Dead Zone Mapping Activity: Graphing Hypoxia

Graphing Dissolved Oxygen From 1993 Cruise Data in the Gulf of Mexico

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Purpose:

The purpose of the following series of activities is to help students visualize the dead zone and to provide them with dissolved oxygen (DO) data to analyze and interpret. Students will plot and analyze DO from the July 23-28, 1993 scientific cruise in the Gulf of Mexico. The activities are designed to engage the student individually, within a group and as a class to plot, observe, analyze and interpret several different spatial slices of the dead zone. In addition, these graphing activities can also be used to graph other variables such as salinity, density and temperature

The Data:

The data provided for these activities was downloaded from the U.S. Department of Commerce/National Oceanic and Atmospheric Administration's (NOAA) Nutrient Enhanced Coastal Ocean Productivity Program (NECOP) website: www.aoml.noaa.gov/ocd/necop/. The website has several data sets which consist of physical, chemical and biological parameters from cruises in the Gulf of Mexico. You will be working with data collected during the 1993 cruise. Remember 1993 was the year of flooding on the Mississippi River that led to an extremely large area of hypoxic water. There are 14 transects with 82 stations in the July 23-28, 1993 cruise data set. The data from Transect C are provided for this activity. The data set has been reduced and formatted in Microsoft Excel to be student and teacher friendly. The activities are set up as pencil and paper exercises. However, some of the graphing activities can be conducted using Excel graphing options. Data sets from additional years on the NECOP website can also be downloaded and used for class activities on the dead zone.

Variables included in the data files are: transect (trn.), station (stn.), depth (m), dissolved oxygen (DO, mg/l), salinity (sal., ppt), temperature (temp., C☐), and latitude (lat) and longitude (long) in degrees, whole/hundredth minutes.

Note:

Provide data sheets for one or more stations to each student. Each student will plot the oxygen vs. depth profile for his or her data set. You may wish to determine a standard range of values for the graphing activities for the class. To set up the graphing for the activities, DO will be plotted on the x-axis beginning with zero at the x,y-intercept and depth will be plotted on the y-axis with zero at the **top** of the graph to show depth. Maximum depth for all stations should be noted and a line drawn to indicate the Gulf bottom.

Students plot points on graph paper and interpolate between each point to draw the dead zone boundary. Draw a line across the graph at <2mg/l where hypoxic values begin. Any plots below this line will be in the hypoxic zone.

Activity #1

Profile Mapping of Dissolved Oxygen (DO) by Depth for Each Station

Individual student

COSEE Teachers – do this one yourself, in Excel it does not take very long. You do NOT need to hand it in.

Introduction/Purpose:

Scientists gather information about the dead zone at several stations. Data from each station is analyzed from the surface to the bottom, so changes in dissolved oxygen (DO) and other variables such as temperature, salinity and nutrients can be observed. These data allow scientists to identify hypoxic zones. This activity will introduce students to the first step in analyzing oceanographic data in a water column profile by plotting and observing the changes in DO from the surface to the bottom at one station. These profiles will be used in Activity # 2.

Objectives:

Each student will:

Work with data from one or more stations.
Plot DO (mg/l) by depth (meters).
Observe and record changes in DO with depth.

Louisiana Science Standards (**Sorry Ms, Al, Fl, & Tx teachers, you are on your own here**):

Grades 5-8: SI-M-A4, A-4-M, D-1-M.
Grades 9-12: SI-H-A3, D-7-H.
Skills: Observing, measuring communicating, formulating models, using data, interpreting data, graphing and determining scale.

Materials:

Station data sheets (see data files)	Graph paper
Pencils	Ruler

***Procedure*:**

As a class:

1) Assign station data sheets to each student.
2) Determine the maximum and minimum depth for the whole project area (all stations).
3) Determine a scale for plotting profiles for all students to use.
4) Discuss reasons for setting “0" at the top of the “y” axis (“0" is at the water surface). Note that the gulf bottom will be determined by depth.

Each Student:

5) Set up the graph by using the agreed upon scale from the class discussion.
6) Draw the gulf bottom on the graphs by plotting depth to bottom for his/her station.
7) Label the upper end of the “y” axis as “0" (“0" will not be at the x, y intercept) to represent the ocean surface.
8) Plot the water column profile by plotting DO (mg/l) by depth (meters).
9) Determine depths where hypoxic conditions occur at each station.
10) Observe and record changes in DO with depth.
11) Answer questions about the profile.

Questions:

Using your data table and profile plot, answer the following questions. The answers to these questions will be used for Activity #2.

1) How deep is your station?
2) What was the maximum and minimum temperature in your water column?
   At what depth does each occur?
   Does the temperature increase or decrease with depth? Why?
3) What was the maximum and minimum salinity in your water column?
   At what depth does each occur?
   Does salinity increase or decrease with depth? Why?
4) What was the maximum and minimum density in your water column?
   At what depth does each occur?
   Does the density increase or decrease with depth? Why?
5) What happens to the salinity and density of the water as the temperature changes?
6) What was the maximum and minimum DO in your water column?
   At what depth does each occur?
   In your station profile does DO consistently change with depth? Why or why not?
7) Does your station fall within the hypoxic zone (<2 mg/l)?
   Does your station have anoxic (0 mg/l) conditions?
8) What is the maximum and minimum depth at which hypoxic conditions exist in your profile? 9) What is the height of the dead zone at your station in meters (difference between the minimum and maximum depth of hypoxic zone)?
10) What percent of the water column is hypoxic at your station (width of dead zone divided by total depth)?
11) Compare your profile with other students' profiles.

Teacher Note:

An additional graphing activity which involves graphing the water column profile through time and observing changes through time was developed by the Virginia Institute of Marine Science on their website **http://www.vims.edu/bridge** (go to previous Data Tips, October 1999). This exercise can be completed using online data and Microsoft Excel software to acquire the data and complete the graphing on an IBM compatible computer. For instructions for this exercise for 1994 cruise data comparing water column profiles from March through October 1994 go to: **http://www.vims.edu.bridge/deadzoneexercise.html.**

Activity # 2

Cross Section Map of the Hypoxic Zone by Transect

Student groups

COSEE Teachers – this one takes more time to do alone. Just look it over and consider using it with your students, because as it uses cooperative learning within and among groups. There is also a helpful statement of translating Latitude and Longitude units into linear measurements on the ground.

Introduction/ Purpose:

A cross section is a diagram that shows features of a vertical section or a slice of something such as the earth or the water column. A cross section can be constructed by interpolating between data points from each station along a transect. A cross section can show changes and similarities in the data with distance and can be used to determine extent, area or volume of a feature within the cross section. For this activity, students will draw a cross section of the dead zone from the near shore shallow stations into the deeper stations of the deeper stations in the Gulf of Mexico.

***Objective*:**

Students will (in groups):

Compare profile graphs within a transect.
Draw a cross section of the dead zone by **interpolating** between data points.
Calculate the distance between stations and the total length of the transect.
Estimate the area of the cross section.
Compare and **discuss** all cross sections from each group.

Standards:

Grades 6-8: SI-M-A4, A-4-M, M-1-M, M-6-M, G-4-M, G-7-M, D-1-M.
Grades 9-12: SI-H-A3, M-2-H, M-3-H, G-2-H, D-7-H.
Skills: Graphing, measuring, estimating, interpolating data, observing, measuring and formulating models.

Materials:

Student graphs from Activity #1	Long sheets of paper from a roll or taped together
Pencils	Colored pencils
Ruler	Calculator
Paper, pencils	

Procedure:

1) Divide students into groups by transect.
2) Compare profiles within the transect. **Discuss** differences and similarities among DO, salinity, temperature and relative shape and size of hypoxic area and answer questions #1–9 using the data table and profiles.
3) Determine horizontal scale, length of x-axis and size of paper required.
4) Set up graph with x and y-axis agreed upon.
5) Determine location of and **mark** each station location for each transect.**6) Place** and **tape** each profile at the appropriate station, **keep** the sea surface constant.
7) Draw the sea floor by interpolating between stations and **shade in** the area below the sea floor.
8) Mark the upper and lower ends of the hypoxic zone of each station profile in red.

9) Draw the upper boundary and the lower boundary of the hypoxic zone in red by **interpolating** between stations. The lower boundary may be the same as the gulf bottom in several stations.

10) Complete questions #10-14 below.

11) Estimate the area of the hypoxic zone in the cross section.

12) Report results of your cross section 2-D model to class

13) Compare all cross sections from each group as a class.

Questions:

As a group:

1) What are the maximum, minimum and average water depths along the cross section?

2) What is the maximum and minimum depth where hypoxic conditions begin (top of hypoxic zone) and end (bottom of hypoxic zone)?

3) Compare the depths where hypoxic conditions occur among the transect profiles.

4) Do hypoxic conditions always occur at similar depths or same location within the water column? What appears to affect the depths of DO along the transect?

5) Where in the water column (top, middle, bottom) do you generally find hypoxic conditions?

6) What is the maximum and minimum percent of a profile that is hypoxic in the transect?

7) Do all stations contain hypoxic conditions?

8) List stations that are hypoxic, and anoxic (use for Activities #4 and 5) and those that are not.

9) In relation to the shoreline, where are the hypoxic stations located? Where are those that are not hypoxic located?

10) Calculate/estimate the distance between each station and the total length of your transect (see "Changing latitude an longitude to distance units" below).

11) Calculate the distance between stations at the sea bottom. Hint: use geometry (rectangles and right triangles and see 'Changing latitude an longitude to distance units" below. Is the length of the transect much greater at the bottom than at the top? What does this say about the slope of the continental shelf off the coast of Louisiana?

12) Estimate the area covered by the entire cross section and describe how you determined this.

13) Estimate the area of hypoxic conditions in your cross section.

14) What percent of the cross section is affected by hypoxia?

Changing Latitude and Longitude Distance Units

To estimate the difference between stations within a transect, you must convert latitude to miles or kilometers. A one-minute change in latitude (north/south distance) is equal to one nautical mile (1.85 km), or 6076 feet (1852 m). There are 60 minutes to one degree; therefore there are 364,560 feet (111,120 m) to one-degree change of latitude, or about 69.1 miles (111.3) km). To determine the distance between stations use minutes and a fraction of a minute and then convert to feet or meters. Remember that one minute of latitude has 60 minutes and each minute has 60 seconds.

Example of distance with a change in latitude:
Find the distance between stations E1 (28° 58.0' N) and E2 (28° 51.5' N) at longitude 91°15.0'W.

Determine the distance between the stations in minutes and a fraction of a minute.

58.0 min - 51.5 min = 6.5 min

Determine number of miles per minute.

69.1 mile/60 min = 1.1517 mile/min (111.3 km/60 min = 1.85 km/min)

Multiply distance by miles per minute.

6.5 min x 1.1517 mile/min = 7.48 mile (6.5 min x 1.85 km/min = 12.02 km)

Several transects (D, E, F, G, H, I, J, K) are parallel, you can determine this distance by using the difference in longitude. A one-minute of change in longitude (east/west distance) varies with the distance north or south of the equator. The further away from the equator, the smaller the east-west distance associated with a change in longitude. Therefore, for each minute of change in longitude, the distance is different. In Louisiana a one degree difference varies from 60.2 miles (96.9 km) at latitude 29°30' to 60.8 miles (97.8 km) at 28°30'. For the purposes of estimating distances in the Louisiana offshore, use an average one-minute change in longitude of about 60.5 miles (97.4 km).

Example of distance with a change in longitude:

Find the distance between transects E (91°15.0'W) and F (91°37.0'W).

Determine the distance between transects in minutes and seconds. 3

7.0 min-15.0 min = 22 min

Determine number of miles per minute.

60.5 mile/60 min = 1.0083 mile/min (96.4 km/60min = 1.60 km/min)

Multiply distance by miles per minute.

22.0 min x 1.0083 mi/min= 22.18 mi (22.0 min x 1.6 km/min = 35.2 km)

For more accurate distances between stations, a conversion is available at **http://jan.ucc.nau.edu/~cvm/latlongdist.php.**