Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.20263

Equatorward Expansion of the North Pacific Oxygen-deficient Zones Over the Past Three Decades

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The potential expansion of oxygen-deficient zones (ODZs) in the ocean under global warming may threaten the health of marine ecosystems and fisheries. The largest ODZs occur in the eastern North Pacific Ocean, where nitrate is used to respire organic matter. Observations have shown that the core of these ODZs has strengthened over the past three decades. However, as high-quality dissolved O_2 measurements are sparse, the spatial extent and expansion of the North Pacific ODZs remain poorly constrained. In this study, we present new biogeochemical data from the southern edge of the North Pacific ODZs (5 to 8 ^{o}N) from a recent cruise in November-December 2021. We found 200-300m-thick oxygen-deficient layers (with $[O_2] < 5$ μmol/kg) at the depths of 300-600 m across all 4 stations. In addition, the ^{15}N and ^{18}O of nitrate indicate active water-column denitrification and loss of fixed nitrogen in these oxygen-deficient layers. Comparing our new data with a previous cruise occupying similar stations from 30 years ago, we found that the thicknesses of oxygen-deficient layers have increased by ~65% from 152 m ± 27 m to 250 m ± 17 m at all stations, indicating an equatorward expansion of the North Pacific ODZs over the past 3 decades. This observation is consistent with a decline in the global ocean oxygen content over the past few decades, mainly driven by climate change [1]. In addition, the strengthening of tropical Pacific winds since the 1990s might have increased the upwelling intensity and the consumption of O_2 in the thermocline water [2]. If the trend continues, the loss of fixed nitrogen and the production of greenhouse gas nitrous oxide in the ocean will also increase, both of which might exacerbate climate change.

[1] Breitburg et al. (2018). *Science* **359**, eaam7240.
[2] Deutsch et al. (2014). *Science* **345**, 665–668.