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# Dinoflagellate cysts distinguish between nutrient pollution and climatic variability in the Gulf of Mexico 'dead zone'

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The northern Gulf of Mexico (NGOM) is well known for its eutrophication and seasonal 'dead' zone caused by anthropogenic nutrient enrichment, primarily from fertilizers derived from the Mississippi River Basin. However, assessing eutrophication in coastal waters such as the GOM is challenging as nutrients can be rapidly taken up. In addition, many of the indicators that are commonly used to monitor eutrophication such as chlorophyll-a, toxic blooms, and bottom water oxygen levels, vary on a daily to seasonal basis and thus require data collection to occur multiple times per year. Climate change and nutrient pollution can co-occur, further complicating the signal.

To combat these challenges we analyzed organic walled microfossils called dinoflagellate cysts. Dinocysts are the resting stage of planktonic dinoflagellates. They are known to reflect sea-surface conditions and are advantageous diagnostic indicators because they are well preserved in the sedimentary record. Our main objective was to decipher between cultural eutrophication and natural climatic variability over the past century in the NGOM dead zone.

Three sediment cores were collected near the mouth of the Mississippi River in 2015 and were dated using lead-210. Standard palynological processing methods were used to concentrate the dinocysts. Dinocyst assemblages were compared to USA nitrogen fertilizer use and climatic indices such as the Atlantic Multidecadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO) using multivariate statistics.

We found that dinocyst assemblages were most sensitive to changes in nutrient pollution, followed by changes in the AMO. Two main dinocyst zones were found using cluster analysis. The first zone spans from 1890-1960 and is characterized by lower nutrient pollution, higher species richness and lower abundances of heterotrophic dinocyst species known to reflect high nutrients. The second zone spans from 1961-2015 and is characterized by high nutrient pollution, lower species richness, and higher abundances of nutrient indicator species. Subzones also differentiated between positive and negative phases of the AMO. This demonstrates that dinocyst assemblages are able to distinguish between both anthropogenic impacts and climatic factors.