REPORT FROM 2021 SHELF-WIDE HYPOXIA CRUISE

LOUISIANA STATE UNIVERSITY
AND
LOUISIANA UNIVERSITIES MARINE CONSORTIUM

AUGUST 3, 2021

The bottom area of low oxygen in Louisiana coastal waters west of the Mississippi River, commonly known as the 'Dead Zone,' was mapped from July 25 – July 31, 2021 and estimated at 16,400 square kilometers (6,334 square miles) (Figure 1). The 2021 size is the 16th largest in 35 years of hypoxia data, i.e., average for the interval.

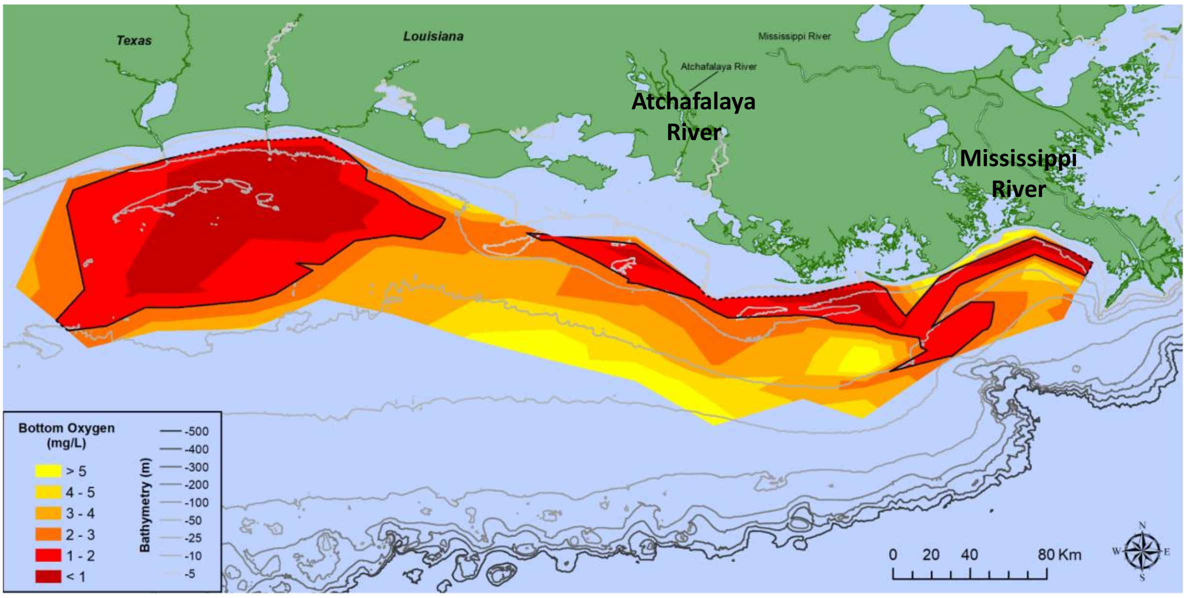

Figure 1. Distribution of bottom-water dissolved oxygen concentration for July 25-31, 2021. The combined area less than 2 mg l^{-1} and 1 mg l^{-1} are the darkest colors and outlined by the black line. Data source: NN Rabalais⁺, RE Turner* & C Glaspie*, *⁺Louisiana State University and Louisiana Universities Marine Consortium. Funding: National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science.*

The forecasted size was based on the nutrient loads of Nitrate+Nitrite-N, in the month of May preceding the hypoxia research cruise (Figure 2). The May 2021 river discharge and calculated nutrient loads indicated an 'average' year, and the estimates for the size of the low oxygen area were average, indicating a size of about 12,330 square kilometers (4,760 square miles).

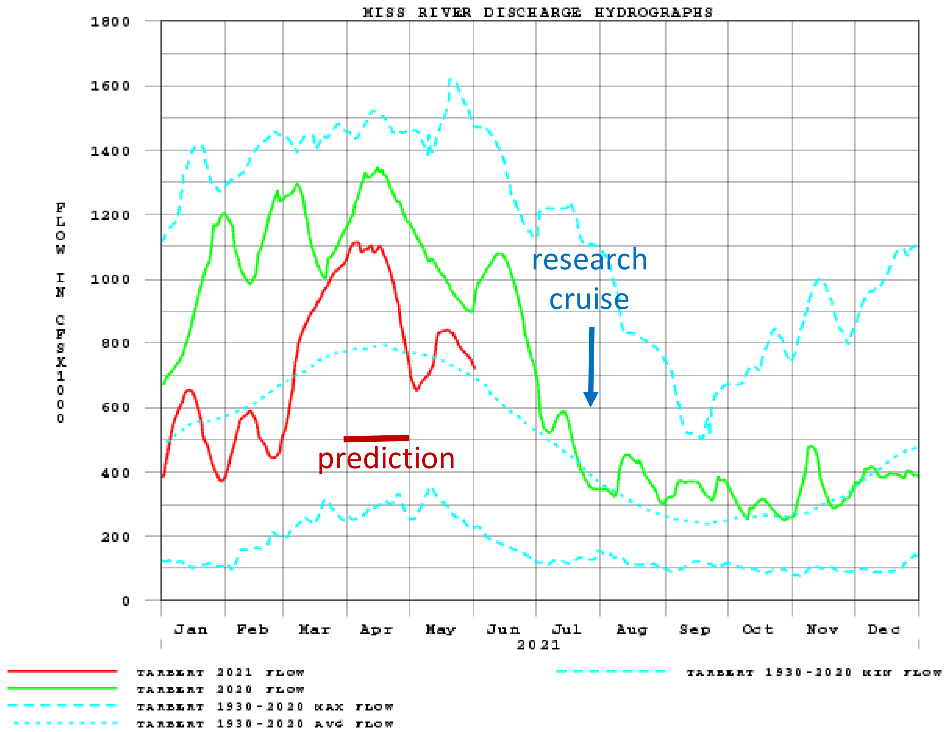

Figure 2. Mississippi River discharge at Tarbert Landing MS for 2021 through June 1. The nutrient load (discharge × nutrient concentration) in the month of May is used to predict the bottom-area size of the hypoxic zone in mid-summer. Last access on 6-1-21, *http://rivergages.mvr.usace.army.mil/WaterControl/Districts/MVN/tar.gif* *[This site no longer in operation]*

The delay from prediction of size in May to measurement of size during the cruise allows for nutrient-enriched river water to reach the Gulf of Mexico and stimulate blooms of algae, followed by their eventual sinking to the bottom, bacterial degradation of the carbon, and the loss of dissolved oxygen during bacterial respiration, in a stratified water column.

The somewhat higher than average discharge in July provided more fresh water to the northern Gulf of Mexico (Figures 3 and 4). This contributed to more algae, more sinking carbon, and more bacterial respiration reducing the dissolved oxygen. The lower surface water salinity combined with the warm surface waters (typically 31 to 32+ °C in the daytime) strengthens the pycnocline (water density differences between surface and bottom water layers), which slows the diffusion of surface water oxygen to the bottom layer. Consistent winds from the south supported the retention of the less saline waters in the northern Gulf of Mexico.

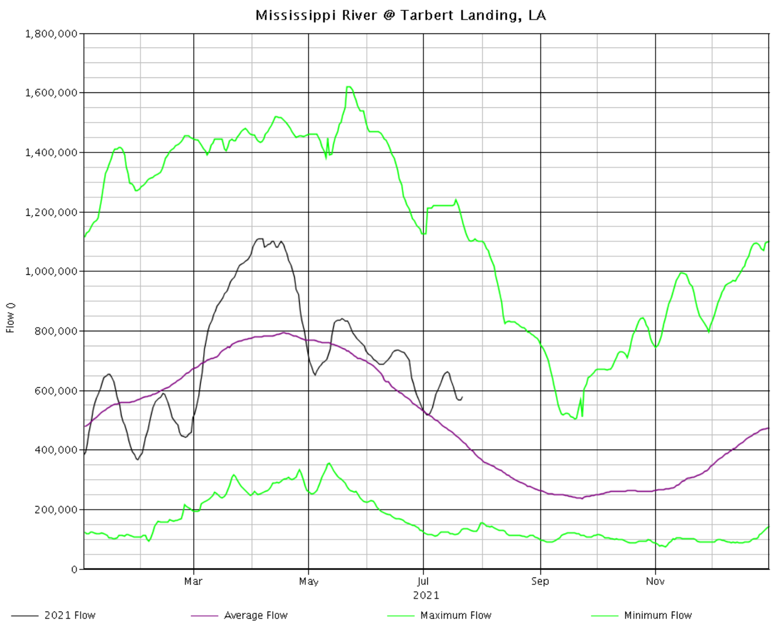

Figure 3. Mississippi River discharge for 2021 up to the time of the hypoxia cruise, 7-25-21, compared to historic levels. May nutrient loads are calculated (discharge × nutrient concentration) and accumulated for the month. Last accessed 8-1-21 at https://rivergages.mvr.usace.army.mil/WaterControl/Districts/MVN/RRLFlow.png.

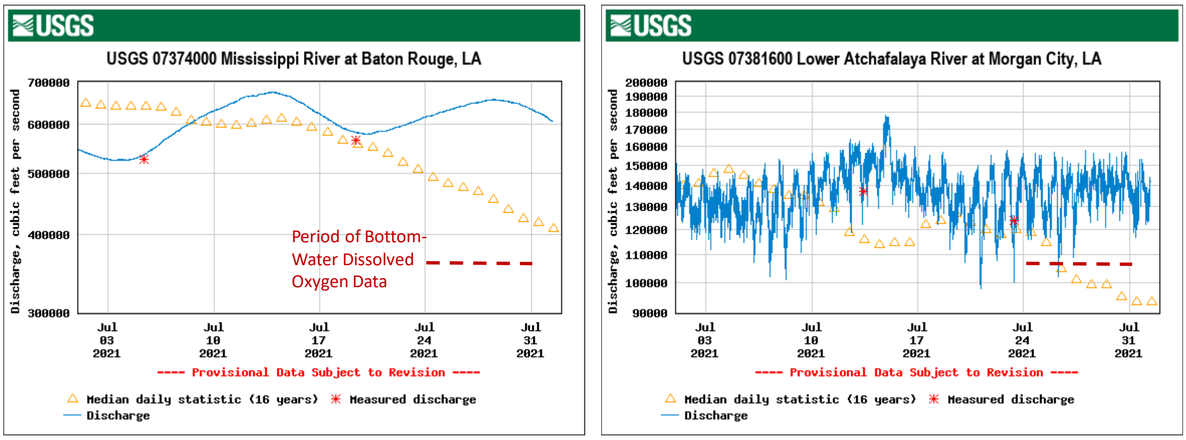

Figure 4. River discharge data (cubic feet per second) for the month of July from Baton Rouge LA (left) and Morgan City LA (right) through the end of the cruise. The river discharges during the cruise are in blue lines and the last 16 yr average discharges are in the orange triangles. The mapping of bottom-water low oxygen (dissolved oxygen less than 2 milligrams per liter) occurred July 25-July 31. Data source: https://waterdata.usgs.gov/

The effects of the higher freshwater discharge are seen in the lower salinity surface waters across the Louisiana continental shelf, especially in the area of the Mississippi River plume and the Atchafalaya River plume (Figure 5).

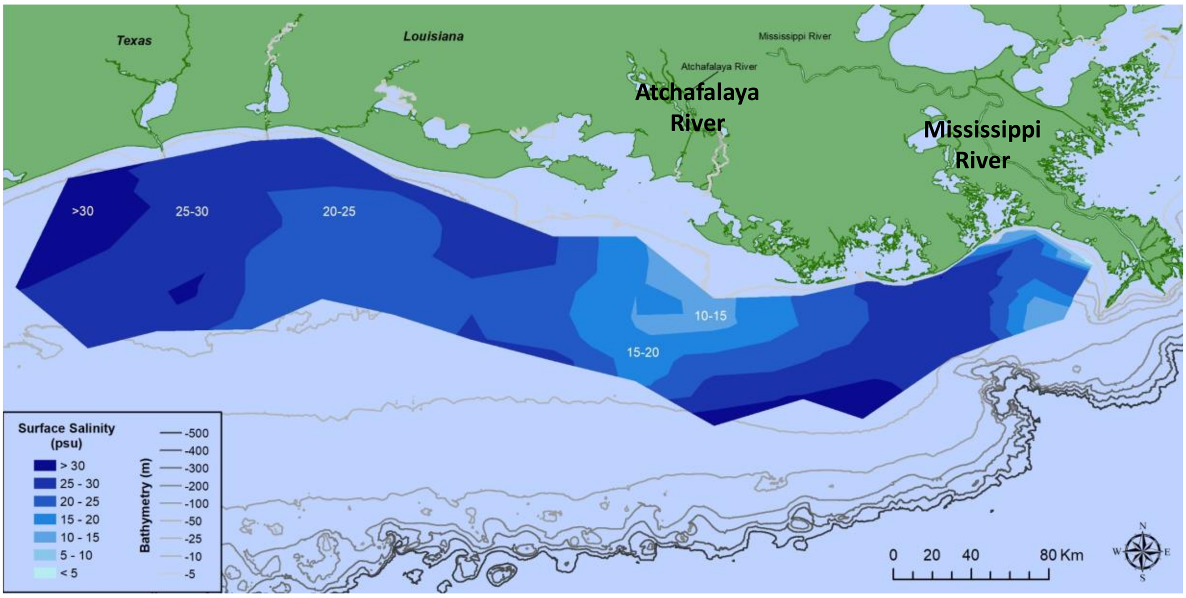

Figure 5. Distribution of surface water salinity July 25-31, 2021, while mapping bottom-water dissolved oxygen. Note the Mississippi River and Atchafalaya River plume waters of 0-20 salinity, and broader areas of 20-30 salinity.

For comparison, we include a distribution of surface water salinity for 2018, which was a year with 'average' summer Mississippi River discharge for surface water salinity (Figure 6). Of course, winds and currents will also shift surface waters around on the shelf. However, it is obvious from the map (Figure 6) that there was much less fresh water on the shelf in 2018 than in 2021 (Figure 5*).* The area of bottom-water hypoxia in 2018 was 7,040 square kilometers (2,720 square miles), or 2.3 × less than in 2021.

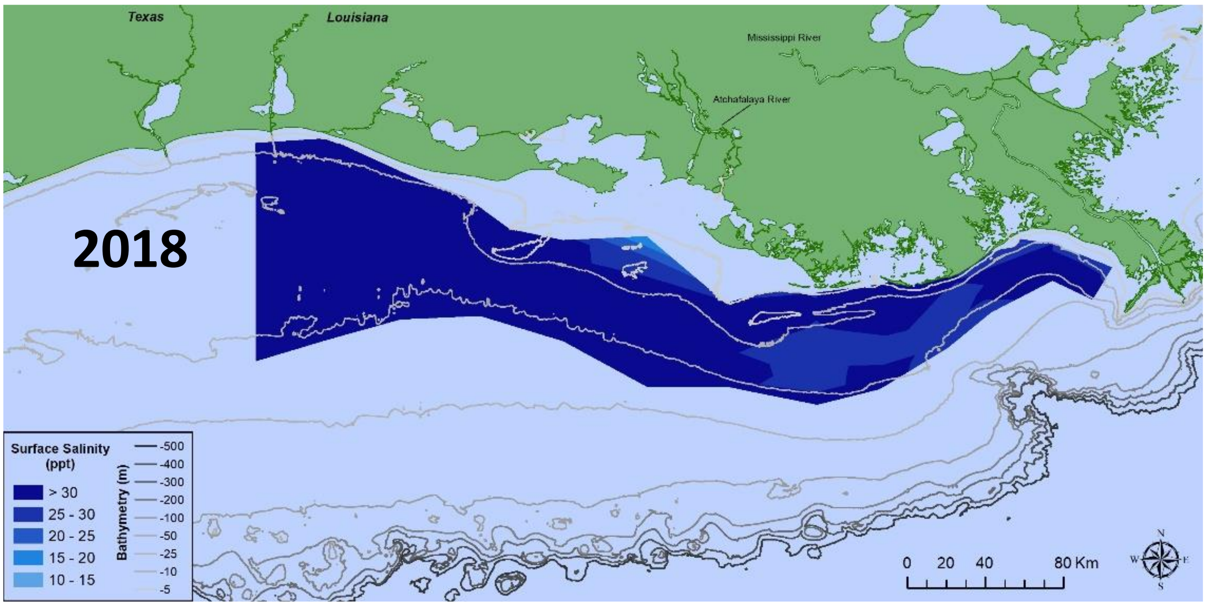

Figure 6. 2018 surface water salinity conditions following a July discharge of near average seasonal low mean flow. This figure is for comparison with the 2021 surface water salinity.

Wind speed and direction (and resulting currents) will affect the distribution of water masses and the dynamics of hypoxia on this shelf. Wind directions and hurricane conditions or both have disrupted the last three years of hypoxia formation and maintenance. Winds primarily from the south, which are typical for the summer season and associated with thunderstorms and cold front passages, were dominant in the weeks before the research cruise departed (Figure 7). The winds also pushed the fresh water input from the Atchafalaya River back onto the shelf where the lower salinity remained to support the strong salinity contribution to the water column density differences in locations to the west west of the river plume. Winds from the same direction affected the Mississippi River plume but were not as spatially relevant because much of the discharge was pushed to the east of the delta. The surface salinity signal in the Louisiana bight indicated that some of the discharge hugged the shore and joined the Louisiana Coastal Current in its westward direction along shore or became entrained in the clockwise gyre within the bight. Thus, the mechanisms of freshwater dispersal differed between the two river inputs and differentially affected the dynamics of hypoxia in the surrounding water column.

The calmness of the winds during the cruise, much less than the two weeks before, also supported the further development of a strong pycnocline.

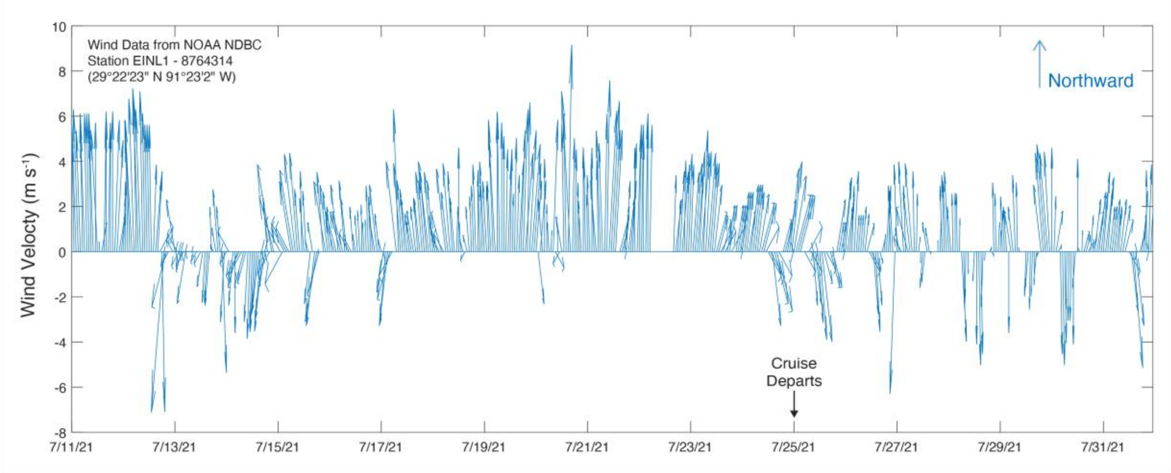

Figure 7. Wind speed and direction for the period of two weeks before the shelfwide hypoxia cruise and during the cruise beginning on July 25, 2021. Wind speed (m s^{-1}) and direction at Eugene Island (the arrows indicate the direction to which the winds are directed). Wind speeds were mostly higher before the cruise departure than during the research cruise.

This is the 37^{th} year that the hypoxia research team of LUMCON, LSU, and many other scientists have been offshore studying hypoxia (with 35 successfully completed mappings of the full area). We have watched as the physics and biology interact to develop and maintain hypoxia over its seasonal development (Figure 8). We have also identified the effects of nutrient enrichment on the algal communities and abundances that contribute to the carbon loading that leads to hypoxia near and on the bottom.

The nitrogen loading of the Mississippi River to offshore remains high. There are efforts by states along the main stem and others in the watershed to reach lower loads of excess nutrients (Mississippi River/Gulf of Mexico Hypoxia Task Force (https://www.epa.gov/ms-htf). The efforts need to continue and intensify as we face many societal and environmental knowns and unknowns in both the watershed and in offshore waters. We, as citizens of the watershed, need to lessen our consumption of nitrogen-based products and reduce other activities that contribute *reactive*-Nitrogen to the environment.

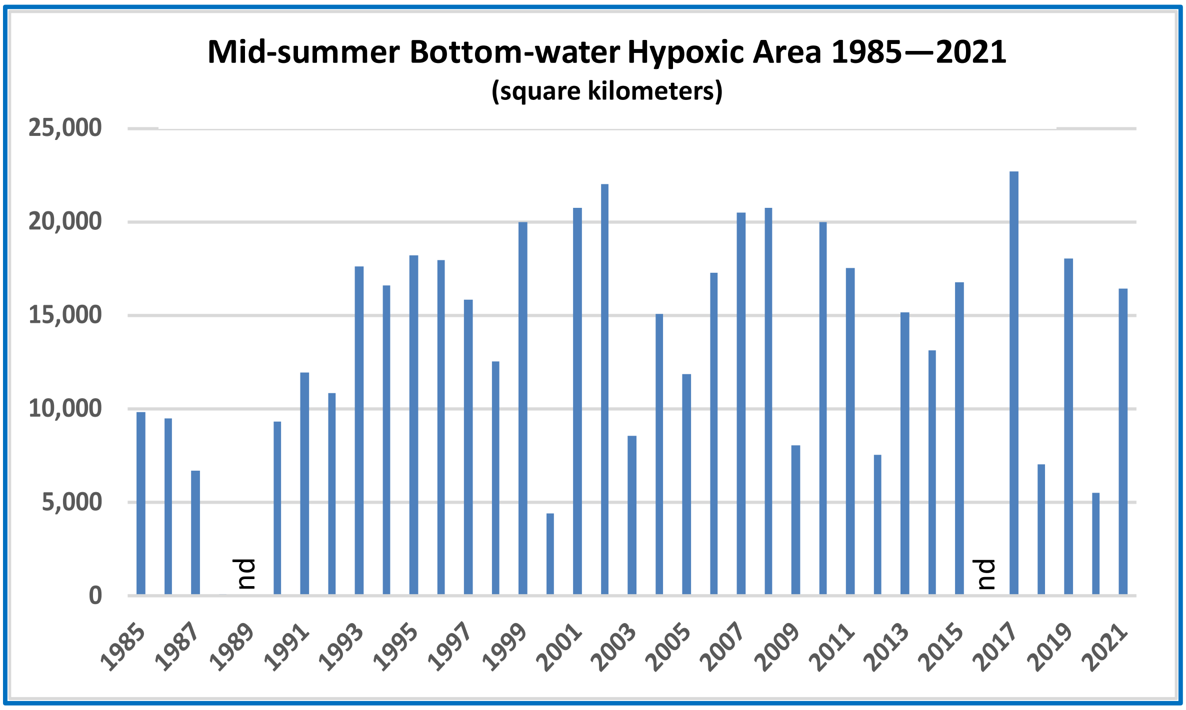

Figure 8. The size of the area of bottom-water hypoxia (dissolved oxygen less than 2 mg l^{-1}) for 1985-2021. "nd" indicates no data—a year without a completely mapped area or no mid-summer shelfwide cruise (1989 & 2016). The area for 1988 is minimal and not visible on the graph.

Contacts for further information:
Nancy N. Rabalais, nrabal@lsu.edu, or
Cassandra Glaspie, cglaspie1@lsu.edu, or
R. E Turner, euturne@lsu.edu

Graphics by Leslie Smith, Your Ocean Consulting LLC, and Nancy Rabalais and Gene Turner, LSU

Visit the Gulf Hypoxia web site at https://www.gulfhypoxia.net for maps, additional graphics and more information concerning this summer's research cruise and previous cruises.

Funding source:
National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, via the Northern Gulf Institute Cooperative Agreement, Mississippi State University