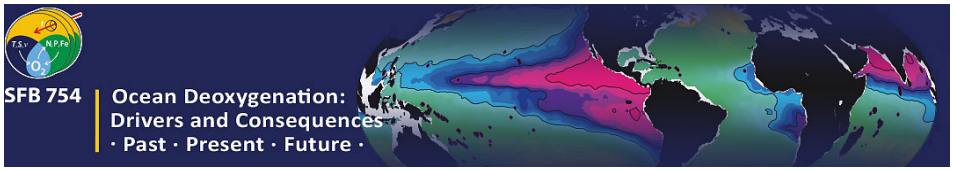

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The Natural Variability of Marine de-oxygenation in the Eastern-Tropical Pacific since the last Glacial Maximum

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Global warming and its effect on the stratification and oxygen solubility of the Ocean is leading to declines in the marine oxygen inventory, with potentially catastrophic consequences for ecosystem and habitat sustainability and marine productivity. Total oxygen inventory has already declined by 2% since 1960 and deoxygenation is predicted to accelerate over the rest of the century (Keeling et al. 2010). Decreased oxygenation in the ocean triggers the rapid expansion of Oxygen Minimum Zones (OMZs) with implications for marine N2O production, fixed nitrogen budget and productivity (the biological CO2 pump). The North Tropical Pacific accounts for up to 40% of the (existing and forecast) oxygen loss and hosts the largest oxygen mimimum zone in the ocean. While decreased solubility, overturning circulation and physical mixing of the top layer of the water column are all observed consequences of global warming leading to ocean deoxygenation, multi-decadal variability such as PDO (Pacific Decadal Oscillation) has been identified in some of the Pacific and Atlantic oxygen records (Schmidtko et al., 2017). However, these instrumental records of marine oxygen and climatology are short, only dating back to the 60's. One of the challenges in quantifying and predicting the global decline in oxygen level is our ability to constrain natural variability. Here we reconstruct the natural, multi-decadal to annual variability in deoxygenation in the Northern Tropical Pacific since the last Glacial Maximum.

We present a continuous, 25,000 year long record of upwelling-induced biological productivity (biogenic silica and organic carbon) and water column deoxygenation (denitrification) in the Gulf of California at centennial timescales. Several 200-year long, annually-varved sections distributed from the Holocene to the last Glacial maximum were selected from this long record, and both denitrification and productivity were measured with annual resolution.

Spectral and wavelet analyses of the annually resolved records reveal the permanence of ENSO- and PDO-like (Pacific Decadal Oscillation) variabilities throughout the record. While we see only minor deviations in the length of the ENSO and PDO periodicities since the last glacial period, changes in the amplitudes of both ENSO and PDO are manifest. This study confirms the mechanistic link between the 2 types of climate variabilities in the Pacific and their suspected role in modulating oxygen levels in the region. Future changes in the amplitudes of the ENSO and PDO climatic cycles in response to global warming might hold the key to deoxygenation trends in the Tropical Pacific.

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