

Long Island Sound

Curricular Resource Guide



About Connecticut Sea Grant

Connecticut Sea Grant, based at the University of Connecticut's Avery Point campus, is a partnership between the university and the National Oceanic and Atmospheric Administration (NOAA). As the Connecticut component of the National Sea Grant program, Connecticut Sea Grant fosters sustainable use and conservation of coastal and marine resources for the benefit of the environment and current and future generations of residents of Connecticut and the region. For more information, please visit web2.uconn.edu/seagrant.



About the Long Island Sound Study

The Environmental Protection Agency's Long Island Sound Study is a cooperative effort involving researchers, regulators, user groups and other concerned organizations and individuals. These people are working together to protect and improve the health of the Sound. For more information, please visit www.longislandsoundstudy.net.



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About the cover: (front)

This photograph of Long Island Sound was taken aboard the Connecticut Department of Environmental Protection's research vessel, the *John Dempsey*, while traveling between water quality testing sites.

(back) *Pagurus pollicaris*, a flatclaw hermit crab, is just one player in the dynamic ecosystem that is Long Island Sound.

Table of Contents

1	<i>Long Island Sound Curricular Resource Guide Overview</i>
3	Background Information about Long Island Sound
3	What is an Estuary?
6	Meeting the Needs for Survival
11	Habitat: It's Where You Live
13	Food Chains and Food Webs: It's All About Eating and Being Eaten
16	Long Island Sound Activities
17	<i>Invasive Species of Long Island Sound</i>
19	<i>Long Island Sound Worth Fighting For!</i>
21	<i>Sound Health 2008</i>
23	<i>The Living Sound</i>
25	<i>Sound Facts and Activities</i>
29	<i>Lobster Fun Facts</i>
32	Lesson Plans
33	Dissolved Oxygen in Long Island Sound
37-38	Dissolved Oxygen Lab Student Activity
39	Nitrogen Loading and Hypoxia
43-44	Student Roles
45	Student Activity
46	Group Activity
47	Macroalgae of Long Island Sound
52	Invertebrate Scrapbook
56-65	Student Activity

Table of Contents

66	Cleaning Up Polluted Water
72	Student Activity
74	Science Lessons at a Long Island Sound Field Site
75	Preface
79	Crab Study and Beach Sample Station
85	Rocky Beach Sample Station Data Sheet
86	Crab Study Station Crab Count Data Sheet
87	Seining
90-91	Seining Diagrams
92	Data Sheet
93	Beach Lab - Marine Biology Field Station
97-98	Data Sheet
99	Sifting Sands and Shifting Tides
103	Data Sheet
104	Sand Sampling
105	Aesthetic Connection to Long Island Sound
109	Drawing Template
110	Leader packet
123	Resources
124	Environmental Calendar
125	How to Preserve Seaweed
126	Resources by Topic

Long Island Sound Curricular Resource Guide Overview

Long Island Sound. It is an estuary of national significance and provides important economic, recreational, and aesthetic value to the citizens of Connecticut and New York. Investigations have been conducted regarding living marine resources and nutrient loading. However, Long Island Sound is often overlooked as an educational resource.

This guide is intended to provide educational resources for formal and informal educators teaching about Long Island Sound. The guide is divided into five sections. The sections are tabbed for quick reference and student pages are formatted for easy recognition and separation from educator pages.

The *Long Island Sound Curricular Resource Guide* begins with an overview of what an estuary is and how organisms survive. This is followed by a discussion about Long Island Sound habitats and food chains/food webs. The second section is a collection of activities developed to work with a few specific Long Island Sound resources - *Invasive Species of Long Island Sound* poster, *Long Island Sound Worth Fighting For!* video, Environmental Protection Agency Long Island Sound Study (EPA LISS) *Sound Health 2008*, *The Living Sound* video, and the *Sound Facts* booklet (the means for obtaining the resources are provided on page 16). This is followed by several lesson plans focused on Long Island Sound topics, and a Long Island Sound field site set of lessons developed by Long Island Sound mentor teachers. Finally, a section of Long Island Sound resources is provided and is organized by topic. A list of these topics is provided on page 123.

Should you have any questions, comments, edits, or would like to contribute to subsequent editions of the *Long Island Sound Curricular Resource Guide*, please contact Diana Payne at diana.payne@uconn.edu.



Charles Island off the coast of Connecticut stands completely surrounded by the productive estuarine waters of Long Island Sound.

What is an Estuary?

3

What does it mean when Long Island Sound is called a “dynamic estuarine system”?

An **estuary** is a body of water where fresh water and salt water meet and mix. In the case of Long Island Sound, fresh water enters from several large rivers and numerous smaller rivers and streams while salt water enters from the Atlantic Ocean.

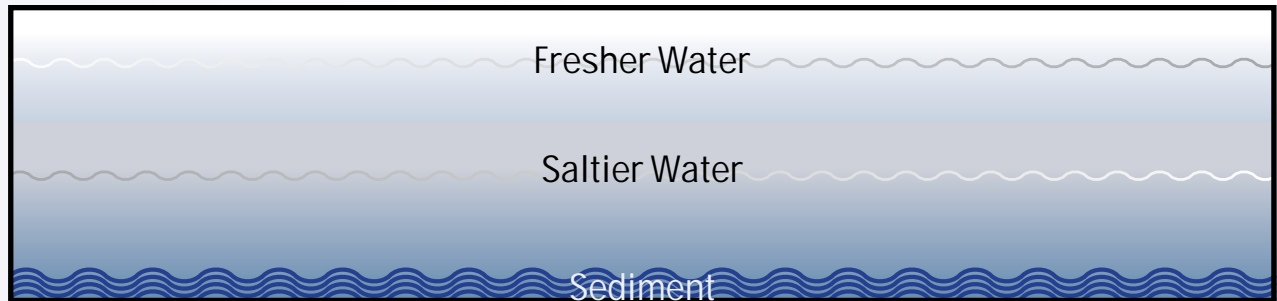


The waters mix and form a tremendously rich habitat for plants, animals, and other life forms. Estuaries are among the most productive ecosystems on Earth. John and Mildred Teal, in *Life and Death of the Salt Marsh* (1969), noted that estuaries and marshes are about ten times as productive as coastal waters, which are, in turn, about ten times as productive as the open waters of the ocean. Estuaries provide feeding, breeding, nesting, and nursery areas for many animals, and abound in plant life as well. It is commonly understood that many of the finfish and shellfish species harvested by anglers and commercial fishermen along the Atlantic coast inhabit an estuary or marsh during some period of their life. Scientists often refer to estuaries as “green waters,” (in contrast to the blue waters of the oceans), because of the brownish-green appearance of the water, which is a reflection both of its productivity due to abundant plankton in the water and the sediment input associated with coastal locations. Plankton is an important food source for many animals.

What does “dynamic” mean? Estuaries are water bodies of constantly varying or wide-ranging conditions. For example, in Long Island Sound, organisms must be able to handle a range of temperatures from 0°C (32°F) in the winter to 23°C (73°F) in the summer. The Sound’s salinity (how salty the water is) also varies. The salinity of the water in the eastern

What is an Estuary?

part of the Sound, near the opening to the Atlantic Ocean, is at or near 35 parts per thousand (ppt). In the western Sound, the salinity of the water is about 23 ppt. The Sound's water can be layered (stratified) from surface to bottom by salinity under certain circumstances. For example, after snow melts or major rain events, the salinity of the surface waters at the mouths of the rivers can approach that of fresh water. Layers of lighter fresh water float on top of layers of heavier or denser, salty water. This distinct zonation, called a pycnocline, can occur when mixing is inadequate.



The organisms in an estuary also cope with the tides, which in Long Island Sound occur twice daily. The tidal range (difference in water height between high tide and low tide) varies with location and with the different phases of the moon. In the eastern part of the Sound, the mean tidal range is about 0.8 meters (2.6 feet), while in the western portion of the Sound, the mean tidal range is greater, averaging more than 2 meters (6.6 feet).

High tide at Avery Point in Groton, Connecticut is just one example of the variety of physical and biological diversity of the estuary that is Long Island Sound.



What is an Estuary?

Organisms that live in the **intertidal zone** (the area of rocks, sand, mud, or marsh between the maximum high and low tides) are under water during high tide and exposed during low tide. These organisms must be able to tolerate constantly changing conditions: wind, sun, freezing air temperatures in the winter; hot air temperatures in the summer; predation from land animals; rainfall and freshwater runoff; strong force and action of the waves. Many of these organisms have **adaptations** (see *Meeting the Needs for Survival*, starting on the next page) to cope with changing conditions.

The Long Island Sound estuary is an **ecosystem**, where the non-living physical environment and all of the living organisms (including humans) that live in and near the Sound, interact, compete for several of the same resources, and are connected in many ways. Changes to the physical environment—such as an increase in the average annual water temperature, pollution, the building of new structures along the coast, or changes to the living resources of the estuary (due to disease, excessive fishing, or the introduction of a new species) can upset the stability of the Sound’s ecosystem. The result may be immediately apparent (for example, few healthy oysters left after a disease outbreak), or apparent after a longer period of time (for example, an increase in the number of warmer water species and a decrease in the number of colder water species as average water temperature increases incrementally over time).

So, what is an estuary? It’s all of the above AND it’s a living classroom. Want to demonstrate key concepts in biology, chemistry, physics, geology, or ecology? Head for our estuary, Long Island Sound, and dive in!

Meeting the Needs for Survival

Surviving to reproduce is what life is all about. Survival depends on the ability of an organism to obtain its basic needs for food, water, oxygen, and shelter from the habitat in which it lives. If an organism can meet its basic needs, it is more likely to reproduce successfully and establish an ongoing presence in that habitat.

Estuaries like Long Island Sound provide a broad range of habitat types (see *Habitat: It's Where You Live*, page 11) that in turn support a wide variety (**diversity**) of individual organism types or **species**. Many species can live in the same habitat by using the resources available in different ways through **adaptation**. Adaptations are changes in characteristics or behavior that enable organisms to reduce competition for limited resources, such as food and shelter.

Rocky Intertidal

Take snails, for example. If you look at the rocks near the shore at low tide, you will find lots of snails about $\frac{3}{4}$ " in length attached to the rocks. They are busy scraping algae off the rocks with tiny rows of teeth called **radula**.

These are periwinkles, and are capable of withstanding exposure during low tide to the sun, wind, and other elements. How do they do it? If you take a moment to observe the snails on the rocks carefully, you will start to notice that they tend to be found on the lower half of the rocks, where it remains moist and out of the direct sun. They crawl under the seaweed attached to the rocks, which flop over during low tide, and provide a dark, moist place to "hang out." If you pull one of the snails off a rock and look at its underside, you may catch a glimpse of its flesh before it pulls its soft foot completely inside and "shuts the door" using the small piece of shell on its foot called an **operculum**. The operculum helps the snail keep its body moist inside its thick shell until the tide comes back in or the snail is put back into the water. It's also very handy when a predator comes to call!



Periwinkles gather at low tide (left and above right) in clusters and below rocks and seaweed. Overturned in a tidepool, the protective operculum is shown to fit the shape of the opening of the shell (lower right).

Meeting the Needs for Survival

Space is an important resource. Everything competes for space, but adaptations can reduce direct competition for the same space. While you are looking at the periwinkle snails, observe the rocks carefully during mid to low tide. Space in the rocky intertidal zone is important because with all the wave action, organisms that do not move in and out with the tide need someplace to hang onto or something to hide under so they are not smashed upon the rocks or pulled away from their habitat by the waves and currents. You may notice zones of color which relate to zones of organisms. The splash zone is highest on the shore. Water never covers this zone, but it is often made wet with sea spray or wave splash and it is characterized by a black band of cyanobacteria, or blue-green algae. Just below this you might see a whitish band of barnacle along the rocks. The next band, slightly darker and lower on the rocks, is where the brown seaweeds (rockweed and knotted wrack) are attached and the periwinkle snails tend to congregate. Even lower, and just submerged, a dark band of blue mussels may be found. These organisms all need space but can live together in the rocky intertidal zone because they are not competing for the exact same space on the same rocks.

These organisms have also adapted a number of different ways to “hang on” and cope with the intense wave action. Blue mussels secrete tiny but incredibly strong threads called **byssus**, which are used to cement the animals to the rocks in clusters. Barnacles cement their shells directly to the rocks or other shells. Seaweeds attach to the rocks with strong but **flexible holdfasts**. In addition to moving towards the underside of the rocks to avoid direct wave action, a periwinkle creates suction between its foot and the rock surface which also helps it to stay put when waves crash on the rocks.

Byssal threads of the blue mussel (right) and the holdfasts of rockweed (below, left and right) enable these organisms to secure themselves to a hard substrate, and remain in place, withstanding tidal currents.



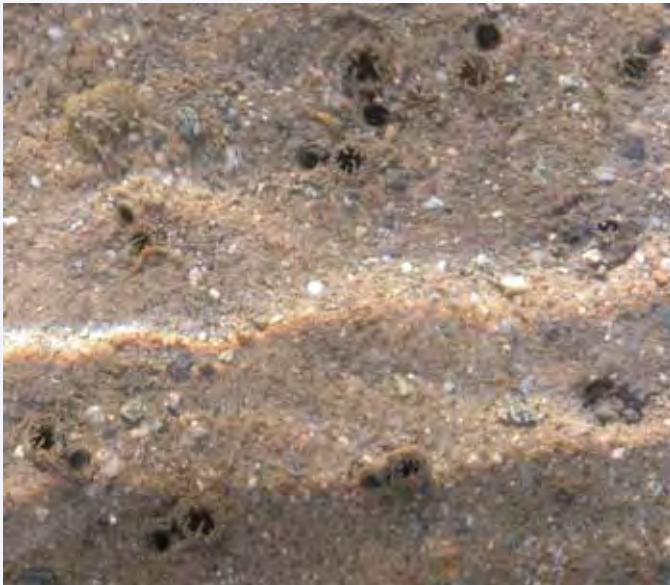
Meeting the Needs for Survival

Tidal Flat

In contrast, take a look at a tidal flat. Tidal flats are lower energy sandy or muddy areas in the estuary, which means the wave action isn't as strong. Different types of snails live in the tidal flats as well, but instead of hiding under rocks or seaweed, they tend to bury in the mud or sand for protection.

Many species of worms and shellfish also live in the mud or sand. Shellfish like razor clams or hard clams extend their feeding siphons up to the surface of the mud to filter plankton from the water. They do not all bury themselves at the same depth (there's that competition for space again!), but instead, different species of clams have different siphon lengths so they can bury at different depths.

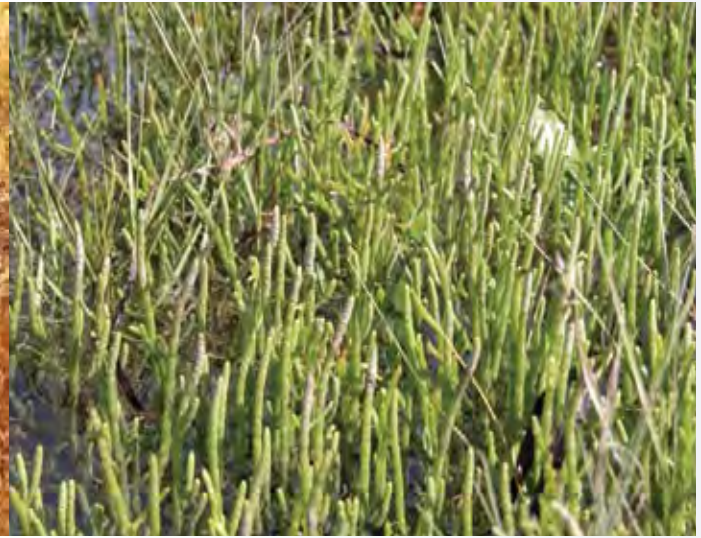
You'll find lots of hermit crabs in these flats as well. They need to live near snails since they use the empty shells of dead snails as protection for their soft tail parts.



Clam siphons emerge from the sand (left) and coiled piles of worm castings (right) are both evidence of the diversity of life within the sediment of a tidal flat.

Salt Marsh

Up along the shore, more adaptations are evident. For example, in the salt marsh there are low lying areas or depressions with little vegetation called **salt pannes**. Salt tends to concentrate in a salt panne as the water evaporates during low tide. Exposure to higher levels of salt causes organisms to lose water more easily, making a salt panne an inhospitable place in which to live. Yet several plants can live in salt pannes successfully. One is called glasswort, a **succulent** plant. Succulent means "juicy." Plants with thick, fleshy leaves or stems that conserve moisture are succulents (like cactus). The fleshy stems of the glasswort hold moisture in so the plant does not dry out and die. If you taste glasswort, you'll note its salty flavor.



The succulent glasswort (above) inhabits the salt panne area of a salt marsh (above left and left).

Dusty Miller (below, top) has woody stems and “wooly” leaves to discourage predators, and a light color to reflect sunlight. The seeds of the Cocklebur (below, bottom) are covered with burs to protect against predation.

Sandy Beach

Plants living on sand dunes, a very harsh environment indeed, exhibit a variety of interesting adaptations. Sand is unstable and easily moved by wind and waves. Plants living on dunes must be able to hang on in these unstable conditions in addition to surviving the scorching sun and salt crystals from sea spray that fill the air.

Dune grasses and other vascular plants living on sand dunes and beaches are very important in helping to keep the sand in place, yet they are very fragile. Keep to paths and stay off the dunes. Avoid stepping on plants living on sandy beaches as you can easily damage their roots.

Notice that a number of the plants living in this habitat are protected from herbivorous predators by thorns (e.g., Rugosa rose), tough woody stems and “wooly” leaves (e.g., Dusty Miller), or burs (e.g., Cocklebur). American beach grass has several



Meeting the Needs for Survival



The stems of the Rugosa rose are covered with thorns to discourage herbivores.

adaptations that help it live in the sandy beach environment. On very hot days, the leaves curl inward to reduce exposure to the sun and moisture loss. The grass's deeply ribbed blades catch sand blown by the wind, causing it to fall to the base of the plant, creating its own "dune". Also note that poison ivy does very well at the beach!

Open Water

Several pressures also exist in the open water, or **pelagic zone**, as well. The pelagic zone lies above the bottom sediments and water of the **benthos** and extends vertically to the surface water. This habitat is home to the **plankton**, or drifting organisms, as well as the **nekton**—the actively swimming organisms. Many species of finfish are found there; some are passing through during migration and some are residents. Other swimmers such as squid and sea turtles are at home in this zone. Factors that influence distribution in the pelagic zone include movements of the tides and currents, as well as temperature, salinity, sunlight, dissolved oxygen, and nutrients. Pelagic animals generally have fins, tails, flippers, or other mechanisms for motility. These adaptations enable them to move through the water to and from regions of variable environmental and biological factors such as dissolved oxygen and food availability, and to evade predators.

Adaptations are everywhere, providing clues to the type of food an organism consumes, the type of habitat in which it lives, or its protection from predation. Spend a few moments looking at the shapes of legs, claws, teeth, leaves, shells, and stems, to see if you can learn something about how different organisms are adapted to fit successfully into the Long Island Sound ecosystem.

Habitat: It's Where You Live

What makes the salt marsh the place to live if you're a ribbed mussel or glasswort? Or the rocky intertidal zone if you're a periwinkle or rockweed? Or the sandy beach if you're a sand flea or beach pea? Habitat...habitat...habitat.

So, what exactly is a **habitat**? A habitat is the place where a group (or population) of living organisms of the same species lives. It is the natural environment in which those organisms live. Many populations of organisms share this same habitat, and as they interact, they form a **community** within that habitat. This community, in turn, interacts with the non-living part of the world around it to form an **ecosystem**.

The habitat must supply the basic needs of the community of organisms, such as food, water, nutrients, oxygen, shelter, and proper temperature. If a population's needs cannot be met by the habitat it must find a better place to live, or it will not survive. Each population within a habitat utilizes the habitat and its resources in a different way in order to meet its basic needs. In other words, each population fits in a **niche** in the habitat based on the resources that are available, and the number of competitors for those resources that are present. A niche is rather like a single puzzle piece fitting in the overall habitat puzzle. Different species can hold similar niches, although no two species can occupy the exact same niche at the same time for an extended period of time. A single species can also occupy different niches.

Sometimes the niche occupied by a species fully meets all its needs, whereas other times a species must adapt to a narrower niche where it can still get by. If some factor, such as disease, environmental change, or a new predator causes a niche to become vacant, other organisms will move in to fill the vacancy. If a species is introduced through some means to a new habitat, this new organism has the potential to invade a niche already occupied by a native organism and out-compete it. If an introduced species dominates its new habitat to the detriment of other species, it is called an **invasive species**.

The Long Island Sound estuary is home to many different habitats. The primary habitats are:

- Rocky intertidal
 - Tidal flat
 - Salt marsh or tidal marsh
 - Submerged bottom (benthic habitat)
 - Sandy beach
 - Water column (pelagic habitat)
- (see next page for an image of each)

For more information on each of these Long Island Sound habitats, please see the following publications:

- *Living Treasures: The Plants and Animals of Long Island Sound* (Power Point presentation; booklet)/ *Tesoros Vivientes: Las Plantas y los Animales de Long Island Sound* available from Connecticut Sea Grant web2.uconn.edu/seagrant
- *Underwater Tour of Long Island Sound* www.lisrc.uconn.edu/lis_uwtour/index.asp

Habitat: It's Where You Live



Rocky intertidal



Salt marsh or tidal marsh



Tidal flats



Submerged bottom



Sandy beaches



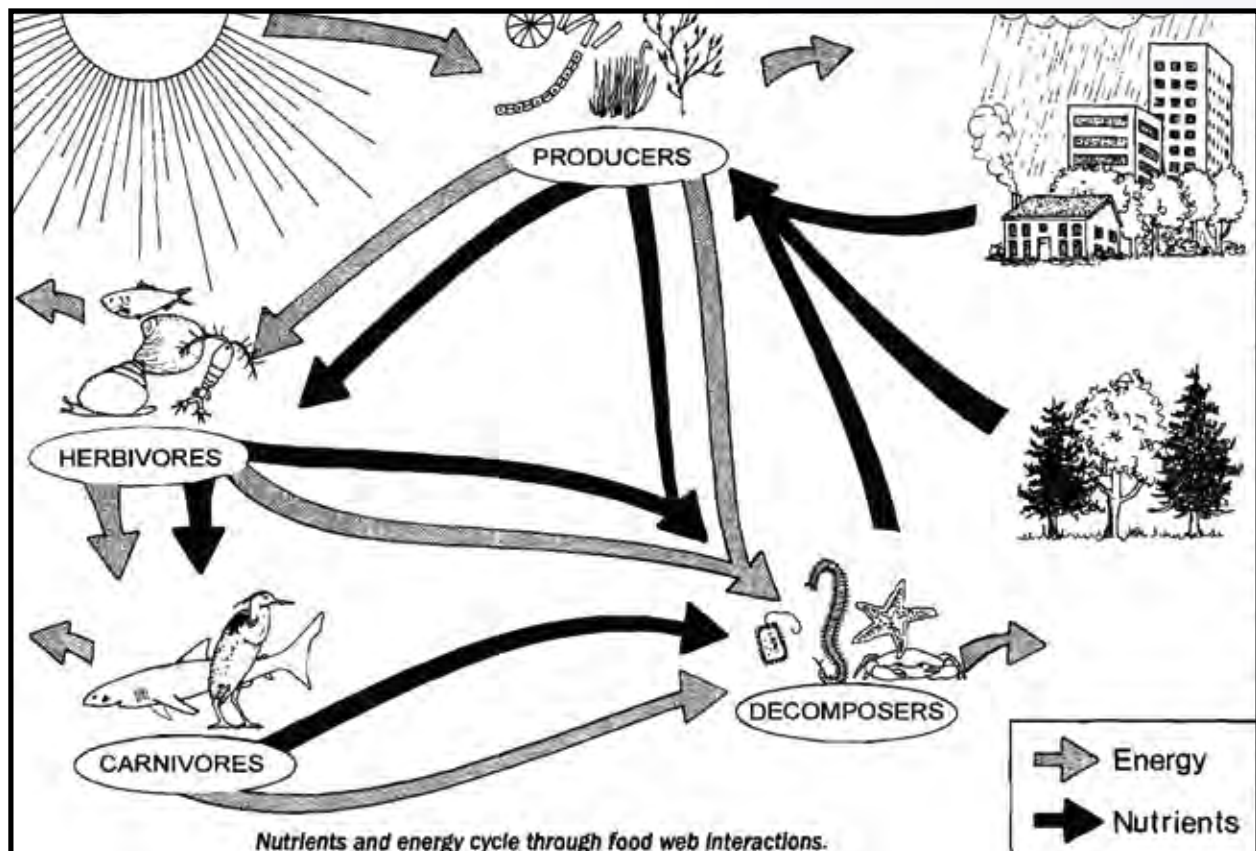
Open water

Food Chains and Food Webs: *It's All About Eating and Being Eaten*

The brownish-green waters of the Sound signal productivity - life! The coloration is largely due to the presence of **phytoplankton** in the water, the basis of the Sound's **food web**. Phytoplankton (microscopic plants) drifting near the surface of the water use the Sun's energy to turn water, carbon dioxide, and chemical nutrients such as nitrates and phosphates, into living tissue and oxygen through the process of **photosynthesis**. Along with seaweed and submerged aquatic vegetation, they are the **producers** of food in Long Island Sound.

Phytoplankton are a food source for **zooplankton** (both microscopic and larger animals that drift or swim weakly with the currents). Bivalve shellfish (e.g., clams, mussels, oysters) and certain finfish species (e.g., menhaden and alewives) start individual food chains by filtering phytoplankton and zooplankton from the water. Other organisms extend those food chains by consuming those fish or shellfish, and still others feed on them. As plants or animals die, they in turn serve as food for even more organisms. Most food chains only have four to five links because the amount of energy transferred from link to link decreases; many animals are part of more than one food chain so that they can meet their energy and nutritional needs. All these different food chains are interconnected, transferring energy and nutrients from one to another. Put them all together and the result is a complex food web for Long Island Sound.

Unlike plants, animals cannot make their own food, and are called **consumers**. Consumers are typically categorized by what they eat: **herbivore** (plant-eater), **carnivore** (meat-eater), **omnivore** (eater of both plants and animals), or **decomposer** (bacteria, fungi, and



Food Chains and Food Webs

other organisms that feed on the decaying remains of animals and plants). In the overall food web, animals can be both **predators** (eating other animals) and **prey** (eaten by other animals). They can also be **grazers** of plant material. Humans are one of the top predators in the Sound's food web. Local examples include:

Herbivores

- Mute swan
- Brandt geese
- Canada geese
- Periwinkle snail
- Sea urchin



Carnivores

- Osprey
- Eagle
- Harbor seal
- Sea star
- Moon snail
- Bluefish
- Winter flounder
- Striped bass
- Knobbed whelk



Omnivores

- Green crab
- Asian shore crab
- Meadow vole
- Diamondback terrapin
- Fiddler crab
- Human



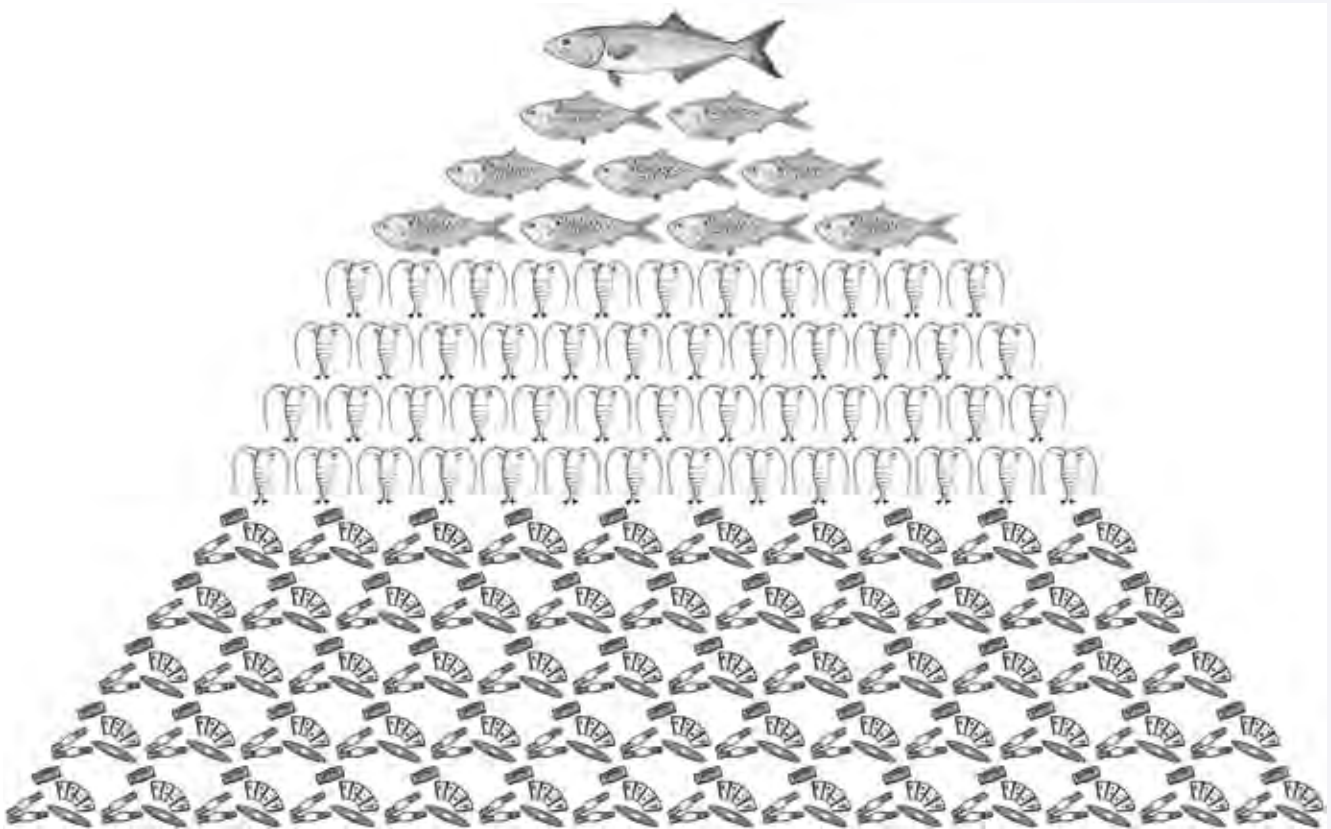
Decomposers

- Worms
- Bacteria
- Fungi



Food Chains and Food Webs

A typical food chain is triangular shaped. The amount of energy that is passed along up the food chain decreases, so it takes many more phytoplankton at the base of the food chain to support the planktivorous menhaden in the middle of the food chain, and ultimately the carnivorous bluefish at the top of the food chain.



Predation and grazing are important ways that animal and plant populations can be kept in balance with the rest of the ecosystem. Predators keep the size of prey populations in check while the size of the prey population also controls the number of predators that can be supported. The same can be said for grazers and the plants they consume. Balance in a food chain is critically important. When balance is lost—due to disease, lack of predators or a newly-introduced species, or environmental changes that favor or disfavor groups of species—the entire food web can be affected.

Long Island Sound Activities

The following student activities were designed using available Long Island Sound resources. The resources listed below will be required for the activities in this chapter unless otherwise mentioned.

Page

- 17 ***Invasive Species of Long Island Sound***
Poster available from Connecticut Sea Grant.
(860) 405-9128 web2.uconn.edu/seagrant
web2.uconn.edu/seagrant/whatwedo/ais
- 19 ***Long Island Sound Worth Fighting For!***
DVD available by loan from Connecticut Sea Grant.
(860) 405-9128 web2.uconn.edu/seagrant
Teacher Dialogue guide also available from Connecticut Sea Grant.
- 21 ***Sound Health 2008***
Hard copies available from Long Island Sound Study (203) 977-1541
and online at: www.longislandsoundstudy.net/soundhealth/index.htm
Hard copies also available from Connecticut Sea Grant.
(860) 405-9128 web2.uconn.edu/seagrant
- 23 ***The Living Sound***
VHS video available on video loan from Connecticut Sea Grant.
(860) 405-9128 web2.uconn.edu/seagrant
- 25 ***Sound Facts and Activities*** - reprinted courtesy of Connecticut Sea Grant and
The Day (New London).
Additional Sound Facts available on the Long Island Sound Educational Resources
CD from Connecticut Sea Grant.
(860) 405-9128 web2.uconn.edu/seagrant
- 29 ***Lobster Fun Facts*** - reprinted courtesy of Connecticut Sea Grant.
See the rest of the *Wrack Lines* issue these were featured in:
web2.uconn.edu/seagrant/publications/magazines/wracklines/fallwinter04

Invasive Species of Long Island Sound

Student Activity

Name: _____ Date: _____

Directions: Examine the poster (front and back) entitled Invasive Species of Long Island Sound, and answer the following questions.

1. What is meant by an invasive species?

2. Give six synonyms for the words "invasive species".
 - a.
 - b.
 - c.
 - d.
 - e.
 - f.

3. The freshwater zebra mussel is a problem in the Great Lakes (not in marine waters). Describe three ways that this species is a problem.
 - a.

 - b.

 - c.

4. Some invasive species bring disease. Explain how this is a problem with oysters in Chesapeake Bay and Long Island Sound.

5. How do introductions of invasive species influence biodiversity of a local marine habitat?

6. Give one example of an intentional introduction of a non-native species to an area.

7. Are most introductions of non-native species intentional or accidental?

Invasive Species of Long Island Sound

Student Activity

18

8. For marine organisms, the most common forms of introduction are ballast water and hull fouling. Explain what each of these is and how each of these can introduce non-native species.

Your teacher will give you the name of an invasive species in Long Island Sound. Use the back of the poster for questions # 9 - 12 and then the internet to answer questions # 13 - 17 about your particular invasive species.

My invasive species is _____

9. What is the scientific name (genus and species)?

10. In what kingdom is it found?

11. In what phylum or division is it found?

12. Approximately when was it introduced to Long Island Sound?

13. How was it introduced to Long Island Sound?

14. For which native Long Island Sound specie(s) is your invasive species a problem?

15. How is your species a problem for other species?

16. Are there currently efforts to deal with or eradicate your invasive species?

17. What are scientists or managers doing to deal with your species? In other words, what actions are being taken?

Long Island Sound Worth Fighting For!

Student Handout

Name: _____ Date: _____

Directions: Answer the following questions after watching the video, *Long Island Sound Worth Fighting For!*

1. What makes Long Island Sound an estuary?
2. Why are estuaries important to us?
3. What is a "Sound"?
4. Why do we have such a diversity of animals in Long Island Sound?
5. What is the watershed of Long Island Sound?
6. What causes hypoxia?
7. What brought Native Americans to the coast of Long Island Sound?
8. What young American captain said "I regret that I have but one life to give for my country" (not mentioned in movie)?
9. What animal supported New London and Waterford in the 1850s?

Long Island Sound Worth Fighting For!

Student Handout

20

10. What are most of the rocks in Long Island Sound named after?

11. In 1904 what happened to the *General Slocum*?

12. During Prohibition what were fisherman doing for extra money?

13. What drove the fishing fleet from New London?

14. What percent of Americans live within 50 miles of Long Island Sound?

15. What is the value of the fish and shellfish taken from Long Island Sound each year?

16. Why is it difficult for people to agree upon the health of Long Island Sound?

17. List five things that can be done to help Long Island Sound.
 - a.
 - b.
 - c.
 - d.
 - e.

Sound Health 2008

Student Handout

Name: _____ Date: _____

Directions: Use the Long Island Sound Study publication *Sound Health 2008* to answer the following questions.

1. What is the LISS?
2. What is hypoxia?
3. What causes hypoxia?
4. Where in Long Island Sound does hypoxia happen most frequently? Why?
5. Why are some male fish developing female traits?
6. Look at the graphs on page 4 and summarize the trend in toxic contaminants in Long Island Sound.
7. What are pathogens and how do they get in Long Island Sound?
8. What weather factor influences beach closures due to pathogens?
9. Why are shellfish beds in Jordan Cove closed after a rain storm?

Sound Health 2008

Student Handout

22

10. List three possible impacts of climate change on Long Island Sound.

11. Compare the general health of the three basins in Long Island Sound (pages 8-9).

12. Why do you think the East and West basins in Long Island Sound have such different health conditions?

13. Summarize the fish consumption advisories on page 10.

14. What has probably caused the population of bluebacked herring to decline?

15. What caused the decline in osprey? How many osprey are around Long Island Sound now?

16. What is happening to Long Island Sound's salt marshes (page13)?

17. Why does water quality in Long Island Sound decline with human development?

18. List 10 things you can do to help save Long Island Sound.

The Living Sound

Student Handout

23

Name: _____ Date: _____

Directions: Answer the questions after watching the video, *The Living Sound*.

1. What endangered osprey in the past? Give two examples.
2. What currently threatens the osprey?
3. List five things that make Long Island Sound an important place.
 - a.
 - b.
 - c.
 - d.
 - e.
4. What is at the base of all food chains in the ocean?
5. How do phytoplankton cause hypoxia?
6. What is non-point source pollution?
7. List four migrating species that enter Long Island Sound.
 - a.
 - b.
 - c.
 - d.

The Living Sound

Student Handout

24

8. Why were the striped bass in danger years ago?

9. How can scales tell us the age of a bluefish?

10. Why do oyster beds need to be cleaner than the water we swim in?

11. List three ways that you can reduce waste going into Long Island Sound.
 - a.
 - b.
 - c.

12. List three benefits of salt marshes.
 - a.
 - b.
 - c.

13. Why is the presence of *Phragmites* (tall reeds) an indicator of a marsh in trouble?

14. Why are plovers and terns endangered?

15. List 10 things that you can do to protect Long Island Sound.

Sound Facts and Activities

Fun Facts About Long Island Sound

25

The colorful Sound Facts graphics in this section were created to raise public awareness of Long Island Sound, but the concepts apply to most estuaries. They originally appeared as a weekly graphic feature in *The Day* (New London) newspaper. Many of the original features, by Peg Van Patten, Milton Moore, and Eamon O'Muin, have been compiled into a booklet available from Connecticut Sea Grant (a project funded by Connecticut Sea Grant and the E.P.A. Long Island Sound Study). The activities on the following pages were also featured in *Nor'easter Magazine*, Vol. 10, #1 & 2. 1998.



DID YOU KNOW?

The oceans contain 97% of all the water on earth.

Contributed by Connecticut Sea Grant

Be a Watershed Detective!

Within a vast watershed like Long Island Sound's, there are many smaller watersheds, related to lakes, rivers, and streams. The boundaries of these watersheds are quite different from the boundaries between towns and states. Learn about your watershed by discovering where the water from your yard and neighborhood goes.

Next time it rains heavily, put on your galoshes and follow the water to see which direction it flows! Then note the storm drains on your street and find out where they lead. (Your town hall may be able to help.) Draw a simple map showing your local water bodies and watershed. Mark sites such as storm drains and major land uses that might impact the water. You might want to display your results in a library or town hall.

Sound Facts



We are the watershed

Do you live in the watershed of Long Island Sound? You do if you live anywhere in Connecticut, southwestern Rhode Island, or any other area shaded on the map. A watershed is land that collects rain water, sediments and dissolved materials that flow to rivers, their tributaries, and estuaries. The three rivers shown are **1** the Connecticut, **2** the Housatonic and **3** the Thames.

The Sound's watershed extends into Canada, covering an area of 15,820 square miles inhabited by 14.6 million people. Any pollutants entering the water in this vast area can ultimately harm the Sound.

Sound Facts and Activities

Fun Facts About Long Island Sound

Sound Facts

There's gold in them thar waves

In addition to salt, the sea water in Long Island Sound contains small amounts of many trace elements, including metals such as gold. While the gold in sea water accounts for only 3 parts per trillion by weight, the volume of the Sound is quite large. If all of the gold could be extracted it would add up to more than 440 pounds, worth well over \$2 million dollars. A warning to prospective prospectors – the gold is so widely dispersed in such small quantities, you'd probably go broke collecting it.



Source: Peg Van Patten, E. O'Muin/Connecticut Sea Grant Milton Moore/The Day

Hidden Riches

The first step in discovering how much treasure lies hidden beneath the waves of Long Island Sound, or any other estuary, is to figure out how much sea water it holds. So calculate the volume of water in the Long Island Sound basin. Give your answer in cubic meters. Hint: Assume that the estuary is a shallow rectangular box, about 110 miles long by 13 miles wide (on average) and typically 60 feet deep. Recall that there are 5,280 feet in a mile, and 0.305 meters in a foot.

Answer: about 68 billion cubic meters (6.8×10^{10} cubic meters)

More Fun:

Write a story about pirates! Then go to the library and find out about real pirates, such as Captain Kidd, who is rumored to have buried treasure on the shores of Long Island Sound.

The Ocean is a Salty Soup

Seawater in the open ocean is said to have a salinity of 3.5 percent, or 35 parts per thousand (ppt), as oceanographers put it. William Dittmar, a marine chemist, pointed out the "Constancy of Composition" of seawater when it comes to the major dissolved constituents. Thus if one seawater sample had a salinity of only 32 ppt compared to an open ocean sample with a salinity of 35 ppt, then the first sample would contain only 91 percent of the sodium contained in the open ocean sample. If an open ocean sample consists of 0.13 percent magnesium by weight, then what percentage of a coastal seawater sample of 28 ppt salinity is made up of that light metal?

The 3.5% Solution

Label one clear glass measuring cup or beaker "fresh water" and another "salt water." Fill each with enough water to submerge an egg. Pour 12 teaspoons of salt into the salt water beaker and stir. Place an egg into each beaker. *What happens?*

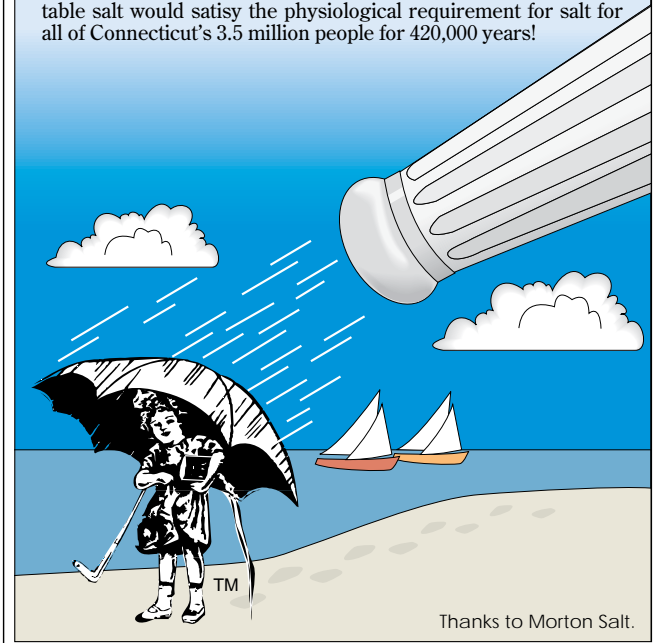
Buoyancy

The egg sank in fresh water but floated in the salty water because salt water is more dense and produces greater buoyancy. How might this affect sea life in a salt water environment?

Sound Facts

Salt to taste

Dissolved in the 67 billion tons of water in Long Island Sound are almost 2 billion tons of sea salt, which gives the waters of the Sound a saltiness — or salinity — of 28 parts per thousand on average. Included among the components of this sea salt are 1.5 billion tons of table salt, sodium chloride. This huge amount of table salt would satisfy the physiological requirement for salt for all of Connecticut's 3.5 million people for 420,000 years!



Source: Peg Van Patten, E. O'Muin/Connecticut Sea Grant Milton Moore/The Day

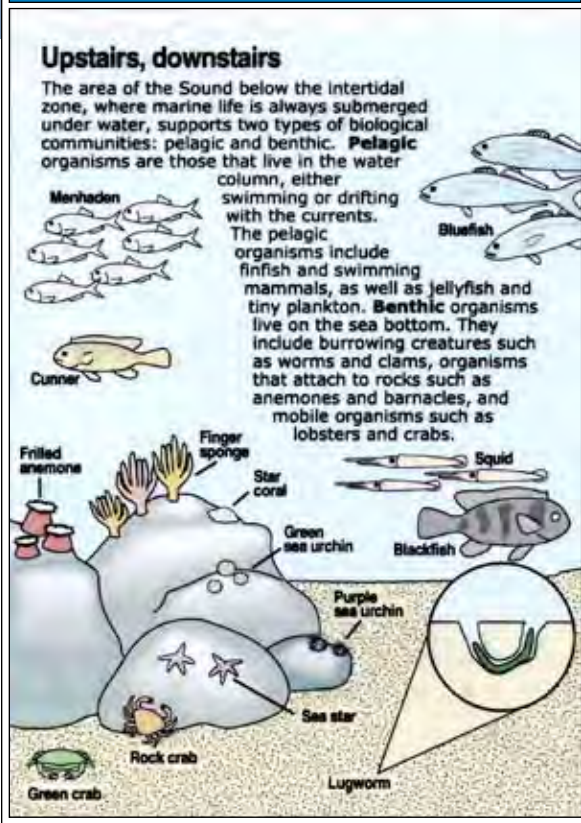
Thanks to Morton Salt.

Answer: 0.104%

Sound Facts and Activities

Fun Facts About Long Island Sound

Sound Facts



Upstairs, downstairs

From the burrowing invertebrate animals of the benthic community to the finfish swimming up above, see if you can create a model living community using a flannel board. Cover a large piece of foam board or heavy cardboard with a length of blue flannel from a fabric store. This will represent Long Island Sound. Set the board on an easel or other stand so everyone can reach it. Use different colors of flannel fabric to cut out the animals that live both "upstairs and downstairs" as well as an area of a sandy bottom and rocks. The flannel cutouts will stick directly on the flannel-covered board as long as the cutouts are not too heavy. You might want to explore alternative materials such as velcro for backing the cutouts or a pegboard with hooks.

Once all the pieces are assembled, you can create your own game of "Upstairs, downstairs." For example, you might form two teams, each with half of the animal cutouts. Each team member would be responsible for placing an animal either in the benthic or pelagic community on the flannel board. You might challenge one another to name each of the animals correctly as you place them or create artistic labels for each. Add more animals that you might know about. Use the flannel board to create a story about the living resources in Long Island Sound.

Contributed by New York Sea Grant

Jelly Fun

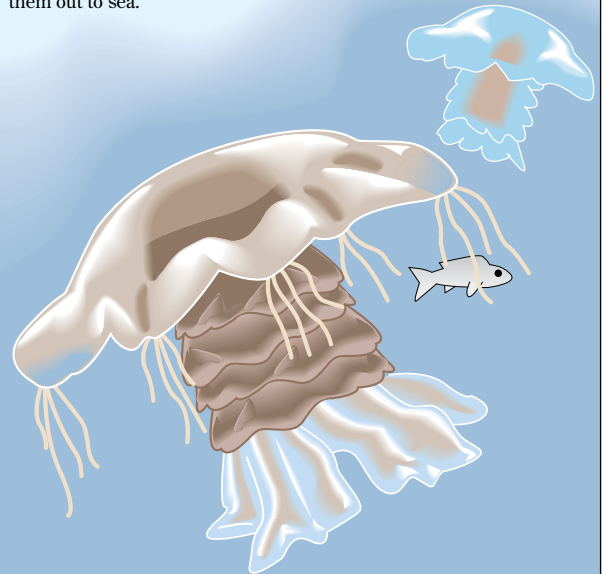
Test your knowledge about jellyfish in this true-or-false quiz:

1. A jellyfish is a type of fish.
2. All jellyfish sting.
3. You're safe from being stung by a jellyfish once it dies.
4. Adult moon jellyfish live for 7–10 years.
5. The biggest jellyfish can reach 8 feet across.
6. Sea turtles, ocean sunfish, and sea slugs aren't the only animals that eat jellyfish. Some people eat them too.
7. Jellyfish appeared on earth about 65 million years after dinosaurs became extinct.
8. Jellyfish are considered to be plankton, as is most of the food that they eat.
9. Jellyfish don't have gills or lungs.
10. Coral and anemones are related to jellyfish.

Sound Facts

Stinging jellyfish

Warm summer waters attract an unwelcome visitor to Long Island Sound, the **lion's mane jellyfish**. This jellyfish, easily identifiable by its eight-lobed umbrella and reddish color, is a plague to swimmers. Its eight clusters of tentacles cause burning and itching when touched. In the Sound, they range from 4 inches to a foot in size, but in Arctic waters, they may grow to a diameter of 8 feet. Many small fish swim with the jellyfish, seeking shelter from predators under its umbrella. The red jellyfish will leave shortly as northerly winds and cooler waters drive them out to sea.



Source: Connecticut Sea Grant

Milton Moore/The Day

Answers: 1. False 2. False 3. False 4. False 5. True 6. True 7. False 8. True 9. True 10. True
 the thin walls of their outer membrane. 10. True
 the dinosaurs. 8. True 9. True: They absorb oxygen directly through
 showed up 650 million years ago, which was 40 million years before
 one summer. 5. True (the lion's mane jelly) 6. True 7. False. Jellyfish

Contributed by The Maritime Aquarium and Connecticut Sea Grant

Sound Facts and Activities

Fun Facts About Long Island Sound

Those Amazing Algae

Kelp has been valued for its health benefits for centuries. In fact, ancient Egyptians are thought to have used kelp to treat breast cancer. Because alginate in kelp binds with some radioactive elements, allowing heavy metals to be released from the body, kelp diets are being used as treatment for some of the children experiencing radiation illnesses related to the Chernobyl nuclear power plant disaster that occurred in Russia in 1986.

Contributed by Connecticut Sea Grant

Kelp = Help for Chernobyl victims



Seaweed farmer Ike Levine, CEO of Coastal Plantations, Inc.

Contributed by Connecticut Sea Grant

What would a seaweed farmer look like?

Draw a picture and write a story about a seaweed farmer.



Sound Facts

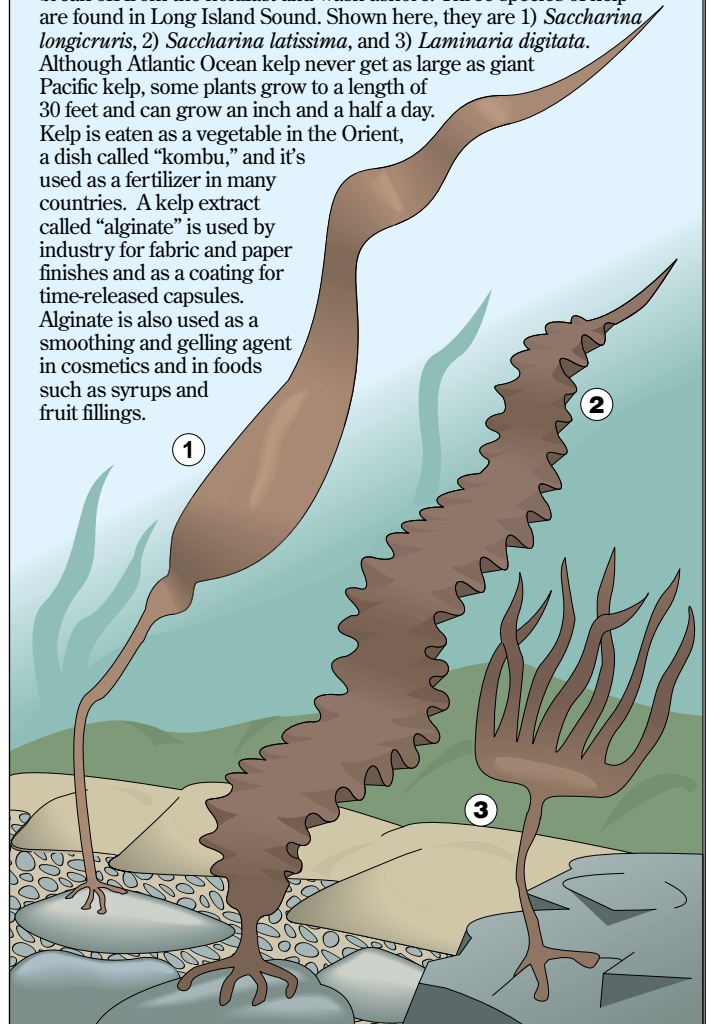
Common and useful kelp

Kelp are subtidal brown algae that attach to rocks by means of a claw-like structure called a "holdfast." During a storm, ruffy banners of kelp may break off from the holdfast and wash ashore. Three species of kelp are found in Long Island Sound. Shown here, they are 1) *Saccharina longicruris*, 2) *Saccharina latissima*, and 3) *Laminaria digitata*.

Although Atlantic Ocean kelp never get as large as giant Pacific kelp, some plants grow to a length of 30 feet and can grow an inch and a half a day.

Kelp is eaten as a vegetable in the Orient, a dish called "kombu," and it's used as a fertilizer in many countries. A kelp extract called "alginate" is used by industry for fabric and paper finishes and as a coating for time-released capsules.

Alginate is also used as a smoothing and gelling agent in cosmetics and in foods such as syrups and fruit fillings.



Source: Peg Van Patten/Connecticut Sea Grant

Milton Moore/The Day

- Kelp
- Holdfast
- Alginate
- Cosmetic
- Ice Cream
- Chocolate Milk
- Salad Dressing
- Algae
- Kombu
- Ocean
- Yogurt
- Catsup
- Syrup

More Fun:

What foods and other products in your home use seaweed to make them creamy or gooey? Hint: ice cream, syrups, fruit fillings, chocolate milk, toothpaste, and soap, to name a few. Check packages in the grocery store for products containing the ingredients "agar", "alginate", or "carrageenan."

Contributed by The Maritime Aquarium and Connecticut Sea Grant

Lobster Fun Facts

Student Handout

The following activities were originally featured in *Wrack Lines* 4:2. Visit web2.uconn.edu/seagrant/publications/magazines/wracklines/fallwinter04 to view this issue and learn about Sea Grant funded research focused on American lobster health as well as the Long Island Sound Lobster die-off of 1999.

Thinking Cap

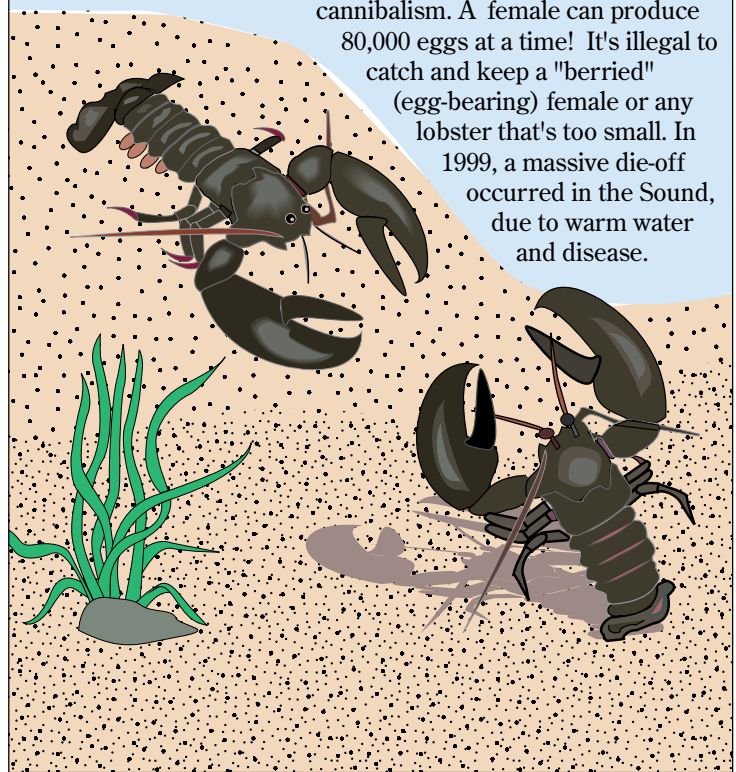
As you read about lobsters in *Wrack Lines* 4:2 and on the following pages answer these questions:

1. Why does the lobster back into its burrow?
2. Who might the predator be?
3. Why is a female lobster carrying eggs said to be "berried"?
4. Do lobsters swim?

Sound Facts

A crusty crustacean

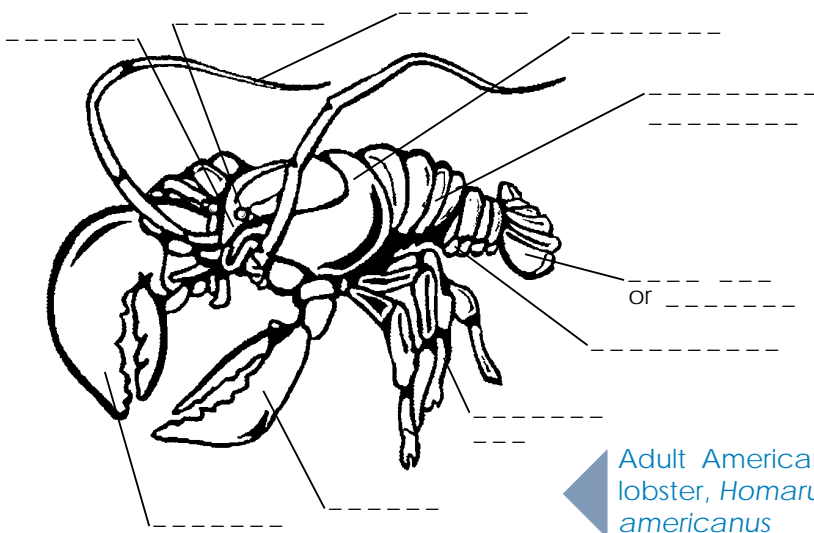
Put up yer dukes and fight! American lobsters, *Homarus americanus*, are aggressive decapod (ten-legged) crustaceans. They assume a fighting posture and wave their large, meaty claws when threatened. Lobsters like to live alone, in burrows or rock crevices. They shed their outer shell, the carapace, many times during their youth—just like you outgrow your shoes. Their diet includes many other sea creatures including their relatives (crabs) and if food is scarce, they may resort to cannibalism. A female can produce 80,000 eggs at a time! It's illegal to catch and keep a "berried" (egg-bearing) female or any lobster that's too small. In 1999, a massive die-off occurred in the Sound, due to warm water and disease.



Source: Peg Van Patten

Connecticut Sea Grant

Name that lobster body part!



Adult American lobster, *Homarus americanus*

Can you name the parts of a lobster's body, filling in the spaces on the drawing at left? Lobsters have a hard outer covering, the shell or "exoskeleton", that is shed many times as they grow. The process is called molting. Their soft flesh is temporarily exposed as they grow a new shell. Like other crustaceans, they have segmented bodies with jointed appendages. Because it has ten legs, it is classified as a decapod (deca=10, pod=foot).

Lobster Fun Facts

Student Handout

How well do you know lobsters??

How does a lobster smell?

The lobster smells or senses its food by using four small antennae located on the front of its head and tiny sensing hairs that cover the body.

Do lobsters have teeth?

The teeth of a lobster are in its stomach. This stomach is located close to the mouth, and the food is actually chewed in the stomach between three grinding surfaces called the "gastric mill" that look like molar teeth.

What color are lobsters?

The American lobster is usually greenish brown when alive. However, they also come in blue, yellow, red, and white. Except for the white ones, they all turn red when cooked.

Is lobster blood red?

No. Lobster blood is usually clear to

gray or pale blue color, but it can sometimes be orange, green, or pink.

How big is a lobster egg?

A lobster egg is about the size of the head of a pin.

How many eggs does a female lobster (a "berried" egger) produce?

It depends on the size of a lobster. A one-pound lobster usually has between 8,000 to 12,000 eggs. However, only about one tenth of one percent of those eggs will develop and survive longer than six weeks.

Are lobsters "right-handed", "left-handed", or both?

You can tell by which side the larger crusher claw is on. Lobsters are usually right-handed-the crusher claw is on the right and the smaller pincer or ripper claw is on the left. It is very rare for a lobster to have two crusher claws.

What do lobsters eat?

Lobsters eat primarily live food, which includes crabs, clams, mussels, starfish, sea urchins, and sometimes even other lobsters.

What part of a lobster is measured to determine if it is large enough to keep?

A gauge is placed between the eye socket and the end of the large body shell, called the carapace, to measure the lobster.

What are "shorts" or "snappers"?

They are undersized lobsters that a lobsterman throws back into the ocean so they can grow to legal size.

How old can a lobster be?

No one has found a way to determine the exact age of a lobster, because it sheds its shell, or molts, periodically. However, researchers think that lobsters can live to be 100 years old. In contrast, Long Island Sound lobsters generally live only 5-7 years.

Lobster Word Search!

Find the 26 words listed below in the puzzle and circle them. Words may be backwards, forwards, vertical, horizontal, or diagonal. When you're done, find the secret message hidden in the remaining letters and fill in the spaces.

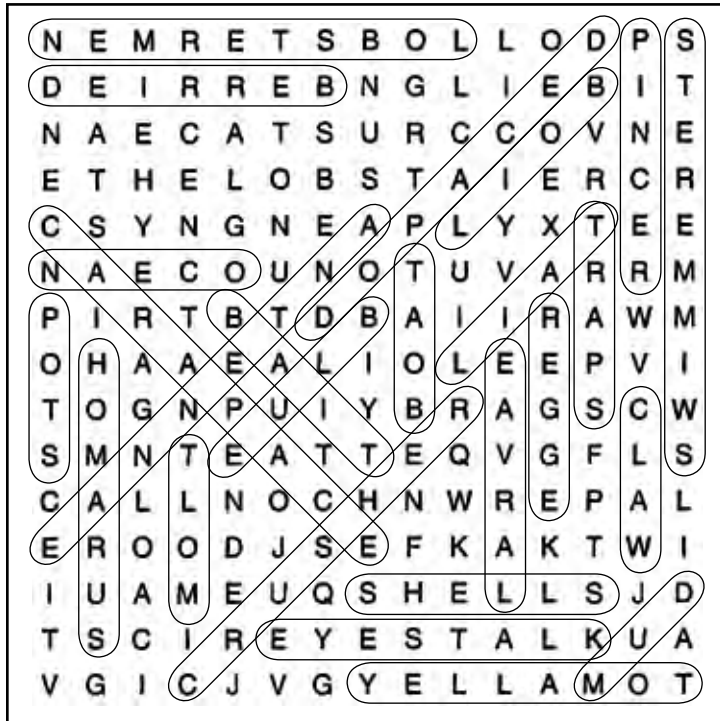
- | | | |
|----------|------------|------------|
| ANTENNAE | CRUSTACEAN | OCEAN |
| BAIT | DECAPOD | PINCER |
| BERRIED | EGGER | POTS |
| BLUE | EYESTALK | RED |
| BOAT | HOMARUS | SHELLS |
| BOIL | LARVAE | SWIMMERETS |
| CARAPACE | LOBSTERMEN | TOMALLEY |
| CRUSHER | MOLT | TRAPS |
| CLAW | MUD | |

N	E	M	R	E	T	S	B	O	L	L	O	D	P	S
D	E	I	R	R	E	B	N	G	L	I	E	B	I	T
N	A	E	C	A	T	S	U	R	C	C	O	V	N	E
E	T	H	E	L	O	B	S	T	A	I	E	R	C	R
C	S	Y	N	G	N	E	A	P	L	Y	X	T	E	E
N	A	E	C	O	U	N	O	T	U	V	A	R	R	M
P	I	R	T	B	T	D	B	A	I	I	R	A	W	M
O	H	A	A	E	A	L	I	O	L	E	E	P	V	I
T	O	G	N	P	U	I	Y	B	R	A	G	S	C	W
S	M	N	T	E	A	T	T	E	Q	V	G	F	L	S
C	A	L	L	N	O	C	H	N	W	R	E	P	A	L
E	R	O	O	D	J	S	E	F	K	A	K	T	W	I
I	U	A	M	E	U	Q	S	H	E	L	L	S	J	D
T	S	C	I	R	E	Y	E	S	T	A	L	K	U	A
V	G	I	C	J	V	G	Y	E	L	L	A	M	O	T

When you've finished the word search, write the hidden message here: _____ !

Lobster Fun Facts - Solutions

Lobster word search solution:

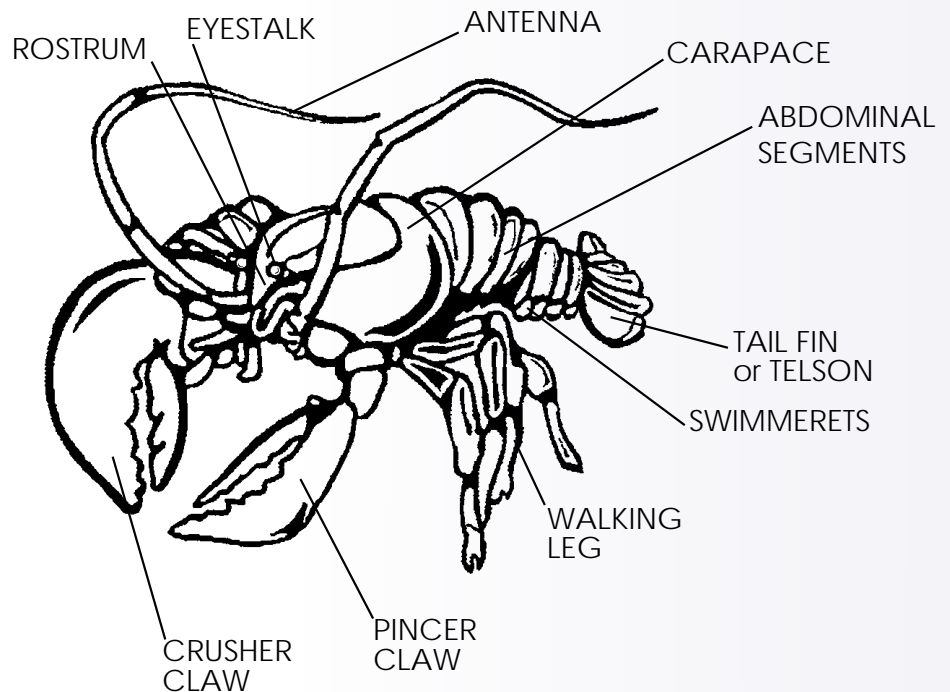


Hidden message: "LONG LIVE THE LOBSTERS"

Thinking Cap answers:

1. The lobster backs into its burrow so that its large claws are facing out - the best position for fighting.
2. The lobster predator could be a bigger lobster, a large fish, an octopus, or perhaps a human.
3. The eggs, which are round and can be many colors, resemble clusters of berries.
4. Although some of the lobsters' legs are adapted for swimming, as adults they prefer to crawl.

Name that lobster body part!



Lesson Plans

Sunrise over the western end of Long Island Sound near Milford, Connecticut. Taken aboard the Connecticut Department of Environmental Protection's research vessel, the John Dempsey, while traveling to the first water quality testing site of the day.



Dissolved Oxygen in Long Island Sound

33

Focus

The natural and anthropogenic causes and impacts of reduced dissolved oxygen levels on Long Island Sound.

Focus Question

What factors influence the amount of dissolved oxygen in the waters of Long Island Sound?

Learning Objectives

- Students will design and conduct an experiment to test a factor that influences the amount of dissolved oxygen in water.
- Students will describe anthropogenic factors that influence dissolved oxygen levels.
- Students will relate low dissolved oxygen levels to the die-off or distress of species in Long Island Sound.
- Students will relate problems in the commercial fishing industry to seasonal hypoxic conditions in Long Island Sound.
- Students will be able to explain how the impact of hypoxia can travel through the food web and the effects it can have on the entire Sound.

Materials

- Various sized beakers
- Dissolved oxygen titration kits or meters
- Refractometer or other method to measure salinity
- pH meter or strips
- Stirring rods
- Access to water
- *Instant Ocean*® www.instantocean.com
- Timer
- Thermometers
- Dissolved Oxygen Lab Student Activity sheets (pages 37-38)
- Hot plates

Logistics

Students should be introduced to the

concepts and materials prior to designing their experiments. All experimental designs must be approved by the teacher to ensure safety standards are being followed. Allow enough time to train the students on the water quality equipment. Access to a sink is required.

Audio/ Visual Equipment

Computers/Internet access

LCD- Possible PowerPoint presentation

Teaching Time

Three 45 minutes periods as follows:

- **Period one** should be used to introduce students to the concept of dissolved oxygen and its use by organisms living in water.
- **Period two** should be used to describe the materials and allow the students to design their experiment. See Dissolved Oxygen Lab Student Activity, pages 37-38.
- **Period three** should be used to conduct and record data from the experiment.

An additional period can be used to allow students to present their finding to the class. Assign a laboratory report for homework and provide samples of exemplars.

Seating Arrangement

Students work in pairs

Key Words

Anoxia
 Anthropogenic
 Aphotic zone
 Dissolved oxygen
 Eutrophication
 Hypoxia
 Nitrogen
 pH
 Photic zone
 Refractometer

Dissolved Oxygen in Long Island Sound

Background Information

Throughout the history of Long Island Sound, the level of nitrogen has continued to grow as populations and industry around the Sound have increased. Nitrogen, a necessity in ecosystems, cycles naturally. As amounts of nitrogen in the Sound build, concern increases because high concentrations lead to a depletion of dissolved oxygen in the water. Nitrogen, in various forms, reaches the Sound through natural and anthropogenic processes. Anthropogenic sources of nitrogen come from industrial waste, sewage, lawns and gardens treated with fertilizers, and the atmosphere. Excess nitrogen accelerates the process of eutrophication, which leads to hypoxic and anoxic conditions. Other factors such as increases in water temperature can also cause depleted levels of oxygen. Depleted levels of dissolved oxygen resulting from these processes impact living things in the Sound. Each species varies in its tolerance range for dissolved oxygen. Key fisheries-related species are of particular concern (e.g., lobsters, clams, and oysters).

Learning Procedure

Teacher Preparation

- It is important to provide students with a basic understanding of how oxygen becomes dissolved in the water and why it is necessary for aquatic life.
- Provide example questions to be investigated to ensure student understanding of the lab, such as:
 - How does temperature affect dissolved oxygen levels?
 - Is there a correlation between salinity and dissolved oxygen?

Learning Procedure

- Provide students with information and readings related to dissolved oxygen, anoxia, hypoxia, and eutrophication.
- Identify anthropogenic and natural factors that contribute to the depletion of oxygen

in the waters of Long Island Sound.

- Introduce students to species found in the Sound and discuss their needs for dissolved oxygen.
- Explain the lab and provide example questions.
- Provide students with time to design and get approval for their experiment.
- Have students conduct experiments and record data.
- Provide students with the opportunity to present their experimental design and results to their classmates.

The Sea Grant Connection

Clean Water Fact Sheet series - Connecticut Sea Grant web2.uconn.edu/seagrant/publications/coastalres

Luck Isn't Enough - The Fight for Clean Water video - loan from Connecticut Sea Grant

Testing Dissolved Oxygen Using the Winkler Method CD-ROM - Indiana-Illinois Sea Grant www.iisgcp.org/health/dotestcd/dotestcd.htm

The "Me" Connection

Explain how hypoxic/anoxic conditions can impact what comes to your dinner table.

Identify the impact depleted dissolved oxygen levels may have on the local and national economy.

Make connections to human activities that may lead to hypoxic/anoxic conditions.

Connection to Other Subjects

History/Geography, Economics

Evaluation

Laboratory report, graphing activity (graph the change in the level of the dissolved oxygen with the change in the independent variable)

Dissolved Oxygen in Long Island Sound

Extensions

- Look at historical data on hypoxic conditions in Long Island Sound and relate it to natural and anthropogenic changes to the environment surrounding the Sound.
- Compare the problems in the Sound to other estuaries around the country and around the world.
- Investigate the influence the shellfishing industry has on the Sound.
- Have students select different sources of pollution to research and create an informational pamphlet. Relate each source of pollution to the conditions it may create in Long Island Sound.
- View and graph dissolved oxygen levels and temperature readings from the MySound buoys. www.mysound.uconn.edu
- Measure the respiration rate of fish in water with various levels of dissolved oxygen.
- Have students research the shellfish industry in Long Island Sound.

Resources

Clean Water Fact Sheet series - Connecticut Sea Grant web2.uconn.edu/seagrant/publications/coastalres

EPA Long Island Sound Study publications about dissolved oxygen
www.longislandsoundstudy.net/publications.htm

Luck Isn't Enough - The Fight for Clean Water video - loan from Connecticut Sea Grant

Long Island Sound Water Monitoring - CT DEP
www.ct.gov/dep

Testing Dissolved Oxygen Using the Winkler Method CD-ROM - Indiana-Illinois Sea Grant
www.iisgcp.org/health/dotestcd/dotestcd.htm

Connecticut Science Frameworks

Grades 6-8

Scientific Inquiry

- Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena.
- Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation.
- Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists.

Scientific Literacy

- Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.

Scientific Numeracy

- Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.

Content Standards

6.4: Water moving across and through earth materials carries with it the products of human activities.

Grades 9-10

Scientific Inquiry

- Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explanation and predict natural phenomena.
- Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation.
- Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists.

Dissolved Oxygen in Long Island Sound

Scientific Literacy

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.

Scientific Numeracy

- Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.

Content Standards

9.8: The use of resources by human populations may affect the quality of the environment.

- Emission of combustion by-products, such as SO_2 , CO_2 , and NO_x by industries and vehicles is a major source of air pollution.
- Accumulation of metal and non-metal ions used to increase agricultural productivity is a major source of water pollution.

9.9: Some materials can be recycled, but others accumulate in the environment and may affect the balance of the Earth systems.

- New technologies and changes in lifestyle can have positive and/or negative effects on the environment.

New York Science Standards

Standard 6: Interconnectedness: Common Themes: OPTIMIZATION: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Living Environment Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard F: Science in Personal and Social Perspectives

- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazard
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably interconnected

Fundamental concept e: Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

Dissolved Oxygen Lab

Student Activity

Activity

Conduct research on dissolved oxygen and hypoxia in Long Island Sound using some of the listed websites below. Decide on a hypothesis to test concerning how a particular variable affects how much dissolved oxygen will be found in water. Remember that your hypothesis must be testable. Gather background knowledge and develop an experiment to test your hypothesis using the materials listed below. (Not all of the materials must be utilized--only the ones related to your particular experiment). Identify dependent and independent variables. Develop a list of procedures to follow in order to conduct your experiment. Your experimental design and procedure list must be approved by the teacher before conducting the laboratory experiment.

Experiment and Follow-up

Upon approval of your experimental design, conduct your experiment. Be sure to run multiple trials and gather accurate qualitative and quantitative data. Follow all safety protocols discussed by your teacher. Clean up all materials and your area before preparing to report back to the class.

Reporting Back and Laboratory Report

Keep good notes during the lab and be prepared to report back to the class in a brief presentation of your methods and findings. Be sure to discuss your hypothesis and if it was refuted or supported by the data. Use the rubric to help guide you through the experiment.

Websites to Visit

Long Island Sound Study - <http://www.longislandsoundstudy.net/>

Soundkeeper - <http://www.soundkeeper.org/>

Materials

You may use the following materials for your experiment:



- Various sized beakers
- Dissolved oxygen titration kits or meters
- Refractometer or other method to measure salinity
- pH meter or strips
- Stirring rods
- Access to water
- Instant Ocean
- Timer
- Thermometers
- Hot plates
- Safety equipment

Dissolved Oxygen Lab

Student Activity

38

Name: _____ Lab Group: _____

-  Each student must turn in the rubric with a lab report.
-  In order to get points for the cleanup you must have the teacher's initials on the rubric.

	Possible Points	Your Score
Scientific question		
Hypothesis	5	
Experimental Design <ul style="list-style-type: none"> • Background research • Variables • Procedure and materials list 	25	
Clean up <ul style="list-style-type: none"> • Clean glassware, return all materials, and wipe down work area • Teacher initials required: _____ 	10	
Presentation <ul style="list-style-type: none"> • State your hypothesis • Briefly describe your experiment • Show your data • State whether your hypothesis was supported or refuted • Error analysis - discuss any problems or potential instrumental error 	10	
Lab Report <ul style="list-style-type: none"> • Introduction • Materials • Procedure • Results • Analysis • Conclusion • Error Analysis 	50	

Nitrogen Loading and Hypoxia

39

Focus

Hypoxia in Long Island Sound

Focus Question

How can the competing interests of different groups of people be reconciled to address the issue of hypoxia?

Learning Objectives

Students will identify the best solutions to reduce hypoxia in Long Island Sound.

Materials

For each group:

- Working group Student Roles, pages 43-44
- Nitrogen Loading and Hypoxia Group Activity, page 46

For each student:

- Nitrogen Loading and Hypoxia Student Activity, page 45
- *Alternative Strategies for Hypoxia Management* www.longislandsoundstudy.net/pubs/facts/hypfsas.pdf
- *Nutrient Reduction: New Solutions for Old Problems* www.longislandsoundstudy.net/pubs/facts/fact11.pdf

Readings for each student role:

Environmentalist:

Sound Health 2008 with focus on hypoxia on page 3, www.longislandsoundstudy.net/soundhealth/part1.08.pdf

Wastewater Treatment Plant Manager:

Fall 2007 Nitrogen Trends in Long Island Sound www.longislandsoundstudy.net/pubs/news/fall2007nitrogen.pdf, specifically the following articles:

- "Trends in Point Source Nitrogen Loads"
- "Connecticut's Trading Tool Controlling Connecticut's Nitrogen Discharges" (For younger students substitute Wastewater Treatment fact sheet: www.longislandsoundstudy.net/pubs/facts/fact3.pdf)

Scientist:

- *How Low Dissolved Oxygen Conditions Affect Marine Life in Long Island Sound* <http://www.longislandsoundstudy.net/pubs/facts/lodo.pdf>
- Long Island Sound Water Quality Monitoring Program hypoxia maps www.ct.gov/dep/cwp/view.asp?a=2719&q=325532&depNav_GID=1654

Citizen:

- *Step by Step Guide* www.longislandsoundstudy.net/pollutionguide/liss_runoff.pdf
- *Nonpoint Source Pollution in Long Island Sound* www.longislandsoundstudy.net/pubs/facts/fact7.pdf

Audio-Visual Equipment

None required for the activity; computer and Power Point may be used for student presentations.

Logistics

If students do not have sufficient content background, cover issues of hypoxia and nitrogen loading in class prior to this activity.

Teaching Time

Two one-hour class periods

Seating Arrangement

Groups of four students

Key Words

Anthropogenic
Dissolved oxygen
Effluent
Hypoxia
Nitrogen loading
Non-point source pollution
Nutrient
Point source pollution
Wastewater treatment
Water quality

Nitrogen Loading and Hypoxia

Background Information

Hypoxia, a condition in which dissolved oxygen levels are considered low (<3.0 mg/L), occurs each summer in Long Island Sound. Although the specific areas of the Sound affected by hypoxic conditions vary due in part to several natural and anthropogenic factors (e.g., temperature, excess nitrogen), the duration and size of each event has been monitored regularly since 1987.

Hypoxia can occur in any body of water, not just Long Island Sound. Other well-documented cases have occurred in the Chesapeake Bay and the Gulf of Mexico.

Learning Procedure

Teacher Preparation

Prior to this activity, students should have a basic understanding of nitrogen loading and hypoxia as well as familiarity with the nitrogen cycle and sources of nitrogen. Understanding can be enhanced by visiting a local sewage treatment plant or through suggested resources (see Resources section of this lesson).

Additionally, students should have an understanding of the following content:

- reactants and products of photosynthesis, cellular respiration, and decomposition
- population growth and carrying capacity
- pollution and human impacts upon the environment

Learning Procedure

- Prior to the in-class lesson, announce the task - "You and your team are members of the Hypoxia Management Working Group. You have been brought together to identify the best and worst solutions to reduce the occurrence of hypoxia in Long Island Sound. Your working group will research these solutions and submit a report. Your report will involve a 5 -10

minute presentation using visuals such as a poster or PowerPoint. You will receive a rubric with details as to what needs to be included in your presentation."

- Divide students into groups of four and assign roles within group as follows:
 - *Environmentalist*: Identify and explain the problem of nitrogen loading
 - *Wastewater treatment plant manager*: Explain the role of point pollution in nitrogen loading and assess solutions involving wastewater treatment plants.
 - *Scientist*: Explain the current data and ecological impacts of dissolved oxygen and nitrogen loading.
 - *Citizen*: Explain the role of non-point pollution in nitrogen loading and assess solutions involving citizens of your state.
- Distribute Nitrogen Loading and Hypoxia Student Roles (pages 43-44) and specific role reading assignments for homework.
- Option for differentiation: Some readings are more difficult than others - you can discretely assign roles according to reading comprehension level.
- *Day One*: Distribute the readings for all group members and final report rubric. Students work as a group in their roles and work towards a consensus of the two most desirable and two least desirable solutions. Students can use solutions presented in the individual readings, group article or their own ideas. Once the decisions have been made, students should create the presentation following the rubric.
- *Day Two*: Groups should complete their presentations and present to the class.

The Sea Grant Connection

Hypoxia in Long Island Sound

<http://nsgl.gso.uri.edu/conn/connng88002.pdf>

Nitrogen Loading and Hypoxia

41

Nutrient Reduction: New Solutions to Old Problems

<http://nsgl.gso.uri.edu/nyext/nyextg90008.pdf>

The "Me" Connection

What are some things do you do each day that can affect hypoxia in Long Island Sound? How can you reduce your impact?

Connection to Other Subjects

Chemistry, Earth Science, Civics/Social Studies

Evaluation

Each group should present their conclusions to the class. Evaluate based on the strength of their reasoning and understanding of biology (ecology).

Extensions

Schedule a visit to a sewage treatment plant and/or an industry located along a local waterway or Long Island Sound. Is it necessary for the plant or industry to be located here? Why or why not?

Present your findings to a local environmental group or town commission. Work to find solutions by consensus for your local town.

Resources

Creeping Dead Zones - NASA Ocean Color
http://daac.gsfc.nasa.gov/oceancolor/scifocus/oceanColor/dead_zones.shtml

EPA Long Island Sound Study overview of hypoxia www.longislandsoundstudy.net/ccmp/hypox.html

EPA Long Island Sound Study publications about nitrogen and hypoxia
www.longislandsoundstudy.net/publications.htm

Long Island Sound Water Quality Monitoring Program maps www.ct.gov/dep/cwp/view.asp?a=2719&q=325532&depNav_GID=1654

Sound Health - EPA LISS

www.longislandsoundstudy.net/soundhealth/index.htm

Traveling Nitrogen Game

www.windows.ucar.edu/tour/link=/teacher_resources/teach_nitrogen.html

Understanding Your Water: From Source to Tap and Back Again - PBS Lesson Plan

www.pbs.org/newshour/extra/teachers/lessonplans/science/jan-june08/water_0324.html

Primary Wastewater Treatment, Water Science for Schools - USGS

<http://ga.water.usgs.gov/edu/wwvisit.html>

Water Cycle Animation - NASA's Observatorium

http://physics.ship.edu/~mrc/astro/NASA_Space_Science/observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro3.html

Connecticut Science Frameworks

Grades 6-8

6.4: Water moving across and through earth materials carries with it the products of human activities.

Grades 9-10

9.8: The use of resources by human populations affects the quality of the environment.

9.9: Some materials can be recycled, but others accumulate in the environment and may affect the balance of the Earth systems.

New York Science Standards

Standard 1- Analysis, inquiry and Design:

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Standard 6 - Interconnectedness: Common Themes: SYSTEMS THINKING: Through systems thinking, people can recognize the

Nitrogen Loading and Hypoxia

commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Standard 6 - Interconnectedness: Common Themes: OPTIMIZATION: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Living Environment Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment

National Science Education Standards

Content Standard C: Life Science

- Interdependence of Organisms

Content Standard F: Science in Personal and Social Perspectives

- Natural Resources
- Environmental Quality

Content Standard G: History and Nature of Science

- Nature of Science

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably connected.

Fundamental concept e: Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

Fundamental concept g: Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Nitrogen Loading and Hypoxia

Student Roles

43

Environmentalist

Identify and explain the problem of nitrogen loading. You believe that the environment should be the number one priority and a solution must be found to reduce hypoxia, regardless of cost.

Concept	Points
Hypoxia and nutrient definitions	4
Identify two harmful impacts of hypoxia on Long Island Sound	4
Connection between nutrient loading and hypoxia	4
Contrast point- versus non-point pollution	4
Two examples of non-point sources of nitrogen pollution	4
Two examples of point sources of nitrogen pollution	4
Management recommendations – the two most desirable and two least desirable solutions	10
Presentation	10
Graphics	6

Wastewater treatment plant manager

Explain the role of point source pollution in nitrogen loading and assess solutions involving wastewater treatment plants. You want to reduce the impact of your industry on the environment but you are wary of the cost and possibility of solutions to the hypoxia problem.

Concept	Points
Hypoxia and nutrient definitions	4
Identify two harmful impacts of hypoxia on Long Island Sound	4
Connection between nutrient loading and hypoxia	4
Contrast point- versus non-point pollution	4
Two examples of non-point sources of nitrogen pollution	4
Two examples of point sources of nitrogen pollution	4
Management recommendations – the two most desirable and two least desirable solutions	10
Presentation	10
Graphics	6

Nitrogen Loading and Hypoxia

Student Roles

44

Scientist

Explain the current data and ecological impacts of dissolved oxygen and nitrogen loading. Your research indicates Long Island Sound is in trouble. Use your expertise to find solutions to hypoxia that will work and not cause additional environmental problems.

Concept	Points
Hypoxia and nutrient definitions	4
Identify two harmful impacts of hypoxia on Long Island Sound	4
Connection between nutrient loading and hypoxia	4
Contrast point- versus non-point pollution	4
Two examples of non-point sources of nitrogen pollution	4
Two examples of point sources of nitrogen pollution	4
Management recommendations – the two most desirable and two least desirable solutions	10
Presentation	10
Graphics	6

Citizen

Explain the role of non-point source pollution in nitrogen loading and assess solutions involving citizens of your state. You enjoy visiting Long Island Sound but you are concerned that large projects might increase your taxes and not solve the hypoxia problem.

Concept	Points
Hypoxia and nutrient definitions	4
Identify two harmful impacts of hypoxia on Long Island Sound	4
Connection between nutrient loading and hypoxia	4
Contrast point- versus non-point pollution	4
Two examples of non-point sources of nitrogen pollution	4
Two examples of point sources of nitrogen pollution	4
Management recommendations – the two most desirable and two least desirable solutions	10
Presentation	10
Graphics	6

Nitrogen Loading and Hypoxia

Student Activity

45

Name: _____ Date: _____

You are a member of a team of decision makers given the challenge to decide what course of action your state should take to reduce the amount of nitrogen entering Long Island Sound. Your team consists of the members and tasks listed below. You will each be assigned individual and group readings that will help you make your decisions.

- *Environmentalist*: Identify and explain the problem of nitrogen loading
- *Wastewater treatment plant manager*: Explain the role of point source pollution in nitrogen loading and assess solutions involving wastewater treatment plants.
- *Scientist*: Explain the current data and ecological impacts of dissolved oxygen and nitrogen loading.
- *Citizen*: Explain the role of non-point source pollution in nitrogen loading and assess solutions involving citizens of your state.

Your group must decide the two best and two least ideal strategies for reducing nitrogen entering Long Island Sound. Keep in mind your roles, project costs, technology available for use, willingness of the public to support your decisions, impacts upon living things, and your understanding of the ecology of Long Island Sound.

Directions: After reading the materials provided, answer the following questions.

1. What is nitrogen loading?
2. Why is it harmful to Long Island Sound?
3. What are the latest impacts of nitrogen loading on Long Island Sound?
4. What is the difference of "point" and "non-point" source pollution?
5. Name two examples each of point and non-point sources of nitrogen entering Long Island Sound.

Nitrogen Loading and Hypoxia

Group Activity

46

Name: _____ Date: _____

Directions: As a group examine "Alternative Strategies for Hypoxia Management: Creative Ideas to Complement Advanced Treatment" to help you identify the top two and bottom two strategies to reduce nitrogen. Also keep in mind some strategies contained in your individual articles. Rank and discuss these strategies and record your decisions below. Provide support for your decisions.

First: _____

Why?

Are there any drawbacks?

Second: _____

Why?

Are there any drawbacks?

Second to last: _____

Why?

Are there any drawbacks?

Last: _____

Why?

Are there any drawbacks?

Final question - Were you all in agreement? Why or why not?

Macroalgae of Long Island Sound

Focus

Seaweeds in Long Island Sound and seaweed products.

Focus Questions

What types of macroalgae are found in Long Island Sound? What resources (e.g., energy, habitat) do seaweeds provide to other organisms in Long Island Sound? Do humans impact seaweeds? How? Are there invasive seaweeds in Long Island Sound? How do the invasives impact native species? What type of products are extracted from seaweed? How are the seaweeds harvested? Are seaweeds cultured? If so, how?

Learning Objectives

- Students will identify, press, and catalog seaweeds.
- Students will research the uses for seaweeds.
- Students will describe how human activities can impact seaweeds and other species that rely on them.
- Students will identify and explain the factors that limit seaweed growth.
- Students will learn about the different pigments in different seaweeds.

Materials

Part 1 - Seaweed identification and pressing

Teacher

- Seaweeds collected by the teacher or by students during a field trip. Provide each pair of students with several different species.
- Seaweed press or heavy weight (cinder blocks work well) to press layers down
- Cardboard pieces cut to fit into the press - must be as big or larger than herbarium sheets
- Blotters or paper towels
- Wax paper
- Examples of pressed seaweed

Students (working in pairs)

- *Seaweeds of Long Island Sound* by Margaret "Peg" Van Patten
- www.algae.uconn.edu
- Microscope
- Slides
- Slide covers
- Drawing paper/pencil
- Herbarium paper
- Spray bottle (filled with sea water)
- Scissors
- Small paint brush
- Tub or tray large enough to fit one whole- or half-sheet of herbarium paper
- Extra sea water

Part 2 - Seaweed chromatography

Teacher

- Rubbing alcohol
- Access to a ventilation hood

Students (working in pairs)

- Sandwich baggie
- Small plastic cup
- Filter paper
- One species of seaweed
- Scissors
- Tape
- Pencil
- Goggles

Part 3 - Seaweed product poster

Teacher

- Background information on seaweed in products
- Grading rubric for student seaweed poster (teacher to develop)
- Examples of products made with seaweed
- List of web sites (see Resources section of this lesson)

Student

- Poster board
- Scissors
- Colored pencils/crayons
- Access to the Internet
- Glue

Macroalgae of Long Island Sound

Logistics

Part 1 - Seaweed Identification and press

- Collect seaweed the morning of the lesson or the day before to ensure that it is fresh. It is more important to keep it cool than moist. *Desmarestia* species will degrade other seaweeds - keep them separate when collecting several species.
- Collect extra sea water to have on hand when pressing. You may want to use a cheese cloth or small sieve to strain out debris if needed. If it is not possible to collect sea water, prepare tap water by adding *Instant Ocean*® (available at pet stores).
- Have enough seaweed available for all students to have several different types to work with.
- Practice pressing your own seaweed ahead of time and be prepared to demonstrate the process to students.

Part 2 - Seaweed chromatography

- Set up a chromatography strip ahead of time so the students can see what the final product should look like.
- With younger students have them set up the cups and then add the rubbing alcohol under the hood after students have left. Older students can set up the cups and add the alcohol on their own.
- Wear goggles.
- See Logistics, Part 1 for collecting seaweed.

Part 3 - Seaweed Poster

- Bring in some products with seaweed or seaweed products to show the students.

Audio/ Visual Equipment

- Computer with internet access
- Color printer (optional)
- Microscope

Teaching Time

Part 1- Two 45 minute periods for

identification and pressing.

Part 2- One half hour period for discussion of seaweed pigments and set-up of chromatography strips - and - 15 minutes of the next class day to analyze the chromatography strips.

Part 3- One night's homework to gather information and pictures for the poster - and - two 45 minute class periods to put the posters together.

Seating Arrangement

Students may work individually or in groups at the discretion of the teacher.

Key Words

Alginate	Invasive species
Aquaculture	Kelp
Blade	Macroalgae
Brown algae	Nori
Carageenan	Photosynthesis
Chromatography	Pigment
Green algae	Red alge
Habitat	Seaweed
Haptera	Stipe
Holdfast	Taxonomy

Background Information

Seaweed is a generic term applied to all marine macrophytes. Macrophytes, or macroalgae, are large algae (as opposed to microscopic, like phytoplankton) that live in marine environments. There are three divisions of algae: brown, red, and green.

Brown algae (phylum Heterokontophyta) are yellow-brown organisms that range from microscopic diatoms and several other orders of phytoplankton to the largest seaweeds in the world (kelp). There are nearly 1,800 species of brown seaweed (class Phaeophyceae). Several brown seaweeds are

Macroalgae of Long Island Sound

harvested as a food source and others for their alginates. You will find brown seaweeds distributed from the mid-intertidal to the subtidal zones. The most common brown seaweeds that are common in Long Island Sound include *Ascophyllum nodosum* and several species of *Fucus*.

Red algae (phylum Rhodophyta) are primarily marine. There are about 6,000 species, making red seaweeds the most diverse of the seaweed groups. One red alga also holds the record for the most cultivated seaweeds. Nori (*Porphyra* sp.) is one of the most valuable marine crops. Also, several species are harvested for their carageenan and agar content worldwide. Red seaweeds are typically found intertidally and subtidally. Their pigment proportions result in an assortment of colors, including pink, maroon, green, yellow, red and brown. Along the shores of Long Island Sound you will likely find *Chondrus crispus*, *Corallina officinalis*, and several species of *Porphyra*, *Ceramium* and *Polysiphonia*. The newly invasive *Grateloupia turuturu* is also spreading south and west. For more information please visit web2.uconn.edu/seagrant/publications/ais/gratelou.pdf.

Green algae (phylum Chlorophyta) are very diverse with nearly 8,000 species, though only about 800 are marine. Several of the green seaweeds are cosmopolitan in distribution and can be found on every continent, including Antarctica! Since the pigments in green algae are very similar to terrestrial plants, they cannot absorb light at deeper depths and are typically found from the high intertidal to the shallow subtidal habitats. In Long Island Sound, one will likely find *Ulva lactuca*, *Ulva intestinalis*, the invasive *Codium fragile* subspecies *fragile*, along with several species of *Chaetomorpha* and *Cladomorpha*.

Learning Procedure

Teacher Preparation

Before this activity, students should have experience with microscopes. Review the process of photosynthesis and ask students to identify other species that use the process to produce their own food. Provide students with background information on seaweed, the various divisions, structures, and necessities for production/survival.

Learning Procedure

Part 1 - Seaweed Identification and press

- Students choose two different species to work with.
- Clip off a piece of the seaweed and create a microscope slide. Observe and draw the seaweed, taking note of structures and cell types.
- Use websites and books to identify the seaweed. It may be necessary to look at the specimen closely under the microscope to identify it.
- Place the herbarium paper in a tub or tray and wet the paper with sea water.
- Lay out the seaweed on herbarium paper.
- Spread the seaweed out and flatten it.
- Carefully lift the seaweed and herbarium paper from the tray and let any excess water drip off the herbarium sheet.
- Add to the seaweed press when the teacher is ready. Layers should go in this order (from the bottom up): cardboard, blotter/paper towel, herbarium sheet with seaweed, wax paper, blotter/ paper towel, cardboard (this top piece of cardboard can be the bottom of the next 'sandwich'). Repeat in this order for each sheet.
- Refer to pages 10-11 of Margaret "Peg" Van Patten's *Seaweeds of Long Island Sound* (reproduced on page 116 of this guide) for more information on preserving seaweed.

Part 2 - Seaweed chromatography

Teacher

- Review photosynthesis and photosynthetic pigments.

Macroalgae of Long Island Sound

- Discuss the three seaweed taxonomic groups: Chlorophyta, Rhodophyta, Phaeophyceae.
- Describe the variety of pigments found in these three divisions of seaweed (visit www.seaweed.ie for lists of pigments for each division) with reference to wavelengths absorbed by different pigments.
- Add rubbing alcohol to the student's cups (under the hood) after they are prepared.
- The next day discard the cups and rubbing alcohol properly and set aside the students filter paper.

Student

- Mash up a small piece of seaweed into a small plastic cup.
- In pencil, write your initials at the top of the filter paper (the taped end).
- Tape the piece of filter paper to a pencil or stirrer. Be sure that the filter paper reaches to the bottom of the plastic cup when the pencil is laid across the top of the cup.
- The teacher will add a small amount of rubbing alcohol to the cup after class.
- The next your teacher will give you your filter paper.
- Describe the variety of pigments extracted from the seaweed.

Part 3 - Seaweed Poster

Teacher

- Provide a list of different types of seaweeds that are most often used in products.
- Allow students to choose one type of seaweed from the list.
- Have some extra poster board on hand for unprepared students.
- Have students collect information on their seaweed for homework and bring it in prepared to work on the next day. Also have the students bring in some printed color pictures to add to their project.

Student

- Using online and print resources, research uses for your particular species.
- Design a poster to display your seaweed along with the following information:
 - Taxonomic grouping (phyla or class)
 - Habitat
 - Ingredients extracted from the seaweed
 - Uses of the seaweed (e.g., food, medicine, beauty supplies)
 - Predators
 - List some specific products the seaweed may be used in.

The Sea Grant Connection

Grateloupia turuturu: A Red Seaweed Invading Long Island Sound web2.uconn.edu/seagrant/publications/ais/gratelou.pdf

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

The "Me" Connection

Find some products that contain seaweed or extracts of seaweed. Seaweed is in some products we use every day.

Discuss the economic importance of seaweed including jobs created by culturing, harvesting, and extracting ingredients from seaweed.

Connection to Other Subjects

History/Cultures; Food Science; Pharmaceuticals

Evaluation

Develop a rubric to score the student poster.

Extensions

Create a commercial for a product that contains alginate or carageenan, Nori, or Kelp.

Create a recipe including seaweed as ingredients.

Macroalgae of Long Island Sound

51

Use the information learned about seaweed pigments to predict which ones live at different depths.

Identify and research invasive species of seaweeds in Long Island Sound. Try to determine how the seaweed got here and what impact it may have on the ecosystem.

Resources

AlgaeBase www.algaebase.org

Benthic Marine Algal Herbarium of Long Island Sound - University of Connecticut University Libraries www.algae.uconn.edu

Micheal Guiry's Seaweed Site www.seaweed.ie

Seaweeds: Their environment, biogeography, and ecophysiology by Klaus Luning. John Wiley & Sons.

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

Connecticut Science Frameworks Grades 6-8

Scientific Literacy

- Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science.
- Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media.

Content Standards

7.4: Technology allows us to improve food production and preservation, thus improving our ability to meet the nutritional needs of growing populations.

Grades 9-10

Content Standards

10.6: Living organisms have the capability of producing populations

of unlimited size, but the environment can support only a limited number of individuals from each species.

New York Science Standards

Living Environment Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

Living Environment Key Idea 6: Plants and animals depend on each other and their physical environment.

National Science Education Standards

Content Standard C: Life Science

- Populations and Ecosystems
- Diversity and Adaptations in Organisms
- Interdependence of Organisms

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 5: The ocean supports a great diversity of life and ecosystems

Fundamental concept a: Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.

Fundamental concept h: Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.

Fundamental concept i: Estuaries provide important and productive nursery areas for many marine and aquatic species.

Essential Principle 6: The ocean and humans are inextricably interconnected.

Fundamental concept b: From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

Invertebrate Scrapbook

Focus

Biodiversity of invertebrate animals in Long Island Sound.

Focus Questions

What is the difference between invertebrate and vertebrate animals? What evolutionary changes can be seen through a survey of invertebrate animal groups?

Learning Objectives

- Students will investigate the biodiversity of invertebrate animals in Long Island Sound using Long Island Sound resource materials and the Internet.
- Students will find information about symmetry, closed versus open circulatory systems, incomplete and complete digestive systems, body cell layers and more features about each invertebrate phylum.
- Students will work cooperatively in groups to create an invertebrate scrapbook using their research results.

Materials

- Research worksheets (pages 56-65)
- Internet access
- Long Island Sound resources (see Resources section)
- Construction paper
- Glue sticks
- Scissors
- Markers/colored pencils
- Assorted embellishments
- Hole punch
- Yarn or string to tie books together
- Cardboard/cardstock for covers (optional)

Logistics

No major logistical considerations.

Audio/Visual Equipment

- Video Projector
- Computers and printer access
- Digital camera (optional)

Teaching Time

To be determined by the teacher.

Suggestion: Four 45 minute periods plus work at home.

Seating Arrangement

Groups of three to four students

Key Words

Animals	Mollusk
Arthropod	Phylum
Circulation system	Porifera
Cnidaria	Respiratory system
Digestive system	Symmetry
Echinoderm	Vertebrate
Evolution	Worms
Invertebrate	

Background Information

Long Island Sound is home to an incredible diversity of organisms virtually unknown to most people. In this lesson students will study the invertebrate animals of Long Island Sound and create a scrapbook of pictures and facts about some of the major phyla of the animal kingdom.

Getting food into the body is of utmost importance to animals. Without it, there is no energy and no successful living. This has led to the evolution of structures considered to be characteristic of animals. Animals usually have some kind of mouth and digestive tract. Other systems evolved to help process the food, such as a respiratory system to bring oxygen to "burn" food, an excretory system to remove unwanted materials and a circulatory system to transport materials throughout the body. Eyes, antennae, filtering systems, muscular feet and tentacles are just a few of the adaptations used by invertebrate animals to help them catch and ingest food.

An increase in complexity of organ systems

can be seen as you observe the invertebrate animals. For example, the sessile colony of cells found in sponges is uncomplicated compared to the more intricate groups, such as arthropods and echinoderms. One opening in the body to process food in a primitive organism turns to two in a more highly developed organism. Likewise, a series of pumping blood vessels is primitive compared to a chambered heart, and an abundance of sensory structures also evolves.

Learning Procedure

Teacher Preparation

- Schedule time in the computer lab. A printer will be needed for animal photos or graphics.
- Copy student worksheets and grading rubric (pages 56-65). These worksheets are research guides designed to lead the students to the major features and attributes of eight invertebrate phyla. Option: pick a fewer number of groups to investigate.
- Organize and display resources that will be useful to students including any Long Island Sound references available.
- Order art supplies such as construction paper, markers, glue sticks, and yarn. You will need a hole punch.

Learning Procedure

- Introduce the lesson by showing students *An Underwater Tour of Long Island Sound* from the DVD or online at: www.lisrc.uconn.edu/lis_uwtour/index.asp. Instruct students to identify any invertebrate animals they recognize.
- Ask the class for a working definition of an invertebrate animal.
- Show pictures of invertebrate animals with a variety of body plans to determine if students understand symmetry.
- List and define the terms bilateral, radial and asymmetry.
- Show students examples of scrapbooks you may have or, in advance, ask them

to bring in their own family scrapbooks to show. Tell them they will be making an invertebrate scrapbook to celebrate the awesome invertebrate animals found in Long Island Sound.

- Determine student groups and distribute research worksheets and grading rubric. Let students begin by discussing the work needed to be done and assigning tasks to each member of the group. Establish a due date for the project and have them write it in the space provided on their rubric.
- Several days should be devoted to work on research in the classroom or computer lab. Check student progress daily and assist where needed. Require that homework time be devoted to the project and that progress reports be submitted.
- When pages are complete show students how to hole punch and tie their pages together. Optional- depending on the resources at your school, the scrapbooks can be laminated and bound.
- Require students to have at least one other group complete a peer review of the project and have the whole group complete a self-assessment before submitting the scrapbook to the teacher.
- Lead a discussion about the biodiversity of invertebrate groups and the evolutionary trends seen from simple animals to the more complex animals.

The Sea Grant Connection

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Visual Guide: Long Island Sound Marine Invasive Species with comparison to some

Invertebrate Scrapbook

native species waterproof field guide/flip book. Connecticut Sea Grant

The "Me" Connection

Compare and contrast body structures of the invertebrates with vertebrates, including humans. Which invertebrates are most closely related to vertebrates? Why?

Connection to Other Subjects

Conservation; Food resources; Geology; History; Anatomy and Physiology

Evaluation

Grading rubric (page 65); unit test

Extensions

Dissect a representative invertebrate animal such as a crayfish, squid or earthworm.

Resources

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Marine Animals of Southern New England and New York by Howard M. Weiss - CT DEP

An Underwater Tour of Long Island Sound - UConn/ NURC/ LIS Resource Center
www.lisrc.uconn.edu/lis_uwtour/index.asp

Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species waterproof field guide/flip book. Connecticut Sea Grant

Connecticut Science Frameworks
PreK-2

Scientific Inquiry Expected Performances

A INQ.1: Make observations and ask

questions about objects, organisms, and the environment.

A INQ.4: Read, write, listen and speak about observations of the natural world.

A INQ5: Seek information in books, magazines and pictures.

A INQ.6: Present information in words and drawings

Content Standards

K.2: Many different kinds of living things inhabit the Earth.

1.2: Living things have different structures and behaviors that allow them to meet their basic needs.

1.3: Organisms change in form and behavior as part of their life cycles.

Grades 3-5

Scientific Inquiry Expected Performances

B INQ.1: Make observations and ask questions about objects, organisms, and the environment.

B.INQ.2: Seek relevant information in books, magazines and electronic media.

B.INQ.8: Search the Web and locate relevant science information.

C.INQ.10: Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

Content Standards

3.2: Organisms can survive and reproduce only in environments that meet their basic needs.

4.2: All organisms depend on the living and nonliving features of the environment for survival.

5.2: Perceiving and responding to information about the environment is critical to the survival of organisms.

Grades 6-8

Content Standards

6.2: An ecosystem is composed of all the populations that are living in a certain space and the physical factors with which they interact.

7.2: Many organisms, including humans, have specialized organ systems that

interact with each other to maintain dynamic internal balance.

Grades 9-10

Scientific Inquiry Expected Performances

D.INQ.10: Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

Content Standards

10.5: Evolution and biodiversity are the result of genetic changes that occur over time in constantly changing environments.

New York Science Standards

Living Environment - Standard 4:

Students will understand and apply scientific concepts, principles and theories pertaining to the physical setting and living environment and recognize the historical development to ideas in science.

Key Idea 1: Living things are both similar to and different from each other and from nonliving things

Key Idea 3: Individual organisms and species change over time

Key Idea 6: Plants and animals depend on each other and their physical environment.

National Science Education Standards

Content Standard C: Life Science

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environments
- Structure and function in living systems
- 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 F: Science in Personal and Social Perspectives

- Population growth
- Environmental quality

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 5: The ocean supports a great diversity of life and ecosystems

Fundamental concept a: Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.

Fundamental concept c: Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.

Fundamental concept d: Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

Fundamental concept e: The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Fundamental concept f: Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Fundamental concept h: Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.

Fundamental concept i: Estuaries provide important and productive nursery areas for many marine and aquatic species.

Invertebrate Scrapbook

Student Activity

56

Name(s): _____

Directions: You will make a scrapbook about invertebrate animals.

Questions

What are the similarities and differences between invertebrate animal groups? What evolutionary changes can be seen through a survey of invertebrate groups?

Learning Objectives

- You will investigate the biodiversity of invertebrate animals in Long Island Sound using Long Island Sound resource materials and the Internet.
- You will find information about symmetry, closed versus open circulatory systems, incomplete and complete digestive systems, body cell layers and more features about each invertebrate phylum.
- You will work cooperatively in groups to create an invertebrate scrapbook using your research results.

Procedure

1. The first page of your scrapbook will include the general characteristics of animals (it could also be the cover).
2. Six major groups of invertebrates must be included.
3. You will be provided with research fill-in worksheets for each group.
4. The information gathered on these worksheets must be included in the scrapbook page about that group along with vocabulary that belongs with each group.
5. You must have a table of contents and a bibliography.
6. There must be a minimum of 9 pages.
7. You may work in groups of 2-4 students.
8. Using the rubric, you must have one other student group rate your project. You must also self-evaluate your project using the rubric.
9. You may use your own scrapbooking materials or use the construction paper and supplies in class.

Project Due Date: _____.

Scrapbook pages:

1. Table of Contents
2. General Animal Characteristics
3. Sponges
4. Cnidarians
5. Worms
6. Mollusks
7. Arthropods
8. Echinoderms
9. Bibliography

Minimum of 9 pages,
maximum of 15

Invertebrate Scrapbook

General Animal Characteristics


Name(s): _____

 Describe and provide an illustration for three types of symmetry.

A.

B.

C.

 Provide a drawing of an animal body. Label it correctly with the terms – dorsal, ventral, anterior, posterior.

 How do animals get energy?

 What type of cells do animals have?




 Describe the differences between invertebrate and vertebrate animals. Include three differences.


Invertebrate Scrapbook


Sponges


58

Name(s): _____

-  What phylum are sponges in?
-  Provide a general description of a sponge.
-  Anatomy – provide a labeled picture.

-  What are spicules?

-  Describe how sponges eat.

-  List human uses for sponges:

Invertebrate Scrapbook

Cnidarians

Name(s): _____

- Provide a general description of the group characteristics.

- Provide a picture and/or a drawing of both the medusa and polyp forms. Label all parts.

- List two similarities and two differences between the medusa form and the polyp form.

- Coral reefs
 - A. Where do they form?

 - B. List the types of pollution that hurt coral reefs.

 - C. How does pollution hurt coral reefs?

Invertebrate Scrapbook

Worms

60

Name(s): _____

- Create a data table on flat, round, and segmented worms. Include: class (scientific name), symmetry, segments present, and distinguishing features.


- Anatomy of the segmented worms – labeled pictures



- Describe two disease-causing worms and how they harm their hosts.

Invertebrate Scrapbook

Mollusks

Name(s): _____

-  Provide a general description of a mollusk.

 -  Provide a labeled drawing or picture of each of the following: a snail, a clam and an octopus.
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-  How do squid, octopus, and their relatives use chromatophores?

Invertebrate Scrapbook

Arthropods

62

Name(s): _____

- Describe the general traits of three groups of arthropods. Include exoskeleton, number of body segments, and the number and type of appendages (legs).


- Provide a labeled picture of an animal from each group.

- Describe the differences between incomplete and complete metamorphosis.

Invertebrate Scrapbook


Echinoderms

Name(s): _____

 Provide the general characteristics of a sea star.

 Provide three other examples from the echinoderm group.

 Describe the water vascular system.

 Compare an echinoderm to an invertebrate chordate.

Invertebrate Scrapbook

Vocabulary

64

General Characteristics

Symmetry
Bilateral
Radial
Spherical
Asymmetrical
Heterotrophic
Multicellular
Eukaryotic
Invertebrate
Vertebrate

Worms

Flat worms
Round worms
Segmented worms
Cephalization
Flame cells
Scolex
Nematode
Parasite
Setae

Arthropods

Crustaceans
Insecta
Arachnid
Centipede
Millipede
Chitin
Exoskeleton
Appendages
Abdomen
Mandibles
Malpighian tubules
Spirales
Metamorphosis
Complete
Incomplete
Mimicry

Sponges

Porifera
Osculum
Pores
Spongins
Spicules
Filter feeders
Gemmule

Mollusks

Univalves
Bivalves
Shells
Gastropod
Oysters
Clams
Snails
Radula
Cephalopods
Octopus
Squid
Tentacles
Chiton
Mantle

Echinoderms

Tube feet
Water vascular system
Ampullae
Eyespot
Madreporite
Sand dollar
Chordate

Cnidarians

Jellyfish
Coral
Sea anemone
Polyp
Medusa
Cnidocytes
Nematocyst

What other new terms have you learned?

Invertebrate Scrapbook

Rubric

65

Name(s): _____

Tasks:	Points Available	Peer Review	Student Score	Teacher score
Table of Contents	5			
Vocabulary – five words used from each section of the list.	35			
General Animal Characteristics	10			
Sponges	10			
Cnidarians	10			
Worms	10			
Mollusks	10			
Arthropods	10			
Echinoderms	10			
Bibliography	5			
Time on task- Did everyone do their jobs?	10			
Creativity	10			
Rubric	10			
Peer Review	5			
DUE:	-10 each day late			
Totals	150			

Use this as a checklist for completion, peer review, your score and the teachers score. Use the vocabulary list and research fill-in pages for details about each section. THIS MUST BE SUBMITTED WITH THE SCRAPBOOK.

Cleaning Up Polluted Water

Focus

Human and natural impacts on water resources.

Focus Questions

What are some common pollutants in water?
What are the sources of pollutants in water?
How are pollutants removed from water? Can all pollutants be removed from water?

Learning Objectives

- Students will learn different techniques used to remove pollution from water.
- Students will understand that it is not possible to clean up some forms of pollution.

Materials

For the teacher:

- Quart containers filled with clean water—one for each group of students
- Measuring spoons
- pH paper or pH test kit
- “Pollutants” (real pollutants indicated in parentheses):
 - 3 tablespoons vegetable oil (petroleum)
 - 2 tablespoons leaf litter (sewage, organic wastes)
 - 1 teaspoon dirt (sediment)
 - 2 drops plant fertilizer (fertilizer and nutrients)
 - 5 drops dish detergent (detergents or general chemicals)
 - 1 drop food coloring (pathogens, toxic chemicals, heavy metals)
 - Assorted litter: small pieces of styrofoam, paper, plastic (floatable debris)
 - 1 teaspoon vinegar (acid rain)

For each small group (2-4 students):

- Water Pollution Cleanup worksheet, pages 72-73
- Pen or pencil
- Wash basin or dishpan
- 6” square of cheesecloth or aquarium filter

fiber

- Small sponge
- 1 or 2 eyedroppers or pipettes
- 1 or 2 spoons
- Empty quart container
- $\frac{3}{4}$ cup filter sand or clean beach sand
- Container for the waste removed during cleanup
- 2 funnels, medium to large sizes
- 1 tablespoon of alum (located in spice section of a grocery store)

Logistics

Preparation and cleanup for this activity is time-consuming. Be sure to prepare all of the containers except one prior to demonstration (prepare one container in front of the students for maximum effect).

If possible, have another person assist you with cleanup, particularly if you intend to repeat the activity in subsequent time periods.

Teaching Time

One 45 minute period.

Seating Arrangement

Groups of two to four students.

Key Words

Bioaccumulation
Contaminant
Effluent
Erosion
Floatable debris
Food web
Hypoxia
Non-point source pollution
Nutrients
Pathogens
pH
Photosynthesis
Point source pollution
Sediment
Toxic contamination

Cleaning Up Polluted Water

Background Information

Growing concern in the 1970's regarding the declining health of Long Island Sound resulted in widespread support to target sources of pollution and other forms of degradation and to plan efforts for cleanup and restoration. In 1985, the Long Island Sound Study (LISS) was launched to comprehensively study the impacts various forms of pollution contribute to the environmental problems facing Long Island Sound. The study recognized five major pollutants that adversely affect the water quality of the Sound: nutrients, pathogens, sediment, toxic contaminants, and floatable debris. Cleanup of polluted waters is an expensive and daunting task and our aim should be preservation and conservation of our water resources to allow their continued and varied use.

Pollutants entering Long Island Sound are classified as either point or non-point sources of pollution. Point source pollution is easy to identify, for example, sewage pipes directly dumping effluent into the Sound.

Nonpoint sources of pollution are more difficult to measure. Because of this difficulty, their effects are more insidious. Rain water running over parking lots collects oil, gas, antifreeze, and other chemicals on the surface of the pavement. This contaminated water then drains to a stream or storm drain, which ultimately leads to the Sound.

Excess nutrients have been found to contribute to the most pressing issue in the Sound. While nutrients are essential for supporting marine life, too many nutrients, particularly nitrogen, can lead to hypoxia (low dissolved oxygen levels). Excess nitrogen promotes algal blooms. These algae die and quickly accumulate en masse on the bottom where bacteria use oxygen to

decompose this overabundance of dead algae. As bacteria continue to feed and reproduce, oxygen concentrations drop to dangerously low levels for other organisms.

Hypoxic conditions are especially prevalent during the summer months following spring algal blooms. Benthic or bottom-dwelling organisms suffer most because the dead algae settle to the bottom and there is limited mixing with oxygenated surface water. Most of the human-supplied nitrogen comes from sewage treatment facilities, the rest from sources as diverse as acid rain, lawn fertilizer and vehicle exhaust.

Pathogens include disease-causing viruses, bacteria, and microorganisms. They are responsible for water-borne illnesses such as hepatitis and dysentery. Swimming areas and shellfish beds are closed when pathogenic organisms are detected in local water samples. Pathogens generally enter the Sound through inadequately treated sewage wastes and fecal material from domestic and wild animals.

Excess sediment from natural and manmade erosion can cloud waters with suspended particles, blocking photosynthesis in plants and choking filter feeders such as shellfish. Major sources of sediments include construction sites, logging, and heavy storms. These activities and events disturb the vegetation's ability to hold the soil, thereby allowing the runoff of sediments.

Toxic contaminants need not be present in large quantities to greatly impact the Sound. Mercury, lead, pesticides, and petroleum products are a few examples of contaminants responsible for negatively impacting marine life. While some contaminants have immediate lethal effects, others are slow and insidious, affecting long-term reproductive potential, for example. Bioaccumulation

Cleaning Up Polluted Water

is an important associated concept. This refers to the increasing concentration of poisonous substances up the food chain. The amount of contaminants ingested exceeds the amount excreted. This has serious implications for marine species, particularly those higher on the food chain, that humans consume.

One form of water pollution that is often overlooked is acid rain. Chemical contaminants from air pollution are washed from the sky by rainfall and end up in our streams, rivers, lakes, and oceans. Much of this contamination is in the form of nitrates and sulfates released through the burning of fossil fuels (coal and petroleum). When these substances mix with water they form nitric acid and sulfuric acid and their addition to water bodies lowers the pH of these waters. Fresh waters acidified by acid rain can experience pHs as low as 3.0. This low pH can have adverse effects on aquatic life because most organisms thrive at a pH of 7-8. Long Island Sound does not experience lowered pH due to acid rain because the salts act as a buffer system. However, the pollutants in acid rain contribute nutrients, adding to the hypoxia problem in the Sound during the summer.

Floatable debris constitutes what most people term "garbage" - plastics, cigarette filters, cans, glass, paper. While aesthetically detracting, "floatables", such as plastic bags, can be ingested by marine life and prove potentially fatal. Many animals can become entangled in debris, like six-pack plastic rings, hindering their ability to feed, reproduce, grow, or escape predators.

Learning Procedure

Teacher Preparation

Before beginning the preparation, check the pH of the clean tap water. If the water used

already has a low pH, the impact of adding the vinegar to the water to represent acid rain will be much less dramatic. If low pH is an issue, use distilled water or add a little baking soda to the water.

There is extensive preparation and cleanup for this activity. Gather the required materials, placing the equipment for each group in their dishpan. Prepare enough polluted water samples for each group by placing the indicated amounts of pollutants into containers half full of clean water. Keep one water sample aside to prepare in front of the students for greatest impact. Before starting the activity, check the pH of the clean water.

Learning Procedure

- Assign small groups then ask the class to list different things that are polluting our rivers, lakes, and Long Island Sound. Write the list on a flip chart or blackboard for reference. The list should eventually include at least: trash, petroleum, sewage, toxic chemicals, other chemicals (including detergents and fertilizers), sand or dirt (from erosion), and acid rain. You may have to ask some leading questions to get a complete listing.
- When the list is complete, take the half jar of clean water, measure the pH, then, referring to the list on the board, add the analogous pollutants from the Materials List. Cap the jar, shake it up, measure the pH of the water; and announce that, working in their groups, they will have 20-30 minutes to clean the water sample to the best of their ability.
- Before passing out the water samples, go over the ground rules listed on the worksheet (in the large bracket on page 72), and the list of cleanup materials available.
- Have each group choose a recorder, and

Cleaning Up Polluted Water

69

- take five minutes to discuss the activity and come up with a “plan of attack” .
- Pass out the cleanup materials, re-emphasizing what the groups have available. After these initial discussions, pass out the polluted water samples.
 - While the groups are cleaning their water samples, visit each group to answer questions and offer suggestions while avoiding giving specific directions. Encourage the groups to think before acting on an idea. Do not allow groups to obtain additional cleaning materials and be careful about allowing innovative groups to request paper towels, etc.
 - When their time is up, have each group place their materials back in the dishpan and bring their labeled jar of “clean” water to a central location for comparison and discussion.

Discussion:

Have the group decide which jar of water looks the cleanest. Measure the pH of that sample. Have a spokesperson from each group describe briefly what techniques they used on their sample. Compare these techniques to real-life techniques used in water treatment plants.

Many communities get their drinking water from reservoirs or rivers and must treat it before piping it to consumers. In water treatment plants, the water is passed through a screen to remove debris, The water then enters large settling tanks and alum, or similar chemicals, is added, causing fine particles to clump together and sink to the bottom of the tank. The water is then drained from the top of the tank and passed through sand filter beds to remove any remaining particles. In a final step, chlorine is usually added to kill bacteria and fluoride is sometimes added as a public service. Sewage treatment plants have similar setups, but slightly different techniques, as

described in the LISS Fact Sheet “Wastewater Treatment” www.longislandsoundstudy.net/pubs/facts/fact3.pdf.

Ask which pollutants were the hardest to remove. Most of the solid material should have been removable with the filter materials provided. Oils and detergents lay over the surface of the water and could be removed by skimming the water with a spoon or a sponge or an eyedropper. The acid rain, fertilizers and toxic chemicals could only be effectively “removed” with one available technique - dilution with clean water. This is the reason most polluters discharge their wastes into streams, for the dilution effect.

Ask if they think the dilution got rid of the pollution. Remind them that there was only one drop of food coloring added to the water sample. Discuss bioaccumulation of pollutants through the food chain.

Some students may think that we could clean up all our water by running it through a water treatment plant. Point out that this is not practical. The only way to keep our waters clean is to keep people from putting pollutants into them. Also note the large amount of waste that was created by cleaning up their water samples and ask the children how they think this material must be treated.

This activity tends to work best for groups that work well together and cooperate during the cleanup. Pollution is everyone’s problem and everyone must work together if we are going to successfully clean up our planet.

The Sea Grant Connection
Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* - Connecticut Sea Grant

Clean Water Fact Sheet series - Connecticut Sea Grant
web2.uconn.edu/seagrant/publications/coastalres

Cleaning Up Polluted Water

The "Me" Connection

What can I do as one person to help keep Long Island Sound healthy?

How do my actions each day affect Long Island Sound?

How can I help other people learn about keeping Long Island Sound healthy?

Connection to Other Subjects

Physical science; Earth science; Environmental science

Evaluation

Have students rate the final product and processes of other groups. Discuss the pros and cons of approaches taken by each group to clean up the polluted water.

Extensions

Investigate Long Island Sound and its watershed in your area, noting what you find that is similar and/or different to the pollutants described in this activity.

Participate in the International Coastal Cleanup, held annually on the third Saturday of September.

See the NSTA publication *Science Scope* (vol.32; No.1; September 2008) for a great inquiry lesson relating to this topic: *Developing the Essential Features of inquiry* by Robin Harris and Kathaleen Burke from Buffalo, New York.

Write a letter to a newspaper or local or state officials regarding cleaning up Long Island Sound.

Encourage student stewardship projects that focus on Long Island Sound and its watershed. View an overview of the Long Island Sound (EPA LISS) Stewardship initiative: www.longislandsoundstudy.net/stewardship/

Resources

Coastal Pollution topics - Woods Hole Oceanographic Institute <http://www.whoi.edu/page.do?pid=11822>

Floatable Debris fact sheet - EPA LISS www.longislandsoundstudy.net/pubs/facts/fact8.pdf

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* - Connecticut Sea Grant

Nonpoint Source Pollution fact sheet - EPA LISS www.longislandsoundstudy.net/pubs/facts/fact7.pdf

Pathogens fact sheet - EPA LISS www.longislandsoundstudy.net/pubs/facts/fact12.pdf

Sound Health 2008 - EPA LISS www.longislandsoundstudy.net/soundhealth/index.htm

Wastewater Treatment fact sheet - EPA LISS www.longislandsoundstudy.net/pubs/facts/fact3.pdf

Connecticut Science Frameworks Grades 6-8

6.4: Water moving across and through earth materials carries with it the products of human activities.

Grades 9-10

9.8: The use of resources by human populations affects the quality of the environment.

9.9: Some materials can be recycled, but others accumulate in the environment and may affect the balance of the Earth systems.

New York Science Standards

Standard 1 - Analysis, inquiry and Design: Students will use mathematical analysis, scientific inquiry, and engineering design,

as appropriate, to pose questions, seek answers, and develop solutions.

Standard 6 - Interconnectedness:

Common Themes: SYSTEMS THINKING:

Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

Common Themes: OPTIMIZATION: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

Living Environment Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard E: Science and Technology

- Abilities of technological design

Content Standard F: Science in Personal and Social Perspectives

- Changes in Environments (K-4)
- Science and Technology in Society (5-8)
- Natural Resources (9-12)
- Environmental Quality (9-12)
- Natural and Human Induced Hazards (9-12)
- Science and Technology in Local, National, and Global Challenges (9-12)

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably connected.

- **Fundamental concept e:** Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out of and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers).
- **Fundamental concept g:** Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Cleaning Up Polluted Water

Student Activity

72

Water Pollution Cleanup

While Long Island Sound and the rivers leading to it have become cleaner since Congress passed the Clean Water Act in 1972, there are still a lot of pollutants entering our waters. Many cities, factories, and other sources still dump wastes into rivers and the Sound. There are laws against water pollution, but they are hard to enforce, so polluters often break these laws and get away with it. Even when polluters are caught and have to clean up their pollution, it is often not an easy task.

Today you are going to try to clean up polluted water. Your group has a sample of polluted water and some equipment you can use to try to remove the pollutants from the water.

Before You Start

Before starting your cleanup project, your group should take a few minutes to plan your procedure. Choose one person in your group to be the recorder. The recorder should write down your group's cleanup plan. If you change your plan or add more steps, the recorder should add them to the plan.

You will have fifteen minutes to get as much pollution out of your group's sample of water as possible. Please keep the following in mind:

Do all pouring over the basin to avoid accidental spills.

The only clean water available is the half-jar with your cleanup equipment. Think hard how you can use this limited amount of clean water. You cannot use clean water from any other source.

Waste removed from the sample should be collected in the appropriate container.

At the end of the fifteen minutes, your group should have at least one half bottle of "clean" sample to compare with the results of the other groups.

DON'T HURRY! Take the time to think about each step of your cleanup project, about what kind of pollutant you are trying to remove, and what tools you have available.

Cleaning Up Polluted Water

Student Activity

Names: _____

	What was tried?	Pollutants removed:
Step 1		
Step 2		
Step 3		
Step 4		
Step 5		
Step 6		
Step 7		

Science Lessons at a Long Island Sound Field Site



Low tide at Hammonasset State Park in Madison, Connecticut reveals a rocky field site ideal for finding Asian shore crabs.

Preface to Science Lessons at a Long Island Sound Field Site

79	<i>Rocky Shore Environment Station:</i> Crab Study and Beach Sample
87	<i>Sandy Beach Environment Stations:</i> Seining
93	Beach Lab-Marine Biology Field Station
99	Sifting Sands and Shifting Tides
105	Aesthetic Connection

The following six learning stations allow students to ask questions and gather data for authentic inquiry investigations at a rocky beach and sandy beach environment at Long Island Sound. The stations can be combined to encourage students to spend a day investigating and collecting evidence in a variety of beach areas or each station can stand alone. Protocols at each station have been used over the course of many years with hundreds of students, teachers and adult volunteers. The stations are organized to help students work

as scientists to find evidence that supports answers to questions they have generated about the survival of life and physical changes noticed in Long Island Sound. As students collect, record, compile and analyze data, they can make a contribution to an ongoing inventory of life and physical changes on the shores of Long Island Sound.

It is recommended that these studies be conducted twice each school year, first in the fall and then in the spring. Doing so will give students a broader picture of life and changes in Long Island Sound. This will create opportunities for them to collect comparative data, allowing them to design and conduct authentic scientific investigations.

All stations described in the following lessons take place at Meigs Point, Hammonasset State Park, in Madison, Connecticut. These inquiry stations can be adapted for use in any comparable state park that has a rocky beach and a sandy beach as well as bathroom facilities and picnic tables (see Alternatives on page 78).

Students work in small groups as they cycle through each station. Students carry their own clipboard, pencil, and packet of simple data collection sheets. The data collection sheets become an integral part of the students' personal science journals. While teachers and students get organized at the beginning of the day (bathrooms, lunch storage, group assignments, etc.), materials are quickly set up in suitable locations by adult volunteers and other teachers and staff who are assigned specific stations. Those adults are responsible for overseeing each station, guiding the learning that takes place, encouraging students to explore, ask questions, collect data or evidence and seek answers to their questions. The adults remain at their assigned station for the day, becoming experts at managing their learning station. This provides consistency for students and ensures a smooth flow of students through the stations.

Teacher preparation:

It is suggested that this field trip be scheduled as an extended school day. Low tide is the best time to collect specimens at the rocky beach. Tide tables are available online, or at outdoor recreation and boating stores. Depending on the time of low tide you may wish to schedule your students to arrive at school earlier than usual and return to school during regular dismissal time or you may want to have students arrive at the usual school start time and return to school later than regular school dismissal time.

Preface to Science Lessons at a Long Island Sound Field Site

Assign at least one adult volunteer or teacher to each station. It is best for students if you include teachers from a variety of disciplines such as art, language arts, math, and physical education. Prior to departure, adults should be given a copy of the lesson plan which includes objectives, materials, procedures, and resources. It is interesting to note that each adult may have a certain expertise or interest that influences their approach to learning at their selected station; this is fine! Although the lessons may seem to have specific directions, there is latitude and flexibility in the execution of the lesson plan, depending on the adult in charge and the interest and level of the students. Each class of students has raised questions to which they seek answers. The inquiry questions each class has determined should be clearly stated because they will provide a focus for the stations.

At school, use the checklists to prepare and pack materials for the stations, being sure to keep materials for each station together. Label all items needed for the rocky beach and, similarly, label all items needed for the sandy beach. When unloading equipment at the site use the checklists again to ensure that all necessary materials and equipment are brought to the designated stations.

For the sandy beach stations, divide each class of approximately twenty-two students into four groups. Recruit an adult to be the timekeeper so rotations occur in a timely manner.

Use the following extended day timetable and rotation schedule as an example for two classes of twenty-two students rotating through morning and afternoon stations at the sandy beach and rocky beach. This schedule can be adapted for use with larger groups.

- | | |
|-----------------|---|
| 7:15 a.m. | Students arrive at school via parents. Load equipment onto the bus and/or into personal vehicles. |
| 7:30 a.m. | Leave school. |
| 8:30 a.m. | Arrive at the pavilion at Meigs Point, Hammonasset. Separate the equipment needed for each station, and enlist the aid of students and adults to bring the equipment to the stations. It is suggested that the group going to the rocky beach first should use the bathroom facilities at this time, since they will be away from the pavilion for the morning. Backpacks, lunches, etc., may be left under a picnic table in the pavilion, but students should bring along drinking water. Hand out clipboards, pencils and packets. |
| 8:45-10:45 a.m. | Students in one class (Class A) bring equipment needed for the rocky beach station (Crab Study and Beach Sample) and proceed to that area. Students in Class B divide into the four predetermined groups and proceed to their first of four stations (Seining, Beach Lab, Sifting Sands and Shifting Tides, Aesthetic Connection). Rotate stations approximately every half hour. |

Preface to Science Lessons at a Long Island Sound Field Site

8:45-10:45 a.m.	<p>Morning - Class A Crab Study station for large group. A small group of students can break out for a short period of time to record weather observations and collect samples from the beach.</p>
8:45-10:45 a.m.	<p>Morning - Class B Four stations for small groups: Seining, Beach Lab-Marine Biology Field Station, Sifting Sands and Shifting Tides, Aesthetic Connection.</p>
8:45-9:15 a.m.	Class B first rotation
9:15-9:45 a.m.	Class B second rotation
9:45-10:15 a.m.	Class B third rotation
10:15-10:45 a.m.	Class B fourth rotation
11:00-11:40 a.m.	All students and adults meet at the pavilion for lunch.
11:45-1:45 p.m.	<p>Afternoon - Class B Crab study station for large group. A small group of students can break out for a short period of time to record weather observations and collect samples from the beach.</p>
11:45-1:45 p.m.	<p>Afternoon - Class A Four stations for small groups: Seining, Beach Lab-Marine Biology Field Station, Sifting Sands and Shifting Tides, Aesthetic Connection.</p>
11:45-12:15 p.m.	Class A first rotation
12:15-12:45 p.m.	Class A second rotation
12:45-1:15 p.m.	Class A third rotation
1:15-1:45 p.m.	Class A fourth rotation
1:45-2:00 p.m.	All groups gather equipment and personal belongings. The lead teacher is the only person who can give permission to take specific living things back to school. Classroom teachers collect clipboards and student packets. Load equipment onto the bus or other vehicles.
2:00 p.m.	Depart from Hammonasset State Park.
3:00 p.m.	Arrive back at school and unload and clean equipment. Place all specimens in prepared school tanks.
3:20 p.m.	Students take their customary form of transportation home from school.

Preface to Science Lessons at a Long Island Sound Field Site

Important note regarding specimens:

You must obtain a specimen permit to collect living things from Connecticut or New York. To collect in Connecticut, contact the Connecticut Department of Environmental Protection (DEP) by calling (860) 424-3000 or download the form at www.ct.gov/dep/lib/dep/fishing/fishing_forms/scicoll.pdf. A sample of this permit is provided on page 120. To collect in New York, contact the New York State Department of Environmental Conservation (DEC) by calling (518) 402-8985 or download the form at www.dec.ny.gov/docs/wildlife_pdf/lcp.pdf.

If living specimens are to be brought back to school, use a cooler for transport. Prepare the salt water tanks for these specimens before the field trip by using a simple aquarium air and filter system and use Instant Ocean salt mixture purchased at a pet store. No special refrigeration system is needed for most Long Island Sound species. Small silverside fish, jellyfish and most shellfish (mussels, clams) will NOT survive in most school tanks. Try to start your tank with Asian shore crabs, green crabs, hermit crabs, mummichogs, killifish, blackfish or eels. With exceptional attention you may become successful with flounder or pipefish and other animals. Start with a SMALL number of organisms, especially if you do not know what types of organisms will survive in your tank.

Alternatives:

The following lessons have been written specific to Hammonasset Beach State Park in Madison, Connecticut. However, as mentioned previously, these same techniques can be done at any shore or park that fit the criteria of having both a sandy beach environment and a rocky shore environment as well as restrooms.

Information about coastal access in Connecticut can be found at the Connecticut DEP coastal access guide web site. www.lisrc.uconn.edu/coastalaccess/. A list of facilities and environmental settings is provided for each site. To see a list of New York state parks and use/permit information, visit <http://nysparks.state.ny.us> or www.dec.ny.gov.

The East Hartford/Glastonbury Elementary Magnet School's science teacher, Donna Rand, assisted by physical educator Donna DuBaldo, developed the protocols for each station, which have been used over the course of many years with hundreds of students, teachers and adult volunteers.

Crab Study and Beach Sample Station

Focus

Design and conduct an authentic scientific biological inventory and/or an investigation.

Focus Questions

What life can be found in a rocky beach area of Long Island Sound today? What is an invasive species? How do matter and energy flow through ecosystems? How are organisms structured to ensure efficiency and survival?

Learning Objectives

- Students will generate their own questions about crabs living in a rocky beach environment of Long Island Sound.
- Students will seek answers to their questions about crabs by using an established scientific protocol to collect and categorize crabs.
- Students will record, compile and analyze pertinent data and then contribute their findings to a state-wide database of information on an invasive crab species.

Materials

- Permit to collect specimens
- 10-12 buckets for collecting crabs
- 6 large containers for sorting crabs (basins or under bed plastic storage containers work well). Mark the containers or use laminated cards to indicate the following:
 - Male Large - larger than 18 mm
 - Male Medium - 9-18 mm
 - Male Small - smaller than 9 mm
 - Female Large - larger than 18 mm
 - Female Medium - 9.1-18.0 mm
 - Female Small - smaller than 9 mm
- Whistle to signal the beginning and end of collection time
- Stopwatch to time the collection period
- Small plastic mm rulers for each person
- Clipboard and pencil for group leader, including Crab Study Station Crab Count Data Sheet (page 86)
- 1-2 calculators

- For each student, copy of each: Beach Sample Station Data Sheets (page 85) and Crab Study Station Crab Count Data Sheet (page 86)
- Optional: cooler to take specimens back to school

For breakout groups:

- Wind meters
- Thermometers to measure air, water, and sand temperatures
- Transect square (“quadrat”) - any size
- 50 meter tape measure or rope line attached to a stake
- Plastic zip lock bags to collect small samples of the rocky beach
- Permanent marker to label bags

Logistics

Remember to check the tides prior to the trip and plan accordingly.

Rocks covered in seaweed can be slippery and footing uneven. Wear appropriate footwear and use caution when walking in the rocky intertidal zone.

Teaching Time

2 hours

Seating Arrangement

Group discussion and planning - sit as a group on the beach

Crab collecting - students spread out in teams or individually along a designated rocky beach area

Sorting and measuring - each group determines an effective and efficient method and arrangement to sort and measure crabs.

Breakout groups - small groups work with an adult in the designated area.

Crab Study and Beach Sample Station

Key Words

Asian shore crab (grapsid crab/ Japanese shore crab/ Pacific shore crab)

Ballast

Carapace

Clutch

Competition

Habitat

Intertidal zone

Invasive species

Native crab

Non-native species

Background Information

Background information about various species of native crabs found on a rocky beach at Long Island Sound may be located in the Sea Grant resources listed under The Sea Grant Connection, and in the leader packet.

More than 20 years ago, spider crabs, calico crabs and green crabs could easily be found on the rocky beach at Hammonasset by turning over rocks and looking in tide pools. Now, at the same beach a class-size number of students (~22) can usually find over 500 Asian shore crabs in 20 minutes. Students may find zero to ten green crabs on a given day at Hammonasset; the rest will be Asian shore crabs, a non-native species that was introduced 100 years ago to Long Island Sound.

The Asian shore crabs, also known as grapsid crabs, Japanese shore crabs, Pacific shore crabs, or *Hemigrapsus sanguineus* were first discovered on the shores of Cape May, New Jersey by a group of high school students and their teacher in 1988. It is believed that the crabs, in adult or larval state, were present in the Japanese waters taken in to balance cargo ships bound for the U.S. Upon arrival on the Atlantic coast, the ballast water was discharged, thereby introducing the species to a new habitat. Eventually the Asian shore crab population flourished in Cape May, New Jersey

and the crabs reproduced and extended their territory northward. These crab invaders can now to be found as far north as southern Maine.

By studying and recording information on the Asian shore crabs in Long Island Sound, your students will be part of a student network that is providing baseline invasive species data for scientists in New England, the

Long Island Sound Network (LISN) Email drand@crec.org for more information.

Students should be able to do the following:

- Safely pick up a crab
- Measure a crab (across the carapace at the widest spot) to the nearest millimeter
- Distinguish between male and female crabs (see page 10.20 in *Marine Animals of Southern New England and New York* by Howard M. Weiss)
- Identify a female crab bearing eggs
- Students in breakout groups should be able to use a wind meter and a thermometer.

Learning Procedure

Teacher Preparation

- Send for Long Island Sound resources from Sea Grant.
- Read and/or copy articles on invasive species including "Invasive Shore Crabs Give Kids Lesson" *Hartford Courant*, Friday, Oct. 13, 2006 - reproduced on pages 121-122, courtesy of the *Hartford Courant*.

Learning Procedure

At the beach

Whole group discussion and planning with students seated on the beach along with teacher and adult volunteers:

- Students will focus on the class question they have chosen to investigate (e.g.,

Crab Study and Beach Sample Station

how many crabs will they find on the rocky beach, will there be more males than females, will they find more large crabs than small crabs?)

- Students will make observations and collect their own data about the crab population living on the rocky shore of Long Island Sound on the specific day of their field trip.
- Students and teacher all identify and agree on boundaries for the collection area.
- Students and teacher agree on collection methods and have plenty of collection buckets near students to reduce the walking distance to deposit a collected crab.
- Students and teacher review safety strategies for handling rocks and walking near a water environment.
- Students and teacher agree on a timekeeper for the 20 minute collection period.

Twenty minutes to collect crabs

- Teams or individuals carrying buckets disperse into the designated collection area. Turn over rocks, check in pools of water and collect as many crabs as possible.
- While collection is taking place, an assigned person can set out in an organized manner the large, labeled containers for sorting crabs. Place a bit of sea water in each container.

One hour to measure and sort collected crabs (whole group)

- **IMPORTANT:** Choose a person to be responsible for recording official class data on the Crab Study Station Total Crab Count Data Sheet (page 86) and returning the data to school. This person should receive all final data tallies for every observed crab category in each session of crab collecting.

- Divide the work. Sort the crabs into the large containers or basins by gender and carapace size: small (<9mm), medium (9.1mm-1.8mm) and large (>1.8 mm).
- When all crabs have been sorted, count the number of crabs in each category and record this on the data sheet. Make note of females with eggs. Also record the total number of crabs caught. Indicate any other species of crabs collected.
- When the sorting, counting and tallying is completed, students should carefully return the animals to the approximate area from which they were taken

Breakout groups

These are especially good for students who choose to give up the opportunity to pick up crabs and are more interested in collecting additional data that is very valuable to the investigation. Retain this data for further reference back in the classroom.

Assign an adult volunteer to help with these small groups and record the information on the Beach Sample Station Data Sheet (page 85).

Weather group

- These students use wind meters and thermometers to record air, water and sand temperatures and general weather and water conditions.
- Record data on the Rocky Beach Sample Station Data Sheet.

Beach sample group

- A member of this small breakout group will place a stake at the edge of the water, then extend the rope or tape measure up to the highest point on the beach. Note this on the Rocky Shore Environment Map (page 119). This is the transect line.
- Place the quadrat at various intervals of noticeable biological or physical

Crab Study and Beach Sample Station

changes along the transect line.

- Note the composition of living and non living things that fill the quadrat and use the zip lock bags to collect small samples of the beach at each interval.
- Label each bag with: sample collector's name (and class or school), date, and height on shore (meter mark collected at).
- Number and mark the collection areas on the map.
- If desired, retain the samples for further study or comparison with other locations. Use this evidence to help students answer additional questions they may have about the environment of the Asian shore crabs.

Data collected on the rocky beach should be shared with the Long Island Sound Network (LISN email: drand@crec.org) and/or student or community newspapers. It should also be saved on a classroom or school computer server where the data can be retrieved and used for comparison in future studies

Learning procedure follow-up:

- Students generate questions about plant and animal life in Long Island Sound, and record these in their science journals.
- Students generate questions about animal life along the rocky shore of Long Island Sound and choose a class question they would like to investigate by making actual observations and collecting data at a rocky beach.
- Identify questions that can be answered by collecting data on a return trip to the same beach in the spring.
- Develop an if...then statement to support a research question you would like to investigate when you return to Long Island Sound in the spring.
- Use the beach samples and weather and water data to help support conclusions.
- Identify sources of error found in student data collection techniques.

The Sea Grant Connection

Exotic Aquatics on the Move - Indiana-Illinois Sea Grant www.iisgcp.org/edk-12/exoticsp/Japanese_Shore_Crab.htm

Invasive Species of Long Island Sound poster- Connecticut Sea Grant

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Marine Bioinvaders - MIT Sea Grant <http://massbay.mit.edu/exoticspecies/index.html>

Nab the Aquatic Invader - Sea Grant Network www.sgnis.org/kids

Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species - waterproof field guide/flip book - Connecticut Sea Grant

The "Me" Connection

Are there invasive species in my own backyard? Are there any other invasive species in the ocean or lakes?

Do I or people I know contribute to spreading invasive species from place to place?

Do invasive species matter to you? Why or why not? How important will this problem be to you in the future?

Do you think invasive species should be eradicated? Why or why not?

How can I learn more about invasive species?

Connection to Other Subjects

Art; Language arts; Math

Crab Study and Beach Sample Station

83

Evaluation

Student journals and written reflection, student news articles and PowerPoint presentations, student products, quiz, response to articles and research

Extensions

- Email invasive crab data to the Long Island Sound Student Network to drand@crec.org.
- Photograph individual specimens.
- Design a bulletin board or Power Point presentation depicting the environment and location where the specimens were found.
- Write an editorial to the newspaper about why life in Long Island Sound should be protected.
- Compare beach samples with samples from the sandy beach or with samples collected from other sites.
- Write an article in the school or town newspaper or website about this study and/or invasive species.
- Write an editorial in the school or town newspaper or website about this study and/or invasive species.
- Research Asian shore crabs and other invasive species.
- Create a bumper sticker that generates awareness of invasive species.
- Teach families or younger students about your findings at Long Island Sound.
- Analyze and graph data collected and compare crab data with data available from other student studies during past years.

Resources

Exotic Aquatics on the Move - Indiana-Illinois Sea Grant www.iisgcp.org/edk-12/exoticsp/Japanese_Shore_Crab.htm

Marine Animals of Southern New England and New York by Howard M. Weiss - CT DEP

Marine Bioinvaders - MIT Sea Grant:

<http://massbay.mit.edu/exoticspecies/invaders/hemi.html>

Nab the Aquatic Invader- Sea Grant Network

www.sgnis.org/kids

Salem Sound Coastwatch Marine Introduced Species identification card:

www.salemsound.org/mis/MISHemigrapsus.pdf

USGS invasive species information:

<http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=183>

Connecticut Science Frameworks

Grades K-2

K.2 Many different kinds of living things inhabit the earth.

K.3 Weather conditions vary daily and seasonally.

1.2 Living things have different structures and behaviors that allow them to meet their basic needs.

1.3 Organisms change their form and behavior as part of their life cycles.

1.4 The properties of materials and organisms can be described more accurately through the use of standard measuring units.

Grades 3-5

3.2 Organisms can survive and reproduce only in environments that meet their basic needs.

4.2 All organisms depend on living and nonliving features of the environment for survival.

4.3 Water has a major role in shaping the Earth's surface.

Grades 6-8

6.2 An ecosystem is composed of all the populations living a certain space and the physical factors with which they interact.

Crab Study and Beach Sample Station

Grades 9-10

10.5 Evolution and biodiversity are the result of genetic changes that occur over time in constantly changing environments.

10.6 Living organisms have the capacity to produce populations of unlimited size, but the environment can support only a limited number of individuals from each species.

New York Science Standards

Living Environment Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

Living Environment Key Idea 6: Plants and animals depend on each other and their physical environment.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- The characteristics of organisms (K-4)
- Life cycles of organisms (K-4)
- Regulation and behavior (5-8)
- Populations and ecosystems (5-8)
- Diversity & adaptations of organisms (5-8)
- Biological evolution (9-12)
- Interdependence of organisms (9-12)
- Behavior of organisms (9-12)

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 5: The Ocean supports a great diversity of life and ecosystems

Fundamental concept d: Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

Fundamental concept f: Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such

as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is “patchy”. Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.

Fundamental concept h: Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.

Fundamental concept i: Estuaries provide important and productive nursery areas for many marine and aquatic species.

Essential Principle 7: The Ocean is largely unexplored.

Fundamental concept b: Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Asian shore crabs (right) are easy to find in great numbers under intertidal rocks at Hammonasset (below) during low tide.



Rocky Beach Sample Station Data Sheet

Scientist's Name: _____ Class: _____

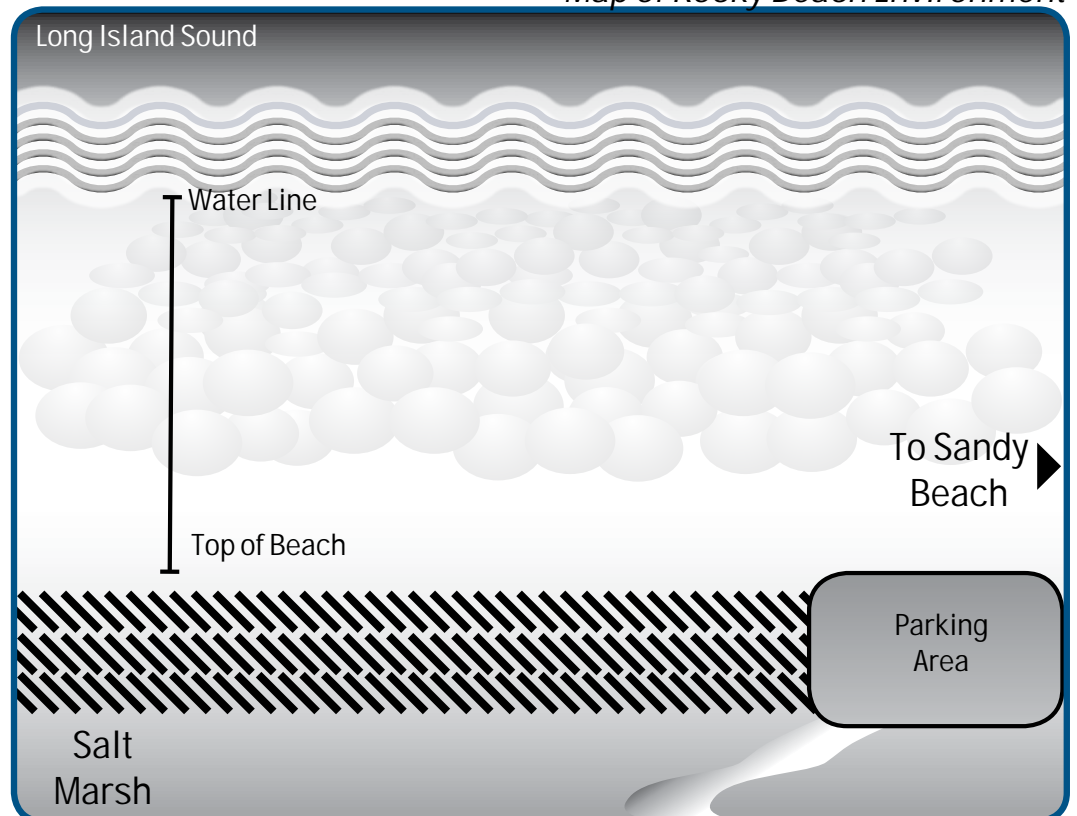
Date:	Time:	Location:
Tide: high mid low	Wind speed:	Wind direction:
Air temperature:	Water temperature:	Sand temperature:

General weather conditions:

Water conditions:

Any additional observations:

Map of Rocky Beach Environment



Crab Study Station

Crab Count Data Sheet

Scientist: _____ Date: _____ Time of Low Tide: _____

All numbers are for Asian Shore Crabs unless otherwise mentioned.

Report data to Long Island Sound Student Network (LISSN): drand@crec.org

Morning Data Time: _____

Type of crab	Small <9mm	Medium 9mm-18mm	Large >18mm	Total
Females				
Females with eggs				
Males				
Other (describe)				
Other (describe)				
Totals				

Afternoon Data Time: _____

Type of crab	Small <9mm	Medium 9mm-18mm	Large >18mm	Total
Females				
Females with eggs				
Males				
Other (describe)				
Other (describe)				
Totals				

It is your turn to use this data to help answer your own question!
 What question did you ask? How can you explain to others what you found out?

Use these data along with graphs, text and pictures to explain your thinking. You may add any additional information to help explain your story such as graphs and tables, drawings, habitat photos, real samples, wind and water information, etc.

Seining

87

Focus

Diversity of marine life in the shallow waters of a sandy beach in Long Island Sound

Focus Questions

What do you think you will find living here today? How can we find out what is living in the water of Long Island Sound? How are organisms structured to ensure efficiency and survival?

Learning Objectives

Working as a team, students will use a seine net and other tools to collect specimens and gather data in order to help them investigate a question about life in the shallow water of a sandy beach environment in Long Island Sound.

Materials

- Seine net and poles (2 sets recommended)
- Five-gallon buckets (4 or more)
- Chest waders - carry these in a large plastic tub or crate
- Life jackets
- Beach towel
- For each student:
 - Seining Data Sheet
 - Clipboard and pencil
- Weather and water equipment:
 - Hand-held wind speed indicator
 - Thermometers with probes
- Compass
- Digital camera with fresh batteries and memory card

Logistics

Water safety is a prime concern. An adult with strong swimming and life-saving experience should remain at this station throughout the day. If the water is warm enough, no waders are necessary when seining. Life jackets must be worn by all people in the water, if they are wearing waders or not. Even a strong swimmer can

be pulled underwater if waders fill with water. It is essential that, at all times, those on the shore carefully watch the participants in the water.

To facilitate the exchange of waders and life jackets, it is helpful to use the carrying crate as a bench for those changing into the waders. Use a beach towel underfoot to eliminate sand being brought into the waders.

The degree of adult help varies depending on the size and strength of the student seiners. One method is to have an adult stand behind each student seiner, with both holding the poles. Be aware that the out-seiner pair will be going deeper in the water. To avoid water getting in the waders, be certain that the water level and waves are below chest high.

Another method is to have a student seiner (with or without adult help) as the in-seiner and an adult as the out-seiner. At least one adult should be responsible for each seine net and set of seiners.

For efficiency, bring several waders of varying sizes, and have students geared up and ready for their turn in the water.

Teaching Time

Each small group of students (6-8 per group) rotates to this station every 30 minutes.

Seating Arrangement

Each group of students is involved in using and monitoring the seine net, taking weather and water measurements, recording an inventory of what is collected in the net and placing living specimens gently into the collection bucket.

Key Words

Air temperature	Seine net
Biodiversity	Seining

Seining

Biological inventory	Species
Environment	Specimen
Living	Water temperature
Organism	Wave height
Parallel	Wind direction
Perpendicular	Wind speed

Background Information

A 20-30 foot seine net is an excellent tool to collect organisms in the shallow waters of a sandy beach area. You will collect more netted specimens in the early fall season, September to mid-October, when the ocean is still warm in Long Island Sound.

Learning Procedure

Teacher Preparation

Prior to trip:

- Adults should be familiar with seining technique. One proven technique is described in the learning procedure section.
- Time can be saved by teaching students the seining technique prior to their visit to the beach. This can be made into an enjoyable physical education activity by having students seine for stuffed animals, small balls and other objects scattered on the gymnasium floor.

Preparation on site:

- Collection buckets partially filled with seawater are placed on the sand close to the water where seining will occur. These buckets will hold specimens for further study, and can be carried to the Beach Lab station.
- Place all equipment on dry sand near the water's edge.

Learning Procedure

- The two people using each seine net will wear life jackets and, if the water is cool, chest waders. Life jackets should be worn by all people in the water, with or without

waders. The taller adult should be in the deeper water.

- The other members of this group should help to tie the net to the poles, set the net straight ensuring that the floaters are on top and the weights are on the bottom, and help the seiners prepare to enter the water.
- Seiners enter the water perpendicular to the beach with the taller person (the out-seiner) in the deeper water and the shorter person (the in-seiner) closer to the shore. The out-seiner should go no farther into the water than just below chest level.
- The seiners then pull the net smoothly as they walk backwards, parallel to the beach, yet keeping the net perpendicular to the beach. Each pole should be held at a slight angle so the bottom of the pole is close to the sand near the seiner's feet, and the top of the pole is tipped away from the seiner. This position is optimal for catching sea creatures, and prevents the creatures from swimming out under the net.
- When the seine net has been pulled far enough, the in-seiner "plants" the pole and holds it in place. The out-seiner then pulls the net toward the shore, forming a horseshoe shape.
- When the two seiners are an even distance from the shore, they pull the net toward the beach, closing the net slightly if necessary, continuing to keep the poles tipped.
- The group helps to pull the seine net up onto the sandy beach where it is stretched out flat; everyone helps to take specimens from the net and gently place them into the collection bucket.
- One person from each group should be responsible for recording on their data sheet the approximate number and types of organisms found in the seine net hauls.
- While the seining is going on, one or two

students in each group may be assigned to record weather observations and water conditions.

- The collection bucket is carried to the Beach Lab Station at the end of each seining group. Specimens collected will be examined at the Beach Lab-Marine Biology Field Station. Someone also has to be available to return the buckets from the Beach Lab-Marine Biology Field Station to the Seining Station for refilling.

The Sea Grant Connection

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Living Treasures: The Plants and Animals of Long Island Sound - Connecticut Sea Grant.

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

The "Me" Connection

What did it feel like to be part of a seining team? What did you notice about the specimens you collected? What are you still wondering about? Were you surprised to find the number and/or the variety of organisms you found today in the net? What was most interesting to you at this station?

Connection to Other Subjects

Art; Language arts

Evaluation

Student data sheets, student journals and written reflection, quiz

Extensions

Photograph individual specimens. Develop a field guide for classroom use.

Design a bulletin board or Power Point presentation depicting the environment and location where the specimens were found.

Seaweeds collected may be formed into a collage or design, or preserved according to the techniques presented in the publication *Seaweeds of Long Island Sound* (reproduced on page 125).

Write an essay describing why life in Long Island Sound should be protected. Submit your essay to your local newspaper.

Resources

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Beachcomber's Guide to the North Atlantic Seashore - Massachusetts Audubon Society

Living Treasures: The Plants and Animals of Long Island Sound - Connecticut Sea Grant

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Marine Animals of Southern New England and New York by Howard M. Weiss - CT DEP

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species waterproof field guide/flip book - Connecticut Sea Grant

****There are no frameworks, standards, or principles for this activity.**

Seining



◀ To begin, the out-seiner walks the net out into the water until it is stretched out between the out-seiner and the in-seiner and the net is mostly submerged at both ends.

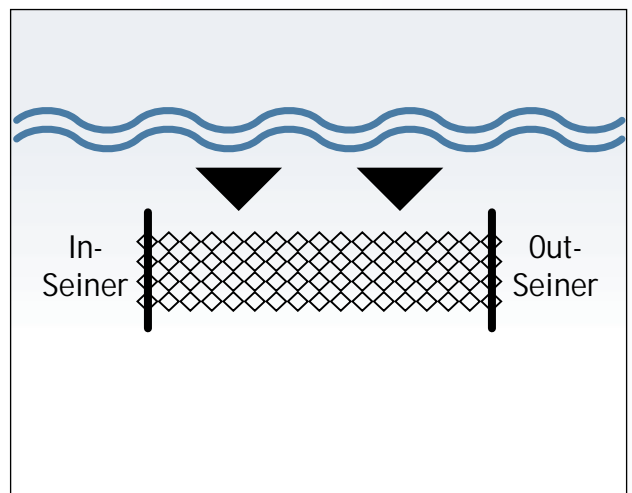
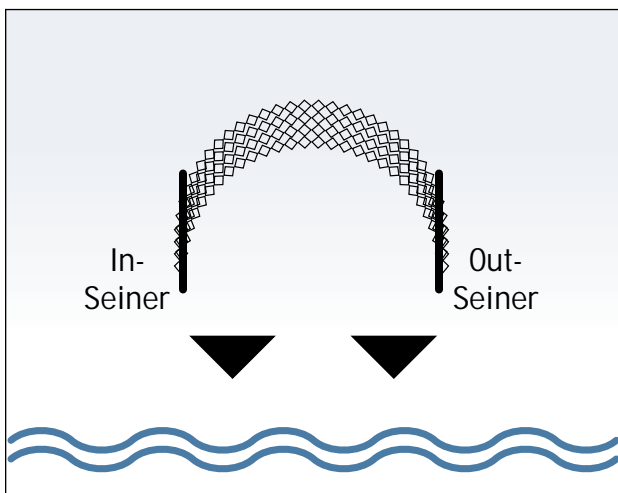
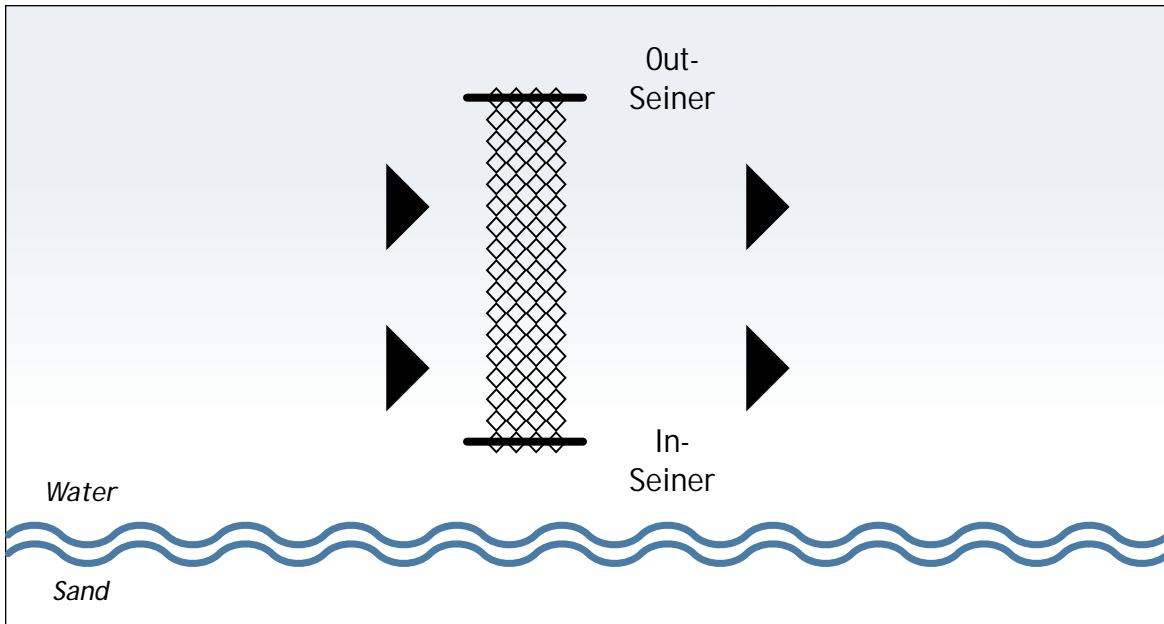
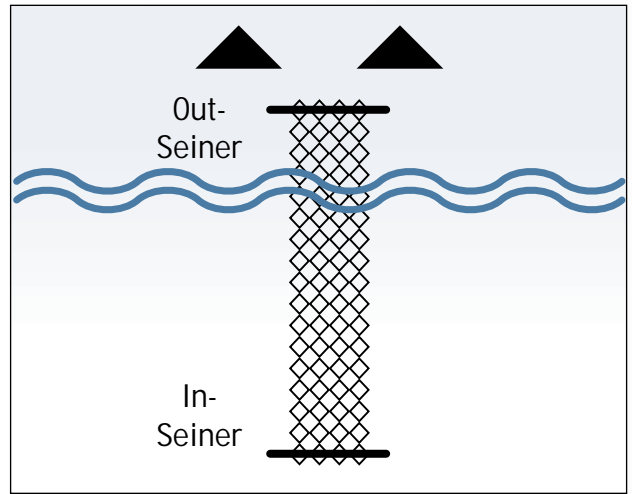
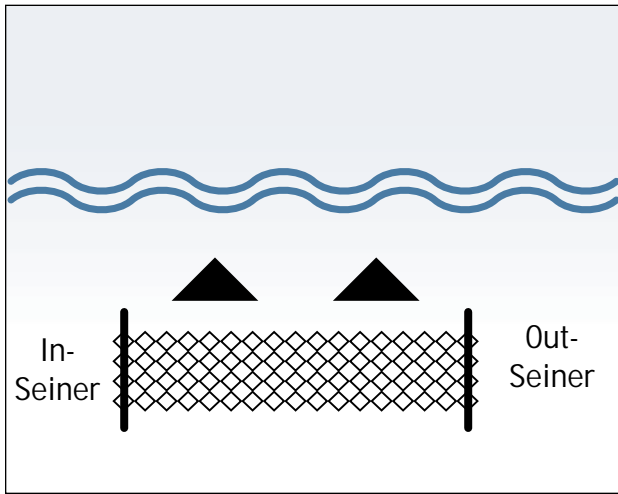
Once the net is brought out into the water the out-seiner and in-seiner walk in sync, drawing the net in one direction while keeping the net tilted. ▶



▶ When the net is ready to be brought to shore, the in-seiner remains stationary as the out-seiner brings the outer end of the net shoreward.

The net is stretched out when brought back to shore and the sorting can begin. ▶





Seining Data Sheet

Scientist's Names:

Class:

Date:	Time:	Location:
Tide: high mid low	Wind speed:	Wind direction:
Air temperature:	Water temperature:	Sand temperature:

General weather conditions:

Water conditions:

What was found in the net?

(If you are unsure of the name of the organism, just describe it as well as you can.)

Type of Life	Approximate Number Found

Beach Lab - Marine Biology Field Station

Focus

Structure and function: organisms are structured to ensure efficiency and survival.

Focus Questions

What life can be found in the water of Long Island Sound? How does life survive between the tides? What structures and systems help these living things sense their underwater world?

Learning Objectives

- Students will use microscopes, hand lenses, resource guides, and appropriate handling techniques to observe and investigate organisms collected in a seine net.
- Students will gather information to help them identify structures the organisms use for surviving and sensing their environment.
- Students will identify several animals and plants that live in the water of Long Island Sound.

Materials

- Magnifiers
- Dissection microscopes
- Petri dishes
- Variety of plastic containers
- Basin
- Eye droppers
- Millimeter rulers
- Sharp pencils
- Beach Lab - Marine Biology Field Station Data Sheets (pages 97-98)
- Clipboards
- Extra paper
- Camera with fresh batteries & memory card
- Small fish net or strainer
- Battery operated bubbler (optional) - available in bait shops and pet stores
- Five-gallon buckets (4 or more)
- Fold-up table if none is available on site

- Optional: cooler to take specimens back to school
- Resources and field guides
 - *Beachcomber's Companion*® - Woods Hole Oceanographic Institute Sea Grant
 - *Beachcomber's Guide to the North Atlantic Seashore* - Massachusetts Audubon Society
 - *Connecticut College Bulletin No. 34- Tidal Marshes of Long Island Sound Ecology, History, and Restoration*
 - *Living Treasures: The Plants and Animals of Long Island Sound* - Connecticut Sea Grant
 - *Marine Animals of Southern New England and New York* by Howard M. Weiss - CT DEP
 - *Seaweeds of Long Island Sound* by Margaret "Peg" Van Patten - Connecticut Sea Grant
 - *Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species* waterproof field guide/flip book - Connecticut Sea Grant

Logistics

If this is the first station of the day, while other students are seining, students at this station set up equipment. Make sure to get the specimens from the first seine net pulled of the day.

Make sure that the microscopes are positioned so that the Sun may be used as a light source. Place resources and utensils within reach of the microscopes.

By using battery operated bubblers in buckets, most specimens can be kept at this station for several hours.

If specimens are to be taken back to school for further study, prepare the salt water tank at least one day in advance. See Important Note Regarding Specimens, page 78.

Beach Lab - Marine Biology Field Station

Teaching Time

Each small group of students rotates to this station for twenty to thirty minutes.

Seating Arrangement

A picnic table with microscopes (facing sunlight if possible) and work space set up as a biology observation station for each group of 6-8 students.

Key Words

Behavior	Lateral line
Brain	Locomotion
Camouflage	Millimeter
Centimeter	Nerves
Environment	Non-living
Eggs	Observation
Field Guide	Organism
Fins	Sessile
Gills	Structure
Holdfast	Vibrations

Background Information

Life survives between the tides. All organisms need food and have different methods and structures for obtaining food. Organisms also need to get rid of wastes.

All organisms use a structure or system to obtain oxygen in a water environment.

All organisms need protection from predators. This protection may be camouflage, special body parts, a heavy protective outer layer, etc.

All organisms need to reproduce. Organisms may or may not need to move around. Some organisms are sessile, or immobile, and only move in their larval stage. Once the adult phase is reached the organism stays in one place. The diverse animals found in the water reveal a wide range of structures and methods for locomotion or staying in one place.

Certain structures help living things sense the underwater world. Some organisms show sensitivity to light, shadows, vibrations, sound, touch, smell, taste, or movement of the water.

Learning Procedure

Teacher Preparation

- At school, gather and pack equipment and materials for the Beach Lab - Marine Biology Field Station.
- At the beach, set up equipment and resources at a picnic table or bring a fold-up table
- Just prior to this activity, students use a seine net to collect specimens of marine plants and animals. Specimens are placed in a large bucket of seawater for easy transport to the Beach Lab - Marine Biology Field Station. See the Seining lesson on page 87 for collecting specimens.

Learning Procedure

- A student gently scoops a specimen from the collection bucket and places the organism with seawater in an appropriate size plastic container or Petri dish for observation.
- Students look at a variety of specimens collected and choose one specimen to observe closely. Students use their own senses, magnifiers, microscopes, rulers, and field guides to identify structures and systems that help the organism survive in Long Island Sound. They record questions and observations in their Beach Lab - Marine Biology Field Station Data Sheets. Special attention is given to answering questions about how this organism uses its senses and survives in Long Island Sound.
- Students also identify the organism, record information and create a sketch on their data sheet. On location, students use the resources provided, and

Beach Lab - Marine Biology Field Station

95

record their findings in their journals. To identify the organism in the classroom, students use the recommended resources along with the information and drawings they recorded in their journals while at the beach lab to identify the organism.

- Optional: photograph and/or video-tape the variety of specimens collected. Photographs can be used for further study at the school.

The Sea Grant Connection

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Living Treasures: The Plants and Animals of Long Island Sound - Connecticut Sea Grant

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

The "Me" Connection

What structures or systems do we as humans use to survive in our environments?

Why is it important to establish a data base or animal and plant inventory of Long Island Sound? How will this help future scientists?

Connection to Other Subjects

Art; Language arts

Evaluation

Student data sheets, student science journals, written reflection, quiz.

Extensions

- Photograph individual specimens.
Develop a field guide or podcast for

classroom use or produce a movie of animal movement and response to stimuli.

- Design a bulletin board or Power Point presentation depicting the environment and location where the specimens were found.
- Form a collage or design from seaweeds collected and preserved according to the techniques presented in *Seaweeds of Long Island Sound* (reproduced on page 125).
- Write an article or editorial to the newspaper about why life in Long Island Sound should be protected.

Resources

Beachcomber's Companion® - Woods Hole Oceanographic Institute Sea Grant
www.beachcomberscompanion.net

Beachcomber's Guide to the North Atlantic Seashore from Massachusetts Audubon Society

Connecticut College Bulletin No. 34 - Tidal Marshes of Long Island Sound - Ecology, History, and Restoration

Living Treasures: The Plants and Animals of Long Island Sound - Connecticut Sea Grant

Marine Animals of Southern New England and New York by Howard M. Weiss - CT DEP

Seaweeds of Long Island Sound by Margaret "Peg" Van Patten - Connecticut Sea Grant

Connecticut Science Frameworks

Grades K-2

K.2 Many different kinds of living things inhabit the earth.

1.2 Living things have different structures and behaviors that allow them to meet their basic needs.

1.3 Organisms change their form and behavior as part of their life cycles.

1.4 The properties of materials and organisms can be described more

Beach Lab - Marine Biology Station

accurately through the use of standard measuring units.

Grades 3-5

3.2 Organisms can survive and reproduce only in environments that meet their basic needs.

4.2 All organisms depend on living and non-living features of the environment for survival.

4.3 Water has a major role in shaping the Earth's surface.

Grades 6-8

6.2 An ecosystem is composed of all the populations living in a certain space and the physical factors with which they interact.

Grades 9-10

10.5 Evolution and biodiversity are the result of genetic changes that occur over time in constantly changing environments.

10.6 Living organisms have the capacity to produce populations of unlimited size, but the environment can support only a limited number of individuals from each species.

New York Science Standards

Living Environment Key Idea 5: Organisms maintain a dynamic equilibrium that sustains life.

Living Environment Key Idea 6: Plants and animals depend on each other and their physical environment.

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard C: Life Science

- The characteristics of organisms (K-4)
- Life cycles of organisms (K-4)
- Regulation and behavior (5-8)

- Populations and ecosystems (5-8)
- Diversity & adaptations of organisms (5-8)
- Biological evolution (9-12)
- Interdependence of organisms (9-12)
- Behavior of organisms (9-12)

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 5: The Ocean supports a great diversity of life and ecosystems.

Fundamental concept a: Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.

Fundamental concept c: Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.

Fundamental concept d: Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.

Fundamental concept e: The Ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.

Fundamental concept h: Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.

Fundamental concept i: Estuaries provide important and productive nursery areas for many marine and aquatic species.

Beach Lab - Marine Biology Station

Data Sheet

Scientist's Name: _____ Date: _____




Directions: After observing several specimens, choose one to study more closely. Draw and label it here (include measurements).







Beach Lab - Marine Biology Station

Data Sheet

98

-  In your drawing, identify and label the structures the organism uses to eat, breathe, protect itself, move, or stay in one place.
-  If this is an animal, think about how *you* use your senses (sight, smell, hearing, taste, touch) to survive and to react to your environment. Then notice which senses *this organism* uses to respond to changes in its water environment.
-  In your drawing, identify and label the structures that the organism uses to sense its environment. Write your observations and conclusions below. Here are some suggestions and questions to guide you: Is this living thing sensitive to light or to shadow? Does it respond to vibrations? Slight touch? Movement of the water? Sound? Where does this sensor seem to be located? What does this sensor look like?

-  What do you notice about the movement (or lack of movement) of this organism?
-  What questions do you have about your specimen?
-  Which books or guides did you use to identify this organism? What is its common name? Scientific name?
-  What is the most interesting feature this organism has which distinguishes it from other types of organisms?

Sifting Sands and Shifting Tides

Focus

Energy in the Earth's Systems -Erosion, weathering, and glaciation change the Earth's surface by moving earth materials from place to place.

Water, wind and the moon's affect on tide levels will produce changes in a beach over a relatively short time, seasonally, and also over a long period of time or a longer geologic timeframe.

Focus Questions

What makes up a beach? Is a beach a pile of sand? Does a beach ever change?

Learning Objectives

Students will compare and contrast beach samples and look for patterns and clues that may indicate changes to the beach over a relatively short time and a long time.

Materials

- Four-piece or five-piece geology sieve
- Metric measuring containers in various sizes (largest must be able to hold 300ml)
- 100 meter measuring tape or a marked rope
- Wood stakes to mark distances at water line, mid-beach, bottom of dune (Optional: more stakes to mark more sample places)
- Sand gauge or mm rulers to compare grain sizes
- Zip lock plastic bags to collect sand samples
- Permanent markers to label bags
- Sheets of contact paper cut in 6-inch squares to collect sand samples
- Clipboards
- Pencils
- Sifting Sands and Shifting Tides Data Sheets (page 103) and Sifting Sands and Shifting Tides Sand Sampling sheets (page 104)

Logistics

- This activity works best on a stretch of sandy beach with several meters of beach between the wrack line and the dunes.
- Be sure to do the waterline section first as this will change with the tide.
- Check tide charts and weather prior to going out to the field site.

Teaching Time

A small group of students rotates to this station for 20-30 minutes.

Seating Arrangement

On location at the beach, students are in small groups (6-8 students).

Key Words

Dune grass	Sand dune
High water mark	Sand grain
Liter	Sieve
Milliliter	Tide
Particle size	Wrack Line

Background Information

Many students will assume that a beach is a homogeneous environment; lots of sand or rocks. By asking students to take a close look at a beach environment as they walk from the water line to the dune they will begin to observe patterns in beach composition such as sand grain and particle size, structure, and whether they find evidence to support life. On closer observation, sand and rocks can also be sorted by shape of particles such as rough edges or whether the samples have been rounded down over a long period of time.

Be sure students understand that the water line changes with the ebb and flow of the tides. Materials carried in the water are carried out onto the beach where they settle, creating a wrack line of material deposited at the high tide mark. At low tide, the area of the beach between high and low tide marks

Sifting Sands and Shifting Tides

(the intertidal area) is exposed to the air; at high tide this area is under water. Heavier objects tend to remain closer to the water line, whereas the forces of wind bring lighter particles of sand and dried plant and animal material higher up the beach where they are stopped by the dune and plants.

Water, wind and the moon's effect on tide levels will produce visible changes in a beach over a period of 24 hours. Seasonally, winter storms can make dramatic changes to a beach. Over a geologic timeframe the beach has changed during the periods of past glaciations (see the Connecticut Department of Environmental Protection's Hammonasset Geologic History article on page 114). Based on evidence they observe, students may want to make predictions about future changes to the beach environment.

Plants growing on sand dunes are vital and delicate. Students should know to stay off the plants growing on any sand dune as any human impact can damage or kill plants that serve to hold the sand on the dune and minimize beach erosion.

Learning Procedure

- Upon arrival, the first small group lays out the measuring tape from the water line or zero meter mark to the base of the sand dune (remind students not to step on the plants growing on the dune). Use a rock to pound a stake into the beach at the waterline. Record the time of day.
- Students next make observations about where they see changes in the beach and they pound stakes at those points on the beach (the stakes can also be placed at

Low tide reveals wrack lines of debris left by successive high water lines (left) and occasionally a deliniation of different sediment sizes and types (right).



Sifting Sands and Shifting Tides

101

- regular 10 meter intervals.)
- Complete the Sifting Sands and Shifting Tides Data Sheet (page 103).
 - The first small group of students selects one staked area to study. Usually the first spot chosen is at the waterline as the tide coming in may cause the first stake to be under water later in the day. Other groups select other points along the rope or tape measure and they follow the same procedure.
 - Collect 300 ml of sand. Use the sand sieve to sort according to grain size. Use the volume containers to measure the amount of sand in each section of the sieve.
 - Ask the students what they notice about the sand in each of the sieve sections. Use the sand gauge or mm ruler to compare grain sizes, shape and composition. Discuss and complete the Sand Sampling (page 104). This information can be further analyzed back at your school.
 - Place each of the samples labeled with the collection location in a zip lock bag to bring back to school for further investigation.
 - AND/OR Take a piece of contact paper, hold the sticky side down on the sand and rub the smooth side with your hand to press sand grains onto the sticky paper at each collection location.
 - Take a photo of each collection location (optional).

The Sea Grant Connection

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

The "Me" Connection

How do you think this beach will change

during your lifetime? What evidence do you see to support this idea?

How have humans influenced this beach environment? How have you affected this beach environment today?

Would this beach environment be a good place to build a house? A hotel? A theme park?

Connection to Other Subjects
Art; Language Arts; Math; Social Studies

Evaluation

Student recorded observations, data collected on student data sheets

Extensions

In the classroom or lab, compare and contrast samples taken at various points on the beach to find evidence which support original focus questions.

Recreate the beach study on a bulletin board using the actual sand samples and/or contact paper samples.

Hold a debate based on an article about beach erosion and \$2 million restoration project at Hammonasset State Beach: www.ct.gov/governorrell/cwp/view.asp?A=1761&Q=290464

Go at a different time of year and compare results.

Resources

Tides and Water Levels - NOAA Ocean Service Education <http://oceanservice.noaa.gov/education/kits/tides/welcome.html>

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound* and *Living Treasures: Plants and Animals of Long Island Sound* - Connecticut Sea Grant

Sifting Sands and Shifting Tides

Connecticut Science Frameworks Grades 3-5

4.3: Water has a major role in shaping the Earth's surface.

Grades 6-8

7.3: Landforms are the result of the interaction of constructive and destructive forces over time.

New York Science Standards

Standard 6: Interconnectedness: Common Themes: SYSTEMS THINKING: Through systems thinking, people can recognize the communalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.

National Science Education Standards Content Standard D: Earth and Space Science

- Structure of the Earth System

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 2: The ocean and life in the ocean shape the features of the Earth.

Fundamental concept c: Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

Fundamental concept d: Sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources by surf. Sand is redistributed by waves and coastal currents seasonally.

A set of sieves is used to sort the sediments into different size classes.



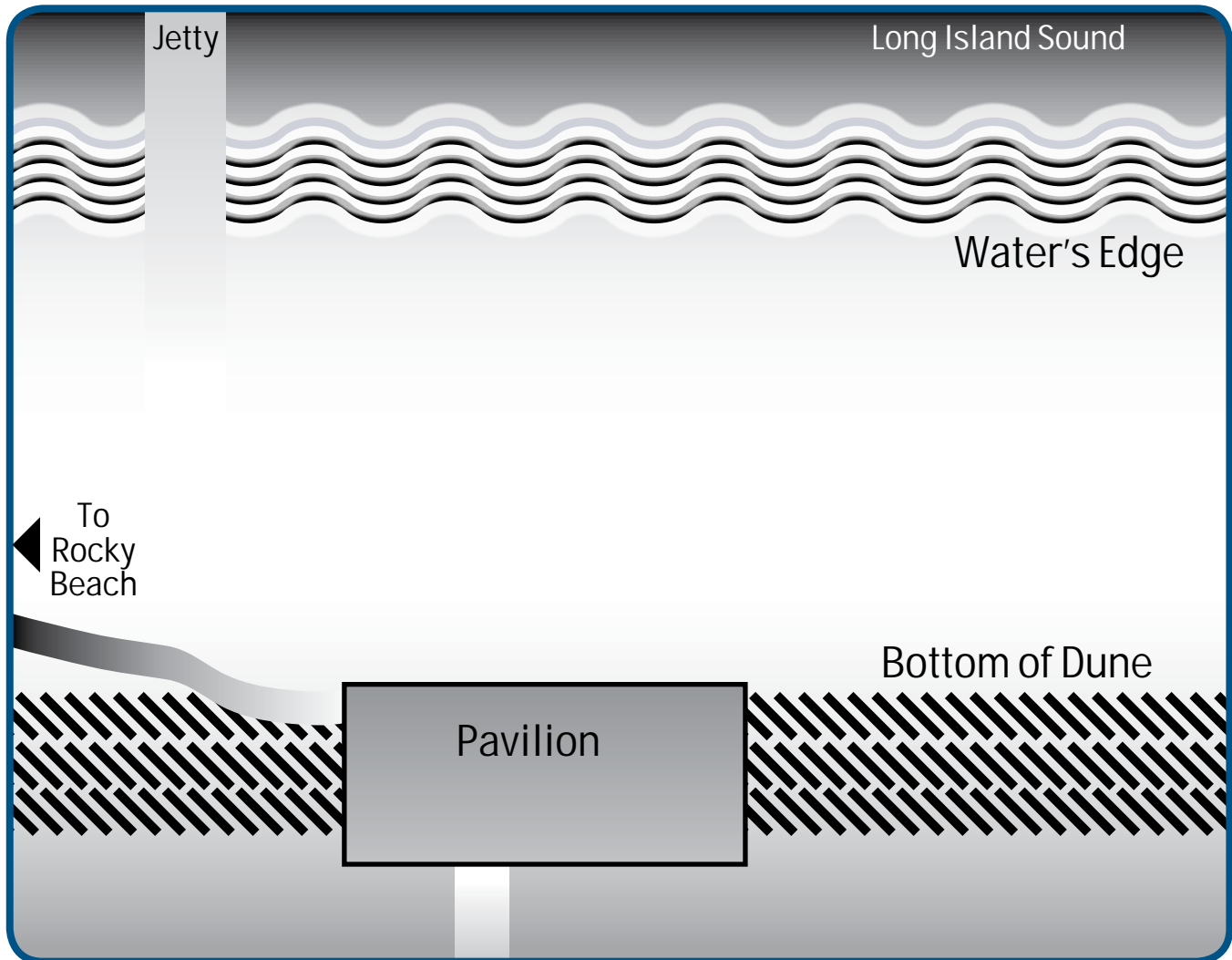
Sifting Sands and Shifting Tides

Data Sheet

103

Scientist's Name: _____ Date: _____

Time: _____ Tide: High Mid Low



As a group, RECORD THE TIME, MEASURE (approximately) on land AND MARK on the map your answers to the following questions:

- 1) About how far is it from the water line to the base of the grassy sand dune?
- 2) About how far is it from the water line to the first wrack line you come to?
- 3) How many wrack lines do you see on the beach today?
- 4) What do you notice about the changes in the sand? Color? Texture? Size?
- 5) Do you find anything else in the wrack line besides sand?

Sifting Sands and Shifting Tides

Sand Sampling

104

Scientist's Name: _____ Date: _____

Sand sample location (estimate distance from the bottom of the sand dune): _____

Additional comments about the location:

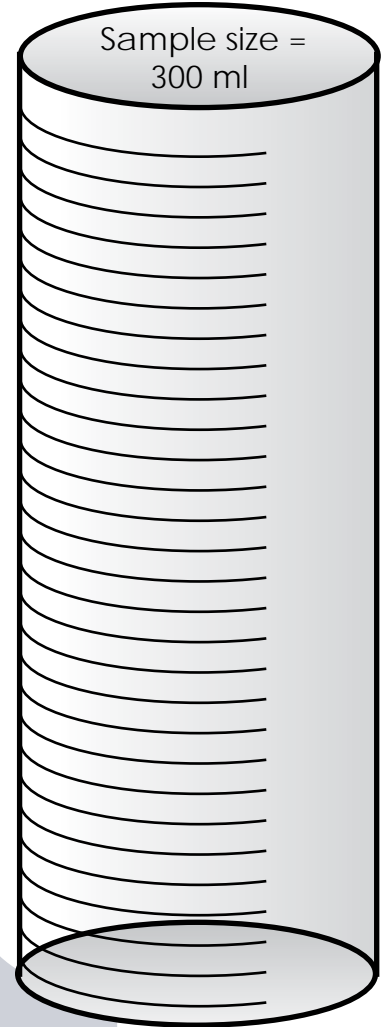
_____ ml _____ grain size

_____ ml _____ grain size

_____ ml _____ grain size

_____ ml _____ grain size

_____ ml _____ grain size



● What do you notice about your sand sample?

● Where do you think this sand came from?

● Where do you think this sand is going next?

● Compare the sand in your sample to the sand in another location.

● What do you wonder about this comparison?

Aesthetic Connection to Long Island Sound

Focus

Long Island Sound provides a wealth of opportunities to help students make positive connections to the natural world. As students develop an appreciation for the environment through personal artistic expression they are developing an important foundation and motivation for future study.

Four activities are explained here. It is recommended that one activity be chosen for each field trip to Long Island Sound.

Focus Questions

How can I express what I see and feel at this ocean environment? In what ways can I demonstrate my creativity and thoughts about the Long Island Sound environment?

Learning Objectives

Artistic Overview - drawing:

Students will create a three-dimensional drawing depicting the environment.

Aesthetic Overview - creative writing:

Students will use language arts techniques as a means of self-expression and communication regarding the environment at Long Island Sound.

Seaweed Collage:

Students will create a collage made from seaweed collected on site.

Photo Montage:

Students will create a photogram using photosensitive paper and objects from nature.

Materials

Artistic Overview - drawing (for each person):

- Aesthetic Connection to Long Island Sound Drawing Template (page 109)
- Drawing pencil, eraser
- Clipboard or backer board
- Tape and scissors for a group leader if completing the project on site

Aesthetic Overview - writing (for each person):

- Several sheets of writing paper
- Pencil or pen
- Clipboard

Seaweed Collage (for each person):

- Several sheets of stiff paper, 80 lb weight. Glossy, stiff paper works well.
- Basin large enough to accommodate paper, seawater and seaweed specimen
- A variety of seaweeds collected on site - Keep these in a bucket of seawater until ready to use.

Photo Montage (for each person):

- One or more sheets of photosensitive paper (Nature Print), found in craft stores
- Cardboard
- Small pieces of masking tape
- Objects from nature collected onsite
- Box with cover to protect completed montages
- Black construction paper cut to the size of the photosensitive paper - to separate the montages in the box
- Stopwatch or timer

Logistics

- For the seaweed collage and photo montage, items must be collected from the site.
- When collecting seaweed for the seaweed collage, try to use fresh material from the wrack or drift to avoid disturbing natural populations.
- Know that the weather conditions and time of year may affect the experience. Warmer weather brings more visitors to field sites and seasonal variations bring changes in flora, fauna, and beach appearance.
- Establish boundaries and time limits for students prior to dispersal.

Teaching Time

Each small group of students rotates to this station for 20-30 minutes.

Aesthetic Connection to Long Island Sound

Seating Arrangement

Artistic and Aesthetic Overviews:

Random seating within stated boundaries.

Seaweed Collage and Photo Montage:

Form a circle for ease of viewing.

Key Words

Aesthetic

Collage

Free write

Horizon

Montage

Photosensitive

Background Information

An important aspect of Long Island Sound is its recreational use. People come to the Sound to enjoy the beach, to bird watch, and to escape from the pressures of everyday life. Although not often mentioned, the aesthetic and inspirational attraction of Long Island Sound is difficult to place a value on.

Learning Procedure

Artistic Overview- drawing

- Distribute pencil, clipboard or backboard and Aesthetic Connection to Long Island Sound Drawing Template.
- Assignment is given - within the designated boundaries, select an area from which you will draw what you observe. In the small triangle, sketch what you see from your location to the horizon line. Draw the sand, shells, plants, etc. Avoid drawing in the X area.
- In the large triangle, record the larger view by sketching what you see at and above the horizon.
- If completing the work on site, cut the square out when finished and then cut along the dotted line. Bring the two corners (marked *) of the paper together and overlap them. Doing so will cause the top of the paper to stand up, creating a three dimensional diorama-like display. Secure with tape.

- If following up in a subsequent class, use watercolor or colored pencils to complete the artwork. Then overlap the two lower corners as described above and secure with tape.

Aesthetic Overview -Writing

- Distribute writing materials to the students.
- Students are encouraged to pause and become aware of all of their senses. They are asked to take "snapshots" or "thoughtshots" of the area and consider what they want to remember when returning home. Depending on what students are learning in their language arts classes they can be asked to write a poem, a haiku, or even to free write. Illustrations are encouraged.
- Students can disperse into the assigned area to work.
- Their writings can be shared on site or in the classroom.

Seaweed Collage

- Prepare a basin with seawater at the selected site.
- Students collect seaweed specimens in water-filled buckets, then gather around the basin.
- Place one sheet of paper in the basin, making sure that it becomes coated with seawater.
- Float a seaweed specimen out in the seawater on the paper and arrange in an appealing manner.
- Slowly lift the paper at a gentle slope, allowing water to drip off.
- Arrange or adjust the seaweed further if necessary to spread it out and be sure that it is not too clumped.
- Set the seaweed-paper ensemble aside to dry. The seaweed will adhere to the paper because it contains a natural binding substance. No glue is needed.
- If desired, several specimens can be layered or arranged on the paper to form an abstract or representational design.

Aesthetic Connection to Long Island Sound

107

- Another option: Use the preservation method described in *Seaweeds of Long Island Sound*, by Margaret “Peg” Van Patten, reproduced on page 125.

Photo Montage

- Staying within the stated boundaries, each student collects several objects from nature, looking for variety in texture, shape and translucency. Bring the collections together.
- With back to the sun so each student is working in a shady space, individuals arrange their objects in a pleasing design on the cardboard.
- Quickly distribute the photosensitive paper. If conditions are windy, you may want to use small pieces of tape to secure the paper to the cardboard. Reproduce the arrangement on the photosensitive paper.
- Students move so their work is now in the sunlight. Process the montage in the sun according to package directions - anywhere from several seconds to several minutes.
- Remove the objects and place the papers in the box, separated by black paper until the processing and setting of the arrangement is complete.

The Sea Grant Connection

Seaweeds of Long Island Sound by Margaret “Peg” Van Patten - Connecticut Sea Grant

The “Me” Connection

- What is your overall impression of this area?
- Do you feel different when you are at the shore than when you are at home? In what ways?
- How can I share my enjoyment of Long Island Sound with others?
- What is my part in keeping this environment clean?

Connection to Other Subjects
Art; Language Arts

Evaluation

Teachers use their own rubrics to assess student work. Artwork and writing produced at this station can enhance the presentation of student science work.

Extensions

Use the artwork created at this station to support presentations of student science work.

Set your poem to music.

Include a display of the shore-related artwork at an all-school sharing of the Long Island Sound adventure.

Combine the writings, illustrations and photographs into a booklet.

Resources

Seaweeds of Long Island Sound by Margaret “Peg” Van Patten - Connecticut Sea Grant

How to Preserve Seaweed instructions (page 125)

Connecticut Science Frameworks

Grades K-2

- K.2 Many different kinds of living things inhabit the earth.
- 1.2 Living things have different structures and behaviors that allow them to meet their basic needs.
- 1.3 Organisms change their form and behavior as part of their life cycles.

Grades 3-5

- 4.2 All organisms depend on living and nonliving features of the environment for survival.

Aesthetic Connection to Long Island Sound

New York Science Standards

Living Environment Key Idea 6: Plants and animals depend on each other and their physical environment.

National Science Education Standards

Content Standard G: History of Nature and Science

- Science as a human endeavor

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably interconnected.

Fundamental concept c: The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

Fundamental concept e: Humans affect the ocean in a variety of ways. Laws,

regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

Fundamental concept g: Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

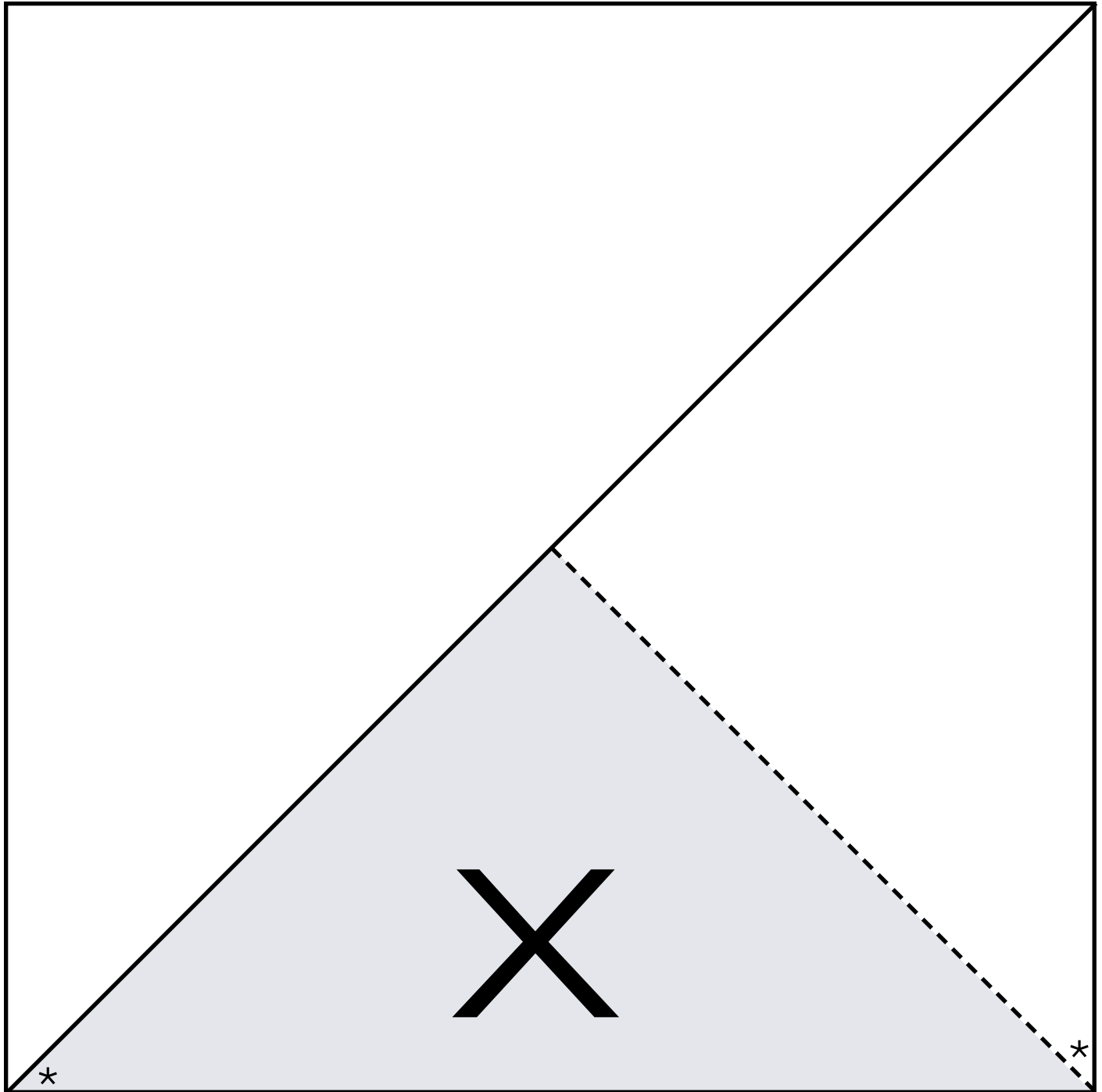
Special thanks to Dan Kaplan, Art teacher, East Hartford/Glastonbury Elementary Magnet School.



Aesthetic Connection to Long Island Sound Drawing Template

109

In the small triangle, with the long side on the bottom, draw everything you see in the foreground *below the horizon*. In the large triangle, with the long side on the bottom, draw everything you see *on and above the horizon*. Avoid drawing in the shaded triangle.



When your drawing is complete, cut along the dotted line. Bring the two * together, overlapping the shaded triangle. Secure with tape.

LEADER PACKET

Science Lessons at a Long Island Sound Field Site

The following pages include information necessary and helpful for conducting the Science Lessons at a Long Island Sound Field Site. Important information including maps, fee and permit specifications, as well as sources for materials have been added to facilitate the process of arranging for and conducting these lessons. While some of the information is specific for Hammonasset State Park in Connecticut, the rest is still relevant to any appropriate field site at Long Island Sound.



Science Lessons at a Long Island Sound Field Site - Leader Packet

Contents:

111	Directions to Hammonasset State Park	
112	Map of Hammonasset State Park	
113	Permits and Fees	
114	Geology of Hammonasset State Park	
116	Master checklist of materials	
118	Where do we get all that gear?	
119	Map of Rocky Shore Environment	
119	Map of Sandy Beach Environment	
120	Sample Scientific Collector Permit for Aquatic Species	
121	“Invasive Shore Crabs Give Kids Lesson” from the <i>Hartford Courant</i>	
76	Schedule of the day*	<i>*This item is not in this section but should be included when making copies for instructors and helpers.</i>
125	How to Preserve Seaweed*	<i>*This item is not in this section but should be included when making copies for instructors and helpers.</i>

Directions to Hammonasset State Park

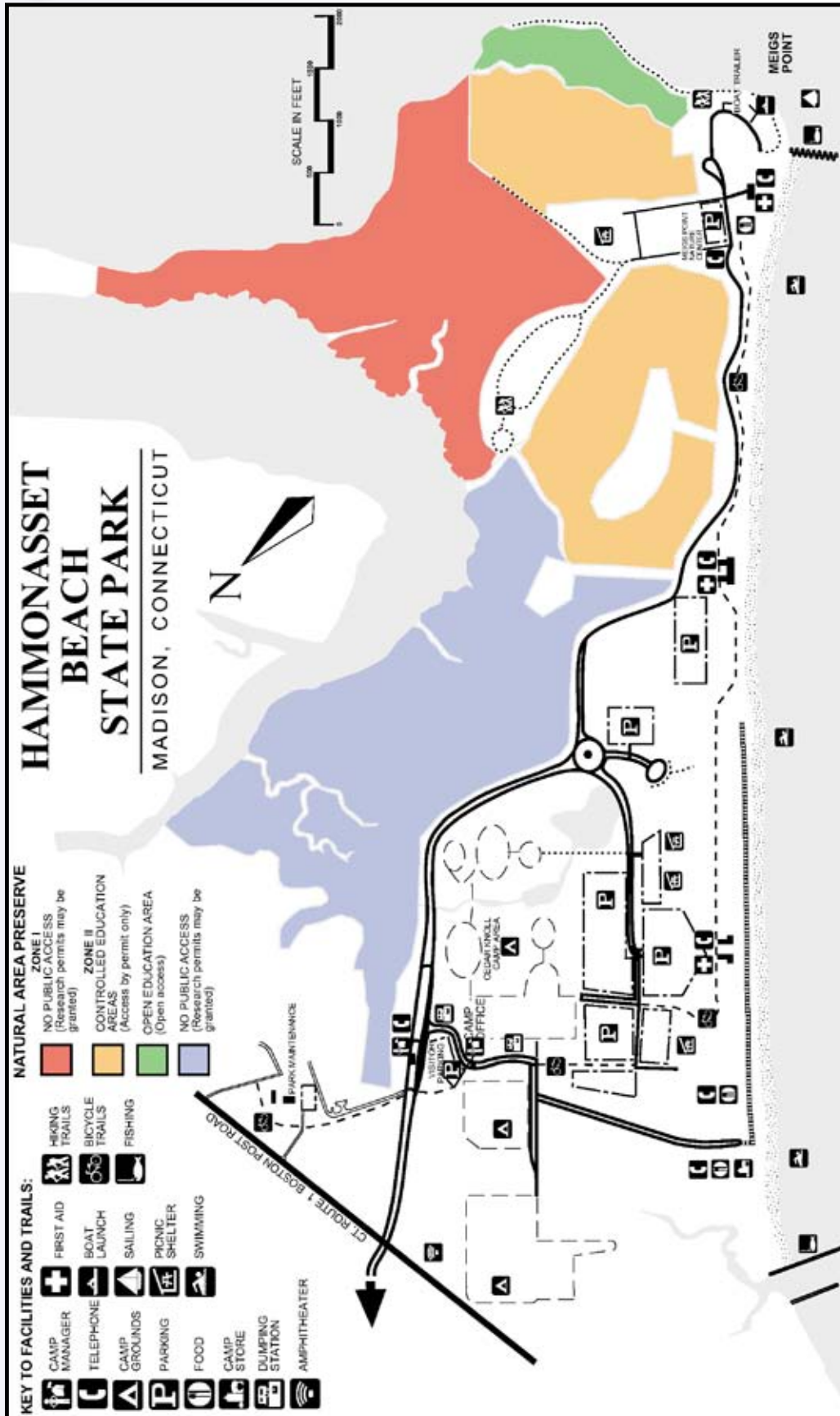
www.ct.gov/dep

From the north/Hartford area: take I-91 south to Route 9 south. Off Route 9, take Exit 9. Turn right (south) onto Route 81; continue down Route 81 until you run into I-95. Turn right onto I-95 entrance ramp and go approximately 1 mile to Exit 62, then turn left off the exit. Head south 1 mile down Hammonasset connector, go straight through the light crossing Route 1 (Boston Post Road) into the park.

From the south area: take I-95 north, Exit 62. Take a right off the exit ramp onto Hammonasset I-95 connector. Park entrance will be 1 mile ahead.

From the east/Rhode Island area: take I-395 south onto I-95 south, Exit 62. Take a left off the exit and go approximately 1 mile. Go straight through the traffic light crossing Route 1 (Boston Post Road).

From the west/New York area: take I-95 north, Exit 62. Take a right off the exit and go approximately 1 mile. Go straight through the traffic light crossing Route 1 (Boston Post Road) into the park.



Rocky Shore Environment

Sandy Beach Environment

Map courtesy of Connecticut DEP

Science Lessons at a Long Island Sound Field Site - LEADER PACKET

113

Permits and Fees

www.ct.gov/dep

Bus permits are issued on a first come/first served basis. A limited number of permits are available for each Park or Recreation Area.

Requests for a bus permit must be made by mail, email or telephone at least fourteen (14) days prior to the intended visit and should be sent to:

CT DEP State Parks Division
79 Elm Street
Hartford, CT 06106-5127
Phone: 860-424-3200
Email: dep.stateparks@ct.gov

Requests can be submitted after February 1st each year and must include:

- Name of the park or recreation area requested.
- Name and address of organization.
- Date of arrival.
- Name, address and phone number of person responsible for, and accompanying bus or buses.
- Number of buses.

Once a permit has been issued, it will be mailed to the organization that has submitted the request. The permit must be brought to the recreation area with the bus it was assigned to.

A separate permit is required for each bus.

Buses **MUST** remain at the recreation area at all times in case of inclement weather or the need for an emergency evacuation.

Bus Fees

Fees are waived for buses carrying Connecticut senior citizens and public school students on officially authorized trips between the beginning of the school year and June 30th.

From Memorial Day Weekend through Labor Day **ONLY** there are separate weekend/holiday and weekday parking fees. On weekends from April 20 through May 20 and again from September 8 through September 23, the weekday rate for parking will be in effect. For additional information on bus permits and

Connecticut State Parks and Recreation Areas Which Require Bus Permits:

Black Rock	Lake Waramaug
Bluff Point	Mansfield Hollow
Burr Pond	Mashamoquet Brook
Chatfield Hollow	Mount Tom
Day Pond	People's Forest
Devil's Hopyard	Quaddick
Gay City	Rocky Neck
Gillette Castle	Sherwood Island
Hammonasset Beach	Silver Sands
Harkness Memorial	Sleeping Giant
Hopeville Pond	Squantz Pond
Indian Well	Stratton Brook
Kent Falls	Wadsworth Falls
Kettletown	Wharton Brook

Science Lessons at a Long Island Sound Field Site - LEADER PACKET

fees, please contact the State Parks Division at (860) 424-3200 Monday through Friday from 8:30 am to 4:30 pm or at dep.stateparks@ct.gov.

Specimen Permit

Please obtain an educational collecting permit from the state park if you will be taking any living specimens back to school. The telephone number of Hammonasset is 203-245-2785.

Geology of Hammonasset State Park

www.ct.gov/dep

Rock Types Found on Main Trail: None

Rock Units: None

Minerals of Interest: None

Interesting Geologic Features: End Moraine, Huge Glacial Erratics

Bedrock (also called ledge) is not exposed anywhere in this park. Bedrock is the rock that is attached to the Earth - it can be seen in road cuts along I-95 and many other roads in Connecticut. The rocks at Hammonasset are all loose sediments, transported here by moving ice. They range in size from fine silt to large boulders. Large rocks appear at the surface only in two places in the park, along the shore at Meigs Point and in the woods to the north of the Meigs Point Nature Center, on the north side of the picnic area. The Cedar Island and Meigs Point trails follow along both of these sites.

Connecticut and Long Island Sound were covered with glacial ice at least a mile thick about 21,000 years ago. That ice continually moved south from its origin near Hudson's Bay in Canada. As it moved, the ice picked up loose material on the Earth's surface, from dust to house-sized boulders. The ice moved continually, though very slowly. By the time the ice moved as far south as Long Island, NY, the temperature was warm enough that the front of the ice melted as fast as the ice advanced. Loose material frozen into the ice was dumped as the ice melted. This created a long east-west ridge of unsorted sediments, called a moraine. As the climate warmed, the ice melted faster than it advanced, so the ice front gradually withdrew north. About 19,500 years ago the ice front became stationary again as the climate temporarily cooled. This formed another moraine. Those two moraines now make up Long Island. The second one, the Harbor Hill-Fishers Island-Charlestown moraine, extended across what is now the mouth of Long Island Sound. As the ice again started melting to the north, the water collected behind this moraine to make Glacial Lake Connecticut, where Long Island Sound is today. When the water level became high enough, a natural spillway developed from the lake where the Race is today.

Then, about 17,500 years ago the climate cooled for a while, so that the ice front stayed along a line from Hammonasset through Ledyard to Queens River, RI. The ice was still moving south, but it was melting at the same rate, so sediments piled up along the front. This formed the Hammonasset-Ledyard-Queens River moraine. It is a double moraine, meaning there are two parallel moraines close together.

Science Lessons at a Long Island Sound Field Site - LEADER PACKET

This happened because a short, warmer period melted the ice farther back to the north again, then a cooler period stopped the melting for a short period, before the ice again melted back to the north. Here in the park the Meigs Point Trail rocks are the older moraine, the Cedar Island Trail rocks are the younger one.

As the glacier was melting back, large amounts of water were flowing downhill from it, washing finer sediments into low-lying areas. This has resulted in sand and gravel deposits in the valleys of Connecticut, where lots of water was moving. On hilltops and flat areas the undisturbed glacial sediments are a mixture of all sized materials, called till. Here at Hammonasset, till underlies the soil at Meigs Point Nature Center, the picnic area behind the center and probably also the salt marsh. Willard Island and the other smaller islands in the marsh are thicker areas of till. All of the campground east of Tom's Creek is underlain by sand, while west of the creek there is more till.

The most obvious sediments are the large boulders along the shore at the east end of the beach at Meigs Point. These are the coarser materials left from the moraine after the waves have been attacking it for a few thousand years. The finer materials near the water have washed out into the Sound, helping to make the beaches, while the huge boulders remain. But farther from the shore the fines still remain in the moraine, supporting a variety of vegetation. A close look at these rocks while walking along the Meigs Point trail will reveal a variety of rock types. Many are striped with light and dark minerals. These are called gneiss. Some of these bands are folded. These metamorphic rocks were once buried deeply, where they were subjected to intense pressure at high temperatures. Some rocks are pink and gray or black, with the large grains randomly arranged. These are granite, a rock which was once melted, then cooled slowly at some depth below the surface.

After walking through the boulders, head toward the trail where it is high above the rocks. In some places you will see the undisturbed moraine mixture of all sizes of material.

A walk along the Cedar Island Trail through the woods leads to a boardwalk that ends in the marsh. Along the trail you will see occasional boulders. The marsh has several large boulders visible above the grass. This chain of boulders continues on out into the water. All of these are part of the north moraine.

Currents moving along the shore constantly move sand along the beach. At Hammonasset, the longshore currents carry sand to the southeast. This is obvious at the jetty, where the sands extend farther out on the northwest side of the rocks than on the southeast side. The waves drop their sand load on the northwest side when they encounter the stone jetty, then remove sand from the southeast side. Thus Hammonasset beach sand currently comes from the areas to the northwest of the beaches.



Science Lessons at a Long Island Sound Field Site - LEADER PACKET

Master Materials Checklist for Science Lessons at a Long Island Sound Field Site

Crab Study and Beach Sample Station

- Permit to collect specimens
- 10-12 buckets for collecting crabs
- 6 large containers for sorting crabs (basins or under bed plastic storage containers work well). Mark the containers or use laminated cards to indicate the following:
 - Male Large - larger than 18 mm
 - Male Medium - 9-18 mm
 - Male Small - smaller than 9 mm
 - Female Large - larger than 18 mm
 - Female Medium - 9.1-18.0 mm
 - Female Small - smaller than 9 mm
- Whistle to signal the beginning and end of collection time
- Stopwatch to time the collection period
- Small plastic mm rulers for each person
- Clipboard and pencil for group leader, including Crab Study Station Crab Count
- Data Sheet (page 86)
- 1-2 calculators
- For each student, copy of each: Beach Sample Station Data Sheets (page 85) and Crab Study Station Crab Count Data Sheet (page 86)
- Optional: cooler to take specimens back to school

For breakout groups:

- Wind meters
- Thermometers to measure air, water, and sand temperatures
- Transect square ("quadrat") - any size
- 50 meter tape measure or rope line attached to a stake
- Plastic zip lock bags to collect small samples of the rocky beach
- Permanent marker to label bags

Seining

- Seine net and poles (2 sets recommended)
- Five-gallon buckets (4 or more)
- Chest waders - carry these in a large plastic tub or crate
- Life jackets
- Beach towel
- For each student:
 - Seining Data Sheet (page 92)
 - Clipboard and pencil
- Weather and water equipment:
 - Hand-held wind speed indicator
 - Thermometers with probes
- Compass
- Digital camera with fresh batteries and memory card

Beach Lab-Marine Biology Field Station

- Magnifiers
- Dissection microscopes
- Petri dishes
- Variety of plastic containers
- Basin
- Eye droppers
- Millimeter rulers
- Sharp pencils
- Beach Lab - Marine Biology Field Station Data Sheets (pages 97-98)
- Clipboards
- Extra paper
- Camera with fresh batteries & memory card
- Small fish net or strainer
- Battery operated bubbler (optional) - available in bait shops and pet stores
- Five-gallon buckets (4 or more)
- Fold-up table if none is available on site
- Optional: cooler to take specimens back to school

Science Lessons at a Long Island Sound Field Site - LEADER PACKET

117

Beach Lab-Marine Biology Field Station FIELD GUIDES AND RESOURCES

- Beachcomber's Companion*® - Woods Hole Oceanographic Institute Sea Grant
- Beachcomber's Guide to the North Atlantic Seashore* - Massachusetts Audubon Society
- Connecticut College Bulletin No. 34 -Tidal Marshes of Long Island Sound Ecology, History, and Restoration*
- Living Treasures: The Plants and Animals of Long Island Sound* - Connecticut Sea Grant
- Marine Animals of Southern New England and New York* by Howard M. Weiss - CT DEP
- Seaweeds of Long Island Sound* by Margaret "Peg" Van Patten - Connecticut Sea Grant
- Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species* waterproof field guide/flip book - Connecticut Sea Grant

Shifting Sands and Shifting Tides

- Four-piece or five-piece geology sieve
- Metric measuring containers in various sizes (largest must be able to hold 300ml)
- 100 meter measuring tape or a marked rope
- A wood stake to mark distances at water line, mid-beach, bottom of dune (Optional: more stakes to mark more sample places)
- Sand gauge or mm rulers to compare grain sizes
- Zip lock plastic bags to collect sand samples
- Permanent markers to label bags
- Sheets of contact paper cut in 6-inch squares to collect sand samples
- Clipboards
- Pencils
- Sifting Sands and Shifting Tides Data Sheets (page 103) and Sifting Sands and Shifting Tides Sand Sampling sheets (page 104)

Artistic Overview - drawing (for each person):

- Aesthetic Connection to Long Island Sound Drawing Template (page 109)
- Drawing pencil, eraser
- Clipboard or backer board
- Tape and scissors for group leader

Aesthetic Overview - writing (for each person):

- Several sheets of writing paper
- Pencil or pen
- Clipboard

Seaweed Collage (for each person):

- Several sheets of stiff paper, 80 lb weight. Glossy, stiff paper works well.
- Basin large enough to accommodate paper, seawater and seaweed specimen
- A variety of seaweeds collected on site - Keep these in a bucket of seawater until ready to use.

Photo Montage (for each person):

- One or more sheets of photosensitive paper (Nature Print), found in craft stores
- Cardboard
- Small pieces of masking tape
- Objects from nature collected on site
- Box with cover to protect completed montages
- Black construction paper cut to the size of the photosensitive paper - to separate the montages in the box
- Stopwatch or timer

Science Lessons at a Long Island Sound Field Site - LEADER PACKET

Where can we get all that gear?

Vendor	Item*
www.Forestry-suppliers.com 800.752.8460 customer service 800.647.5368 sales 800.543.4203 fax	<ul style="list-style-type: none"> • Hubbard #3076 Four screen sieve kit item # 53716 \$57.95 (five screen available) • Sand gauge item # 77332 \$6.95 • Chest waders & suspenders \$45.95, \$8.50
Fisher scientific www.fishersci.com	<ul style="list-style-type: none"> • 1" deep Petri dishes 150x25 mm item # 08-757-10E
Farr's Sporting Goods 2 Main Street, Manchester, CT 06040 860.643.7111 contact = Debbie	<ul style="list-style-type: none"> • Seine net (provide your own poles) item # MSF 4x20 \$34.95 • Minnow trap \$9.99
Edmund Scientifics 60 Pearce Ave., Tonawanda, NY 14150 800.728.6999 www.scientificsonline.com	<ul style="list-style-type: none"> • Digital hand-held thermometer, item # 3105400 \$29.95
Dwyer Instruments, Inc. P.O. Box 373 - 102 Indiana Highway 212 Michigan City, Indiana 46361-0373 219.879.8000 sales only 219.879.8868 general office www.dwyer-inst.com	<ul style="list-style-type: none"> • Hand-held Dwyer wind meter (mph) \$21.75
Connecticut DEP Bookstore 79 Elm St. Hartford, CT 06106-5127 860.424.3555 or 860.424.3692 Fax: 860.424.4088 dep.store@ct.gov www.ctdepstore.com	<ul style="list-style-type: none"> • <i>Connecticut College Bulletin No. 34 - Tidal Marshes of LIS Ecology, History and Restoration</i> • <i>Marine Animals of Southern New England and New York</i> by Howard M Weiss • <i>Beachcombers Guide to the North Atlantic Seashore pamphlet - Massachusetts Audubon Society</i>
Connecticut Sea Grant 1080 Shennecossett Rd. Groton, CT 06340 860.405.9128 860.405.9109 fax web2.uconn.edu/seagrants	<ul style="list-style-type: none"> • <i>Sound Facts, Living Treasures The Plants and Animals of LIS</i> - These are combined, enhanced and published by Sea Grant as a CD entitled Long Island Sound Educational Resources • <i>Seaweeds of Long Island Sound</i> by Margaret "Peg" Van Patten

*Prices accurate as of June 2008.

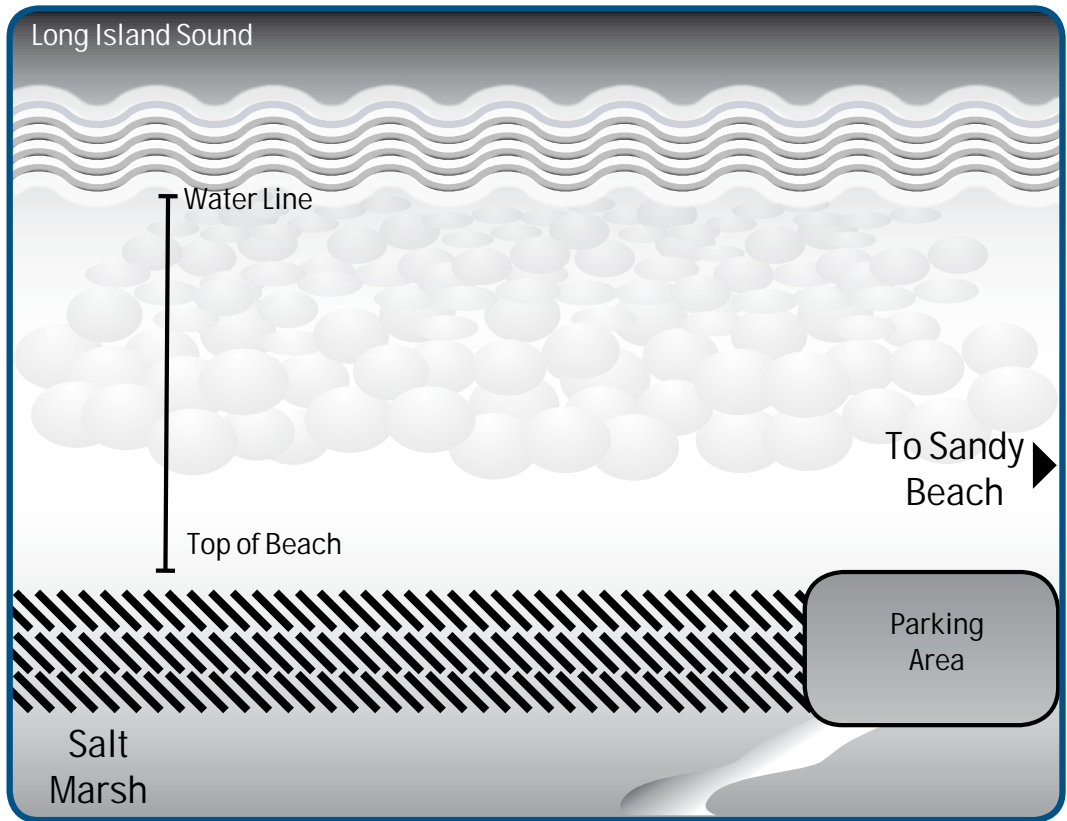


Science Lessons at a Long Island Sound Field Site - LEADER PACKET

Crab Study Area:
Rocky Shore
Environment

Time of Day:

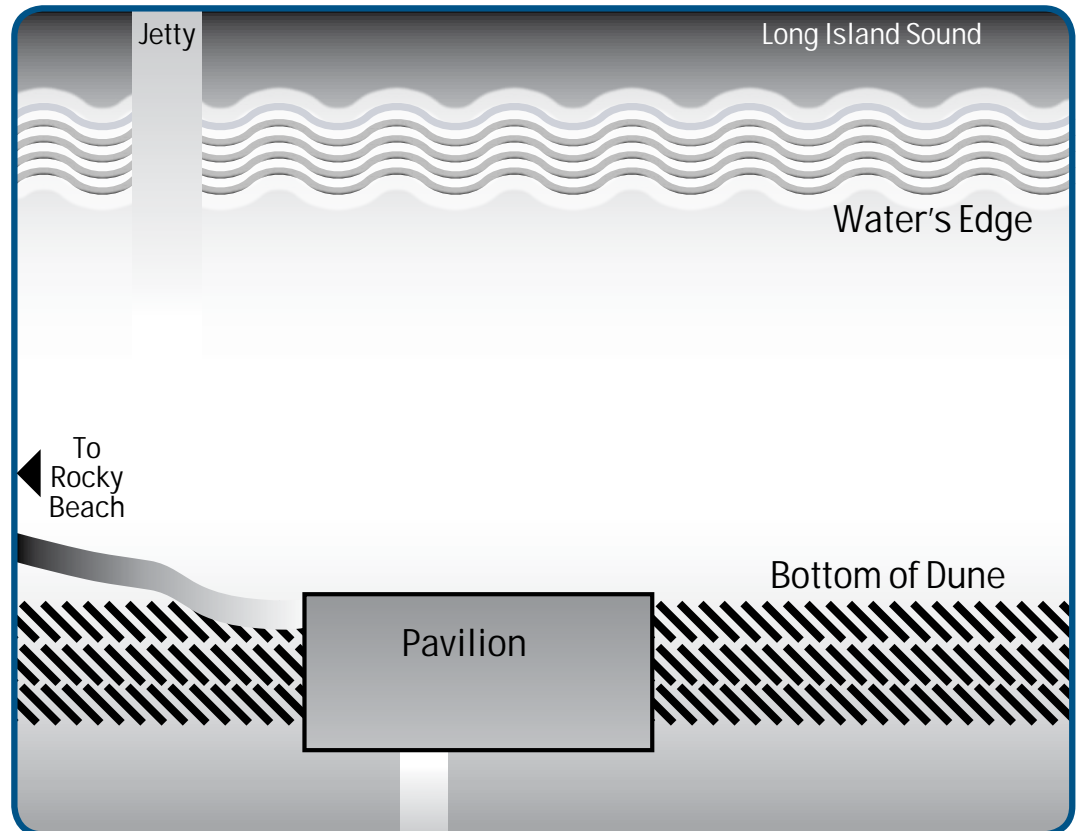
Tide:
high mid low



Sandy Beach
Environment

Time of Day:

Tide:
high mid low



Science Lessons at a Long Island Sound Field Site - LEADER PACKET

Sample Scientific Collector Permit for Aquatic Species

This form can be downloaded directly from the Connecticut Department of Environmental Protection web site at www.ct.gov/dep/lib/dep/fishing/fishing_forms/scicoll.pdf.



Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

Permit # _____
Flag # _____
Official Use Only

BUREAU OF NATURAL RESOURCES - FISHERIES DIVISION
SCIENTIFIC COLLECTOR PERMIT APPLICATION

Connecticut Public Act 91-3 specifies that an annual fee of \$20.00 will be charged for the issuance of a COLLECTOR PERMIT. Please submit the appropriate amount with this application.

<p>APPLICANT</p> <p>Name: _____</p> <p>Affiliation: _____</p> <p>Street Address: _____</p> <p>City: _____ State: _____ Zip: _____</p> <p>Telephone: _____ Office Home</p>	<p>VESSEL (if applicable) (Use additional sheet for additional vessels)</p> <p>Vessel Name: _____</p> <p>Home Port: _____</p> <p>Reg. No./Document No.: _____</p> <p>Hull Material: _____</p> <p>Hull Color: _____</p> <p>Propulsion: _____</p>
<p>Type of collection requested: (Check all that apply)</p> <p><input type="checkbox"/> Aquatic species in the Inland District</p> <p><input type="checkbox"/> Aquatic species in the Marine District</p> <p><input type="checkbox"/> Wildlife species</p>	<p>This permit is requested for the period from:</p> <p>_____ to _____</p> <p>Date Date</p> <p><i>Note: A Collector Permit may be issued for a period of up to three years.</i></p>

COLLECTING DETAILS

Type of collecting gear to be used:

Species and numbers of each to be collected:

Purpose of collection:

Specific areas of the State where collections are to be made:

Specimens will be deposited at:

If collecting program involves tag and release studies, describe in detail. Include tag design, legend and numbers or series. (Use additional sheet if necessary.)

Persons authorized to collect under this permit: (Use additional sheet if necessary.)

Mail To:
Dept. Of Environmental Protection
Fisheries Division
79 Elm Street
Hartford, CT 06106-5127

Signature _____
Applicant

CONNECTICUT

WWW.COURANT.COM

FRIDAY, OCTOBER 13, 2006

IN★ THE HARTFORD COURANT SECTION B



KEEPING COUNT OF CRABS

FIFTH-GRADER Jennifer Paradis of East Hartford, left, shows off the only green crab found by fifth-graders from East Hartford-Glastonbury Elementary Magnet School, during a field trip to Hammonasset Beach State Park in Madison Thursday. Above, fifth-grader Dustin Murray-Simmons of East Hartford and science teacher Donna Rand watch several small Japanese shore crabs scurry away after turning over a rock at the park. The shore crabs were plentiful. See story, **Page B5**.

PHOTOS BY BOB MACDONNELL | THE HARTFORD COURANT

INVASIVE SHORE CRABS GIVE KIDS LESSON

Peter Marteka is branching out from the hills of eastern Connecticut to the mountains and trails west of the Connecticut River and along the state's shoreline. His new column, "Nature's Path," debuts next Friday in the Town News section.



PETER MARTEKA
THE PATH LESS TRAVELED

As a light breeze barely ruffled the surface of Long Island Sound Thursday, children wearing boots and old sneakers tipped over slick, weed covered rocks along Meigs Point at Hammonasset Beach State Park in Madison.

"I found a big one! Ow! Ow! OK, hurting!" cries one boy as a large crab held onto his finger with a claw.

"I'm picking them up like crazy," says another. "Oh, he's trying to run to the ocean."

Welcome to the annual crab study by fifth-grade students at the East Hartford-Glastonbury Elementary Magnet School. During a visit to the state park Thursday, on a day that felt more like summer than fall, students spent 20 minutes along Rock Beach collecting all the crabs they could find. The tally at the end was 474 Japanese shore crabs and one green crab.

"The results are similar to what we've been finding year after year," says Donna Rand, a science and technology teacher at the school. "We find one or two green crabs and the rest shore crabs."

Years ago, Rand would visit the beach and find rock crabs, calico crabs, blue crabs and green crabs hidden beneath rocks. Since 1998, the students have been collecting 700 to 1,000 of the

shore crabs — an invader from East Asia — and not much else.

That's because the shore crab — a very aggressive and voracious predator — has become the bully of the intertidal and subtidal areas of the Sound. Although only 2 to 3 inches wide, shore crabs will attack and kill green crabs — invaders themselves a century ago — twice their size. The invasive creatures also go after shellfish and lobster.

"The world is becoming smaller," Rand says. "It's unbelievable how hardy they are and how quickly they reproduce. Invasive species as a whole are a very big problem."

Although Rand says the green crabs were also invaders, they found their own niche in the ecosystem. Now it seems one invader is being replaced by another.

"But the Japanese shore crabs are so dominant they have absolutely taken over the ecosystem," she says. "It puts everything out of balance. ... Invasive species are a part of everyday life now, whether it is plants or these crabs. It's important for children to learn about them at a young age so they become more aware of them and the damage they cause."

Penny Howell, a fisheries biologist with the state Department of Environmental Protection, said Wednesday that there's not

"The crabs were a little iffy for me."

ALEYAH SEABROOK,
EAST HARTFORD

enough staff to study the crabs, adding it was low on the priority list. She says that although the crabs are dominating the shallow areas, they are becoming more appetizing to fish deeper out.

"I understand they are not as successful when they move out, so there is some sort of limit out there," she said. "The tautog love crabs and we are finding shore crabs in them. So some of the tautog, although they prefer the other species, are learning how to eat the new prey."

After the search, the students spent the rest of the morning taking inventory of the species by separating them by gender and size. While inventorying and counting, the students noted that the crabs are feisty and the males outnumber the females.

"At first I was scared to pick one up," said Aleyah Seabrook of East Hartford. "The crabs were a little iffy for me. But once you got one in your hand, you couldn't stop picking them up. You are not only hunting for them, you are learning about them at the same time."

Principal Glen Peterson, who donned hip waders and joined the students Thursday, says the situation is "an important issue everyone should know about."

"These days if we find one or two native species [of crab], it's a miracle," he said. "Our main theme is science and having kids

Contents of this section:

124	Environmental Calendar
125	How to Preserve Seaweed from <i>Seaweeds of Long Island Sound</i>
126	Resources by topic
126	Aquaculture
126	Aquariums
126	Careers
126	Conservation
127	Curriculum
130	Education Organizations
132	Estuaries
132	Exploration
133	Geology
133	Government Agencies and Programs
134	Hypoxia
135	Invasive Species
136	Long Island Sound
138	Marine Education and Teaching Tools
140	Marine Flora and Fauna
142	Marshes and Wetlands
142	Museums
143	Oceanography and Physical Science
144	Pollution and Water Quality
145	Programs
146	Sea Grant Programs
147	Shipwrecks
147	Undersea
148	Watersheds

Environmental Calendar

February

2 - World Wetlands Day www.ramsar.org/wwd/wwd_index.htm

12 - Darwin's Birthday / Darwin Day www.darwinday.org

March

20 - World Frog Day www.herparts.com

22 - World Water Day www.worldwaterday.org/

23 - World Meteorological Day www.wmo.int/pages/wmd/

Late March - Earth Hour www.worldwildlife.org/sites/earthhour/

April

21 - International Creativity and Innovation Day www.creativityday.org

22 - Earth Day www.earthday.net www.allspecies.org/neigh/blocka.htm

May

22 - International Biodiversity Day www.cbd.int/ibd/

23 - World Turtle Day www.herparts.com

Last Friday before Memorial Day - Long Island Sound Day www.lisfoundation.org

June

5 - World Environment Day www.unep.org/wed

8 - World Oceans Day www.theoceanproject.org/wod/

14 - World Sea Turtle Day www.herparts.com

September

Third Week - Clean Up the World Campaign www.cleanuptheworld.org/en/

Third Saturday - Coastal Clean Up Day www.coastalcleanup.org

Last Saturday - National Estuaries Day www.estuaries.gov

October

Energy Awareness Month www1.eere.energy.gov/femp/services/energy_aware.html

4 - World Animal Day www.worldanimalday.org.uk

December

5 - International Volunteer Day www.worldvolunteerweb.org/int-l-volunteer-day.html



How to Preserve Seaweed From *Seaweeds of Long Island Sound* by Margaret “Peg” Van Patten

To make a permanent collection, you will need to dry and press your algae on acid-free paper. Herbarium sheets, which can be purchased from biological and archival suppliers, are best but good artist’s paper or even index cards can be used too.

On the bottom right-hand corner of your paper, put the following information: first, the species you believe you have collected. If you don’t know yet, you can add it later. On the next line(s), put the date and location where you collected the sample. Next, add any important additional information about the habitat, the condition of the water, etc. Finally, put your name, as the collector. You may also want to number your sheets for easy identification later on. This way of labeling the collection is a convention that botanists use. It makes it easy if someone wants to compare samples or ask questions later on. Since these collection sheets can potentially last for hundreds of years, it may be much later.

Put your sheet of paper into a large tray, or even in a tub. After it has been gently rinsed, arrange your specimen on the sheet so that it is attractive, and somewhat centered. The holdfast should be at the base, if there is one, as in nature. Now either immerse your sheet and specimen in a very thin covering of water, or gently spray or squirt water on it to spread out the branches. This is particularly important for the red algae, which may be a dense clump until you spread the branches. If you have a particularly bulky specimen, you may trim away some of the branches so that the basic structure is clearly seen.

Once your specimen looks the way you want it to, gently slide it out of the water and let it “drip dry” for a few minutes. While it is draining, start a “sandwich” by laying down a sheet of corrugated cardboard at least as large as your herbarium sheet, then add a sheet or two of blotting paper (or several layers of paper towels). Now put down your herbarium sheet with the specimen on top. If you have a piece of nylon stocking or panty-hose handy, place it on top of the specimen. This step is optional but allows air to circulate nicely and keeps the specimen from molding or sticking to the next layer. Finish your “sandwich” by reversing the order of the layers-waxed paper, blotting paper or paper towels, then another sheet of cardboard. Make as many “sandwiches” as you need to accommodate all of the specimens you wish to dry, and stack them. Once all of your “sandwiches” are assembled, you can put them in a press. The quick and dirty method is to place them in a cool environment and put a couple of heavy weights such as rocks on top. Or use a couple pieces of thin plywood or pegboard, strapped together with belts or bungee cords. A simple press can be purchased or replicated using pieces of scrap lumber and straps. Holes drilled in the top and bottom encourage air circulation, preventing mold. Handles can be added for convenience.

You may be wondering about the fact that no glue has been mentioned. The colloid substances that keep algae moist, and are so important to industries, act as a natural glue, oozing forth as the piece dries and adhering it to the paper. If by chance a specimen comes loose after drying, you can always touch it up with a clear-drying glue.

In a couple of days, your specimens will be dry and ready to archive. Keep them in a place where the temperature stays pretty constant and doesn’t overheat. One of the marvelous things about seaweeds is that, if you ever need to examine a structure microscopically, you can always cut a small piece from your dried specimen later on, reconstitute it with water, and observe the structures nearly “as good as new”.



Resources by Topic

The following resources are focused on Long Island Sound and marine education. The descriptions for the websites below were taken directly from the websites. Please see those websites for more details.

Aquaculture

Resources for Aquaculture Educators: Lists websites and resources for educators and students of aquaculture. Connecticut Sea Grant. web2.uconn.edu/seagrant/whatwedo/aquaculture

ALEARN-Education: This area of ALEARN is dedicated to educators. Educators are continually looking for new resources and different, more effective ways to present information. This area will assist in the location and identification of resources that can be used in teaching aquaculture and other related aquatic sciences. Resources include lesson plans, curricula evaluations, activities, access to resources, teaching materials, suppliers and new methods. If you have additional items or resources that could be added to our list or have special interests or request please contact us.

www.aces.edu/dept/fisheries/education/

Aquariums

Mystic Aquarium and Institute for Exploration: Mystic Aquarium & Institute for Exploration is a division of Sea Research Foundation, Inc., a nonprofit institution. The Foundation's mission is to inspire people to care for and protect our ocean planet through education, research and exploration.

www.mysticaquarium.org

The Maritime Aquarium at Norwalk: The Maritime Aquarium inspires people of all ages to appreciate Long Island Sound and protect it for future generations. A vibrant and entertaining learning environment, the Maritime Aquarium achieves this goal through living exhibits, marine science, and environmental education. www.maritimeaquarium.org

Careers

Careers in Oceanography and Marine-Related Fields: The Oceanographic Society. www.tos.org

Marine Science Careers: Marinecareers.net will introduce you to a wide range of marine career fields and to people working in those fields. In addition, it will give those men and women a chance to tell you what they like and dislike about their careers, what they see for the future in their fields, and much more. This site also provides you with some experts' views on what the future holds for marine science careers. Sea Grant. www.marinecareers.net

OceanCareers.com: At the heart of www.oceancareers.com are four databases in which you'll find detailed information about: Educational Institutions - descriptions of more than 300 educational institutions offering ocean-related programs; Careers - descriptions of more than fifty ocean occupations, including task and duties, knowledge and skills, salary range, and workforce trends; Educational Competencies - what you need to know and be able to do in twenty-four different discipline areas to be marketable in today's workplace; and professional societies - links to more than 200 professional societies. www.oceancareers.com

Conservation

The Ocean Conservancy: Ocean Conservancy promotes healthy and diverse ocean ecosystems and opposes practices that threaten ocean life and human life. Through research, education, and science-based advocacy, Ocean Conservancy informs, inspires, and empowers people to speak and act on behalf of the oceans. In all its work, Ocean Conservancy strives to be the world's foremost advocate for the oceans. www.oceanconservancy.org

The Ocean Project: Through this collaboration among aquariums, zoos, science, technology, and natural history museums, and other educational institutions that together serve more than 200 million visitors each year, The Ocean Project aims to significantly increase the success of ocean conservation. The Ocean Project seeks to complement and build upon the work of existing institutions and organizations. We also collaborate with local, regional, and national nonprofit conservation and environmental organizations to actively involve people in conservation activities in their communities and better connect them to the ocean. www.theoceanproject.org

Curriculum

Curriculum Research & Development Group (CRDG): The CRDG with its Laboratory School is an organized research unit in the College of Education at the University of Hawai'i that conducts research and creates, evaluates, disseminates, and supports educational programs that serve students, teachers, parents, and other educators in grades preK-12. www.hawaii.edu/crdg

The Ocean Crisis: A Curriculum for Global Problem Solving. Linda MacRae-Campbell and Bruce Campbell. Zephyr Press. www.zephyrpress.com

Ocean Literacy Essential Principles and Fundamental Concepts: The following Essential Principles of Ocean Sciences may also be downloaded from: <http://coexploration.org/oceanliteracy/>

1 - The Earth has one big ocean with many features.

- a. The ocean is the dominant physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian and Arctic.
- b. An ocean basin's size, shape and features (islands, trenches, mid-ocean ridges, rift valleys) vary due to the movement of Earth's lithospheric plates. Earth's highest peaks, deepest valleys and flattest vast plains are all in the ocean.
- c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.
- d. Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as seawater expands and contracts when ocean water warms and cools.
- e. Most of Earth's water (97%) is in the ocean. Seawater has unique properties: it is saline, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. The salt in seawater comes from eroding land, volcanic emissions, reactions at the seafloor, and atmospheric deposition.
- f. The ocean is an integral part of the water cycle and is connected to all of the Earth's water reservoirs via evaporation and precipitation processes.
- g. The ocean is connected to major lakes, watersheds and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments and pollutants from watersheds to estuaries and to the ocean.
- h. Although the ocean is large, it is finite and resources are limited.

2 - The ocean and life in the ocean shape the features of the Earth.

- a. Many earth materials and geochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.
- b. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.
- c. Erosion—the wearing away of rock, soil and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean move sediments.

Resources

- d. Sand consists of tiny bits of animals, plants, rocks and minerals. Most beach sand is eroded from land sources and carried to the coast by rivers, but sand is also eroded from coastal sources by surf. Sand is redistributed by waves and coastal currents seasonally.
- e. Tectonic activity, sea level changes, and force of waves influence the physical structure and landforms of the coast.

3 - The ocean is a major influence on weather and climate.

- a. The ocean controls weather and climate by dominating the Earth's energy, water and carbon systems.
- b. The ocean absorbs much of the solar radiation reaching Earth. The ocean loses heat by evaporation. This heat loss drives atmospheric circulation when, after it is released into the atmosphere as water vapor, it condenses and forms rain. Condensation of water evaporated from warm seas provides the energy for hurricanes and cyclones.
- c. The El Niño Southern Oscillation causes important changes in global weather patterns because it changes the way heat is released to the atmosphere in the Pacific.
- d. Most rain that falls on land originally evaporated from the tropical ocean.
- e. The ocean dominates the Earth's carbon cycle. Half the primary productivity on Earth takes place in the sunlit layers of the ocean and the ocean absorbs roughly half of all carbon dioxide added to the atmosphere.
- f. The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.
- g. Changes in the ocean's circulation have produced large, abrupt changes in climate during the last 50,000 years.

4 - The ocean makes Earth habitable.

- a. Most of the oxygen in the atmosphere originally came from the activities of photosynthetic organisms in the ocean.
- b. The first life is thought to have started in the ocean. The earliest evidence of life is found in the ocean.

5 - The ocean supports a great diversity of life and ecosystems

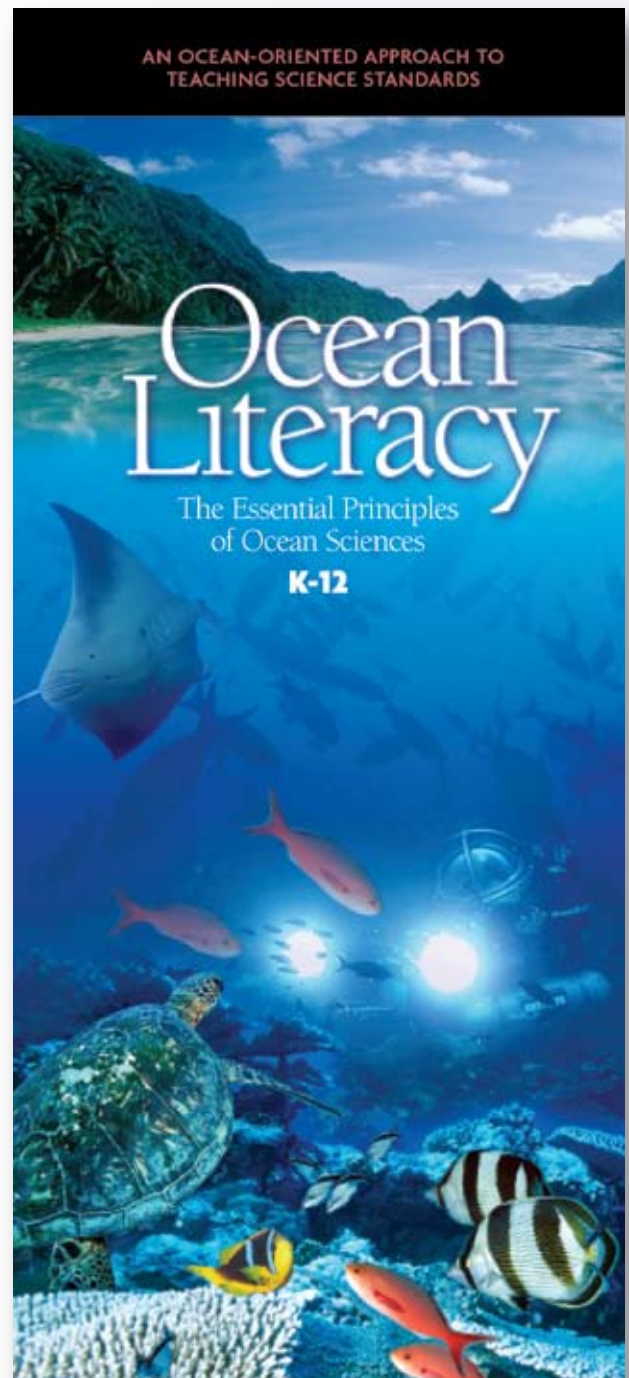
- a. Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.
- b. Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean. Not only are they the most abundant life form in the ocean, they have extremely fast growth rates and life cycles.
- c. Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
- d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
- e. The ocean is three-dimensional, offering vast living space and diverse habitats from the surface through the water column to the seafloor. Most of the living space on Earth is in the ocean.
- f. Ocean habitats are defined by environmental factors. Due to interactions of abiotic factors such as salinity, temperature, oxygen, pH, light, nutrients, pressure, substrate and circulation, ocean life is not evenly distributed temporally or spatially, i.e., it is "patchy". Some regions of the ocean support more diverse and abundant life than anywhere on Earth, while much of the ocean is considered a desert.
- g. There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, methane cold seeps, and whale falls rely only on chemical energy and chemosynthetic organisms to support life.
- h. Tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms.
- i. Estuaries provide important and productive nursery areas for many marine and aquatic species.

6- The ocean and humans are inextricably interconnected.

- a. The ocean affects every human life. It supplies freshwater (most rain comes from the ocean) and nearly all Earth's oxygen. It moderates the Earth's climate, influences our weather, and affects human health.
- b. From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
- c. The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
- d. Much of the world's population lives in coastal areas.
- e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.
- f. Coastal regions are susceptible to natural hazards (tsunamis, hurricanes, cyclones, sea level change, and storm surges).
- g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

7 - The ocean is largely unexplored.

- a. The ocean is the last and largest unexplored place on Earth— less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
- b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
- c. Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of ocean resources depends on our understanding of those resources and their potential and limitations.
- d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- e. Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems.
- f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.



Project Learning Tree® (PLT): Project Learning Tree® is an award winning, multi-disciplinary environmental education program for educators and students in PreK-grade 12. PLT, a program of the American Forest Foundation, is one of the most widely used environmental education programs in the United States and abroad. PLT continues to set the standard for environmental education excellence. PLT helps students learn how to think, not what to think, about the environment. PLT meets state and national education standards. The curriculum materials provide the tools educators need to bring the environment into the classroom and their students into the environment. Topics range from forests, wildlife, and water, to community planning, waste management and energy. www.plt.org

Project Soundwise: A Curriculum and Teacher's Guide to Long Island Sound for Grades K-4: By Dana McArdle, Kirsten Conway, and Laura Norwitz. 1992. Schooner, Inc. www.schoonerinc.org

Project Soundwise: A Supplemental Teacher's Guide to Long Island Sound for grades 5-8: By Dana McArdle and Laura Norwitz. 1992. Schooner, Inc. www.schoonerinc.org

Project WET (Water Education for Teachers): Project WET is an award-winning, nonprofit water education program and publisher. The program facilitates and promotes awareness, appreciation, knowledge, and stewardship of water resources through the dissemination of classroom-ready teaching aids and the establishment of internationally sponsored Project WET programs. Project WET is: a publisher of materials and lesson plans for teachers and for children; a source of leadership training and capacity building courses, seminars, and workshops for water education providers; a global water education delivery network designed to reach children through educators; and a provider of information, support services, and consultation for people that have questions regarding water education for teachers and children. Project WET is committed to global water education that is implemented at the community level. www.projectwet.org

Project WILD: Project WILD is one of the most widely-used conservation and environmental education programs among educators of students in kindergarten through high school. It is based on the premise that young people and educators have a vital interest in learning about our natural world. A national network of state wildlife agency sponsors ensures that Project WILD is available nationwide --training educators in the many facets of the program. Emphasizing wildlife because of its intrinsic value, Project WILD addresses the need for human beings to develop as responsible citizens of our planet. www.projectwild.org

The Water Sourcebooks: The Water Sourcebooks contain 324 activities for grades K-12 divided into four sections: K-2, 3-5, 5-8, and 9-12. Each section is divided into five chapters: Introduction to Water, Drinking Water and Wastewater Treatment, Surface Water Resources, Ground Water Resources, and Wetlands and Coastal Waters. This environmental education program explains the water management cycle using a balanced approach showing how it affects all aspects of the environment. All activities contain hands-on investigations, fact sheets, reference materials, and a glossary of terms. Activities are organized by objectives, materials needed, background information, advance preparation, procedures, and resources. US EPA. www.epa.gov/safewater/kids/wsb

WOW!: The Wonders of Wetlands: *WOW!: The Wonders of Wetlands* is an instructional guide for educators that provides a resourceful and creative collection of wetland activities, information, and ideas. *WOW!* includes: over 50 hands-on multidisciplinary activities in lesson plan format, extensive background information on wetlands, ideas for student action projects, and a wetlands resource guide. www.wetland.org/education_wow.htm

Education Organizations

Connecticut Outdoor and Environmental Educators Association (COEEA): COEEA is a network of classroom educators, naturalists, environmental educators, youth leaders, administrators, professors,

and students who work toward a future where increasingly: an appreciation for and understanding of the environment is an integral part of all community education - including formal, non-formal, and informal education; educators, environmental professionals, and the organizations and agencies they represent are well informed and are willing to work together to maximize resources; and people of all ages are environmentally literate and act as environmental stewards. COEEA serves its members by supporting professional development, providing networking opportunities, and promoting environmental education in Connecticut. We are also the state affiliate of the New England Environmental Education Alliance and the North American Association for Environmental Education. www.coeea.org

Connecticut Science Teachers Association (CSTA): Since 1952, the Connecticut Science Teachers Association has spoken for the needs and interests of science teachers in Connecticut. CSTA has been your voice in professional development, science curriculum, instruction, certification, and communication with the Connecticut State Department of Education, the Connecticut Academy for Education in Math, Science, & Technology and many others about the direction that science education should take. Wherever you teach science, and whatever level, CSTA has represented you, the science teacher. www.csta-us.org

National Marine Educators Association (NMEA): NMEA brings together those interested in the study and enjoyment of both fresh and salt water and provides a focus for marine and aquatic studies all over the world and includes professionals in education, science, business, government, museums, aquariums and marine research. www.marine-ed.org

New England Environmental Education Alliance (NEEEA): The mission of NEEEA is to promote quality environmental education across New England in partnership with the state environmental education organizations. NEEEA members include all state organizations in the six New England states. www.neeea.org

New York State Marine Educators Association (NYSMEA): NYSMEA exists to promote marine awareness and encourage the growth and exchange of instructional resources within the scientific, commercial, and educational communities. Members include educators from all levels; museum, aquarium, and environmental center staff, research scientists, laboratory technicians and those with interests in SCUBA, fishing, boating, maritime history, folklore, archeology and the arts. www.nysmea.org

North American Association of Environmental Educators (NAAEE): NAAEE is a network of professionals, students, and volunteers working in the field of environmental education throughout North America and in over 55 countries around the world. Since 1971, the Association has promoted environmental education and supported the work of environmental educators. There are many environmental interest groups, and many organizations dedicated to improving education. NAAEE uniquely combines and integrates both of these perspectives, and takes a cooperative, nonconfrontational, scientifically-balanced approach to promoting education about environmental issues. www.naaee.org

Science Teachers Association of New York State, Inc. (STANYS): STANYS is New York's oldest and most respected professional organization of science educators. Our membership of primary, secondary, and tertiary educators creates a collaborative association that is invaluable for our organization and for science education in New York State. STANYS promotes excellence in science education. Its mission is to work with educators and communities to provide opportunities for all students to participate in and learn science. www.stanys.org

Southeastern New England Marine Educators (SENEME): SENEME is the Rhode Island and Connecticut regional chapter of the National Marine Educators Association. SENEME's vision is to create a society of empowered citizens who will make a difference in the world of water with the mission to develop an appreciation and stewardship for the world of water by supporting both freshwater and marine environmental education. www.seneme.org

Estuaries

Discover Bays & Estuaries: Learn how we all impact and depend on bays and estuaries. Students work their way through a food web, identify animals that live in the “mixing zone,” and decide how to conserve, protect, and restore bays and estuaries by drawing pictures of Best Management Practices (BMP) throughout a watershed. Ages 8-12. 16 pp. <http://store.projectwet.org>

Estuaries: A Day at the Bay: A program for Middle and Junior High School Students. David Grant and Linda Stefaniak. Ocean Institute, Brookdale Community College.

Estuaries Tutorial: The Estuaries Tutorial is an overview of estuarine habitats, the threats facing them, and efforts to monitor and protect estuaries nationwide. The Roadmap to Resources complements the information in the tutorial by directing you to specific online estuary-related materials from NOAA and other reliable resources. NOAA Ocean Service Education. <http://oceanservice.noaa.gov/education/kits/estuaries/welcome.html>

Estuaries.gov: Estuaries.Gov helps educators bring the beauty and the importance of estuaries into classrooms and educational programs. This site provides, primarily, an avenue for elementary, middle and high school students, and their teachers, to learn more about estuaries, research, and explore NOAA’s “living laboratories” - the National Estuarine Research Reserves. www.estuaries.gov

Learn About Estuaries: Educational information about estuaries, including: what estuaries are, why they are important, and links to more information about estuaries. US EPA. www.epa.gov/region1/eco/lis/estuaries.html

National Estuarine Research Reserve System (NERRS): NERRS is a network of protected areas established for long-term research, education and stewardship. This partnership program between NOAA and the coastal states protects more than one million acres of estuarine land and water, which provides essential habitat for wildlife; offers educational opportunities for students, teachers and the public; and serves as living laboratories for scientists. www.nerrs.noaa.gov

Exploration

From Sea to Shining Sea: Exploring America’s Ocean Realms. National Geographic Education Foundation. www.ngsednet.org/oceans

National Geographic: Since 1888, National Geographic has traveled the Earth, sharing amazing stories with each new generation. National Geographic’s Mission Programs support critical expeditions and scientific fieldwork, encourage geography education for students, promote natural and cultural conservation, and inspire audiences through new media, vibrant exhibitions, and live events. www.nationalgeographic.com

NOAA Ocean Explorer: NOAA Ocean Explorer is an educational Internet offering for all who wish to learn about, discover, and virtually explore the ocean realm. It provides public access to current information on a series of NOAA scientific and educational explorations and activities in the marine environment. The site provides a platform to follow explorations in near real-time, learn about exploration technologies, observe remote marine flora and fauna in the colorful multimedia gallery, read about NOAA’s 200-year history of ocean exploration, and discover additional NOAA resources in a virtual library. www.oceanexplorer.noaa.gov

Ocean Detectives, Solving the Mysteries of the Sea: Explorer book. Mary Cerullo. Woods Hole Oceanographic Institution.

Geology

Geologic History of Long Island Sound: Chapter in Connecticut College's *Tidal Marshes of Long Island Sound - Ecology, History, and Restoration* by Ralph Lewis. <http://arboretum.conncoll.edu/publications/34/CHP1.HTM>

Ocean Energy: U.S. Department of the Interior Minerals Management Service. U.S. Department of the Interior. www.mms.gov

Sedimentary Environments in Long Island Sound: A Guide to Sea-Floor Management in a Large Urbanized Estuary: USGS factsheet. <http://marine.usgs.gov/fact-sheets/fs41-98/>

Government Agencies and Programs

Connecticut Department of Environmental Protection (DEP): Founded in 1971, the mission of the DEP is to conserve, improve and protect the natural resources and environment of the State of Connecticut in such a manner as to encourage the social and economic development of Connecticut while preserving the natural environment and the life forms it supports in a delicate, interrelated and complex balance, to the end that the state may fulfill its responsibility as trustee of the environment for present and future generations. The DEP achieves its mission through regulation, monitoring, inspection and enforcement, and licensing procedures that help control air, land and water pollution in order to protect health, safety, welfare and natural resources. The DEP also improves and coordinates the state's environmental plans, functions and educational programs in cooperation with federal, regional and local governments, other public and private organizations and concerned individuals, while managing and protecting the flora and fauna for compatible uses by the citizens. www.ct.gov/dep

DEP Education: The CT DEP can help with information and resources for use in the classroom, at home, or in your local community including educator workshops, student field trips, educational resources and public education courses. http://www.ct.gov/dep/cwp/view.asp?a=2691&q=322500&depNav_GID=1627&depNav=

National Oceanic and Atmospheric Administration (NOAA): NOAA is an agency that enriches life through science. Their mission is to understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs. From daily weather forecasts, severe storm warnings and climate monitoring to fisheries management, coastal restoration and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision makers with reliable information they need when they need it. www.noaa.gov

NOAA Education: NOAA's many educational activities are distributed across the agency. This site has been designed to help students, teachers, librarians and the general public access the many educational activities, publications, and booklets that have been produced. www.education.noaa.gov

New York State Department of Environmental Conservation (DEC): The New York State Department of Environmental Conservation was created on July 1, 1970 to bring together in a single agency all state programs directed toward protecting and enhancing the environment. Its mission is to conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being. DEC's goal is to achieve this mission by embracing the elements of sustainability - the simultaneous pursuit of environmental quality, public health, economic prosperity and social well-being, including environmental justice and the empowerment of individuals to participate in environmental decisions that affect their lives. www.dec.ny.gov

DEC Education: To make the right environmental choices, we all need to understand how our natural environment works, and how resources are affected by the things we do. This is why state law directs DEC to provide environmental education programs that help every citizen to be a steward of the environment. All DEC divisions and regions constantly make information available for the public; five divisions and one region offer established, formal environmental education programs. Links from this page will help you access these programs. <http://www.dec.ny.gov/26.html>

United States Environmental Protection Agency (EPA): In July of 1970, the White House and Congress worked together to establish the EPA in response to the growing public demand for cleaner water, air and land. Prior to the establishment of the EPA, the federal government was not structured to make a coordinated attack on the pollutants that harm human health and degrade the environment. The EPA was assigned the daunting task of repairing the damage already done to the natural environment and to establish new criteria to guide Americans in making a cleaner environment a reality. www.epa.gov

Teaching Center: This site is for both formal and nonformal educators who wish to teach about the environment. It offers background information on a variety of topics, lesson plans, and activities that work in and out of the classroom. You will also find information on workshops, conferences, grants, awards and a variety of other information that will assist you in your educational goals whether you teach in a traditional classroom setting, an outdoor classroom, a community center or in your home. www.epa.gov/teachers

Environmental Education Training and Partnership (EETAP): This site offers educators information, resources, and links for promoting academic achievement and environmental literacy. It describes the EETAP, participating organizations, services, and achievements. EETAP is a national leader in the delivery of environmental education training for education professionals. EETAP is funded by the U.S. Environmental Protection Agency's Office of Environmental Education through a cooperative agreement with the University of Wisconsin-Stevens Point. www.eetap.org

United States Geological Survey (USGS): As an unbiased, multi-disciplinary science organization that focuses on biology, geography, geology, geospatial information, and water, it is dedicated to the timely, relevant, and impartial study of the landscape, our natural resources, and the natural hazards that threaten us. www.usgs.gov

The USGS and Science Education: The USGS provides scientific information intended to help educate the public about natural resources, natural hazards, geospatial data, and issues that affect our quality of life. Discover selected online resources, including lessons, data, maps, and more, to support teaching, learning, education (K-12), and university-level inquiry and research. <http://education.usgs.gov>

Hypoxia

Alternative Strategies for Hypoxia Management: Factsheet produced by the EPA LISS. www.longislandsoundstudy.net/pubs/facts/hypfsas.pdf

Long Island Sound Study overview of hypoxia: An overview of the problem, the plans and the costs of the hypoxia issue in Long Island Sound. EPA LISS. www.longislandsoundstudy.net/ccmp/hypox.html

Long Island Sound Study publications about nitrogen and hypoxia: A list of reports and documents produced by the EPA Long Island Sound Study available to download or available from the LIS Office. 203-977-1541. www.longislandsoundstudy.net/publications.htm

NASA Ocean Color - Creeping Dead Zones: Focus on anoxia using satellite image data, or "ocean color data". The phrase "ocean color data" refers to accurate measurements of light intensity at visible wavelengths. As ocean color data is related to the presence of constituents (primarily phytoplankton and

inorganic particulates) it may therefore be used to calculate the concentrations of material in surface ocean waters and the level of biological activity. Ocean color observations made from Earth orbit allow an oceanographic viewpoint that is impossible from ship or shore -- a global picture of biological activity in the world's oceans. http://daac.gsfc.nasa.gov/oceancolor/scifocus/oceanColor/dead_zones.shtml

Invasive Species

Aquatic Invasive Species: An Educator's information and materials guide. This booklet is a compilation of elected educational materials on aquatic invasive species (AIS). Materials have been assembled from agencies nationwide by the University of Minnesota Sea Grant Program to assist K-12 teachers and nonformal educators in raising awareness and integrating AIS studies into their curriculums. http://www.seagrant.umn.edu/education/ais_guide.pdf

Exotic Aquatics on the Move: Currently, teachers are more frequently requesting information on Aquatic Nuisance Species (ANS) to use in their classrooms. They seek clear, concise lesson plans that include multi-disciplinary concepts to help their students attain high academic goals and meet state and national education standards. This project is designed to assist teachers with research-based information for the classroom. A joint project of National Sea Grant Network and Geographic Education Alliances. <http://www.iisgcp.org/edk-12/exoticsp/>

Invasive Species of Long Island Sound: Poster with images and information about 14 invasive species of Long Island Sound. Includes a description of what invasive species are, why they are of concern, how they get into Long Island Sound, and what is being done about them. Connecticut Sea Grant. web2.uconn.edu/seagrant

Invasive Species of Long Island Sound: Web page. Invasive species occur in many different habitats within the waters and around the shores of LIS and come in an astonishing variety of sizes, shapes and forms, from the tiniest microscopic parasites to very large organisms. The species included here will provide a glimpse of the array of non-native species now occupying LIS and its surrounding coastlines. Connecticut Sea Grant. web2.uconn.edu/seagrant/whatwedo/ais/listour.php

The Lionfish Invasion!: Learn about the environmental and economic consequences of invasive species, using the recent invasion of the lionfish as a case study. <http://oceanservice.noaa.gov/education/stories/lionfish>

Marine Bioinvasions: MIT Sea Grant Center for Coastal Resources site for information, research, education, links and resources, exotic maps, and conferences related to marine bioinvaders. <http://massbay.mit.edu/exoticspecies>

Nab the Aquatic Invader: Major arrests need to be made in the fight against invading aquatic plants and animals. These invaders have hitchhiked to U.S. waters and are on the loose creating huge problems, such as impacts on biodiversity. We're looking for kids in grades 4-10 who want to help "book these bad guys" for their disruptive activities. You can be a private investigator on the case and help the other detectives "book the bad guys." Start by meeting the suspects and then read their profile sheets. Uncover more clues by solving the case files on each detective page and collect evidence and background information to help you catch each suspect. When you think you have enough evidence to "book a bad guy" click on the "Book'em" file and answer the questions. Don't forget to read them their rights! Sea Grant Network. www.sgnis.org/kids

Nonindigenous Aquatic Species (NAS): An information resource for the United States Geological Survey. Located at the Florida Integrated Science Center, this site has been established as a central repository for spatially referenced biogeographic accounts of nonindigenous aquatic species. <http://nas.er.usgs.gov/>

Visual Guide: Long Island Sound Marine Invasive Species with comparison to some native species: Waterproof field guide/flip book with color photographs, scientific and common names, and brief descriptions of each species. Connecticut Sea Grant. web2.uconn.edu/seagrant

Long Island Sound

Connecticut Coastal Access Guide: The Connecticut Coastal Access Guide is designed to help you explore the Connecticut shore of Long Island Sound. Use the guide to identify sites open to the public for boating, swimming, fishing, hiking and other outdoor activities. www.lisrc.uconn.edu/coastalaccess

Favorite Activities Book: Long Island Sound Educators Conference March 23, 1996. Long Island Sound activity reference for educators. (Out of Print)

The Living Sound: A kid's video about Long Island Sound. Ages 8-13. Activity book included. Available to borrow through the Connecticut Sea Grant Video Lending Library. web2.uconn.edu/seagrant

Long Island Sound Environmental Education Activity Kit: Activity kit and lesson plans focused on Long Island Sound. (Out of print)

Long Island Sound in a Jar: Activities for youth demonstrating human impact on aquatic systems. Lesson plans and activities. Edited by Heather Crawford. Connecticut Sea Grant. web2.uconn.edu/seagrant

Long Island Sound Facts, Figures and Maps: A list of physical facts (area, depth, etc.) and downloadable maps of Long Island Sound. US EPA. <http://www.epa.gov/region1/eco/lis/facts.html>

Long Island Sound Foundation (LISF): The mission of LISF is to facilitate the exchange of information among individuals and organizations and enhance their ability to address issues impacting Long Island Sound; enhance public learning, awareness, understanding and involvement focused on Long Island Sound; and establish an environmental fund by fund-raising and fund dispersing to support scientific and public policy research, education and community programs. The LISF holds a calendar contest for student artwork every year. Visit the website for more details about the latest calendar competition. <http://lisfoundation.org>

Long Island Sound Integrated Coastal Observing System (LISICOS): The goal of the Long Island Sound Integrated Coastal Observing System is the development of a sustained capability to observe the Long Island Sound ecosystem and an adequate capability to understand and predict its response to natural and anthropogenic changes. <http://lisicos.uconn.edu/>

Long Island Sound Resource Center (LISRC): The Resource Center was established in 1988 as a central clearinghouse for information and data related to the Sound. This web site is an ongoing project to provide access to data and information about the Sound. Visitors can learn about scientific research, access data, view interactive maps, search literature related to the Sound, browse a directory of organizations and information sources, or look for locations to access the Sound. www.lisrc.uconn.edu

Long Island Sound Resource Directory: Directory of agencies and organizations focused on the environment, Long Island Sound, and its watershed. 2004. Long Island Sound Foundation. <http://lisfoundation.org>

Long Island Sound Study (LISS): The Environmental Protection Agency's Long Island Sound Study (EPA LISS) is a cooperative effort involving researchers, regulators, user groups and other concerned organizations and individuals. These people are working together to protect and improve the health of the Sound. Be sure to check out the factsheets (<http://www.longislandsoundstudy.net/publications.htm#factsheets>) and the Kids/Teachers link for useful resources and links. www.longislandsoundstudy.net

Long Island Sound: Worth Fighting For!: In this 30-minute video produced by Connecticut Public Television, one will discover links between Long Island Sound's colorful past and its threatened future. See the beauty of a vast ecosystem that supports a biological bouillabaisse, and the science behind it. Find out what the issues are today, and what some people are doing to help. 1992. Available to borrow through the Connecticut Sea Grant Video Lending Library. web2.uconn.edu/seagrant



MYSound: MYSound provides comprehensive, real-time water quality, weather and wave data from Long Island Sound, its harbors and estuaries. The objective of the MYSound Project is to provide real-time water quality monitoring data from Long Island Sound to a broad spectrum of users - enhancing the appreciation, knowledge and use of the Sound. The approach consists of establishing telemetering data buoys at several locations throughout The Sound. Currently there are six active stations, with two more stations in transition. The data are posted realtime to this site as provisional data, while longer term and historical data are available as ASCII files via FTP. The sensor data available includes: water temperature, salinity (from conductivity), and dissolved oxygen as indicators of water quality. Due to the initial popularity of the weather station located in the eastern Sound, weather sensors were added to the central Sound and western Sound buoys. The central Sound buoy is also equipped with a wave monitor. University of Connecticut Department of Marine Sciences. www.mysound.uconn.edu

Proceedings of the Biennial Long Island Sound Research conferences: Since 1992, the Long Island Sound Foundation has sponsored the Long Island Sound Research conferences, in cooperation with the Connecticut and New York Sea Grant programs. Proceedings include abstracts and papers about Long Island Sound research. http://lisfoundation.org/lisf_pubs.php

Sound Health: Sound Health is the EPA LISS report to the public on the environmental issues affecting Long Island Sound. It provides information on water quality, the abundance of animal and plant life in the Sound, and trends in land use along the shore. It also illustrates some of the efforts to protect the Sound. www.longislandsoundstudy.net/soundhealth

S.O.S. Saving our Sound: Book of illustrations of Long Island Sound that promote Long Island Sound stewardship. Created by Mrs. Carter's 4th Grade students at Hart Magnet Elementary School in Stamford, Connecticut. 2005. (Out of Print)

Soundkeeper: Soundkeeper is dedicated to the protection and enhancement of the biological, physical, and chemical integrity of Long Island Sound and its watershed. Laws established by the Clean Water Act, as well as others, were designed to protect the Sound, and other waters, from pollution. But citizens are responsible for seeing that these laws are enforced. Soundkeeper is the vital link — the voice and action of concerned citizens — in making the waters of Long Island Sound fishable and swimmable. By raising awareness and attacking critical issues with the commitment and support of a dedicated citizen network, Soundkeeper is the advocate for the Sound. Its daily work is patrolling, investigating, intervening, and raising public awareness of the Sound's problems. www.soundkeeper.org

An Underwater Tour of Long Island Sound: This web site is designed to share this view with others, to show a glimpse of the other side of the shore. Take a tour through the broad types of habitats of Long Island Sound and see a diversity of animals that live in them. Click on the links in the map to tour seagrass meadows, boulder and gravel reefs, sand, mud, and midwater habitats. No diving experience is required. Long Island Sound Resource Center. www.lisrc.uconn.edu/lis_uwtour

What Makes Long Island Sound Special?: On this website you can learn about what Long Island Sound is

and where to find information about the vast array of environmental issues that impact the Sound. You will also find information and links to understand issues that impact the waters, land and air in the State of Connecticut and the waters of Long Island Sound. US EPA. www.epa.gov/ne/eco/lis

Wrack Lines: The official magazine of the Connecticut Sea Grant College Program. Articles center around Long Island Sound topics and include perspectives from several disciplines. This magazine is FREE and available in print or to download. Visit the *Wrack Lines* home page for a list of issues available to download. web2.uconn.edu/seagrant/publications/magazines/wracklines

Marine Education and Teaching Tools

Awesome Ocean Science: Investigating the secrets of the underwater world, a Williamson Kids Can! book. 2006. Cindy A. Littlefield. Ages 7-12. Ideal Publications, 120 pp.

The Bridge: The Bridge is a growing collection of the best marine education resources available on-line. It provides educators with a convenient source of accurate and useful information on global, national, and regional marine science topics, and gives researchers a contact point for educational outreach. Resources are organized as indicated on the sidebar on the left side of the screen. The Bridge is supported by the National Sea Grant Office, the National Oceanographic Partnership Program (NOPP), and the National Marine Educators Association (NMEA). Their goal is to provide educators with content-correct & content-current marine information and data, support researchers in outreach efforts, and improve communications among educators and between the education and research communities. www.marine-ed.org/bridge

Centers for Ocean Sciences Education Excellence (COSEE): The COSEE promote partnerships between research scientists and educators; disseminate best practices in ocean sciences education; and promote ocean education as a charismatic, interdisciplinary vehicle for creating a more scientifically literate workforce and citizenry. www.cosee.net

Coasts in Crisis: Public issues in Earth science. It discusses the dangers posed to coasts and coastal communities by "development, recreation, and waste disposal," among other activities. It describes the ever changing nature of coastlines, and both the natural and human causes of coastal change. Four case studies are very briefly described. While not an exhaustive treatment of its subject, this is an effective introduction that may encourage further study. A small bibliography is provided. U.S. Geological Survey Circular 1075. S. Jeffress Williams, Kurt Dodd, and Kathleen Krafft Gohn.

Discover Nature at the Seashore: Things to know and things to do. In this handy guide you'll find all you need to know to make a scientific expedition to the beach (or to a rocky shore, a salt marsh, and more). The author, science professor Elizabeth Lawlor, is completely practical: along with guidelines about what to take along in order to perform mini-scientific experiments right at the beach, she includes advice about how to dress and other ways you can be prepared for anything that might arise. 1992. Elizabeth P. Lawlor. Stackpole Books, 224 pp.

Discovery of Sound in the Sea (DOSITS) Teacher Resources and Weblinks: The Discovery of Sound in the Sea web site introduces you to the science and uses of Sound in the Sea. There are several major sections on the site such as The Science of Sound in the Sea, People and Sound in the Sea, and Animals and Sound in the Sea. The site's Audio Gallery is a fascinating place to visit and listen to underwater sounds created by marine animals, human activities, and natural phenomena such as lightning, earthquakes, and rain. Check out the technology gallery and discover a variety of equipment that uses sound to investigate the ocean. Watch video interviews with scientists that study how marine animals produce and hear sounds. Investigate how scientists use underwater acoustics to track ocean currents, identify potential obstacles, and quantify fish distributions. There is also a special section for teachers with resources and classroom activities. University of Rhode Island. www.dosits.org/teacher/teach1

Hands-On Ecology - Real-Life Activities For Kids: Children naturally are fascinated by the world around them, exploring the make-up of their world, including the animals, plants, and organisms that inhabit it, at an early age. Hands-On Ecology develops children's fascination with their world by giving them a front-row seat in the exploration of various ecological habitats. The book gives teachers the tools they need to create an extensive, in-depth study of ecology, including background information on ecosystems, how to set up a hands-on study of their local ecosystem, a look at how human populations affect the environment, and viable ways classrooms can contribute to conservationism. 2007. Colleen Kessler. Grades 3-5. Prufrock Press Inc., 168 pp. www.prufrock.com

Investigating Earth Systems: An inquiry earth science program from It's About Time Oceans. Teachers Guide. Michael J. Smith, John B. Southard, Colin Mably. It's About Time. www.its-about-time.com

Learning with Limulus: A model for teaching marine education by Dave Grant and Nancy Church, focusing on horseshoe crab form and function. Students will describe physical adaptations used by horseshoe crabs for locomotion, feeding, protection and vision. Students will also use familiar items as analogies to "construct" and study a horseshoe crab. Grades 4-8. <http://ux.brookdalecc.edu/staff/sandyhook/dgrant/field/LWL/LWL.html>

NOAA Ocean Explorer Education: This Web site provides an innovative way for students of all ages to learn about the oceans by offering near real-time access to a series of multidisciplinary ocean explorations. It also provides compelling imagery, video, and topical essays related to the ocean. This particular section of the site offers formal education materials, including a listing of professional development opportunities. <http://oceanexplorer.noaa.gov/edu>

NOAA Ocean Service Education Program (NOS): The National Ocean Service education team engages formal and informal education audiences to build environmental literacy through products and programs that incorporate the applied science of NOS. The team supports teacher infusion of NOS content into local curricula through professional development opportunities at conferences and through Web-based avenues. Be sure to check out the Discovery Kits-topics include pollution, currents, and invasive species. <http://oceanservice.noaa.gov/education>

Ocean Currents: Marine Science Activities for Grades 5-8, Teachers Guide. Developed at the Lawrence Hall of Science, this guide is one of more than 70 teacher's guides and handbooks from the Great Explorations in Math and Science program. Catherine Halversen, Kevin Beals, Craig Strang.

Oceans: Activity Guide for Ages 6-9. Oceans approaches a study of the ocean through games, activities and experiments. With more than 50 hands-on activities, children will explore the oceans from tide pools to the deep-water world. They will learn about sharks, sea turtles, octopuses, dolphins and more. The chapters include ocean information in "Ocean Notion," lots of fun facts, vocabulary words, and many literature selections, including stories, fables and legends. The hands-on explorations provides an insight to the information that will help children to have a deeper understanding of the ocean. Nancy F. Castaldo. Chicago Review Press. www.ipgbook.com

Oceans: Activity Guide for Grades 6-8. This Activity Guide is intended as a resource to assist teachers in incorporating the study of aquatic science, specifically as it relates to the ocean, into their existing curricula. The goals of this Activity Guide are to provide teachers with an interactive teaching tool and curriculum on oceans for grades 6-8; build students' critical thinking skills and scientific literacy; approach the study of science in an interdisciplinary way; and offer students a fun, hands-on learning experience. Shedd Aquarium. http://www.sheddaquarium.org/pdf/education/edu_guide_oceans.pdf

Only One Ocean: Marine Science Activities for Grades 5-8, Teachers Guide. Developed at the Lawrence Hall of Science, this guide is one of more than 70 teacher's guides and handbooks from the Great Explorations in Math and Science program. Catherine Halversen and Craig Strang. <http://lhs.berkeley.edu/gems/gemspubs>

Seashore Life: One of several titles on a website designed to provide users with a number of simple games and activities that help to nurture an interest in natural sciences. Designed to compliment the K-12 science curriculum, the materials range from simple games and quizzes to activities and experiments that can take a number of hours or days. James Kavanagh. Waterford Press.
www.waterfordpress.com

Take a Beach Walk: A discovery guide to finding, observing and identifying the plants and animals of North American seaside beaches. 2005. Jane Kirkland. Ages 8 and up. Take a Walk Books, Stillwater Publishing, 108 pp. www.takeawalk.com

Marine Flora and Fauna - Identification and Information

Across the Wide Ocean: The why, how, and where of navigation for humans and animals at sea. 2007. Karen Romano Young. Ages 9-12. Harpercollins Childrens Books, 80 pp.
http://www.harpercollins.com/books/9780060090869/Across_the_Wide_Ocean/index.aspx

AlgaeBase: AlgaeBase is a database of information on algae that includes terrestrial, marine and freshwater organisms. At present, the data for the marine algae (photographs, taxonomic, and species information), particularly seaweeds, are the most complete. For convenience, sea-grasses have been included even though they are flowering plants. www.algaebase.org

Beachcomber's Companion®: Web site and cards. The *Beachcomber's Companion*® web site, provides plenty of information about Atlantic coast marine invertebrates. Waterproof and portable, *Beachcomber's Companion*® features 50 common Atlantic coast marine invertebrates, beautifully illustrated (and scientifically accurate), and held together with a clip. Packaged in a mesh collecting bag, each set comes with a special marking pencil for the checklist card, so every critter found on each trip to the beach can be recorded—and wiped clean for next time! Cards provide common and scientific names for each organism, along with classification information, details on size, shape, and color, and where to look for it. Fun and strange facts for each organism are also included. Woods Hole Oceanographic Institution (WHOI) Sea Grant. www.beachcomberscompanion.net

Benthic Marine Algal Herbarium of Long Island Sound: Digital archive of scanned seaweed herbarium sheets. University of Connecticut University Libraries. www.algae.uconn.edu

Discover Marine Mammals: Swim in the ocean with a dolphin or under the sea with a blue whale. In this book, activities lead students on a journey of discovery as they explore the world of marine mammals. Lessons on the habitats in which marine mammals reside, the conditions and challenges marine mammals face, and how to be a marine mammal steward are taught through hands-on activities. Ages 8-12. 16 pp. <http://store.projectwet.org>

Fish: An Introduction to The Living Ocean: Biology and Technology of the Marine Environment: Curriculum Research and Development Group. University of Hawai'i at Manoa. www.hawaii.edu/crdg

Fish and Fishing: From facts about fins to funny phrases, kids learn about the lives of fish and human-kind's long history of pursuing them. "A Fine Kettle of Fish" increases awareness of water pollution, whirling disease, drought, loss of habitat, and over-fishing. Ages 8-12. 16 pp. <http://store.projectwet.org>

Fishes: Activity Guide for Grades K-8. This Activity Guide is designed to provide teachers with a resource for incorporating the study of aquatic science, specifically fishes, into their existing curricula. The goals of this Activity Guide are to provide teachers with an interactive teaching tool and curriculum on fishes for grades K-8; build students' critical thinking skills and scientific literacy; approach the study of science in an interdisciplinary way; and offer students a fun, hands-on learning experience. Shedd Aquarium. http://www.sheddaquarium.org/pdf/education/edu_guide_fishes.pdf

The Horseshoe Crab: Natural history, evolution, anatomy and more. The Ecological Research & Development. <http://horseshoecrab.org>

Horseshoe Crab Model: This life-sized paper model, to cut out and assemble with tape, is a great activity for 4th graders and up. It's also a perfect companion to the horseshoe crab MAS Bulletin. Includes background on the horseshoe crab and a crossword puzzle to test readers' knowledge. Copies are free to Delaware schoolteachers for classroom use. Requests should be submitted on school letterhead. Marine Advisory Service University of Delaware Sea Grant College Program. www.ocean.udel.edu/seagrant

Living Treasures of Long Island Sound: Connecticut Sea Grant has revised its old favorite, *Plants and Animals of Long Island Sound*. *Living Treasures* has more beautiful line drawings and updated expanded text. Reading level: middle school. By Lisa Wahle and Nancy Balcom. Also in Spanish translation: *Tesoros Vivientes*. Single copies are FREE! Teachers can also request multiple copies for classes and pay shipping. web2.uconn.edu/seagrant

Lobster Life Cycle and Habitat: Life as a lobster in Long Island Sound. Colorful illustrated life cycle poster and facts on reverse. New York Sea Grant. www.seagrant.sunysb.edu Also available from Connecticut Sea Grant. web2.uconn.edu/seagrant

Long Island Sound Educational Resources CD including *Sound Facts: Fun Facts About Long Island Sound and Living Treasures: Plants and Animals of Long Island Sound*: PowerPoint presentation. Connecticut Sea Grant. web2.uconn.edu/seagrant

Long Island Sound's Marine Mammals and Sea Turtles: Brochure with descriptions of Marine Mammals and Sea turtles of LIS and info on their protection. Mystic Aquarium and Institute for Exploration. www.mysticaquarium.org

Marine Animals of Southern New England and New York: Published by the Connecticut Department of Environmental Protection, this book will help identify most marine animal species found throughout the region. A complete reference on invertebrates and vertebrates, it features up-to-date keys to identifying 1,500 species. In addition, it contains more than 200 additional species references, 2,154 black and white illustrations, and 116 color prints. A perfect addition to any classroom or for any coastline explorer. Edited by Howard M. Weiss. 344 pages. www.ctdepstore.com

Marine Advisory Service (MAS) Bulletins: MAS bulletins are four- to eight-page publications that offer in-depth information about popular topics. Marine flora and fauna subjects include blue crab, hard clam, horseshoe crab, Phragmites, jellyfish, and sharks. Delaware Sea Grant. www.ocean.udel.edu/seagrant/publications

Michael Guiry's Seaweed Site: This educational website provides biological and taxonomic information on the three divisions of seaweed, world wide production statistics, and an introduction to the commercial uses of seaweed. www.seaweed.ie

Seaweeds of Long Island Sound: 104 page, lavishly illustrated guide to the seaweeds of Long Island Sound. Topics include species identification and when, where, and how to collect and preserve specimens. Many habitat views and microscopic images are included with pages for individual species. 162 photographs. By Margaret "Peg" Van Patten with introduction by Dr. Charles Yarish. Funded by an education grant from the EPA LISS, *the book is free to K-12 educators*. Connecticut Sea Grant. web2.uconn.edu/seagrant

Scott Tucker's Expedition New England: Scott Tucker created and currently hosts his television program called Expedition New England. Using his training as an artist and photographer, Scott documents the adventures of his family as they scuba dive the oceans and comb the front yards, backwoods and swamps of New England looking for wildlife. www.expeditionnewengland.com

Sharks: Activity Guide for Grades 3-5. This Activity Guide is designed to provide teachers with a resource for incorporating the study of aquatic science, specifically fishes, into their existing curricula. The goals of this Activity Guide are to provide teachers with an interactive teaching tool and curriculum on fishes for grades 3-5; build students' critical thinking skills and scientific literacy; approach the study of science in an interdisciplinary way; and offer students a fun, hands-on learning experience. Shedd Aquarium. http://www.sheddaquarium.org/pdf/education/edu_guide_sharks.pdf

Marshes and Wetlands

Connecticut College Arboretum Bulletin no. 25 - *Salt Marsh Plants of Connecticut:*

Illustrated guide to 22 plants which grow in our tidal wetland. 32 pp., 1980. Available in print at www.conncoll.edu/ccrec/greennet/arbo/pub.html

Connecticut College Arboretum Bulletin no. 27 - *Birds of Connecticut Salt Marshes:*

Illustrations and descriptions of 24 birds commonly seen on our tidal marshes. 48 pp., 1981. Available in print at www.conncoll.edu/ccrec/greennet/arbo/pub.html

Connecticut College Arboretum Bulletin no. 34 - *Tidal Marshes of Long Island Sound - Ecology, History, and Restoration:* Edited by Glenn D. Dreyer and William A. Niering. Describes the ecology and chronicles the history of Long Island Sound tidal marshes. Photographs and illustrations. 73 pp., 1995. Available in print at www.conncoll.edu/ccrec/greennet/arbo/pub.html or online at <http://arboretum.conncoll.edu/publications/34/MAIN.HTM>.

Connecticut College Arboretum Bulletin no. 37 - *Living Resources and Habitats of the Lower Connecticut River:* Focuses on the lower reaches of the Connecticut River that is a major New England estuary and tidal river recognized as globally significant. Photographs and illustrations. 76 pp., 2001. Available in print at www.conncoll.edu/ccrec/greennet/arbo/pub.html

The Connecticut River Tidal Marshes: Educational CD consisting of a PowerPoint presentation and photographs of the Connecticut River tidal marshes, Wetlands of International Importance under the Ramsar Convention. The content of the CD covers the geology and formation of the lower Connecticut River and the beautiful and diverse flora and fauna to be found in its salt, brackish and freshwater tidal marshes. Connecticut Sea Grant. web2.uconn.edu/seagrant

Wetlands, Oceans, and Watersheds: Information and links to specific topics on the connectivity of wetlands, oceans, and watersheds - what is being done and what you can do to protect them. US EPA. www.epa.gov/owow

Museums

Connecticut River Museum: Located on the waterfront in historic Essex, the Connecticut River Museum is the perfect place to explore the heritage and experience the wonders of New England's Great River. If you are drawn to the Connecticut River by the beauty of its unspoiled marshlands, the Museum offers an exceptional vantage point in any season. From its docks you can see bald eagles, migratory birds, and a wide variety of waterfowl. Recognized as one of The Last Great Places in the Northern Hemisphere by the Nature Conservancy, the tidal wetlands that surround the Connecticut River Museum are an environmental treasure worth the trip from anywhere. If you are intrigued by the rich history of the River and its peoples, there is no better starting point than the Museum's galleries. Designed to appeal to children as well as adults, the family-friendly exhibits are filled with art and artifacts that link the River's stories to our lives today. From dinosaurs to Dutch explorers, from Native American canoes to the first American submarine, there is something to capture every visitor's interest. www.ctrivermuseum.org

Peabody Museum of Natural History: The mission of the Peabody Museum is to serve Yale University

by advancing our understanding of earth's history through geological, biological, and anthropological research, and by communicating the results of this research to the widest possible audience through publication, exhibition, and educational programs. Fundamental to this mission is stewardship of the Museum's rich collections, which provide a remarkable record of the history of the earth, its life, and its cultures. Conservation, augmentation and use of these collections become increasingly urgent as modern threats to the diversity of life and culture continue to intensify. Yale University. www.peabody.yale.edu

Museum of Long Island Sound Natural Sciences: The Museum of Long Island Natural Sciences is associated with the Geosciences Department at the State University of New York at Stony Brook, Stony Brook, Long Island, New York. Its mission is to promote education, research, and public service in the natural sciences. In this context, the Museum: provides science education programs to the community, public schools, and general public through lectures, seminars, exhibits, films, publications, and special projects; promotes science literacy and serves as a catalyst for continued exploration in the natural sciences; and acts as a community resource on issues of science and the environment through timely dissemination of information and provision of learning opportunities for the public and other organizations, agencies and institutions. www.geosciences.stonybrook.edu/museum

Oceanography and Physical Science

Discovery of Sound in the Sea (DOSITS): The Discovery of Sound in the Sea web site introduces you to the science and uses of Sound in the Sea. There are several major sections on the site such as The Science of Sound in the Sea, People and Sound in the Sea, and Animals and Sound in the Sea. You will find the site's Audio Gallery a fascinating place to visit where you can listen to underwater sounds created by marine animals, human activities, and natural phenomena such as lightning, earthquakes, and rain. Check out the technology gallery and discover a variety of equipment that uses sound to investigate the ocean. Watch video interviews with scientists that study how marine animals produce and hear sounds. Investigate how scientists use underwater acoustics to track ocean currents, identify potential obstacles, and quantify fish distributions. There is also a special section for teachers with resources and classroom activities. University of Rhode Island. www.dosits.org

Hurricanes... Unleashing Nature's Fury: A preparedness guide. NOAA.
<http://www.weather.gov/os/hurricane/pdfs/HurricanesUNF07.pdf>

Hurricane Brochures: A digital library of hurricane facts and preparedness guides. Atlantic Oceanographic and Meteorological Laboratory. www.aoml.noaa.gov/general/lib/hurricane.html

Project Earth Science: Physical Oceanography: The paperback includes 18 activities and five readings on water properties, currents, waves, tides, characteristics of the ocean, and human impacts. Each section is introduced by a selection from classic prose or poetry that reinforces a theme of respect for Earth's ocean. The activities require common materials, and include background information, easy-to-follow procedures, questions to guide the student, and reproducible directions. The helpful teachers' guide features more detailed background information, a summary of key concepts, time allocations, extensions, and a suggested list of readings for integrating the activity into other disciplines. One of the unique features used in many of the activities is sciLINKS--NSTA's Internet connection system. An extensive appendix provides a master materials list, resources, and directions for constructing a wave tank. National Science Teachers Association. Second Edition. Brent A. Ford and P. Sean Smith. NSTA Press. Grades 5-12. 224 pp

Tidal Current Predictions: This system will allow you to obtain tidal predictions computed by CO-OPS for more than 2700 tidal current stations. Each region presents a list of the water level stations in the area. The stations are listed geographically; thus, stations that are near each other along the shoreline are near each other in the listing. NOAA. http://tidesandcurrents.noaa.gov/curr_pred.html

Traveling Nitrogen Game: Students play the role of nitrogen atoms traveling through the nitrogen cycle

to gain understanding of the varied pathways through the cycle and the relevance of nitrogen to living things. www.windows.ucar.edu/tour/link=/teacher_resources/teach_nitrogen.html

Understanding Your Water: From Source to Tap and Back Again: Lesson Plan. Students will research where their local drinking water comes from; explore pollution and other risks to drinking water sources; investigate the relationship between water treatment and public health; examine what happens when water goes down a toilet, down the drain, and into sewers; understand drinking water and wastewater treatment processes; and become familiar with the laws that govern drinking water and wastewater treatment.

http://www.pbs.org/newshour/extra/teachers/lessonplans/science/jan-june08/water_0324.html

Water Cycle Animation: An educational animation of the hydrologic cycle. NASA's Observatorium is a public access site for Earth and space data. They have pictures of the Earth, planets, stars, and other cool stuff, as well as the stories behind those images. http://physics.ship.edu/~mrc/astro/NASA_Space_Science/observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html

Pollution and Water Quality

Long Island Sound Water Quality Monitoring Program maps: Maps depict the extent of low dissolved oxygen in Long Island Sound for bi-weekly surveys conducted by the Connecticut Department of Environmental Protection, Bureau of Water Protection and Land Reuse's Long Island Sound Water Quality Monitoring Program from June to September.

www.ct.gov/dep/cwp/view.asp?a=2719&q=325532&depNav_GID=1654

Luck Isn't Enough: The Fight for Clean Water: A 12-minute video, narrated by Mason Adams, that describes the causes and effects of nonpoint source water pollution and suggests ways citizens and local decision makers can combat it. Connecticut and New York Sea Grant Extension Programs.

web2.uconn.edu/seagrant and www.seagrant.sunysb.edu

Nutrient Reduction: New Solutions for Old Problems: Nutrient Reduction Action Plan Demonstration Projects fact sheet. EPA LISS. www.longislandsoundstudy.net/pubs/facts/fact11.pdf

USGS Water Science for Schools - Primary Wastewater Treatment: A step-by-step guide describing what happens at each stage of the wastewater treatment process and how pollutants are removed to help keep our waterways clean. USGS. <http://ga.water.usgs.gov/edu/wwwisit.html>

Pathways to a Sustainable Future: A curriculum guide for schools exploring waste management issues. In order to better help schools and other institutions understand and review their waste management issues Pathways offers a *Waste Management Curriculum Guide*. This guide is available free to individuals or institutions and facilitates the exploration of complex issues surrounding waste management, as well as for planning for a sustainable future and implementing meaningful solutions today. The Chewonki Foundation. www.chewonki.org/pathways

Pollution Tutorial: The Pollution Tutorial will help you learn about nonpoint source pollution, which is pollution from sources that can't be tied to a specific location (city streets, farm fields, etc.) You'll read about the history and types of nonpoint source pollution, methods used to detect pollutants, and assess and reduce their damaging effects on the environment. The Roadmap to Resources complements the information in the tutorial by directing you to additional information and data from NOAA and other reliable resources. <http://oceanservice.noaa.gov/education/kits/pollution/welcome.html>

Understanding Marine Debris: The NOAA Marine Debris Program serves as a centralized marine debris capability within NOAA in order to coordinate, strengthen, and increase the visibility of marine debris issues and efforts within the agency, its partners, and the public. This Program is undertaking a national and international effort focusing on identifying, reducing, and preventing debris in the marine

environment. Additionally, the MDP supports and works closely with various partners across the U.S. to fulfill the Program's mission. www.marinedebris.noaa.gov

Water Quality Testing Kits: Choose from an assortment of tests; from 5-11 parameters, turbidity tests, and pH buffer solutions. <http://store.projectwet.org>

Programs

Bridgeport Regional Vocational Aquaculture School (BRVAS): The mission of BRVAS high school is to provide a rigorous educational program that ensures that students are able to examine problems and make informed decisions concerning society's relationship with the aquatic environment. The Aquaculture School serves a diverse community of students with a broad range of social, economic, cultural, and ethnic backgrounds who bring to the school a variety of skills, talents, and learning styles. We offer students from school systems in the greater Bridgeport region, the opportunity to enhance the traditional academic high school curriculum with a specialized emphasis on science and technology instruction related to the development of aquaculture in the State of Connecticut. The educational program is designed to provide students with experiences developed in collaboration with industry, government agencies, post-secondary educational institutions, and community organizations from local municipalities. Our goal is to enable students to meet rigorous academic standards through selected educational experiences that them to require work with technologies used by professionals in the maritime industry and aquatic research community. The Aquaculture School has, and will strive to maintain, a unique educational program that is relevant, focused, innovative, and continually evolving with an emphasis on high academic standards that will enable students to meet the needs of a changing world. <http://bridgeport.ct.schoolwebpages.com/education/school/school.php?sectionid=349>

The Marine Sciences Program at University of Connecticut Avery Point: The Marine Sciences Program for undergraduate and graduate studies is located on UConn's coastal campus at Avery Point, on the shores of Long Island Sound. The program includes the Department of Marine Sciences and the Marine Sciences and Technology Center. Within this program, faculty, staff, and students carry out cutting-edge research in coastal oceanography using cross-disciplinary approaches. It offers both undergraduate and graduate degrees that are characterized by an interdisciplinary foundation, high faculty-to-student ratio, and individualized plans of study and research. The program offers the intimacy and support of a small campus, coupled with the resources of a top-notch public university and internationally renowned scientists. www.marinesciences.uconn.edu

The School of Marine and Atmospheric Sciences (SoMAS) at Stony Brook University: SoMAS is the State University of New York's center for marine and atmospheric research, education, and public service. More than 200 graduate and undergraduate students from 16 different nations currently work and study at SoMAS. The Center's students study coastal oceanographic processes and atmospheric sciences in a natural and academic setting that offers abundant opportunities for conducting field work, solving real problems in both local and distant environments, and learning to express their opinions in the weekly seminars. The SoMAS faculty are internationally known for their leadership in research in both the atmospheric sciences and all the major disciplines of oceanography-biological, chemical, geological, and physical, and also atmospheric sciences. www.msrm.sunybs.edu/index.html

Project Oceanology: Project Oceanology's mission is to nurture interest and enthusiasm for science and our planet's marine environment. Their waterfront location is adjacent to a diverse variety of marine habitats and offers hands-on learning opportunities for any age. The school programs for students in grades 5 through 12, scout programs and summer enrichment overnight and day camps feature an inquiry oriented approach to science. The lighthouse expeditions, oceanographic research cruises and seal watches are unique educational outings for families. The travel programs for grown-ups provide learning adventures in marine ecology and lighthouse preservation. Located at the University of Connecticut's Avery Point Campus in Groton, Connecticut. www.oceanology.org

Schooner, Inc.: Schooner, Inc. is a nonprofit 501(c)(3) organization dedicated to protecting Long Island

Sound through environmental education and sailing. All of Schooner, Inc.'s programs are centered around hands-on learning opportunities. These programs include academic programs in the classroom, at shore sites and on board the tallship Quinnipiack; teacher training; summer camp adventures; public sails and charters; and attendance at festivals. www.schoonerinc.org

The Sound School: The Sound School Regional Vocational Aquaculture Center is accredited inter-district, college preparatory, high school, one of the 19 vocational agriculture centers in Connecticut, and a part of The New Haven Public School System. We are the first (full-time center) to concentrate in the study of aquaculture and marine trades. The expanded Sound School curriculum provides an excellent background for a wide range of choices after graduation. Solid training in math, science and the marine trades allows students to pursue further education in college, the technical trades, or apply their vocational and personal skills directly in the job market. Students who are interested in land and sea sciences, trades, & careers are urged to apply. www.soundschool.com

SoundWaters: SoundWaters is an educational nonprofit organization founded in 1989, specializing in environmental education organization on Long Island Sound. Programs take place at the Coastal Education Center in Cove Island Park, in Stamford, Connecticut, on the SoundWaters, an 80' three-masted schooner; at schools, community centers and field sites throughout the region; and at our summer program for children ages 2-14. The mission of SoundWaters is to educate children and adults about the wonders and beauty of Long Island Sound and its watershed. Through education, SoundWaters provides people with an understanding and awareness of the changes they can make in their lives and communities to restore, protect and preserve Long Island Sound and the environment. www.soundwaters.org

Sea Grant Programs

Connecticut Sea Grant (CTSG) College Program: CTSG collaborates with maritime industries and coastal communities to identify needs, and fund research, outreach, and educational activities that have special relevance to Connecticut and Long Island Sound. Our mission is to work towards achieving healthy coastal and marine ecosystems and consequent public benefits by supporting integrated locally and nationally relevant research, outreach and education programs in partnership with stakeholders. web2.uconn.edu/seagrant

CTSG Education Program: The CTSG Education Program provides: training and workshops for K-12 educators; marine curriculum consultation; resources and publications; links among educators and administrators; and links between educators and scientists. web2.uconn.edu/seagrant/whatwedo/marineed

National Sea Grant College Program: Environmental stewardship, long-term economic development and responsible use of America's coastal, ocean and Great Lakes resources are at the heart of Sea Grant's mission. Sea Grant is a nationwide network (administered through NOAA), of 32 university-based programs that work with coastal communities. The National Sea Grant College Program engages this network of the nation's top universities in conducting scientific research, education, training, and extension projects designed to foster science-based decisions about the use and conservation of our aquatic resources. Sea Grant is NOAA's primary university-based program in support of coastal resource use and conservation. Its research and outreach programs promote better understanding, conservation and use of America's coastal resources. In short, Sea Grant is "science serving America's coasts." www.seagrant.noaa.gov

Sea Grant Educator's Network: The Sea Grant Educators Network operates both locally and as a national force, providing highly respected marine and aquatic science education nationwide and partnering (links to partnerships page) with other national education efforts. The common goal of all Sea Grant programs is to provide educators with insights into contemporary marine and aquatic science issues and research, and to also provide strategies to bring this information to their students.

The Sea Grant network offers a variety of programs and resources in marine and aquatic sciences for K-12 students and teachers, undergraduate and graduate students and the general public. These include publications, workshops, conferences, summer internships, informal education for the general public, radio programs, websites, videos and other electronic media on topics ranging from coastal ecosystems to marine biotechnology. The Sea Grant Educators Network offers a variety of resources for students and teachers. www.seagranted.net

New York Sea Grant (NYSG) College Program: “Bringing science to the shore.” The NYSG vision is to have coastal decision-making influenced by science-based information and educated stakeholders. The NYSG mission is to bring science to the shore through high quality research, outreach, and extension. www.seagrant.sunysb.edu

NYSG’s Focus on Education: NYSG’s Marine and Great Lakes educators work with K-12 classroom teachers and partner with nature centers, museums and aquaria to deliver science-based information to students and the general public in order to create the informed citizenry needed for wise coastal resource decision-making. We believe that through such education efforts, coastal resource development and protection will be supported by a new generation of motivated, highly educated scientists and environmentally aware stewards.

<http://www.seagrant.sunysb.edu/article.asp?ArticleID=50>

Shipwrecks

Shipwrecks of Connecticut: The state of Connecticut has some 600 miles of undulating coastline along the north shore of Long Island Sound. For centuries the Sound has provided a protected waterway for coastal marine traffic, but over the years it has been the site of numerous shipwrecks.

www.wreckhunter.net/ctwrecks.htm

Long Island Shipwrecks: Long Island is the home of the famous “Wreck Valley”. Hundreds of charted wrecks can be found in the waters off Long Island. And there are hundreds, maybe even thousands of wrecks that are yet to be discovered or have not been charted.

<http://longislandgenealogy.com/shipwrecks.html>

Undersea

National Deep Sea Submergence Facility: The unique vehicles of the NDSF carry humans and a virtual “human presence” beneath those waters and down to the largely unexplored sea floor. Whether diving 4,500 meters (14,764 feet) or remaining submerged for several days, each vehicle offers unique tools to explore the mysteries beneath the ocean’s surface. Learn about the submersible vehicles and look at data and photographs recorded on missions. Woods Hole Oceanographic Institute.

www.whoi.edu/page.do?pid=8124

National Undersea Research Center (NURC): The National Undersea Research Center for the North Atlantic is one of six undersea centers established by NOAA’s Undersea Research Program (NURP) to provide the research community the support needed to work underwater. As part of the University of Connecticut, NURC also contributes to the research enterprise of the institution. www.nurc.uconn.edu

NURC Education: NURC is one of only a handful of programs or institutions that annually sponsor expeditions to explore, study, measure and sample our underwater world. Therefore, the Center feels it is incumbent to provide opportunities for educators and students to share in the discovery and experience the research process first hand. Pursuant to this belief the Center has established two ongoing educational initiatives:

Aquanaut Program (AP): The AP is an educational initiative designed to rekindle a sense of curiosity and quest for scientific knowledge in high school students and to provide a resource for teachers to enhance the teaching of marine science at their schools. The program is a rigorous,

Resources

exciting professional development activity for in-service teachers, and a hands-on learning experience for students. The AP is particularly successful in enhancing understanding of the research process, motivating students' decisions to pursue science as a career and promoting environmental stewardship on the part of all participants. <http://ap.nurc.uconn.edu>

Classroom of the Sea (COS) Program: COS was an innovative, comprehensive, three-year demonstration project that addressed many of the special needs of deaf learners in science. http://www.cos.uconn.edu/media_index.htm

Watersheds

Coastal Watershed Factsheets: Titles include "Your Coastal Watershed", "The Beach and Your Coastal Watershed", "Near Shore Waters and Your Coastal Watershed", and "Estuaries and Your Coastal Watershed." US EPA. www.epa.gov/owow/oceans/factsheets

Focus on the Coast: Focus on the Coast is an online resource for information on Connecticut's coastal natural resources and current issues and projects along our coast. The website provides descriptions of major coastal habitats that you will find in Connecticut and some of the threats that are impacting these habitats as well as ongoing projects that are restoring or managing these resources. At this site, you can link to digital maps and information via the Community Resource Inventory on priority coastal resource areas and land cover or, link to a variety of other sites that can help you protect your valuable coastal habitat areas. This website was developed as an educational resource and technical tool that is complementary to the NEMO Focus on the Coast workshop, which is available for the asking to come to your town. Focus on the Coast is a collaborative effort between the Connecticut NEMO Program and Connecticut Sea Grant. <http://nemo.uconn.edu/tools/fotc>

Fifteen Things You Can Do to Make a Difference in Your Watershed: Learn about, become active, and help increase public awareness in your watershed. US EPA. www.epa.gov/adopt/earthday

Long Island Sound Watershed: Downloadable figure of all watersheds draining into Long Island Sound. US EPA. <http://www.epa.gov/region1/eco/lis/assets/images/abasin.jpg>

Surf Your Watershed - Connecticut: Click on an interactive map of Connecticut to find out more information about the watershed you live in. US EPA. <http://cfpub.epa.gov/surf/state.cfm?statepostal=CT>

Surf Your Watershed - New York: Click on an interactive map of New York to find out more information about the watershed you live in. US EPA. <http://cfpub.epa.gov/surf/state.cfm?statepostal=NY>

Watershed Protection: What is a watershed? How can you protect a watershed using simple, everyday actions? Who manages a watershed? What watershed habitats support different plants and animals? Learn the answers to these questions and more through this interactive booklet. Kids can even become a certified Watershed Hero! Ages 8-12. 16 pp. <http://store.projectwet.org>

Wetlands, Oceans, and Watersheds: Information and links to specific topics on the connectivity of wetlands, oceans, and watersheds -what is being done and what you can do to protect them. US EPA. www.epa.gov/owow

What is a watershed?: With special reference to Long Island Sound. US EPA. www.epa.gov/region1/eco/lis/watershed.html

It's always ourselves we find in the sea.

—E.E. Cummings

The longer the island of knowledge, the longer the shoreline of wonder.

— Ralph W. Sockma

It is to the sea that man must turn to meet the last great challenge of exploration this side of outer space.

—H. B. Stewart

Probably the greatest enticement for those who today are devoting their lives to the study of the sea is the lure of the unknown, the challenge of the undiscovered, the thrill of discovery on what is truly the last frontier on earth.

—H. B. Stewart

To me the sea is a continual miracle; The fishes that swim - the rocks - the motion of the waves - the ships, the men in them, What stranger miracles are there?

—Walt Whitman

All we do is touched with ocean, yet we remain on the shore of what we know.

—Richard Wilbur




Sea Grant
Connecticut