

CENTRAL CASE STUDY

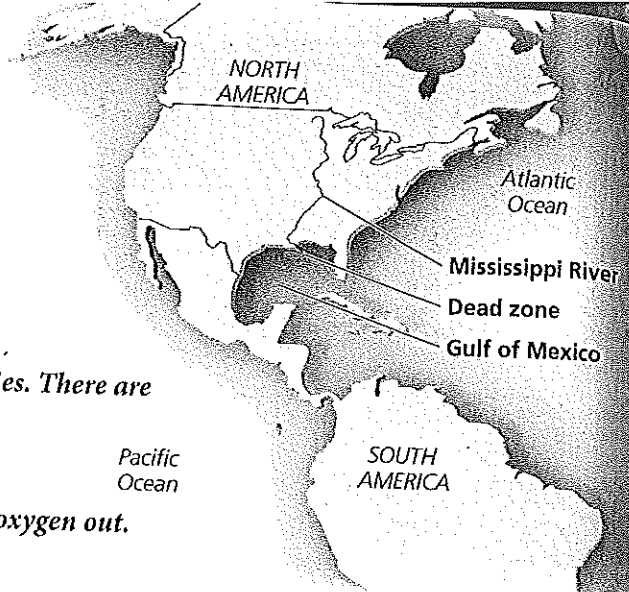
The Gulf of Mexico's "Dead Zone"

"In nature there is no 'above' or 'below,' and there are no hierarchies. There are only networks nesting within other networks."

—Fritjof Capra, theoretical physicist

"Let's say you put Saran Wrap over south Louisiana and suck the oxygen out. Where would all the people go?"

—Nancy Rabalais, biologist for the Louisiana Universities Marine Consortium

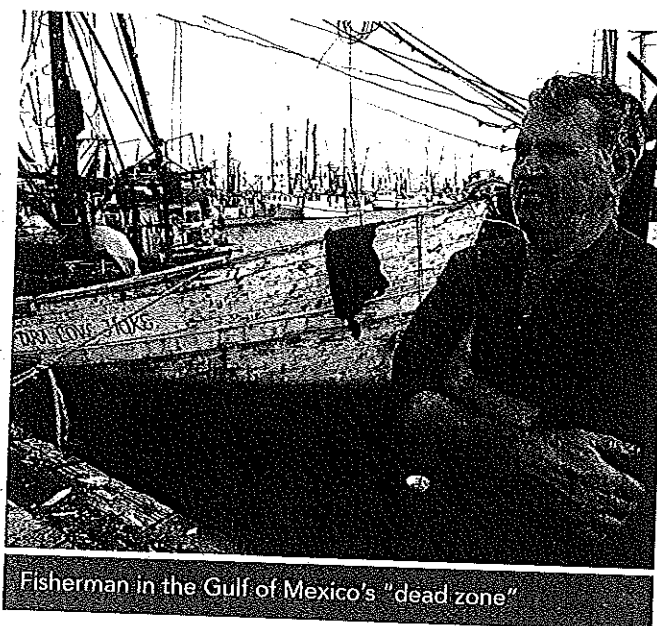


Each year, Louisiana's fishermen ply the rich waters of the Gulf of Mexico and send a billion pounds of shrimp, fish, and shellfish to our dinner tables.

But in recent years, fishing in the Gulf has become difficult. Catches of shrimp, menhaden, and other common species are just half of what they were in the 1980s. These fisheries began declining years before oil gushed from the Deepwater Horizon drilling platform and fouled the region in 2010 (pp. 445, 447, 547–548). And they began before Hurricane Katrina and Hurricane Rita pummeled the region in 2005 and left boats, docks, and marinas in ruins. These disasters were like adding insult to injury, worsening a long decline already underway.

The reason for the decline? Each year billions of marine organisms have been suffocating in the Gulf's "dead zone," a region of water so depleted of oxygen that organisms are killed or driven away.

The low concentrations of dissolved oxygen in the bottom waters of this region represent a condition called **hypoxia** (see Figure 5.4, p. 114, and **THE SCIENCE BEHIND THE STORY**, pp. 112–113). Aquatic animals obtain oxygen by respiring through their gills, and, like us, these animals will asphyxiate if deprived of oxygen. Fully oxygenated water contains up to 10 parts per million (ppm) of oxygen. When concentrations drop below 2 ppm, creatures will leave, or die.



Fisherman in the Gulf of Mexico's "dead zone"

The Gulf's dead zone appears each spring and grows through the summer and fall, beginning in Louisiana waters offshore from the mouths of the Mississippi and Atchafalaya rivers. The dead zone reached its largest size in 2002 when it covered 22,000 km² (8,500 mi²)—an area larger than New Jersey. Shrimp boats came up with nets nearly empty. One shrimper derided his

meager catch as "cat food." Others, ironically, said they hoped a hurricane would strike and stir some oxygen into the Gulf's stagnant waters.

What's starving these waters of oxygen? Scientists studying the dead zone have identified the culprit: modern Midwestern farm practices and other human impacts hundreds of miles away. Farmers throughout the Mississippi River's vast watershed use fertilizers to nourish their crops. Rain and runoff carry excess nitrogen and phosphorus from these fertilizers off the fields and into streams and rivers, eventually flushing these nutrients down the Mississippi River. As this nutrient pollution from farms heads downriver toward Louisiana and the Gulf, other sources—urban runoff, industrial discharges, fossil fuel emissions, and municipal sewage outflow—add additional nitrogen and phosphorus pollution to the river (**FIGURE 5.1**).

Once the excess nutrients reach the Gulf, they trigger blooms of plankton in the surface waters. As

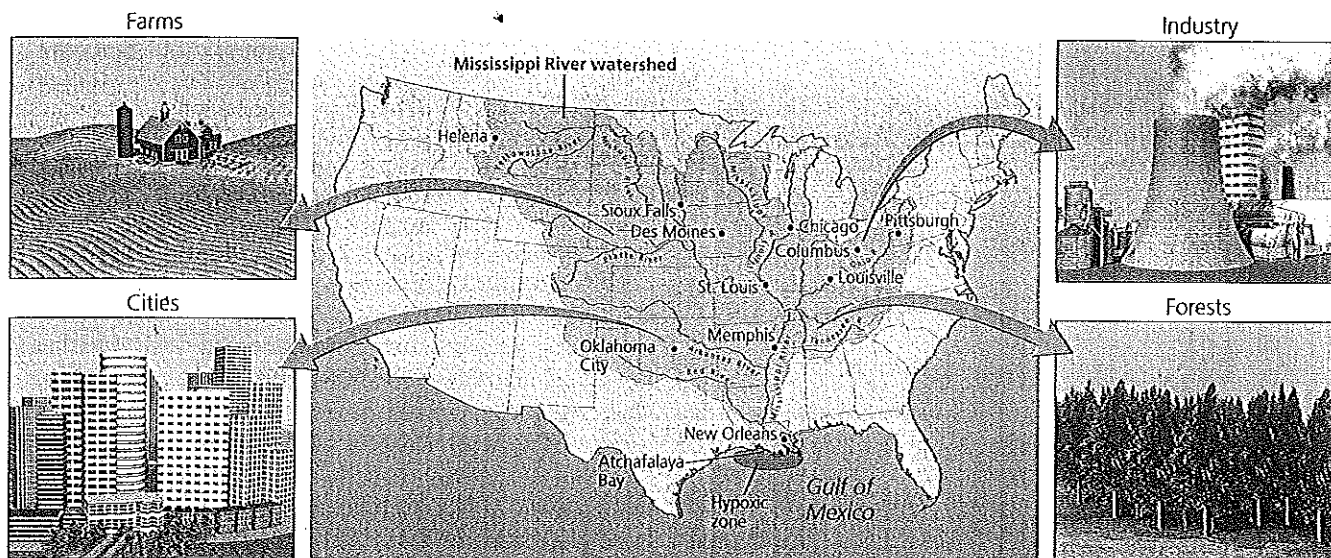


FIGURE 5.1 ▲ The Mississippi River system is the largest in North America. The river's watershed encompasses 3.2 million km² (1.2 million mi²), or 41% of the area of the lower 48 U.S. states. The river carries water, sediment, and pollutants from a variety of sources downriver to the Gulf of Mexico, where nutrient pollution has given rise to a hypoxic zone.

the masses of plankton begin to die and drift toward the bottom, they nourish bacteria, which also become overabundant. Bacteria need oxygen, and as they decompose the masses of dead plankton, they deplete dissolved oxygen from the bottom waters.

In 2010, scientists debated whether the Deepwater Horizon oil spill was worsening the dead zone. An explosion of oil-eating bacteria would worsen the hypoxia—but if oil was killing phytoplankton, that could lessen hypoxia. As of late summer when this book went to press, the dead zone was larger than expected, leading many researchers to suspect that the oil spill had worsened the dead zone.

Responding to the links that scientists have found between the dead zone and nutrient pollution from far upriver, U.S. government regulators have proposed that farmers in states such as Ohio, Iowa, and Illinois cut down on fertilizer use. Farmers' advocates protest that farmers are being singled out while urban pollution sources are ignored. Meanwhile, scientists have documented coastal dead zones in 400 other areas throughout the world, from Chesapeake Bay to Oregon to Denmark to the Black Sea. The story of how researchers determine the causes of these dead zones—and how we as a society respond—involves understanding environmental systems and the complex behavior they exhibit.

EARTH'S ENVIRONMENTAL SYSTEMS

Our planet's environment consists of complex networks of interlinked systems. These include physical systems ranging

from matter and molecules up to magma and mountains (Chapter 2). They include biological systems ranging from organisms and populations (Chapter 3) to communities of interacting species (Chapter 4). At the level of the ecosystem, they involve the interaction of living creatures with the nonliving entities around them. Earth's systems encompass cycles involving rock, air, and water that shape our landscapes and guide the flow of chemical elements and compounds that support life and regulate climate. We depend on these systems for our very survival.

Assessing questions holistically by taking a "systems approach" is helpful in environmental science, in which so many issues are multifaceted and complex. Such a broad and integrative approach poses challenges, because systems often show behavior that is difficult to predict. The scientific method (pp. 10–12) is easiest when researchers can isolate and manipulate small parts of complex systems, focusing on manageable components one at a time. However, environmental scientists are rising to the challenge of studying systems holistically, helping us to develop solutions to problems such as the Gulf of Mexico's hypoxic zone.

Systems show several defining properties

A **system** is a network of relationships among parts, elements, or components that interact with and influence one another through the exchange of energy, matter, or information. Earth's environmental systems receive inputs of energy, matter, or information, process these inputs, and produce outputs. As a system, the Gulf of Mexico receives inputs of fresh water, sediments, nutrients, and pollutants from the Mississippi and other rivers. Shrimpers and fishermen harvest some of the Gulf system's output: matter and energy in the form of shrimp and of fish. This output subsequently becomes input to the nation's economic system and to the digestive systems of all of us who consume the seafood.