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TITLE: Vertical zonation and distributions of calanoid copepods through the lower oxycline of the Arabian Sea oxygen minimum zone

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ABSTRACT:

This paper provides the first comprehensive analysis of calanoid copepod vertical zonation and community structure at midwater depths (300–1000 m) through the lower oxygen gradient (oxycline) (0.02 to ~0.3 ml/L) of an oxygen minimum zone (OMZ). Feeding ecology was also analyzed. Zooplankton were collected with a double 1 m<sup>2</sup> MOCNESS plankton net in day and night vertically-stratified oblique tows from 1000 m to the surface at six stations during four seasons as part of the 1995 US Joint Global Ocean Flux Study (JGOFS) Arabian Sea project. The geographic comparison between a eutrophic more oxygenated onshore station and an offshore station with a strong OMZ served as a natural experiment to elucidate the influence of depth, oxygen concentration, season, food resources, and predators on the copepod distributions. Copepod species and species assemblages of the Arabian Sea OMZ differed in their spatial and vertical distributions relative to environmental and ecological characteristics of the water column and region. The extent and intensity of the oxycline at the lower boundary of the OMZ, and its spatial and temporal variability over the year of sampling, was an important factor affecting distributional patterns. Calanoid copepod species showed vertical zonation through the lower OMZ oxycline. Clustering analyses defined sample groups with similar copepod assemblages and species groups with similar distributions. No apparent diel vertical migration for either calanoid or non-calanoid copepods at these midwater depths was observed, but some species had age-related differences in vertical distributions. Subzones of the OMZ, termed the OMZ Core, the Lower Oxycline, and the Sub-Oxycline, had different copepod communities and ecological interactions. Major distributional and ecological changes were associated with surprisingly small oxygen gradients at low oxygen concentrations. The calanoid copepod community was most diverse in the most oxygenated environments (oxygen >0.14 ml/L), but the rank order of abundance of species was similar in the Lower Oxycline and Sub-Oxycline. Some species were absent or much scarcer in the OMZ Core. Two copepod species common in the Lower Oxycline were primarily detritivorous but showed dietary differences suggesting feeding specialization. The copepod *Spinocalanus antarcticus* fed primarily on components of the vertical particulate flux and suspended material, a less versatile diet than the co-occurring copepod *Lucicutia grandis*. Vertical zonation of copepod species through the lower OMZ oxycline is probably a complex interplay between physiological limitation by low oxygen, potential predator control, and potential food resources. Pelagic OMZ and oxycline communities, and their ecological interactions in the water column and with the benthos, may become even more widespread and significant in the future ocean, if global warming increases the extent and intensity of OMZs as predicted.

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