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Severe dead-zone eddies in the open North Atlantic Ocean

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Ocean volumes with very low dissolved oxygen, so called “dead-zones”, have been observed in many coastal areas of the world ocean. Dead-zones are characterized by a dissolved oxygen content below 2 mg/l (approx. 60 μmol/kg) and making them inhabitable for many marine organisms. Here we report on severe dead-zones in the open North Atlantic, several hundreds of kilometres away from the coast, where so far concentrations below about 40 μmol/L have not been reported. The severe dead-zones are contained within mesoscale eddies that originate from the West African upwelling region and propagate slowly (100km per month) westward. Local dynamics isolate the dead-zone eddy from surrounding waters and create, within the rather well oxygenated North Atlantic, a biogeochemical realm comparable to the major oxygen minimum zone (OMZ) of the Pacific and Indian Ocean. Below a well oxygenated upper mixed-layer of some 20 to 50m depth follows a drastic drop in oxygen, which is the actual dead-zone. In one the most dramatic case of a North Atlantic dead-zone eddy, the oxygen content right below the mixed layer (50m depth) was approximately 0 μmol/kg, while the 60μmol/kg dead-zone threshold was reached at about 200m depth, resulting in a dead-zone 150m deep. It was found that mobile marine organisms are unable to follow their diurnal vertical migration and are trapped in the mixed layer, above the dead-zone, instead. Our data suggest that most severe low-oxygen ocean conditions ($\sim$0 μmol/L) are created just below the surface mixed layer in anti-cyclonic Mode Water type eddies, but still significant ($\sim$15 μmol/L) concentrations were observed in a cyclonic eddy.