



## LESSON PLAN: INTRODUCTION TO ESTUARIES

Overview: This lesson provides background information to lead a discussion about estuaries including their environmental and economic benefits.

Objective: Following the completion of this lesson, students will be able to:

1. Describe what an estuary is and describe its value to the environment as well as our own well-being.
2. Name four estuarine types based on their formation and list examples of each type.
3. Name three categories that can be used to further describe an estuary.
4. Know that the NY/NJ Harbor Estuary is often termed an “urban-industrial” estuary and describe several reasons why.
5. Begin to become aware of the need to wisely manage estuaries to sustain their economic, aesthetic and recreational and ecological resources.

Grade level: 5-12

Procedure: Discussion of background information followed by activity, “A Day in the Life of an Estuary” simulation game.

Materials: Goldfish crackers or other similar game markers (bingo chips), paper bowls or blue construction paper, game card sets (one per team).

Background: An estuary is a partially enclosed coastal body of water where salt water from the ocean mixes with fresh water draining from the land. Bays, inlets and tidal river valleys are all examples of estuaries. Estuaries are among the most productive ecosystems on the planet. Over 80% of the fish and shellfish we eat spend at least part of their lives in estuaries. Estuaries provide other important ecological functions too, acting as filters for pollution and providing protection from flooding. Finally, estuaries are often of great importance economically, providing us with food, jobs, consumer goods (through ocean-based shipping) and recreation.

Estuaries provide important habitat for many coastal organisms, providing them with food and shelter (habitat). Salt marshes are one of the habitats located within an estuary. They are ideal places for juvenile finfish and shellfish to hide, rest, eat and grow. Many of these animals later provide food for people. This “nursery function” of a salt marsh is critical to our continued supply of fresh seafood to eat.

Salt marsh are flooded and drained twice each day by the ocean’s tides. A special grass (*Spartina alterniflora* or salt marsh cord grass) that is salt water tolerant grows within the shallow “intertidal” areas that make up the salt marsh. Salt marsh cord grass dies off each year

and its decomposition produces detritus. Detritus, along with microscopic plants (phytoplankton) near the marsh's surface waters, provide food for many small organisms including Mummichogs (*Fundulus heteroclitus*) and Atlantic Silversides (*Menidia menidia*). Together the detritus, phytoplankton and small fish support not only the marsh food web, but because of the tides and the migration of fish and shellfish to adjacent bays and lagoons, contribute to the food web of the entire estuary and nearshore ocean zone.

Estuaries are divided into four types, depending on how they are formed:

1. **Coastal Plain Estuaries** are formed by sea level rising and filling an existing river valley. Chesapeake Bay in Maryland and the harbor of Charleston, South Carolina are two examples of **Coastal Plain Estuaries**.

2. **Tectonic Estuaries** are caused by the folding or faulting of land surfaces. These estuaries are found along major fault lines, like the San Francisco Bay area in California.

3. **Bar-built Estuaries** form when a shallow lagoon or bay is protected from the ocean by a sand bar or barrier island. Examples of these are found along the Eastern Seaboard and the Gulf Coast of North America.

4. **Fjords** are U-shaped valleys formed by glacial action. Fjords are found in areas with long histories of glacier activity, like northern Europe, Alaska and Canada.

Estuaries can further be classified into the following three types:

1. **Urban-Industrial Estuaries** (NY/NJ Harbor Estuary, Upper Delaware Bay) are estuaries that support intense human use. Surrounded by millions of people and subject to many uses, including income-producing commerce, the NY/NJ Harbor Estuary is a prime example of an urban-industrial estuary. People depend on urban-industrial estuaries like NY/NJ Harbor and the areas surrounding them for living space, jobs (at port-related industries, for example), resources (energy production), recreational outlets (fishing, water sports) and transportation (ferries).

The natural habitats and biodiversity of a typical urban-industrial estuary are, not surprisingly, severely impacted by human use. In the case of NY/NJ Harbor, human use has meant major changes to the natural environment and a reduction in natural resources. It has also meant the development one of the largest, busiest ports in the world, generating hundreds of thousands of good paying jobs. Furthermore, as NY/NJ Harbor also demonstrates, an urban-industrial estuary that is successful at providing for human needs does not have to be of poor environmental quality. Instead, through sound management practices and careful conservation efforts, people can continue to use urban-industrial estuaries to serve their needs while maintaining the well-being of the natural environment.

2. **Production Estuaries** (Barnegat Bay and Lower Delaware Bay) are estuaries where seafood for human consumption is gathered or cultivated. These estuaries provide places for commercial and recreational fishing, and aquaculture, such as the cultivation or growing of oysters. In

Barnegat Bay and Lower Delaware Bay species gathered or cultivated include oysters, hard clams, blue crabs, striped bass, flounders and weakfish. In a production estuary, it is important that the people caring for or managing the area care for or repair natural habitats (or, in some cases, create “new” habitats through the construction of artificial reefs) and monitor other conditions (such as water quality) that directly affect the health and growth of fish and shellfish. Production estuaries that are well cared for can also provide people with other important resources including places for recreation, education, and eco-tourism or simply enjoying the beauty of nature.

**3. Conservation Estuaries** (Mullica River Estuary) are for the most part undisturbed, self-sustaining ecosystems with minimal human use. They are usually in areas where human population is low. Estuarine Reserves, such as the Mullica River Estuary (Jacques Cousteau Estuarine Reserve) is an example of a conservation estuary in the United States. In these estuaries, priority is given to conservation and restoration efforts focused on habitats that support finfish and shellfish, wildlife, including endangered or threatened species, migratory birds, and resident species of the estuary.

In many larger estuaries such as the Chesapeake Bay all three estuarine types may be present (as sub-estuaries) and are managed as a continuum.

### **Activity – “A Day in the Life of an Estuary” simulation game.**

During the course of this game, students will experience a simulation of actions that can change estuaries in both positive and negative ways.

To play this game, divide students into teams of four or five, with one student designated as the “fish” banker and card holder. Each team will need: a blue bowl or sheet of blue paper (this represents the estuary), one set of game cards (see below), goldfish crackers.

To set up for play, each team places 10 goldfish crackers in bowl or on sheet of blue paper. The “Fish” banker holds the additional crackers and deck of game cards. Then, the following passage should be read aloud:

“Estuaries are places where the fresh water from rain, creeks, and rivers meets with the salty water from the ocean. This place is special for many animals. The shallow estuary water has saltmarsh areas that are nurseries for many young animals like fish, shrimp, and crabs. Pollution from people’s activities ends up in the estuary too. Sometimes pollution in the rivers makes tiny water plants, or algae, grow, and too much can grow sometimes. These algae use up the oxygen in the water. Like us, fish need oxygen to breath. When there is not enough oxygen there can be a “fish kill.” During a fish kill, many fish are found dead in the water—there simply wasn’t enough oxygen to go around! Good things happen, too. People can clean up the waterways, set aside habitat for wildlife, and make sure they only to catch fish when they are big enough and plentiful enough to catch.”

To play the game, one by one, each student will draw a card and complete the action, adding or subtracting “fish” as directed. Game continues until all cards have been drawn or each team’s “estuary” (represented by the bowl or blue paper), is depleted of “fish.”

<p>Bluefish closes in on school of smaller fish.</p> <p>Take out 3 fish.</p>	<p>Mr. Farmer sprayed for insects in his field on the edge of the waterway. When it rained, the runoff killed 3 fish.</p> <p>Take out 3 fish.</p>
<p>Legal protection for your fish species.</p> <p>Add 5 fish.</p>	<p>Volunteers do a "Clean Sweep" along the estuary.</p> <p>No fish lost.</p>
<p>Ms. Farmer fertilized her bean crop. Extra algae grew in the water. Fish die.</p> <p>Take out 2 fish.</p>	<p>The nursery has lost 3 fry. (fish babies)</p> <p>Take out 3 fish.</p>
<p>3 fish are caught in a gill net set by Ms. Jones.</p> <p>Take out 3 fish.</p>	<p>Salt marsh area set aside as nature reserve.</p> <p>Add 4 fish.</p>
<p>Seals feed in the estuary.</p> <p>Lose 2 fish.</p>	<p>New marina attracts 20 new boats to stay in the estuary.</p> <p>Lose 3 fish.</p>
<p>Great weather increases habitat.</p> <p>Add 2 fish.</p>	<p>A boater dropped a can of oil in the water and 3 fish died.</p> <p>Take out 3 fish.</p>

<p>A seagull flies over. It eats a fish for dinner.</p> <p>Take out 1 fish.</p>	<p>Salt marsh left undisturbed. Each player gets to add</p> <p>4 baby fish.</p>
<p>Something mysterious in the water kills fish.</p> <p>Take out 8 fish.</p>	<p>New fry hatch.</p> <p>Add 5 fish.</p>
<p>A vacationing family went fishing. Mr. and Mrs. Jones, little Jim and Judy each caught a fish. How many fish will you take out?</p>	<p>Area becomes protected for wildlife, fishing is prohibited.</p> <p>Add 3 fish.</p>
<p>A shark ate 3 fish.</p>	<p>Someone builds a new dock without a permit. 2 fish are killed when pilings hurt their habitat.</p> <p>Take out 2 fish.</p>
<p>Big algae bloom due to over fertilization of golf course nearby. No oxygen left.</p> <p>Take out 10 fish.</p>	<p>A fish ate a rubber worm Mr. Jones lost while fishing, the fish dies.</p> <p>Take out 1 fish.</p>
<p>Artificial reef installed.</p> <p>Add 4 fish.</p>	<p>Fish ate a piece of plastic trash and dies.</p> <p>Take out 1 fish</p>

### **Closure Discussion Questions:**

1. What are some things that effect estuaries in good ways? bad ways?
2. What kinds of things can we do to help preserve and protect estuaries?
3. Did your population completely die off? Why? Do you think that in real life this would happen? Why or why not?

**Simulation game adapted from the North Carolina National Estuarine Research Reserve Education Office, January 2001.**

The North Carolina Coastal Reserve Program, within the Division of Coastal Management, was authorized by the NC General Assembly in 1989 to protect unique coastal sites. The program includes the North Carolina National Estuarine Research Reserve, part of the NOAA.



**This lesson plan was developed by the Education Program at the NJ Marine Sciences Consortium/NJ Sea Grant.**  
For complete program information contact the NJMSC/NJSG at 732-872-1300 or [www.njmssc.org](http://www.njmssc.org)