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# K-12 Partnership Lesson Plan

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# *Sex Changes, Drugs, and Rockin’ Dead Zones*

# *A trifecta of lessons*

## Overview

## This lesson consists of 3 activities, all interrelated yet can be split into individual lessons as well. The overall theme of the lessons are to investigate the effect human introduced contaminants into aquatic systems have on individual organisms, populations, communities, and ecosystems. We will investigate how farming in the “Bread Basket” of America can contribute to a growing “Dead Zone” in the Gulf of Mexico and then create our own dead zones in lab. Students can then become a participant in the formation of dead zones in an interactive simulation/game. The final component of the lesson focuses on investigating the effect a novel (or never before seen) contaminant has on vulnerable frog populations.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Be able to describe how a dead zone occurs- from the human sources of pollution to how it sparks blooms of life resulting in death
* Simulate the formation of a thriving ecosystem and dead zone
* Be able to describe how human sources of pollution can impact population dynamics
* Understand the flow of energy through aquatic ecosystems

**Length of Lesson**

Dead zone lab: 30 min introduction, 10 min of sampling every other day for 3 weeks, 50 min wrap-up lesson, graphing, and analysis

Dead zone game: 30-50min

Novel contaminants and frog sex ratio (lecture intro, activity): 50 min

**Grade Levels**

8th – 12th grade

Notes for grade-level appropriate content or extension are noted throughout lesson plan.

**Standards covered (NGSS)**

Disciplinary Core Ideas:

*Middle School*

* **MS-LS1-6**: construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms
* **MS-LS2-1**: analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem
* **MS**-**LS2-3**: develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem
* **MMS-LS2-4**: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations
* **MS-ESS3-4**: construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems

*High School*

* **HS-LS1-5**: use a model to illustrate how photosynthesis transforms light energy into stored chemical energy
* **HS-LS2-3:** construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions
* **HS-LS2-6**: evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem
* **HS-LS4-5**: evaluate the evidence supporting the claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species

Cross Cutting Concepts:

* Patterns
* Scale, proportion, and quantity
* Systems and system models
* Stability and change of systems

Science and Engineering Practices

* Asking questions and defining problems
* Developing and using models
* Planning and carrying out investigations
* Analyzing and interpreting data
* Using mathematics and computational thinking
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **B1.1**: scientific inquiry
* **B1.2**: scientific reflection and social implications
* **B2.1**: transformation of matter and energy in cells
* **B2.3**: maintaining environmental stability
* **B2.4**: cell specialization
* **B2.5**: living organism composition
* **B3.1**: photosynthesis and respiration
* **B3.2**: ecosystems
* **B3.3**: element recombination
* **B3.4**: changes in ecosystems
* **B3.5**: population

**Materials**

Dead Zone Lab Activity

* Number of 500 mL beakers, mason jars or 1 L bottles (with neck cut off)
  + Number depends on the number of places sampled
* Vernier dissolved oxygen (DO) probe
* Household fertilizer (N:P:K ratio of 3:10:3—avoid urea based fertilizers)
* Natural aquatic systems to sample (lakes, streams, ponds, etc)
* Plastic wrap
* Access to a high light area and dark area (cabinet or drawer) with same temperatures

Dead Zone Simulation

* A chalkboard or whiteboard to write out equations for photosynthesis and respiration and to keep a running tally of before and after numbers of each system component. Other information (diagrams, etc.) may be needed to clarity
* Name cards for each student- either phytoplankton/nutrients or carbon dioxide/oxygen cards
* Long rope that can stretch across the classroom

Frog Contaminants Lesson

* Scenario instructions/data handout
* Decks of cards for 40% female and 90% female populations
  + 10 sets of pre-sorted decks available from GK-12 program

**Background**

Humans have a large impact on their environment. Burning fossil fuel sources has led to an increase in atmospheric CO2­ levels resulting in rising temperatures, rising sea levels and other climatic changes. Here we investigate a few examples of how humans directly impact their surroundings as we increase the use of fertilizers and herbicides.

Aquatic organisms require oxygen, just as we do, to perform basic functions of life. The more organisms that are present in an area, the more oxygen is consumed, this is termed the biological oxygen demand (BOD). With the increase in fertilizer usage to increase crop yields, like corn and soy beans, more and more fertilizer is washing off the farms and entering local drainage ditches. Ultimately, these nutrients are being discharged out of the Mississippi River into the Gulf of Mexico at the Mississippi River Delta. This nutrient rich water sparks algal growth (or algal blooms) resulting in large amounts of algae that ultimately die and sink to the bottom of the ocean. These dead algae settle to the bottom and are decomposed by microbes that require large amounts of oxygen in the process. These microbes take up most of the oxygen out of the water, creating an area with low oxygen concentrations, or a **“hypoxic”** area. Anything that requires oxygen and is trapped in these hypoxic areas essentially suffocate, leading to a “dead zone” or an area devoid of life. In this lab we will investigate these sequence of events and create our own dead zones.

Amphibian populations are in decline worldwide. Many species are very susceptible to changes in aquatic environments, including novel human contaminants. While people may be familiar with some changes these contaminants may have on the individual level, such as causing frogs to grow additional legs, individual-level changes may also have effects on population dynamics. This activity explores how two types of novel contaminants affect frog populations. Endocrine disruptors are any chemicals that alter an animal’s hormone system. One result of these endocrine disruptors entering aquatic systems is a change in the sex ratio in the population, resulting in a greater proportion of females. Herbicides are another major class of contaminant. While many herbicides will not immediately kill frogs that are exposed to them, they can have other effects on population dynamics, such as reducing population growth rates or affecting the immune system, making them more susceptible to disease which can lead to higher population mortality. Adult size strongly influences reproductive success in many species of frogs.

### Activities of the session

Dead Zone Lab Activity

### Follow instructions established on the “Dead Zone Student Worksheet” (can be found on the “Sex change” lesson page on the KBS GK-12 website).

### Key notes before starting: This lesson will require sampling of an aquatic system, and should be done when the weather is favorable to productivity (aka in the late Spring- early Fall). Also, once the experiment has started, sampling will have to take place daily for 2-3 weeks. Sampling will take a maximum of 10 minutes per class.

### Also included in the “Dead Zone Student Worksheet” is a graphing activity (using the data they collected) and follow-up questions that can be used as a group assignment or homework.

### Dead Zone Simulation

1. Before the Lesson
   1. Set up a large playing area that students can move around in – designate one end of the room the air-water interface and the other end the sediment-water interface. One side will be the Mississippi River discharge where nutrients come out.
   2. Calculate the numbers of each of the four players to be assigned based on the number of students in the classroom and the desired ratios (see dead zone game instructions)
2. Introduce key terms
   1. Hypoxia – low dissolved oxygen content
   2. Eutrophication – enrichment of nutrients nitrogen and phosphorus needed for plant growth
   3. Stratification – the layering of water bodies due to different physical properties that impede their mixing
   4. Pycnocline – the surface across which water densities change abruptly
3. Write the equations for photosynthesis and respiration on the blackboard. It is a good idea to keep these up during the game so that students can refer back to them. It is also important to describe where these take place (photosynthesis occurs near the air-water interface while respiration occurs in all organisms). For the purpose of the game we are simulating the respiration from bacteria that decompose organic matter- this occurs near the bottom (water-sediment interface).
4. Get two volunteers to help simulate the processes before the class plays. (See dead zone game instructions.) It is useful to walk the class through the process of photosynthesis and reproduction as a phytoplankton, and then decomposition involving respiration.
5. Pass out name cards for each student to wear in proportion to the number of students in your class (see dead zone game instructions). It is useful to keep a running tally of the numbers of each player at the beginning and end of each round on a chalkboard or whiteboard visible to the class. Play the first round together, making sure each student understands their roles before moving on, and clarifying any confusion. Once the simulation is over, write down the numbers of each player.
6. Set up a long rope across the playing area to serve as the pycnocline. Instruct students that only phytoplankton are large enough to move across this playing area. See instructions for round 2.
7. Continue with round 3, writing down before and after starting numbers of each player type and discussing as a class what changes have occurred and why. It may be useful to pause the game during round 3 when the number of phytoplankton have peaked to have students look around and describe what is going on (algae bloom). At the end of the round discuss what happened.
8. Additional simulations involving other organisms can also be performed or discussed(see instructions).

### Frog-Contaminants Activity

1. If you will not be using pre-sorted decks from GK-12, assemble a 40% female deck and 90% female deck for each group of students in the class. Each deck contains 40 cards. The 40% female deck should contain 16 red suit cards and 24 black suit cards, while the 90% female deck should contain 36 red suit cards and 4 black suit cards. Red and black cards should be evenly split among the suits (unless that is something being modeled in an extension). If possible, 10 cards in each deck (4 red and 6 black for 40% female, 9 red and 1 black for 90% female) should have a different color back, to indicate these cards as the starting population deck.
2. Follow instructions on handout to have students model populations with different sex ratios (40% female or 90% female) that have either been exposed to an herbicide or have not been exposed.
3. Have students collect data from each scenario and graph the results.
4. Discuss the answers to follow-up questions.

**Resources**

* Kastler 2009 (pdf posted on “Sex changes” lesson page on the KBS GK-12 website)
* Lake Erie as a case study: <http://www.epa.gov/lakeerie/eriedeadzone.html>
* Other activities you can do in your classroom- see Activity (Explore)- Density- for an activity that investigates water stratification: <http://www.teachoceanscience.net/teaching_resources/education_modules/dead_zones/access_classroom_resources/>
* Another water stratification lesson: <http://oceanservice.noaa.gov/education/lessons/hot_cold_lesson.html>

**Extensions and Modifications**

Dead Zone Simulation

* Have students predict how many nutrients can be added to a system before hypoxia occurs. The class can go through simulations to test these predictions (see more info in Kastler 2009)
* Have students discuss how humans can prevent dead zones from occurring. Possibilities:
  + Town hall meeting where the class forms different sides who argue for competing interests
  + Write a letter to the editor of a local newspaper to discuss the problems associated with nutrient runoff

Frog-Contaminants Activity

* Chytrid fungus could affect populations in all scenarios – in this case, roll a die to determine whether the individual gets the disease (a 1 is chytrid in an individual not exposed to herbicide, 1-3 is chytrid in individuals that have been exposed)
* Pre-sorted decks contain equal numbers of hearts/spades and diamonds/clubs (not exposed vs. exposed). Students could adjust decks to determine how increasing the proportion of exposed individuals alters population dynamics.
* Students could also experiment with additional sex ratios to see how that would affect population dynamics.

**Assessment**

Both activities contain discussion questions that can be used for assessment.