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Coastal eutrophication drives acidification, oxygen loss, and ecosystem change in a major oceanic upwelling system

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ABSTRACT

Global change is leading to warming, acidification, and oxygen loss in the ocean. In the Southern California Bight, an eastern boundary upwelling system, these stressors are exacerbated by the localized discharge of anthropogenically enhanced nutrients from a coastal population of 23 million people. Here, we use simulations with a high-resolution, physical–biogeochemical model to quantify the link between terrestrial and atmospheric nutrients, organic matter, and carbon inputs and biogeochemical change in the coastal waters of the Southern California Bight. The model is forced by large-scale climatic drivers and a reconstruction of local inputs via rivers, wastewater outfalls, and atmospheric deposition; it captures the fine scales of ocean circulation along the shelf; and it is validated against a large collection of physical and biogeochemical observations. Local land-based and atmospheric inputs, enhanced by anthropogenic sources, drive a 79% increase in phytoplankton biomass, a 23% increase in primary production, and a nearly 44% increase in subsurface respiration rates along the coast in summer, reshaping the biogeochemistry of the Southern California Bight. Seasonal reductions in subsurface oxygen, pH, and aragonite saturation state, by up to 50 mmol m^{-3}, 0.09, and 0.47, respectively, rival or exceed the global open-ocean oxygen loss and acidification since the preindustrial period. The biological effects of these changes on local fisheries, proliferation of harmful algal blooms, water clarity, and submerged aquatic vegetation have yet to be fully explored.