

Draft Teacher's Guide



Estuaries – where rivers meet the sea

ESTUARYLIVE 2004

TEACHER'S GUIDE

Estuaries – where rivers meet the sea



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INTRODUCTION

Welcome Teachers!

Take your students on an EstuaryLive telecast! On Saturday September 25, 2004 we will be celebrating National Estuaries Day - an annual celebration of the magical places where fresh water from rivers mix with salt water from the ocean. EstuaryLive kicks off the celebration September 23 and 24 by bringing free, live Internet field trips in seven different estuaries around the country right to your classroom!

Designed as interactive for classrooms, this program can be viewed by anyone; all you need is a computer hooked up to the Internet. As you and your classroom embark on these estuarine excursions, you can ask questions and have them answered live during the telecast. Join us! It is a great way to teach your students about estuarine ecology, compare ecosystems from all three of our coasts, and discover the exciting and innovative technology used to bring these field trips to you.

Explore www.estuaries.gov to learn more about estuaries and how to protect them. We invite you to share your thoughts, ideas, and questions about EstuaryLive and this Web site. Also, help to tailor EstuaryLive and www.estuaries.gov to the needs of your classroom by participating as an EstuaryLive evaluator. Please contact Becky Weidman, National Estuaries Day Coordinator (Rebecca.Weidman@verizon.net) if you are interested in becoming an EstuaryLive evaluator or if you have any questions or comments.

Overview of the Teacher's Guide to EstuaryLive

EstuaryLive is a one of a kind educational program. The field trips offered throughout the two-day exploration allow teachers to bring estuaries into the classroom. These interactive, "next best thing to an actual trip to an estuary," field trips, provide students with an exciting and new way to learn about these unique ecosystems. EstuaryLive inspires students to learn by providing them with the opportunity to guide their scientific discoveries through questions- helping to shape the field trip that they are taking over the Internet.

One of the most exciting aspects of EstuaryLive is the technology involved in its production. EstuaryLive uses state-of-the-art satellite technology to broadcast remote field trips over the Internet and KU band satellites. The technology used in EstuaryLive is very similar to the satellite technology used during news casts and sporting events. The use of this type of technology allows for an interactive platform for students of all ages to learn about estuaries. In addition, EstuaryLive provides classrooms with an opportunity to tour several different ecosystems from around the nation, offering an excellent tool for comparative studies. Curriculum tailored to each field trip and locality, as well as curricula and activities to help compare these ecosystems, is available in this document and on www.estuaries.gov for teachers to help prepare their classroom and to provide follow-up materials for the program.





This guide to EstuaryLive will take teachers through the process of preparing for and participating in EstuaryLive. The document provides a complete program schedule, with program content and curricula; information about how EstuaryLive correlates with national science standards; how to make sure your classroom's technology is ready to support EstuaryLive; and a plethora of other materials to help teachers insert EstuaryLive into their annual science curriculum.





Overview of the EstuaryLive Program

Participate in EstuaryLive September 23 and 24, 2004! EstuaryLive is the feature event of National Estuaries Day- a campaign to educate the public about estuaries and the need to protect them. EstuaryLive will take you on an interactive field trip of our nation's estuaries. You can join from your home or classroom. The entire journey takes place over the Internet. EstuaryLive is a telecast brought to you by National Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve System (NERRS) and the U.S. Environmental Protection Agency's (U.S. EPA) National Estuary Program (NEP).

EstuaryLive is a one in a kind program that is produced each year to provide students the opportunity to tour the nation's estuaries. Since you can't bring your classrooms to each of these estuaries- we bring them to you! The goals of EstuaryLive are to: provide an opportunity for students around the country and world to experience, in real-time, a field trip to the unique habitat of an estuary; give students the opportunity to compare different estuaries around the country; take students on an exploratory trip to the estuary with the opportunity to interact with research scientists, education professionals, and natural resource management professionals; increase students' understanding of estuarine ecological, social and economical principals; and to provide a resource for further information.

This year's program features seven estuaries from around the country:

- Rachel Carson site in North Carolina
- Mullica River-Great Bay in New Jersey
- Padilla Bay in Washington
- Peconic Bay in New York
- South Slough in Oregon
- Weeks Bay in Alabama
- Waquoit Bay in Massachusetts

During the program, naturalists from NOAA's National Estuarine Research Reserves and U.S. EPA's National Estuary Programs will take participants on a journey through each unique ecosystem. Participants can interact with the tour guides by emailing questions during the field trips. Most questions will be answered live during the broadcast. An educator will respond to any questions not answered live during the Internet broadcast by emailing the author directly.

Each of these field trips will feature different topics and will be targeted towards a specific age group- the overall program targets a K-12 audience, but many colleges and universities participate as well. Additional information about each of this year's seven field trips can be found in the program content section. Some highlights from previous year's programs include: using radio telemetry equipment to track Eastern box turtles and sora rails from the Chesapeake Bay; discovering how robots are being used to study the coastal ocean in New Jersey; exploring





bogs with bug eating plants in Alabama; investigating the unique issues facing urban estuaries in Seattle, Washington; and discussing the process of restoring an estuary in Oregon. While preparing for EstuaryLive, make sure to check www.estuaries.gov for information on each field trip, associated activities and curriculum, and the targeted age group for each field trip.

EstuaryLive is an excellent opportunity for you and your classroom to discover the differences between estuaries located on the nation's three coastlines. Throughout the summer, new activities will be developed to help you and your classroom compare and contrast the different estuaries featured during EstuaryLive. You are encouraged to send a copy of these activities, as well as other activities that you and your classroom have completed, for a chance to win an EstuaryLive educational tool kit, filled with educational materials, posters, magnets, and lots of other estuarine items. Please visit www.estuaries.gov for more details. We also encourage you to send us any activities that you have developed to compliment your students' EstuaryLive expedition. With your permission, we would like to add these materials to our suite of EstuaryLive activities posted on www.estuaries.gov.

History

EstuaryLive was conceived in 1998 by Susan Lovelace, marine educator and Bill Lovin, founder of MarineGrafics as a way for the North Carolina National Estuarine Research Reserve to take those students in North Carolina who could not physically visit the Reserve, on a tour of the estuary. The North Carolina Reserve offered (and still does) field trips twice a year and over the years, developed a loyal audience of classrooms from both North Carolina and other parts of the country.

In 2001, EstuaryLive was adopted as the feature event for National Estuaries Day due to its past success reaching and engaging North Carolina classrooms. The first year of the national EstuaryLive program, twelve estuaries were featured, but only three of those field trips were live. The remaining field trips were pre-recorded, with naturalists available by phone to answer students' questions. In the following two years the pre-recorded field trips were phased out and now EstuaryLive offers two days of live, interactive estuarine field trips. In 2002, Susan Lovelace and Bill Lovin were recognized by the Tech Museum of Innovation for EstuaryLive and were named Intel Tech Laureates for the Environment.

About the NERRs and NEPs

National Estuaries Day and its feature event, EstuaryLive are brought to you by NOAA's National Estuarine Research Reserves and U.S. EPA's National Estuary Programs. The Reserves and NEPs have a unique partnership, they work together to protect estuaries around the country, but take a slightly different approach to achieve their common goal.

What are the NERRs?

The National Estuarine Research Reserve System (<http://nerrs.noaa.gov/welcome.html>) is a network of twenty-six protected areas established for long-term research, water quality monitoring, education and stewardship. Each of the 26 Reserves represents a different





biogeographic region of the United States. A biogeographic region is a geographic area with similar dominant plants, animals and prevailing climate. There are 11 major biogeographic regions around the coast, with 29 sub regions. Established by Section 315 of the Coastal Zone Management Act of 1972, as amended, the reserve system is a partnership program between NOAA and the coastal states. NOAA provides funding, national guidance and technical assistance. Each reserve is managed on daily basis by a lead state agency or university, with input from local partners.

Reserve staff work with local communities and regional groups to address natural resource management issues, such as nonpoint source pollution, habitat restoration and invasive species. Through integrated research and education, the reserves help communities develop strategies to deal successfully with these coastal resource issues. Reserves provide adult audiences with training on estuarine issues of concern in their local communities. They offer field classes for K-12 students and support teachers through professional development programs in marine education. Reserves also provide long-term water quality monitoring as well as opportunities for both scientists and graduate students to conduct research in a “living laboratory.”

What are the NEPs?

U.S. EPA’s National Estuary Program (<http://www.epa.gov/owow/estuaries/>) was established by Congress in 1987 to improve the quality of estuaries of national importance. The Clean Water Act Section 320 directs the U.S. EPA to develop plans for attaining or maintaining water quality in an estuary. This includes the protection of public water supplies, the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife, and allows recreational activities, in and on water, and requires the development of supplemental controls for point and nonpoint sources of pollution.

The NEPs work with local stakeholders, including state agencies, universities, other not-for-profit organizations, the local community- to name a few, to develop and implement a Comprehensive Conservation and Management Plan (CCMP). The CCMP addresses all aspects of environmental protection for the estuary, including issues such as water quality, habitat, living resources, and land use. The CCMP is based on a scientific characterization of the estuary, and is developed and approved by a broad-based coalition of stakeholders. The CCMP establishes priorities for action, research, and funding, and serves as a blueprint to guide future decisions and activities related to the estuary.

Working Together to Achieve the Same Goal

The Reserves and National Estuary Programs are working together to improve the health of estuarine ecosystems around the country. Both the Reserves and NEPs work with local stakeholders to protect these delicate ecosystems. Both programs provide outreach and education for the general public and conduct research. As mentioned above, Reserves are tasked with preserving pristine ecosystems in the different biogeographic regions of the country. These





ecosystems are maintained and preserved under the guidance of Reserve staff. All Reserves have educational and research facilities on-site, providing an opportunity for visitors to come to the Reserve and learn about the research and stewardship activities currently underway. The NEPs are tasked with enhancing the water quality and health of impaired ecosystems or estuaries that may be susceptible to degradation. The NEPs do not all have educational and research facilities on-site. The NEPs work closely with a group of stakeholders to improve the water quality of an estuary and to develop and implement their educational programs and research initiatives.





Alignment with National Science Education Standards

EstuaryLive 2004 is aligned with the National Science Education Standards (NSES) listed below. How thoroughly each topic is addressed is dependent upon the individual field trips and more importantly, the questions that you and your students ask during the field trip. Below is a general list of the NSES that will be addressed throughout the entire EstuaryLive program.

In addition, you will also find that, for each of the EstuaryLive 2004 programs, there are a set of educational activities (available on www.estuaries.gov, EstuaryLive, Program Schedule) correlated to the specific standards.

Correlation	K-4	5-8	9-12
Content Standard A: Science as inquiry			
○ Abilities necessary to do scientific inquiry	√	√	√
○ Understanding about scientific inquiry	√	√	√
Content Standard B: Physical science.			
Transfer of energy		√	
○ Chemical reactions		√	
○ Interactions of energy and matter		√	
Content Standard C: Life science.			
○ Characteristics of organisms	√		
○ Life cycles of organisms	√		
○ Organisms and environments	√		
○ Structure and function in living systems		√	
○ Reproduction and heredity		√	
○ Regulation and behavior		√	
○ Populations and ecosystems		√	
○ Diversity and adaptations of organisms		√	
○ Biological evolution			
○ Interdependence of organisms			
○ Matter, energy, and organization in living systems			
○ Behavior of organisms			
Content Standard D: Earth and space science.			
○ Properties of earth materials	√		
○ Structure of the earth system		√	
○ Earth's history		√	





Correlation	K-4	5-8	9-12
○ Energy in the earth system			
○ Geochemical cycles			
○ Origin and evolution of the earth system			
Content Standard E: Science and technology.			
○ Abilities of technological design			√
○ Understanding about science and technology	√	√	√
Content Standard F: Science in personal and social perspectives.			
○ Personal health	√	√	√
○ Characteristics and changes in populations	√		√
○ Types of resources	√		√
○ Changes in environments	√		√
○ Science and technology in local challenges	√		
○ Populations, resources, and environments		√	
○ Natural hazards		√	√
○ Risks and benefits		√	
○ Science and technology in society		√	√
Content Standard G: History and nature of science.			
○ Science as a human endeavor	√	√	√
○ Nature of science		√	√





ESTUARYLIVE 2004

Goals of EstuaryLive 2004

Through the use of live interactive video EstuaryLive will increase students understanding of estuarine ecological, social and economical principals.

EstuaryLive will increase students understanding by:

1. Providing an opportunity for students around the country and world to experience, in real-time, a field trip to the unique habitat of an estuary;
2. Giving students the opportunity to compare different estuaries around the country;
3. Taking students on an exploratory trip to the estuary with the opportunity to interact with research scientists, education professionals, and natural resource management professionals; and
4. Providing a resource for further information.

Performance Objectives:

- o Given a picture of an estuary, students will be able to locate two habitats, identify two plants and two animals within the estuary, and describe the tidal and salinity regimes normally found in estuaries.
- o Through submitting questions, students will direct the movement and exploration of students actually in the estuary.
- o Asked how they traveled to the estuary, students will be able to describe the technologies they used in their classroom to access EstuaryLive and submit questions to the program.
- o When prompted with terms like runoff, non-point source pollution, and erosion, students will be able to identify two things they can do in their personal life to protect estuaries.
- o Responding to a quiz about estuaries students will discuss two reasons that estuaries are valuable.

Intended Audience

EstuaryLive is developed primarily for a K-12 audience, with an emphasis on middle and high school classrooms. An advantage of the EstuaryLive program is that questions can be answered in the same developmental level in which they are asked. During the fall 2003 National Estuaries Day program, the teacher evaluation showed that roughly equal numbers of 4-6, 7-8, and 9-12 students participated. There were college students, science center visitors, and K-3 students as well.

Key Themes and Messages

Estuary Live is the featured event for National Estuaries Day – and interagency campaign to promote the importance of estuaries and the need to protect them. What makes Estuary Live unique is that EstuaryLive is an interactive live field trip that uses innovative technology to provide students with an opportunity to explore these natural resources– including those students who live far from the coast or may not have may not have an opportunity to visit an estuary. Listed below are some of the key themes and messages for EstuaryLive.





Themes:

1. Key plants and animals found in the local ecosystem
 - a. Illustrate the similarities and differences between the flora and fauna found at the host site as compared to other coastal regions
 - b. Explain invasive species, emphasizing the management strategies used locally
2. Habitats and ecosystems that are unique to the locality
 - a. Explain the importance of the ecosystem and ways to protect it
3. Discuss the research, conservation and educational programs at your site
 - a. Focus on activities and programs where these three components overlap
4. Touch on research and other opportunities for community involvement at your site
 - a. Invite viewers to learn more about estuaries and to help to protect them
5. Focus on issues that are important to your ecosystem and local community

Messages:

1. The protection and restoration of estuaries are important because:
 - a. Estuaries are spawning grounds for at least two thirds of the nation's commercial fish and shellfish populations. Estuaries provide these organisms with habitat and shelter.
 - b. Estuaries act as buffers from coastal storms and flooding.
 - c. Estuaries help to reduce pollution entering the ocean from the land.
 - d. Estuaries are among the most productive ecosystems on the earth. The mixing of nutrients from the land and the sea result in the production of more food per acre than the richest Mid-Western farmland.
2. EstuaryLive promotes
 - a. Habitat Restoration
 - b. Pollution Control and Abatement
 - c. Maintenance of Biodiversity
 - d. Sustaining Estuarine Ecosystems



Tentative EstuaryLive 2004 Schedule

Please note: This is a field program and is subject to change depending on weather, people and nature. Program plans will be updated if major changes are made prior to EstuaryLive.

Thursday September 23

Friday September 24

State	Sites	EDT	CDT	PDT	State	Sites	EDT	CDT	PDT	
North Carolina	North Carolina NERR and Albemarle-Pamlico NEP	9:00-10:10am	8:00-9:10am	6:00-7:10am	Washington	Padilla Bay NERR	11:30-12:55pm	10:30-11:55am	8:30-9:55am	
Alabama	Weeks Bay NERR and Mobile Bay NEP	10:10-11:15am	9:10-10:15am	7:10-8:15am	New Jersey	Jacques Cousteau NERR and Barnegat Bay NEP	12:55-2:00pm	11:55 am-1:00 pm	9:55-11:00am	
New York	Peconic Bay NEP	11:15-12:20pm	10:15-11:20am	8:15-9:20am	Compare East Coast and West Coast Estuaries! Join New Jersey, North Carolina and Oregon in a live comparison of their local estuaries.			2:00-2:50pm	1:00-1:50pm	11:00-11:50am
Massachusetts	Waquoit Bay NERR	12:20-1:30pm	11:20-12:30pm	9:20-10:30am	Oregon	South Slough NERR and Tillamook Bay NEP	2:50-4:00pm	1:50-3:00pm	11:50-1:00pm	





Participating National Estuarine Research Reserves and National Estuary Programs

This year, the following National Estuarine Research Reserves and National Estuary Programs will participate in EstuaryLive, and in several cases will work together to compare different estuaries. Visit each of these reserves and/or NEPs to learn more about estuaries:

- Rachel Carson site in North Carolina: North Carolina (NCNERR) www.ncnerr.org and the Albemarle Pamlico NEP Program (APNEP) <http://www.epa.gov/owow/estuaries/programs/aps.htm>
- Mullica River-Great Bay in New Jersey: Jacques Cousteau (JCNERR) www.jcnerr.org and the Barnegat Bay Estuary Program (BBEP) <http://www.epa.gov/owow/estuaries/programs/barn.htm>
- Padilla Bay in Washington: Padilla Bay NERR www.padillabay.gov the Puget Sound Action Team (NEP) <http://www.epa.gov/owow/estuaries/programs/ps.htm>
- Peconic Estuary, in Eastern Long Island, New York: Peconic Estuary Program <http://www.epa.gov/owow/estuaries/programs/pb.htm>
- South Slough, in Oregon: South Slough NERR www.southsloughestuary.org/ and the Tillamook Bay (NEP) <http://www.epa.gov/owow/estuaries/programs/till.htm>
- Weeks Bay, in Alabama: Weeks Bay NERR www.weeksbay.org and Mobile Bay NEP www.mobilebaynep.com
- Waquoit Bay in the Cape Cod area of Massachusetts: Waquoit Bay NERR www.waquoitbayreserve.org

Program Content

Each of the seven field trips will address a suite of different estuarine topics. These topics are generally selected based on their relevance to the estuary addressed in the field trip. Naturalists discuss topics ranging from the very general, i.e. what is an estuary, to very specific, i.e. the life cycle of a Dungeness crab. The Reserves and NEPs are currently in the process of putting together their programs for EstuaryLive 2004. Tentative program content for each of the programs are located in the following pages. Please note, the programs are subject to change depending on weather, people and nature. Information about each field trip will be updated on-line as changes are made. Activities referenced within each of the program contents can be downloaded from www.estuaries.gov.





North Carolina

North Carolina NERR and Albemarle-Pamlico NEP

Thursday September 23, 9:00-10:10am EDT/ 8:00-9:10am CDT/ 6:00-7:10am PDT

Program Content

Basic estuary information

1. Identify location along NC coast, highlight Reserve locations as well as APNEP locations
2. Identify location within a watershed context
3. Identify geographical location in regards to proximity to different biogeographic regions and offshore currents that influence climate, weather (including hurricanes)
4. Estuarine influences from freshwater and saltwater inputs and influences
5. (saltwater and freshwater influences see above)
6. Total acres in NC
7. Estuarine habitats
8. Briefly describe some typical estuary life that is characteristic to NC estuaries and their roles in the estuary
 - a. Plants – aquatic and terrestrial
 - b. Vertebrates – mammals, reptiles, birds, fish
 - c. Invertebrates – Mollusk, crustaceans, tunicates, Cnidaria, Ctenophore
9. Abiotic factors
 - a. Salinity changes (tides, rain, water depth)
 - b. Water temperature changes (seasons, tides, water depth)
 - c. Water depth changes
10. Biotic factors
 - a. Predator/prey

Resource management

1. Estuarine influences from freshwater and saltwater inputs and influences
2. Importance to NC socio/economic and culturally
3. Include resource management issues
4. Shoreline/development issues/rules
5. Community involvement

Research insight

1. Focus on current NC issues such as beach nourishment.
2. Endangered species
3. Habitat restoration

Cultural connect

1. Importance to NC socio/economic and culturally
2. Human uses
3. Include resource management issues
4. invasive species





Link to local sites:

North Carolina NERR, www.ncnerr.org

Albemarle-Pamlico NEP, www.apnep.org

Additional Local Partner, North Carolina Sea Grant, www.ncseagrant.org

Activities

Estuarine Habitats

Water Babies

Eco-logical: A Coastal Logic Problem

Standards





Alabama

Weeks Bay NERR and Mobile Bay NEP

Thursday September 23, 10:10-11:15am EDT/ 9:10-10:15am CDT/ 7:10-8:15am PDT

Program Content

Introduction: Geology & Estuaries -You know all that muddy muck you sink up to your knees in when you go into that special part of the estuary? That is very special stuff. **Dr. Doug Haywick**, Earth Science Department, University of South Alabama gives students an overview of maps showing Alabama, its geology, Mobile Bay watershed, and Weeks Bay sub-watershed.

Action: Bowling for Bay Bottoms demonstration with students. Where does all this sediment come from? This demonstration will show how weathering and erosion bring the mountains to the beach to become the foundation of life. Dr. Haywick and Lee Yokel will demonstrate how erosive forces break down rocks, transport them to new locations and deposit sediments to create important environments.

Mountains:	Granite
Streams:	Conglomerate
Beaches:	Sand
Bays:	Silt, Mud, Sand, Clay, Organic Muck

Lee Yokel, Education Coordinator, Mobile Bay NEP and Dr. Doug Haywick, USA – Now that we've established the source and importance of sediments, let's look at deposition of the materials, what lives in them, and why there can be too much of a good thing - different sediments can affect the **biodiversity of this area**.

Action: Sediment Settlement Race – At the beginning of the beginning of this segment, students (viewing from the classroom) will be asked to predict how fast they think it will take different size sediments to sink to the bottom of a cylinder filled with water and email us their predictions. Sediment sizes will include pebble, sand, silt, and mud. Student assistants will dump sediments of different sizes into separate cylinders of clear water with the start of the whistle. This activity will be timed for each sediment size as students wait for sedimentation to occur. The concept of turbidity will be introduced and discussed.

Action: The Muddy Meddlers (transition to the edge of the shore). The very foundation of life around us is just beneath our feet! Look at that gooey mud – how wonderful! What sorts of things could possibly live in this mucky mess? Students will be asked what they think will be found in the mud? Student assistants will help Dr. Haywick and Lee Yokel in making an inventory of what is found in the mud (fiddler crabs, salt marsh plants, and what may be there at the dock). But wait! There is something very special about South Alabama and the Weeks Bay Watershed in particular Guess everyone what it might be?





Segment Three: Carnivorous Plant Bogs!

Margaret Sedlecky, Education Coordinator Weeks Bay Reserve – Ever heard of plants that eat bugs? Where do they live? Why do they eat bugs? Explanation of: the ecology of a bog (soils, prescribed burn); how and why carnivorous plants trap insects.

Action: Pitcher Plant Particulars –Dissection of a pitcher plant to show the variety of insects that have been trapped. Show the two types of sundews and point out that they are only able to trap gnats and other very small insects.

Link to local sites:

Weeks Bay NERR, www.weeksbay.org

Mobile Bay NEP, www.mobilebaynep.com

Activities

- [pH Potential \(PDF\)](#)
- [Carnivorous Plants: A Bug's Nightmare! \(PDF\)](#)
- [Do you dig? \(PDF\)](#)

Standards





New York

Peconic Estuary NEP

Thursday September 23, 11:15-12:20pm EDT/ 10:15-11:20am CDT/ 8:15-9:20am PDT

Program Content

Segment 1: Welcome, Location, Overview (5 min)

- Welcome to the Peconic Estuary
- Locator map
- Background on the Peconic Estuary and why The Nature Conservancy named it one of the “Last Great Places in the Western Hemisphere”
- Overview of why EPA designated the Peconic System as an “Estuary of National Significance” and a brief description of the PEP and what is being done to protect and restore the estuary

Segment 2: Habitats & Inhabitants (10 min)

- Discussion of the diverse habitats and natural communities of the Peconics
- Show and tell with various critters (*e.g.*, horseshoe crab, oyster toadfish, sea stars, scallop, sea urchin, whelk, sea horse, skate) from touch tanks
- Show and tell with various macroalgae
- Questions

Segment 3: Habitat Spotlight—Eelgrass (15 min)

- What is eelgrass?
- Why is it important?
- Where is it found in the Peconics?
- Why has it been depleted?
- What is being done to restore it?
- Questions

Segment 4: Shellfish Hatchery (15 min)

- Introduce shellfish species
- Discussion of the ecological, economic and cultural importance of shellfish
- Discussion of how Brown Tide has virtually wiped out a once nationally significant bay scallop shellfishery and affected other species; mention other issues that could be affecting shellfish
- Walk through hatchery to see how shellfish are being cultured; discuss life stages; look at shellfish larvae through microscope with video projection
- Questions

Segment 5: SPAT (10 min)

- What is SPAT program? History of SPAT?
- How upwellers/aquaculture works





- Why citizens join program; what they've learned; what they get out of it
- Questions

Segment 6: National Atmospheric Deposition Program (4 min)

- Overview of NADP
- How Peconic site fits in
- Protocol for sample collection
- Acid Rain
- Questions

Segment 7: What You Can Do to Help (5 min)

Link to site page

Peconic Bay NEP, www.epa.gov/owow/estuaries/programs/pb/htm

Activities

- [What is an Estuary? \(PDF\)](#)
- [What Can Students Do to Help Peconic Bay? \(PDF\)](#)
- [Water Quality Issues Impact the Peconic Bay Estuary System \(PDF\)](#)

Standards





Massachusetts

Waquoit Bay NERR

Thursday September 23, 12:20-1:30pm EDT/ 11:20-12:30pm CDT/ 9:20-10:30am PDT

Program Content

Clam Bake

1. Working with Joan Avant-Tavares, Director of the Indian Education Program in the Mashpee Schools, we will stage a traditional Wampanoag Clam Bake on the beach at the Reserve Headquarters including how the Wampanoags collected the ingredients (such as clams) to show the connection to the estuary. We plan to have Wampanoag children helping and to invite non-Wampanoag children to participate as well.
2. As the clambake is steaming, we'll cut away to show how others use the estuary. For example, a commercial clammer will show us how they dig the clams and perhaps shuck one or the shellfish warden or the local company will show their aquaculture operation.
3. We plan to pull a seine net with the children to find the creatures living in the bay and explain their adaptations.
4. Joe Costa, from the Buzzards Bay National Estuary Program, will present research at on the decline of eel grass. We'll interview him about the process of eutrophication and the overgrowth of algae in the Bay (overlay maps will show how the eelgrass has disappeared). Heidi Clark, D. Angel and H. Kite-Powell from the Woods Hole Oceanographic Institution received a CICEET grant to work on shellfish aquaculture and N-loading mitigation. We'll interview one of them to find out what their work with quahogs has shown so far. Ruth Carmichael from the Boston University Marine Program at the Marine Biological Laboratory will show how the story of nitrogen loading can be seen in the shell of a quahog- the subject of her current research at the Reserve.
5. We'll have our sand tank model set up to show how nutrients from septic systems, fertilizers and atmospheric deposition can move through the ground water to the bay.
6. We'll ask the children what they think they or their parents can do to protect the bay.
7. We'll end with uncovering the clam bake.

Link to site page

Waquoit Bay NERR, www.waquoitbayreserve.org

Additional Partners

Mashpee Schools, www.mashpee.k12.ma.us

Activities

- [The Clambake: A Wampanoag Tradition \(PDF\)](#)

Standards





Washington

Padilla Bay NERR

Friday September 24, 11:30-12:55pm EDT/ 10:30-11:55am CDT/ 8:30-9:55am PDT

Program Content

Topics

1. This program will take place at Padilla Bay Reserve, at the beach and in the mud flats of Padilla Bay would be divided into five sections illustrating aspects of the scientific method:
 - a. Observation
 - b. Hypothesis
 - c. Prediction
 - d. Experimentation
 - e. Results

2. This program will feature actual research recently or currently being conducted in Padilla Bay and Puget Sound. Several research projects will be selected to illustrate key themes including habitat restoration, pollution control and abatement, maintenance of biodiversity, and sustaining estuarine and coastal ecosystems. Actual research projects by middle and high school students will also be included.

Link to sites pages

Padilla Bay NERR, www.padillabay.gov

Additional Partners

Seattle Aquarium, www.seattleaquarium.org

People For Puget Sound, www.pugetsound.org

Activities

Salish Sea Map

Food Web!

Estuary Party

Standards





New Jersey

Jacques Cousteau NERR and Barnegat Bay NEP

Friday September 24, 1:45-2:50pm EDT/ 12:45-1:50am CDT/ 10:45-11:50am PDT

Program Content

Topics

This Live program will be broken into segments that:

- Discuss how estuaries act as coastal buffers, filters for pollution, and have high levels of primary production when looking at the plants of the marsh
- Discuss estuaries as nursery grounds for fish and shellfish, and the cultural history of their harvest, during the fish and clamming segments
- Discuss and compare pollution control/abatement and restoration when comparing the Barnegat Bay and Great Bay systems
- Discussing research and monitoring efforts during the ocean technology and monitoring segment

Links to sites pages

Jacques Cousteau NERR , www.jcnerr.org

Cool Classroom, www.coolclassroom.org/home.html

Barnegat Bay NEP, www.bbep.org

Activities

Plants and Animals

Density Layers

Pinelands National Reserve

Water Filtration

Virtual Community Ecotour

Standards





Oregon

South Slough NERR and Tillamook Bay NEP

Friday September 24, 2:50-4:00pm EDT/ 1:50-3:00pm CDT/ 11:50-1:00pm PDT

Program Content

Topic

“Life on the Edge” which explores:

- Edges or ecotones which tend to be interesting areas of transitions
- Estuaries are comprised of multiple edges between various types of habitat.
- Phrase implies action that may be catastrophic, unpredictable, challenging, and novel.

Setting

The seaside community of Charleston is like many towns located near the mouth of an estuary, many different forces have interacted to create the dynamic social, physical, and ecological environment that we hope to explore. We will use three different perspectives to frame our field study.

- A View from the Sea
- A View from the Land
- A View from the People

We will work with a cast of students to conduct investigations focused on the factors – biological, physical, economic, social, climatic; that influence and sustain the estuary. Students will explore this community at the mouth of the estuary for what it has been, currently is, and for what it may become using the tools that the disciplines of science and social studies can offer.

For example, we will focus our content to improve viewers understanding that the Pacific Ocean has a significant influence on the waters of the estuary as an origin for weather, oxygen and nutrients, a variety of animals, plants, flotsam, and detritus, and pollution. We will tie ocean-related events such as upwelling or commercial and recreational fisheries to the effects on the many forms of life that inhabit the land and waters of this coastal community.

We will interview a researcher that has explored the ocean-estuary interface aboard the NOAA research vessel the McArthur followed by an on-camera survey of the adjacent inter-tidal zone for evidence of ocean influence.

Link to sites page

South Slough NERR, www.southsloughestuary.org

Tillamook Bay NEP, www.co.tillamook.or.us/gov/estuary/tbnep/nephome.html





Additional Partners

University of Oregon – Oregon Institute of Marine Biology
Tillamook County Performance Partnership-
Oregon Coast National Wildlife Refuge
US Fish and Wildlife Service
Coos Bay School District
US Coast Guard – North Bend Air Station
Oregon Coast Environmental Awareness Network

Activities

- Elementary School
- Middle School
- High School
 - Salmon Activities
 - Background Information Sheet A
 - Background Information Sheet B
 - Salmon Field Diagram and Life History
 - Salmon Game
 - South Slough Sleuths Activities
 - South Slough Sleuths Worksheet
 - Landuse Activities
 - Activity Sheet A
 - Activity Sheet B
 - Activity Sheet C
 - Landuse Simulation Game

Standards





PARTICIPATING IN ESTUARYLIVE

How to access the telecast over the Internet

What you Need

You will need to have a computer connected to the Internet on which you have installed, in advance, one of two free software programs: either Windows Media Player, <http://www.microsoft.com/downloads> or RealPlayer, www.real.com (you may need to look very thoroughly to find the free RealPlayer product). Many prefer Windows Media Player because there seem to be fewer problems with school security (firewall) and other technical issues. Please note, there also seem to be more problems with Apple computers- though many people experience no problems.

A higher speed Internet connection and a faster computer is recommended- if available, but a dialup connection and older computer, will suffice- it may provide a lower grade version of the program (video images will take longer to update). Once you have the appropriate software installed and you are ready to participate in EstuaryLive, you will have a choice of streaming speeds. Choose the streaming speed based on your Internet connection speed. Closed captioning is also available. The best way to participate in EstuaryLive via the Internet is with: a newer computer with a high speed connection, hooked up to a digital projector for class facilitation; an additional computer connected to the Internet for submitting questions; and an additional computer connected to the Internet for background research.

EstuaryLive is also available via a KU band satellite connection. Downloading the satellite feed to a TV monitor will provide the best possible audio and video reception; however, classes will still need to have an active Internet connection to submit questions. For more information about satellite coordinates, please contact Becky Weidman (Rebecca.Weidman@verizon.net).

Teaching

Our experience is that these field trips work the best if the teacher facilitates the trip- asking your students and acknowledging good participation just as you would on an educational field trip. Once you are ready to have your classroom begin asking questions, there will be a form available on the Web site that you will use to submit the questions. Many of these questions will be answered live during the field trip.

We do not recommend that you have your students participate in the program in a computer lab setting where each individual has their own connection. Each computer will stream the field trip at a slightly different rate and we have found that we are simply overwhelmed with questions. This does not apply to individual students who may be participating, for example, as part of an extension program or class.





What is the quality of the broadcast?

The quality of the downloaded satellite broadcast should be excellent, as good as any live TV shot that you might see on the news. Some school systems can download the satellite signal and route it to their school system's video channels. Viewing the program via the satellite download will provide a television quality image. The Internet view will depend on the computers and Internet connections that you are using. A school on high speed access with relatively good equipment will receive a smoothly moving picture and excellent audio. Slow Internet speeds will receive a jerkier video, but should still receive good audio. This is the case even on dial-up connections. It is important that participants use the newest free version of software available for the best connection.

What are the steps for watching and interacting during the day(s) of broadcast?

1. You will need to have a computer with the downloaded free software, either Windows Media Player, <http://www.microsoft.com/downloads> or RealPlayer, www.real.com (look very thoroughly to find the free RealPlayer product), connected to the Internet.
2. Register for the program on the www.estuaries.gov website.
3. Prepare for the program using on-line materials and curricula.
4. Test your set-up by playing live video (you can view previous EstuaryLive programs on www.estuarylive.org). If given the opportunity, connect to EstuaryLive to test the day before the program.
5. On the day of the program, go to the Web site and look for the "Click here for EstuaryLive" button. Clicking the link will take you to a page where you can choose your player (windows media or realplayer) and your Internet speed (high speed or lower, dial-up speed). At this point, you may also chose to watch the program using closed captioning.
6. By selecting your player and speed link, EstuaryLive will open your player to the live feed. Another page on your computer will have the question window where you can submit your name and question.
7. If you should have a hang up or other problems, shut down your player and select your player and speed again. Sometimes it also helps to shut your browser and restart it.





How to prepare your students to participate in EstuaryLive

EstuaryLive is an interactive, “next best thing to an actual trip to an estuary,” field trip. In anticipation of the program you can:

- Have your students compare different estuaries. One of the programs will compare East Coast and West Coast Estuaries! Join New Jersey, North Carolina and Oregon in a live comparison of their local estuaries. Check the EstuaryLive schedule in the estuaries.gov website for information on this new program. Also, to help your classroom make this comparison, check the Comparison Chart at the end of this document. This is an excellent tool to help discuss the similarities and differences of the estuaries located around our nation’s coasts. This chart describes each of the estuaries that will be featured during this year’s EstuaryLive program. This chart describes each of the estuaries that will be featured during this year’s EstuaryLive program.
- Have your students develop a research project on a particular theme addressed by one of the EstuaryLive programs or for one of the estuaries featured.
- Review, with your students, one of the past telecasts, these are available on www.estuarylive.org. Then, ask your students to find the estuary in a map, and discuss the specific characteristics of this estuary- the type of estuary it is, and the kind of plants and animals you might find in that particular estuary. This can be a very useful way to start an exercise in comparing estuaries.
- Invite an Education Coordinator from a nearby NERRS or NEP to give a presentation on their estuary. Contact Becky Weidman, EstuaryLive Coordinator (Rebecca.Weidman@verizon.net) to help you coordinate it.
- Before the broadcast, have your students draft questions on particular topics they might be interested to learn more about, for example: the animals or plants that live in an estuary; the different type of estuaries; habitats; the importance of tides; and others.

Keep in mind that at the beginning of the broadcast, students will be encouraged to submit questions via the web which will then be answered live. EstuaryLive is different from simply watching a movie or a video. Students in the classroom have the ability to ask what something feels like, smells like or even tastes like. This program provides students with an exciting and new tool to learn about these unique ecosystems. EstuaryLive inspires students to learn by providing them with the opportunity to guide their scientific discoveries through questions- helping to shape the field trip that they are taking over the Internet.

Questions are submitted through a form on the Web page created for the EstuaryLive. This is a form for the questions, school/teacher/student name, and email address. Once the participant hits “submit,” the question and other information will post to a Web site where the field trip host can view the question. As the field trip host begins to receive questions, they will begin to answer them live during the field trip. Please note, due to the volume of questions that are received, not all questions will be answered live during the programs, but naturalists from each site do their best to respond to all of the questions after the event.







Resources on Estuaries

In this section of the Teacher's Guide, you will find educational materials that will help you introduce your classroom to some basic estuarine concepts. These educational materials and specific program activities are available on the www.estuaries.gov website, they are not included as part of this Guide. For specific program activities check the EstuaryLive schedule.

This section of the Teacher's Guide also provides you with tools to help your classroom compare the estuaries you will visit in this year's EstuaryLive program. This Teacher's Guide also provides you with some lists of additional Web sites and books that you can refer to for more information, as well as a glossary of estuarine terms.

Educational Materials

The following list of activities will help you introduce your classroom to some basic estuarine concepts. These are organized by content and grade level, and are available in the estuaries.gov website.

LIST OF ACTIVITIES DIVIDED BY CONTENT FOR TEACHERS	GRADE LEVEL		
	K-4	5-8	9-12
TOPIC			
Estuaries, in general			
• Density Layers	√	√	
• Water Filtration	√	√	
• Middle Grades Activities		√	√
Environment Monitoring and Water Quality			
• Waterbabies	√		
• Water Quality Issues Impact the Peconic Bay Estuary System	√	√	√
• Density Layers	√	√	
• Water Filtration	√	√	
• Elementary Activities	√	√	
• Middle Grades Activities- Moons and Tides, Mystery Water		√	√
Species and Food Webs			
• Plants and Animals of Great Bay	√	√	
• Food Web!		√	√
• Estuary Party	√	√	√
• Carnivorous Plants: A Bug's Nightmare!		√	√
• Pitch Me a Fly	√		
• Middle Grades Activities- Food Webs		√	√
Coastal Resource Management including Land Use			
• Watersheds		√	√
• Salmon simulation			√





LIST OF ACTIVITIES DIVIDED BY CONTENT FOR TEACHERS	GRADE LEVEL		
	K-4	5-8	9-12
<ul style="list-style-type: none"> Land Use simulation 			√
Cultural Traditions			
<ul style="list-style-type: none"> Salish Sea 	√	√	√
<ul style="list-style-type: none"> Virtual Coastal Community Ecotour 	√	√	
<ul style="list-style-type: none"> The Clambake: A Wampanoag Tradition 	√	√	
Habitat			
<ul style="list-style-type: none"> Mangroves 		√	√
<ul style="list-style-type: none"> Sea Grasses 		√	√
<ul style="list-style-type: none"> West Coast Eelgrass Activities 		√	√
<ul style="list-style-type: none"> Estuarine Habitats (PDF) 		√	√
<ul style="list-style-type: none"> Eco-logical: A Coastal Logic Problem 	√	√	
<ul style="list-style-type: none"> Pinelands National Reserve 	√	√	
<ul style="list-style-type: none"> Do you dig wetland soil? 	√	√	√
<ul style="list-style-type: none"> Elementary Activities- Eel Grass, Salt Marsh 	√	√	
<ul style="list-style-type: none"> Middle Grades Activities- Saltmarshes, Eelgrass, Tidal Flats, Upland Forests 		√	√
Geography, including watersheds			
<ul style="list-style-type: none"> Watersheds 		√	√
<ul style="list-style-type: none"> Simulating the Estuary with a stream table 	√	√	
<ul style="list-style-type: none"> Salish Sea Map 	√	√	√
Citizen Action			
<ul style="list-style-type: none"> What is an Estuary? 	√	√	√
<ul style="list-style-type: none"> What Can Students Do to Help Peconic Bay 	√	√	√

Resources for Comparing Estuaries

Estuaries vary greatly from ecosystem to ecosystem. These similarities and differences make for an excellent way to engage your students in doing research, analyzing the different features of an estuary, and getting them to ask some critical questions about habitats, plants and animals that live in the different estuaries.

The following educational materials will compliment any of the seven individual EstuaryLive field trips that you and your students will take. These materials focus on key plants, animals, and concepts that will be addressed throughout the two-day program. One goal of this year's program is to help students conduct a comparison of different estuarine ecosystems around the country. The following materials are excellent tools to help guide your students through a comparison of the different estuaries featured during EstuaryLive. Also, please see the EstuaryLive comparison chart in the next section. This chart will help to illustrate the commonalities and differences between each of the seven ecosystems.





List of Resources for Comparing Estuaries

The educational package for comparing estuaries includes:

1. **An EstuaryLive program dedicated exclusively to comparing** estuaries located on the Atlantic and Pacific Coasts of the United States. Join the South Slough Reserve in Oregon, the Jacques Cousteau Reserve in New Jersey, and the North Carolina Reserve in comparing their unique estuarine habitats. See the schedule under the section titled “EstuaryLive 2004”, Program Schedule, or look for it under the estuaries.gov website.
2. Brief Introduction to some **Elements of Comparison between Estuaries** - available in this Teacher’s Guide and on the estuaries.gov website
3. A **Comparison Chart**: This Chart describes each of the estuaries that will be featured during this year’s EstuaryLive program. The Chart highlights the key plants and animals of each estuary, as well as those plants and animals that are considered to be endangered and invasive- not native to the ecosystem. The plants and animals that reside in more than one of the estuaries are color coded by species. Note, that some plants and animals that are key, native species in one ecosystem are invasive or endangered in another ecosystem. This chart is available in this Teacher’s Guide and on the estuaries.gov website for download.
4. A **set of activities** that will help you introduce your students to some basic concepts on estuarine ecology. See the list below. These educational materials are available for download in the estuaries.gov webpage under “Teachers Guide” within the Comparing Estuaries section. Please note, you can also find specific educational materials for each of the programs.
5. **Videos**: There are six videos from the EstuaryLive 2003 telecast that can be used to help prepare your students to view this year’s telecast. The videos can be used for comparing estuaries. The videos are available upon request by sending an e-mail to estuariesweb@noaa.gov. - Limited quantities.

List of Activities used to Compare Estuaries:

Estuary Overview (targeted for grades 4-8):

- General Estuarine Ecology for Middle School Students, developed by the South Slough Reserve in Oregon
 - *This estuary overview is the compilation of activities aimed at introducing students to estuaries. Activity topics include: tidal impacts, web of life, salt marshes, upland forests, eelgrass beds, migrating birds, historical uses of an estuary, and wetland restoration. These activities were intended to be used in a series. The time per activity and materials needed to complete each activity are highlighted in the left hand column of each separate activity.*

Materials on Energy Flow:

- Energy Flow in the Estuary, developed by the Galveston Bay NEP in Texas





- *The following activities are intended to stimulate class discussion related to the energy flow in an estuary. The activities include a discussion of ecosystems, food webs, and the impacts of abiotic factors on estuaries. These activities take approximately 30 minutes and all materials are provided.*
- Estuaries and their Ecosystems: Discussion Questions and Answers for 4th-6th grade
- Estuaries and their Ecosystems: Discussion Questions and Answers for 6th-8th grade

Materials on Birds:

- Adaptations: Birds of the Estuary, developed by the Galveston Bay NEP in Texas
 - *The following activities are intended to stimulate class discussion related to the adaptations of various estuarine organisms. These activities take approximately 30 minutes and all materials are provided.*
 - Adaptations and Interactions in an Estuary: Discussion Questions and Answers for 4th-6th grade
 - Adaptations and Interactions in an Estuary: Discussion Questions and Answers for 6th-8th grade

Materials on Grasses:

- Sea Grasses, developed by the Charlotte Harbor NEP in Florida
 - *This activity targets an elementary school audience. The goals of this activity are to: enhance the students understanding of estuaries, introduce students to key water quality and sea grass vocabulary, and to discuss the impacts of human activity on sea grasses. In addition to a copy of this activity, students will need: access to the Internet, spaghetti, linguine, and fettuccini noodles, scissors, glue, green food coloring and poster board. This activity can be broken down into several shorter activities (30 minutes) or a longer activity, approximately 1.5 to 2 hours.*
- Eelgrass Bed Exploration, developed by the South Slough Reserve in Oregon
 - *This activity targets grades 8 through 10. The objective of this activity is to help students to understand the function and biological value of eelgrass beds and their habitat. This activity takes approximately 30 minutes and all materials are provided.*





Elements of Comparison between Estuaries

Estuaries are highly variable ecosystems comprised of numerous different and unique habitats. Estuaries are often defined as places where rivers meet the sea. Consider the wide range of characteristics of an estuary: from fresh water to salt water, from relatively warm surface water to much cooler bottom water, and from being submerged underwater to being high and dry just hours later. Also, consider that these conditions change frequently and on a regular basis. What a difficult environment in which to survive! Other features of this estuarine home are a plentiful supply of nutrients and safe places in which to live as you develop from larva to a young adult. Estuaries possess a plentiful variety of characteristics, enough to spark anyone's interest; yet there is much we have yet to learn about these places where terrestrial and aquatic life melds.

Estuaries are highly variable ecosystems, providing habitat for a wide variety of organisms. Estuaries are extremely productive areas that serve as a nursery for up to 90% of commercially important species. Humans have established civilizations along estuaries for thousands of years. We can all benefit from learning to appreciate these places where terrestrial and aquatic life melds.

We will investigate some of the physical, chemical and biological characteristics of estuaries in order to compare them. Most of these parameters occur on a continuum. For example, the salinity or saltiness of water ranges from 0-35 parts per thousand (ppt). Fresh upstream water has a salinity of approximately 0 ppt. and open ocean water is about 35 ppt. salt. In geographic areas where rivers meet the sea, salinity can fall anywhere along the continuum of 0-35 ppt. This is dependent on several factors such as rainfall, tidal flows and evaporation. Often, one of these parameter affects another. For example, the salt concentration of water affects its density. Below is an outline of some basic estuarine characteristics offered with the hope of making these complex ecosystems easier to understand and appreciate.

PHYSICAL

Types (geomorphology)

- Lagoon: oriented parallel to the coast, with a large fraction of surface area in water, little in marshes (*For example: Indian River Lagoon, Florida*)
- Fjord: formed by glaciers moving seaward, shallow sill at mouth restricts exchange of water (*For Example: coasts of Alaska, British Columbia, Norway, Chile*)
- Coastal plain estuary (drowned-river valley): broad, flat and shallow water mass, salt marshes form along low-lying coastal areas (*For example: Chesapeake Bay, Pamlico Sound many east coast estuaries*)
- Tectonic estuary: caused by faulting, volcanic eruption (*For example: San Francisco Bay*)





WATER BALANCE

- Positive estuary: fresh water input from ground water, rivers and rainfall exceeds evaporation; most estuaries are positive (a net flow of fresh water into ocean exists)
- Negative estuary: evaporation exceeds fresh water input. This can occur in tropical lagoons with little fresh water input (salinity > 35ppt.) In Indian River Lagoon (FLA), 42ppt has been recorded.
- Neutral estuary: fresh water input = evaporation

MORE VARIABLE PARAMETERS

- Salinity: fractional measure of salt (predominantly NaCl) in water; range: 0-35 parts per thousand (ppt.)
- Temperature: surface waters tend to warm via the sun; warm water, being less dense than cold, tends to remain at surface, resulting in thermal stratification (separated layers of water based on temperature differences)
- Dissolved Oxygen: fully saturated water contains 5.7% oxygen; range: 0(anoxia) - 5.7% (Note: our atmosphere when saturated contains 21% oxygen). Lower temperature and lower salinity waters are able to contain more oxygen.
- Light/Turbidity: amount of sunlight affects photosynthesis (primary production); amount of turbidity (suspended particles) affects the amount of sunlight reaching certain depths
- Wind: provides mechanism for mixing, can influence tidal flows
- Tides: water movement caused by gravitational pull of sun and moon on Earth; provides mechanism for mixing; most US estuaries have semi-diurnal tides (two high and two low tides each day)

CHEMICAL

- Nutrients: tend to flow downstream from nutrient-rich river basins and are slowly processed (consumed, degraded) in estuary. This process occurs with beneficial and harmful compounds. Nitrates and phosphates are often limiting factors for primary production. Too high of a nutrient composition (eutrophication) can upset food web balance, causing major problems in ecosystem.

BIOLOGICAL (in brief)

- Terrestrial: many microorganisms, many plants, insects, many invertebrates, amphibians, reptiles, birds, mammals
- Aquatic: many microorganisms, algae, submerged aquatic vegetation (SAV), plankton, many invertebrates, fish, marine mammals
- Food Webs: a network of whom feeds on whom; energy and chemical elements are thus





- transferred from organism to organism
- Habitats: a certain set of physical, chemical and biological parameters can define a particular habitat; Note: any combination of parameters produces a unique habitat, which benefits some organisms more than others
 - Salt Marshes: communities of emergent plants rooted in soils alternately inundated and drained by tidal action
 - Mud Flat: a near-shore area where organic matter accumulates providing abundant potential food supply for many invertebrate organisms (such as diatoms, worms and other burrowing animals)
 - Tidal Creeks: natural or channelized ravine areas which are subject to tidal conditions

Author: Chris Maser, ECU Fall 2002



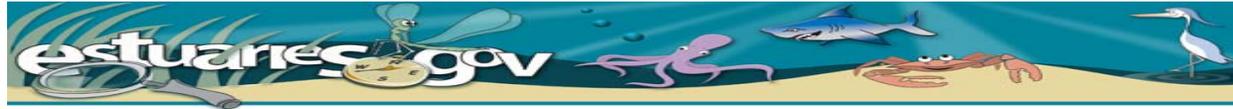




Comparison Chart – EstuaryLive Site

Reserve Site	Site Area (acres)	Type (geo-morphology)	Watersheds (and associated waterways)	Location (latitude + longitude)	Key Plant Species**	Key Animal Species**	Invasive or Exotic species**	Endangered Plant Species**	Endangered Animal Species**
North Carolina, Rachel Carson site of NCNERR	2,700	Coastal Plain	White Oak Watershed North River Newport River	35°0' N 76°5' W	Smooth cordgrass, <i>Spartina alterniflora</i>	Feral Horses, <i>Equus caballus</i> Migratory Birds Eastern Oyster, <i>Crassostrea virginica</i> Fiddler Crab, <i>Uca sp.</i> Marsh Periwinkle, <i>Littorina irrorata</i>	Salt Cedar, <i>Tamarisk sp.</i>	Sea Beach Amaranth, <i>Amaranthus pumilus</i> Sea Beach Knotweed, <i>Polygonum glaucum</i>	Loggerhead Sea Turtle, <i>Caretta caretta</i> Piping Plover, <i>Charadrius melodus</i>
Alabama, Weeks Bay NERR	Reserve Property approx. 6,000 acres. Watershed approx. 200 sq. miles or 129,000 acres.	Coastal Plain	Fish River Watershed Magnolia River Watershed	30° 23' N 87° 50' W	Black needle rush, <i>Juncus romerianus</i> Smooth Cordgrass, <i>Spartina alternifolia</i> Sawgrass, <i>Cladium jamaicense</i> Bald cypress, <i>Taxodium disticum</i> Sweetbay, <i>Magnolia virginiana</i>	American alligator, <i>Alligator mississippiensis</i> Brown pelican, <i>Pelicanus occidentalis</i> Osprey, <i>Pandion haliaetus</i> American bald eagle, <i>Haliaeetus leucocephalus</i> Red drum, <i>ocellatus</i> Spotted sea trout, <i>Cynoscion nebulosis</i> Striped mullet, <i>Mugil cephalus</i> Blue crab, <i>Calinectes sapidus</i>	Water spangles, <i>Hydrilla verticillata</i> , <i>Salvinia minima</i> Cane, <i>Phragmites australis</i> Chinese tallowtree, <i>Triadica seberifera</i> Japanese climbing fern, <i>Lygodium japonicum</i> Chinese privet, <i>Ligustrum sinense</i> Cogongrass, <i>Imperata cylindrica</i>	White-topped pitcher plant, <i>Sarracenia leucophylla</i> Yellow fringed orchid, <i>Habenaria ciliaris</i> Nodding nixie, <i>Apteria aphylla</i>	Alabama redbelly turtle, <i>Pseudemys alabamensis</i> West Indian manatee, <i>Trichechus manatus</i> Piping Plover, <i>Charadrius melodus</i>





Reserve Site	Site Area (acres)	Type (geomorphology)	Watersheds (and associated waterways)	Location (latitude + longitude)	Key Plant Species**	Key Animal Species**	Invasive or Exotic species**	Endangered Plant Species**	Endangered Animal Species**
New York, Peconic Estuary NEP	Land: > 125,000 Surface water: > 158,000	Coastal Plain	Peconic River Flanders Bay Great Peconic Bay Little Peconic Bay Gardiners Bay	41°0' N 72°5' W	Eelgrass, <i>Zostera marina</i> Smooth cordgrass, <i>Spartina alterniflora</i> Saltmeadow Cordgrass, <i>Spartina patens</i>	Peconic bay scallops, <i>Argopecten irradians</i> Hard clams, <i>Mercenaria mercenaria</i> Osprey, <i>Pandion haliaetus</i> Sea ducks Diamondback terrapin, <i>Malaclemys terrapin</i>	Common reed, <i>Phragmites australis</i> Green fleece, <i>Codium fragile</i>	Sandplain gerardia, <i>Agalinis acuta</i>	Eastern Mud Turtle, <i>Kinosternon subrubrum</i> Kemp's Ridley Sea Turtle, <i>Lepidochelys kempii</i> Leatherback Sea Turtle, <i>Dermochelys coriacea</i> Tiger salamander, <i>Ambystoma tigrinum</i> Piping Plover, <i>Charadrius melodus</i> Roseate Tern, <i>Sterna dougallii</i>
Massachusetts, Waquoit Bay NERR	more than 2700 acres	Coastal Plain	Main watershed: Waquoit Bay Subwatersheds: Quashnet River Child's River Sage Lot Pond Eel Pond Hamblin Pond Jehu Pond	40°35' N 70° 32' W Falmouth and Mashpee on Cape Cod, Mass.	Eel grass, <i>Zostera marina</i> Cord grass, <i>Spartina alterniflora</i> Marsh hay, <i>Spartina patens</i>	Quahog, <i>Mercenaria mercenaria</i> Blueback herring, <i>Alosa aestivalis</i> Alewife, <i>Alosa pseudoharengus</i> Osprey, <i>Pandion haliaetus</i>	Common Reed, <i>Phragmites australis</i> Asian Shore Crab, <i>Hemigrapsus sanguineus</i> Alga, <i>Codium fragile</i>	Sandplain gerardia, <i>Agalinis acuta</i>	Roseate Tern, <i>Sterna dougallii</i>





Reserve Site	Site Area (acres)	Type (geo-morphology)	Watersheds (and associated waterways)	Location (latitude + longitude)	Key Plant Species**	Key Animal Species**	Invasive or Exotic species**	Endangered Plant Species**	Endangered Animal Species**
Washington, Padilla Bay NERR	11,000	Delta Tectonic Fjord	Skagit River	48°0' N 122° 5' W	Eel grass, <i>Zostera marina</i>	Bald Eagle, <i>Haliaeetus leucocephalos</i> Peregrine Falcon, <i>Falco peregrinus</i> Black Brant, <i>Branta bernicula nigricans</i> Salmon, <i>Oncorhynchus sp.</i> Dungeness Crab, <i>Cancer magister</i> Clams	Smooth Cordgrass, <i>Spartina alterniflora</i> Eel grasses, <i>Zostera japonica</i>		Salmon, <i>Oncorhynchus sp.</i>
Oregon, South Slough NERR	4,7000	Coastal Plain Tectonic	Coos River Coos Bay	43°5' N 124°5' W	Eel grass, <i>Zostera marina</i> Sitka Spruce, <i>Picea sitchensis</i> Red Alder, <i>Alnus rubra</i>	California Sea Lion, <i>Zalophus californianus</i> Harbor Seal, <i>Phoca vitulina</i> , Migratory Birds Salmon, <i>Oncorhynchus sp.</i> Heart Cockle <i>Clinocardium nuttallii</i> Gaper or Empire clam, <i>Tresus capax</i> , Macoma clams, <i>Macoma nasuta or balthica</i> Dungeness Crab, <i>Cancer magister</i>	Japanese eelgrass, <i>Zostera japonica</i> A little beach hopper named <i>Corophium acherusicum</i>	SaltMarsh Bird's Beak, <i>Cordylanthus maritimus</i> Western Marsh Rosemary, <i>Limonium californium</i>	Bald Eagle, <i>Haliaeetus leucocephalos</i> Marbled Murrelet, <i>Brachyramphus marmoratus</i> Western Snowy Plover, <i>Charadrius alexandrinus nivosus</i> Coho Salmon, <i>Oncorhynchus kisutch</i>





Reserve Site	Site Area (acres)	Type (geo-morphology)	Watersheds (and associated waterways)	Location (latitude + longitude)	Key Plant Species**	Key Animal Species**	Invasive or Exotic species**	Endangered Plant Species**	Endangered Animal Species**
New Jersey, Jacques Cousteau NERR	114,700	Coastal Plain	Mullica River Great Bay Barnegat Bay	39°5' N 74°5' W	Smooth cordgrass, <i>Spartina alterniflora</i> , Widgeon Grass, <i>Ruppia maritima</i> Eel grass, <i>Zostera marina</i>	Migratory Birds Fiddler Crab, <i>Uca sp.</i> , Horseshoe Crab, <i>Limulus polyphemus</i> Clams, <i>Mercinaria sp.</i> Ribbed Mussels, <i>Geukensia demissa</i> Terrapins, <i>Malaclemys terrapin</i> Great Blue Heron, <i>Ardea herodias</i> Snowy Egret, <i>Egretta thula</i> Great Egret, <i>Casmerodius albus</i>	Reedgrass, <i>Phragmites sp</i>	American Chaffseed, <i>Schwalbea americana</i> Bog Asphodel, <i>Nartheicum sp.</i> Long's Bull Rush <i>Scirpus longii</i> New Jersey Rush, <i>Juncus caesariensis</i> Pine Barren Boneset, <i>Eupatorium resinsum</i>	Fin Whale, <i>Balaenoptera physalus</i> Peregrine Falcon, <i>Falco peregrinus</i> , Piping Plover, <i>Charadrius melodus</i> Leatherback Sea Turtle, <i>Dermochelys coriacea</i> Tiger Salamander, <i>Ambystoma tigrinum</i> Timber Rattlesnake, <i>Crotalus horridus</i> Pine Barrens Treefrog, <i>Hyla andersonii</i> Northeastern Beach Tiger Beetle, <i>Cicindela dorsalis dorsalis</i>

**Plant and animal names list the common name followed by the *taxonomic nomenclature in italics*.

Original author Chris Maser, ECU Fall 2002







Website Resources

National Science Education Standards (www.nap.ed/books/0309053269/html)
Science Benchmarks (www.project2061.org/tools/benchol/bolframe.htm)

An **interagency Web site** intended to provide students, educators and the general public with information on a variety of estuarine issues.
<http://Estuaries.gov>

NOAA's National Estuarine Research Reserve System is a network of 25 protected areas that provide research and education to promote informed coastal resource management.
<http://nerrs.noaa.gov/>

EPA's National Estuary Program was established in 1987 by amendments to the Clean Water Act to identify, restore and protect nationally significant estuaries of the United States.
epa.gov/owow/estuaries

Exploring Estuaries The U.S. Environmental Protection Agency developed this Web site to introduce kids of various ages to the ecology of estuaries. Teachers also can use this resource in the classroom to enhance their lesson plans and activities.
<http://www.epa.gov/owow/estuaries/kids/>

Authorized by the Coastal Zone Management Act of 1972, this unique state-federal partnership leaves day-to-day management decisions at the state level in the 33 states and territories with federally approved coastal management programs:
www.coastalmanagement.noaa.gov/czm

Coastal America is a unique partnership of federal agencies, state and local governments and private organizations. The partners work together to protect, preserve, and restore our nation's coasts:
www.coastalamerica.gov

CICEET supports the scientific development of innovative technologies for understanding and reversing the impacts of coastal and estuarine contamination and degradation:
www.ciceet.unh.edu

National Marine Education Association

The National Marine Educators Association brings together those interested in the study and enjoyment of the world of water--both fresh and salt. Affiliated with the National Science Teachers Association and the American Association for the Advancement of Science, NMEA provides a valuable focus for marine and aquatic studies world-wide.
<http://www.marine-ed.org/>





List of books on estuaries and estuarine ecology

1. The Ecology of Soft Shores and Estuaries (C. Little, 2000 / Oxford Univ. Press)
2. Ecology and Management of Tidal Marshes: A Model from the Gulf of Mexico (C. Coultas & Y-P. Hsieh, 1997 / St. Lucie Press)
3. Ecology of Estuaries. Vol. I. Physical and Chemical Aspects (M. Kennish, 1986 / CRC Press)
4. Ecology of Estuaries. Vol. II. Biological Aspects (M. Kennish, 1990/ CRC Press)
5. Estuarine Research, Monitoring, and Resource Protection (M. Kennish, 2004 / CRC Press)
6. Marine Community Ecology (Chapt. 10. Soft-Sediment Communities / Chapt. 11. Salt Marsh Communities / Chapt. 12. Seagrass Community Ecology) (M. Bertness, S. Gaines, M. Hay, eds. 2001 / Sinauer Assoc., Inc.)
7. Ecology of Coastal Waters (Part 1. Estuarine Ecosystems and their Components) (K. Mann, 2000, Blackwell Science)
8. Concepts and Controversies in Tidal Marsh Ecology (M. Weinstein and D. Kreeger, 2000 / Kluwer Academic Publishers)





Glossary

A:

Abiotic factors: non-living characteristics of a habitat or ecosystem that affect organisms' life processes.

Adaptation (adapt): a genetically-based body feature or behavior that allows an organism to be better suited to its environment.

Aerobic: with air, oxygen

Algae: chlorophyll containing non-vascular organisms, plant or plant-like

Anerobic: without air, no oxygen

Anoxic: without oxygen, anaerobic.

Anthropogenic: arising from human activity.

Aquatic organisms: organisms that live in or on the water.

B:

Back dune: area immediately behind fore dune; inhabited by mixture of grasses, beach heather and lichen.

Bar-built estuaries: areas where sandbars form parallel to the shore, partly enclosing the water behind them as the sandbars become islands.

Barrier beaches: spits of sand that form parallel to the shore.

Barrier islands: barrier beaches with a cross-section profile that often includes dunes, shrub thickets, maritime forests, and saltmarshes

Beach/Ocean interface: where waves meet beach.

Benthic (adj.) relating to the ocean bottom.

Benthos: bottom-dwelling flora and fauna; from tiniest microbenthos (bacteria) to medium-sized meiobenthos (nematode worms) to the highly visible macrobenthos (clams, polychaete worms).

Biotas: assemblages of living things

Biotic factors: relationships among organisms that affect their survival.

BOD: biological oxygen demand

Brackish: slightly salty water with a salinity between 0.5 ppt and 32 ppt

C:

Carnivores: animals that eat other animals as opposed to herbivores, which eat only plants.

Chlorine: poisonous, gaseous substance.

Coastal plains estuary: estuary formed when rising sea level flooded existing river valley.

Coliform bacteria: bacteria commonly found in colon and used as an indicator of water contamination.

Commensalism: form of relationship in which one species gains from the interaction and the other is neither positively nor negatively affected.

Community: an association of interacting populations.

Competition: occurs between organisms using a finite resource, whether they are of the same or different species.





Conditions: characteristics of the environment that influence the survival of an organism but are not consumed by it (e.g., temperature, salinity)

Contamination: an undesirable element, impure or unclean, something that is not supposed to be there (such as oil or insecticides in water)

Consumer: individual that eats other organisms to obtain energy rather than producing its food through photosynthesis or chemosynthesis.

Copepods: one of most common herbivorous zooplankton.

Crustaceans: arthropods having hard-shelled bodies and jointed ligaments such as crabs, shrimp and lobsters.

Currents: large-scale circulation of water caused by thermodynamics and winds

D:

Desiccation: loss of water.

Detritus: newly dead or decaying organic matter coated with bacteria.

Diatoms: one of most common groups of phytoplankton; single-celled organism that reproduces asexually.

Dinoflagellates: common type of phytoplankton, most abundant in fall; responsible for “red tides” as well as bioluminescence.

Disturbance: any event that opens up space for colonization, such as the falling of a tree in a forest or removal of marsh grass by storm waves.

E:

Ecosystem: the biotic community and its abiotic environment.

Epibenthos: organisms that live on the bottom, rather than burrowed into, of an aquatic system.

Estuary: A semi-enclosed body of water which has a free connection to the open sea and within which seawater is measurably diluted by fresh water derived from land drainage.

Euryhaline: able to live at a variety of salinities

Eutrophication: process by which large additions of nutrients causes an overgrowth of algae and subsequent depletion of oxygen

F:

Fjords: a glacial trough valley now flooded with seawater to create a steep-walled inlet.

Food chain: a representation of the flow of energy between producers, consumers, and decomposers.

Food web: a representation of the linkages between food chains in a community.

Foreshore: the area between mean low water and mean high water.

Frontal dune: the dune closest to the water's edge.

G:

Gastropod: one of a class of mollusks that includes the snails and nudibranchs.

Groundwater: water contained below ground in soil and rock.





H:

Habitat: the place where an organism lives.

Haul-out: an area on the shore where marine mammals rest.

Herbivore: an animal that eats plants.

High marsh: the area of the marsh flooded infrequently by the high tides associated with new and full moon.

Hypoxia: very low oxygen levels

I:

Infaua: organisms living between the grains of sand or mud.

Isopods: aquatic crustaceans with flat, oval body and seven pairs of legs.

Intertidal: estuary habitat flooded by high tide waters only

J:

Jellyfish: carnivorous zooplankton; common in Gulf of Maine and Wells Reserve.

L:

Light: energy source used by plants to form carbohydrates, an important abiotic factor.

Low marsh: the area of marsh flooded twice daily by tides and dominated by *Spartina alterniflora* in Gulf of Maine region.

M:

Mangrove: tree species that grow in non-freezing estuaries. There are about 12 species though the black, red, and white are most common.

Maritime forest: forest dominated by pitch pine and located on the mainland side of a barrier beach or island.

Marshes: soft wet land usually characterized by grasses

Mesohaline: intermediate levels of salinity, about 15ppt

Metadata: the reference information about how the data is collected

Mobile epibenthos: bottom-dwelling animals that move on top of sediments: crabs, shrimp, snails, amphipods, isopods.

Mollusks: soft bodied, shelled animals such as clams, oysters, nudibraches and octopi (the latter two have either small remnant shell within their bodies or an embryonic shell)

Mudflat: part of benthic (bottom) zone exposed at low tide and comprised of extremely fine sediments.

Mummichogs: *Fundulus heteroclitus*; common small salt-marsh fish

Mutualism: form of relationship in which both species involved gain from the interaction (example: lichen).





N:

National Estuarine Research Reserve: network of 26 protected areas established for long-term research, education and coastal stewardship authorized as part of the [Coastal Zone Management \(CZM\) Act of 1972](#), which called for the establishment of a network of estuaries that represent different biogeographical regions of the United States.

Natural selection: the differential survival and/or reproduction of individuals within a population based on hereditary characteristics.

Neap tides: Average tides that occur between full and new moons.

Nekton: all aquatic animals that can swim through the water against currents: marine mammals, fish, squid and some crustaceans.

Niche: the role of a species within a community.

Non-point source pollution: water pollution arising from indistinct sources such as petroleum products from roadways or pesticides from farmland.

Nursery: term used colloquially to refer to estuaries. Many fish species are dependent on estuaries for part of their lives.

Nutrients: substances required by organisms in order to grow and survive such as nitrogen and phosphorus.

O:

Oligohaline: low salinity areas, 0-15ppt

Omnivores: animals that feed at several levels of food web; diet includes a mix of living and/or dead plants and animals.

Oxygen: used in respiration, the process in which organisms release stored chemical energy.

P:

Panne: small pond or pool in the salt marsh.

Parasitism: similar to predation in that one species benefits from the relationship and the other is harmed; differs from predation in that parasitism generally not fatal to adversely affected organism.

Peat: soil in marsh composed of partially decayed moisture-absorbing plant matter.

Petroleum derivatives: toxic pollutants from crude oil products; mixture of hydrocarbons, which are organic solvents.

Photosynthesis: process of using energy in sunlight to convert water and carbon dioxide into carbohydrates and oxygen.

Phytoplankton: floating plants or plant-like photosynthetic single cellular organisms

Pioneer species: plant species that first invades unvegetated area.

Pipefish: elongate fish related to seahorses.

Plankton: free-floating organisms drifting in water, unable to swim against currents.

Point source pollution: pollution from a clearly defined, localized source such as a sewage outfall.

Pollution: contamination of natural environment.

Polyhaline: high salinity about 30-335 ppt

Population: all the individuals of a particular species within a defined area.





Precipitation: rain, snow, sleet, freezing rain, mist

Predation: the killing and/or consumption of living organisms by other living organisms.

Primary dune: foredune; dune closest to water's edge.

Producer: autotroph; organism that creates energy-rich compounds from sunlight (through photosynthesis) or certain chemicals (through chemosynthesis); first level in any food web; in estuarine systems, most abundant producers are phytoplankton.

Protists: often unicellular but they can be multi-cellular or colonial the organisms in this Kingdom have characteristics of plants, animals and fungi and contains most algae

R:

Reef: chain or string of coral, oysters, rocks or other hard substrate

Resource: entity (e.g., food, light, water, space) that an organism uses or consumes during its lifetime.

Respiration: process that, using oxygen, releases stored chemical energy to power an organism's life processes; opposite reaction of photosynthesis.

Response: ecological responses are behavioral and physical changes that happen during the lifetime of a single organism and increase individual's chance of survival as opposed to evolutionary adaptation, which takes place

over multiple generations and is a result of a change in the species genetic makeup.

Restoration: Make physical changes in a destroyed or impaired habitat that returns a site to the type of habitat it was prior to human made impacts.

Runoff: precipitation that drains into a water body from the surface of the surrounding land.

S:

Salinity: the concentration of salts dissolved in salt water.

Salts: most commonly NaCl or table salt but includes other salts such as $MgCl_2$

Salt marsh: wetland flooded regularly by tidal, brackish water.

Sand eel: *Ammodytes americanus*; American sand lance.

Sandflat: area of bottom of aquatic system that is exposed by low tides and composed of sand - particles of sediment larger than those of mud.

Scud: Scud gammarus; a type of amphipod to one inch that live in masses of seaweed, scuttle under rocks, and swim on their sides in tide pools.

Sediments: particles deposited by wind or water.

Shags: *Phalacrocorax auritus*; sea bird similar to cormorant.

Silversides: *Menidia* spp.; small schooling fish that spawn in estuaries in April/May, then return to sea; young fish stay in estuary until September.

Space: resource needed by all organisms; most pronounced need by organisms that require substrate.

Speciation: formation of new species through natural selection; occurs when selective force is intense; accounts for diversity of living things on planet today.

Spring tides: Extreme high and low tides that occur about twice a month, with the full and new moons





Sticklebacks: Gasterosteidae spp.; small estuarine fish named for spines that line the dorsal fin; three species found at Wells Reserve.

Sublittoral zone: portion of rocky shore always submerged.

Substrate: the surface on which an organism grows.

Subtidal: area usually flooded near edge of tidal waters

Succession: progressive replacement of populations in a habitat.

Supratidal: occasionally flooded by very high or storm tides.

Surface water: water in streams, brooks, rivers, ponds and lakes, etc.

Swash zone: part of foreshore washed by waves.

Synthetic compounds: manufactured compounds.

T:

Tectonic estuaries: land flooded by sea due to subsidence, not sea-level rise.

Temperature: important abiotic factor affecting distribution and abundance of organisms; influences metabolic rate and affects rates of growth and reproduction.

Tidal height: difference between water level at high tide and mean sea level, the average height of the ocean.

Tidal range: difference between high and low tide.

Tides: periodic rise and fall of ocean waters due to gravitational pull of sun and moon, and rotation of earth.

Trophic level: level in a food chain, e.g., producer, primary consumer, secondary consumer, tertiary consumer.

U:

Uplands: lands lying above the reaches of the highest high tides.

V:

Vertical stratification: laying of fresh water on top of salt water, also known as “salt wedge” effect; occurs when the fresh and salt water is not vigorously mixed together by turbulence.

W:

Water: a molecule-composed compound of hydrogen and oxygen.

Watersheds: area of land drained by a river or river system, lake or estuary.

Wetland: “areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” (US Army Corp of Engineers for Section 404 support of the 1977 Clean Water Act Amendments)

Wrack line: a string of debris stranded by last high tide; cast ashore seaweeds, isolated sources of food and shade support an important community of isopods and amphipods as well as providing food for birds.





Z:

Zonation: distribution of plants or animals arranged in zones or bands, caused by gradations of abiotic and/or biotic factors.

Zooplankton: animal or animal-like protists, small or microscopic, that drift with the currents, may be either herbivores or carnivores.

Some of this material was adapted from the Estuary-Net Curriculum, Estuarine Ecology Section, developed by the National Estuarine Research Reserves.

