PROJECT *OCEANOLOGY*

Mystery Water Educator Guide

This educator guide includes NGSS alignment information for middle school, an educator key to the results table and background information about the abiotic factors measured in this investigation.

Overview

Students will have an opportunity to compare three different environments through this virtual field trip; estuaries, oceans and rivers. A series of short videos depict multiple sampling methods with scientific equipment from three different locations. There was a mix up with the samples so the students must explore 5 stations and fill out a data table as they go to help solve the mystery. Students will read a thermometer, hydrometer, Forel-Ule color scale and field kit to measure dissolved oxygen concentrations as they work through the stations. Students will analyze their results and construct explanations about which samples were collected from the ocean, estuary and river.

I. NGSS Alignment for Middle School

<u>Performance Expectations</u> MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Students will gather empirical evidence about the physical components of oceans, estuaries and rivers and discuss how they are similar and different. Students will use the information to make an assessment about each ecosystem.

<u>Science and Engineering Practices</u>
Students will **Analyze and interpret Data** the data they collect to **Construct Explanations** for what physical characteristics help define different environments and then **Engage in Argument from Evidence** as they rely on their data table to defend their explanations. Students will use **Math/Computational Thinking** to read scientific instruments to help characterize the physical environment.

<u>Crosscutting Concepts</u>
Students will learn about **Scale, proportion, and quantity** as they collect data using a variety of oceanographic equipment, and use correct units and conversions. Students will consider **Stability and Change** as they collect empirical data on the physical characteristics of the water, and investigate which variables remain constant and which change from one location to the other. They will also practice **Communicating Information** to their teachers and classmates as they explain their results.

<u>Disciplinary Core Ideas</u>
LS2.A: Interdependent relationships in ecosystems.
Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors. Students will gather empirical data on non-living components of multiple ecosystems and discuss how they are connected.

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LS2.C: Ecosystem dynamics, functioning, and resilience. Ecosystems are dynamic in nature; their characteristics vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. Students will gather empirical data on the non-living components of multiple ecosystems and discuss how and why they vary.

Mystery Water Results Table

	Sample 1	Sample 2	Sample 3	Notes
Clarity (m) 	24 meters	2.5 meters	3.5 meters	**To our surprise the camera lens was able to "see" the secchi disk deeper into the water than our eyes could detect! As students watch the videos the Project O educators talk about not being able to see the secchi disk any longer, even though it is still visible in the video. Rest assured the clarity depths we mention in the video were true to our eyes.**

Sample 1 had the greatest clarity by far. Oceans, on average, are much deeper than estuaries and rivers. Such a deep clarity reading only makes sense for the ocean (24 meters is greater than the average depth of Long Island Sound!). The amount of nutrients in the open ocean is much less abundant compared to both estuaries and rivers. Less nutrients mean fewer plankton which in turns contributes to increased water clarity. There are also fewer sources of suspended sediment in the open ocean so the water tends to be much clearer.
Sample 2 was taken in the river and has the poorest visibility due to high amounts of suspended sediment and organic material in the water. These materials can easily run off the land into the river especially after a rain or storm event.
Sample 3 was collected in the estuary. The estuary is strongly influenced by the river and the sediment, nutrients, and organic materials it carries. Nutrients allow plankton to flourish in the estuary making it one of the most productive ecosystems on the planet. According to Save the Sound clarity readings greater than 2.28 meters in Long Island Sound receive an A rating.
Water color and clarity are closely related. Standard Ranges

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Color 	V Blue color	XVII Bright yellow color	XVII Yellow/ green color	*It may be difficult for some students to read all the roman numerals on the Forel-Ule color scale. Students should be able to describe the water color in words if numbers are difficult to decipher. Students can view a larger image of the color scale here* (standard ranges)
Sample 1 showed a blue color which is typical in the ocean. Nutrient levels are low so there is less productivity here. Light is able to penetrate deeper into the water because there are less things for it to bump into and reflect off of. **Sample 2** showed a bright yellow color in the river. Yellow and brown colors indicate suspended sediment in the water column from run off, organic matter and plankton. **Sample 3** showed a yellow/green color in the estuary. The green color is a good indication phytoplankton is abundant and a sign of being in coastal waters. Water color and clarity are closely related. Standard Ranges				
Salinity (ppt) 	36 ppt	6 ppt	24 ppt	*The hydrometer measures the specific gravity and salinity of a liquid, based on the density of the needle inside. Students may read just above or below the needle, but accurate readings are taken from the center of the point.*
Sample 1 had the greatest amount of salt. Oceans are the saltiest of the three environments with an average salinity of 35 ppt. **Sample 2** didn't have very much salt at all. It was close to zero which would indicate fresh water which is typically 0 ppt. **Sample 3** represents the salinity in an estuary. Estuaries contain a mix of fresh water from rivers and salt water from the ocean. Long Island Sound has an average salinity of about 28 ppt. Standard Ranges				
Dissolved Oxygen (ppm)	7 ppm	9 ppm	9 ppm	*It may be difficult for some students to tell the difference between the shades of blue color on the videos. For that reason it would be acceptable*

				*to accept a range of answers between 6-9 ppm. It is clear that all readings were less than 12 ppm and greater than 5 ppm.*
Sample 1 had the lowest salinity at 7 ppm. The average dissolved oxygen (DO) concentrations in the ocean range from 9 ppm near the poles down to 4 ppm near the equator. Salt water holds less oxygen than freshwater. Increased temperatures at the equator lead to higher rates of evaporation and saltier water. Ocean DO concentrations tend to be lower than those of freshwater. **Sample 2** (river) and **Sample 3** (estuary) both had a DO concentration of 9 ppm. The river is constantly flowing which helps increase the amount of DO through diffusion and wave action. Swift moving rivers tend to have higher DO concentrations than slower moving rivers. Estuaries can experience a lot of mixing since they are influenced by tides, current and wind. The western end of Long Island Sound is wide and highly influenced by the ocean. Low level oxygen conditions are not an issue in this part of the estuary. Standard Ranges				
Temperature (C) 	9 degrees Celsius	13 degrees Celsius	11 degrees Celsius	*These glass thermometers read to the nearest degree Celsius.*
Sample 1 had the coldest temperature because the ocean is large and deep. It takes longer for the water temperature to warm up compared to the air. **Sample 2** had the warmest water temperature and it was also the shallowest location allowing the sunlight to penetrate further into the water. **Sample 3**, the estuary, had a water temperature in between that of ocean and river. Estuaries consist of river water mixing with ocean water so a temperature warmer than ocean and colder than the river make sense. Standard Ranges				

Background Information

Water Clarity

Water clarity is a measure of how clear or cloudy the water is. This is important because the water clarity will determine how much light is able to penetrate into the water. Sunlight is essential for photosynthesising marine plants and phytoplankton. It also allows animals that

depend on their eyesight to find food or to avoid predators. The more transparent (clear) the water is, the deeper the light will reach.

Many factors can influence the color and clarity of water in an estuary like Long Island Sound. Water coming out of river mouths can sometimes be carrying suspended sediment from erosion, particularly if it has rained recently. Ocean water is typically quite deep and clear compared to the nutrient rich waters of the estuary or river. The average water in the clarity is 24 meters.

Water Color

Water color can offer information about the environmental conditions in an area as well. Water color can be influenced by the things that are suspended in the water - this can include phytoplankton, suspended sediment, dissolved organic material and even pollution.

Typically open ocean waters are an indigo blue color because the water is clearer - sediment that washes down rivers mostly settles out before the water reaches the open ocean, and open ocean water has less nutrients and therefore less phytoplankton than coastal waters. In an estuary like Long Island Sound, brownish-green colors are common because these waters are nutrient-rich, abounding in phytoplankton, and may also contain sediments from rivers. Water color in coastal areas like Long Island Sound is highly influenced by weather, because storms can dramatically increase the amount of sediment travelling down rivers.

Salinity

Salinity is the measurement of salt concentration in water. Salinity is usually measured in parts per thousand (ppt). Oceans are consistently salty with the average salinity of about 35 ppt while freshwater environments like lakes and ponds have little to no salt (0 ppt). Estuaries are environments where ocean water and river water meet and mix. This makes the salinity variable. The salinity is higher at the mouth of the river because it's closer to the salt water source and becomes less salty as you move towards the head of the river or farther away from the salt water.

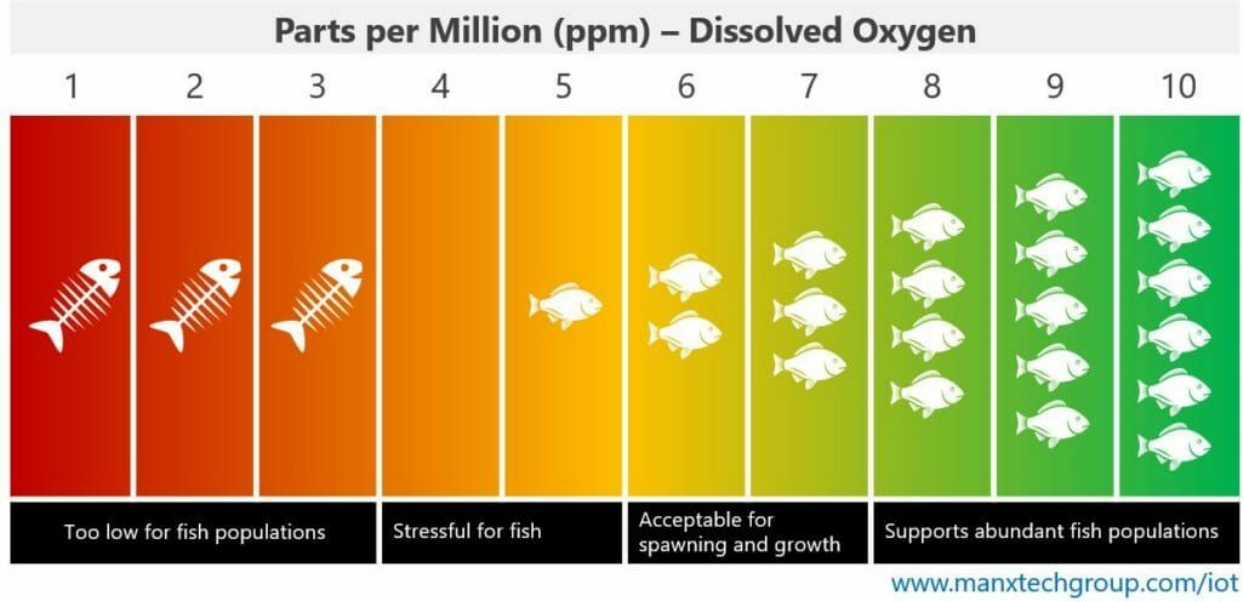
The salinity in estuaries like Long Island Sound changes constantly over the course of a day. It is influenced by how much salt water is flowing in from the Atlantic Ocean tides and how much freshwater is flowing down the Thames River (and the other major rivers in Connecticut). Saltwater and freshwater have different densities. Dense salt water will sink below less dense fresh water. Therefore, the estuary is often composed of layers of water of different densities and salinities.

Dissolved Oxygen

Dissolved Oxygen is essential for the survival of living things in the estuary. Animals like crabs, lobsters, fish and clams all need a sufficient amount of oxygen in order to survive. So how does dissolved oxygen enter into the estuary anyway? One way oxygen gets into the water is through

diffusion. That means the air that is in contact with the surface of the water naturally mixes into the water. Wave action and wind also help bring atmospheric oxygen into the water. The second way oxygen gets into the water is through plants. As plants, seaweed, and phytoplankton perform photosynthesis, oxygen is produced as a by-product of this process.

It is normal for dissolved oxygen levels to fluctuate in Long Island Sound. For example, the temperature and salinity of the water affect the amount of oxygen that is able to dissolve. Cold water can hold more oxygen than warm water, and fresh water can hold more oxygen than salt water. Healthy levels of oxygen range from about 5-15 mg/L or ppm.



There are times when the oxygen levels get to unhealthy levels. Rapid changes in temperature and salinity may decrease oxygen levels. Excess nutrients and entering the estuary can cause large blooms of phytoplankton, which may sound like a good thing. The problem arises when these phytoplankton die. Bacteria and other decomposers use up oxygen to break down the organic matter. These low oxygen conditions are called hypoxia which is a stressful amount of oxygen for most organisms (0-3 mg/L). There are times when the estuary experiences dead zones in which no organisms are able to live because it's a lethal level of oxygen in the water.

To learn more about low oxygen conditions in LIS watch this video about dead zones.
https://www.youtube.com/watch?time_continue=108&v=rc4f8K4cgyo&feature=emb_logo
You can also click here to check out more information about hypoxia from the Long Island Sound Study.

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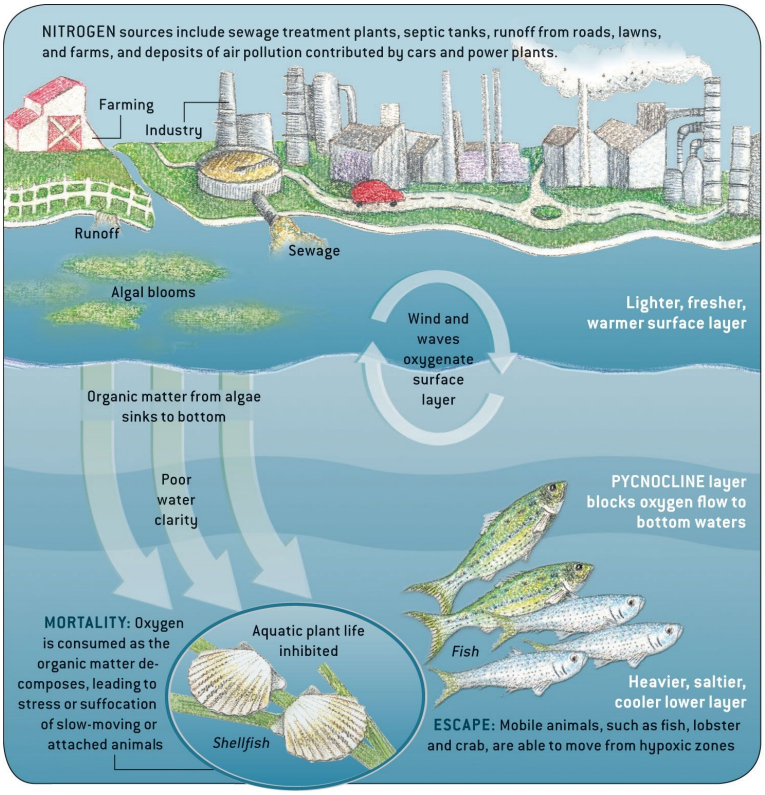


This is a visual representation of "eutrophication," or oxygen-depletion caused by nutrient runoff from the watershed.

Graphic Source: https://longislandsoundstudy.net/ecosystem-target-indicators/lis-hypoxia/

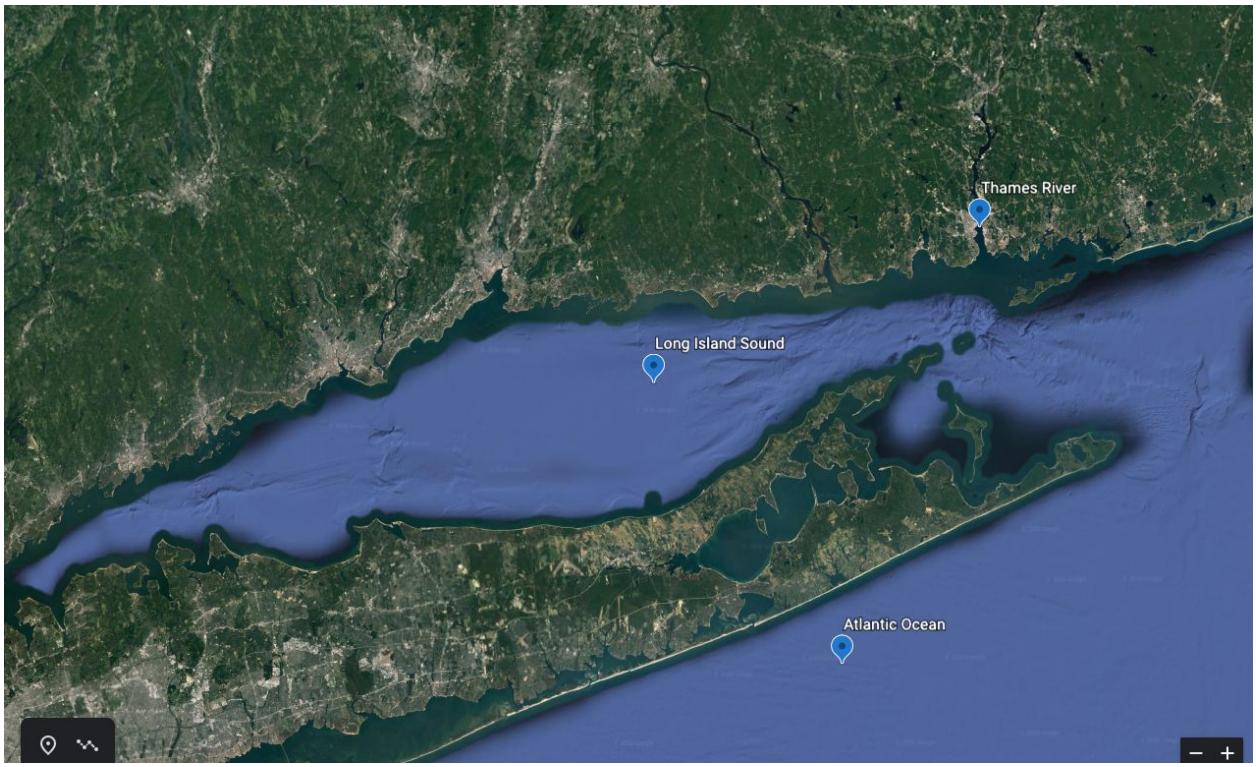
Water Temperature

Water temperature is very important because it helps to determine what kinds of organisms we expect to find in the estuary. Animals and plants have a certain temperature range that they can be successful in. If the temperature gets too cold or too hot, some of the organisms in the estuary could die, or might be forced to move to a different area. Some animals in Long Island Sound can withstand large temperature ranges and can be found in the sound year round, while others migrate in and out of the sound seasonally.

Air temperature, tide and time of year all influence the water temperature. The temperature of the air can influence the water temperature because heat can be exchanged between the air and the surface of the water. Tide influences the water temperature in coastal areas like Long Island Sound because water flowing into Long Island Sound from land via rivers and streams may be a different temperature than water flowing in from the Atlantic Ocean. Time of year influences the water temperature, because Long Island Sound gradually heats up in the summer and then gradually cools in the winter.

Water temperature is measured in degrees Celsius (℃). The temperature in Long Island Sound varies based on time of year and sample location. It can range from 1-24℃ depending on the season. The water temperature may also change with depth. The surface of the water is often a different temperature than the bottom water.

Sample Location Map



Sample 1: Atlantic Ocean
Sample 2: Long Island Sound Estuary
Sample 3: Thames River