

# Dead Zones

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## How do humans affect the size of dead zones?

Students expand on their understanding of human disruption of ecosystems by looking at a more complex problem: the creation and expansion of dead zones. Students use their analysis of a variety of data to inform a debate on limiting human use of fertilizers to prevent dead zones.

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## Rationale and NGSS Integration

This Elaborate activity challenges students to apply their understanding of the core ideas of population dynamics and resource use, as well as human impacts on Earth, to the issue of dead zones. Students use what they have learned in the previous activities about population limits in ecosystems to analyze a more complex situation where both biotic and abiotic factors are being changed. This provides students an opportunity to expand their understanding of the complexity of stability and change, how that concept relates to the interactions and relationships in an ecosystem, and how they can be affected by changes in abiotic and biotic factors.

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## Activity Overview

In this Elaborate activity, students analyze data about nitrogen input, streamflow, and the size of dead zones. They use this data and additional evidence from a video to construct an explanation about the effect of these factors on the size of the dead zone in the Gulf of Mexico. They then gather additional evidence from a short reading to inform a debate on fertilizer use and dead zones.

## Activity 3.4

### Key Vocabulary

dead zone

### Materials and Advance Preparation

#### For the teacher

- Access to computer with Internet connection  
*The video clip, “Big River: A King Corn Companion | Agricultural Runoff and the Gulf of Mexico Dead Zone,” is available from PBS Learning Media. You may need to register for a free account to access the video. A direct link to the segment follows.*  
[http://ca.pbslearningmedia.org/asset/envh10\\_vid\\_deadzone/](http://ca.pbslearningmedia.org/asset/envh10_vid_deadzone/)
- 1 large computer monitor or projector

#### For each student

- Explanation Tool

### Teaching Summary

#### Getting Started

1. Introduce the concept of dead zones.

#### Doing the Activity

2. Students investigate the effects of abiotic factors on the size of dead zones.
3. Students construct an explanation for the effect of water flow on nitrogen input.

#### Follow-Up

4. Facilitate a class debate about fertilizer use and dead zones.
5. Revisit the Guiding Question.

## References

- Goolsby, D. & W. Battaglin (December 2000) Nitrogen in the Mississippi Basin – Estimating Sources and Predicting Flux to the Gulf of Mexico. United States Geological Survey. Retrieved July 2015 from <http://ks.water.usgs.gov/pubs/factsheets/fs.135-00.html>
- National Oceanographic and Atmospheric Administration. (August 4, 2014) NOAA-, EPA-supported scientists find average but large Gulf dead zone. (website). U.S. Department of Commerce. Retrieved July 2015 from [http://www.noaanews.noaa.gov/stories2014/20140804\\_deadzone.html](http://www.noaanews.noaa.gov/stories2014/20140804_deadzone.html)
- United States Geological Survey. (May 8, 2015) Streamflow and Nutrient Flux of the Mississippi-Atchafalaya River Basin and Subbasins Through Water Year 2014. (website). Retrieved July 2015 from [http://toxics.usgs.gov/hypoxia/mississippi/flux\\_estimates/delivery/graphics/index.html](http://toxics.usgs.gov/hypoxia/mississippi/flux_estimates/delivery/graphics/index.html)

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## Teaching Suggestions

### Getting Started

- 1. Introduce the concept of dead zones.** (10 minutes)
  - a. Have students read the introduction independently, in pairs, or as a class.

Review the map of the Mississippi Watershed with the students, making sure they understand that the entire watershed, including all of the fertilizer run-off from all of the farms, drains into the Gulf of Mexico (because water flows downhill). You may need to explain to students that most organisms that live under water get their oxygen from the dissolved oxygen in the water (not from the air). Note that the key vocabulary term, dead zone, is defined in the introduction as an area in a body of water where the water at the bottom has little or no dissolved oxygen. Have a short class discussion about how dead zones are created, based on the information given in the introduction. Students will learn more about this in the activity.

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### Doing the Activity

**2. Students investigate the effects of abiotic factors on the size of dead zones.** (25 minutes)

- a. Show the students the video segment on the dead zone in the Gulf of Mexico.

Ask the students to list any new information they have learned from the video, listing the students' answers on the board for them to reference.

- b. Have students work in groups of four to analyze and interpret the graph in Step 3.

You may need to work with individual groups, or the class as a whole, to help them understand the graph in Step 3 with two y-axes. Students should come to the conclusion that nitrogen input and water flow from the Mississippi Basin to the Gulf of Mexico are fairly closely correlated. Ask students why they think the correlation is not perfect. Students should be able to suggest additional factors affecting nitrogen input such as changes in fertilizer use by farmers upstream, storms and other weather conditions affecting when and how much water flows at different times of year, etc.

**3. Students construct an explanation for the effect of water flow on nitrogen input.** (15 minutes)

- a. Have students use the Explanation Tool to construct their explanations.

Depending on the class, you may wish to encourage students to try constructing their explanations without the scaffolding of the Explanation Tool, or to give individual students that option.

This is a good point to conclude the first class period for the activity.

### Follow-Up

**4. Facilitate a class debate about fertilizer use and dead zones.** (40 minutes)

- a. Have the students analyze data on dead zone size.

Assist students as needed with analysis of the graph on the size of dead zones in the Gulf of Mexico. Students should notice that the size of the dead zone does not necessarily have a direct correlation to the nitrogen input and water flow data from the previous graph. If necessary, have a short class discussion about other factors that might affect the dead zone size (changes in temperature, currents in the Gulf of Mexico, storms or other weather events that affect the Gulf, etc).

- b.** Have students complete the reading on the Gulf of Mexico dead zone.

Have students complete the reading in pairs or groups. Students should note from the data table in the reading that a majority of the nitrogen input in the Gulf of Mexico is from human-made sources.

- c.** Have the class conduct a Walking Debate to debate the question “Should fertilizer use be limited to help prevent dead zones?”

See the More Information section at the end of this activity for more details on how to conduct a Walking Debate. Designate one area of the room as “limit fertilizer use” and a second area as “do not limit fertilizer use.” If students are not relatively equally distributed at the beginning of the debate you may choose to assign them a viewpoint. For example, you could assign half the class to take the position they think a fisher would take, and half to take a farmer’s position. This debate provides an opportunity to evaluate students understanding of the connection to the nature of science crosscutting concept, science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. This is also a good time to briefly introduce the idea of constraints on potential solutions, an important concept in Chapter 5. Have student suggest possible solutions to the problem of dead zones, then ask what the limitations, or constraints, are on those solutions. For example, the solution of not using any fertilizer means farmers will not be able to grow as many crops and will make less money.

Note that for Analysis question 3, students may need some scaffolding to construct their answers. You may wish to draw a template on the board for students, with four numbered panels. Note the sample student response in the Suggested Answers to Analysis section.

## **5. Revisit the Guiding Question.** (5 minutes)

- a.** Revisit the guiding question, how do humans affect the size of dead zones?

At this point students should understand that the effect of humans on the size of dead zones is not entirely straightforward, but that there clearly is an effect due to human use of fertilizers. Have students add this example to the crosscutting poster for cause and effect if they have not done so already, as well as the phrase “dead zone” to the class word wall.

## Suggested Answers To Analysis

1. **What are the abiotic and biotic factors that are affected in a dead zone? How do they differ from a healthy ecosystem?**

**Assessment – DCI and CCC**

Use this question to assess students' understanding of the core idea of population dependence on environmental interactions (DCI – MS LS2.A.1) and cause and effect (CCC).

*In a dead zone abiotic factors that are affected include oxygen levels and the amount of nitrogen. The oxygen levels are much lower than in a healthy ecosystem and the nitrogen levels are much higher. The biotic factors that are affected are the amount of plankton, bacteria, and fish and other organisms. The plankton increase because of the higher nitrogen levels. When the plankton die they feed the bacteria, which increase and consume more oxygen. This causes the fish and other organisms to either die or leave the ecosystem. When nitrogen levels are lower, plankton remain at lower level, oxygen levels increase, and fish populations increase.*

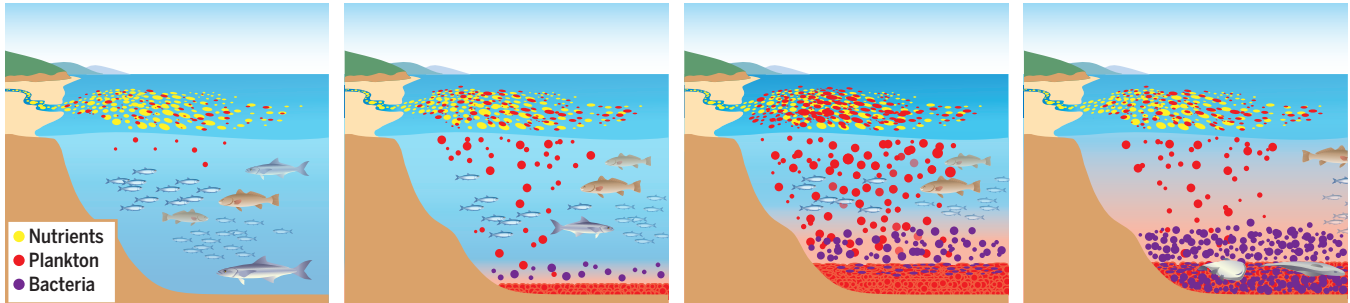
2. **How might an increase in the size of the dead zone in the Gulf of Mexico affect the red snapper fishery, or other fisheries?**

**Assessment – DCI and CCC**

Use this question to assess students' understanding of the core ideas of population dependence on environmental interactions and how the increase of human populations affects the Earth (DCI MS ESS3.C.2) and cause and effect (CCC).

*An increase in the dead zones might cause a decrease in the red snapper fishery, or other fisheries in the Gulf of Mexico, because there would not be enough oxygen for the fish to survive. This would mean fewer fish, and that the fishermen would not have as much to catch so they would make less money.*

3. Draw a diagram with four panels showing the main stages in the creation of a dead zone. The panel below[see student book] is an example of what the fourth panel in your diagram might look like. Include a caption for each panel that explains what is happening in the diagram.



*Panel 1: Nutrients in the water, like nitrogen, increase from runoff from farms*

*Panel 2: Plankton population increases. As they die they sink to the bottom.*

*Panel 3: An increase in dead plankton causes an increase in bacteria (decomposers).*

*Panel 4: Increased bacteria populations use up the oxygen, causing fish and other organisms to die or leave the ecosystem.*

## More Information

### Walking Debate

A walking debate allows students to express their opinions about an issue by moving from one area of the room to another. Each area represents a certain side of an issue. Students select an area to stand in based on the side of an issue they agree with. The “sides” then discuss the issue and present their arguments to the other groups. Students can opt to change their location if the presentations given change their opinions about the issue.

In asking students to choose a position and stand in the corresponding area of the room, the Walking Debate requires students to physically commit to a position. This serves several purposes. First, it requires that students take a position. Secondly, students will more clearly see the distribution of thoughts, ideas, or opinions among their classmates. Walking Debate allows students yet another way to practice identifying evidence and reasoning in a group setting, which is an important component of scientific argumentation.

Begin by identifying the question or issue that is being debated, and designate different parts of the classroom as representing certain points of view. For example, for the question “Has the zebra mussel had a positive or negative effect

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on the Hudson River ecosystem?” one area of the room would be designated as the “positive” area and another the “negative” area. Students walk to the area that best represents their point of view and talk within that group to come up with a convincing argument to bring people from other areas to their own area. The groups make their presentations, students ask questions of the other groups, and those who change their minds move to the area that represents their final position. Over the course of one activity, several activities, or a unit, the class may encounter more evidence related to the debate issue. If the first Walking Debate was successful, the teacher might give students a chance to repeat the debate and decide if they will change positions. It is helpful to have students keep a record of the evidence they will consider for the Walking Debate, especially when they are new to the strategy. Have students record their evidence on an index card to which they can easily refer during the debate. Students might do this in pairs when they are becoming familiar with the strategy.



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# Elaborate: Dead Zones

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## Materials and Advance Preparation

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### For each student

- Explanation Tool
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## Teaching Suggestions

### Getting Started

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### Doing the Activity

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  - b. Have students work in groups of four to analyze and interpret the graph in Step 3.
- 3. Students construct an explanation for the effect of water flow on nitrogen input.** (15 minutes)
  - a. Have students use the Explanation Tool to construct their explanations.

## Follow-Up

- 4. Facilitate a class debate about fertilizer use and dead zones.** (40 minutes)
  - a. Have the students analyze data on dead zone size.
  - b. Have students complete the reading on the Gulf of Mexico dead zone.
  - c. Have the class conduct a Walking Debate to debate the question “Should fertilizer use be limited to help prevent dead zones?”
  
- 5. Revisit the Guiding Question.** (5 minutes)
  - a. Revisit the guiding question, how do humans affect the size of dead zones?