Hurricane Impacts on Ocean Organisms

Materials

For the leader:

-Projector

-Copy of all graphs

-Copy of maps depicting region of study

For the activity:

-Copy of graphs for each group

-Divide the graphs into 2 groups:

1: Rainfall, Wind-speed, Barometric Pressure

2: Water Depth, Salinity, Dissolved oxygen, pH

Overview

Hurricanes are intense low-pressure weather systems that form in tropical waters. Hurricanes are classified into 5 categories by wind speeds, ranging from a Category 1 with wind speeds of 74 mph to a Category 5 with wind speeds above 155 mph. Hurricanes begin as an area of low pressure known as a disturbance, if the circulation becomes more organized the storm is upgraded to a tropical storm and when sustained winds reach 74 mph it is classified as a hurricane. Hurricane season begins on June 1st and continues through November 30th in the Northern Atlantic Ocean.

Hurricanes can cause catastrophic damage to areas in their path. Atlantic hurricanes have strong impacts predominately in the Gulf Coast region and the eastern seaboard. Hurricane Sandy made land fall on October 29th, 2012 near Atlantic City, NJ. At the time of landfall Sandy had a maximum sustained winds of 130km/h (81mph). The storm surge created by Sandy was most dramatic along the New York/New Jersey coasts. The National Hurricane Center lists Sandy as the second costliest hurricane in history with damages totaling $60+ billion.

As Sandy developed scientists collected data on both atmospheric and ocean conditions to monitor the storm's progress. For example scientists measured barometric pressure, which is a measure of force per unit area exerted on the Earth's surface by the weight of air above the surface. Barometric pressure ranges from 980 to 1050 mb (millibars). Areas where the barometric pressure is lower are associated with warm air and increased wind-speeds, this often produces clouds, precipitation, and other strong weather events, like hurricanes. Ocean condition measurements include: salinity, dissolved oxygen, and pH. Salinity is a measure of the dissolved salt content in a body of water. Typical ocean salinity is 30 ppt (parts per thousand), while freshwater has an average salinity of 0-0.5 ppt. Dissolved oxygen is the measure of the amount of gaseous oxygen (O_2) dissolved into an aqueous solution, in this case water (H_2O). Many ocean organisms use dissolved oxygen to breath, thus if dissolved oxygen levels are too low (below 80% saturation) organisms are physiologically stressed due to insufficient oxygen. pH is a measure of how acidic or basic an aqueous solution is, it is measured on a log scale with levels above 7 being basic and levels below 7 being acidic. The average pH of the ocean is close to 8.

Hurricane Sandy not only had an impact on humans, it also had a strong impact on many organisms that live along the eastern seaboard. These organisms were affected by the winds associated with the storm, for example many seabirds relocated from their habitats, as well by the storm surge which brought saltwater into freshwater habitats, thus affecting organisms that live in freshwater. Other organisms may also have been affected due to flooding in different regions.

Motivating Questions: What physical features of the ocean and atmosphere change during a hurricane? How do hurricanes affect organisms that live in the ocean?

Take Home Message

Hurricanes cause physical changes in both the atmosphere and the ocean. These changes not only have an impact on humans, but can also affect marine organisms.

Structure

In this activity, students will be exposed to two different data sets that show how physical features of the ocean and atmosphere change during a hurricane. First they will look at how atmospheric conditions change, and discuss how storms have an impact on themselves. They will then look at how ocean conditions change as a result of storms. Finally, they will brainstorm ways that these changes could affect ocean organisms.

Time required:

45-65 minutes

Activity Outline:

Engage: Have the students explore graphs of barometric pressure, wind speed, and rainfall to discover how the atmosphere changes as a result of a storm. You will then lead the class in a discussion on how the students were impacted by Hurricane Sandy. What do they remember?	15-20 minutes
Explore: Facilitate a Think, Pair, Share discussion on How non-humans/organisms are impacted/ survive storms. Explore graphs on ocean conditions to determine how changes in water depth, salinity, dissolved oxygen and pH, might affect ocean organisms.	20-30 minutes
Make Sense: Lead a class discussion on how ocean conditions could impact marine organisms.	10-15 minutes
Total:	**45-65 minutes**

Audience

High School Students (9-12th grade).

New Jersey Core Curriculum Content Standards - Science

Grade	Content Statement	CPI#
12	Scientific reasoning is used to evaluate and interpret data patterns and scientific concepts	5.1.12.B.4
12	Stability in an ecosystem can be disrupted by natural or human interactions	5.3.12.C.2
12	Empirical evidence is used to construct and defend arguments.	5.1.12.B.3
12	Natural and human activities impact the cycling of matter and the flow of energy through ecosystems	5.4.12.G.4
12	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	5.1.12.D.1

Next Generation Science Standards

Performance Expectation	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts

Earth Systems **HS-ESS-2**	Analyzing and interpreting Data	**ESS2.D** Weather and Climate	Stability and Change
Engineering Design,**HS-ETS1-1**	Asking Questions and Defining Problems	**ETS1.A**- Defining and Delimiting Engineering Problems	Influence of Science, Engineering, and Technology on Society and the Natural World
Earth's Systems, **HS-ESS2-5**	Planning and Carrying out Investigations	**ESS2.D**- Weather and Climate	Structure and Function

Preparation (5 minutes)

1. Write the motivating questions on the board:

   Q. What physical features of the ocean and atmosphere change during a hurricane?

   Q. How do hurricanes affect organisms that live in the ocean?

2. Prepare copies of all graphs for each group (attached at the end of this document), separate the graphs into 2 groups:
   a. Group 1: Graphs for the engage section are:
      i. Eastern Seaboard Barometric Pressure
      ii. Eastern Seaboard Wind-speeds
      iii. Eastern Seaboard Rainfall
   b. Group 2: Graphs for the explore section are:
      i. Salinities at the JCNERR SWMP Stations
      ii. Dissolved Oxygen at the JCNERR SWMP Stations
      iii. pH at the JCNERR SWMP Stations
3. Prepare maps of the eastern seaboard and New Jersey to be projected on the white board to use during class.
4. Prepare Water Depth at the JCNERR SWMP Stations Graph to be projected on white board for entire class to see.

Engage (15-20 minutes)

1. Explain to the students that they will be looking at graphs of atmospheric conditions that together tell the story of a weather event lasting almost 3 weeks. The graphs illustrate data collected from 3 different locations along the eastern seaboard of the United States: Massachusetts, New Jersey, and South Carolina.
2. Project the map of the Eastern Seaboard of the United States on the white board to give the students a reference point of the locations of each observation station.
3. The students will work in small groups to interpret a data set. Each group will be given a different dataset to interpret. The students will need to work together to understand the data set, draw conclusions from the data set, and determine how their piece of evidence fits in with the particular weather event they are studying (Hurricane Sandy). At the end of their 5-minute brainstorming sessions each group will present their data set to the class.

4. Explain to the students that their goal as a group is to try and determine what these graphs are showing and to try and determine what weather event(s) may have occurred.
5. Divide the class into small working groups (3-5 students).
6. Pass out copies of the following graphs to the groups (each group should only receive one data set).
    a. Eastern Seaboard Barometric Pressure: This graph shows the recorded barometric pressure, before, during, and after when Hurricane Sandy made landfall, for Waquiot Bay, MA; Jacques Cousteau National Estuarine Research Reserve (JCNERR), NJ; and North Inlet Winyah Bay, SC.
    b. Eastern Seaboard Wind-speeds: This graph shows the recorded wind-speeds, before, during, and after when Hurricane Sandy made landfall, for Waquiot Bay, MA; JCNERR, NJ; and North Inlet Winyah Bay, SC.
    c. Eastern Seaboard Cumulative Rainfall: This graph shows the recorded cumulative rainfall, before, during, and after when Hurricane Sandy made landfall, for Waquiot Bay, MA; JCNERR, NJ; and North Inlet Winyah Bay, SC.
7. As the students are reviewing the graphs, remind them to take a close look at the axis of the graphs and the units on the both the x- and y-axis. Walk around to answer any questions the students may have about their graphs.
8. After ten minutes has passed (or the students begin to wrap-up their work), have the groups report to the class what they believe their graph demonstrates. Have the groups respond to the following prompt questions when reporting to the class:
    a. What is included in their graph?
    b. What conclusions did they draw from their graph?
    c. What does their graph tell us about the weather event?
9. Have the students work together to use the different pieces of data to understand that: As Hurricane Sandy approached land barometric pressure decreased, wind-speed increased, and the cumulative rainfall increased. (Note-it might be helpful to write this on the board as the students are working through how all of their graphs are connected).
10. After the students have worked to link the three graphs together into a story of the weather event, share with the students that the 3 graphs provide evidence for a storm system known as a hurricane. More specifically, these graphs illustrate data collected from Hurricane Sandy.
11. Have the class spend 5 minutes reflecting on Hurricane Sandy. How did it impact them? What do they remember?
12. After the students have had time to reflect, allow students to share with the class what they remember about the storm.

Explore (20-30 minutes)

1. After a few students have shared their reflections, provide the following question to the students:

    Q. How are non-humans organisms impacted by storms such as hurricanes?

    Q. How are they able to survive?

2. Have the students brainstorm possible answers to this question, on their own for a couple of minutes. After they have had some time to think have them pair up with another student in the class to discuss the question. After they have had time discuss as a pair have each pair of students share with the class.
3. Explain to the class that they are going to take a look at a couple more graphs to determine how hurricanes have an impact on the water conditions in an estuary. Explain that the data displayed in the graphs were collected during Hurricane Sandy from 2 locations near the Jacques Cousteau National Estuarine Research Reserve (JCNERR) in Tuckerton, NJ. Buoy 126 is located near the Great Bay opening and the Chestnut Neck station is located further up bay. Project the map of New Jersey with a close up view of Great Bay to give the students a reference point and understanding of where the data were collected.

13. Explain to the class that first the whole class will make observations about one variable together as a class. Then the students will be working in small groups (3-5) students to interpret three additional graphs. Each group will be given a different dataset to interpret. The students will need to work together to understand the data set, draw conclusions from the data set, and determine how their piece of evidence fits in with the particular weather event (exactly what they did for the atmospheric data sets). At the end, each group will present their data set to the class.
4. Project the graph "Water Depths at the JCNERR SWMP Stations 10/25/12-11/12/12" for the whole class to see.
5. Have the class take a few minutes and look over the graph, reminding them to take a close look at what the axes are showing and to pay close attention to the units. After a couple of minutes have student volunteers share what they interpreted from the graph. Have the students share their responses to the following prompt questions again:
    a. What is included in this graph?
    b. What conclusions did you draw form this graph?
    c. How do you think this would impact organisms living in the area?
6. As class discussion slows down, share with the students that the graph illustrates water depths at the two stations for the three-week time period around Hurricane Sandy. As Sandy approached on October 29th there is a spike in water depths at both stations. Explain to the students that the depths shown in the graph are from the storm surge on top of an already high tide.
7. Break the students back up into smaller groups and distribute the following graphs to the groups (each group should only receive one graph and do not explain the graphs to the students):
    a. Salinities at the JCNERR SWMP Stations- This graph shows the salinity in parts per thousands (ppt) at each station before, during and after Hurricane Sandy. As Hurricane Sandy made landfall salinity increased in the upper bay (Chestnut Neck) and remained relatively constant at Buoy 126.
    b. Dissolved Oxygen at the JCNERR SWMP Stations- This graph shows the dissolved oxygen levels in percent saturation at each station before, during, and after Hurricane Sandy. After Hurricane Sandy made landfall dissolved oxygen levels decreased (on October, 30/31st, 2012) at the Chestnut Neck region but remained relatively constant at Buoy 126.
    c. pH at the JCNERR SWMP Stations- This graph shows pH levels at each station before, during and after Hurricane Sandy. pH decreased at Chestnut Neck after the storm made

landfall, while pH levels near buoy 126 remained relatively constant. A small change in pH is actually a large change due to pH being measured on a log scale.

8. Explain to the students that they are going to work in groups to interpret their graph. As the groups are interpreting their graphs, walk around to each group to answer any questions they may.
9. After ten minutes have passed (or the students being to wrap-up their work), have each group share with the class what they observed and their responses to the following prompting questions:
    a. What is included in their graph?
    b. What conclusions did they draw from their graph?
    c. Were there any difference between data collected at Buoy 126 and Chestnut Neck?
    d. How do you think this would impact organisms in the Great Bay?
10. Have the students work together to use these graphs to understand that: As hurricane Sandy approached water depths increased, salinity levels decreased, dissolved oxygen levels decreased, and pH decreased. They should also understand that these effects are felt more strongly the more inland you are than they are in the open bay.

Make Sense (10-20 minutes)

1. Lead a class discussion on how these changes to the estuary environment could have an impact on the organisms that call this area home. Some questions to lead the discussion could include:
    a. How could increased water depth affect marine organisms?
    b. How could a change in salinity affect marine organisms?
    c. How could decreased dissolved oxygen levels affect organisms?
    d. How could a change in pH levels affect marine organism?
    e. How could all of these changes together impact marine organisms?
    f. What are some ways that marine organism can protect themselves from these changes during storms such as hurricanes?
2. Have the students reflect on all of the graphs that they have looked at during the class period. And then take a couple of minutes to discuss in their groups the motivation behind today's lesson.

    Q. What physical feature of the ocean and atmosphere change during a hurricane?

    Q. How do hurricanes affect organisms that live in the ocean?
3. Have each group briefly share with the class their opinions on how these changes could affect ocean organisms.
4. Finally, ask if the students have any final questions about what they learned today.