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Interannual variability of biological production and carbon export in the California Current System from 1979 to 2016

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As an eastern boundary upwelling system, the California Current System (CalCS) belongs to those highly productive oceanic environments that sustain a complex ecosystem structure and food supply chains of high economic values. The intense coastal biogeochemical cycling of carbon and nutrients inherent in the CalCS experiences substantial year-to-year variability, most of which is associated with El Niño-Southern Oscillation (ENSO). Here, we assess the response of the coastal cycling of carbon and nutrients to ENSO within the CalCS between 1979 and 2016 based on a high-resolution modeling study. We use the Regional Oceanic Modeling System coupled to a biogeochemical/ecological model with three plankton functional types. Our basin-scale model setup with substantial grid refinement toward coastal regions facilitates an investigation of the complex coastal dynamics while still permitting large-scale connectivity to the tropical Pacific, where ENSO is originating. Our findings underpin the substantial changes in nutrient supply, biological production and carbon export associated with ENSO. Composite means based on all El Niño events falling into the analysis period reveal strong reductions in the upwelling of inorganic nutrients to the coastal euphotic zone (-30%) and a subsequent drop in coastal production (-35%) along central California, consistent with in situ observations for the major events. These changes in nutrient supply and production translate into changes in the redistribution of organic and inorganic matter. In response to the lower production during El Niño events, vertical export (-30%) and offshore transport of organic carbon from coastal to open ocean regions are strongly reduced (-40%) as well. This is essentially a result of the strong decrease in production that is mainly confined to the coastal ocean, but effectively communicates ENSO induced changes along the coast to regions beyond the upwelling front. Reflecting the coastal El Niño response, water masses characterized by negative anomalies of inorganic nutrient and organic carbon concentrations thus reach offshore regions up to 500km from the coast with several months delay. During La Niña conditions, the observed tendencies are reversed with similar magnitudes. ENSO induced modifications within the upwelling region thus not only pertain to the magnitude of coastal production (which has profound implications for ocean management). They also have repercussions for ecosystems of adjacent waters, whose metabolism is partly supported by the offshore transport of carbon and nutrients from the coastal region.