Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
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The Scientific Method Goes Swimming in the Long Island Sound

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by Larissa Spreng

Introduction

Water. Merriam-Webster defines water as "the liquid that descends from the clouds as rain, forms streams, lakes, and seas, and is a major constituent of all living matter and that when pure is an odorless, tasteless, very slightly compressible liquid oxide of hydrogen H_2O which appears bluish in thick layers, freezes at 0° C and boils at 100° C, has a maximum density at 4° C and a high specific heat, and is a poor conductor of electricity and a good solvent." Middle school students might instead define water as something "wet" that they use to: wash their hands, rehydrate with on the basketball court, and cool off with on a hot summer day.

Growing up outside of Cleveland, OH I spent a great deal of time exploring and enjoying the freshwater of Lake Erie. Many of my fondest childhood memories include Lake Erie, as this shallow Great Lake provides transportation, employment, food, and recreation to residents and visitors of Northeast Ohio. When I moved to Connecticut almost two years ago I was so excited to once again be close to water. One of the selling points of New Haven for me was the fact that is sits along an estuary, the Long Island Sound. However, I must admit, over the past two years I have learned little about this brackish water supply. I have also discovered by probing my students with questions about the Long Island Sound, that they too know little about this rich natural resource.

In order to create transformational change, teachers need to impact all areas of their students' lives, from academic growth to communication skills and character building. Creating a curriculum unit focused on asking questions in biology, allows for a combination of these skills. Academically, students can gain a deeper understanding of how biologists ask questions. This unit also focuses on creating a sense of community and understanding about the local area around New Haven, as the Long Island Sound is right in our backyard. And finally, this unit provides students with the knowledge and skills they need to become responsible citizens who are curious about the world around them and capable of making informed decisions about social and ethical issues relating to pollution, organisms, and the environment as a whole.

The New Haven 7 th and 8 th Grade General Science Curriculums focus heavily on inquiry skills and the biological sciences. The 7 th grade curriculum includes units on properties of matter, chemical properties, cells, genetics and reproduction, life systems (musculo-skeletal and biochemical), and microbes. By beginning the year with a curriculum unit on "The Scientific Method Goes for a Swim in the Long Island Sound" students can

refer their inquiry skills and gain confidence in their first ever class devoted completely to science. The 6th grade science content cover ecosystem populations and water pollution, a subject tested on in the 8th Grade Science CMT. Over the past two years I have discovered that very little science is actually being taught until students reach 7th and 8th grade. Students are supposed to come in with skills and knowledge that are just not present. This unit can be used to quickly elevate students where they need to be. This unit covers abiotic and biotic factors, food webs, invasive species, and both natural and man-made pollution to the Long Island Sound. It also allows for a smooth transition into the first 7th grade science unit on Properties of Matter, as much of the pollutants to the Long Island Sound (phosphorus, sulfur, lead, nitrogen) can be found on the Periodic Table of Elements. In addition to background knowledge, this unit also includes activities that will allow students to continue to make connections to the Long Island Sound throughout the course of the school year. Some possible concepts to make connections to include density, chemical properties of pollutants, types of unicellular organisms (algae), plant cells, characteristics of a living thing, comparing and contrasting organ systems of different animals in food chains, levels of biological organization, effects of bacteria on other organisms, and erosion and runoff.

Overall, this unit addresses inquiry skills and allows for application of biological content. The focus of this unit is not only to introduce students to the scientific method, but also to give them the tools necessary to state a problem, develop a hypothesis, design an experiment, collect data, analyze trends, and draw conclusions. This is accomplished through the lens of ecology and centers around experience in the field with a class trip to the Long Island Sound. Students need to make the connection of how using the scientific method is a logical and procedural way to go about solving problems in the ecological field. The famous biologist Charles Darwin and his trip to the Galapagos Islands serve as the perfect backdrop for this unit. The big idea students should take away from this unit ties to the following statement: the scientific method is a process used to answer questions about the natural world. This unit encourages students to ask questions about the Long Island Sound through the help of a classroom fieldtrip that gives students a chance to explore and inquire about their local community. This curriculum unit can also serve as a springboard for the New Haven Science Fair. Through participation in this event, students can practice proposing questions, evaluating their thinking, and defending their conclusions, just like other famous biologists that came before them!

The Long Island Sound

What is it?

It's located at 41 degrees North latitude, 73 degrees West longitude. It's 110 miles long. It averages 65 feet in depth. Its water masks a sandy, bedrock bottom. It's comprised of currents and tides that explain its variation in salinity. And it's home to plants, animals, and humans alike. [5]

The question "What is it?" can be answered in many ways depending on your frame of reference. And an even better understanding of this body of water can be gained by understanding the cause and effect relationship these characteristics have on this body of water and the creatures that live in and around it. [5]

Figure 1. The Long Island Sound is shown highlighted in pink between Connecticut and Long Island. Based on public domain satellite photo courtesy of NOAA. © 2004 Matthew Trump.

Location

The Long Island Sound is in fact a "sound." This geographical term is used to describe a body of water found between an island and mainland. The Long Island Sound lies between Connecticut, to the north, and Long Island, New York to the south. On a globe, it is also important to recognize that the Sound is almost directly between the North Pole and the Equator. As a result, the temperatures can get as cold as -1°C in the winter and as hot as 22°C in the summer. This change in temperature from artic to tropical conditions gives the Sound four distinct seasons and changes both biotic and abiotic factors. Biotic factors are living or once living parts of an environment including plants, animals, bacteria, and fungi. Abiotic factors are non-living and include light, temperature, weather, soil, water, air, and minerals. [5]

Water

Long Island Sound can also be described as an estuary because it is a partially enclosed coastal body of water, in which freshwater from rivers and stream meets and mixes with salt water from the ocean. This estuary has one major saltwater sources (the Atlantic Ocean) and four major freshwater sources (the Connecticut River, Thames River, Housatonic River, and Quinnipiac River) and many minor freshwater sources (streams). At 110 miles long the Sound receives salt water from both ends. On the eastern side the Race dumps about 25 billion gallons of salt water with each incoming tide. And on the western side the East River supplies more salt water. In addition to rivers and streams the Sound also gains freshwater in the form of precipitation from both rain and snow. Although most of the region surrounding the Sound receives an average of 30 to 40 inches of precipitation a year, the fresh water actually reaches the Sound via the rivers and streams. In this summer this process happens rapidly, but in the winter the freshwater remains on the land and does not enter the Sound until the snow melts. Therefore, the Sound has more freshwater in the early spring and less in the late summer. Another water factor that varies with season is salinity, or the salt content. The Long Island Sound averages a salt content of 28 parts per thousand (28 ppt), while ocean water contains around 35 ppt. It's also important to note that cold saltwater lies below warm freshwater giving the Sound an intricate circulation pattern. This fluctuation in salinity and temperature allows for greater biodiversity among organisms within the Sound. Organisms must have the ability to adapt to these changing estuary conditions. [5]

Figure 2. The Long Island Sound near Guilford, CT.

Aquatic Life

In addition, the Long Island Sound is a wonderful example of an aquatic ecosystem, or community of organisms living with one another and interacting with the physical environment around them. If one part of the environment is altered, such as oxygen levels or the addition or removal of a species, the entire ecosystem can be affected. And within this ecosystem, multiple habitats exist. Habitats, or areas in which organisms live, must provide the necessities to survival including: food, oxygen, water, space, and shelter. Some commonly found habitats in the Sound are intertidal zones (rocky intertidal zones, sandy beaches, tidal flats, salt marshes), water-land interfaces, and subtidal zones, which includes pelagic (open water) and benthic (bottom-dwelling). Each of these habitats has a unique landscape made up of various soils and rocks. Much of the landscape was shaped over 20,000 years ago by glacial movement. When the temperature rose, the glacier melted leaving sediments that formed a ridge down the middle of Long Island, New York. This left a freshwater lake until 19,000 to 15,000 years ago when the sea levels rose to the level of the Sound. Over time plants and animals took advantage of the Sounds varying habitats and made it a permanent home. [5]

Intertidal Zone

The intertidal zone is located between the highest high tide and lowest low tide. Several habitats exist in this area including rocky intertidal, beaches, sand or mud flats, and salt marshes. Organisms living in any of these zones must be equipped to survive exposure to sun, wind and water submergence.

Rocky Intertidal

The rocky intertidal zone is dry between tides, but it also receives the powerful force of waves. Organisms living in this habitat must have adaptations that allow them to anchor to the rock bottom floor. For example, mussels use byssal threads and barnacles use cement to avoid being swept away. Seaweeds that live in this area also have a special chemical compound that allows them to hold more water to prevent dehydration from exposure to sun and wind.

Sandy Beaches

Sandy beaches also experience waves and dry conditions during low tide. In this area, organisms such as worms, clams, and mole crabs burrow into the sand to avoid the heat and dryness of the sun.

Tidal Flats

Tidal flats are usually made of sand or mud and they occur in places where grasses are unable to grow due to waves. Without vegetation, sediments move easily providing even less safety from the sun and wind. Animals living in this area, like worms and clams, burrow into the sand or mud. During high tide many organisms move to tidal flats to find food.

Salt Marshes

Salt marshes are broken into two areas, high and low. High marshes can tolerate occasional flooding of salt water and plants such as cordgrass exist here. The low marsh experiences flooding twice a day and is home to tall cordgrass and organisms such as fiddler crabs and fish, which swim away with the tide. Salt marshes allow provide nutrients, feeding grounds, spawning areas, and temporary homes for many other organisms. Shellfish, crabs, snails, worms, and small land mammals utilize marshes. Many species of migratory birds stop to rest and feed in the marshes. Marshes also prevent flooding, as an acre of salt marsh can hold 30,000 gallons of water. The grasses also help filter the water and trap sediments and contaminants.

This area is also most in need of our help. An estimated 50-65% of Connecticut's salt marshes have disappeared due to human development, especially dredging, filling, and overharvesting. Much of what is left of the marshes experiences pollution. Fishermen worry that this loss of marsh habitat is threatening the sustainability of Connecticut's fisheries. The Tidal Wetlands Act of 1969 and the Coastal Management Act of 1979 seek to conserve these areas. [14,15]

Water-Land Interface

Although the water-land interface does not experience daily tidal changes it is affected by spring tides, which occur twice each month, along with salt spray and heavy flooding. These factors restrict the organisms that can live in these sometimes-salty environments. [9]

Subtidal Zone

The subtidal zone is always submerged water and because this habitat offers constant conditions a variety of organisms can survive here. This area is divided into two parts: benthic zone and pelagic zone. The benthic zone is where benthos, or bottom dwellers live including flatfish and crabs. The pelagic zone is where jellyfish and many roundfish, such as bluefish live because they thrive in the water column.

Food Chains – Linking Life in the Sound

Organisms interact with one another in very complex ways in order to gain energy necessary for life. Depictions of food chains often show theses relationships as simple pictures, depicting one organism eating something and it in turn being eaten by something else. Instead of thinking of these relationships as a chain they are better represented by a web. A food web is able to encompass all of the food chains in a given habitat or environment. [16.17]

Every food chain, no matter how big or how small, begins with producers, because they are the only organisms that are able to make their own food, through a process called photosynthesis. Plants are the most well known producers, but some bacteria can do this too, especially cyanobacteria which photosynthesize and are responsible for perhaps most of the world's photosynthesis. Photosynthesis involves taking in energy from the sun and transforming it into food. Plants are thus referred to as primary produces. Although they are at the bottom of the food chain they are actually located near the top of the Long Island Sound water column, because they need proximity to sunlight to do their very important job. Most plants in the Sound are a special type of one-celled (unicellular) organism called phytoplankton. Multicellular plants, such as macroalgae and seaweeds, are usually found in shallow waters along the coast. [13,14] Animals are all consumers because they are not capable of producing their own energy. First-order consumers, or herbivores, feed on plants. Zooplankton (tiny animals that float in the water column), several fish (herrings and sardines), shellfish, and some crustaceans (crabs and shrimp) are found in this group. The next group, second-order consumers, or carnivores, are animals that eat first-order consumers. This group is made up of fish and birds. Third-order consumers eat second-order consumers and include mammals, such as seals and otters.

While producers make the energy necessary for the food chain to flourish there are also special organisms that break down once living things. These organisms, known as scavengers and decomposers, play a special role in the ecosystem by breaking down dead plants and animals into nutrients. Once broken down these nutrients are released into the water and settle on the ocean floor, where other organisms can use them. Without decomposers energy would not circulate through the ecosystem, which would lead to breaks in food chains and trouble for the Sound ecosystem. It is also important to note that there are varying amounts of mater at each level of the food chain. A food pyramid is a great way to visualize the number of organisms at each level. Primary producers would make up the pyramid's base and then first-order, second-order, third-order and so on, as you climb the pyramid. [10, 11]

Invasive Species

On a boat ride along the Sound's it is easy to note some of the beautiful habits and ecosystems that exist along the shoreline. One flower that people often believe heighten the beauty of the Sound is the purple loosestrife. However, what people often down realize is these pretty purple flowers are actually a biological pollutant in disguise. These non-native aquatic plants were introduced accidentally. These colorful flowers may be beautiful from above, but from underwater their destructive nature can be seen. The purple loosestrife's roots are choking the roots of native plants like cattails that provide salt marsh organisms with foot and shelter.

Connecticut has its share of biological invaders, which can subtly or dramatically alter the Sound's ecosystem. Some of these invaders like periwinkle and the green have been here for so long that ecologists do not know what the natural ecosystem is supposed to look like. Others, such as gypsy moth caterpillars and zebra muscles, threaten the environment and the economy.

Early European settlers introduced periwinkle in the 1840s as a common food source from home. Today these little snails can be found along the rocky shoreline. Ecologists believe these snails dramatically reshaped the costal ecosystem, as they competed for food and space with native organisms. It is believed that if this snail were introduced today it would be a disaster for the Sound ecosystem. The green crab also originated from Europe in the early 1800's. This crab now serves an important role as both a predator and prey in the rocky shore habitat.

Another invasive species that is a nuisance to humans, especially boat owners and fisherman are sea squirts. Sea squirts originated from Asia and California and they attach to anything in the water. They have grape-like, elongated or vase-shaped bodies with two projecting spouts. When poked and prodded they often squirt out water. And to make matters worse they do not serve as a food source for humans or marine organisms.

In addition to animals, plants can also be invasive species. "Deadman's fingers" is a spongy green seaweed from Asia that invaded in 1957. This seaweed can damage entire shellfish beds because it attaches to the hard surfaces of oysters and scallops with a tremendous grip.

How did they get here?

Invasive species can invade an ecosystem in a variety of ways. Some, as mentioned above, were deliberate introduced by humans, usually to serve as a food source. Others accidentally arrived on the bottom of ships or fishing gear. They can also be transported in ballast water or packaging containers that release into open waters, like the Sound. But just because new organisms arrive in the Sound does not mean they are going to survive. Conditions must be just right for organism to grow and develop in its hijacked habitat.

The Future of the Sound

Long Island Sound has earned the nickname of "The Urban Sea" because it is surrounded by people. With a population of 2,300 people per square mile in the coastal areas surrounding the Sound, it is one of the most urbanized major water bodies along America's coastlines. European settlers arrived on the East Coast they quickly began using the Sound for major transportation. Bridgeport, New Haven, New London, Middletown, and Hartford grew and flourished as cities because of their ability to serve as natural harbors with a strategic spot along the Sound or Connecticut River.

Now more people than ever before want to work, play, and live close to the Sound. However, it is ironic that the same qualities (beautiful beaches, clean water, fresh seafood) that are drawing people closer to the Sound are the same things that are being threatened by humans. In a sense humans can also be added to the invasive species list.

As mentioned earlier one of the main habitats that has been negatively compromised by human impact are

salt marshes. Many of these coastal wetlands have been removed by dredging, or turned into buildable land with the addition of fill. Although the importance of salt marshes is known today, ecologists weren't able to get their laws past to protect the marshes in New England until the 1960's and 1970's. The 1979 Coastal Management Act makes it illegal to dredge or fill salt marshes this law doesn't help in undoing the damage we have already done.

Invasive species also threaten the future of the Sound. Opinions on how threatening these new organisms are vary widely. Fishermen welcome the introduction of new species of gamefish. Scientists, on the other hand, fear the changes these intruders have on the local ecology and food chain. While increased regulation is likely to slow the number of invasions that occur within the Sound and other bodies of water it is worth asking the question: What species will "rule" the Sound in 100 years?

Teaching Strategies

Food Chain Game [5]

Students will be able to understand the concepts of food chains and food webs and how energy flows through these chains.

This game of food chain tag can be used to show how organisms in a food chain obtain energy. Students should wear different color arm bands based on the organism they represent. Students must chase organisms below them in the food chain, while avoiding being caught by organisms above them. Dried beans are to be exchanged when one student (organism) is tagged (eaten) by another student (organism) higher up on the food chain. The student with the most beans at the end of the game wins. [5]

Materials

The materials necessary for this activity include: dried beans, colored arm bands, timer, bell to ring, large open area

Preparation

Armband colors represent the different levels of the food chain. They are to be passed out according to the following ratios: Phytoplankton (12), Copepods (8), Mummichogs (4), Striped Bass (2), and Decomposers (2). The teacher will represent the sun and pass out the energy (dried beans) to each organism. The decomposers can chase any organism. If the decomposer tags an organism they get all of that organism's dried beans.

Before beginning the game discuss the role of the sun with the students. Then review the food chain of the Long Island Sound. The plants in the Sound are the phytoplankton. Copepods eat the phytoplankton. Mummichogs eat the copepods. And striped bass eat these little fish. Ask students which level of the food chain each of these organisms represent. Also, have them make a prediction as to which level of the food chain they think will have the most beans at the end of the game.

Rules

1. Phytoplankton are the only organisms that can receive dried beans from the sun and they may do this as often as they like. Copepods can only tag phytoplankton, mummichogs can only tag copepods and striped bass can only tag mummichogs.

2. There is no tackling or pulling of organisms, only tagging.

3. Players are safe while a bean exchange is taking place, and players cannot be tagged.

After about 10 minutes of play each group should count their total number of beans

Discussion/Variations

At the end of the game most of the beans should have made their way to the striped bass and the decomposers. If time allows try the game again but this time have equal numbers of individuals in each food chain group. "Safe spots" can also be created for copepods and mummichogs to hide from their predators, but they cannot stay there the entire game or they will "starve." [5]

Invasive Species of the Long Island Sound Scrapbook

Students can have the option to choose their own invasive species or the teacher can put the names of invasive species (both plants and animals) in Long Island Sound in a jar and have students draw their species at random. Students should then create a scrapbook page about their species including a picture and the following information:

· What is the scientific name (genus and species)?

· In what kingdom is it found?

· Approximately when was it introduced to Long Island Sound?

· How was it introduced to the Long Island Sound?

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

· Are there currently efforts to deal with or eradicate your invasive species? If so what actions are being taken?

Students can utilize the Internet to find answers to the above questions. Once each student's scrapbook page is completed a class book can be assembled so students can share what they learned with others.

Nab the Aquatic Invader

This interactive website (http://www.iiseagrant.org/NabInvader/index.html) allows students to become detectives and make major arrests in the fight against invading aquatic plants and animals. These invaders have hitchhiked their way to places like the Long Island Sound and are no causing destruction and wreaking havoc on the biodiversity of the Sound. Students can help "book these bad guys" by first meeting the suspects and then collecting clues, gathering evidence, and other background to catch the right invader. When students think they have gathered enough information they can make an arrest.

This activity can be used as a differentiation technique for students or a whole class activity that can be done in a computer lab setting.

Long Island Sound Unit Vocabulary Ring

I have found a great teaching strategy that empowers my students to use scientific language and put concepts into their own terms by creating vocabulary card rings. Each vocabulary word gets its own note card, which can then be punched and strung on a ring. This is a great reference tool for students to have when they ask a question that relates to a word they should be able to recognize and understand. The student is able to find and eventually recall word and it's meaning rather than having the teacher tell them the answer. This is also a great exercise for students to do if they finish an assignment early.

One of my favorite models for creating vocabulary cards is the Frayer model in which the card is broken up into four squares (See Figure 3). [1] In the middle, the vocabulary word is written and circled. In the top left square, the student writes the definition in his or her own words. In the top right square, facts or characteristics of the word are written. In the bottom left, the student writes examples and in the bottom right, the student writes non-examples. I also ask my students to draw a picture to help them remember the word on the back. This also provides a way for them to quiz themselves using the picture they drew. [1]

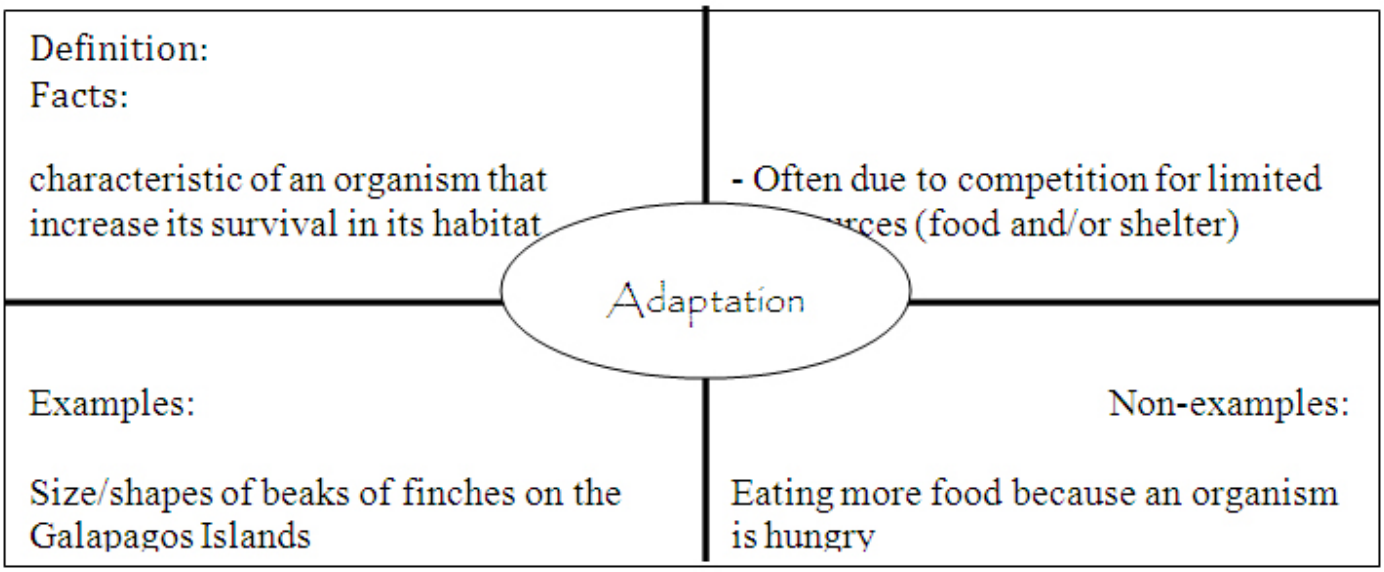

Figure 3. A sample Frayer Model vocabulary card.

Carnivore – meat-eaters

Consumer – organisms unable to produce their own food and must eat other organisms

Community – many populations of organisms sharing the same habitat and interacting within that habitat

Decomposer –organisms that feed on dead matter and break it down into nutrients

Ecosystem –community of organisms and their physical environment

Estuary – a body of water where fresh water and salt water meet and mix

Food Chain – sequence of organisms feeding successively upon the next

Food Web – all interconnected food chains

Herbivore – plant-eaters

Habitat – a place where and organism live

Invasive Species – a non-native species that once introduced dominates its new habitat to the detriment of other species

Omnivore – eater of both plants and animals

Photosynthesis – use the Sun's energy to turn water, carbon dioxide, and chemical nutrients such as nitrates and phosphates, into living tissue and oxygen

Phytoplankton – microscopic plants that drift near the surface of water and use the Sun's energy to undergo photosynthesis

Predator – eats other organisms

Prey - eaten by other organisms

Producer – organisms capable of making their own food

Species – individual organism types

Zooplankton – both microscopic and larger animals that drift or swim weakly in the water column

Science Lessons at a Long Island Sound Field Site

When choosing a topic for this unit, I purposefully selected a theme that directly connected to my students' lives. Long Island Sound is something that students in New Haven can relate to because it is right in their backyard. In fact, Long Island Sound is THE natural resource of Connecticut that affects economy, public health, the identity of city, and quality of life. While learning about the Sound in a classroom setting can be engaging middle school students need to be encouraged to think, reason, question, and experiment. [5]

Books to Add to Your Classroom Library

Lucky Science: Accidental Discoveries from Gravity to Velcro

By: Royston and Jeanie Roberts

Mistakes That Worked: 40 Familiar Inventions and How They Came to Be

By: Charlotte Jones

Sound facts: fun facts about Long Island Sound

By: Peg Van Patten, Milton Moore, and Eamon O'Muin

Appendix A. Implementing District Standards

Current Connecticut Standards

Content Standards

Matter and Energy in Ecosystems – How do matter and energy flow through the ecosystems?

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.

a. Populations in ecosystems are affected by biotic factors, such as other populations, and abiotic factors, such as soil and water supply.

b. Populations in ecosystems can be categorized as producers, consumers, and decomposers of organic matter.

Science and Technology in Society – How do science and technology affect the quality of our lives?

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

a. Most precipitation that falls on Connecticut eventually reaches Long Island Sound.

CMT Expected Performances

C.4 Describe how abiotic factors, such as temperature, water, and sunlight, affect the ability of plants to create their won food through photosynthesis.

C.5 Explain how populations are affected by predator-prey relationships.

C.6 Describe common food webs in different Connecticut ecosystems.

C.10 Explain the role of septic and sewage systems on the quality of surface and ground water.

C.11 Explain how human activity may impact water resources in Connecticut, such as ponds, rivers, and the Long Island Sound ecosystem.

Current New Haven Curriculum Standards

Grade-Level Expectations

1. Analyze and interpret how biotic and abiotic factors interact within a given ecosystem.

2. Design and conduct a scientific investigation to explore the porosity and permeability of soils and their ability to support different plan life.

3. Defend the statement, "The sun is the main source of energy on Earth."

4. Express in general terms how plants and other photosynthetic organisms use the sun's energy.

5. Investigate and report on the effects of abiotic factors on a plant's ability to photosynthesize.

6. Compare and contrast how energy and matter flow in Connecticut ecosystem emphasizing the interactions among producers, consumers, and decomposers.

7. Identify local examples of predator-prey relationships, and justify the impact of each type of population on the other.

8. Create and interpret graphs that illustrate the fluctuation of populations over time.

9. Distinguish a food chain from a food web and identify local examples of each.

10. Explain the impact of environmental conditions such as climate, elevation, topography or water quality on food chains.

11. Predict what will happen to a population based upon current trends (fires, disease, overhanging, development) and defend the prediction.

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