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Multidecadal to millennial-scale changes in Oxygen Minimum Zone intensity off Peru during the last 20 kyr: Proxy – Model comparison

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Oxygen minimum zones (OMZ) have expanded in all tropical oceans during the last decades resulting in habitat contraction and considerable changes in marine biogeochemistry. However, it is still an open question as to how the magnitude and temporal changes in oceanic dissolved oxygen of the last few decades compare to the natural variability on longer timescales and how local and remote mechanisms were driving OMZ changes in the past. We discuss climatic and biogeochemical processes as potential controls for the intensity and the spatial extent of the OMZ off Peru during the last 20 kyr. First, we use multiple sediment records along the Peruvian margin (from 3°S to 17°S) to reconstruct changes in OMZ intensity during the last 20 kyr. Analysis of a suite of proxies, including the presence of laminations, redox sensitive metals and δ15N measurements on organic matter, highlight changes in ocean oxygenation and are combined with proxy records for past variations in sea surface temperature and productivity. Second, we compare our records with results from transient global climate and biogeochemistry model simulations to identify mechanisms that have driven past oxygenation changes. Our results imply pronounced centennial to millennial-scale changes in sub-surface oxygenation off Peru during the last 20 kyr, as well as increased centennial-scale variability during the last 3 kyr BP. Globally recognized cold climate periods such as the Last Glacial Maximum and the Little Ice Age were associated with a weak OMZ and low export production, while warm intervals such as the Last Deglaciation, part of the Medieval Climate Anomaly and the last 100 years are associated with a stronger OMZ and high export production. Contrary to previous assumptions and model projections for climate warming during the next few decades, we observe weak OMZ and colder conditions in the Eastern Tropical South Pacific (ETSP) during the overall warm Middle Holocene. This was probably the result of a stronger Walker Circulation that intensified the ETSP cold water tongue and, via equatorial undercurrents, brought more oxygen to intermediate depths off Peru. Accordingly, a re-amplification in water column deoxygenation and denitrification during the Late Holocene could be the result of a slowdown of the equatorial Pacific Ocean circulation at mid-depths. Our model-data comparison, in combination with other paleoceanographic reconstructions, implies that oxygen variability in the ETSP-OMZ was mainly influenced by ocean circulation changes and to a lesser degree by changes in local upwelling and biological production.

Position

Professor

Affiliation

Institute of Geosciences, Kiel University

Email Address

ralph.schneider@ifg.uni-kiel.de

Are you a SFB 754 / Future Ocean member?

Yes

Primary author(s) : Dr SALVATTECI, Renato (Institute of Geosciences)

Co-author(s) : Prof. SCHNEIDER, Ralph (Institute of Geosciences); Dr SEGSCHNEIDER, Joachim (Institute of Geosciences); Prof. SCHNEIDER, Birgit (Institute of Geosciences); Dr BLANZ, Thomas (Institute of Geosciences); Prof. MARTINEZ, Phillipe (Paléoclimatologie-Paléocéanographie, UMR5805 EPOC)

Presenter(s) : Prof. SCHNEIDER, Ralph (Institute of Geosciences)

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