



A Primer on Gulf of Mexico **HYPOXIA**

Common questions and answers for stakeholders, decision makers, coastal managers, and the education community.



On the cover:

Photo credit: NOAA

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What is hypoxia?

Hypoxia means “low oxygen.” Hypoxic water bodies are depleted in dissolved oxygen, the amount of free oxygen that is dissolved in water. The dissolved oxygen concentration is depleted to a level that no longer supports most living aquatic organisms (GulfHypoxia website).



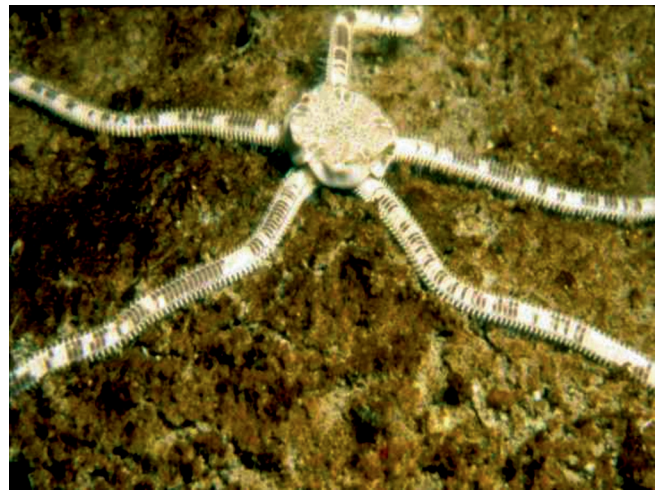
Dead Polychaete and Sulfur Oxidizing Bacteria, Photo: V. J. Viola



Dead Spider Crab, Photo: F. J. Viola



Stressed Burrowing Anemone, Photo: D. E. Harper, Jr.



Stressed Brittle Star, Photo: D. E. Harper, Jr.

What causes it?

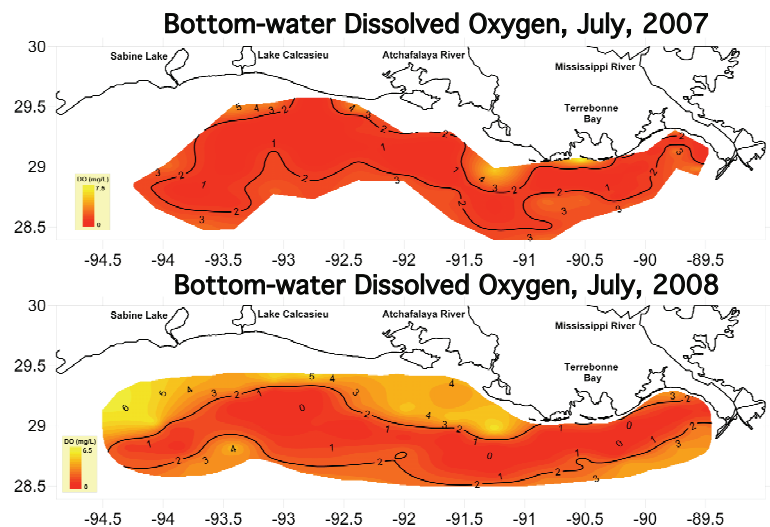
Hypoxia is caused by several environmental factors acting in tandem. In the northern Gulf of Mexico, large amounts of nutrients are discharged into the Gulf by rivers, such as the Mississippi and Atchafalaya rivers. The nutrients provide food for microscopic phytoplankton, and the discharge of nutrients can increase the growth of algae in the water. The algae are either passed up through multiple levels of the food web, or their remains sink as dying cells or as zooplankton fecal pellets. The remains of the algae that settle in the deeper water and on the seabed are decomposed by bacteria. This decomposition uses the dissolved oxygen contained in the water. If the oxygen is not replenished, such as when the water column is stratified, or layered, so that oxygen from the atmosphere cannot reach the bottom, then most of the oxygen



Fish kill, Grand Isle, LA, 1990, (K. St. Pé, 1990)

in the water is used up, leaving little or no oxygen for the aquatic animals to use (U.S. DOI website). With little or no oxygen left in the water, fish leave the area while less mobile animals die due to lack

of adequate oxygen (Ferber 2001). The stratification is controlled primarily by freshwater discharge of the Mississippi and Atchafalaya rivers, along with summer warming of the surface waters. Stratification is maintained in calm spring and summer weather but is broken down by fall and winter storms.



Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University Funded by: NOAA, Center for Sponsored Coastal Ocean Research

What are the sources of the nutrients?

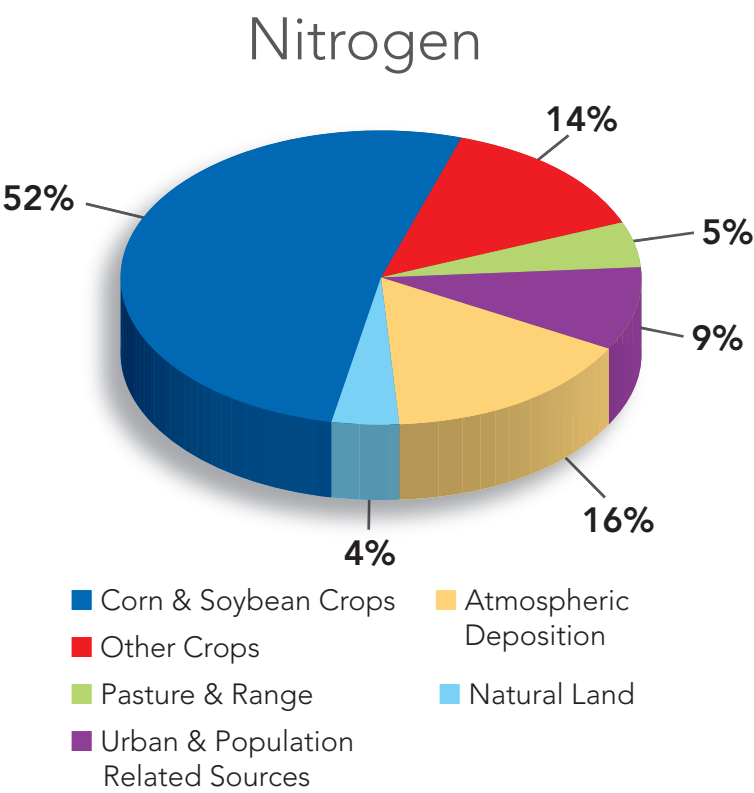
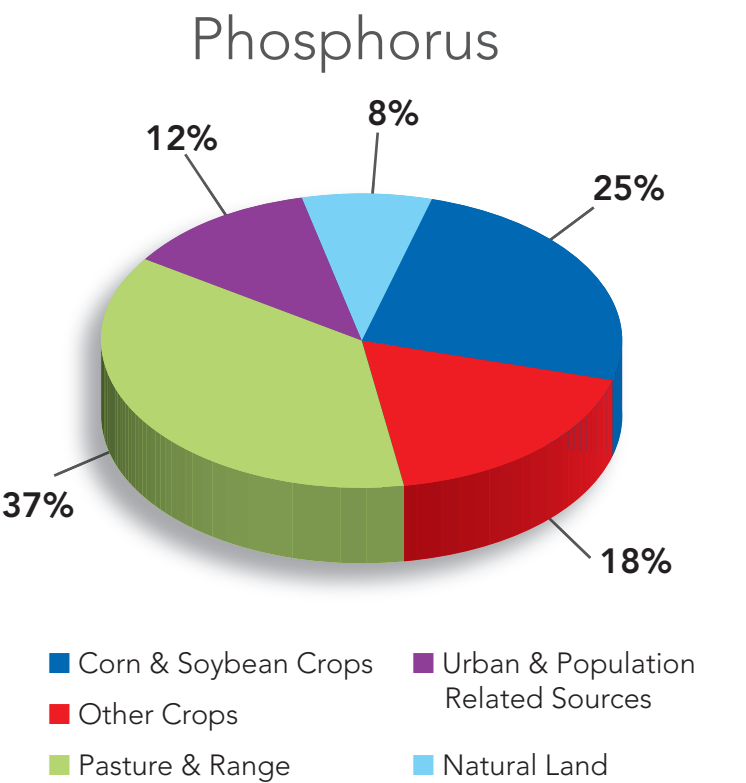
Nutrients can come from two sources: point sources and nonpoint sources. A point source is a water discharge that enters a water body from easily identifiable places (Alabama Smart Yards 2010). Common point sources include discharges from factories and sewage treatment plants. A nonpoint source is water discharge that cannot be traced back to any one source (Alabama Smart Yards 2010). Examples of nonpoint nutrient sources include agricultural fertilizers, fertilizers applied to golf courses and lawns, atmospheric deposition of nitrogen, and erosion of soil containing nutrients (U.S. DOI website). It is estimated



The Mississippi River turbidity plume entering the blue water of the Gulf of Mexico. Photo by N. Rabalais.

that 90% of the nutrient load to the Gulf is derived from nonpoint sources and, of these, agricultural sources dominate, but urban nonpoint sources are also a significant source. Point sources are 10% of the nutrient load and these are principally from urban areas (Alexander et al. 2008) (see figure 2 for an analysis of point and nonpoint sources of nutrients entering the Gulf of Mexico).

Point and Nonpoint Sources of Nutrients Delivered into the Gulf of Mexico



Facts about hypoxia in the northern Gulf of Mexico

How much of the U.S. drains into the Gulf of Mexico?

The Mississippi and Atchafalaya rivers drain 41% of the lower 48 United States, which accounts for 90% of the fresh water that enters the northern Gulf of Mexico. This fresh water releases about 1.6 million metric tons of nitrogen and 0.1 million metric tons of phosphorus into the Gulf each year (Goolsby et al. 1999).

What is the size of the Gulf of Mexico hypoxic zone?

The northern Gulf of Mexico hypoxic zone is the largest hypoxic zone in the United States, and it is the second largest human-caused area of coastal water hypoxia on earth. In recent years, the hypoxic zone in the Gulf of Mexico averaged 17,000 km², about 7,700 square miles (Petrolia and Gowda 2006). In 2002, it reached 22,000 km², about 8,500 square miles, an area about the size of Massachusetts (Rabalais, Turner and Scavia 2002; Rabalais et al. 2007a).

What historical changes have occurred in the hypoxic zone?

The northern Gulf of Mexico hypoxic zone was first recorded on the continental shelf in the early 1970s. This zone of hypoxia has been persistent ever since consistent data collection on its distribution and dynamics began in 1985 (Rabalais, Turner and Scavia 2002; Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico 2009). Retrospective analyses of sedimentary records and model hindcasts suggest that hypoxia in this region has intensified since the 1950s and that large-scale hypoxia began in the 1970s (reviewed in Justić et al. 2007, Rabalais et al. 2007b). The areal extent of the hypoxic zone, monitored in mid-summer since 1985,



Photo credit: NOAA



has increased from an average of 6,900 km² from 1985-1992 to 16,900 km², about 6,500 square miles, from 1993-2010, (updated from Rabalais et al. 2007a). These observations indicate the spatial extent of hypoxia is enlarging.

What is the average duration of the zone each year?

Gulf hypoxia can begin in late February and last through mid-November. It is most severe from June through August



Photo credit: NOAA



Photo credit: NOAA

(Rabalais et al. 2007a). The Gulf hypoxic zone occurs at a crucial time of year for commercial and recreational fisheries and threatens the economy of the Gulf (National Centers for Coastal Ocean Science: Gulf of Mexico Hypoxia Assessment 2000; EPA SAB 2007).

What disrupts hypoxia (hurricanes, winds, less fresh water, etc.)?

Hypoxia in the Gulf of Mexico is a seasonal phenomenon dependent in part on the cycle and strength of the winds for establishing the conditions of strong stratification that prevent oxygen replenishment in the bottom waters. During the hypoxia season, tropical storms and hurricanes may temporarily reduce hypoxia due to the mixing of stratified waters that occurs during these events (Rabalais et al. 2007a; Ariyama and Secor 2010). Although nutrient loads and freshwater discharge were sufficient to develop hypoxia in June 1998, the historical low discharge of the Mississippi River that summer resulted in no stratification and therefore a small area of hypoxia (Rabalais, Turner and Scavia 2002). Disruption by tropical storms led to less hypoxia than expected in 2003, 2005, 2006 and 2010.

What efforts are under way to reduce the hypoxic zone?

The interagency Mississippi River Gulf of Mexico Watershed Nutrient Task Force (<http://www.epa.gov/msbasin/taskforce.htm>) was established in the fall of 1997 as part of a process of considering options for responding to the northern Gulf of Mexico dead zone. In 2001, the task force issued an action plan that set a goal to reduce the size of the hypoxic zone to 5,000 km² by 2015 (based on an average of 5 years). The action plan, which included 11 specific implementation actions, suggested that a 30% reduction in nitrogen load was needed to reach the goal. A U.S. Environmental Protection Agency Science Advisory Board Science Reassessment updated the science on Gulf hypoxia in support of a revised action plan under an adaptive management framework. This information has been incorpo-

rated into a 2008 Gulf Hypoxia action plan (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2008), which retains the coastal goal of reducing the hypoxic zone areal extent to 5,000 km² by 2015, but calls for nutrient loading reduction targets of 45% for both nitrogen and phosphorus, based on revised model predictions. To learn more go to http://water.epa.gov/type/watersheds/named/msbasin/msbasin_index.cfm.

Additionally, the Gulf of Mexico Alliance (GOMA), a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas, has identified six priority issues that are regionally significant and can be effectively addressed through increased collaboration. One of the six priority issues is nutrients and nutrient impacts. A team of state, federal, and academic professionals makes up the GOMA Nutrient Priority Issue Team. This team is currently implementing nutrient-reduction initiatives throughout the Gulf. To learn more go to <http://www.gulfofmexicoalliance.org>. These are two of the numerous efforts underway to reduce the hypoxic zone in the Gulf of Mexico.



Photo credit: NOAA

How can you help?

As citizens, we each can contribute to reducing the size of the hypoxic zone through our individual actions. Here are a few suggestions:

- Fertilizer run-off from our yards, fields, and lands contribute to the nutrient loading. You can help reduce this by becoming educated on proper fertilization practices or by minimizing your use of fertilizers overall.
- Preserve land adjoining rivers and streams. This land helps prevent nutrient runoff (Bledzki 2009).
- Support the protection and restoration of natural wetlands and construction of artificial wetlands that can help reduce nutrients before they enter streams.
- Support best waste-water management and treatment practices in your community.

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http://water.epa.gov/type/watersheds/named/msbasin/msbasin_index.cfm

www.gulfhypoxia.net