

# Hume-Fogg Academic High School Lesson Plan

Teacher Name: Kyle Strom

Course Name: AP Environmental Science

The following is a lesson plan that I used in the classroom with my AP environmental science students to discuss eutrophication and the formation and impacts of the Gulf of Mexico's dead zone. This was a multi-day lesson in which students modeled the dead zone; learned about eutrophication, dissolved oxygen, biological oxygen demand, and the oxygen sag curve; and, then completed initial models of the phenomenon. Sample student work of their final models is provided after the lesson plan.

<p><b>List Content Standards (National, State, AP, ACT, etc.) Alignment:</b></p>	<p><b>AP Environmental Science, Unit 8 Topic 5: Eutrophication</b></p> <ul style="list-style-type: none"> <li>● Enduring Understanding STB-3: Human activities, including the use of resources, have physical, chemical, and biological consequences for ecosystems.</li> <li>● Learning Objective STB-3.F: Explain the environmental effects of excessive use of fertilizers and detergents on aquatic ecosystems.</li> <li>● Essential Knowledge (EKs):             <ul style="list-style-type: none"> <li>- STB-3.F.1: Eutrophication occurs when a body of water is enriched in nutrients.</li> <li>- STB-3.F.2: The increase in nutrients in eutrophic aquatic environments causes an algal bloom. When the algal bloom dies, microbes digest the algae, along with the oxygen in the water, leading to a decrease in the dissolved oxygen levels in the water. The lack of dissolved oxygen can result in large die-offs of fish and other aquatic organisms.</li> <li>- STB-3.F.3: Hypoxic waterways are those bodies of water that are low in dissolved oxygen.</li> <li>- STB-3.F.4: Compared to eutrophic waterways, oligotrophic waterways have very low amounts of nutrients, stable algae populations, and high dissolved oxygen.</li> <li>- STB-3.F.5: Anthropogenic causes of eutrophication are agricultural runoff and wastewater release.</li> </ul> </li> </ul>
<p><b>List Assessment Components:</b></p>	<ul style="list-style-type: none"> <li>● Students will construct a model to explain the causes and impacts of water pollution and eutrophication on the abiotic and biotic conditions of the Gulf of Mexico.</li> <li>● The model needs to visually represent and explain the impacts of: nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life.</li> <li>● The model will show conditions before, during, and after eutrophication.</li> </ul>
<p><b>List Overall Learning Objective/Target:</b></p>	<p>SWBAT model the causes and effects of eutrophication in the Gulf of Mexico's dead zone.</p>
<p><b>List Brief Lesson Plan Overview /Details:</b> (Summary of the task, challenge, investigation, career-related scenario, problem, or community link)</p>	<ol style="list-style-type: none"> <li>1. Students will begin the lesson by examining a news story and images that show dead fish washing up on the gulf coast of Texas. They will be asked to think about what is going on and what could cause this phenomenon.</li> </ol>

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Good afternoon! What's going on here? Talk about it with your group.



2. Next, students will explore a map of the tributaries to the Mississippi River that lead to the Gulf. Then, they will examine several data sources NASA and NOAA (<https://docs.google.com/document/d/1VzBJdxE0BXFIARJ2vRQQ6ZzXGkOI7s-YtluAhab3WqY/edit?usp=sharing>), which include:
  - Sediment and phytoplankton satellite images from NASA MODIS
  - Summer and winter Gulf of Mexico phytoplankton data from NASA's Goddard Space Flight Center Scientific Visualization Studio
  - Gulf of Mexico Dissolved Oxygen (DO) Data from NOAA
3. Students will be tasked to figure out what is happening in each of the data sources and then think of connections between them as well as what environmental factors could be causing the data trends observed.
4. Students will then construct an initial model using the data, using the supplied template ([https://docs.google.com/document/d/1ku0df\\_11bY8ple6nX6dap0rAe7lkxy852QV-Pig\\_Ay0/edit?usp=sharing](https://docs.google.com/document/d/1ku0df_11bY8ple6nX6dap0rAe7lkxy852QV-Pig_Ay0/edit?usp=sharing)). In the model, students should visually represent and describe the following factors: nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life.
5. After modeling, students will then learn about the steps to eutrophication, the relationship between dissolved oxygen and biological oxygen demand (oxygen sag curve), and the feedback loop involved in creating a dead zone, such as seen in the Gulf of Mexico. During this, students will annotate a model of the oxygen sag curve to accompany their notes.

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## Eutrophication Steps

1. Limiting nutrients such as nitrogen/phosphorus enter water, leading to an explosion in algae
2. Algae bloom covers the surface of water, blocking sunlight, which can impair growth of or kill plants below surface (↓ photosynthesis, overall)
3. Algae are r-selected species, so they eventually die-off
4. Bacteria/decomposers break down the dead algae, consuming dissolved O<sub>2</sub> (DO) in the water
5. Lower DO in water impairs the growth of or kills aquatic animals, especially fish
6. As other animals die, bacteria/decomposers use up even more DO to decompose dead animals
7. This creates hypoxic water → areas of low DO (hypo meaning low)

## Dissolved Oxygen & Biological Oxygen Demand

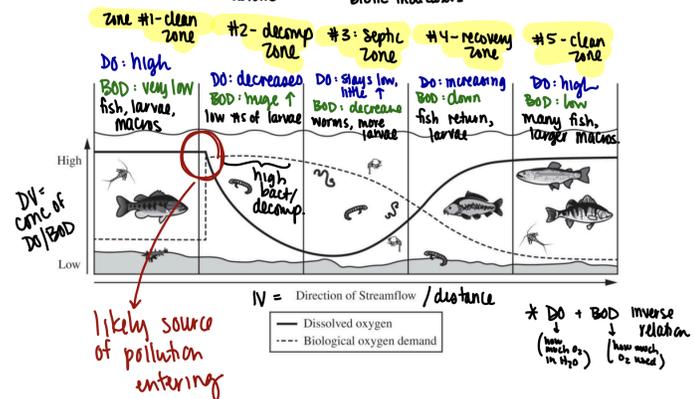
### Dissolved Oxygen (DO)

- It measures the amount of oxygen in water (in mg/L or ppm)
- All aquatic life require dissolved oxygen (DO) for respiration
- DO is added to water via photosynthesis or diffusion from the atmosphere which can be impacted by waves, water moving over rocks, etc.
- As DO decreases, fish can be pushed outside their range of tolerance
  - Below 5 mg/L, most fish cannot survive

### Biological Oxygen Demand (BOD)

- Amount of oxygen a quantity of water uses over a period of time at a specific temperature
- The more microbes/algae/decomposers in water, the higher the BOD
- Low BOD values = a water body is less polluted
- High BOD values = a water body is more polluted

What it is: graph shows relation b/w DO + BOD + how that Δ in water based on distance from source of pollution  
 Why?: take samples of DO + BOD + macroinvertebrates → ID a source of poll.  
 abiotic biotic indicators



6. After instruction, students will revise their models and submit.
7. To conclude the lesson, students will watch “Dead Zone in the Gulf of Mexico” a short video from NOAA Ocean Today (<https://oceantoday.noaa.gov/deadzonegulf/welcome.html>) that ties together all of the factors discussed in the lesson and the Gulf’s hypoxic waters.

### Performance Level 5 Planning Descriptors

#### Instructional Plans

Instructional plans include:

- measurable and explicit goals aligned to state content standards;

### My Lesson

- This lesson is directly aligned with the essential knowledge and learning objectives for Topic 8.5 Eutrophication. Students will demonstrate their understanding of this content on the Unit 8 Aquatic and Terrestrial Pollution exam in class and the AP Environmental Science exam in May.

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<ul style="list-style-type: none"> <li>• activities, materials, and assessments that:             <ul style="list-style-type: none"> <li>▪ are aligned to state standards.</li> <li>▪ are sequenced from basic to complex.</li> <li>▪ build on prior student knowledge, are relevant to students' lives, and integrate other disciplines.</li> <li>▪ provide appropriate time for student work, student reflection, and lesson unit and closure;</li> </ul> </li> <li>• evidence that plan is appropriate for the age, knowledge, and interests of all learners; and</li> <li>• evidence that the plan provides regular opportunities to accommodate individual student needs.</li> </ul>	<ul style="list-style-type: none"> <li>• This phenomenon was chosen because it is an area many of our students are familiar with. Additionally, it is generative in that there is ample satellite and other data sources (both quantitative and qualitative) that can allow students to develop their data analysis skills, while specifically targeting skill 2.C: Explain how environmental concepts and processes represented visually relate to broader environmental issues (the College Board's suggested skill for Topic 8.5).</li> <li>• Furthermore, the topic of eutrophication and specifically, the Gulf's dead zone, has appeared on numerous past AP exams, on both MCQ and FRQ sections.</li> <li>• This lesson also follows the modeling cycle laid out by <i>Ambitious Science Teaching</i>, in which students:             <ul style="list-style-type: none"> <li>o Engage with an accessible phenomenon (dead fish on the coast)</li> <li>o Generate questions/hypotheses (what's going on here)</li> <li>o Analyze data sources (NOAA and NASA data assets)</li> <li>o Create an initial model (model template)</li> <li>o Receive just-in-time direct instruction (steps to eutrophication and feedback loops)</li> <li>o Revise to construct a final model (model template w/ must-haves)</li> </ul> </li> </ul>
<p><b>Student Work</b></p> <p>Assignments require students to:</p> <ul style="list-style-type: none"> <li>• organize, interpret, analyze, synthesize, and evaluate information rather than reproduce it;</li> <li>• draw conclusions, make generalizations, and produce arguments that are supported through extended writing; and</li> <li>• connect what they are learning to experiences, observations, feelings, or situations significant in their daily lives both inside and outside of school.</li> </ul>	<ul style="list-style-type: none"> <li>• Students are generating initial ideas and hypotheses surrounding the phenomenon at the opening of the lesson. Students are familiar with using the <i>See-Think-Wonder</i> protocol from Project Zero to generate ideas.</li> <li>• Students are analyzing qualitative and quantitative data from NOAA and NASA assets to identify and understand trends in data. Students will need to connect general environmental processes (eutrophication) within a specific, applied context.</li> <li>• Students are creating a model which visually represents and explains in writing the causes and impacts of water pollution and eutrophication on the abiotic and biotic conditions of the Gulf of Mexico. Their models need to include the impacts of: nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life. A template is provided, requiring students to model these effects before, during, and after eutrophication has occurred.</li> <li>• Students have freedom in choosing how they represent and draw their models.</li> </ul>
<p><b>Assessment</b></p> <p>Assessment Plans:</p> <ul style="list-style-type: none"> <li>• are aligned with state content standards;</li> <li>• have clear measurement criteria;</li> <li>• measure student performance in more than three ways (e.g., in the form of a project, experiment,</li> </ul>	<ul style="list-style-type: none"> <li>• The work of this lesson directly aligns with the College Board's suggested skill for Topic 8.5: 2.C Visual Representations - Explain how environmental concepts and processes represented visually relate to broader environmental issues.</li> <li>• Students' final model includes a list of must-haves which include both a visual and written representation of nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life. This will be assessed via a rubric</li> </ul>

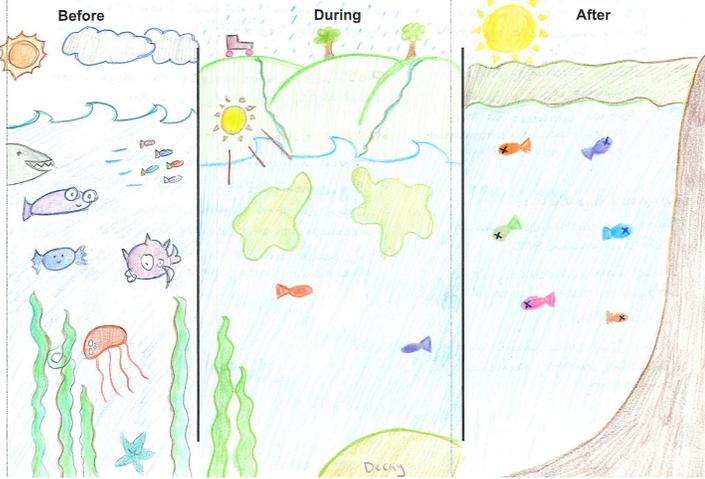


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Your Task: Construct a model to explain the causes and impacts of water pollution and eutrophication on the abiotic and biotic conditions of the Gulf of Mexico. The model needs to visually represent and explain the impacts of: nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life.



Nutrient runoff (sources)

• excess nutrients, primarily nitrogen and phosphorus, enter the water through a source. In my image this is agricultural runoff, but it can also be sewage discharge, urban stormwater, etc.  
↳ farm fertilizers, livestock waste, waste water treatment plants, industrial pollution

Dissolved O<sub>2</sub> and Biochemical O<sub>2</sub> demands

• DO: before eutrophication, DO levels are sufficient enough to support marine life. However, as algal blooms grow and decompose, DO levels drop significantly, creating hypoxic conditions  
• BOD: increases as decomposers break down dead algae, consuming O<sub>2</sub> in the process

Impact on Aquatic life:

• Before: a healthy ecosystem w/ diverse marine life  
• During: fish and other organisms struggle to survive due to low O<sub>2</sub>, (suffocate)  
• After: dead zone remains until conditions improve, reducing biodiversity

Steps of Eutrophication:

1. Excess nutrients enter the water through runoff
2. Algae grows rapidly due to surplus nutrients
3. Algae die and decompose, leading to an inc. in decomposers that use up O<sub>2</sub>
4. O<sub>2</sub> levels drop to a point where most marine life cannot survive, creating a dead zone

DO & BOD steps to eutrophication on my Gulf of Mexico Dead Zone Model

Your Task: Construct a model to explain the causes and impacts of water pollution and eutrophication on the abiotic and biotic conditions of the Gulf of Mexico. The model needs to visually represent and explain the impacts of: nutrient runoff (which ones/sources), DO and BOD conditions, steps of eutrophication, and aquatic life.

