

Current Ocean Studies

1:

Ocean Dead Zones - Interaction Among Earth's Sub-systems

***Note:** This Activity is the same as AMS Ocean Studies' Current Ocean Studies 1 from Preview Week. Students only need to complete the Activity once.*

Do Now:

1. Print this file, if directed by your instructor.
2. Read the *Weekly Ocean News* file, print if directed to do so by your instructor.
(**Note:** Check the AMS Ocean Studies website during the week as breaking ocean news stories may have been added.)

Welcome to *AMS Ocean Studies*. This is the first of weekly Current Ocean Studies which supplement and build upon the corresponding chapter investigations of the *AMS Ocean Studies Investigations Manual*. We hope your use of current environmental information will become an engaging experience. We encourage your exploration of the AMS Ocean Studies website products.

To Do Investigation:

1. Reference: Chapter 1 in the *AMS Ocean Studies* text.
2. Complete Investigations 1A and 1B in the *AMS Ocean Studies Investigations Manual* as directed by your instructor.
3. Complete this online-delivered *Current Ocean Studies* activity if directed by your instructor.

Introduction:

On 11 December 2008, the National Research Council published a report urging the U.S. Environmental Protection Agency and the U.S. Department of Agriculture to jointly establish an initiative leading to the mitigation of nutrient pollution in the Mississippi River basin and the northern Gulf of Mexico. The scientists authoring the report called for immediate government action to reduce urban and Midwest farmland runoff blamed for feeding a broad and expanding lifeless swath of water, called a “dead zone,” which forms off the Louisiana and northeastern Texas coasts every summer.

A prime example of the interconnectedness of ocean, land, and impacts of human activity in the Earth system is the increase in number and intensity of such dead zones. Dead zones are ocean areas where dissolved oxygen in bottom and near-bottom waters declines to deadly proportions. Such areas of the seafloor with too little oxygen for most marine life are produced when excess nutrients, especially nitrogen and phosphorus compounds, enter coastal surface waters and spur algal blooms. When the algae die, they sink to the seafloor. Their decomposition consumes the oxygen dissolved in the bottom waters,

leaving a “hypoxic” (low oxygen) or “anoxic” (no oxygen) environment that is lethal to many marine species.

1. Ocean dead zones are primarily a coastal phenomenon. It has been estimated that over 400 such areas exist worldwide (see http://www.eurekalert.org/pub_releases/2008-08/viom-ssc081108.php). A dead zone was first reported in the Chesapeake Bay in the 1930s. Most are seasonal, typified by the largest dead zone in the United States which expands off the coast of Louisiana and Texas in late spring and summer. It results from the Mississippi River system which transports huge quantities of nutrients originating as farm fertilizers and organic wastes to the Gulf of Mexico. **Figure 1** displays the drainage system of the Mississippi River and its tributaries that drain about 40% of the coterminous U.S. Consequently, Iowa farmers fertilizing their land to increase corn crop yield are contributing to a key stressor on marine ecosystems over a thousand miles away that ranks with over-fishing, habitat loss, and harmful algal blooms as global environmental problems. This demonstrates clearly that human activity far from the ocean [can]cannot] have dramatic effect on the ocean.



Figure 1. The Mississippi River and its tributaries that drain into the Gulf of Mexico.
[Goddard Space Flight Center/NASA]

2. **Figure 2** graphically depicts how the Gulf of Mexico dead zone forms. During the spring, relatively warm freshwater discharge from the Mississippi River system flows into the Gulf and floats over the [more]less] dense seawater. This surface water layer acts as a barrier that prevents the replenishment of dissolved oxygen in the seawater from the overlying atmosphere.

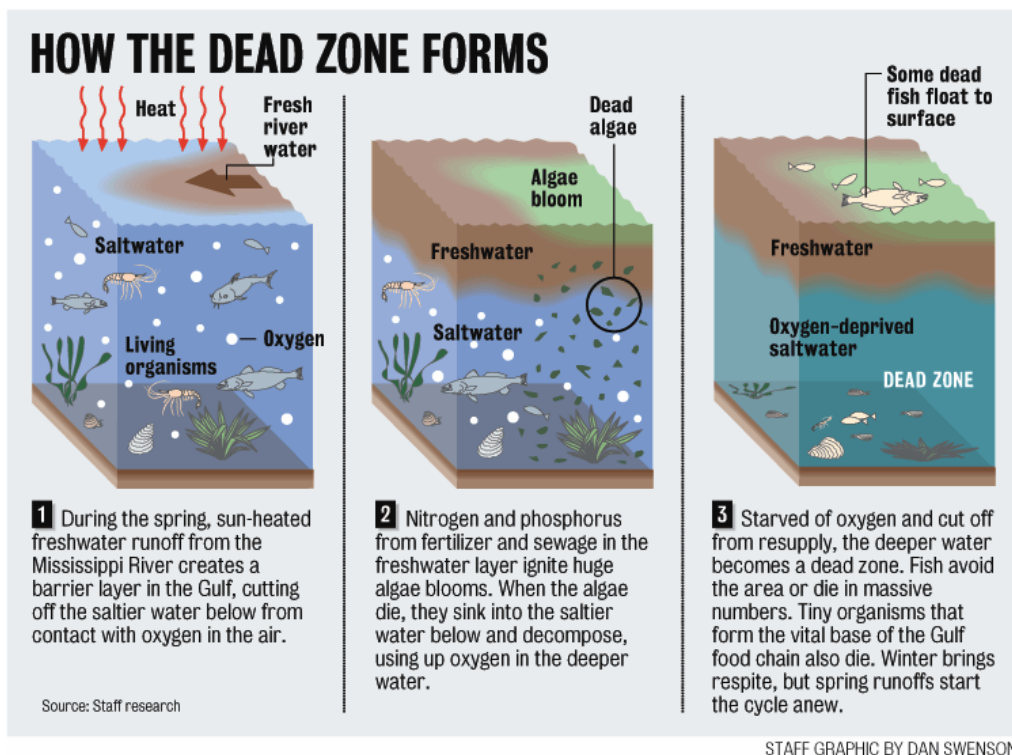


Figure 2. How the Dead Zone Forms. [*The Times-Picayune*, http://blog.nola.com/graphics/deadzone_how061007.gif]

[Seeing it in motion: A Flash animation describing the nutrient process that leads to hypoxia in the northern waters of the Gulf of Mexico can be found at: http://www.gulfhypoxia.net/Overview/hypoxia_flash.asp.]

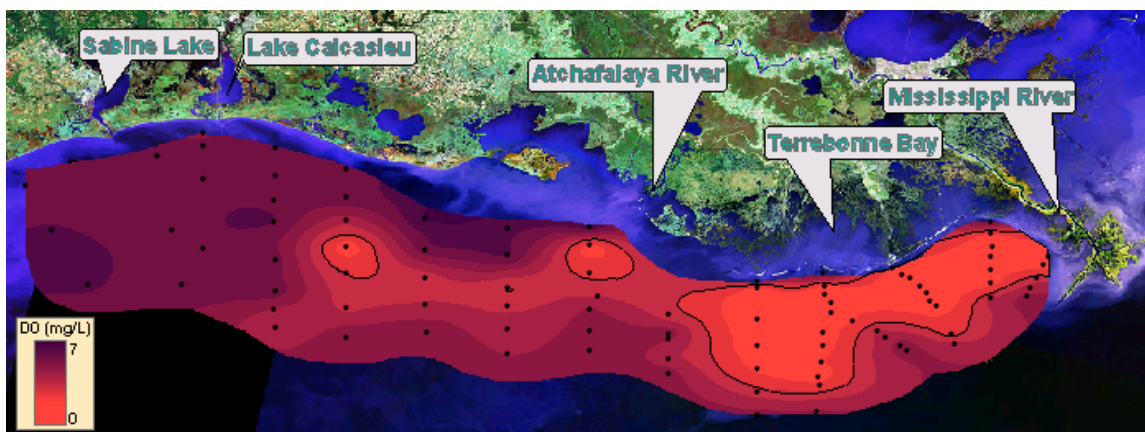
- The nutrients, including those from fertilizer runoff and from sewage discharged into the Mississippi River system, ignite algal blooms in the warmed surface water subjected to the increasingly intense sunlight during spring that remains strong into summer. The dead algae then sink and begin to decompose as they settle through the underlying seawater to the ocean bottom. The decomposition process results in the **[(loss)(gain)]** of dissolved oxygen in the deeper seawater.

Dissolved oxygen is an essential ingredient for sustaining life in the marine food chain. With little or no oxygen, commercially important fish and shellfish (e.g., crabs and oysters) die or are driven from their habitat. The result is the creation of a dead zone in bottom and near-bottom waters. The Gulf of Mexico dead zone typically persists until late summer and into early autumn when passing storms, including hurricanes, and cooler temperatures act to stir and break up the layered water structure.

- Figure 3** depicts the bottom-water dissolved oxygen (DO) concentration in milligrams per liter (mg/L) along the Gulf of Mexico coast extending from Louisiana to eastern Texas as observed 18-23 July 2009. The area shaded red essentially shows where bottom-water dissolved oxygen values were measured. The lighter the red

shading, the lower the dissolved oxygen concentration. The dark isoline (line of constant value) in the figure surrounding the lighter red shadings has a value of 2 mg/L. Dead zones are generally defined as places where the dissolved oxygen concentration falls below 2 mg/L. Based on this criterion, the figure reveals the centers of [(1)(2)(3)] dead zones in the sample area.

Bottom-Water Dissolved Oxygen 18-23 July 2009



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

Figure 3. Gulf of Mexico Dead Zone Bottom Dissolved Oxygen, 18-23 July 2009.
[Louisiana Universities Marine Consortium (LUMCON)]

The size of the 2009 low-oxygen Gulf of Mexico dead zone, as measured from the Louisiana Universities Marine Consortium's research vessel *Pelican* by a group of scientists led by Dr. Nancy Rabalais, extended over 8,000 square kilometers (just over 3,000 square miles). The 2009 dead zone was surprisingly small, since the average over the past five years is 15,670 square kilometers (6,000 square miles). A number of factors determine the size of the dead zone (e.g., in July 2009 the flow of the Mississippi River fell below average).

Figure 4 shows the history of the size of the Gulf of Mexico dead zone since 1985. Included on the graph are horizontal dashed lines indicating the average size over the period of record, the 5-year running average (average of the most recent five years), and the goal size sought by some attempting to reduce the human impact on the aquatic system.

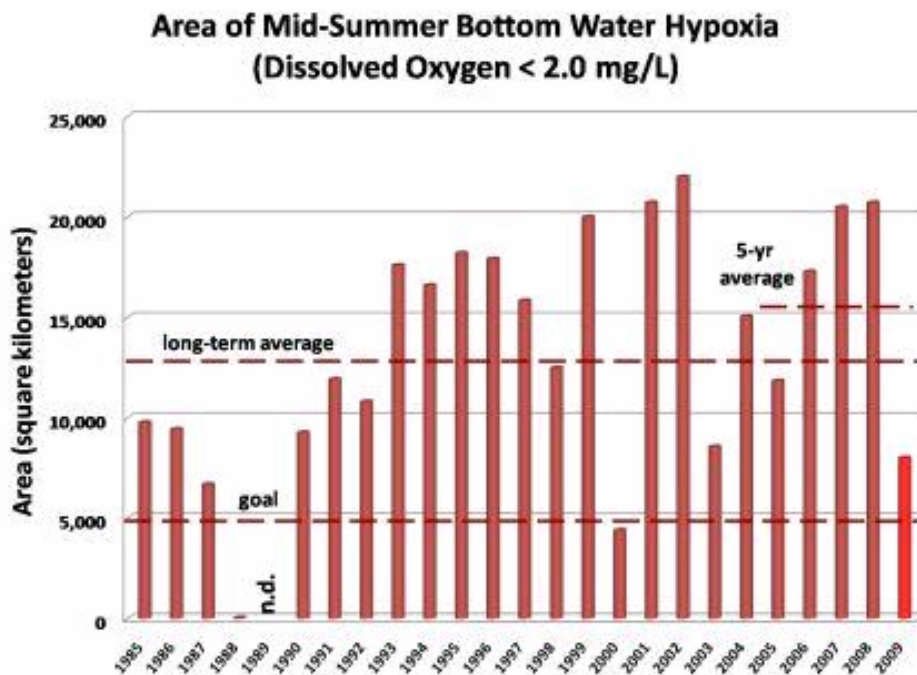


Figure 4. Annual maximum areas of mid-summer Gulf of Mexico dead zone, 1985-2009. [Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, Louisiana State University]

- Figure 4 shows that in 2009 the Gulf of Mexico experienced a dead zone that was about [(half)(the same as)(double)] the size of the average dead zone over the most recent five-year period.
- Figure 4 shows that over the period of record, there has been considerable variability in the size of the mid-summer Gulf of Mexico dead zone. At the same time, it shows a general long-term trend toward [(lower)(steady)(higher)] annual maximum areas of mid-summer Gulf of Mexico dead zones.

The phenomenon of dead zones, an example of cultural eutrophication (accelerated process of nutrient and sediment concentration in an aquatic system due to human activity), clearly evidence growing human impacts on the ocean environment. It, along with other observational evidence, demonstrates that we live in and are part of an Earth system. It also shows that no matter where we live, our actions can impact all the sub-systems of the Earth, including the ocean.

To learn more about the National Research Council report, *Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico*, go to: <http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=12544>. To learn more about the 2009 Gulf of Mexico dead zone, go to the LUMCON Hypoxia Site: <http://www.gulfhypoxia.net/>.

If directed by your instructor, place the answers to this Current Ocean Studies on the [Current Ocean Studies Answer Form](#) linked from the *AMS Ocean Studies website*.

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