2023 Gulf of Mexico Hypoxia Forecast

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August 2, 2023

This model has been transferred to operations at the National Oceanic and Atmospheric Administration. It is combined with other models to produce an official ensemble forecast. We will continue to provide our forecast here. Our press release is here.

The Gulf of Mexico annual summer hypoxia forecasts are based on average May total nitrogen loads from the Mississippi River basin. This year's load estimate, recently released by USGS, is 3990 metric tons per day. Based on that estimate, we predict the area of this summer's hypoxic zone to be 12,344 square kilometers (95% credible interval: 4,730 to 19,958). This year's meansured extent was 7,920 square kilimeters.

Our forecast hypoxic volume is 44 km^3 (95% credible interval, 18 to 71 km^3), below the long term average of 60 km^3. A hypoxic volume goal has not been established.

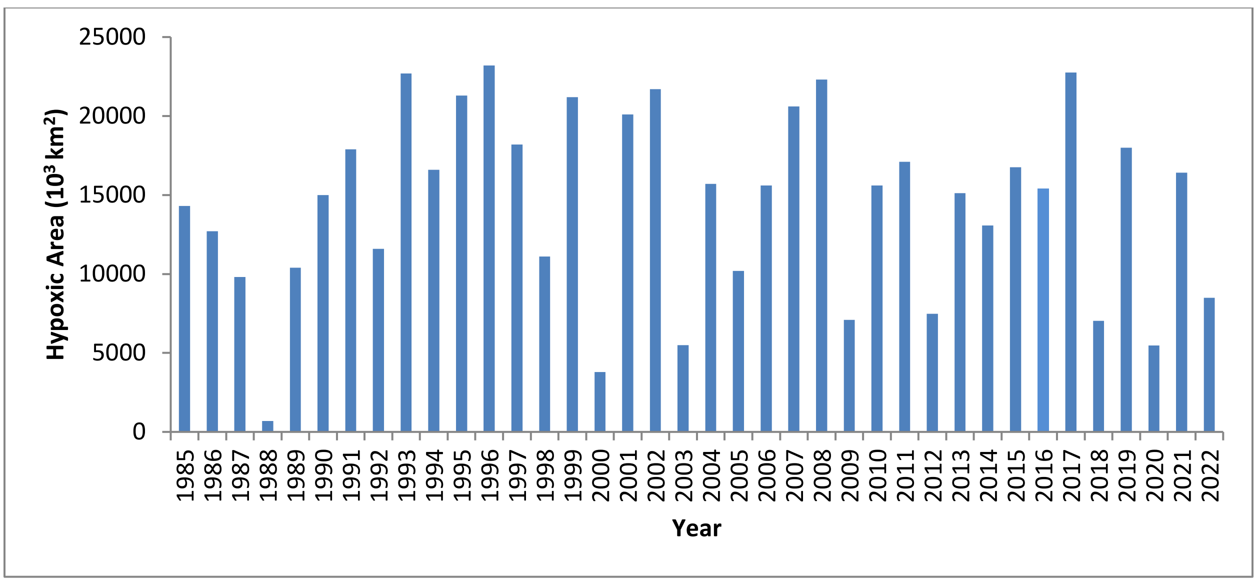

Figure 1: Mid-summer hypoxic area (Obenour et al. 2013 and Rabalais and Turner, LUMCON, 2019). The 2016 value is the average of two 3D ecological model reanalysis project from A. Lewitus, NOAA.

Hypoxia in the Gulf of Mexico – The Gulf of Mexico hypoxic zone (i.e., the area of bottom water with oxygen concentrations below 2 mg/l) is the second largest human-caused zone of hypoxia in the world's coastal waters, second only to that in the Baltic. Important fisheries are impacted at these low oxygen levels because fish, shrimp, and crabs are forced to move from their preferred habitats and animals that cannot move away die. Above (Figure 1) is a graph showing the annual changes in hypoxic area derived from geospatial analysis (Obenour et al 2013) of observations from the Louisiana Universities Marine Consortium shelfwide cruises (Rabalais et al. 2002). Support for this work has been provided by NOAA's Center for Sponsored Coastal Ocean Research since 1990 (http://www.cop.noaa.gov/).

Model track record **–** Hypoxic area forecasts have been generated each spring since 2002 and compared to the area measured later that summer (Figure 2). The model predicts mid-summer hypoxic area based on nitrogen load from the Mississippi River basin (Evans and Scavia, 2011). The model calibration has varied over the years as more has been learned about hypoxia in the Gulf. This year's forecast uses an updated model that corrects for some of the differences observed in the historical track record. In general, forecasts have performed well. Removing the year 2009 (see below) and four years when tropical storms impeded measurement of the hypoxic area (2003, 2005, 2018, and 2020), these forecasts explained 70% of the variation in observed hypoxic area. Forecasts were notably off in storm years.

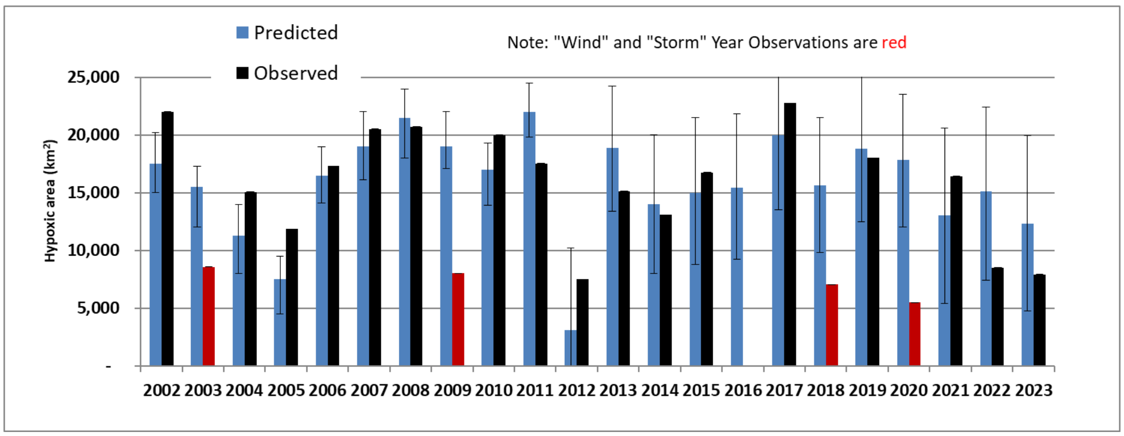

Figure 2: Forecast track record showing model forecast and observed hypoxic area for each year since 2002. "Wind" and "Storm" year observations (years when atypical weather interrupted measurement cruises) are indicated in red. Model calibration procedures have varied through time as more has been learned about the drivers of hypoxia in the Gulf.

Updated Hypoxia Model **–** This year we are using the model calibration described in Scavia et al (2013). This calibration was conducted, in part, to account for deviations in the relationship of hypoxia to nutrient loads caused by weather events such as tropical storms and winds that compress hypoxia to the eastern shelf (as in 2009, Figure 2). This calibration uses the model developed originally to relate Gulf of Mexico hypoxic area to loads from the Mississippi and Atchafalaya Rivers (Scavia et al. 2003). This model has been used in comparisons to other models (Scavia et al. 2004), for exploration of nitrogen vs. phosphorus control (Scavia and Donnelly 2007), to provide guidance for the 2001 and 2008 Gulf Action Plans (Task Force, 2001, 2008), and to explore potential impacts of climate-induced changes in nutrient delivery (Donner and Scavia 2007). It is an adaptation of the Streeter-Phelps river model that simulates oxygen concentration downstream from point sources of organic matter loads using mass balance equations for oxygen-consuming organic matter.

The model produces a DO concentration profile stretching from the mouth of the Mississippi River toward the Louisiana-Texas border. From that profile, we determined the total length for which DO < 3 mg L^{-1}. A value of 3 mg L^{-1} was used because that average sub-pycnocline DO concentration roughly corresponds in time to a bottom water DO concentration of 2 mg L^{-1} and hypoxic conditions (Scavia et al. 2003). Hypoxic length is then converted to area and volume using an empirical formula determined from geospatial model output (Scavia et al. 2013).

Nutrient Loads - A substantial body of scientific evidence links long-term changes of this hypoxic region to loads of nitrogen from the Mississippi River system (e.g., Scavia and Donnelly 2007, Justić et al. 2002; Turner et al. 2007, 2012). Previous forecasts have been based on various loads (e.g. NO_3 vs. TN; May-June, vs. May; etc). This version has been calibrated with May TN loads. The graph below (Figure 3) represents those loads from the Mississippi basin between 1985 and 2022 from the USGS LOADEST AMLE method (http://toxics.usgs.gov/hypoxia/mississippi/oct_jun/index.html).

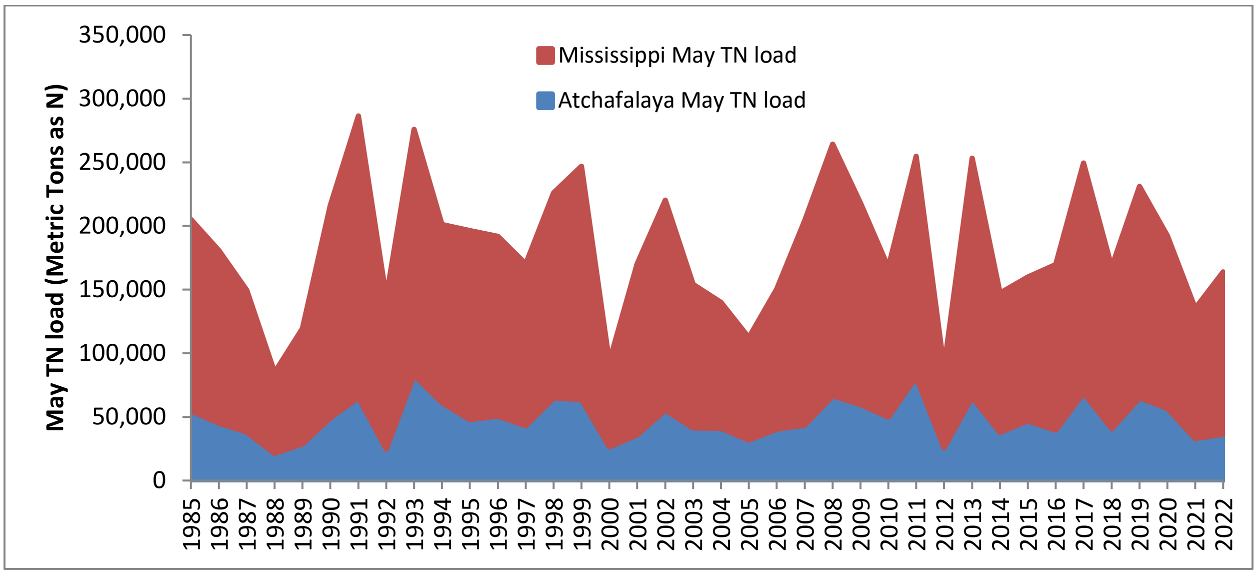

Figure 3: May total nitrogen loads from the Mississippi and Atchafalaya Rivers since 1985. The Mississippi load is the red area and the Atchafalaya load is the blue area such that the height of the combined shaded areas is the total load.

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