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Decadal to multidecadal changes in marine subsurface oxygenation off central Peru since the XIX century

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Permanent oxygen deficiency in intermediate-depth waters is an important feature of the ocean. These water volumes are known as oxygen minimum zones (OMZ) and exhibit a high sensitivity to climate variability providing feedbacks on climate drivers. Over the last decade, several studies have reported global ocean deoxygenation trends since the 1960s and a consequent OMZ expansion. However, paleoceanographic reconstructions of subsurface waters from Eastern Boundary Upwelling Ecosystems (e.g. California, Concepción) show a centennial OMZ weakening over the XX century, instead of an OMZ strengthening as observed for the last decades. This pattern has been associated to several climate variabilities, but the mechanisms behind the subsurface (de)oxygenation trends in these areas are still not well understood.

At the South East Pacific, the upper Peruvian continental margin is characterized by a shallow and intense OMZ which has been preserved since the ending of the Little Ice Age period. In this study, we aim to reconstruct the (multi)decadal oxygenation variability off central Peru to identify the influence of both large-scale and local factors, differentiate between trends and multidecadal variability, and the potential underlying mechanisms governing in the East Pacific. We combined a multiproxy approach based on multiple paleoceanographic records for the last ~180 years and instrumental records of subsurface oxygen content since the 1960s. Finely laminated sediments were retrieved in the upper margin off Callao (180 m) and Pisco (~300 m). We analyzed benthic foraminiferal assemblages and compared them with records of redox-sensitive metals (Mo, Re, U) and TOC, biogenic silica and $\delta^{15}\text{N}$. Foraminiferal assemblages from sulfidic, postoxic and mixed conditions were identified in the record with different trends, mostly showing more permanent sedimentary postoxia.

We identified three major multidecadal periods: i) the mid to late nineteenth century, characterized by a strong OMZ and reducing sedimentary conditions, in parallel with enhanced siliceous productivity; ii) the late nineteenth century to mid-twentieth century, with a relaxing trend of OMZ and redox conditions, superimposed to a slight multidecadal variability; and iii) the late twentieth century until the early 2000's, when despite the high variability, there was a slight oxygenation trend over the upper Peruvian margin. The general OMZ relaxation trend until 1960s is similar to those in other upwelling areas. However only Peru maintains the oxygenation in the last decades in intermediate waters, meanwhile the shelf showed reducing conditions. We suggest that subsurface ventilation and local productivity are the main controlling factors generating this scenario.

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