

HYPOXIA AND THE DEAD ZONE IN THE GULF OF MEXICO: IS IT THE MISSISSIPPI RIVER'S FAULT?

GRADES 5 - 8
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TIME ALLOTMENT:

Introductory Activity: 20 minutes
Learning Activity: Two 50 minute periods
Culminating Activity #1: 50 minutes
Culminating Activity #2: 30 minutes

OVERVIEW:

The Mighty Mississippi—Old Man River—the longest river in the United States. The Mississippi River flows 2,348 miles from its source in northwestern Minnesota to its mouth in the Gulf of Mexico. The Mississippi River watershed is composed of several thousand smaller watersheds that drain much of the nation's most productive agricultural and industrial regions. These areas contribute a large amount of the pollution that eventually ends up in the Gulf of Mexico. Due to the huge volume of nutrients from fertilizers, industrial discharges, sewage treatment discharges, and other sources, a huge area known as a dead zone has formed in the Gulf of Mexico. This had had an enormous impact on the biological diversity of the Gulf and the economic base created by the fishing industry.

Dead zones are created when areas of high biodiversity are depleted of the necessary oxygen they need to survive, creating a hypoxic or anoxic environment. In this lesson, students learn the causes of hypoxia, the characteristics of a watershed, and how the actions and management practices of people can both negatively and positively affect aquatic ecosystems far away.

SUBJECT MATTER: Environmental Science,
Geography



LEARNING OBJECTIVES:

Students will be able to:

- Define nutrient, eutrophication, phytoplankton, zooplankton, anoxia, and hypoxia
- Explain that excess nutrients enter a water body from different sources
- Explain the relationship between nutrient enrichment and oxygen depletion in water bodies
- Explain how nutrient enrichment and oxygen depletion creates dead zones in water bodies
- Trace the Mississippi River from its source to its mouth
- Identify the tributaries that contribute water to the Mississippi River
- Identify the source for most of the nutrients entering the Mississippi River

STANDARDS:

National Science Education Standards

<http://bob.nap.edu/html/nses/html>

Content Standard F: Populations, resources, and environments and science and technology in society

Louisiana Science Frameworks:

State Standards for Curriculum Development

<http://www.doe.state.la.us/doe/assessment/standards/SCIENCE.pdf>

LS-M-C4: Explaining the interaction and interdependence of nonliving and living components within ecosystems;

LS-H-D4: Exploring how humans have impacted ecosystems and the need for societies to plan for the future;

SE-M-A1: Demonstrating knowledge that an ecosystem includes living and nonliving factors and that humans are an integral part of ecosystems;



GE Fund



- SE-M-A2:** Demonstrating an understanding of how carrying capacity and limiting factors affect plant and animal populations;
- SE-M-A3:** Defining the concept of pollutant and describing the effects of various pollutants on ecosystems;
- SE-M-A4:** Understanding that human actions can create risks and consequences in the environment;

Louisiana Geography Standards

<http://www.lcet.doe.state.la.us/doe/conn>

- E-1B-E5:** Identifying the major goods and services produced in the local community and state;
- G-1B-M2:** Identifying and describing significant physical features that have influenced historical events;
- G-1D-M1:** Analyzing and evaluating the effects of human actions upon the physical environment;
- G-1D-M4:** Identifying problems that relate to contemporary geographic issues and researching possible solutions.

MEDIA COMPONENT:

Video:

Enviro-Tacklebox™ , Hypoxia: The O₂ Blues—an LPB Production—investigates the effects of nutrient enrichment and the development of hypoxic conditions in coastal waters, especially the Gulf of Mexico. Students learn about phytoplankton, zooplankton, algal blooms, oxygen depletion, hypoxia, and anoxia and their effects on the fishing industries of coastal Louisiana.

Web site:

Gulf of Mexico “Dead Zone” <http://www.americanrivers.org/mississippiriver/deadzone.htm> This Web site provides information about the size of and sources of pollution contributing to the dead zone in the Gulf of Mexico.

Do-s and Don-t-s Around the Home <http://www.epa.gov/owow/nps/dosdont.html> At this Web site are suggestions for ways to protect surface and ground waters from non-point source pollution that can be done at your home.

MATERIALS:

Per Group:

- Enviro-scape Model

OR

- 5-10 rocks, ranging in size from 2 to 6 inches in height (each group that builds a model will need their own rocks)
- Square or rectangular aluminum tray, large enough to hold the rocks
- Thick plastic wrap
- White scrap paper, newsprint, or butcher paper

AND

- Large map of United States including the Gulf of Mexico
- Individual maps of United States that include major river systems and state boundaries
- Spray bottle
- Blue Food Coloring
- Water
- Pepper
- Red Powdered **Kool-Aid** or other brand drink mix

PREP FOR TEACHERS:

1. Preview the video *Hypoxia: The O₂ Blues* and **CUE** it to the segments indicated.
2. Obtain a large map of the United States showing the Mississippi River, its tributaries, and the Gulf.
3. Bookmark the needed Web sites on all computers.
4. Gather supplies for Learning activity.
5. **When using media, provide students with a FOCUS FOR MEDIA INTERACTION, a specific task to complete and/or information to identify during or after viewing of video segments, Web sites or other multimedia elements.**

INTRODUCTORY ACTIVITY:

1. Ask students if they can tell you what all organisms need to survive (water, oxygen, food). Ask, "What happens if one of these is removed? (the organism must leave or die). What are some reasons that organisms might not be able to get water, food, or oxygen? (none available, all used by other organisms) What might happen if a particular essential was removed completely from a habitat? (the organisms would leave the area or die) What do we call an area that has few or no organisms living in it?" (a dead zone) Tell students that a large area in the Gulf of Mexico has a dead zone in it that stretches many miles. Ask them what essential do they think is missing? (either food or oxygen). Ask, "How do you think a large body of water could be missing oxygen?" (Record all guesses on the board.) **Tell students that today they will learn what is causing a dead zone to be formed in the Gulf of Mexico.**
2. *Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to view the video to understand how oxygen can be removed from a body of water, causing the potential for a dead zone to form. CUE the video to the beginning of the tape and PLAY the video until you hear the words, "Let's step outside. I want to show you something," and you see them walking away from the fish tank.*
3. Ask, "What caused the cloudiness in the fish tank? (bacteria, fungi, microscopic organisms using the oxygen supply or the temperature could have gotten too warm, reducing the water's ability to hold oxygen) What depleted the oxygen supply? (the oxygen was used up by organisms that were in the process of decomposition and warm water can not hold as much oxygen as cooler water)"
4. *Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to find out what caused the oxygen depletion in the pond. RESUME the video until you see the words, "Holy Mackerel" and hear the fact about a person's blood becoming hypoxic.*
5. **Ask students,** "What are the millions of microscopic plants found floating in all water bodies?" (algae) "What organisms feed on them?" (zooplankton) "What causes this food chain to get out of balance?" (excess nutrients causing algae blooms) "What causes low oxygen levels in water?" (when these excess algae die, they are decomposed by bacteria, depleting the oxygen levels)"
6. *Provide students with a FOCUS FOR MEDIA INTERACTION, asking them, "What are the sources of nutrients that are getting into the Gulf of Mexico?" RESUME the video until you hear, "I think we've shown that it's a problem and that it's a problem people have contributed to and people can solve," and you see the map of the United States with the agricultural products. Pause the video and be prepared to resume from this point after the Learning Activity.*
7. **Ask,** "From where do the nutrients that end up in the Gulf of Mexico come from? (city wastewater treatment, industrial discharge, farmland fertilizer, and burning of fossil fuel)"

8. Show students the map of the United States. Have a student identify the Mississippi River. Ask students what facts they know about the Mississippi River. (Possible answers include: chief river of North America, longest river in United States, source is in Minnesota and mouth is at the Gulf of Mexico, major waterway to carry agricultural goods, industrial products, and raw materials, etc.)
9. Ask students to define a **watershed** (an area of land in which all precipitation collects and drains into a common body of water). Ask students to give the name of the watershed in which they live (the Mississippi River Basin Watershed or more locally, the Lake Pontchartrain Basin).
10. Give each student an outline map of the United States with the drawn rivers/tributaries of the Mississippi River Basin Watershed (Handout 1). Students should use a blue colored pencil to outline the Mississippi River from its source to its mouth. Use green pencils to outline each of the major contributing rivers to the Mississippi. Label them with the name of the river. Tell students that these rivers and the states they drain make up the Mississippi River Watershed.
11. Tell students, "Many of the activities that occur in these states create pollutants that potentially may end up in a tributary of the Mississippi River." Ask students, "How might these pollutants get from the tributary all the way to the gulf?" (Students should respond that the tributaries connect to the Mississippi and eventually empty into the Gulf of Mexico.) Tell students that they will be building a model of a watershed to observe how it drains several land areas and to see where all the water ends up.

LEARNING ACTIVITIES:

Adapted from: **Project Wet, Branching Out! Pg. 129**

Students will use a watershed model to demonstrate how pollutants from areas far away from a basin contribute to its pollution. Students can build their own watershed model or the teacher can use the Enviroscape Model to illustrate how water travels through a watershed.

1. To build the model, have students wrap the rocks in white paper and they lay them in the aluminum pan with the larger ones at one end and the smaller ones at the other end. Cover the rocks snugly with plastic wrap, tucking the plastic under the outer edges of the entire model. The created model should have at least two streams, preferably three, that extend toward the lower end of the pan. (Each group can make its own model or it can be done as a classroom model for the entire group to use.)
2. Tell students that the model represents a watershed. Have students observe the high and low areas of the watershed and predict where they think water will flow during a rainstorm. Using a spray bottle of blue-colored water, spray water at the top of the watershed. Have students observe the flow of water and identify the streams it traveled through to reach the basin at the bottom. Remind students about the rivers that flowed into the Mississippi before traveling on to the Gulf and compare them to the model.
3. Sprinkle a small amount of powdered Kool-Aid near the top of one of the streams and some pepper near the top of another stream. Tell students that this represents pollution that is being created nearby. Have them predict what will happen to the pollutants when it begins to rain. (Students should predict that the pollutants will enter the stream and travel down to the basin.)
4. Fill a spray bottle with blue-colored water. Spray water on the model by the pollutants and observe the flow of the pollutants. Ask students if their predictions were correct.
5. Ask students to use what they just observed to explain possible reasons for the dead zone in the Gulf of Mexico. (Students should mention that pollutants from high in the watershed travel down the Mississippi River and empty into the Gulf. These nutrients initiate an algal bloom. When the algae die and decompose, oxygen is depleted.)

CULMINATING ACTIVITIES:

Students will do research to find out where most of the nutrients that enter the Gulf of Mexico originate. *Provide students with a **FOCUS FOR MEDIA INTERACTION**, telling them to use the following Web sites to learn more about where exactly the pollutants in the Mississippi River Basin are coming from and what they can do around their homes to keep from contributing to the problem:* <http://www.americanrivers.org/mississippiriver/deadzone.htm> and <http://www.epa.gov/owow/nps/dosdont.html>.

1. Provide students with the Activity Sheet called ***What is Creating the Dead Zone in the Gulf of Mexico?*** (Handout 2) Have students work in pairs to answer the questions. Once students are finished, review answers using the answer key provided (Handout 3).
2. The video should be ready for viewing from the point where it was paused before doing the activity. *Provide students with a **FOCUS FOR MEDIA INTERACTION**, asking them to view the video to see how the pollution issue is being handled by those creating the pollution in the Mississippi River Basin.* **PLAY** the video until you see the farmer standing in his field and hear the words from the farmer, "So it's not only the farmer's responsibility, but everyone who uses fertilizers and anything that can run off into the groundwater. You've got to keep it safe, you've got to do it responsibly." **STOP AND FAST FORWARD** to the part of the video where Greg Grady is looking through the glass of the aquarium and says, "We've learned there's an important relationship between what goes in our water and the conditions that follow."
3. Ask students, "What are several ways that farmers are helping to prevent fertilizer and animal waste runoff from entering the rivers near their farms?" (not tilling the ground so many nutrients remain in the soil instead of flowing into nearby bodies of water, putting grass strips at the end of the field to absorb floating sediments, and fertilizing at the right temperature to help the nutrients be better absorbed into the ground). Ask students, "What do you think are some ways we can prevent polluting groundwater or surface water near our homes?"

CROSS-CURRICULAR EXTENSIONS:**LANGUAGE ARTS:**

- Access EPA's "Surf Your Watershed" Web site to access data about your local watershed. Find out what industries in your area contribute nutrients to the Mississippi River Basin and write a letter informing them of their contribution to the increasing dead zone in the Gulf of Mexico.

SCIENCE:

- Have students test different types of fertilizers on pond water to determine which ones encourage the most algae growth.

SOCIAL STUDIES:

- Have each student or group research the major industries of a city on the Mississippi River. The names of cities on the Mississippi River or one of its tributaries can be found by accessing the Web site: <http://www.irpt.net/miss-upmap.htm> or <http://www.irpt.net/miss-lomap.htm>. Determine which ones create potential pollution that could be contributing to the Dead Zone in the Gulf of Mexico. Create a large map and have each student or group share their research and locate the source of possible pollution on it. Discuss the ramifications of all of these cities discharging their pollution into the river and how they have contributed to the problem we have today.

COMMUNITY CONNECTIONS:

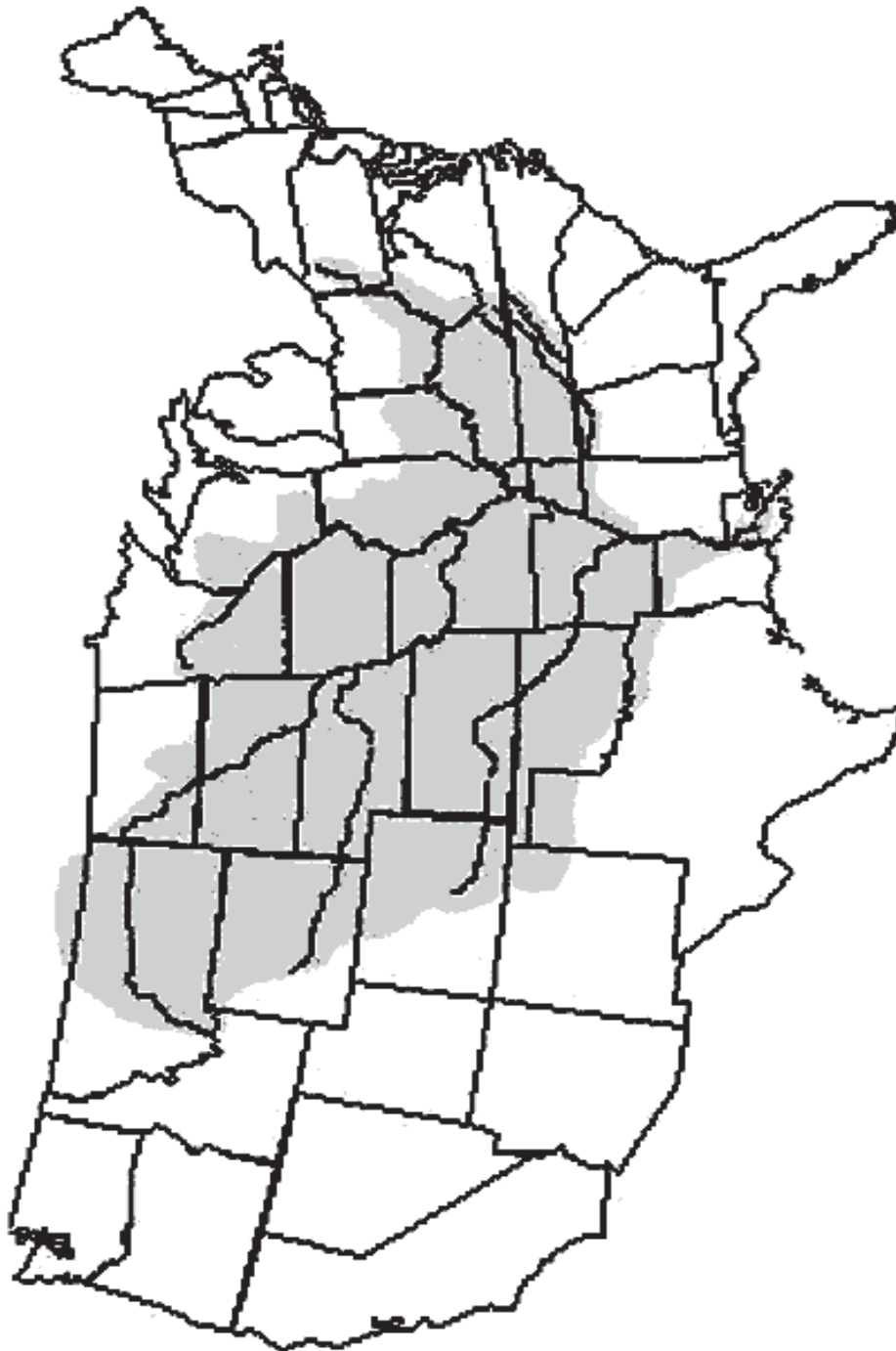
- Visit a farm that uses fertilizers on their crops or a livestock farm to see how they handle pollutants. If they are not using Best Management Practices, devise a method that might work for their farm and share it with them.
- Invite a representative from the State Department of Natural Resources to visit the class and discuss how they monitor the pollutants entering the Mississippi River.

STUDENT MATERIALS:

- Handout 1: Map of Mississippi River Watershed with the main tributaries of the Mississippi River
- Handout 2: ***What is Creating the Dead Zone in the Gulf of Mexico?*** Activity Sheet
- Handout 3: Answer Key for ***What is Creating the Dead Zone in the Gulf of Mexico?***

Handout # 1

Map of the Mississippi River Watershed including the main tributaries:



Map based on information from the NOAA Coastal Ocean Program
http://www.cop.noaa.gov/Fact_Sheets/NGOMEX.htm

Handout # 2

What is Creating the Dead Zone in the Gulf of Mexico?

Work with a partner to learn about the Dead Zone in the Gulf of Mexico.

Use the website: <http://www.americanrivers.org/mississippiriver/deadzone.htm> to find the answers to the following questions:

1. Approximately how large is the dead zone in the Gulf of Mexico?
2. How far does the dead zone stretch across the Gulf of Mexico?
3. What is the primary reason for the dead zone?
4. What states mostly contribute to the nitrogen washing into the Gulf of Mexico?
5. From streams in which two states does as much as 35 percent of the nitrogen washing into the Mississippi River originate?
6. What has caused the increase in the nitrate concentrations in the Mississippi River over the last one hundred years?
7. Name the sources and percentages of nitrogen and phosphorus that enter the Mississippi River.
8. What is the largest single pollution source entering the Mississippi River?

Use the website: <http://www.epa.gov/owow/nps/dosdont.html> to learn what you can do to protect surface and ground waters from becoming polluted. List one thing you can do about each topic:

- 1) Household chemicals:
- 2) Landscaping and gardening:
- 3) Septic systems
- 4) Water conservation

Handout # 3

**What is Creating the Dead Zone in the Gulf of Mexico?
(Answer Key)**

Work with a partner to learn about the Dead Zone in the Gulf of Mexico.

Use the website: <http://www.americanrivers.org/mississippiriver/deadzone.htm> to find the answers to the following questions:

1. Approximately how large is the dead zone in the Gulf of Mexico?
 - 20,000 square kilometers or 7, 728 miles
 - about the size of New Jersey
 - would extend from Chicago, Illinois to Des Moines, Iowa
2. How far does the dead zone stretch across the Gulf of Mexico?
 - from the Mississippi River west all the way to the Texas border
 - from very near shore along most of the Louisiana coast out to 100-foot water depths
3. What is the primary reason for the dead zone?
 - polluted runoff from Midwestern farmland
4. What states mostly contribute to the nitrogen washing into the Gulf of Mexico?
 - states in southern Minnesota, Iowa, Illinois, Indiana, and Ohio
5. From streams in which two states does as much as 35 percent of the nitrogen washing into the Mississippi River originate?
 - streams draining Iowa and Illinois
6. What has caused the increase in the nitrate concentrations in the Mississippi River over the last one hundred years?
 - the use of fertilizers
 - polluted runoff from farms and streets
7. Name the sources and percentages of nitrogen and phosphorus that enter the Mississippi River.
 - fertilizers applied to farms contribute 50 percent of nitrogen
 - animal manure contributes 15 percent of nitrogen
 - municipal and industrial sources contribute 11 percent
8. What is the largest single pollution source entering the Mississippi River?
 - fertilizers from farms

Use the website: <http://www.epa.gov/owow/nps/dosdont.html> to learn what you can do to protect surface and ground waters from becoming polluted. List one thing you can do about each topic:

- 1) Household chemicals:
- 2) Landscaping and gardening:
- 3) Septic systems
- 4) Water conservation