

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.



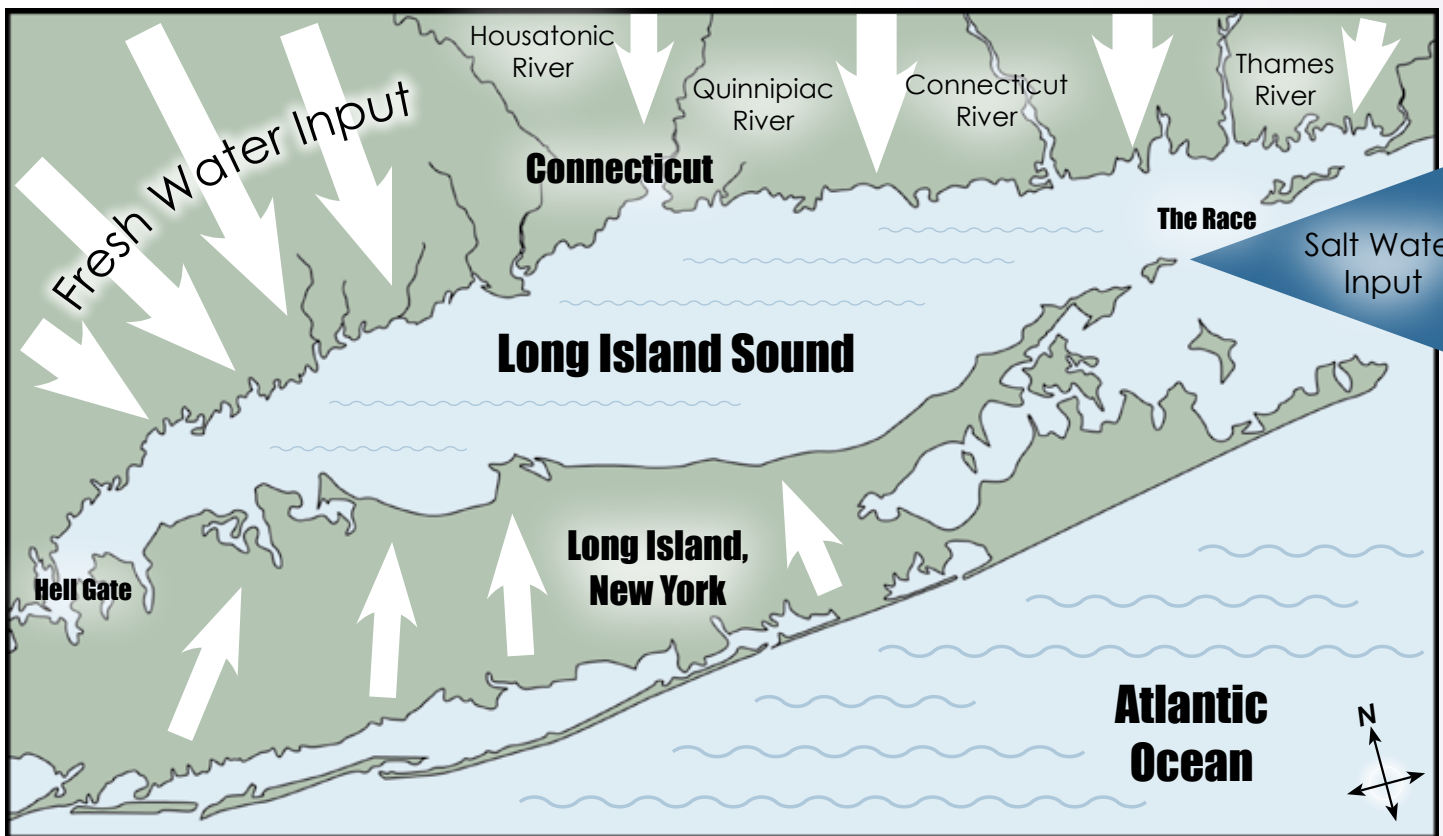
Charles Island off the coast of Connecticut stands completely surrounded by the productive estuarine waters of Long Island Sound.

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.

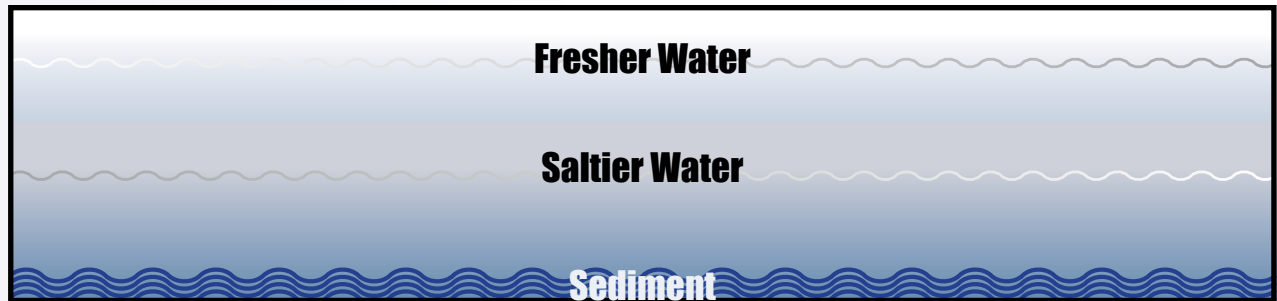


The waters mix and form a tremendously rich habitat for plants, animals, and other life forms. Estuaries are among the most productive ecosystems on Earth. John and Mildred Teal, in *Life and Death of the Salt Marsh* (1969), noted that estuaries and marshes are about ten times as productive as coastal 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?

5

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

7

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.

Meeting the Needs for Survival

9



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

11

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**.

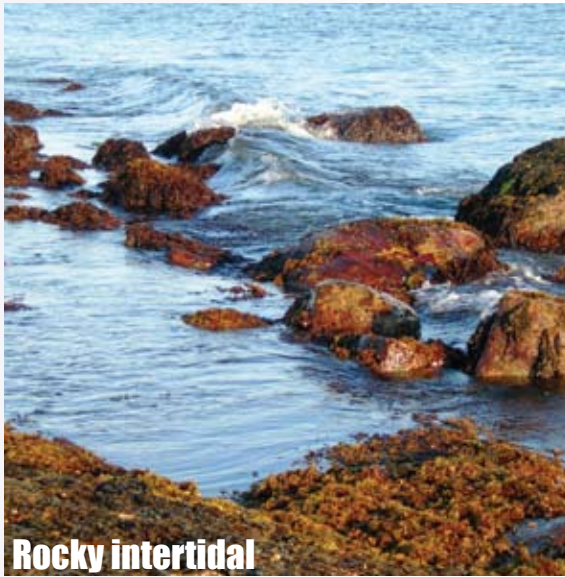
The Long Island Sound estuary is home to many different habitats. The primary habitats are:

- 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

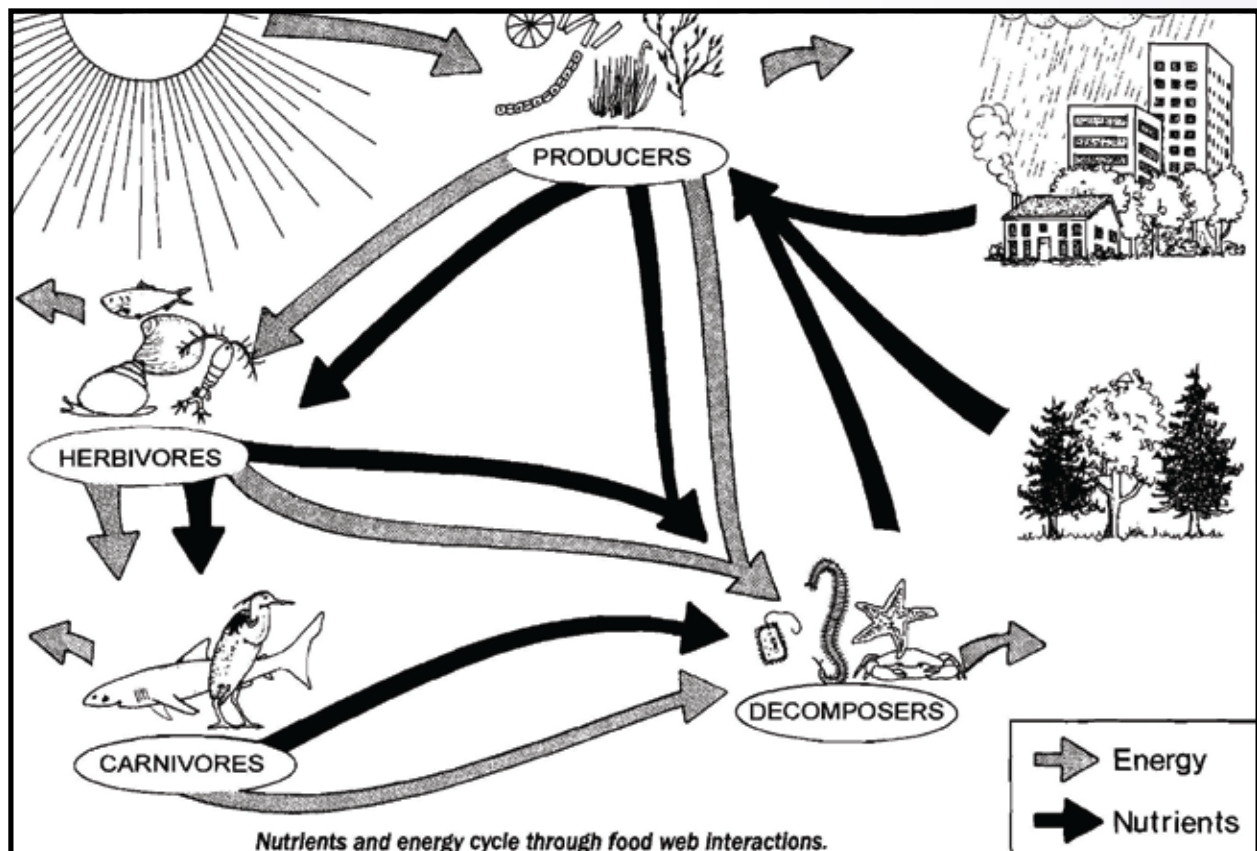
Food Chains and Food Webs: It's All About Eating and Being Eaten

13

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 web from *Living Treasures: The Plants and Animals of Long Island Sound*

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

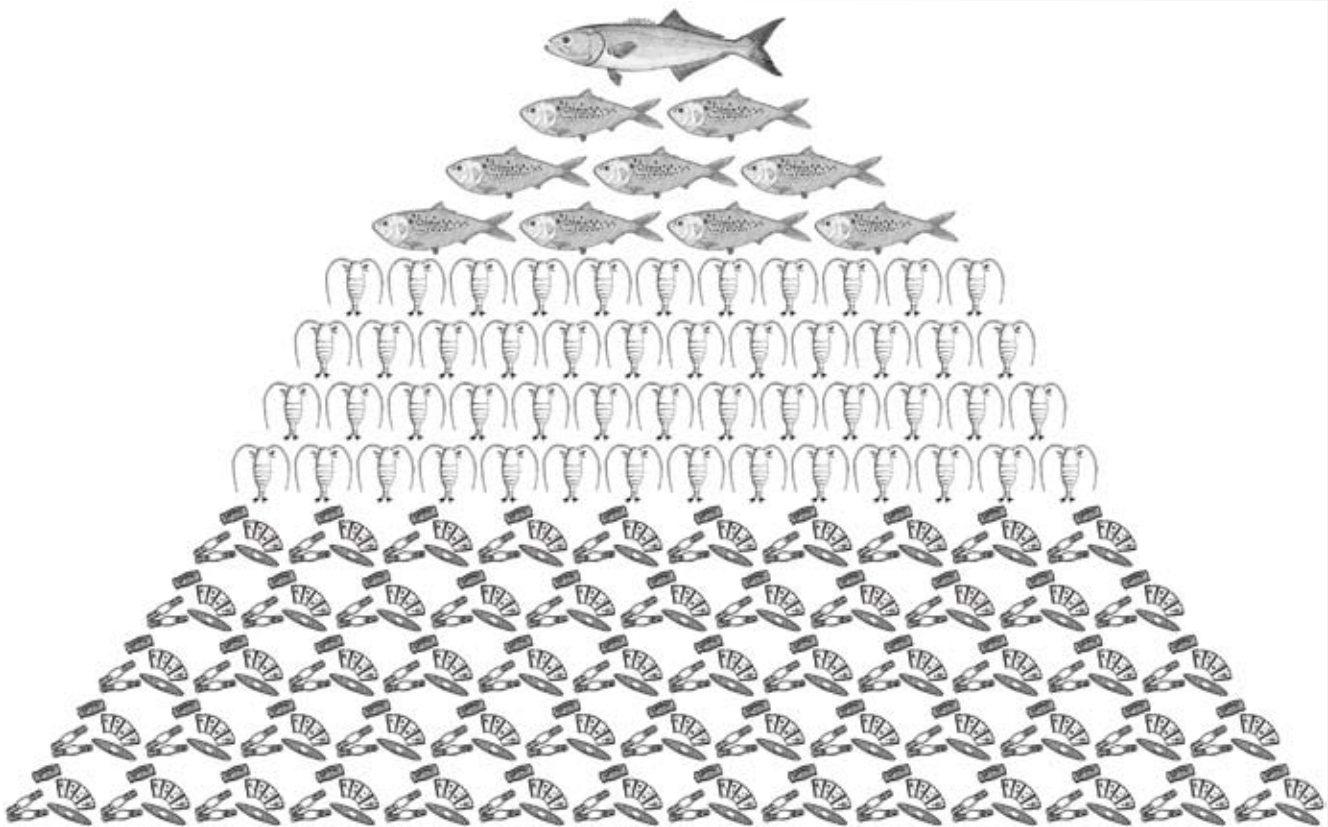
Worms
Bacteria
Fungi



Food Chains and Food Webs

15

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.