

Catch Your Breath?

A Tale of Trying to Catch Critters Trying to Catch Their Breath

Answer Key

Get in the Zone



Compare the Dead Zone areas of each map and rank the years based on the size of the Dead Zone, starting with the largest and ending with the smallest.

1. 2002
2. 2001
3. 2004
4. 2005
5. 2003
6. 2001

Go with the Flow



Review the graphs of river flow and nitrogen flux data for the Mississippi River from 2000-2005, and answer the following questions.

1. Describe the pattern or trend you see over the course of the year in the data for each graph. Are there any similarities in the trends between the two graphs?

River flow tends to peak between late winter and early summer, and the amount of nitrogen carried by the river (nitrogen flux) also tends to peak at the same time of year. The trends in the two graphs closely mimic one another because the nitrogen flux is related to the river flow – as more water flows in the river, more nitrogen is carried to the Gulf of Mexico.

2. Describe how the trends in the data might relate to the Dead Zone, knowing that hypoxia in the northern Gulf of Mexico typically occurs during the summer.

Since the data shows that the highest river flows and nitrogen levels tend to occur in spring, it would appear that these two factors might play a role in causing the conditions that lead to the formation of the Dead Zone at anytime between late spring and early fall.

3. Compare the data for each year to the Dead Zone size map for that year. Does the data support your ranking of the Dead Zone sizes from largest to smallest?

In general, the size of the Dead Zone is larger in years when the river flow and nitrogen flux are higher.

This may not always be the case, however, as other factors can play a role in controlling the development and size of the Dead Zone. For example, the river flow and nitrogen flux data for 2003 would indicate that the size of the Dead Zone should be relatively close to other years such as 2002 or 2001. However, the map of the Dead Zone for 2003 shows a much smaller size than might be expected, leading one to believe that other factors can be involved in controlling the development and size of the Dead Zone.

Mixing it Up (or Down?)



Write down any ideas you have that might explain how the surface water could be mixed down to the bottom for such a large area of the northern Gulf of Mexico during the summer.

Surface and bottom waters in shallow areas of the ocean often form two distinct layers in the summer months. As the surface water is warmed by the sun, it becomes lighter and less dense than the colder water at the bottom. In addition, the surface water in coastal areas often contains fresh water from rivers, which is lighter and less dense (it has no salt!) than the saltwater. The differences in density caused by the temperature and salinity are enough to create two layers of water (surface and bottom) that do not mix very easily under normal conditions.

So what can cause these two layers to mix? One factor is temperature. As the warm surface water cools in the fall, it becomes denser and can eventually sink and mix with the bottom water.

But what about in the summer when hypoxia is happening? Think physical forces! Storms can easily mix surface water with deeper water in shallow areas of the ocean, and it's no secret that the Gulf of Mexico is prone to tropical storms during the summer months. A tropical storm or hurricane can easily disrupt the Dead Zone by mixing oxygen-rich surface water with hypoxic bottom water.



Did any tropical storms have an impact on the Dead Zone during 2000-2005?

Looking at the maps of tropical storms for 2003, it should be evident that two tropical storms (Tropical Storm Bill and Hurricane Claudette) passed through or near the northern Gulf of Mexico in early to mid-July, just prior to the annual dissolved oxygen sampling to determine the size of the Dead Zone. These storms had mixed the surface and bottom waters, disrupting the Dead Zone. This fact helps to explain why the 2003 Dead Zone was smaller than expected based on predictions using the river flow and nitrogen flux data only.

As the "Hint" in the activity suggests, tropical storms can disrupt the Dead Zone any time between early summer and late fall. But keep in mind that the scientists who measure the amount of

oxygen in the water and map the Dead Zone each year usually take samples only once in mid- to late July.

Therefore, any storms that happen after the sampling and mapping in late July could disrupt the Dead Zone, but these effects wouldn't show up on the Dead Zone maps. Likewise, the effects of any early season storms (prior to the beginning of July) may not show up on the Dead Zone maps either because there would be enough time after the storm for the surface and bottom layers to reform. It should also be noted that any late season storms (later than mid-October) may have less of an impact on the Dead Zone as the surface water has started to cool, making natural seasonal mixing with the deeper water more likely, and hypoxia less likely.

This logic can be applied to assess the timing and potential impact of tropical storms for each year.

Back to the Beginning



Use your new knowledge and scientific reasoning to put the following statements in order to describe how hypoxia and the Dead Zone develop (example – 3, 1, 6, 5, 2, 7, 4):

1. As bacteria feed on the decomposing phytoplankton they respire (breathe) and use up oxygen in the water, leading to hypoxia
2. Some of the phytoplankton are eaten by other microscopic animals (zooplankton), but others die from natural or other causes and sink towards the bottom
3. Hypoxic bottom water is prevented from mixing with oxygen-rich surface water in the summer because of density differences created by temperature and/or salinity
4. High levels of nutrients, such as nitrogen and phosphorus, are carried by the Mississippi River into the Gulf of Mexico
5. Phytoplankton (microscopic single-celled algae) in the surface waters of the Gulf of Mexico use the abundant nutrients to conduct photosynthesis and quickly grow and multiply
6. Tropical storms and the cooling of surface water in the winter can lead to mixing of the surface and bottom waters and disruption of the Dead Zone
7. Bacteria in the bottom waters of the Gulf of Mexico feed on decomposing phytoplankton as they sink to the bottom

Answer: 4, 5, 2, 7, 1, 3, 6

Go Fish....or Shrimp



How might the behavior of fish and shrimp gathering at the edges of the Dead Zone impact the multi-million dollar fishing industry? Try to provide at least one positive and one negative example.

This question is intended to promote open thinking and discussion, and can have any number of potential (and arguable) responses. In many (or most) cases, the students' responses will be based on educated guesses, limited scientific knowledge or sheer creativity, all of which should be encouraged. However, when considering the legitimacy of the responses, it is suggested to

ask the students to consider how any hypotheses generated could be tested scientifically. While not exhaustive, most of the following points are paraphrased from the article associated with this part of the activity.

Positive: Fishermen can benefit by using sonar to find the schools of fish and shrimp along the edges of the zone and catch them more effectively, potentially making them more money.

Negative: The ability to catch fish and shrimp more effectively along the edges of the Zone may allow the species' to more easily be overfished. Forcing the fish and shrimp into condensed schools also complicates the ability of scientists to realistically assess the size and health of the populations of these animals. If the condensed schools lead scientists and fisheries managers to believe that there are large numbers of the animals, they may not set realistic catch limits, and the fish and shrimp populations could rapidly be overfished.

Negative: Another concern is the fact that the size and exact location of the Dead Zone changes each year could mean that the fishermen have to travel further or spend more time trying to find the fish and shrimp along the edges of the zone.

Negative: A potential longer term problem for fishermen is that although shrimp can usually move to avoid areas of hypoxia, those that live near the edges of the zone may grow more slowly. This is bad news for fishermen, because smaller shrimp are worth less money (note: students should learn this from reading the article associated with this part of the activity)

Slow the Flow



Write down three ideas you have that might help farmers to more effectively use fertilizer on their crops, or to help filter out nutrients from the Mississippi River and it's tributaries before they reach the Gulf of Mexico.

Again, this question is intended to promote open thinking and discussion, leading to any number of potential (and arguable) responses, and it is suggested to ask the students to consider how any hypotheses generated could be tested scientifically.

Following brainstorming and discussion, students should read the article associated with this part of the activity and compare any of their ideas with those presented in the article.