Notes from the Field

Young Scientist Newsletter

Gulf Hypoxia

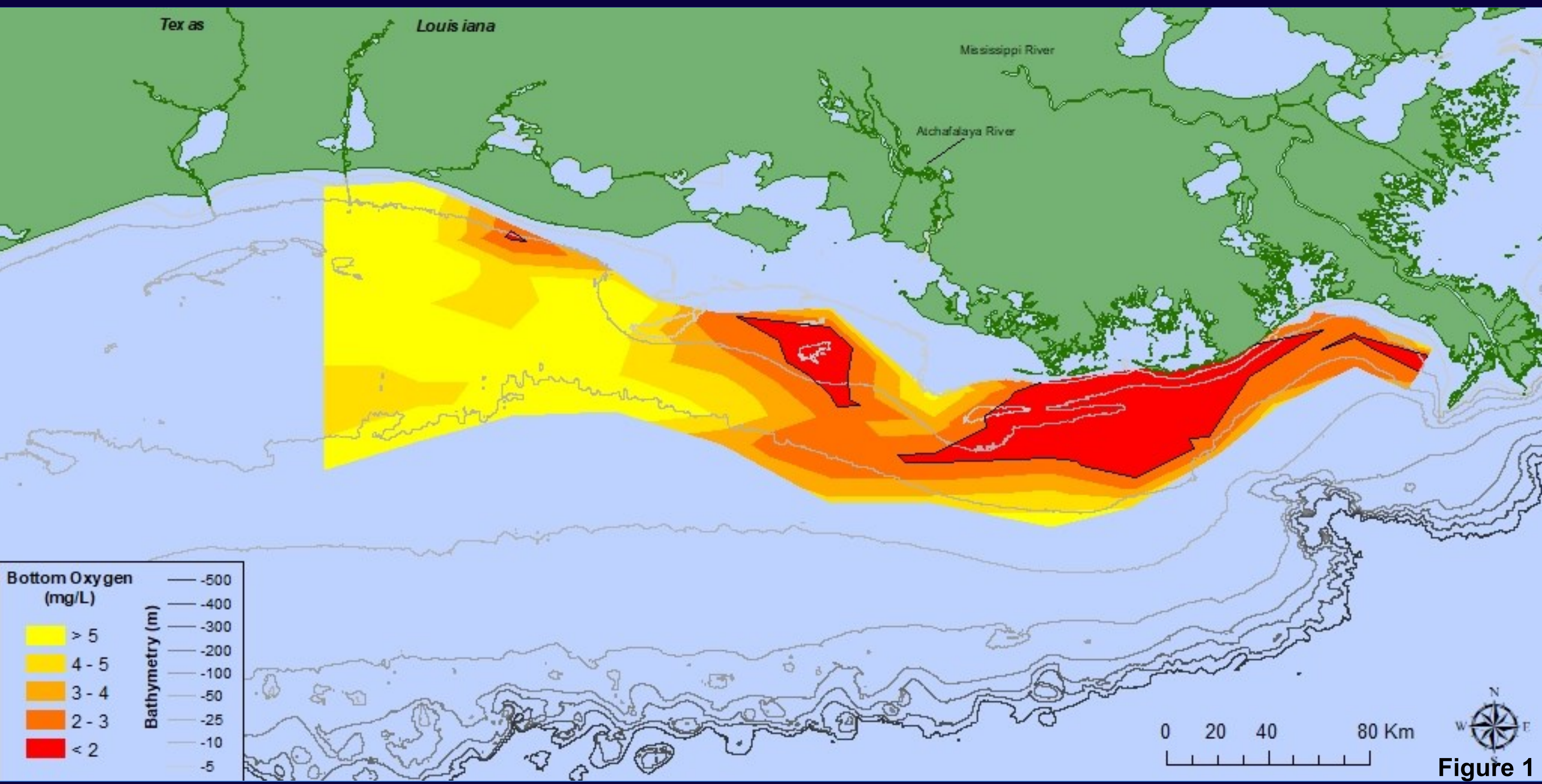

Figure 1

October 2018

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What is hypoxia?

Hypoxia is an environmental event when the amount of **dissolved oxygen** in a body of water falls below a level that can support life. Hypoxic zones, also called "dead zones", have occurred naturally throughout geologic time but have grown in size and number due to human activity.

Oxygen is an **essential element** for most organisms on Earth. It is produced by plants and plant-like organisms, like trees and **phytoplankton**, and consumed by animals through **respiration**. Oxygen is needed for survival. In the water, oxygen becomes dossiolved and is then available for organisms with gills to breathe. After observing the movements and behavior of fish and shrimp in oxygen-**depleted** waters, scientists determined that a dissolved oxygen concentration below 2mg/L (2ppm) is unable to support most life. That measurement is now used all over the world to locate and map hypoxic areas of water.

Hypoxic zones can form and go away naturally, but scientists have found that high levels of **nutrients** from fertilizers, pesticides, animal waste, and waste water treatment plants are contributing to the problem. When river water high in nutrients flows into another body of water, like the Gulf of Mexico, it fuels rapid algae growth that can lead to oxygen-depletion. This combination of factors is a process called **eutrophication**.

★ **Bold words** can be found in the Glossary on page 8

What's happening exactly?

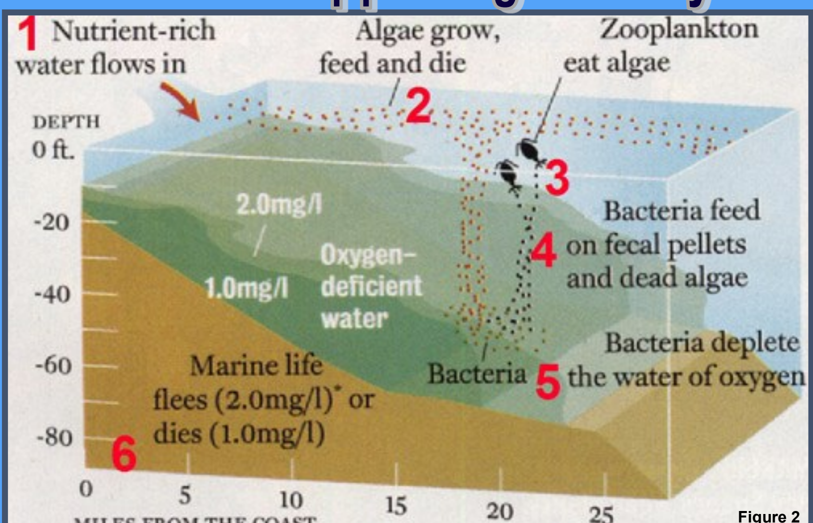

Figure 2

1. Nutrient rich water from a river flows into a body of water.
2. Those nutrients act as food for algae and other phytoplankton to quickly reproduce and grow. These organisms have a short lifespan so they then die and start sinking to the bottom.
3. At the same time, **zooplankton** and other **planktivores** move into the area to feed on the abundant food supply.. These consumers produce waste that also sinks in the water.
4. Bacteria feed on the dead algae and zooplankton waste as it sinks lower in the water column.
5. As bacteria **decompose** all this material, they consume oxygen in the water through respiration. This process is happening at the bottom of the water column at a faster rate than the oxygen can be resupplied from the surface.
6. If layering, or **stratification,** is present, the hypoxic water is trapped below the less dense surface water. Organisms that can swim (i.e. fish, shrimp, and crabs) will leave and organisms that cannot move (i.e. oysters, mussels) or that can't swim far enough because of their size, begin to die.

What is the impact??

An immediate impact of hypoxia is that organisms die or are forced to flee. Whole ecosystems can be disrupted when groups of animals are lost or damaged by the presence of large algae blooms. Hypoxia will also affect the health and economy of the human community.


Figure 3

Environmental: Many hypoxic zones can be reduced or eliminated by controlling the amount of nutrients that enter the water. However, the animals that die because there is not enough oxygen to survive cannot be replaced right away. The loss of these animals can affect the whole ecosystem because they are an important part of the food web, filter the surrounding water, or help prevent sediment erosion and land loss. The algae itself can also cause problems as come contain poison that is dangerous for other plants and animals in the area


Figure 4

Economic: When fish and other marine organisms die or leave an area, there is an immediate impact on the local fisheries. Some local economies rely heavily on the fish, shrimp, and shellfish industries because they bring in a lot of money and provide thousands of jobs. When coastal water is hypoxic, commercial fishing boats must travel further and stay out longer to bring in the same amount of catch. Hypoxic or toxic water can also affect sport fishing, boating, and other coastal activities that support the local economy.


Figure 5

Human Health: A key part of the formation of a hypoxic zone is the initial algal bloom. And the algae itself can pose the largest threat to human health. Some algae species contain toxins that make humans sick if consumed directly or indirectly through raw seafood. Harmful algal blooms, like the one currently plaguing the Gulf coast of Florida, can produce vapors that can cause asthma attacks and other respiratory illnesses. Farmers are often cautioned not to water their crops with contaminated water although there is limited research on whether or not it would negatively affect the plants or people that consume those plants.

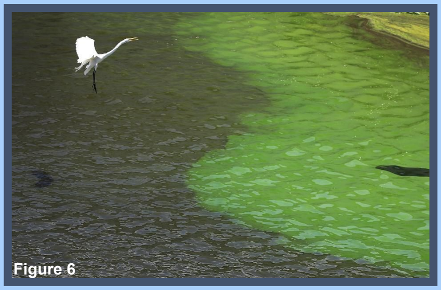
Figure 6


Figure 7

Hypoxia in the Gulf of Mexico

The Mississippi River is the longest and largest river in the United States. It is the primary river in the 4th largest **drainage basin** in the world. Before reaching the Gulf of Mexico, it flows through ten states and picks up large amounts of sediment and nutrients. Sediment, which used to build land along the Louisiana coast, ends up lost off the continental shelf but the nutrients contribute to Gulf hypoxia during the summer months when stratification is present.

Figure 8

The Gulf of Mexico is a large body of water tucked back behind the Florida and Yucatan peninsulas. It is connected to the Atlantic Ocean by way of the Caribbean Sea with a large source of freshwater in the Mississippi River. The Gulf of Mexico is a warm, saltwater sea with great diversity and high **productivity**. It produces more finfish, shrimp, and shellfish each year than the whole of the eastern seaboard combined! All of these factors also make it highly prone to hypoxic conditions.

Figure 9

Hypoxia can have wide sweeping impacts beyond the immediate loss of aquatic life. In Louisiana specifically, the state's economy relies heavily on the seafood industry as well as tourism and sport fishing. All of these are negatively affected by Gulf hypoxia during their peak seasons.

Continue on for research from the CWC's own scientists!

Straight from the Scientists

Hypoxia was first recorded in the Gulf of Mexico in the early 1970s and was periodically observed. The first scientific cruises dedicated to studying and mapping areas of hypoxia were in 1975 and 1976. These cruises reported small, disconnected patches of hypoxia off the Louisiana coast. It wasn't until 1985, with funding from the National Oceanic and Atmospheric Administration (NOAA), that the first rigorous and continuous research was initiated. The project was headed up by Dr. Nancy Rabalais of LUMCON and Drs. R. Eugene Turner and William J. Wiseman, Jr. of LSU. There is now 32 years of data on the formation, size, and impacts of hypoxia in the Gulf of Mexico that could be used to make responsible decisions about agricultural runoff, **nonpoint source pollution**, and sediment erosion.

Figure 10

The 2018 cruise data was recently released. The data indicates a smaller than predicted hypoxic zone. While this may seem like progress at first glance, Drs. Rabalais and Turner, both scientists within the CWC, are quick to point out that this is more likely due to wind and waves from the west "piling" and mixing water just before the survey rather than a decrease in nutrient runoff upstream. In a recent interview, Dr. Rabalais explained that an offshore storm caused the water to be rough the first couple of days of the cruise. This wave activity mixed oxygen-rich water into layers that may have been hypoxic. Sustained winds out of the west may have helped shrink the size of the zone by pushing hypoxic water to the east. This year's hypoxic zone was just one-third the size of the zone recorded in 2017 (2017 was the largest ever measured at 8,775 square miles or roughly the size of New Jersey).

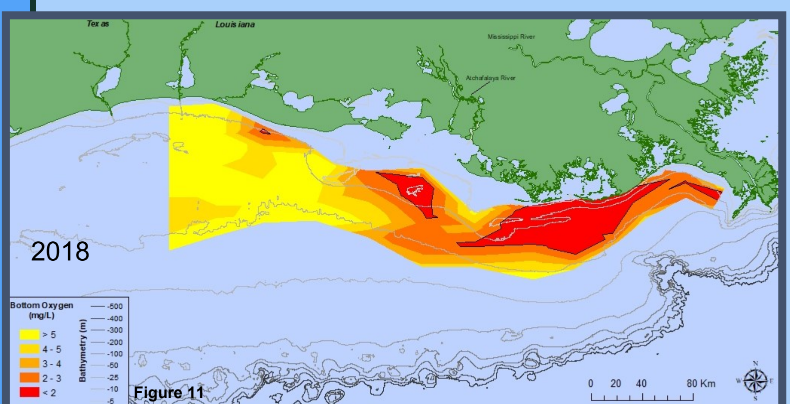

Figure 11

In a recent interview for the 2018 cruise, Dr. Rabalais emphasized that "Although the area is small this year, we should not think that the low-oxygen problem in the Gulf of Mexico is solved. We are not close to the goal size for this hypoxic area and continued efforts at nutrient mitigation are needed."

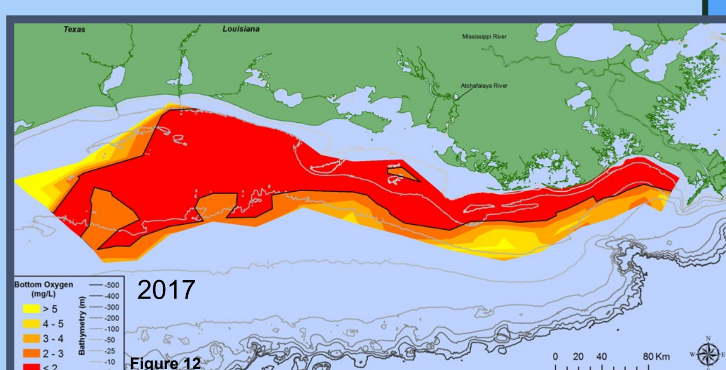

Figure 12

Continued on page 5

How did they do it?

Since establishing a procedure for that 1985 cruise, little has changed with how Gulf Hypoxia data is collected. **Transect lines** were drawn perpendicular to the coast and measurements are taken at regularly spaced points. Scientists aboard a large research vessel move up and down along the transects measuring water temperature, salinity, **pH**, **clarity**, and dissolved oxygen. Stops may be added to help clarify confusing measurements and lines may be extended or shortened based on the data collected. Dr. Rabalais has been conducting and leading this research for over 30 years and has the data and background knowledge to make informed decisions about how each cruise should proceed. For example - if the dissolved oxygen measurements at multiple stops along line F are not showing hypoxic conditions, the lead scientists may decide that the boundary of the zone is closer to the shoreline and move onto the next transect.

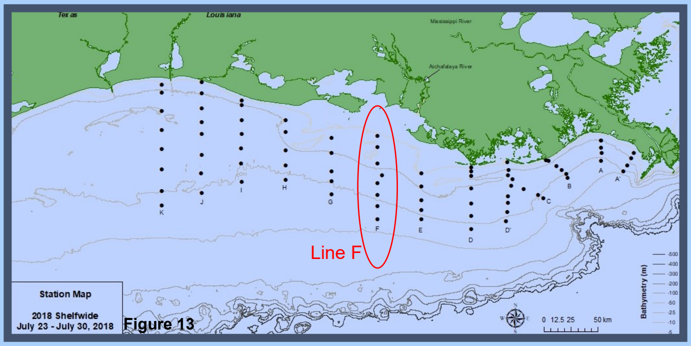

Figure 13

A Global Phenomenon

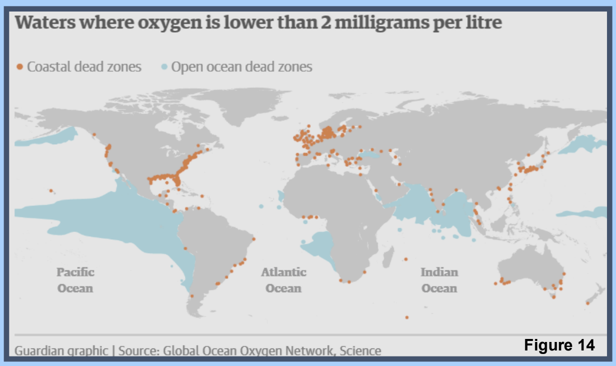

Figure 14

Hypoxia is not limited to the Gulf of Mexico or large drainage basins like the Mississippi River's - this is a global issue! Scientists from all over the world are observing high nutrient levels, algal blooms, fish kills, and other animal behaviors that might indicate low-oxygen conditions in the water. Those areas are then monitored and researched in an attempt to find the root cause. There are four times as many hypoxic zones around the world than there were in 1950 but there have been a few success stories. Hypoxic zones in the Hudson Bay and off San Francisco were reduced following rigorous cleanup efforts. An area located in the North Sea has decreased in size after countries along the Rhine River began reducing sewage and industrial runoff. Other naturally occurring low-oxygen zones are unrelated to coastal runoff. They form when oxygen-depleted water is not replaced because the deeper hypoxic water is not mixing with the oxygen-rich surface water . These types of hypoxic zones are often call Oxygen Minimal Zones (OMZs). Enclosed water bodies, like fjords and the Black Sea, and even the open ocean in the eastern tropical Pacific Ocean and the northern Indian Ocean are examples of OMZs.

What can YOU do?

The hypoxic zone in the Gulf of Mexico forms each year due to large amounts of nutrients being brought in by the Mississippi River. The Mississippi River falls within a large watershed that covers over 40% of the United States. A watershed is an area of land where all the water, above and below ground, ends up in a single body of water. The Gulf of Mexico is that single body of water for the Mississippi River Watershed.

Storms drains in your town or city connect you to that watershed. If pollutants and trash wash down the storm drain, they can reach the Gulf of Mexico and contribute to hypoxic conditions.

Figure 15

So what can you do?

- Pick up your dog's poop and get into a trash can.
- Don't wash grass trimmings down the drain. Sweep them up and put them in the trash or compost them.
- Make sure your family's trash stays in the trash can and recycle what you can.
- Participate in local clean-ups and keep public areas, waterways, and beaches trash free.
- Encourage your family to plant shrubs, flowers, and other plants in your yard to help keep the soil in place.
- Keep reading and learning about hypoxia and other environmental issues
- Talk to your friends and family about environmental issues and help them make these same changes.

Figure 16

Hypoxia is a large and complex global issue. It may seem like too big of a problem to get involved with as just one person. But these seemingly small actions can inspire others to make changes as well!


Figure 17


Figure 18


Figure 19

Puzzles

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Hypoxia Word Search

M	J	A	O	P	T	G	Q	F	L	Z	X	H	J	H	S	P	Y	N	B
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J	V	F	D	Y	Q	M	I	X	A	Q	T	T	U	Y	G	O	M	U	G
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OXYGEN
HYPOXIA
PLANKTON
ALGAE
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BACTERIA
SHRIMP
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FISHERIES

★ **Answer Key** on page 10

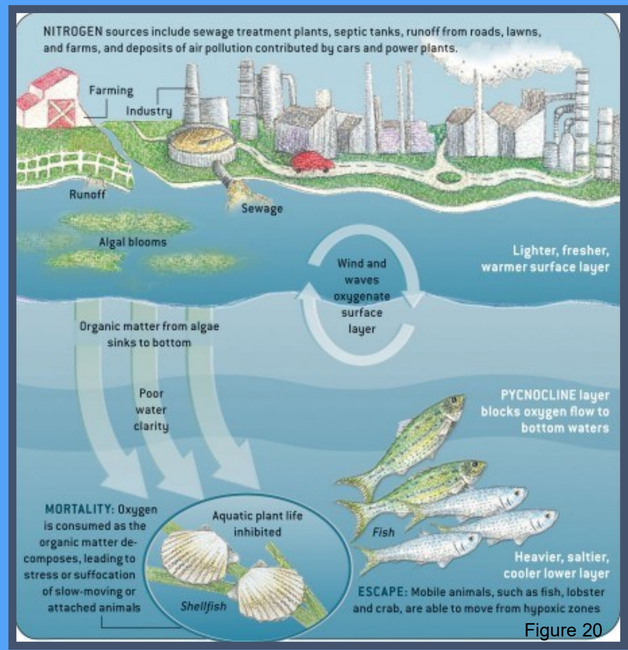
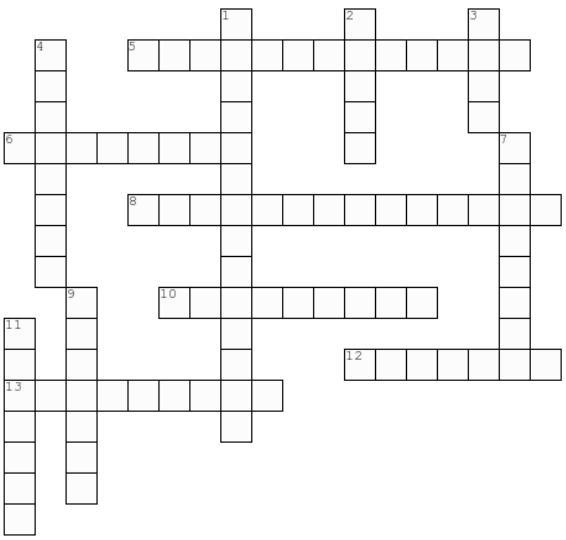


Figure 20

"Dead Zone" Formation

Hypoxia Crossword Puzzle

Complete the crossword below



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Across

5. an aquatic, free-floating, photosynthetic organisms that are typically microscopic
6. a path along which one counts and records occurrences of the species of study
8. the large, warm body of water bordered by five U.S. states and Mexico (3 words)
10. another commonly used name for a hypoxic zone (2 words)
12. relating to or near a coast
13. when gases, smoke, or chemicals are introduced into the environment in large doses that makes it harmful for humans, animals

Down

1. layers of water separated due to different masses because of salinity, temperature, oxygen, or density
2. two hydrogen molecules and one oxygen molecule
3. National Oceanic and Atmospheric Administration abbreviation
4. a substance that provides nourishment essential for growth and the maintenance of life - sulfur, phosphorus, nitrogen, and s
7. the organism that decomposes falling waste and dead plankton and also uses up the oxygen creating hypoxic conditions
9. to use up the supply
11. an environmental condition where dissolved oxygen falls below 2mg/L

Glossary of Terms

Clarity—a measurement of the underwater visibility in a body of water. Can be used to determine how deep in the water column sunlight can penetrate and support photosynthetic activity.

Decompose—to rot, decay, to break down into small parts, to disintegrate into the earth.

Depleted—to use up the supply of something (i.e. bacteria and decomposition deplete the water of its supply of oxygen)

Dissolved oxygen (DO)—the amount of gaseous oxygen [O_2] that is mixed into water and available for respiration for aquatic organisms.

Drainage basin—any area of land where water collects and drains off into a common outlet, such as into a river, bay, or other body of water.

Essential element—chemical elements, such as oxygen, carbon, hydrogen, nitrogen, and sulfur, that are needed for survival .

Eutrophication— when dissolved nutrients (such as phosphates) enter into a body of water and stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

Hypoxia—meaning low oxygen, is an environmental phenomenon where the amount of dissolved oxygen in the water column decreases to a level that can no longer support living aquatic organisms.

Nonpoint source pollution—a term used to describe pollution from many unknown sources, such as agricultural runoff and marine debris. As opposed to point source pollution that can be traced to a source, such as a specific pipe or manufacturing facility.

Nutrient—a substance that provides nourishment essential for growth and the maintenance of life. Hypoxia related examples include nitrates and phosphates

pH— the measurement of a solution's hydrogen ion [H^+] activity. It is measured on a scale of 0-14 where 7 is neutral, less than 7 is acidic, and greater than 7 is basic.

Phytoplankton—aquatic, free-floating, photosynthetic organisms that are typically microscopic

Planktivore—an organism that eats plankton, such as whale sharks, butterflyfish, menhaden, and perch.

Productivity—the ability of an ecosystem or habitat to support new and growing biomass.

Respiration—a process in living organisms where oxygen is taken in(using lungs or gills) and carbon dioxide is produced and released.

Stratification—when water masses with different properties (salinity, temperature, dissolved oxygen) form layers that act as barriers to water mixing which could lead to hypoxic conditions. These layers are normally arranged according to density, with the least dense water masses sitting above the more dense layers.

Transect line— a path along which one counts and records individuals of the species of study. An observer moves along a fixed path and counts individuals along the path in a regular or random pattern.

Zooplankton—animals that are suspended in water and drift with the current or weakly swim; usually, but not always, very small in size.

For More Information:

- The “dead zone” of the Gulf of Mexico| Nancy Rabalais—TED
  https://www.youtube.com/watch?v=5zWmdHmJMd0
- Gulf of Mexico Hypoxia
  https://gulfhypoxia.net/about-hypoxia/hypoxia-flash/
- Mississippi River/Gulf of Mexico Hypoxia Task Force—EPA
  https://www.epa.gov/ms-htf
- Oceans suffocating as huge dead zones quadruple since 1950, scientists warn—The Guardian
  https://www.theguardian.com/environment/2018/jan/04/oceans-suffocating-dead-zones-oxygen-starved
- The Effects: Dead Zones and Harmful Algal Blooms—EPA
  https://www.epa.gov/nutrientpollution/effects-dead-zones-and-harmful-algal-blooms
- What Causes Ocean “Dead Zones”? — Scientific American
  https://www.scientificamerican.com/article/ocean-dead-zones/
- How do you solve a problem like dead zone? — Illinois-Indiana Sea Grant
  http://www.iiseagrant.org/newsroom/how-do-you-solve-a-problem-like-the-dead-zone/
- The dead zone in the Gulf of Mexico—Lake Forest College
  https://www.lakeforest.edu/academics/programs/environmental/courses/seniorseminar/2013/students/burke.php

Stay up to date with CWC events through social media!

Website: cwc.lumcon.edu
Facebook: Coastal Waters Consortium
Twitter: @CWCeducator
Instagram: cwceducator

Answer Key

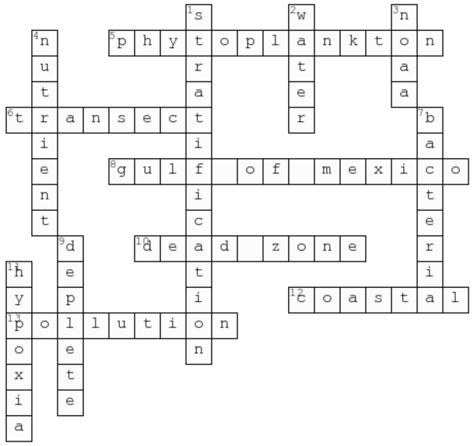
Figure 21 © Peijnenburg & Goetze 2013 (Ecology & Evolution)

Zooplankton

Name:________________

Hypoxia Crossword Puzzle

Complete the crossword below



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Across

5. an aquatic, free-floating, photosynthetic organisms that are typically microscopic (**phytoplankton**)
6. a path along which one counts and records occurrences of the species of study (**transect**)
8. the large, warm body of water bordered by five U.S. states and Mexico (3 words) (**gulf of mexico**)
10. another commonly used name for a hypoxic zone (2 words) (**dead zone**)
12. relating to or near a coast (**coastal**)
13. when gases, smoke, or chemicals are introduced into the environment in large doses that makes it harmful for humans, animals (**pollution**)

Down

1. layers of water separated due to different masses because of salinity, temperature, oxygen, or density (**stratification**)
2. two hydrogen molecules and one oxygen molecule (**water**)
3. National Oceanic and Atmospheric Administration abbreviation (**noaa**)
4. a substance that provides nourishment essential for growth and the maintenance of life - sulfur, phosphorus, nitrogen, and s (**nutrient**)
7. the organism that decomposes falling waste and dead plankton and also uses up the oxygen creating hypoxic conditions (**bacteria**)
9. to use up the supply (**deplete**)
11. an environmental condition where dissolved oxygen falls below 2mg/L (**hypoxia**)

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Hypoxia Word Search

M	J	A	O	P	T	G	Q	F	L	Z	X	H	J	H	S	P	Y	N	B
N	S	C	E	F	W	Z	C	H	L	C	M	B	H	Q	C	L	D	U	P
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DEPLETE
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BACTERIA
SHRIMP
SHELLFISH
FISHERIES

Figure 22

Phytoplankton

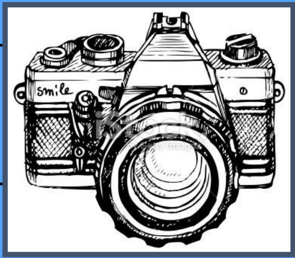

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Figure 1—Gulf of Mexico Hypoxic Zone 2018, Gulf Hypoxia-2018 Shelfwide Cruise: July 23-July 30, accessed 19 Sept 2018, <https://gulfhypoxia.net/research/shelfwide-cruise/?y=2018>
Figure 2—Nutrient based hypoxia formation 2012, Gulf Hypoxia-About Hypoxia, accessed 19 Sept 2018, <https://gulfhypoxia.net/about-hypoxia/>
Figure 3—O'Meara, Chris/AP 2018, Dead fish on boat ramp near Bradenton Beach, Fla., Concord Monitor, accessed 21 Sept 2018, <https://www.concordmonitor.com/Devastating-toxic-algae-bloom-plagues-Florida-s-Gulf-Coast-19405439>
Figure 4—Lovett, Greg 2016, An algal bloom in Stuart, Florida, in June led to a state of emergency, Nature, accessed 21 Sept 2018, <https://www.nature.com/news/study-role-of-climate-change-in-extreme-threats-to-water-quality-1.20267>
Figure 5—Pointe Aux Chenes Shrimp Boat, Realest Nature, accessed 21 Sept 2018, <http://www.realestnature.com/south-louisiana-salt-marsh-fishing/pointe-aux-chenes-shrimp-boat/>
Figure 6—Raedle, Joe/Getty Images 2018, A crane flies over the green algae bloom, Pacific Standard, accessed 21 Sept 2018, <https://psmag.com/environment/stopping-toxic-algae-in-florida>
Figure 7—O'Meara, Chris/AP 2018, Alex Kuizon covers his face in early August in Bradenton Beach, Fla., Concord Monitor, accessed 21 Sept 2018, <https://www.concordmonitor.com/Devastating-toxic-algae-bloom-plagues-Florida-s-Gulf-Coast-19405439>
Figure 8—Gulf of Mexico Political Map, On The World Map, accessed 19 Sept 2018, <http://ontheworldmap.com/oceans-and-seas/gulf-of-mexico/gulf-of-mexico-political-map.html>
Figure 9—Map of the course, watershed, and major tributaries of the Mississippi River, Wikipedia, accessed 19 Sept 2018, <https://en.wikipedia.org/wiki/Mississippi_River_System>
Figure 10—Hypoxia Map 1985, Gulf Hypoxia-Aerial Extent of Hypoxia 1985-2005, accessed 25 Sept 2018, <https://gulfhypoxia.net/research/shelfwide-cruises/annual-shelfwide-hypoxia-maps/>
Figure 11—Gulf of Mexico Hypoxic Zone 2018, Gulf Hypoxia-2018 Shelfwide Cruise: July 23-July 30, accessed 19 Sept 2018, <https://gulfhypoxia.net/research/shelfwide-cruise/?y=2018>
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