Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
2005 Volume V: Ecology and Biodiversity Conservation

Historical Harbor Habitats

Curriculum Unit 05.05.04
by Matthew D. Cacopardo

Objectives

1. Students will understand that energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers.

2. Students will know that plant cells and many microorganisms contain chloroplasts, the site of photosynthesis.

3. Students will recognize that organisms both cooperate and compete in ecosystems.

4. Students will be aware that the complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

5. Students will recognize that many factors influence environmental quality.

6. Students will comprehend the significance of the fact that human beings live within the world's ecosystems and that human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

7. Students will understand that the distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.

8. Students will understand that the great diversity of organisms is the result of 4 billion years of evolution that has filled every available niche with life forms.

Implementing District Standards

Scientific Inquiry and Literacy

Students will use New Haven harbor to conduct ecological research. By accessing information about the harbor generated by government agencies and local scientists students will search for and assess the relevance and credibility of scientific information found in various print and electronic forms. This information will be used to describe pollution levels found throughout in the sediment of the harbor. Students will then predict the environmental quality of the harbor with a hypothesis. Collecting biological, chemical and geological data at four locations within the harbor will test this prediction. Students will then analyze and interpret the data with a written conclusion.

Scientific Numeracy

This unit includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas. Students will calculate species richness, species evenness and a diversity index to determine the overall heath to the selected sampling sites found in New Haven harbor.

School Population and Rational

This unit will be ideal for a 10th grade biology class. It will review chemical, physical, and geological applications which were previously covered in their past science classes. This review will be important in taking the CAPT science test. The unit will additionally teach several biology topics taught throughout the 10th grade biology curriculum. Tenth grade biology topics include:

The Five Characteristics of Living Things

The Scientific Method

Microscope

Producers and Consumers

Diffusion

Autotrophs and Heterotrophs

Photosynthesis and Cellular Respiration

Food Cycles

Ecology

Species Diversity

Most New Haven schools are located within a few miles from New Haven harbor. Many of my students have never seen a natural ecosystem. Some have not been down to the harbor. I would like to change this by implementing a research project for interested students on the overall health of our harbor and surrounding coastline. What I would like to answer is do marine organisms have a greater abundance in the inner more polluted harbor or in the outer harbor and surrounding coastline. I plan to do this by looking at species distribution and abundance as well as determining the geologic, physical and chemical profiles of four parks located along the coastline of New Haven harbor.

Overview

Historically an estuary was thought to be immune to environmental problems. Shorelines have been used for centuries as a disposal ground for sewage and industrial waste. It was originally thought that the dilution of wastes in vast ocean waters would render them harmless. Because of this rational and historical lack of concern coastlines are some of the most threatened environments on the planet. Only 300 years ago Long Island Sound was teeming with oyster beds but due to anthropogenic activity loss of these organisms and their ability to increase water clarity now prevents sea grass and seaweed beds from colonizing. Over-harvesting, pollutants and introductions of invasive species are now the most pressing issues.

Anthropogenic sources of heavy metals in Long Island Sound have accumulated from a long history of industrialization. Long Island Sound is bordered by large cities such as New York, Bridgeport, and New Haven. Rivers such as the Housatonic, Thames, and Connecticut drain extensive inland areas of the New England states into the sound.

Sediments in the sound are known to be a repository for contaminant metals. New Haven Harbor is a bay located in the central region of Long Island Sound. It is the most active port in the state, which plays a role in keeping Connecticut recognized on the global market. New Haven harbor is responsible for the shipping of petroleum products, pharmaceuticals and building supplies. It is an industrial harbor with oil storage tanks, sewage treatment plants and electrical power plants. New Haven harbor is also important in the growth and cultivation of natural resources such as the Eastern oyster *Crassostrea virginica* and the blue mussel *Mytilus Edulis* . Studies have shown that sediments in the inner harbor have a higher concentration of pollution than the rather unpolluted sediment of the outer harbor. This is due to past and current discharge of municipal and industrial wastewater.

New Haven Harbor

New Haven Harbor is an embayment located on the north shore of Long Island Sound estuary. An estuary is a body of water partially surrounded by land where fresh water from a river mixes with salt water. This area creates many diverse habitats. The water is highly productive containing large populations on phytoplankton resulting in a community full of diversity. The outer harbor is 4 miles wide protected by three breakwaters.

The inner harbor is located 4miles in and narrow. Three tributary rivers have a direct relationship with the harbor. The Quinnipiac River is a densely populated 38 mile river. It is heavily urbanized and industrialized with 20 industries and municipalities permitted to release effluent into the river. The harbor was ranked 56 out of 150 ports in total tonnage moved in the United States in 2002. Sewer overflows, industry, sewage treatment, and river and atmospheric inputs make up the sources of pollution in to the harbor.

New Haven Harbor and the Industrial Revolution

The health of the harbor is a product of New Haven's prominence during the industrial revolution. New Haven began its industrial growth by making carriages. One of the earliest uses of machinery to cut costs and increase efficiency was conducted by John Cooke. Several carriage makers then used steam power to further reduce costs and increase production. The largest carriage manufacturer G & D Cook and Co. successfully increased production from one to 10 carriages and day.

In 1818 New Haven was beginning its population growth. Going from agriculture to industry it was home to hat and nail factories and cotton, powder, and paper mills. Fifty years later 28,000 men and women were employed by some 550 companies.

The arms industry can be credited to Eli Whitney. He was responsible for making New Haven one of the major arms-manufacturing centers of the United States. Beginning with his cotton gin Whitney emerged with a reputation for mass production. Receiving an opportunity to make muskets for the federal government he built machines to eliminate the laborious and time-consuming hand labor. Because of this Whitney has been labeled the inventor of mass production. In 1888 the Winchester Arms Company bought the Whitney Arms Company becoming the largest employer in the city.

New Haven was also known for its many hardware production companies. In 1864 J.B. Sargent and Company opened and is still in business today. Paper mills, pulp and box factories popped up around the city. On James street the National Folding Box Co. was said to be the largest paper box factory in the world. It has been boasted that the match industry in the U.S. grew from the efforts of New Haven industry. Thomas Sanford and partner Anson Beecher, devised a series of machines to convert raw lumber in to finished, packed matches. Charles Goodyear the inventor of the rubber vulcanizing process was responsible for the L. Candee Rubber Co. which manufactured rubber shoes. By 1892 Candee was the third largest rubber factory in the nation. By the beginning of the 1900's many factories were converting to electrical motors to give their operators better control and to improve working conditions. In 1899 the United Illuminating Co. was formed. To this day it sits at the base of the inner harbor welcoming all who enter our beautiful city.

With this massive industrialization came enormous quantities of raw material and waste products. In a time without government regulation factories dumped wastes into local rivers and the harbor itself. It is because of the hundreds of years of abuse that New Haven harbor has accumulated so much marine pollution.

Marine Pollution

The definition set forth by the United Nations Group of Experts on the Scientific Aspects of Marine Pollution for marine pollution is mans' introduction of substances or energy to the marine environment resulting in hazards to human health, hindrance of marine activity, such as fishing; impairments of the quality of sea water and the reduction of amenities. It should be noted that this definition is human focused and does not take other organisms into consideration. It is therefore a bit anthropocentric.

In order to make judgments about the impact of pollution on New Haven harbor a quantitative analysis must be made on the significance of environmental impacts of inputs to the harbor. Historically, New Haven harbor was a center of population and industry. The urban and industrial wastes were discharged directly into the harbor without treatment. Today wastes from human activities being introduced to the harbor are composed of variety of sources. Degradable and dissipating wastes breakdown and rapidly dilute to harmless levels. Examples of these wastes in New Haven harbor include oil, urban sewage and heat. Conservative wastes are metals and halogenated hydrocarbons, which are essentially permanent to the ecosystem.

The inputs into New Haven harbor are complex. Most come from the surrounding industries as well as the urban population. In addition the rivers flowing into the harbor may carry amounts of pesticides and other products of agricultural activity over the area of the entire catchment area. The power station's main effluent is hot water, which also contains chlorine to evade invertebrates from settling in the cooling system. Small amounts of metals are leached from the cooling system and turbines. Urban sewage, which often gets dispersed directly into the harbor contains amounts of metals, oils and greases, detergents and industrial wastes. When these inputs of wastes result in detectable amounts by causing damage to the environment then pollution exists.

These toxins will have little environmental consequences if few individuals perish. It is only when mortality results in the reduction of a population that humans begin to take notice. Population changes of a species may cause an impact on the community of which they are part of. Although many species in the community may be affected attention is often placed on only a few key species. Indicator species, which may be resistant or sensitive to pollutants, are often monitored to determine overall health of a community.

Several programs have been put into effect to monitor New Haven harbor and Long Island Sound. The National Oceanic and Atmospheric Administration's (NOAA) Nation Status and Trends Mussel Watch Project began in 1984. Its goal is to measure contaminant concentrations in bivalve tissue and in sediments to determine temporal changes in the concentrations and document biological responses to contamination. There are 150 collection sites across the coastal United States. New Haven harbor is one of the sites. At this site the blue mussel, *Mytilusis edulis,* is the indicator specie used.

The Long Island Sound Study began in 1985. Congress had the U.S. EPA, Connecticut and New York characterizes environmental conditions in Long Island Sound and develops and ecosystem-focused management plan. In 1994 the Comprehensive Conservation and Management Plan (CCMP) was established. This plan begins by determining the problems within the Sound and then sets forth plans to restore and protect the Sound with the help of the government. Since then goals for improvement of water quality by reducing point source and non point source pollution have been accomplished as well as the Habitat Restoration Initiative, which hopes to restore 2000 acres of coastal habitat and 100 miles for fish passage in rivers which have been blocked by dams. Water quality information from the study can be accessed by www.mysound.uconn.edu, which provides real time data on the Long Island Sounds water quality.

The Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 was enacted after Americans became more aware and concerned for water pollution. In 1977, this law became commonly known as the Clean Water Act. As a result it established initial regulations for discharging pollutants into U.S. waters. It gave the EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also continued requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under the construction grants program and recognized the need for planning to address the critical problems posed by nonpoint source pollution.

Today the Clean Water Act also includes the Clean Water State Revolving Fund. This new funding strategy addressed water quality needs by building on EPA-State partnerships (www.epa.gov).

Heavy Metals

Heavy metals are conservative pollutants. Metals are not subject to bacterial decomposition. Therefore they are permanent additions to our environment. These metals include:

Lead Nickel

Copper Aluminum

Cadmium Silver

Iron Mercury

Zinc Arsenic

Normally metals are essential for many biological activities such as the proper functioning of enzymes and respiratory fluids of animals. Absorption of these metals in most plants and animals is by passive diffusion. Natural inputs of metals into the sea occur from erosion of ore-bearing rocks, wind blown dust, volcanic activity and forest fires. Problems arise when the balanced natural inputs are elevated by anthropogenic sources. Metal pollution is a by-product of the Industrial Revolutions. Inputs form human activity is by atmospheric deposition, rivers and direct discharges or dumping. These human introduced metals eventually sediment out of the water column but are continuously redistributed by dredging and digging up contaminated harbor sediment.

Plant and animals differ in their ability to regulate their metal content. Most are able to excrete metals from their systems but often uptake of metals exceeds the excretion rates. When this occurs it is called bioaccumulation. Metals in the food web begin with the uptake of metal ions by marine algae. The metal is then stored in their tissues. Once ingested by an animal or absorbed through its skin or gills, metals can be concentrated as they progress from smaller to larger organisms within the food chain. The effect of metal pollution in water does not stop at the individual organism. It impacts the species as a whole, the community and the ecosystem. There have been reports that certain species disappear completely when a marine ecosystem is polluted with metals. The loss of a species can have detrimental effects to the food web (Clark, R.B. 2001).

How Much Is A Part Per Million

Metal concentrations in organisms are expressed in µg/g (parts per million) and µg/kg (parts per billion). The concentrations are calculated on the basis of wet weight and dry weight. Wet weight is the weight of a sample of a whole organism and dry weight is the weight of the tissue after drying at a temperature of 105ºC to remove unbound water.

An example to help with the parts per… idea is that if you cut a pizza pie into 10 equal pieces then each piece would be 1 part per 10. If, instead, you cut this pie into a million pieces, then each piece would be very small and would represent a millionth of the total pizza or one part per million of the total pizza. One droplet of water in an Olympic sized swimming pool can be expressed as 1 part per billion.

Local Scientists Who Have Studied Metals in New Haven Harbor and Long Island Sound

Dr. Gaboury Benoit, Yale School of Forestry and Environmental Studies

Dr. Benoit has conducted a Connecticut Sea Grant research project to identify the sources and quantities of heavy metal pollution in the Quinnipiac River, New Haven harbor and Long Island Sound. He found higher concentrations of metals in heavily industrialized areas.

Dr. Vincent Breslin, Southern Connecticut State University School of Science Education and Environmental Studies

Dr. Breslin is creating a sediment metal concentration database in the industrialized harbors throughout the Connecticut coastline. His research shows that in New Haven harbor the higher concentrations of sediment heavy metal concentrations are located in the inner more industrialized harbor. This area is composed of fine grain sediments. Results showed that concentrations were less as he sampled in the outer less industrialized harbor. His web site is http://www.southernct.edu/programs/utpp/breslin/

The Ecology of Long Island Sound

Rocky Intertidal

There are several dominant shoreline habitats found throughout the harbor and the surrounding shoreline. These include rocky shores, soft sediment beaches and salt marshes. This study will be conducted on intertidal zone at each location. The intertidal or littoral zone comprises the area of extreme low tide to extreme high tide. It is important that the teacher checks the time of low tide for the day of sampling because this is the time for most effective sampling.

Rocky shores are wonderful places to find many sessile and slow moving invertebrates along with hardy algae that are able to deal with constant fluctuating physical environments. These environments are usually abundant with species due to the plankton rich water. This water is constantly replenished due to a diurnal (twice a day) tidal cycle.

Rocky intertidal algae range from microscopic diatoms to large seaweeds and kelp. These plants do well in the areas due to the abundant nutrient rich water. These nutrients come from terrestrial runoff and from the rise of deeper oceanic currents. Major seaweeds include green, brown and red algae. Phytoplankton is also found in great abundance. (see Activity).

Rocky intertidal herbivores include sessile filter feeders and slow moving resident grazers that have modified mouth parts for scraping hard surfaces and slicing tissue from macroalgea. Common grazers include periwinkles *Littorina littorina* , limpets *Acmaea testudinalis* , amphipods and isopod crustaceans. Due to high levels of pelagic microorganisms, phytoplankton, Cyanobacteria and zooplankton are abundant food sources for sessile filter feeders. Typical sessile filter feeders that students will find are ribbed mussels, blue mussels *Mytilis edulis* , and barnacles (Bertness. 1999.).

Predation on rocky shores is rampant with such an abundance of species. This predation causes some of the most unique invertebrate species in search of a tasty treat. Shell drilling snails, starfish and crabs rely on this productive environment. Species that may be found are:

Dog Welks *Nucella lapillus* ,

Oyster Drills *Uroslapiny cinera* ,

Starefish *Asterias* ,

European Green Crabs *Carcinus maenas* ,

Japanese Shore Crabs *Hemigrapus sanguinis* ,

Blue Crabs *Callenecties sapidus* .

Tidal Flats

The east coast has been geologically stable for the past 150 years. Throughout this time erosional sediments have accumulated along this coastline which has left sandy or muddy shores. These soft sediment habitats are sheltered from waves. At first sight they may appear to be a barren scene but they are actually biologically rich. Because of the stability of the habitat they can host a diverse assemblage of organisms. Tidal flats contain sediments that range form fine mud 0.05mm in diameter to coarse sand 1.0 mm in diameter. Sediment sizes on tidal flats generally increase with increasing intertidal height. The softer sediment is home to bacterial and protozoan which are feed on by burrowing worms and bivalves which are caught by crabs. These benthic food chains rely heavily on the water column supply of clean water filled with primary producing plankton and detritus. Typical organisms that will be found in these environments include filter feeders, deposit feeders and predators.

Filter Feeders include

Surf Clam *Mulinia lateralis*

Razor Clam *Ensis*

Quahog *Mercenaria mercenaria*

Blue Mussel *Mytilis edulis*

Ribbed Mussel *Geukensia demissa*

Deposit feeders are among the most diverse species found in the tidal flats. Members of many taxonomic groups which include worms, amphipods and shrimp, sea cucumbers clams and snails survive by extracting detritus and organic material from the tidal flat sediments. These organisms are important in food chains by converting detritus into microorganisms biomass for higher trophic levels as well as biotubators which resuspend substrate into the water column.

Deposit Filter Feeders include

Mud Snails

Fiddler Crabs

Spaghetti worms *Amphitrite*

Bamboo Worms

Lugworm

Predators include crabs. The dominant predator in these environments is the blue crab. Blue crabs are quite vicious and should only be collected if a shell remain is found. (Bertness. 1999.).

Species Diversity

Species diversity is a characteristic of a community structure. The most useful measures of species diversity are the determination of the number of species (richness) and the distribution of individuals among species (evenness) in a community. A community with high species diversity has many equal of nearly equally abundant species within it. On the other hand a community consisting of very few species or if only a few species are abundant then species diversity is low. High species diversity indicates a complex community with a larger array of species interaction. This means that food webs are more complex. Some ecologists have stated that species diversity is a measure of community stability. They have used Diversity Index calculations to determine the maturity of a community under the idea that communities become more complex and stable as they mature. Students will calculate a species diversity index for the communities in-which they will sample from in Activity 5 (Brower et al. 1998)

Format of the Unit

This unit is a complete ecological research project. By examining a natural estuary habitat questions like what kinds of organisms live along the coastline and how do theses organisms depend on one another should be answered. By using a tidal flat one can develop a good understanding of the typical species necessary for a productive environment (Activity 1). With this you could then integrate the tidal flat food webs and the importance of biodiversity (Activity 2). By introducing heavy metals an abundant pollutant in the harbor the class can then make predictions on how the food web and biodiversity of the environment can be altered (Activity 3). Students will then collect data on recent heavy metal research conducted in New Haven harbor to get an understanding of what local scientists are doing (Activity 4). To conclude the students will determine geological, chemical and biological profiles of four city parks located along the harbor. They will then determine environmental quality of the harbor from their data through calculating species richness and evenness (Activity 5).

Location of Sampling Sites

I would like to begin by categorizing the harbor into three different areas: the inner, middle and outer harbor. Current research shows that there are higher levels of sediment metal contamination located at the inner harbor and appears to dissipate as you sample from the middle and outer harbor. Students will sample from four sites along the harbor to determine relationships along a coastline. These are the four sites that have been chosen from inner to outer harbors.

Preliminary Site: Outer Island

Natural Habitat

The beginning of the year sampling site is Outer Island. It is the last island in the Thimble Islands. It has been set aside for Connecticut public schools to conduct research and should also be considered. It is ideal for this research because it is isolated from heavy human activity and can represent a natural habitat. It contains sandy beaches, intertidal flats and rocky shores. Visits to Outer Island can be arranged by contacting the Center for Education and Research at Outer Island (CEROI) by phone at (203) 392-6265. School groups visiting the island do not pay a fee for access to the island or for the supervision provided by faculty and staff of the CSU system. There is a website for CEROI which will give all the details. It is http://www.ctstateu.edu/ceroi/ceroi.htm.

Site One: Quinnipiac River Park

Inner Harbor

The Quinnipiac River Park is located at mouth of the west bank of the Quinnipiac river between Grand Avenue and Brewery Square. It is a four acre riverfront strip that has been home to many industries over the past three centuries. Fishing and oystering industries, shipbuilding yards and a coal yard have occupied this site. In the 1940's the land was used by a major scrap iron dealer and oil tank farm.

In 1969 the Fair Haven Renewal Plan designated the land for open space to be made into a park. In 1985 construction of the park was delayed when toxic materials were found in the soil. This material was removed and replaced with fill. Today the park appears to be totally revived which makes it an excellent location for our first site. It

provides us with a tidal river for sampling. This will be a great location for testing in the contaminated area (Tucker. 1994.).

Site Two: John P. Criscuolo Park (Quinnipiac Park)

Inner Harbor

John P. Criscuolo Park is located at the tip of the Fair Haven peninsula. After World War II Quonset huts were placed in the park for the use of veterans and their families. Once torn down the park was used for recreation. Over the years the park deteriorated into a barren wasteland with the smell of the heavily polluted Mill River and nor greenery to relieve it (Tucker. 1994.).

Site Three: Long Warf Park

Middle Harbor

Long Warf Park is a narrow strip of land on the west side of New Haven harbor. It runs parallel to I-95. At the southern most point lies the Long Warf Nature Preserve. It has a tidal marsh, sandy beach and a rocky shore. It is an invertebrate and nutrient rich environment (Tucker. 1994.).

Site Four: Sandy Point

Outer Harbor

Sandy Point in West Haven is located in the outer harbor. During the 1800's Sandy Point was home to flourishing oyster beds. Oysters were taken from the Chesapeake Bay and transplanted along the site. Today the only signs of oysters on the beach are the signs, which read that oyster beds are contaminated and that shellfishing is prohibited. Today Sandy point is home to migrating Piping Plovers. Teachers should check to make sure this site is open to the public. There are times when the plovers are nesting and access is denied. It has a tidal marsh, tidal river, a sandy beach and an intertidal flat.

Activity 1

Outer Island Field Trip

Begin the unit with a trip to Outer Island. More Information on this site can be directed the Center for Education and Research at Outer Island (CEROI) website: http://www.ctstateu.edu/ceroi/ceroi.htm. This would be great beginning of the year trip that can be quite effective in developing an understanding of proper sampling techniques and introducing typical flora and fauna of a natural habitat. There is an Outer Island video that can be sent to schools for free by contacting Dr. Breslin. His website is: http://www.southernct.edu/programs/utpp/breslin/ .

Have students make a list of the organisms that they observed in the field. A good book that can be used to identify these animals is the Peterson Field Guide to the Atlantic Seashore. With the use of the list of organisms assign an organism to each student or group of students to write a short paper on how the "Five Characteristics of Living Things" are observed in their model organism.

By using a plankton net you could have students cast out into the water and collect samples of plankton which could be brought back to the classroom to introduce the use of the microscope. At this time the teacher should introduce the concepts such as autotrophs and heterotrophs and producers and consumers. The importance of biological illustrations can then be implemented by having the students draw their observations. By using colored pencils they will begin to see a color trend in the producers and autotrophs. The teacher could then use this knowledge to begin to discuss photosynthesis and cellular respiration.

Activity 2

Food Webs

A good flow from cellular respiration into food webs can then be made. Once the concept of energy production is understood the class will begin to look at how this energy is transferred in the food webs of the intertidal habitat.

A typical food web of an intertidal habitat includes

Plankton ? Filter Feeders ? Shorebirds

Or

Diatoms ? Deposit Feeders ? Predatory Crabs ? Shorebirds

With a general knowledge of their model organisms the students will access images via internet of their model organism. Groups of students can then make their own food web displays, which can then be used as a decorative piece for the classroom.

Activity 3

Food Webs and the Bioaccumulation of Heavy Metals

It would be beneficial to introduce Heavy Metals at this time. Have students look around their house and neighborhood and make a list of all the products that are made of metal. It may be a good idea to review the metals on the periodic chart.

Once students have compiled a list the teacher should begin to talk about pollutants in the environment. These pollutants are a product of the Industrial Revolution. The teacher should tie in the relationship of New Haven as a heavily industrialized city during this period and the use of the harbor as an industrial dumping ground. A trip to the New Haven Colony Historical Society can be planned. A slide show can be scheduled to see how New Haven was a prominent port during the Industrial revolution. The museum is at 114 Whitney Avenue New Haven, CT, around the corner from the Peabody Museum of Natural History. The telephone number is 203-562-4183. A scavenger hunt can be assigned to locate the various factories found on the Quinnipiac, and Mill rivers and New Haven Harbor.

Activity 4

Heavy Metal Data in New Haven Harbor

Have students collect information on sediment and bivalve tissue metal concentration data in New Haven Harbor. This information can be obtained at the websites of:

NOAA's Status and Trends Mussel Watch Program

Dr. Breslin http://www.southernct.edu/programs/utpp/breslin/

Long Island Sound Study www.longislandsoundstudy.net

Connecticut Department of Agriculture Aquaculture Division

Students should be given a map of New Haven Harbor. Have them place the sediment and tissue metal concentration values at the locations on the map. They can then create a table and a graph, which displays the trends that the data shows. A conclusion should be drawn from this information. Students should begin to see that the metal concentrations for both sediment and bivalve tissue are higher in the inner harbor and decrease in values as you move toward the outer harbor.

Activity 5

The Geological, Chemical and Biological Profile of New Haven Harbor

Once the students have made the connection that there is a pollution gradient form the inner to the outer harbor the class will now sample from four parks located in the inner middle and outer harbor to see if there are any trends in geological, physical, chemical and biological entities.

Geological Analysis

Now the real fun begins. At this time trips to the four parks will be planned. You will need at least an hour and half at each site. We will begin by taking samples of sediment at the four different locations within the harbor. Sediment samples will be taken back to the lab and analyzed for physical characteristics. The sediment will be categorized by its size according to the U.S. Department of Agriculture sediment size categories. These samples will be used to compare the information they generated from Activity Four. Are there differences in sediment size in heavily polluted inner harbor from the less polluted outer harbor? With this information we will determine which sediment type carries more heavy metals. You should see fine sediment in the inner harbor and coarse sediment in the outer harbor. Have the students make predictions why there is a greater concentration of metal in the fine sediment as opposed to the more coarse types. Hint: Because the fine sediment has more surface area it allows more metal to bind to its surface.

Chemical Analysis

Students will begin to look at the chemical properties of the water. For the chemical profile dissolved oxygen concentration, phosphates and nitrate concentrations can be determined. Have students record their values in the data sheet provided.

Biological Analysis

We will then look at specie richness and evenness at the different locations within the harbor. Marine invertebrates and macroalgae will be collected using a plot sample method. This procedure randomly selects multiple areas of one square meter. At each plot species will be identified and the number of each individual within the species will be counted. Students will record the numbers in the data sheet provided.

Once a data sheet is completed for each sampling site students will then fill in the Diversity Index Table for all sites on the following sheet provided. Students will then calculate a richness, evenness and a diversity index for each site to determine which site is the most productive. Below is an example of how this is done.

(table available in print form)

s , number of species = 3

N, number of individuals = 85

R, richness = 1.55

Ds, Simpson Diversity index = Ds = 1- (50(49) + 25(24) + 10(9)) / 85(84) = 0.56

E, evenness = 0.8301

The formulas for R, Ds, and E are as follows:

R = *s* / log N

Ds = 1 – (SUM ni (ni – 1)) / (N (N – 1))

Dmax = (s-1/s) x (N/N-1)

E = Ds/Dmax

So a Diversity Index takes into account species richness and the evenness of the individuals' distribution among species. Richness can be expressed simply as the number of species. Evenness is expressed by considering how close a set of observed species abundances are to those from and aggregation of species having maximum possible diversity for a given N and *s* .

If we see a significant difference in our data between locations we can then start to discuss if sediment pollution concentrations relate to specie abundance and distribution. My intent in this research project is to solidify the scientific method to young scientists while building a better understanding for a sustainable future. Good Luck.

Historical Harbor Habitats Data Sheet

Materials

1. New Haven Harbor Heavy Metal Sediment Concentration Data can be found at the home page of Dr.Vincent Breslin Associate Professor Science Education and Environment Studies at Southern Connecticut State University: http://www.southernct.edu/programs/utpp/breslin/

2. Map of the harbor with locations labeled

Procedure:

Students will receive a blank map of New Haven Harbor with the location of the sampling sites. You will then fill in the data.

Location____

1. Longitude and Latitude. _____________

____

Geology

2. Sediment Type _____________

Chemistry

3. O2 Concentration _____________

4. Phosphate Concentrations _____________

5. Nitrate Concentration _____________

6. Heavy Metal sediment concentration. _____________

7. Heavy Metal mussel tissue concentration. _____________

Biology

Table.____

Species Number Counted

Producers

Phytoplankton

Consumers

Zooplankton

Filter Feeders

Deposit Feeders

Predators

Diversity Index Table

(table available in print form)

s , number of species

N, number of individuals

R, richness

Ds, Simpson Diversity index

E, evenness

The formulas for R, Ds, and E are as follows:

R = *s* / log N

Ds = 1 – (SUM ni (ni – 1)) / (N (N – 1))

Dmax = (s-1/s) x (N/N-1)

E = Ds/Dmax

Reading List

Bertness , Mark D., The Ecology of the Atlantic Shoreline., Sinauer Associates, Inc.1999.

Brower, James., J.H. Zar., and C.N. von Ende., Field and Laboratory Methods for General Ecology. McGraw-Hill 1998

Clark, R.B.., Marine Pollution., Oxford University Press., 2001

Kennedy, Victor S., R.I.E. Newell, & A. F. Eble., The Eastern Oyster Crassostrea virginica., Maryland Sea Grant., 1996.

Connecticut Costal Access Guide Key to the Coastal Region, Connecticut Department of Environmental Protection.

Anderson. Tom., This Fine Piece of Water : An Environmental History of Long Island Sound

www.dep.state.ct.us/coastalaccess is a Connecticut Coastal Access guide

References

Bertness , Mark D., The Ecology of the Atlantic Shoreline., Sinauer Associates, Inc.1999.

Brower, James., J.H. Zar., and C.N. von Ende., Field and Laboratory Methods for General Ecology. McGraw-Hill 1998

Clark, R.B.., Marine Pollution., Oxford University Press., 2001

Protection and Progress, 2003-2004 Long Island Sound Study Biennial Report.

Tucker, Susan., New Haven Outdoors a guide to the City's Parks., Citizens Park Council of Greater New Haven., 1990

Van Patten. P., Metals More than Rock Music., Nor'Easter Fall/Winter 1997

http://www.epa.gov

Materials

Plankton Net

O2, Phosphate and Nitrate Test Kits

U.S. Department of Agriculture sediment size categories

Classroom set of The Petersons Guide to the Atlantic Seashore