EarthEcho Expeditions

Oyster Reef Ecology Lesson Plan

Objectives

As a result of these activities, students will be able to:

- Understand the relationships between aquatic animals and their abiotic environment, specifically sunlight, oxygen, and nutrients
- Generate a basic food web from sample ecological data
- Define and calculate species richness and species abundance as ecological measures of diversity
- Appreciate the impact of humans on ecosystems like oyster reefs
- Make predictions about the effect of the dead zone on an oyster reef ecosystem

Materials

Either photocopies or electronic copies of Food Item Index and Species Count Worksheets
Butcher or poster paper
Markers, enough for at least one per student
Computer or tablet with simple graphing capability or calculators and graph paper

Teacher Background

By viewing *EarthEcho Expedition: Into the Dead Zone* Episode 1, we observed that the Chesapeake Bay supports a diverse array of wildlife, from bald eagles to blue crabs to barnacles. More than 2,700 plant and animal species call this estuary their home. Local marine residents include fish and shellfish, which are economically vital to local communities, and some species that are threatened and endangered. This system provides nursery habitat for fresh and saltwater fish species plus a permanent home and migration region for hundreds of species of birds. The Chesapeake Bay nourishes vast underwater gardens of bay grasses that provide food and habitat for a variety of animals. However one unassuming yet critical creature that defines this area is *Crassostrea virginica*, or the Eastern oyster!

The commercial and environmental importance of the Eastern oyster extends far beyond the Chesapeake Bay. This oyster species ranges the entire East Coast of North America, from the Gulf of St. Lawrence in Canada to Key Biscayne, Florida, and then continues along the Gulf coast through the Caribbean to the Yucatan Peninsula of Mexico and Venezuela. Oysters are *sessile bivalves*, soft-bodied animals that spend most of their lives in a hinged shell attached to another surface. Juvenile oysters, or *spat*, generally attach to other oyster shells and create a myriad of three-dimensional structures on what would otherwise be a muddy or sandy bottom. These oyster reefs create habitat for invertebrates and provide shelter for numerous inhabitants by effectively acting as an ecological niche. A wealth of research confirms the role oyster reefs play in increasing both the number and types of flora and fauna associated with these structures.

Two measures that scientists use to analyze habitats are: 1) species richness and 2) species abundance. Species richness is a measure of how many different species live within the boundaries of a given habitat or ecosystem. Species abundance, on the other hand, looks at how many individuals of each species are present within the same area. Habitats and ecosystems benefit from high species richness; this diversifies the food web and allows for greater stability during natural disasters or disease. However, without an abundance of species, ecosystems can suffer from resource limitations and reduced resilience.

Engage

1. Have students watch *What is Dead Zone?* video and specifically observe the work of NOAA's Chesapeake Bay Office and the Oyster Recovery Partnership.
2. Allow students time to explore additional video and photo links from the Day 1 webpage.
3. Ask students to describe the top predators in marine food webs. Ask them to identify what the top predator would be for the oyster reef ecosystem that they saw Philippe Cousteau monitoring.
4. Discuss how scientists in the video collect and evaluate data to help them understand how to better control the way humans impact these ecosystems. Encourage discussion about measuring animals and the variety of animals that were found in the trawl. Explore why baseline data is important in the research these scientists are doing.

Explore

Review concepts of ecosystems, habitats, and food webs with your students. As a class, make a list of the critical elements that support healthy ecosystems.

Provide the Food Item Index from page 5 and explain that this is an excerpt of data from a study from Texas A&M University, Corpus Christi, Texas, that examined habitats in Galveston Bay (Stunz et al. 2010). These animals were collected from an oyster reef habitat and this index represents the fish and crustaceans found on the reef. For each species of animal present, the food preferences are indicated.

Working in groups, have students create a food web, a visual representation of how each of the animals collected from the oyster reef are connected through energy and matter. Remind students that energy and matter are always moving through organisms in ecosystems through processes like photosynthesis, predation, and decomposition. How does each animal relate to one another? Encourage all members of a group to participate in creating this depiction and all contribute to the drawing.

As they are working, suggest that students may want to include organisms and energy sources to create a more complete picture, including items not listed on the index; for example, the sun, bacteria for decomposition, oysters, seagrass, benthic algae, or phytoplankton.

Once students are satisfied with their visuals, have them participate in a "gallery walk," where they walk and observe all the visuals, as if in a museum. Allow time after the viewing for students to make any additions to their drawings.

Explain

Engage in discussion about the shared food webs. Did students get ideas from the work of their peers? If so, how did they incorporate those ideas?

Which organisms would they classify as producers? Primary, secondary, and tertiary consumers?

Did anyone include humans in their food web? Why or why not? Would any information explored in *EarthEcho Expedition: Into the Dead Zone* support the addition of humans into the food web?

Ask students to go back and define the major relationships that they outlined in their food webs. Other than predation, what other kinds of relationships do they see? Are some organisms competing for similar food materials? Where can students identify potential competition in this ecosystem?

Many species that live on the oyster reef utilize the protection afforded by the structure built from the clustering of oyster shells, and feed on detritus and microalgae that grows on oyster shell. Have students identify relationships that are *mutualism*. Were these relationships already identified on their food webs? Explain.

Extend

Ask students how population size or number of individuals of any particular species in their food webs could impact the ecosystem. What happens if there is no phytoplankton or no blue crabs? What happens if we remove oysters? What happens if the number of pinfish were to double?

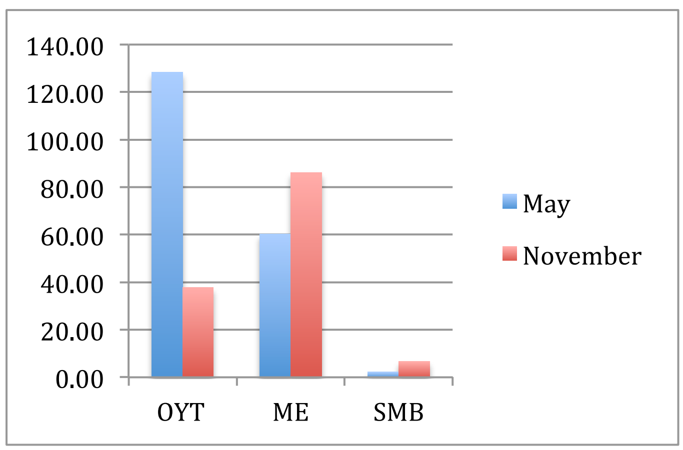
Students will now use a modified data table from the same study (Stunz et al. 2010) to examine and compare the species richness and abundance between three different habitat locations: an oyster reef, a marsh edge, and a shallow muddy bottom. Students will use the Species Count in Galveston Bay handouts (found on page 6-7) to calculate additional ecological profile information. The data was collected in Galveston Bay, Texas, in 2000 by sampling each habitat for ten days each month. The data shown in the charts is an average of the number of individuals of each species found in each sample. By analyzing the data, students will construct two graphs that will help them make inferences about how oysters may influence ecosystem structure with regard to species richness and abundance.

First, to calculate species richness, students will count the total number of species that were found for each date and habitat. Then to calculate abundance, students will add up the total values of all species for each habitat and date. Students should then construct two graphs comparing May and November sampling dates for each habitat. One graph will show species richness totals and the second will examine species abundance totals across the three habitats.

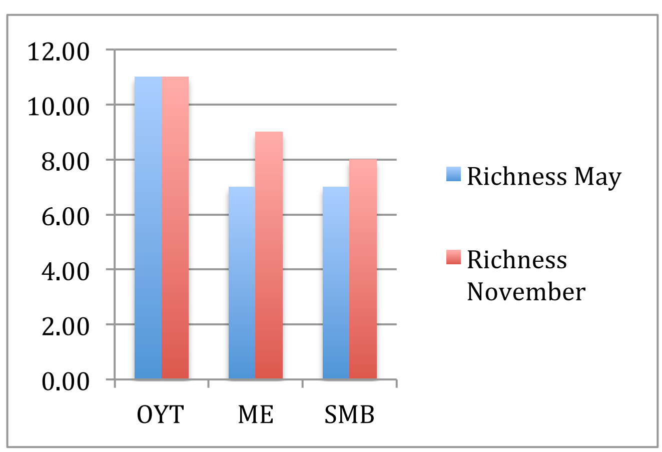
The graphs that your students create will look similar to those above.

Have students respond to the questions found on page 9 following their richness and abundance calculations.

These activities will provide foundation to explore additional ecological measures such as relative abundance and biodiversity indices. Additional resources to explore these extensions can be found at:



Species Richness



Abundance

http://www.alyoung.com/labs/biodiversity_calculator.html
http://www.envsci-ed.brockport.edu/Spreadsheet Models/SSA Exercise/Div.Sim.Ex.doc
http://www.carolina.com/teacher-resources/Interactive/calculating-flying-insect-biodiversity/tr10670.tr

Evaluate

A keystone species is a species that has a disproportionately large effect on its ecosystem. Why are oysters considered a keystone species in most estuaries?

When considering the dead zone in the Chesapeake Bay, what impact do students think it would have on species richness and abundance in the areas where oxygen levels drop significantly?

Engage students in summarizing the lessons learned from examining the ecology of oyster reefs. Upon reflection, have students identify parallel roles and activities in other ecosystems. Can they identify ecosystem engineers or keystone species in other habitats?

Resource

Stunz, Gregory W., Thomas J. Minello, and Lawrence P. Rozas. "Relative Value of Oyster Reef as Habitat for Estuarine Nekton in Galveston Bay, Texas." Marine Ecology Progress Series 406 (2010): 147-59.

Next Generation Science Standards Addressed

	Middle School	High School
LS2.A	Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth; Competitive, predatory and mutually beneficial interactions vary across ecosystems but the patterns are shared.	The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem
LS2.B	The atoms that make up the organisms in an ecosystem are cycled repeatedly between living and nonliving parts of the ecosystem; Food webs model how matter and energy are transferred between producers, consumers and decomposers as the three groups interact within an ecosystem	
LS2.C	Ecosystem characteristics vary over time and can lead to shifts in all of its populations;	
LS4.D	Changes in biodiversity can influence humans' resources and ecosystem services they rely on.	Sustaining biodiversity is essential to supporting life on Earth.

Food item index:

Survey of fish and crustacean species found on a Galveston Bay, Texas, oyster reef. Each type of animal is listed with the most common food items that each animal utilizes.

	Species	Food Items
Fishes	Inland silverside *Menidia beryllina*	Zooplankton
	Gulf toadfish *Opsanus beta*	Crustaceans (shrimp, crabs, amphipods, copepods), occasionally small fishes and mollusks (snails, clams, squid)
	Pinfish *Lagodon rhomboides*	Crustaceans (shrimp, crabs, amphipods, copepods), occasionally worms and small fishes
	Naked goby *Gobiosoma spp.*	Worms and small crustaceans (amphipods, copepods); also attracted to injured or dead oysters
	Atlantic croaker *Micropogonias undulatus*	Worms, crustaceans (shrimp, crabs, amphipods, copepods) and fishes
Crustaceans	Green porcelain crab *Petrolisthes aramtus*	Filter-feeder – plankton or detritus
	Grass shrimp *Palaemonetes sp.*	Filter feeder – plankton or detritus
	Shrimp *Penaeus spp.*	Detritus and algae; very small snails and juvenile fish, worms, and various small crustaceans (shrimp, amphipods, copepods)
	Snapping shrimp *Alpheus heterochaelis*	Worms, small crustaceans (shrimp, crabs, amphipods, copepods) and even small fish such as pearlfish and gobies
	Depressed mud crab *Eurypanopeus depressus*	Detritus and algae
	Mud shrimp *Upogebia sp.*	unconfirmed
	Blue crab *Callinectes sapidus*	thin-shelled bivalves like oysters and mussels, other crustaceans (crabs, shrimp), fish, marine worms, plants.

Species count in Galveston Bay Habitats

November 2000

Data collected in Galveston Bay, Texas, shows the average number of individuals of each species.

	Species	**Oyster Reef**	**Marsh Edge**	**Shallow Muddy Bottom**
		Average # of individuals counted over a 10 day period		
Fishes	Inland silverside *Menidia beryllina*	0.00	0.77	0.04
	Gulf toadfish *Opsanus beta*	0.00	0.00	0.00
	Pinfish *Lagodon rhomboides*	0.00	0.00	0.00
	Naked goby *Gobiosoma bosc*	2.35	0.12	0.00
	Darter goby *Gobionellus boleosoma*	2.77	4.31	0.50
	Atlantic croaker *Micropogonias undulatus*	1.62	0.00	1.15
	Bay anchovy *Anchoa mitchillli*	0.92	0.00	3.35
Crustaceans	Green porcelain crab *Petrolisthes aramtus*	0.00	0.00	0.00
	Grass shrimp *Palaemonetes sp.*	10.19	53.81	0.00
	Brown shrimp *Farfantepenaeus aztecus*	0.71	4.69	0.05
	Snapping shrimp *Alpheus heterochaelis*	5.65	0.08	0.00
	White shrimp *Litopenaeus setiferus*	0.54	1.70	0.12
	Pink shrimp *Farfantepenaeus duorarum*	0.95	1.49	0.19
	Depressed mud crab *Eurypanopeus depressus*	0.00	0.00	0.00
	Mud shrimp *Upogebia sp.*	6.31	0.00	0.00
	Blue crab *Callinectes sapidus*	5.73	19.31	1.23

Species count in Galveston Bay Habitats

May 2000

Data collected in Galveston Bay, Texas, shows the average number of individuals of each species.

	Species	Oyster Reef	Marsh Edge	Shallow Muddy Bottom
		Average # of individuals counted over a 10 day period		
Fishes	Inland silverside *Menidia beryllina*	7.00	0.27	0.22
	Gulf toadfish *Opsanus beta*	7.54	0.00	0.00
	Pinfish *Lagodon rhomboides*	2.81	1.69	0.38
	Naked goby *Gobiosoma bosc*	3.23	0.00	0.00
	Darter goby *Gobionellus boleosoma*	0.00	0.00	0.00
	Atlantic croaker *Micropogonias undulatus*	0.00	0.00	0.00
	Bay anchovy *Anchoa mitchillli*	0.04	0.00	0.13
Crustaceans	Green porcelain crab *Petrolisthes aramtus*	41.38	0.08	0.06
	Grass shrimp *Palaemonetes sp.*	32.65	42.65	0.32
	Brown shrimp *Farfantepenaeus aztecus*	7.82	14.14	0.92
	Snapping shrimp *Alpheus heterochaelis*	15.54	0.08	0.00
	White shrimp *Litopenaeus setiferus*	0.00	0.00	0.00
	Pink shrimp *Farfantepenaeus duorarum*	0.00	0.00	0.00
	Depressed mud crab *Eurypanopeus depressus*	9.35	0.00	0.00
	Mud shrimp *Upogebia sp.*	0.00	0.00	0.00
	Blue crab *Callinectes sapidus*	1.00	1.35	0.22

Species Abundance & Richness

Using data adapted from a survey by Stunz et al. (2010), examine the species of fish and crustaceans that live within three distinct habitats in Galveston Bay in Texas: oyster (*Crassostrea virginica*) reef, marshgrass (*Spartina alterniflora)* edge, and sandy/mud bottom. The study collected animals from three habitats in the Galveston Bay estuary by sampling each habitat for ten days each season. The data shown in the charts is an average of the number of individuals of each species they found in each sample.

1. Calculate the species **richness** for each habitat and month.
   Species richness is a measure of how many different **species** are living in a given habitat or ecosystem. Calculate this by counting the number of different types of animals the scientists collected at each site during each month and record your results in the table below.

Species Richness

	May 2000	November 2000
Oyster Reef		
Marsh Edge		
Shallow Muddy Bottom		

2. Calculate the **abundance** of species in each habitat and month.
   Abundance is measure of how many individual animals are living within a given habitat or ecosystem. Calculate this by adding the total number of all animals found in a given month and habitat. Record your results in the table below.

Abundance

	May 2000	November 2000
Oyster Reef		
Marsh Edge		
Shallow Muddy Bottom		

3. Using graph paper or graphing tools in Microsoft Excel or other program, create bar graphs for both species **richness** and **abundance** using the data that you created above.

Evaluating Ecological Data

Using your graphs and the data you created answer the following questions.

1. Throughout the study we saw changes in both species richness and abundance. What does species richness mean in a habitat? Why do you think this is important?

2. What does abundance mean within a habitat? Why do you think this is important?

3. Looking at your graphs, the species richness did not change from May to November for the oyster reef but the species abundance changed dramatically. What do you think may lead to this type of change? How does this help to differentiate between species richness and abundance?

4. In both the marsh edge and the shallow muddy bottom, we saw greater abundance and richness in November than in May. What are possible causes or reasons to explain this?

5. Which of the three habitats are most likely to be home to a diverse range of species? Support your opinion with evidence.

   Which was the least favorable habitat for animals? Support your opinion with evidence.