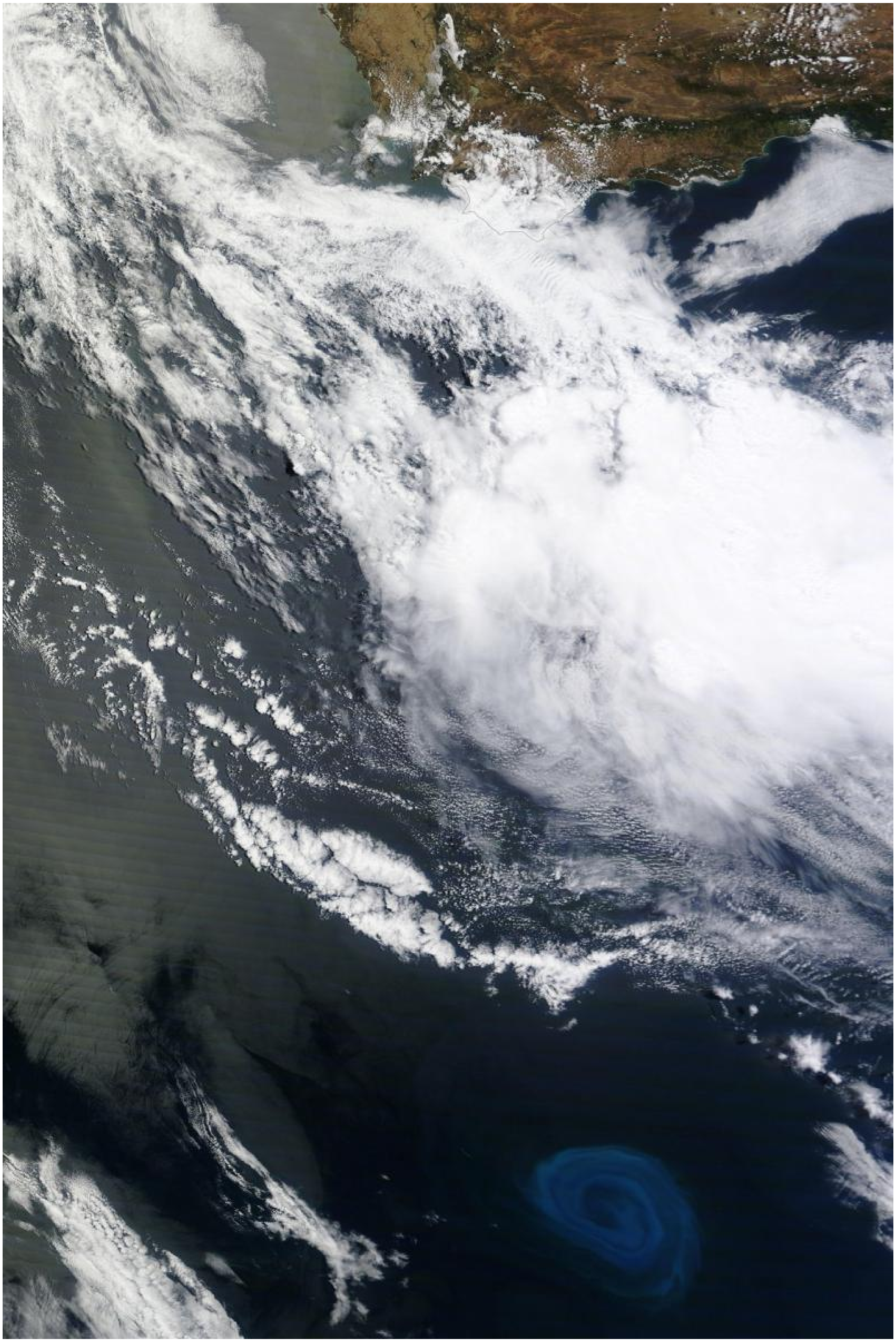
'Dead zones' found in Atlantic open waters

April 30 2015



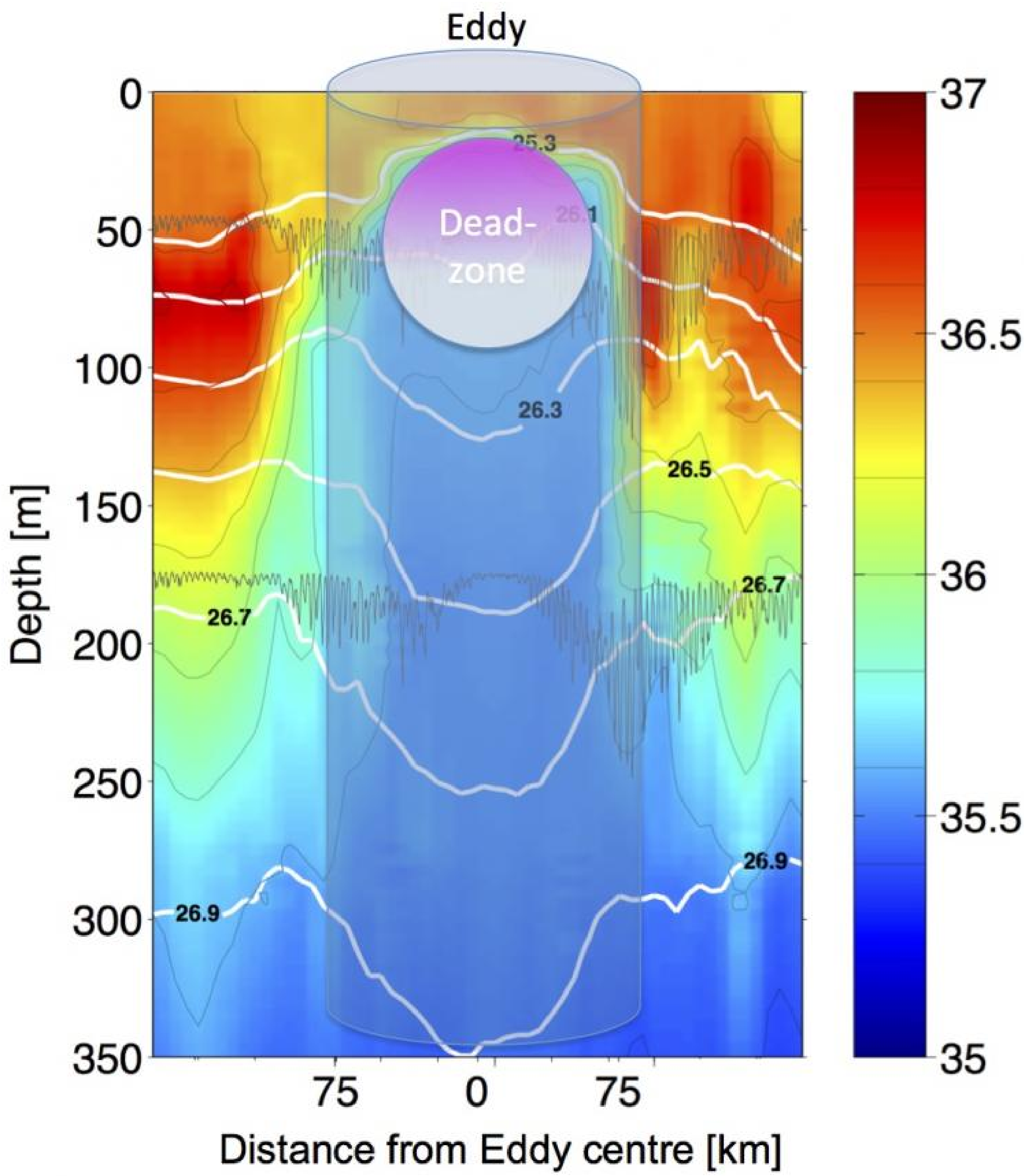
The dead-zone eddies found in the *Biogeosciences* study are somewhat similar to the one seen in this picture, which was captured by the Moderate Resolution Imaging Spectroradiometer on NASA's Terra satellite in late 2011. Credit: NASA Earth Observatory

A team of German and Canadian researchers have discovered areas with extremely low levels of oxygen in the tropical North Atlantic, several hundred kilometres off the coast of West Africa. The levels measured in these 'dead zones', inhabitable for most marine animals, are the lowest ever recorded in Atlantic open waters. The dead zones are created in eddies, large swirling masses of water that slowly move westward. Encountering an island, they could potentially lead to mass fish kills. The research is published today in *Biogeosciences*, an open access journal of the European Geosciences Union (EGU).

Dead zones are areas of the ocean depleted of oxygen. Most marine animals, like fish and crabs, cannot live within these regions, where only certain microorganisms can survive. In addition to the environmental impact, dead zones are an economic concern for commercial fishing, with very low oxygen concentrations having been linked to reduced fish yields in the Baltic Sea and other parts of the world.

"Before our study, it was thought that the open waters of the North Atlantic had minimum oxygen concentrations of about 40 micromol per litre of seawater, or about one millilitre of dissolved oxygen per litre of seawater," says lead-author Johannes Karstensen, a researcher at GEOMAR, the Helmholtz Centre for Ocean Research Kiel, in Kiel, Germany. This concentration of oxygen is low, but still allows most fish to survive. In contrast, the minimum levels of oxygen now measured are some 20 times lower than the previous minimum, making the dead zones nearly void of all oxygen and unsuitable for most marine animals.

Dead zones are most common near inhabited coastlines where rivers often carry fertilisers and other chemical nutrients into the ocean, triggering algae blooms. As the algae die, they sink to the seafloor and are decomposed by bacteria, which use up oxygen in this process. Currents in the ocean can carry these low-oxygen waters away from the coast, but a dead zone forming in the open ocean had not yet been discovered.



This plot shows a salinity section of the upper 350 metres of sea water observed across an eddy passing through the Cape Verde Ocean Observatory mooring. As the water in the eddy originates from the African Coast it is much lower in salinity than the surrounding water. The white contours represent levels of constant sea-water density, which bend downward towards the centre of the eddy, indicating rotation. The dead-zone (represented by the magenta circle) develops in the centre of the eddy at a depth range of about 20 to 100 metres, below a shallow surface layer that is under the direct impact of atmospheric forcing (wind, warming and cooling). This eddy has a diameter of about 120 to 140 km. Credit:J. Karstensen/GEOMAR/Biogeosciences

The newly discovered dead zones are unique in that they form within eddies, large masses of water spinning in a whirlpool pattern. "The few eddies we observed in greater detail may be thought of as rotating cylinders of 100 to 150 km in diameter and a height of several hundred metres, with the dead zone taking up the upper 100 metres or so," explains Karstensen. The area around the dead-zone eddies remains rich in oxygen.

"The fast rotation of the eddies makes it very difficult to exchange oxygen across the boundary between the rotating current and the surrounding ocean. Moreover, the circulation creates a very shallow layer - of a few tens of meters - on top of the swirling water that supports intense plant growth," explains Karstensen. This plant growth is similar to the algae blooms occurring in coastal areas, with bacteria in the deeper waters consuming the available oxygen as they decompose the sinking plant matter. "From our measurements, we estimated that the oxygen consumption within the eddies is some five times larger than in normal ocean conditions."

The eddies studied in the *Biogeosciences* article form where a current that flows along the West African coast becomes unstable. They then move slowly to the west, for many months, due to the Earth's rotation. "Depending on factors such as the [eddies'] speed of rotation and the plant growth, the initially fairly oxygenated waters get more and more depleted and the dead zones evolve within the eddies," explains Karstensen. The team reports concentrations ranging from close to no oxygen to no more than 0.3 millilitres of oxygen per litre of seawater. These values are all the more dramatic when compared to the levels of oxygen at shallow depths just outside the eddies, which can be up to 100 times higher than those within.

The researchers have been conducting observations in the region off the West African coast and around the Cape Verde Islands for the past seven years, measuring not only oxygen concentrations in the ocean but also water movements, temperature and salinity. To study the dead zones, they used several tools, including drifting floats that often got trapped within the eddies. To measure plant growth, they used satellite observations of ocean surface colour.

Their observations allowed them to measure the properties of the dead zones, as well as study their impact in the ecosystem. Zooplankton - small animals that play an important role in marine food webs - usually come up to the surface at night to feed on plants and hide in the deeper, dark waters during the day to escape predators. However, within the eddies, the researchers noticed that zooplankton remained at the surface, even during the day, not entering the low-oxygen environment underneath.

"Another aspect related to the ecosystem impact has a socioeconomic dimension," says Karstensen. "Given that the few dead zones we observed propagated less than 100 km north of the Cape Verde archipelago, it is not unlikely that an open-ocean dead zone will hit the islands at some point. This could cause the coast to be flooded with low-oxygen water, which may put severe stress on the coastal ecosystems and may even provoke fish kills and the die-off of other marine life."

Provided by European Geosciences Union