ACTIVITY 4

Estuary Food Pyramid

Estuary Principle

Estuaries support an abundance of life, and a diversity of habitat types.

Research Question

What role do plants and animals play in the estuary food pyramid?

Introduction

When animals eat plants or other animals in order to survive, there is a flow of food energy through the ecosystem. What starts out as energy from the sun is converted into food energy by organisms that use photosynthesis, and is transferred to other organisms as they consume food. The layers of the resulting food pyramid, called trophic levels, represent available energy. In this activity, students will construct an example of a food pyramid for estuary organisms and examine this flow of energy.

Climate Extension

Students will consider climate change potential impacts to marine food webs.

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This curriculum was developed and produced for:

The National Oceanic and Atmospheric Administration (NOAA) and The National Estuarine Research Reserve System (NERRS)

1305 East West Highway NORM/5, 10th Floor
Silver Spring, MD 20910

www.estuaries.noaa.gov

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TEACHER GUIDE

Estuary Food Pyramid

Research Question

What role do plants and animals play in the estuary food pyramid?

Content Objectives

Students will understand that:

- There are three major categories of living organisms in an ecosystem and each has a special role. They are: producers, consumers, and decomposers.
- The food energy produced by producers is cycled through the ecosystem through food chains and complex food webs by way of a series of energy levels called trophic levels.
- Energy is lost as it flows through the ecosystem. A food pyramid reflects fewer and fewer organisms at each level, supported by larger numbers of organisms at the trophic level just below.
- Students will learn that climate change has the potential for far reaching affects within marine food webs.

Exercises

Estuary Food Pyramid

Students will build a food pyramid to examine the flow of food energy through the estuary ecosystem by placing organisms in the correct order on a food web energy pyramid.

Climate Extension

Students will use the organisms in the food pyramid to draw a marine food web. Students will then read and discuss a scientific article about marine plankton food webs and climate change.

Assessment Questions

Assessment questions based on content covered in *Estuary Food Pyramid* can be downloaded on the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov.

Vocabulary

Adaptation – an inherited change in a living thing that helps it survive better in its environment.

Consumer – organism that feeds upon something else.

Decomposer – microorganism that breaks down dead tissue and returns the nutrients to the ecosystem.

Ecosystem – the biotic community and its abiotic environment.

Estuary – a partially enclosed body of water where two different bodies of water meet and mix.

Food pyramid – structure that demonstrates the movement of food energy through an ecosystem. "Producers" (plants) serve as the foundation level and an apex consumer is at the top level.

Food chain – arrangement of organisms detailing the order in which things are produced/consumed. .

Food Web – a network of interacting food chains.

Habitat – the particular part of the environment where a plant or animal naturally lives.

Photosynthesis – process by which plants, using chlorophyll and/or other photosynthetic pigments, manufacture food energy from sunlight & CO2, generating O2 as a byproduct.

Phytoplankton – microscopic photosynthesizing organisms that drift with the currents; microalgae including diatoms and dinoflagellates.

Predator – an animal that hunts, kills, and eats other animals.

Prey – an animal that is hunted, killed and eaten by other animals.

Producer – organism that manufactures its own food energy by photosynthesis. Green plants and some bacteria are producers. .

Trophic Level – level within a food pyramid demonstrating an organism's place in the feeding order within an ecosystem.

Zooplankton – animal plankton; many are microscopic but include larger animals such as jellyfish. Some, such as copepods, remain plankton for entire life cycle, while others, such as crabs, are planktonic only during larval stages.

Taking It Further

Perhaps your school is located in a freshwater area or near a Great Lakes estuary. If so, show your students the *Lake Erie Food Web Chart* that you will find under the Downloads tab on the web page for this activity on the Estuary Education website. See if you can identify the role of each organism and the organism's trophic level. For the Lake Erie area, which organisms are apex predators, analogous to the shark and osprey in this activity?

EXERCISE

Estuary Food Pyramid

Estuary Concept

Estuaries provide a rich food source for a wide variety of organisms.

Focus Questions

- What roles do different organisms play in the estuary food pyramid?
- In what ways could climate change impact marine food webs?

Performance Tasks

Students will:

- Build a food pyramid to examine the movement of food energy through an estuary ecosystem.
- Use the organisms in the food pyramid to draw a marine plankton food web. Students will then read and discuss an article about marine plankton food webs and climate change.

Overview

Students will use their understanding of five estuary organisms to explore food webs and the energy flow in an estuary ecosystem as shown in a food pyramid. These five organisms (or groups of organisms) correspond to the five separate activities within the Estuaries Support an Abundance of Life story that examine the organisms in more detail. In the separate activities, students look at the characteristics, life cycles, adaptations, and anatomy of these organisms.

Time Required

One 45-minute class session

Teacher Background

(Adapted with permission from Margaret Olsen's *Georgia's Wetland Treasures*)

There are three major categories of living organisms in an ecosystem and each has a special role. Together, producers (plants), consumers (animals), and decomposers (and detritus feeders) are the building blocks of the food pyramid.

The food energy produced by producers via photosynthesis is cycled through the ecosystem through food chains and complex food webs by way of a series of energy levels or feeding levels called trophic levels. Producers make up the first trophic level or base of the food pyramid. Primary consumers rely on the producers for food energy and make up the second level. The secondary consumers make up the third trophic level and so on. Each level depends on the levels below it for food energy.

Climate Extension

In many coastal systems, primary production is almost entirely a function of the phytoplankton. Even in salt marsh estuaries, where marsh grass and sedge biomass can greatly exceed that of algae, phytoplankton can contribute substantially to overall primary production. Phytoplankton plays an integral role in coastal food webs with primary production almost entirely a function of this microscopic organism. Phytoplankton are highly sensitive to the environmental variables within the estuary and respond quickly to changes in the estuary. Consequently plankton are often the first to be impacted by climate change. As the climate shifts it will likely change the abundance and types of species present in the estuary. While most scientists expect climate change to cause dramatic impacts to phytoplankton and the estuary food web, little is known concerning how these changes will occur.

The largest amount of available food (or biomass) is found in the first trophic level, the base of the food pyramid. The available amount of food energy and biomass decreases drastically at each higher trophic level. Less than 10% of the amount of food that is available in one trophic level is available to the consuming organisms living in the level just above. Because the amount of available food energy available in each successive level is less, each successive level can support fewer and fewer animals. That is, the population of organisms is less at higher levels as some energy is lost and the remaining energy concentrated, moving up the pyramid.

All food chains and food webs in estuaries start with the sun, which provides energy for plants and other producers. A healthy ecosystem must have suitable environmental conditions to support the growth of abundant producers. In this exercise, the producers are phytoplankton found in rich estuary waters. For consumers, use oysters, horseshoe crabs, birds, and sharks as examples.

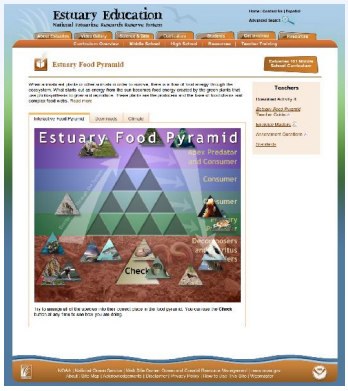
Teacher Preparation

1. Read the Teacher Background above to review food webs, trophic levels, and energy transfer within food pyramids.
2. Visit the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov and explore using the Estuary Food Pyramid simulation. You will use this as in-class demonstration for your students, so arrange for a computer with Internet access and a projector. Your students will then use the simulation themselves after they have completed the Student Master: *Estuary Food Pyramid*.
3. You may also want to have the food pyramid diagram available to project on a screen. Make a copy you can use from the Teacher Master: *Food Pyramid*.
4. Make copies of Student Master: *Estuary Food Pyramid* and Student Master: *Estuary Food Pyramid Organisms*.

Procedure

1. Begin the lesson by reviewing the definitions of food web, food pyramid, and trophic levels with your students. Use the Teacher Master: *Food Pyramid* and material found in the Teacher Background to explain how the food pyramid shows the flow and concentration of food energy from one organism to the others at higher trophic levels.
2. Use a computer and projector to show your students the Estuary Food Pyramid simulation found on the web page for this activity. Point out that an estuary has many diverse habitats that support an equally diverse range of organisms. Run your cursor over organism images to show your students how pop-up descriptions of the organisms appear. Read one or two of these descriptions. Try to only show organisms not used in this exercise. That is, avoid moving your cursor over the phytoplankton, oyster, horseshoe crab, shark, or osprey. Instead, mouse over other organisms such as the cordgrass, fiddler crab, clam worm, etc. You may show students that the organism images can be dragged to the pyramid, but do not complete a food pyramid at this time. Students will do that for themselves later.
3. Divide your students into pairs or small teams. Distribute copies of Student

You'll find multimedia and other resources on the web page for this activity in the Middle School Curriculum section of the Estuary Education website: http://estuaries.noaa.gov.



Take Note

This activity includes a Climate Extension. Please make sure to review the procedures and materials related to the Climate Extension before proceeding with this activity.

Materials

Per student pair or team:

- Computer with Internet access
- Student Master: *Estuary Food Pyramid*
- Student Master: *Estuary Food Pyramid Organisms*

Master: *Estuary Food Pyramid*. Have students quickly scan the list of organisms to explore (phytoplankton, oyster, horseshoe crab, shark, or osprey). Tell students that their assignment for this exercise is to explore how and where these organisms get the energy they need to survive in the estuary.

4. Assign each student team one of the five organisms. Ask students to first read the paragraph about their assigned organism and predict at which trophic level their organism belongs on the food energy pyramid.
5. Next students read the descriptions of the other four organisms. They then predict which organism belongs on the trophic level just above and just below their assigned organism.
6. Stop student work at this point and ask students to consider why their assigned organism belongs at a particular trophic level. Is it related to what they eat? You may choose to have teams with the same assigned organism compare their work at this time and see if separate teams agree on their organism's trophic level.
7. Allow student teams to visit the web page for this activity on estuaries.noaa.gov and use the Estuary Food Pyramid simulation to build a food pyramid based on the work they've done on the Student Master. Students should drag their assigned organism to the proper place on the pyramid, then drag the one or two other organisms they drew on their pyramid to the trophic levels above and below. Students should use any of the other available organisms in the simulation to fill in the remaining trophic levels. Students can click the "Check" button to check the work as they add organisms on the pyramid. The simulation will indicate how many organisms that have been placed at the correct trophic levels.
8. Students should answer the questions on the Student Master. Possible answers are shown below.

Climate Extension

9. Have students add organisms (clam worm, raccoon, mussel, Bald Eagle, striped bass, blue crab, shrimp, and diamondback terrapin,) from the online Estuary Food Pyramid or their Estuary Food Pyramid handout at the correct trophic level. Then have students build a food web, making sure to remind the students to always draw the arrow from the organism that is being eaten to point at the organism that is doing the eating. Students can use the descriptions of each of the organisms from the online Estuary Food Pyramid to help them build the food web.
10. Using their completed food web, have them complete the 3 related questions on the Student Master. Ask the students to explain what kind of role they think phytoplankton plays in the estuary food web.
11. Provide students or groups of students with a copy of the white paper "Marine Plankton Food Webs and Climate Change" written by scientists at the Virginia Institute of Marine Science. This can be downloaded from the Climate Extension tab for this activity (insert web address as well?). Either in groups or individually have the students read and answer the questions on the Student Master. Note depending on time and class you can assign students different sections of the article and have a group discussion to answer the questions.

For resources and links related to this Climate Extension, look for the Climate tab on the web page for this activity in the Middle School Curriculum section of the Estuary Education website: http://estuaries.noaa.gov.

Questions and Possible Answers

Q1. Is your assigned organism a producer or a consumer? Explain.

Student answers will vary depending on their assigned organism. The only producer is the phytoplankton. A producer creates food using energy from the sun. The other organisms are all consumers; they get their energy by consuming either a producer or other consumers.

Q2. Where does your organism get its energy?

Student answers will vary depending on their assigned organism. The producer gets its energy from the sun. The consumers get their energy by consuming either a producer or other consumers.

Q3. Do you think there are many or few organisms located in your assigned organism's trophic level? Why or why not?

Student answers will vary depending on their assigned organism. The higher on the pyramid their organism is found, the less biomass or food energy is available on the food pyramid. The student should realize that, in terms of numbers, the populations of organisms decrease going up the pyramid. It takes more of the prey to support fewer of the predators as energy flows through the system.

Q4. Write a paragraph describing the roles different organisms play in the estuary food pyramid.

Student paragraphs should include discussions of the ultimate source of energy in an ecosystem (the sun), the role of producers, and the flow of energy from producers to primary consumers, secondary consumers, and so on.

Climate Extension

Q5. How many organisms in your estuary food web rely directly on primary producers like phytoplankton as a food source?

There are two organisms – Eastern oyster and mussel.

Q6. How many organisms in your estuary food web rely indirectly on phytoplankton?

There are ten organisms that rely indirectly on phytoplankton because they are a higher level consumer or an apex predator and phytoplankton is the driver of the food web –horseshoe crab, American oystercatcher, shrimp, clam worm, blue crab, diamondback terrapin, raccoon, striped bass, bull shark, and Bald Eagle.

Q7. List three environmental variables, associated with climate change, that are expected to have impacts on plankton?

Students could have a variety of answers including: nutrients, temperature, salinity, precipitation, or CO_2 concentrations.

Q8. How could climate change cause an increase in some jellyfish populations and what impact would the increase have on other organisms in a coastal food web?

Increase in temperature related to climate change could cause an increase in

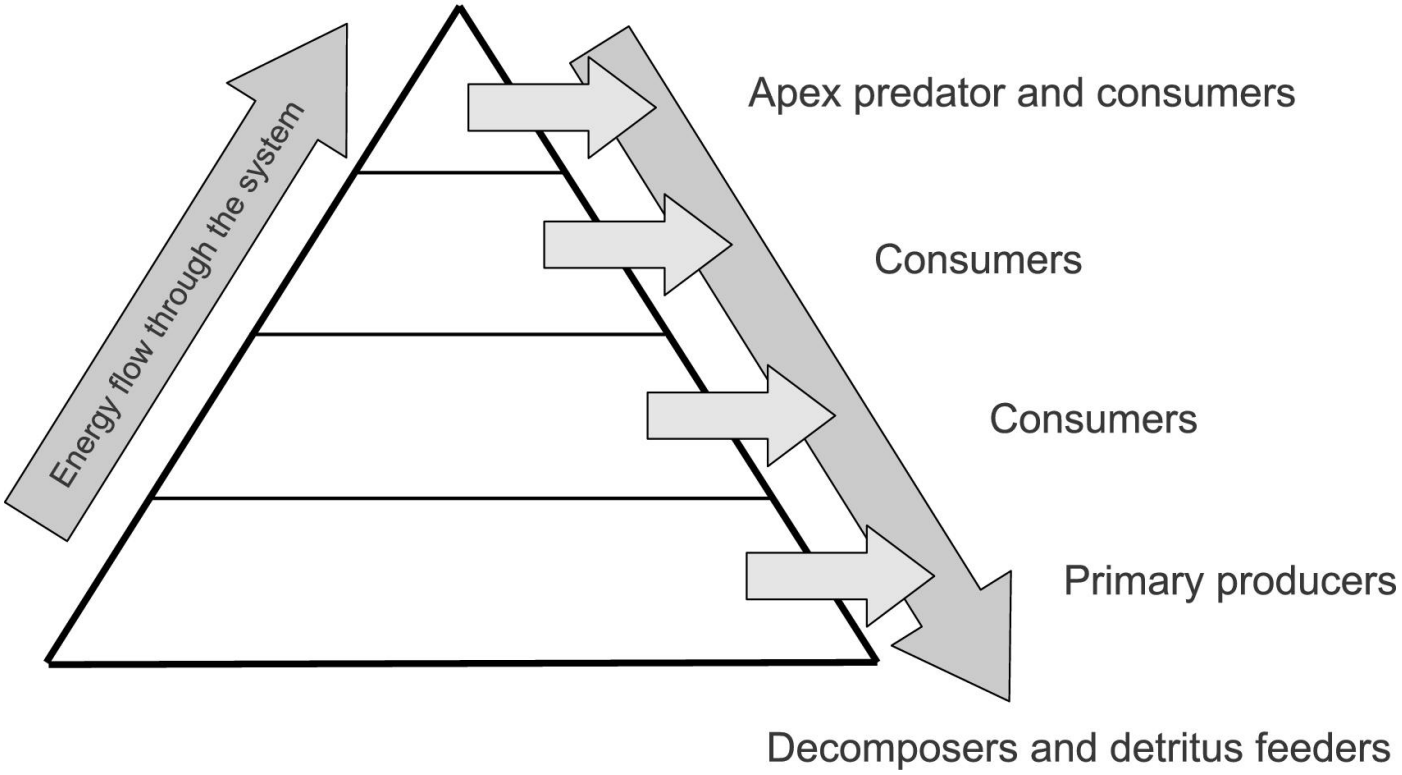
the jellyfish populations. For example sea nettle can become extremely abundant and grow rapidly when water temperatures exceed 25º C. Jellyfish species, like sea nettles and comb jellies, are significant consumers of copepods, an important species of zooplankton. Many fish and whale species also rely on copepods and could starve or be stressed if jellyfish consume a significant amount of the copepods.

Q9. Why is it important for scientists to continue to study the impacts of climate change on estuarine and coastal plankton?

While scientists acknowledge that climate change will have impacts on plankton communities and estuary food webs, much more research is needed to understand the specific mechanisms of how these changes will occur. Scientists need more information to understand how climate change impact on plankton's abundance, growth rates and diversity of species will specifically play out in the estuaries. More research is needed on this topic to understand how impacts to food webs will affect coastal economies like the fishing and tourism industry that many human life styles are dependent on. The Virginia Institute of Marine Science included four major research questions that their researchers think should be addressed to help Virginia be able to understand, mitigate, and adapt to some of the impacts of climate change.

TEACHER MASTER

Food Pyramid

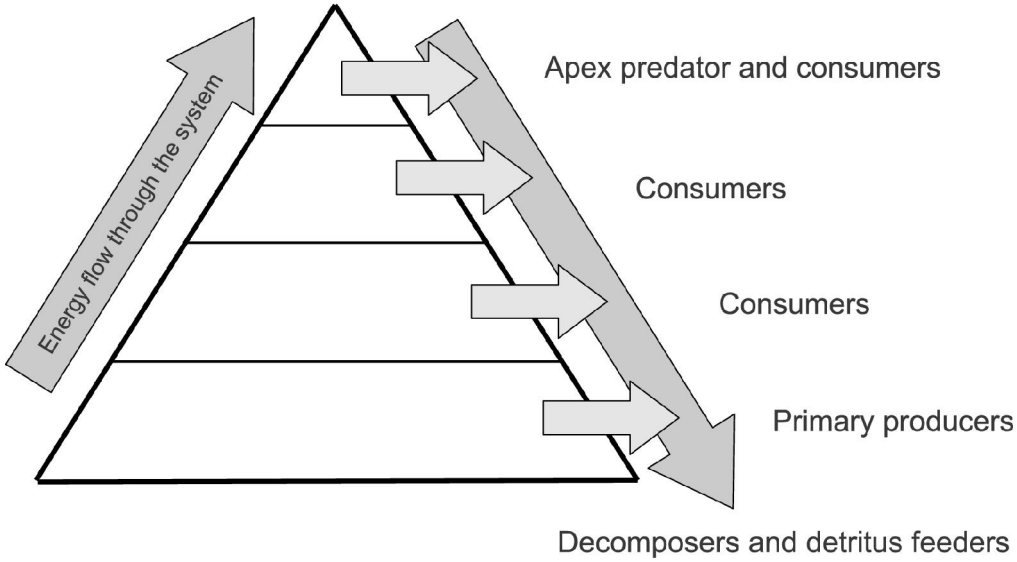


STUDENT MASTER

Estuary Food Pyramid

When animals eat plants or other animals in order to survive, there is a flow of food energy through the ecosystem. What starts out as energy from the sun becomes food energy created by the green plants that use photosynthesis to grow and reproduce. These plants are the producers and the base of food chains and complex food webs.

As one thing eats another, the layers of the food pyramid narrow. These layers, called trophic levels, represent available energy. Animals at each trophic level depend on animals living in the levels below them for food energy. The largest amount of available food energy is found on the first trophic level, the base of the pyramid. Less than 10% of the amount of food energy that is available in one level is available to the animals in the trophic level just above. That means each higher level can support fewer and fewer organisms.



Procedure

1. Your teacher will assign you one of the organisms found on the Student Master: Estuary Food Pyramid Organisms. Read the description of your assigned organism.
2. Draw a picture of your assigned organism on the food pyramid at the trophic level where you think it exists and/or feeds. Write your organism's name beneath your drawing.
3. Now read the descriptions of the other four organisms on the Student Master: Estuary Food Pyramid Organisms. Based on the descriptions, draw and label an organism that exists on the trophic level just above your assigned organism and an organism that exists on the trophic level just below your assigned organism. (Of course, this is no level above if your assigned organism is an apex predator. And there's no level below if the organism is the producer, except the decomposers and detritus feeders!)
4. Next, use the computer to use the Interactive Food Pyramid simulation. You will find it in on the web page for this activity in the Middle School Curriculum section of the Estuary Education website at estuaries.noaa.gov. Duplicate your food pyramid from this Student Master by dragging the onscreen image of your assigned organism to its proper trophic level. Drag to add the organisms you have selected for the adjacent trophic levels. Now fill in other trophic levels with other available organisms in the simulation. Click the Check button to check your work as you add organisms to see the food web.
5. Answer the questions on the next page.

Questions

Q1. Is your assigned organism a producer or a consumer? Explain.

Q2. Where does your organism get its energy?

Q3. Do you think there are many or few organisms located in your assigned organism's trophic level? Why or why not?

Q4. Write a paragraph describing the roles different organisms play in the estuary food pyramid.

STUDENT MASTER

Estuary Food Pyramid Organisms

Use the following information to help place your assigned organism in its proper position on the estuary food pyramid.

Oyster

Oysters and other bivalves are filter feeders. As they filter water over their gills, the oysters take in and eat algae, a kind of phytoplankton. The oyster spat or larvae are eaten by a wide variety of fish and invertebrates. Larger, mature oysters may be eaten by crabs, fish, starfish, worms, or birds.

Bull shark

Immature sharks may be prey to larger fish. However, adult sharks almost always find themselves at the top of the food web and the food pyramid. In an estuary, the shark is the apex (top) predator. Some sharks, such as leopard sharks, may feed on worms, clams, and crabs. Other sharks, such as the bull shark, may hunt for other sharks, turtles, and birds, among other prey.

Phytoplankton

Plankton are floating or drifting plants and animals and are found in bodies of water ranging from fresh to salty. Phytoplankton, the plant plankton that use the sun's energy to make food, are the base of the estuary food web and food pyramid. Plankton are critical in maintaining the health and productivity of the estuary ecosystem.

Horseshoe crab

Horseshoe crabs are bottom dwellers. Their diet usually consists of mollusks (various species of clams), gastropods (snails), and marine worms which are abundant on the bottom of estuaries. Horseshoe crab eggs and larvae are also a great food source for other animals, including birds such as the red knot sandpiper. Although juvenile and mature horseshoe crabs have a hard shell for protection, even they can be eaten. Mature horseshoe crabs are a food source for sea turtles and larger marine animals.

American Oystercatcher

The American Oystercatcher is a dark-colored, wading shorebird. Oystercatchers have long, large, heavy beaks that they use for smashing or prying open mollusks, including bivalves such as oysters, as well as mussels, barnacles, etc. Like other shorebirds, the main predatory threat to the oystercatcher occurs when their eggs are still in the nest, where the eggs can be eaten by other birds or small mammals or even some types of crabs.

CLIMATE EXTENSION

Estuary Food Webs and Climate Change

In this activity extension you will consider ways that the estuary food web could be impacted by climate change.

Procedure

1. Add the following organisms at the correct trophic level on your Estuary Food Pyramid: clam worm, raccoon, mussel, Bald Eagle, striped bass, blue crab, shrimp, and diamondback terrapin.
2. Create a food web with the organisms on your Estuary Food Pyramid by drawing arrows that start at the an organism being eaten to the organism that is doing the eating. Next use your completed estuary food web answer the following question:

   Q5. How many organisms in your estuary food web rely directly on phytoplankton as a food source?

   Q6. How many organisms in your estuary food web rely indirectly on phytoplankton?

3. Read the document titled "Marine Plankton Food Webs and Climate Change" and answer the following questions:

   Q7. List three environmental variables, associated with climate change, that are expected to have impacts on plankton.

   Q8. How could climate change cause an increase in some jellyfish populations and what impact would the increase have on other organisms in a coastal food web?

   Q9. Why is it important for scientists to continue to study the impacts of climate change on estuarine and coastal plankton?