., bio-optical, microstructure) to be flown aboard the undulating vehicle SeaSoar is scheduled aboard R/V Wecoma for January 2001. A second test cruise aboard the R/V Thompson will test a new high-speed vertical pumped profiler system in March 2001. This cruise will also be used to work out a sampling protocol for simultaneous use of the pumped profiler and a microstructure profiler so that the turbulent flux of nutrients and carbonate species may be estimated. Coordination of the aircraft overflights with ship activities is underway and a hyper-spectral ocean color radiometer is being added to the airborne instrument suite. Lastly, effort has been spent on designing the mooring array, including purchasing physical and bio-optical sensors, which will be deployed in mid-May 2001.

To model the upwelling response of the ecosystem off the Oregon coast and address the hypotheses of COAST (CoOP Newsletter, December 1999), we first have to select an appropriate ecosystem model. While similar in structure (e.g. nitrogen budget), the ecosystem models can vary greatly in their complexity and the parameterization of the processes that they include. We compared the behavior of three ecosystem models. The first ecosystem model has three-components (nitrogen-phytoplankton-zooplankton) as in Franks et al. (1986). The second has four- components (nitrogen-detritus-phytoplankton-zooplankton) and is based on Denman and Peña (1999). The third, five-component model (Wroblewski, 1977), is similar to the second except that the nitrogen pool is divided into nitrate and ammonium components. The parameterization of the various processes is identical in all three models (e.g, Ivlev formulation for grazing, linear mortality, Michaelis-Menten uptake) and the parameters are chosen to give equivalent steady state solutions for an unforced one-dimensional application.

These three models are first run in wind-forced, one-dimensional experiments with observed winds from July-August 1973 (Figure1). Comparisons of the model results reveal that it is necessary to have vertical transport due to sinking so that nutrients do not accumulate in the surface layer. For the four- and five-component models, sinking is naturally implemented in the equation for detritus. For the three-component model, it is possible to sink phytoplankton to remove nitrogen from the surface layer, but it is not clear how to choose objectively the sinking rate to mimic the combined effect of sinking and remineralization of detritus that is included in the other two models. In the subsequent two-dimensional model runs, we selected the vertical sinking rate for phytoplankton that leads to the same phytoplankton concentration in the upper 30m in these one-dimensional experiments.

The three models were then coupled to a two-dimensional circulation model (Allen et al., 1995; Federiuk and Allen, 1995) and started with equivalent initial conditions obtained from the wind-forced one-dimensional runs. The model domain is 200 km wide and bounded by a solid wall at the coast and offshore. The shelf and slope topography represent the Oregon shelf at 45º 15' N with a minimum depth of 10 m at the coast and an offshore maximum depth of 500 m. The grid spacing is uniform with 60 vertical sigma levels and a horizontal resolution of 250 m. We find that the general spatial patterns of the mean (Figure 2) and rms concentration fields are similar for the three models. Zooplankton biomass is at a maximum just offshore of the upwelling jet while the maximum phytoplankton is located inshore of the upwelling jet. The magnitudes of the comparable variables of the three-component model can differ appreciably from those of the four- and five-component models, however, depending on the specified sinking rate of the phytoplankton. The effects of variable shelf topography on the across-shelf transport of primary production, on the nearshore retention of phytoplankton and on the alongshore variations of biomass are currently under study using a three-dimensional coupled ecosystem and ocean circulation model.

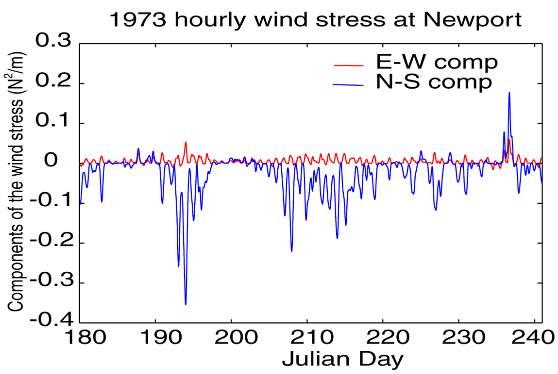

Figure 1. Hourly wind stress components at Newport between June 29 and August 29, 1973. Negative N-S wind stress corresponds to upwelling favorable winds.

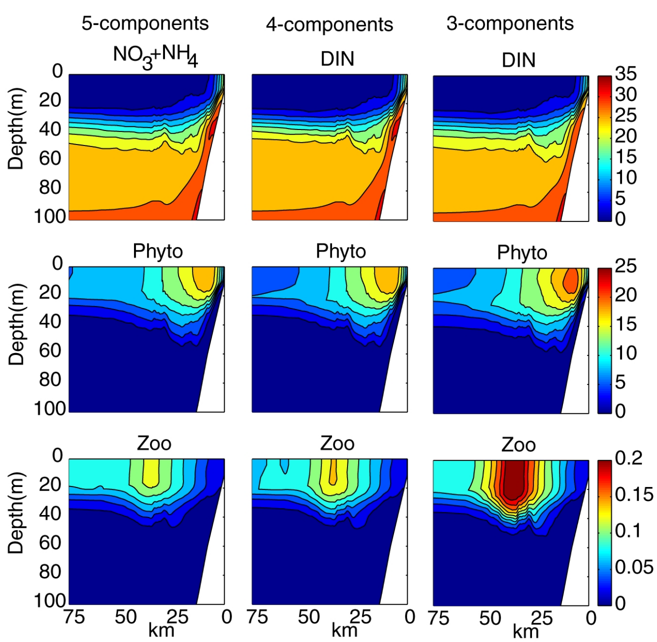

Figure 2. Time mean dissolved inorganic nitrogen, phytoplankton and zooplankton (color contours, mmol N m^{-3}) for the three-, four- and five-components ecosystem models when coupled to a two-dimensional circulation model. Spitz et al., ms. in preparation.

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