Hurricanes & Oysters

Materials

For the leader:

Computer

Projector

Graphing paper

For the activity:

Graphing paper or graphing program

2010-11 Oyster Mortality Data Tables

2010-11 Rainfall & Salinity Figures

2010-12 Rainfall & Salinity Figures

2010-12 Oyster Mortality Figures

Overview

Hurricane Irene made its first landfall in St. Croix on August 20, 2011. Irene again made landfall on the Outer Banks of North Carolina on August 27th and in the Little Egg Inlet in southeastern New Jersey on August 28th. Throughout its path, Irene caused widespread destruction. Shortly after Hurricane Irene, Tropical Storm Lee hit the gulf coast and eastern seaboard (making its first landfall on September 2nd in Louisiana and impacting the mid-Atlantic area on September 5th). Due to Lee's large size and its slow forward movement, heavy rainfall was associated with the storm. In fact, the heavy rainfall resulted in historic flooding in the mid-Atlantic region.

In 2012, Hurricane Sandy became the second-costliest hurricane in United States history. While Sandy was only a Category 2 storm off the coast of the Northeast, it was the largest Atlantic hurricane on record (as measured by diameter, with winds spanning 1,100 miles (1,800 km)). In the early hours of October 29th, Sandy curved north-northwest and moved ashore near Brigantine, NJ. Hurricane Sandy affected 24 states, including the entire eastern seaboard from Florida to Maine and west across the Appalachian Mountains to Michigan and Wisconsin, with particularly severe damage in New Jersey and New York.

One of the major impacts of hurricanes on estuaries/bays is a change in the physical properties of the water. For example, more saline water can enter a bay if there is a high oceanic storm surge associated with the hurricane (often a short-term impact). Or large rainfall in the watershed during a hurricane can drop the salinity of the estuary (a short- to long-term impact). While estuarine organisms have evolved to live in a habitat with constant fluxes of the physical properties of the environment, every organism has physiological limits.

The Eastern oyster (*Crassostrea virginica*) is an important species both ecologically and economically. Ecologically, oysters create habitat and filter water. Economically, eastern oysters is an important fishery along the Atlantic coast of the United States, in 2010 an estimated 18.2 million pounds of meat was landed worth $76.2 million dollars. However, a trade-off exists for where oysters can live in estuaries/bays. In higher salinity environments, oysters experience faster growth but reduced survival due to disease and predation, whereas in lower salinity habitats, oysters grow more slowly, but disease and predation pressure is lower. Salinity is a primary factor limiting oyster distributions within estuaries. Oysters can tolerate a wide range of salinity allowing them to live in most regions of estuaries. Additionally, oysters can withstand periods of unfavorable conditions (e.g., exposure during low tide or episodic fresh water) by closing their shells and shifting to anaerobic metabolism. But, that means they are also unable to flush out toxic metabolites and constrained by

the amount of energy resources available to sustain glycolysis and to maintain muscular closure of the shells.

Motivating Question:

- **How can hurricanes impact oysters and other marine organisms?**

Take Home Message

Organisms have evolved to live in their environments, but there are limits to every organism's survival. Natural storms can produce conditions that some organisms cannot survive. But, not every storm results in death.

Structure

The students will be exposed to a range of data relating to oyster health in the Delaware Bay. The students will observe and interpret rainfall, salinity, and oyster mortality data from 2010-2012. The lesson is cyclical so the students build upon prior knowledge of the system and their skills in interpreting the data sources to discover the story of the impacts of hurricanes on oysters.

Time Required

60 minutes

Activity Outline

Engage: Students think about their experience in hurricanes and then interpret rainfall and salinity in 2010 and 2011 to see Hurricane Irene and Tropical Storm Lee.	15 minutes
Explore: Students make predictions about what impacts the storms may have on oysters. Then students interpret oyster mortality data from the upper portion of Delaware Bay from 2010 and 2011 to determine the impacts of Hurricane Irene and Tropical Storm Lee on the oyster population. Students then make predictions about the impacts of Hurricane Sandy (2012) and interpret the data from 2012.	35 minutes
Make Sense: Students synthesize what they have learned to think about how hurricanes impact oysters and other marine organisms	10 minutes
Total:	**50 minutes**

Audience

Late elementary and middle school students (4^{th}-8^{th} grade).

Next Generation Science Standards

Performance & Expectation	**Science & Engineering Practice**	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Earth's Systems, **MS-ESS2-5**	Planning and Carrying out Investigations	**ESS2.D**-Climate and Weather	Cause and Effect
Earth's Systems, **5-ESS2-1**	Developing and Using	**ESS2.C**-The Roles of Water	Scale, Proportion, and

	Models	in Earth's Surface Processes	Quantity
Engineering Design, **3-5-ETS1-2**	Constructing Explanations and Designing Solutions	**ETS1.B**- Developing Possible Solutions	Influence of Science, Engineering, and Technology on Society and the Natural World.
Earth and Human Activity, **MS-ESS3-2**	Analyzing and Interpreting Data	**ESS3.B**- Natural Hazards	Patterns

New Jersey State Science Standards

Grade	Content Statement	CPI#
4	Organisms can only survive in environments in which their needs are met. Within ecosystems, organisms interact with and are dependent on their physical and living environment	5.3.4.C.1
4	Some changes in ecosystems occur slowly, while others occur rapidly. Changes can affect life forms, including humans.	5.3.4.C.2
6	Weather is the result of short-term variations in temperature, humidity, and air pressure.	5.4.6.F.1
4	In order to determine which arguments and explanations are most persuasive, communities of learners work collaboratively to pose, refine, and evaluate questions, investigations, models, and theories (e.g., scientific argumentation and representation).	5.1.4.D.2
8	Science involves practicing productive social interactions with peers, such as partner talk, whole-group discussions, and small-group work.	5.1.8.D.1
8	Carefully collected evidence is used to construct and defend arguments	5.1.8.B.3

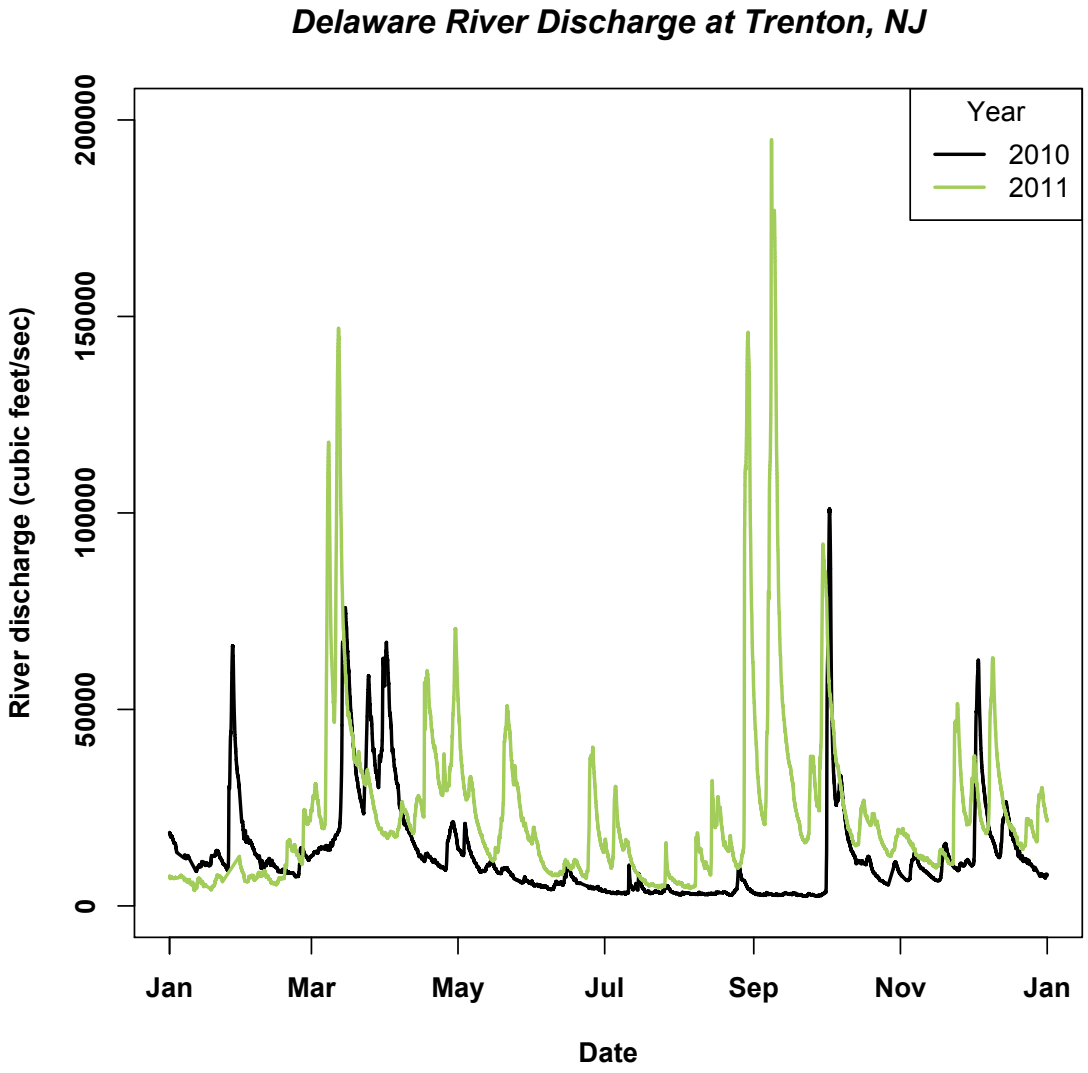
Preparation (20 minutes)

1. Write the motivating question up on the board:

   Q. How can hurricanes impact oysters and other marine organisms?
2. Make sure you have enough copies of the figures to pass out to each table group: 2010-11 Hope Creek Oyster Mortality.
3. Make sure you can project the Delaware Bay map of oyster beds, 2010-11 River Discharge, 2010-11 Salinity, 2010-12 River Discharge, 2010-12 Salinity, and 2010-12 Hope Creek Oyster Mortality.

Engage (15 minutes)

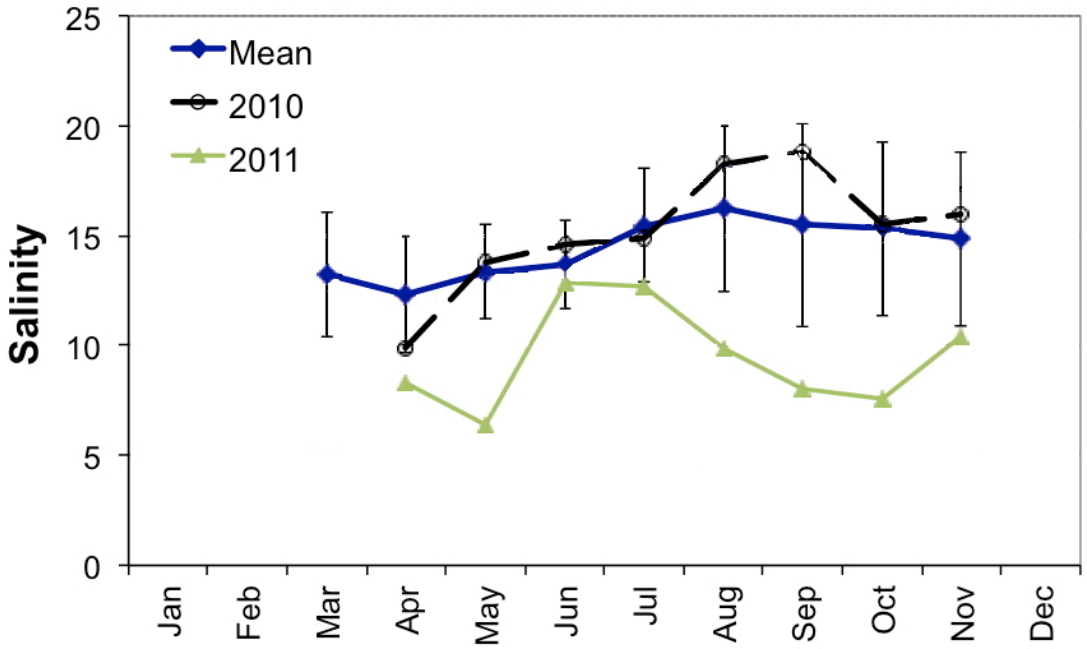
1. To begin class, have the students share things that they remember about how hurricanes impact their lives. Allow the students to share their experiences in a popcorn style, but steer the students away from sharing stories and towards reflections on the conditions (e.g., lots of rain → my street flooded, lots of wind → trees came down → lost electricity).
2. As the conversation slows, project the "Delaware River Discharge at Trenton, NJ" figure for 2010 and 2011 data. Orient the students to what is included in the graph:
   a. River discharge is one way in which scientists measure how much water runs off of the land into a river.
   b. The river discharge data were collected every 15 minutes from January 1st to December 31st each year.
   c. The students can look at how much rain there was in 2010 (black line) and in 2011 (green line) near Trenton, NJ. (Note – if your students are not familiar with where Trenton, NJ or the Delaware Bay is, it may be good to have a map of the area available for them to look at as well.)



3. After you have oriented the students to the figure have them work with a partner to think through what the spikes in the figure are showing.
4. As the conversations slow down, pull the class back together and have the students share what they were talking about in their partner groups. As the students are responding be accepting of all answers and remind students to state what evidence they used to draw their conclusions. Make sure the students understand the general patterns in the data:
    a. Spikes in the river discharge data (lines) means that there was a storm, ice, snow, or rain, which increased the amount of water flowing into the river.
5. Lead the students in a thought discussion about the relationship between increased fresh water coming into a river/bay and the salinity of the river/bay.[1] By the end of the conversations the students should understand the connections among increased precipitation (rain, ice, snow, etc.) → more fresh water running off into the river/bay → decrease in salinity in the river/bay.
6. After the students understand these connections, project the "2010-2011 Salinity" figure. Orient the students to what is in the figure:
    a. Measurements of salinity in the Delaware Bay are taken every month between March and November.

[1] If the students are not familiar with salinity, you will need to explain that concept here.

b. The blue line represents the average (mean) salinity in the Delaware Bay over the last 14 years. The black lines coming up and down from each point on the blue line is the variation around the average (mean) salinity.[2]
c. 2010 was a relatively typical year (salinity data aligns well with the 14-year mean salinity and falls within the variation, error bars, around the mean).
d. 2011 was a low salinity year (salinity data below the mean and mostly far below the observed variation) due to multiple large influxes of water into the system (high spikes in river discharge data).



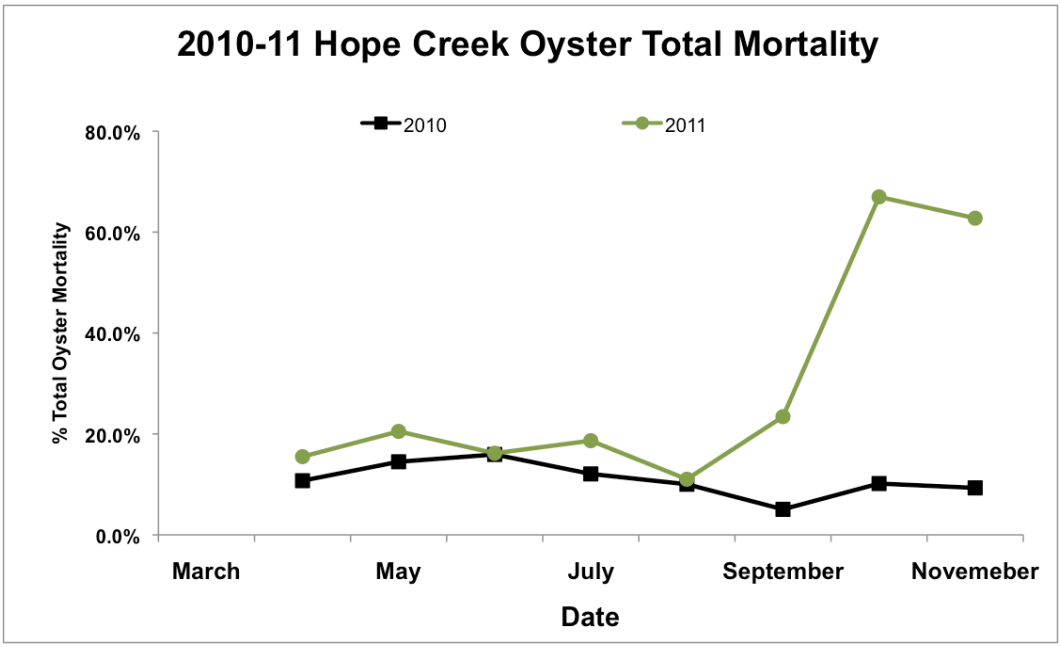
7. After you have oriented the students to the figure, ask them if they can see the impacts to the salinity in the Delaware Bay due to Hurricane Irene and Tropical Storm Lee. As the students are responding be accepting of all answers and remind students to state what evidence they used to draw their conclusions. Make sure the students understand the general patterns in the data:
    a. The students should notice that the salinity in general is low in 2011, and that it is especially love in September and October.

Explore (35 minutes)

1. Point to the motivating question: How can hurricanes impact oysters and other marine organisms? Have the students think about this question for a minute and then turn to their partner and share their initial predictions and thoughts.

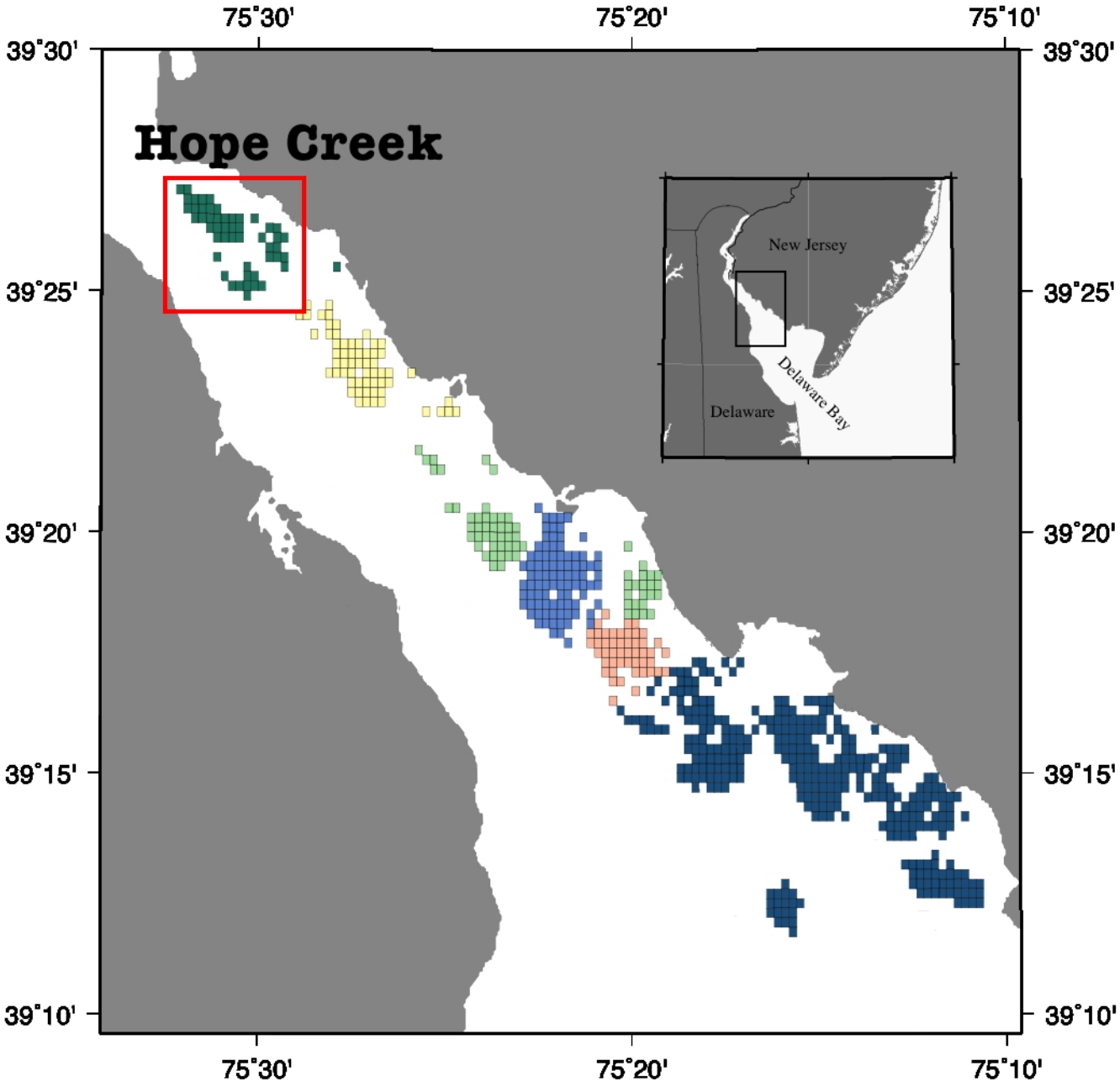
[2] If the students are struggling to understand what the error bars mean in terms of the variation around the 14 year mean, take a moment to demonstrate average and variation by collecting data on the height of all students in your classroom. A fun way to do this is to have the students stand up and order themselves by height. The shortest person represents the bottom bar, the tallest person represents the top bar, the person who is average height for the class represents the point, and all the rest of the students make up the line.

2. After the students have shared with one another ask for a few volunteers to report out what the partner groups were discussing about the impacts of hurricanes on marine organisms. Be accepting of all answers and encourage students to state what evidence or previous knowledge they used to come up with their predictions.
3. Provide the students with some background information about oysters:
    a. Oysters create habitat through oyster beds (oyster larvae only settle on other oysters) and filters particles out of the water for food, which cleans the water for other marine organisms.
    b. Oysters can tolerate a wide-range of salinity and withstand periods of unfavorable conditions, which is necessary living along the shores of tidal estuaries.
    c. During unfavorable conditions, oysters close their shells and shift to anaerobic metabolism in order to survive. However, oysters are unable to flush out toxic metabolites when their shells are closed. In addition, oysters are constrained by their energy stores, or resources, that are required for maintained function of their systems and to keep their shells closed.
    d. There is also a tradeoff for where oysters live. When oysters live in higher salinity areas, oysters are able to grow faster but there is an increase in the death from disease and predation. However, when oysters live in lower salinity areas the prevalence of disease and predation is decreased but oysters also grow more slowly.
    e. In the Delaware Bay are the annual natural mortality of oysters is <5 – 55% per year.
4. Explain to the students that they will be looking oyster mortality (number of dead oysters in a sample) from 2010 and 2011 in the Delaware Bay.



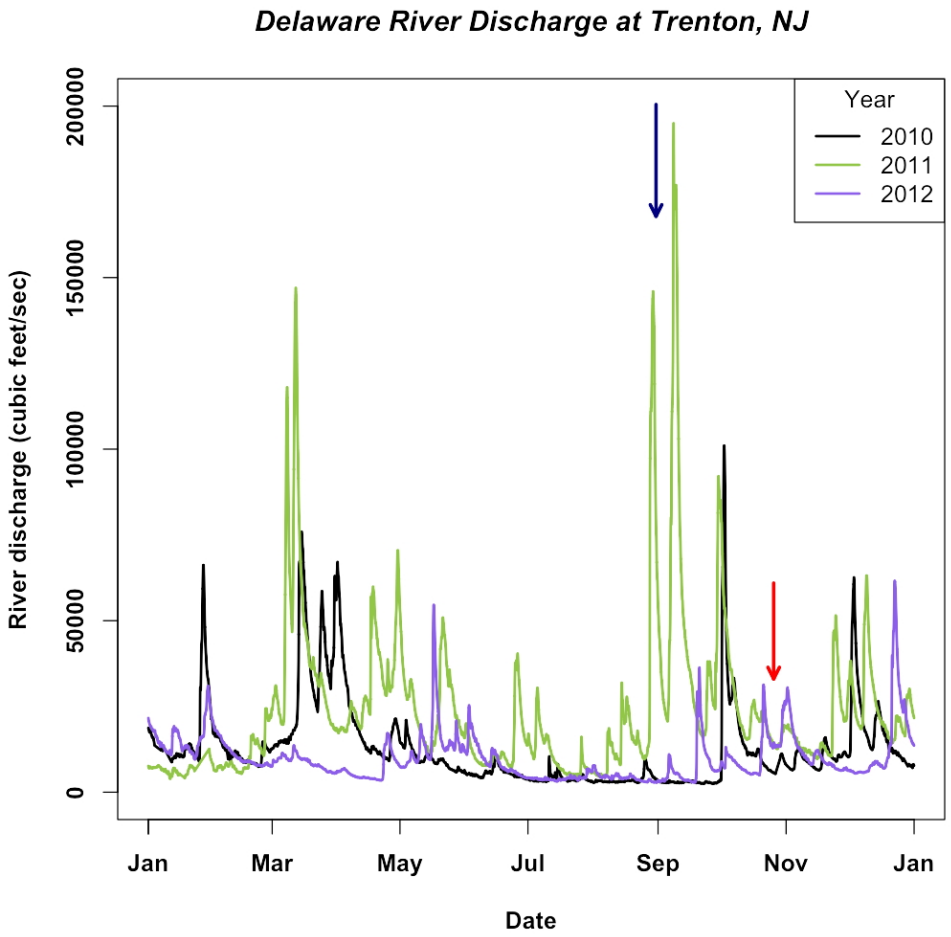
5. The students will work in small groups to interpret the data. It may be helpful to display the "Delaware Bay Oyster Stations" map as you are explaining where the data came from. Each of the

colored boxes on the map is an oyster bed, and they all have names. We will be working with data from Hope Creek in the upper part of the Bay.

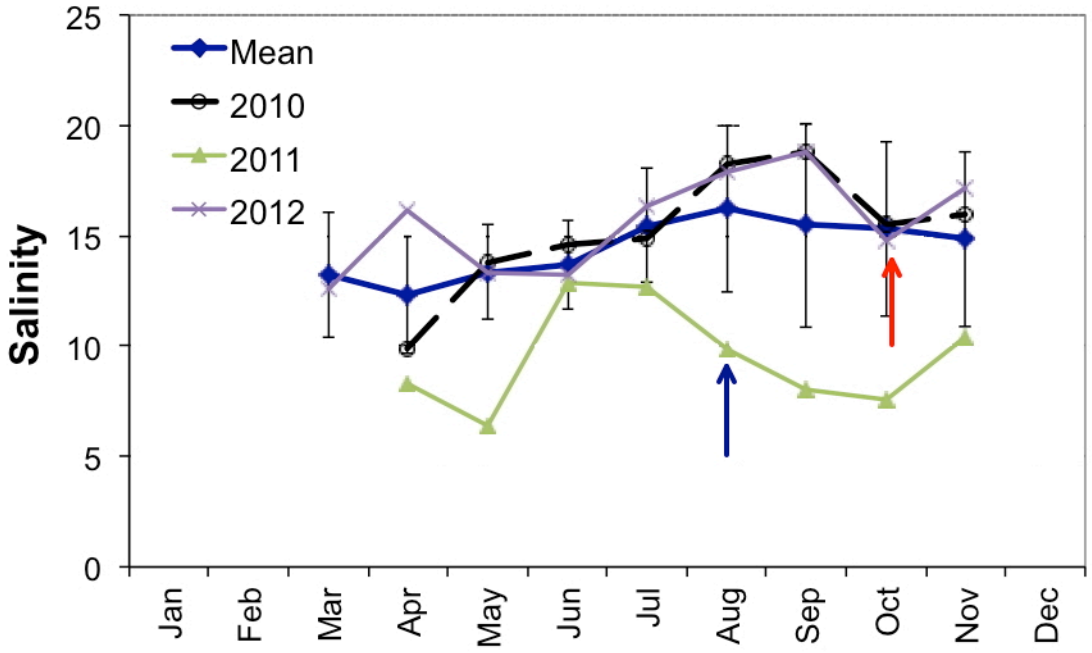


6. Provide each group with a copy of the "2010-11 Hope Creek Oyster Mortality" figure. Provide the students with enough time to interpret the data figure. Have the students work together to determine the impact of Hurricane Irene and Tropical Storm Lee (August-September) on the health of the oyster population. Encourage the students to think back to what you were previously talking about with respect to rainfall and salinity in 2010 and 2011.
7. When the students have interpreted the data, have them connect with another small group to present to one another what their determined from the data about oyster mortality in the Delaware Bay.

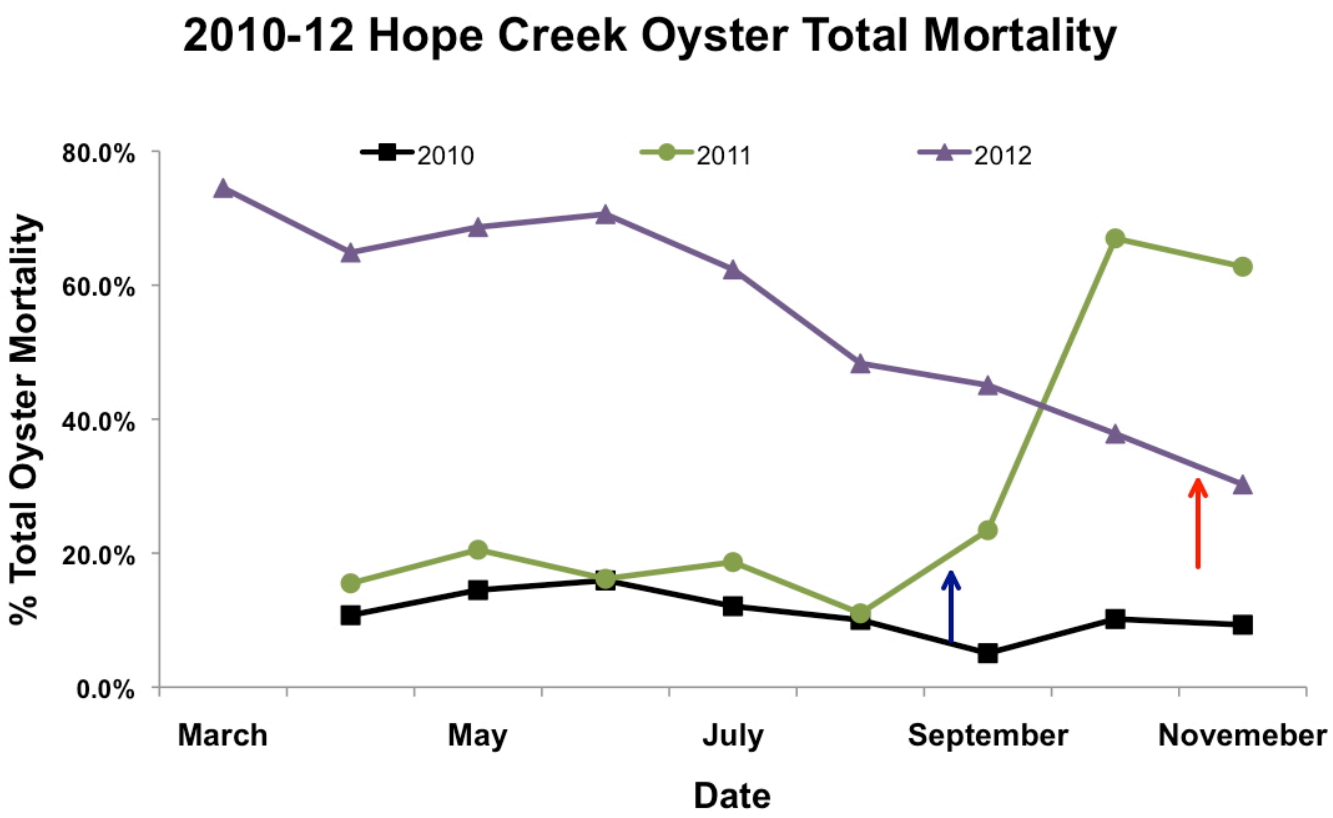
8. The students should work together to develop an understanding of the impact of Hurricane Irene and Tropical Storm Lee on oysters in Delaware Bay. As the students are discussing this, have them right down their two main conclusions from the data.
9. After a few minutes bring the students back together as a class to discuss what patterns the students observed with respect to hurricanes and oyster mortality.
    a. The students should observe that oyster mortality increased significantly at in 2011. The increase coincides with the monitoring collections after Hurricane Irene and Tropical Storm Lee (September, October, November).
    b. The students should be able to articulate that the low salinity due to Hurricane Irene and Tropical Storm Lee is correlated with a significant increase in oyster mortality in the Hope Creek oyster bed. Help the students understand that this was because of the physiological limits of oysters in low saline conditions.
10. When the conversation slows down, ask the students what impacts they predict Hurricane Sandy had on the oyster population in the Delaware Bay in 2012, knowing what they now know about hurricanes, oysters, and salinity. Allow the students to think to themselves, before turning to a neighbor to discuss their predictions.
11. After a minute or so, have the class come back together and share out what they were talking about with their partners. Write a few of the predictions on the board.
12. Project the 2010-2012 "Delaware River Discharge at Trenton, NJ" graph for the students to make observations about the amount of rainfall from Hurricane Sandy (red arrow) compared with Hurricane Irene/Tropical Storm Lee (blue arrow).
    a. Students should see that while Hurricane Sandy was a larger storm, it did not result in a lot of rain entering the Delaware Bay.



13. Have the students make a quick prediction about the salinity levels of the Delaware Bay after Hurricane Sandy as compared with the big decreased in salinity after Hurricane Irene/Tropical Storm Lee.
14. Project the 2010-2012 "Salinity" graph for the students to make observations about the amount of rainfall from Hurricane Sandy (red arrow) compared with Hurricane Irene/Tropical Storm Lee (blue arrow).
    a. Students should see that because there was not a lot of rain associated with Hurricane Sandy there was a small drop, but still in the realm of normal levels, in salinity in the Delaware Bay.



15. Have the students make a prediction about the oyster mortality in the Delaware Bay after Hurricane Sandy as compared with the big increase in oyster mortality after Hurricane Irene/Tropical Storm Lee. Have the students think to themselves and write down their hypothesis. Remind students to state what evidence they are using to form their hypotheses.
16. Once everyone has written their hypotheses ask the students to share what they expect to see in the oyster mortality data.
17. After writing down a few of the students predictions, project the "2010-12 Hope Creek Oyster Total Mortality" figure for the students to observe. Give the students a few minutes to look at the figure and process the data in relation to their predictions.



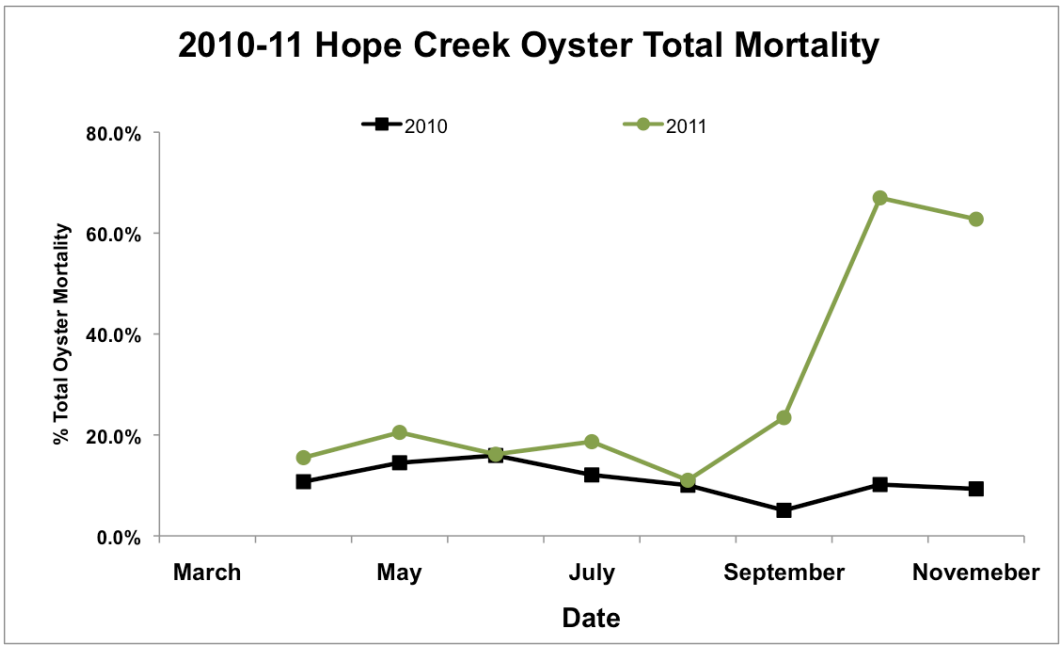
18. After a few minutes have the students work together in their small groups to talk through the impacts of Hurricane Sandy on oyster health.

Make Sense (10 minutes)

1. After the students have come to consensus on how to interpret the figures bring the class back together and lead a discussion with the students about what they found.
    a. The students should have observed that the mortality of oysters in fall 2012 in Delaware Bay was similar to 2010.
    b. The students may wonder why the oyster mortality decreased at Hope Creek throughout 2012; this is the residual result of the dye off from Hurricane Irene and Tropical Storm Lee. The important piece is that the mortality did not increase following Hurricane Sandy, but rather continued to decline towards 2010 levels.
2. Once the discussion slows down, point to the motivating questions and ask:
   Q. How can hurricanes impact oysters and other marine organisms?

1. Ask students to share their ideas about the question with a partner. After a minute, ask volunteers to share the ideas they discussed with the entire class. Be accepting of all responses from the students. This is your opportunity to make sure the students understand the "take home message" of the section.
2. Ask if the students have any final questions about the activities and presentations of the day.

Hurricanes & Oysters – Data Table & Figure 2010-11



Hope Creek % Total Oyster Mortality

	2010	2011
March		
April	10.7%	15.5%
May	14.5%	20.5%
June	15.9%	16.2%
July	12.1%	18.7%
August	10.0%	11.0%
September	5.1%	23.4%
October	10.2%	67.0%
November	9.3%	62.8%

Hurricanes & Oysters – Data Figure 2010-12