Plankton ecosystem dynamics in eddies in the California Current System

The California Current System (CCS) is an eastern boundary upwelling system characterized by high biological production along the coast contrasted with oligotrophic offshore waters, creating a cross-shore gradients of biological and physical properties. This cross-shore gradients are affected by intense mesoscale eddy activity that modulates and exports biological production from the coastal upwelling system, entraining and redistributing nearshore nutrients and associated planktonic organisms. High planktonic biomass can be found in these eddies months after detaching from the coast. The mechanisms driving these patterns, and their ecological impacts in EBUSs are still in debate.

First, to characterize and quantify the ability of mesoscale eddies to affect the local and regional planktonic ecosystem of the CCS, we analyzed a 10-year-long physical-biological model simulation (ROMS-NEMURO, at 5 km horizontal resolution), using eddy detection and tracking to isolate the dynamics of cyclonic and anticyclonic eddies. Using a composite analysis of thousands of detected eddies, we found that as they propagate westward across the shelf, cyclonic eddies efficiently transport coastal planktonic organisms, and maintain locally elevated production for up to one year (800 km offshore). Anticyclonic eddies, on the other hand, have a limited impact on local production over their ~6 month lifetime as they propagate 400 km offshore. At any given time ~8% of the model domain was covered by eddy cores. Though the eddies cover a small area, they explain ~50 and 20% of the transport of nitrate and plankton, respectively.

Then, to elucidate the mechanisms that influence the dynamics of ecosystems trapped in eddies, and the relative contribution of horizontal and vertical advection in determining local production, we analyze one single cyclonic eddy from our model simulation, using Lagrangian particle-tracking analyses. The eddy formed in a coastal upwelling system, and sustained enhanced biological production within its core for several months. Coastal waters trapped in the eddy enabled it to leave the upwelling region with high concentrations of plankton and nutrients. We highlight the role of this eddy in altering local planktonic ecosystem dynamics, and contrast those dynamics with the coastal upwelling source waters, and the waters surrounding the eddy. We conclude that cyclonic eddies play a key role for biological production in the CCS: they contribute both to the redistribution of the coastal upwelling ecosystem and are local spots of new production. Together, these processes impact cross-shore gradients of important biological properties.

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