Lesson Plans

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

Dissolved Oxygen in Long Island Sound

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

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

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

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

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

Audio/ Visual Equipment
Computers/Internet access
LCD- Possible PowerPoint presentation

Teaching Time
Three 45 minutes periods as follows:
- **Period one** should be used to introduce students to the concept of dissolved oxygen and its use by organisms living in water.
- **Period two** should be used to describe the materials and allow the students to design their experiment. See Dissolved Oxygen Lab Student Activity, pages 37-38.
- **Period three** should be used to conduct and record data from the experiment.

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

Seating Arrangement
Students work in pairs

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

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Background Information

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

Learning Procedure

Teacher Preparation

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

Learning Procedure

- Provide students with information and readings related to dissolved oxygen, anoxia, hypoxia, and eutrophication.
- Identify anthropogenic and natural factors that contribute to the depletion of oxygen in the waters of Long Island Sound.
- Introduce students to species found in the Sound and discuss their needs for dissolved oxygen.
- Explain the lab and provide example questions.
- Provide students with time to design and get approval for their experiment.
- Have students conduct experiments and record data.
- Provide students with the opportunity to present their experimental design and results to their classmates.

The Sea Grant Connection

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

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

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

The "Me" Connection

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

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

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

Connection to Other Subjects

History/Geography, Economics

Evaluation

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

Extensions

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

Resources

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

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

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

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

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

Connecticut Science Frameworks

Grades 6-8

Scientific Inquiry

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

Scientific Literacy

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

Scientific Numeracy

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

Content Standards

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

Grades 9-10

Scientific Inquiry

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

Dissolved Oxygen in Long Island Sound

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

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

Content Standards

9.8: The use of resources by human populations may affect the quality of the environment.
- Emission of combustion by-products, such as SO_2, CO_2, and NO_X by industries and vehicles is a major source of air pollution.
- Accumulation of metal and non-metal ions used to increase agricultural productivity is a major source of water pollution.

9.9: Some materials can be recycled, but others accumulate in the environment and may affect the balance of the Earth systems.
- New technologies and changes in lifestyle can have positive and/or negative effects on the environment.

New York Science Standards

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

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

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard F: Science in Personal and Social Perspectives
- Personal and community health
- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazard
- Science and technology in local, national, and global challenges

Content Standard G: History and Nature of Science
- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably interconnected

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

Dissolved Oxygen Lab
Student Activity

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

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

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

Websites to Visit
Long Island Sound Study - http://www.longislandsoundstudy.net/
Soundkeeper - http://www.soundkeeper.org/

Materials
You may use the following materials for your experiment:
- Various sized beakers
- Dissolved oxygen titration kits or meters
- Refractometer or other method to measure salinity
- pH meter or strips
- Stirring rods
- Access to water
- Instant Ocean
- Timer
- Thermometers
- Hot plates
- Safety equipment

Dissolved Oxygen Lab
Student Activity

Name:_____ Lab Group:_____

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

	Possible Points	Your Score
Scientific question **Hypothesis**	5	
Experimental Design • Background research • Variables • Procedure and materials list	25	
Clean up • Clean glassware, return all materials, and wipe down work area • Teacher initials required:_____	10	
Presentation • State your hypothesis • Briefly describe your experiment • Show your data • State whether your hypothesis was supported or refuted • Error analysis - discuss any problems or potential instrumental error	10	
Lab Report • Introduction • Materials • Procedure • Results • Analysis • Conclusion • Error Analysis	50	

Nitrogen Loading and Hypoxia

Focus
Hypoxia in Long Island Sound

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

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

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

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

Readings for each student role:

Environmentalist:

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

Wastewater Treatment Plant Manager:

Fall 2007 Nitrogen Trends in Long Island Sound www.longislandsoundstudy.net/pubs/news/fall2007nitrogen.pdf, specifically the following articles:
- "Trends in Point Source Nitrogen Loads"
- "Connecticut's Trading Tool Controlling Connecticut's Nitrogen Discharges" (For younger students substitute Wastewater Treatment fact sheet: www.longislandsoundstudy.net/pubs/facts/fact3.pdf)

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

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

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

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

Teaching Time
Two one-hour class periods

Seating Arrangement
Groups of four students

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

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Background Information

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

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

Learning Procedure

Teacher Preparation

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

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

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

Learning Procedure

- Prior to the in-class lesson, announce the task – "You and your team are members of the Hypoxia Management Working Group. You have been brought together to identify the best and worst solutions to reduce the occurrence of hypoxia in Long Island Sound. Your working group will research these solutions and submit a report. Your report will involve a 5 -10 minute presentation using visuals such as a poster or PowerPoint. You will receive a rubric with details as to what needs to be included in your presentation."
- Divide students into groups of four and assign roles within group as follows:
  - *Environmentalist:* Identify and explain the problem of nitrogen loading
  - *Wastewater treatment plant manager:* Explain the role of point pollution in nitrogen loading and assess solutions involving wastewater treatment plants.
  - *Scientist:* Explain the current data and ecological impacts of dissolved oxygen and nitrogen loading.
  - *Citizen:* Explain the role of non-point pollution in nitrogen loading and assess solutions involving citizens of your state.
- Distribute Nitrogen Loading and Hypoxia Student Roles (pages 43-44) and specific role reading assignments for homework.
- Option for differentiation: Some readings are more difficult than others – you can discretely assign roles according to reading comprehension level.
- ***Day One*:** Distribute the readings for all group members and final report rubric. Students work as a group in their roles and work towards a consensus of the two most desirable and two least desirable solutions. Students can use solutions presented in the individual readings, group article or their own ideas. Once the decisions have been made, students should create the presentation following the rubric.
- ***Day Two*:** Groups should complete their presentations and present to the class.

The Sea Grant Connection

Hypoxia in Long Island Sound
http://nsgl.gso.uri.edu/conn/conng88002.pdf

Nutrient Reduction: New Solutions to Old Problems
http://nsgl.gso.uri.edu/nyext/nyextg90008.pdf

The "Me" Connection

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

Connection to Other Subjects

Chemistry, Earth Science, Civics/Social Studies

Evaluation

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

Extensions

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

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

Resources

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

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

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

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

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

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

Understanding Your Water: From Source to Tap and Back Again – PBS Lesson Plan
www.pbs.org/newshour/extra/teachers/lessonplans/science/jan-june08/water_0324.html

Primary Wastewater Treatment, Water Science for Schools - USGS
http://ga.water.usgs.gov/edu/wwvisit.html

Water Cycle Animation - NASA's Observatorium
http://physics.ship.edu/~mrc/astro/NASA_Space_Science/observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro3.html

Connecticut Science Frameworks

Grades 6-8

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

Grades 9-10

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

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

New York Science Standards

Standard 1- Analysis, inquiry and Design: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

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

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

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

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

National Science Education Standards

Content Standard C: Life Science
- Interdependence of Organisms

Content Standard F: Science in Personal and Social Perspectives
- Natural Resources
- Environmental Quality

Content Standard G: History and Nature of Science
- Nature of Science

Ocean Literacy Essential Principles and Fundamental Concepts

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

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

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

Nitrogen Loading and Hypoxia
Student Roles

Environmentalist

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

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

Wastewater treatment plant manager

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

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

Nitrogen Loading and Hypoxia
Student Roles

Scientist

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

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

Citizen

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

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

Nitrogen Loading and Hypoxia
Student Activity

Name:_____ Date:_____

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

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

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

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

1.What is nitrogen loading?

2. Why is it harmful to Long Island Sound?

3. What are the latest impacts of nitrogen loading on Long Island Sound?

4. What is the difference of "point" and "non-point" source pollution?

5. Name two examples each of point and non-point sources of nitrogen entering Long Island Sound.

Nitrogen Loading and Hypoxia
Group Activity

Name:_____ Date:_____

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

First: _____
Why?

Are there any drawbacks?

Second: _____
Why?

Are there any drawbacks?

Second to last:_____
Why?

Are there any drawbacks?

Last:_____
Why?

Are there any drawbacks?

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

Macroalgae of Long Island Sound

Focus
Seaweeds in Long Island Sound and seaweed products.

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

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

Materials
Part 1 - Seaweed identification and pressing

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

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

Part 2 - Seaweed chromatography

Teacher
- Rubbing alcohol
- Access to a ventilation hood

Students (working in pairs)
- Sandwich baggie
- Small plastic cup
- Filter paper
- One species of seaweed
- Scissors
- Tape
- Pencil
- Goggles

Part 3 - Seaweed product poster

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

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

Macroalgae of Long Island Sound

Logistics

Part 1 - Seaweed Identification and press

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

Part 2 - Seaweed chromatography

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

Part 3 - Seaweed Poster

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

Audio/ Visual Equipment

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

Teaching Time

Part 1- Two 45 minute periods for identification and pressing.

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

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

Seating Arrangement

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

Key Words

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

Background Information

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

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

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

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

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

Learning Procedure

Teacher Preparation

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

Learning Procedure

Part 1 - Seaweed Identification and press

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

Part 2 - Seaweed chromatography

Teacher

- Review photosynthesis and photosynthetic pigments.

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

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

Part 3 - Seaweed Poster

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

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

The Sea Grant Connection

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

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

The "Me" Connection

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

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

Connection to Other Subjects

History/Cultures; Food Science; Pharmaceuticals

Evaluation

Develop a rubric to score the student poster.

Extensions

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

Create a recipe including seaweed as ingredients.

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

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

Resources

AlgaeBase www.algaebase.org

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

Micheal Guiry's Seaweed Site www.seaweed.ie

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

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

Connecticut Science Frameworks

Grades 6-8

Scientific Literacy

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

Content Standards

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

Grades 9-10

Content Standards

10.6: Living organisms have the capability of producing populations of unlimited size, but the environment can support only a limited number of individuals from each species.

New York Science Standards

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

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

National Science Education Standards

Content Standard C: Life Science

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

Ocean Literacy Essential Principles and Fundamental Concepts

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

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

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

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

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

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

Invertebrate Scrapbook

Focus
Biodiversity of invertebrate animals in Long Island Sound.

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

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

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

Logistics
No major logistical considerations.

Audio/Visual Equipment
- Video Projector
- Computers and printer access
- Digital camera (optional)

Teaching Time
To be determined by the teacher.
Suggestion: Four 45 minute periods plus work at home.

Seating Arrangement
Groups of three to four students

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

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

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

An increase in complexity of organ systems

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

Learning Procedure

Teacher Preparation

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

Learning Procedure

- Introduce the lesson by showing students *An Underwater Tour of Long Island Sound* from the DVD or online at: www.lisrc.uconn.edu/lis_uwtour/index.asp. Instruct students to identify any invertebrate animals they recognize.
- Ask the class for a working definition of an invertebrate animal.
- Show pictures of invertebrate animals with a variety of body plans to determine if students understand symmetry.
- List and define the terms bilateral, radial and asymmetry.
- Show students examples of scrapbooks you may have or, in advance, ask them to bring in their own family scrapbooks to show. Tell them they will be making an invertebrate scrapbook to celebrate the awesome invertebrate animals found in Long Island Sound.
- Determine student groups and distribute research worksheets and grading rubric. Let students begin by discussing the work needed to be done and assigning tasks to each member of the group. Establish a due date for the project and have them write it in the space provided on their rubric.
- Several days should be devoted to work on research in the classroom or computer lab. Check student progress daily and assist where needed. Require that homework time be devoted to the project and that progress reports be submitted.
- When pages are complete show students how to hole punch and tie their pages together. Optional- depending on the resources at your school, the scrapbooks can be laminated and bound.
- Require students to have at least one other group complete a peer review of the project and have the whole group complete a self-assessment before submitting the scrapbook to the teacher.
- Lead a discussion about the biodiversity of invertebrate groups and the evolutionary trends seen from simple animals to the more complex animals.

The Sea Grant Connection

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

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

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

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

The "Me" Connection

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

Connection to Other Subjects

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

Evaluation

Grading rubric (page 65); unit test

Extensions

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

Resources

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

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

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

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

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

Connecticut Science Frameworks

PreK-2

Scientific Inquiry Expected Performances

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

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

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

A INQ.6: Present information in words and drawings

Content Standards

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

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

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

Grades 3-5

Scientific Inquiry Expected Performances

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

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

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

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

Content Standards

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

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

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

Grades 6-8

Content Standards

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

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

interact with each other to maintain dynamic internal balance.

Grades 9-10

Scientific Inquiry Expected Performances

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

Content Standards

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

New York Science Standards

Living Environment – Standard 4: Students will understand and apply scientific concepts, principles and theories pertaining to the physical setting and living environment and recognize the historical development to ideas in science.

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

Key Idea 3: Individual organisms and species change over time

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

National Science Education Standards

Content Standard C: Life Science

- The characteristics of organisms
- Life cycles of organisms
- Organisms and environments
- Structure and function in living systems
- Regulation and behavior
- Populations and ecosystems
- Diversity and adaptations of organisms
- Biological evolution
- Interdependence of organisms
- Matter, energy and organization in living systems
- Behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

- Population growth
- Environmental quality

Ocean Literacy Essential Principles and Fundamental Concepts

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

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

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

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

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

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

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

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

Invertebrate Scrapbook
Student Activity

Name(s):_____

Directions:You will make a scrapbook about invertebrate animals.

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

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

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

Project Due Date:_____.

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

Minimum of 9 pages, maximum of 15

Invertebrate Scrapbook
General Animal Characteristics

Name(s):_____

- Describe and provide an illustration for three types of symmetry.

  A.

  B.

  C.

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

- How do animals get energy?

- What type of cells do animals have?

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

Invertebrate Scrapbook
Sponges

Name(s):_____

- What phylum are sponges in?
- Provide a general description of a sponge.
- Anatomy – provide a labeled picture.
- What are spicules?
- Describe how sponges eat.
- List human uses for sponges:

Invertebrate Scrapbook
Cnidarians

Name(s):_____

- Provide a general description of the group characteristics.

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

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

- Coral reefs
  - A. Where do they form?

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

  - C. How does pollution hurt coral reefs?

Invertebrate Scrapbook
Worms

Name(s):_____

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

- Anatomy of the segmented worms – labeled pictures

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

Invertebrate Scrapbook
Mollusks

Name(s):_____

- Provide a general description of a mollusk.

- Provide a labled drawing or picture of each of the following: a snail, a clam and an octopus.

- How do squid, octopus, and their relatives use chromatophores?

Invertebrate Scrapbook
Arthropods

Name(s):_____

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

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

- Describe the differences between incomplete and complete metamorphosis.

Invertebrate Scrapbook
Echinoderms

Name(s):_____

- Provide the general characteristics of a sea star.

- Provide three other examples from the echinoderm group.

- Describe the water vascular system.

- Compare an echinoderm to an invertebrate chordate.

Invertebrate Scrapbook
Vocabulary

General Characteristics

Symmetry
Bilateral
Radial
Spherical
Asymmetrical
Heterotrophic
Multicellular
Eukaryotic
Invertebrate
Vertebrate

Sponges

Porifera
Osculum
Pores
Spongin
Spicules
Filter feeders
Gemmule

Cnidarians

Jellyfish
Coral
Sea anemone
Polyp
Medusa
Cnidocytes
Nematocyst

Worms

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

Mollusks

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

Arthropods

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

Mimicry

Echinoderms

Tube feet
Water vascular system
Ampullae
Eyespot
Madreporite
Sand dollar
Chordate

What other new terms have you learned?

Invertebrate Scrapbook
Rubric

Name(s):_____

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

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

Cleaning Up Polluted Water

Focus
Human and natural impacts on water resources.

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

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

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

For each small group (2-4 students):
- Water Pollution Cleanup worksheet, pages 72-73
- Pen or pencil
- Wash basin or dishpan
- 6" square of cheesecloth or aquarium filter fiber
- Small sponge
- 1 or 2 eyedroppers or pipettes
- 1 or 2 spoons
- Empty quart container
- ¾ cup filter sand or clean beach sand
- Container for the waste removed during cleanup
- 2 funnels, medium to large sizes
- 1 tablespoon of alum (located in spice section of a grocery store)

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

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

Teaching Time
One 45 minute period.

Seating Arrangement
Groups of two to four students.

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

Cleaning Up Polluted Water

Background Information

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

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

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

Excess nutrients have been found to contribute to the most pressing issue in the Sound. While nutrients are essential for supporting marine life, too many nutrients, particularly nitrogen, can lead to hypoxia (low dissolved oxygen levels). Excess nitrogen promotes algal blooms. These algae die and quickly accumulate en masse on the bottom where bacteria use oxygen to decompose this overabundance of dead algae. As bacteria continue to feed and reproduce, oxygen concentrations drop to dangerously low levels for other organisms.

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

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

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

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

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

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

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

Learning Procedure

Teacher Preparation

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

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

Learning Procedure

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

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

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

Many communities get their drinking water from reservoirs or rivers and must treat it before piping it to consumers. In water treatment plants, the water is passed through a screen to remove debris, The water then enters large settling tanks and alum, or similar chemicals, is added, causing fine particles to clump together and sink to the bottom of the tank. The water is then drained from the top of the tank and passed through sand filter beds to remove any remaining particles. In a final step, chlorine is usually added to kill bacteria and fluoride is sometimes added as a public service. Sewage treatment plants have similar setups, but slightly different techniques, as described in the LISS Fact Sheet "Wastewater Treatment" www.longislandsoundstudy.net/pubs/facts/fact3.pdf.

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

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

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

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

The Sea Grant Connection

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

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

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The "Me" Connection

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

How do my actions each day affect Long Island Sound?

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

Connection to Other Subjects

Physical science; Earth science; Environmental science

Evaluation

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

Extensions

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

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

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

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

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

Resources

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

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

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

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

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

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

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

Connecticut Science Frameworks

Grades 6-8

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

Grades 9-10

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

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

New York Science Standards

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

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

Standard 6 - Interconnectedness:
Common Themes: SYSTEMS THINKING: Through systems thinking, people can recognize the commonalities that exist among all systems and how parts of a system interrelate and combine to perform specific functions.
Common Themes: OPTIMIZATION: In order to arrive at the best solution that meets criteria within constraints, it is often necessary to make trade-offs.

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

National Science Education Standards

Content Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard E: Science and Technology
- Abilities of technological design

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

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 6: The ocean and humans are inextricably connected.
- **Fundamental concept e:** Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out of and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers).
- **Fundamental concept g:** Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Cleaning Up Polluted Water
Student Activity

Water Pollution Cleanup

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

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

Before You Start

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

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

Do all pouring over the basin to avoid accidental spills.

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

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

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

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

Cleaning Up Polluted Water
Student Activity

Names:_____

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