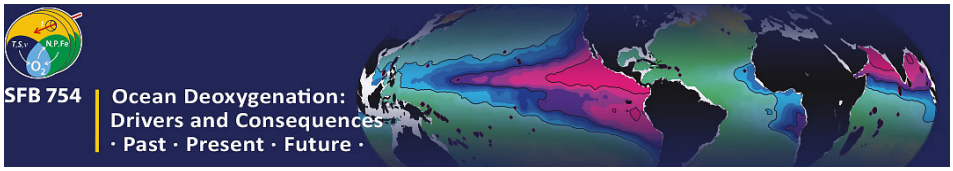

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Decadal to millennial-scale changes in oxygen minimum zone intensity, export production and fish fluctuations in the Humboldt Current System

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The Humboldt Current System (HCS) off Peru yields about 10% of the global fish catch, producing more fish per unit area than any other region in the world ocean. The current high productivity is fuelled by the upwelling of cold, nutrient-rich water from the oxygen minimum zone (OMZ). However, the potential impacts of climate change on upwelling dynamics and fish productivity as well as the response of fish populations to the expected future expansion of the OMZ are uncertain, but may have large impacts on local economies and foreign aquaculture feeds. To unravel the response of these fish populations to past climate changes, we here present reconstructions of their variability for several time windows during the last 130 000 years using fish scales and vertebrae deposited in multiple laminated sediments off Peru. Specifically, we discuss the role of temporal changes in the intensity of the OMZ and productivity on fish population fluctuations, since both oxygen and productivity seem to be the major drivers during the fishery period. During the Holocene, characterized by high productivity and a relatively strong and temporal variable OMZ, we observe high abundance of anchovy, sardine, jack mackerel, chub mackerel, saury, hake and mesopelagic fishes, suggesting that the oceanographic conditions were favorable for fish productivity. The deglaciation, characterized by a strong OMZ and a relatively low productivity, was more favorable for anchovy and mesopelagic fishes, while sardine abundance was very low. During the glacial periods, characterized by a weak OMZ and low productivity, the fish productivity in general was low, the oceanic species were particularly reduced. Finally, during the last interglacial (MIS 5e) characterized by a strong OMZ, high productivity and enhanced water column stratification, anchovy biomass was extremely low. Our results indicate that anchovy and sardine, and other fishes, are strongly linked to changes in productivity at multiple timescales and that changes in water column oxygenation seems to be an important factor regulating sardine abundance off Peru. The results support the idea that the warming climate observed during the last decades is favorable for anchovy, since the shallow-oxygenated habitat, promoted by the strong OMZ and upwelling, concentrates the anchovy prey near the surface, which enhances anchovy foraging, promotes a massive anchovy biomass and gives the base for the largest mono-specific fishery in the world. However current prediction for future climate in the HCS show that these favorable conditions are likely to be altered in the future.

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