

Regional deoxygenation events in the Northern Humboldt Current System during the late nineteenth century

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In the Northern Humboldt Current System, at interannual timescales, La Niña (El Niño) conditions promote the reduction (increase) in subsurface oxygen content, primarily due to the shoaling (deepening) of the thermocline across the Equatorial Pacific and the corresponding decrease (increased) in oxygen supply to the region via eastward equatorial currents. Nevertheless, on a yearly basis, enhanced subsurface oxygen depletion nearshore occurs during summer, when alongshore winds weaken and primary productivity is higher, as well as in spring, when coastal upwelling intensifies. Sedimentary multiproxy records including $\delta^{15}\text{N}$ in the sedimentary organic matter, redox-sensitive metals, diatom valve composition and dinocysts and high-resolution alkenone-derived near sea surface temperatures, reveal at least three regional-scale deoxygenation events in the coastal waters off Central-Southern Peru between 1860 and 1890. These regional events were associated with massive diatom-rich fluxes. To elucidate the drivers and mechanisms operating at interannual and intra-annual timescales, we compared the proxy records with re-analysis data of SST (HadISST) and other climatic records and indices. Except for two large El Niño events, the 1860 - 1890 period was characterized by La Niña-like and neutral conditions in the Central Pacific, along with variable regional Sea surface temperature (SST) in the Tropical Southeast Pacific, particularly sub annual warm events. Prevailing La Niña-like conditions may have contributed to thermocline/oxycline shoaling off Peru and northern Chile. During this period, according to reanalysis data, a higher amplitude of the gradient variability of the offshore-coastal SST anomaly gradient was observed, as compared to 1890-1970, particularly during austral summers (with a 73% larger standard deviation), indicating stronger and more frequent alternations between coastal upwelling and relaxation. Thus, a proposed mechanism driving the deoxygenation events is this rapid

alternation, enabling the blooming of coastal diatoms, followed by massive sedimentation, intense oxygen depletion in the water column, and the development of anoxia in the bottom. There are no records of analogs of these regional events in the observational period. Nevertheless given the global projections of increased variability of atmospheric and oceanic processes, regional modelling studies are needed to explore the likelihood of these deoxygenation events in future scenarios.