Biological Responses to Intensified Upwelling and to the Pearl River Plume in the Northeastern South China Sea

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A coupled three-dimensional physical model and a nitrogen-based NPZD (dissolved inorganic nitrogen, phytoplankton, zooplankton, and detritus) ecosystem model was used to study the ecosystem responses to the wind-driven summer upwelling and to Pearl River plume over a distinctly widened shelf in the northeastern South China Sea (NSCS). Forced with an idealized, but representative upwelling-favorable wind and the river discharge for the purpose of process-oriented study, we identified two high chlorophyll-centers which are typically observed over the NSCS shelf and stimulated by nutrient enrichment from intensified upwelling over the widened shelf and from the river plume. The nutrient enrichment has strong along-shore variability involving the variable cross-isobath nutrient transport between the middle and the inner widened shelf during the upwelling and an eastward expansion of the nutrient-rich plume. About 20% of the upwelled nutrient-rich deep water from the outer shelf reaches the inner shelf where biological blooms occur. Nutrient enrichment in the plume stretches over a broad extent of the shelf and produces significant biomass on the NSCS shelf. The plume is physically governed by intensified surface Ekman dynamics that leads to a strong offshore nutrient transport and eventually offsets the shoreward transport caused by the upwelling in the NSCS. Biological forcing and circulation dynamics of the surface Ekman layer jointly form the spatial dislocation and temporal variation of NO_3, phytoplankton and zooplankton biomasses in the upwelled and plume waters. The simulated results qualitatively resemble field and satellite measurements and demonstrate the physically modulated biological responses to the intensified upwelling and plume-influenced NSCS shelf.