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2013 Volume IV: Asking Questions in Biology: Discovery versus Knowledge

Just Ask! Exploring Marine Life of Long Island Sound

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Introduction

Life. Thriving, struggling, competing, adapting, and evolving. An exploration of marine life in the Long Island Sound will reveal the intricate, complex interdependent relationships between marine creatures and their environment. Promoting observation, nurturing wonder, and cultivating curiosity, this study will enable students to construct a reservoir of knowledge from which questions will evolve. Thirsty for answers, reflection upon research and new insights will inspire and develop further inquiry. As one dives deeper into the subject, connections between marine lives within ecosystems will be revealed. The creation of a classroom wall mural will be continuous through this unit providing a visual display of collective learning as well as a vehicle for reflection, discussion, and new questions. This unit will prove to be an exciting voyage, as students learn to pave their own path of learning by developing their own questions, which will propel them deeper into the subject to discover the intriguing intimate relationships of the sea life.

Imagine a world that believed the Earth was flat, functioning from that point of view, and willing to die to defend that belief, unable to see beyond accepted understandings. How did they not see what is now obvious? Where were the questions? Who were the brave ones that dared to think beyond the established framework of principles? What sparked their pursuit to question? Why did they notice what others missed? Were their observations keener or were they more curious and persistent in their quest to understand? How does one synthesize what is known to make a new sense of what commonly lays before us as did Isaac Newton when pondering the action of an apple falling off a tree to the ground. What do those who have made these profound, life-changing discoveries have in common? Is there a common thread that they share? If so, as educators, how can we harness this to propel our students forward as thinkers? Do we need to add "Thinking" to our curriculum, teaching it as explicitly as math, science, or reading? Is this the key to instruction? The ability to wonder and think differently about what lies before us is worth exploring.

Rationale

Where is "Awe and Wonder" in our curriculum? Students no longer have the time to develop a sense of wonder and curiosity, which naturally promotes questions. This invaluable space has been stripped from the curriculum. As a fourth grade teacher in the New Haven Public Schools, my students are strapped with the demands of testing; DRA's (Developmental Reading Assessments), DRP's (Degrees of Reading Power), CMT's (Connecticut Mastery Test), CMT prep, monthly CFA's (Common Formative Assessments), as well as district Math, Language Arts, and Reading assessments. Subjects compete for center stage, often squeezing the science curriculum to its bare bones. I would like to bring science back to center stage as students learn to ask their own questions through the exploration of the marine ecosystems of the Long Island Sound. Although questioning strategies have been taught since first grade, my fourth grade students continue to have difficulty formulating their own questions. I would like to infuse the curriculum with explicit instruction of student-driven questioning along with the time, opportunity, and classroom culture for this inquiry-based exploration. The content would reach across the curriculum, allowing students the opportunity to exercise and develop their curiosity and questioning techniques as their passion for learning ignites.

We want our students to develop a love, joy, and enthusiasm for learning. The feeling of surprise and awe as one discovers is engaging, empowering, and contagious. However, as educators we face many challenges in reaching this goal. Class sizes are large; student to teacher ratios are often twenty-seven to one. In addition, the urban setting offers unique social and economic issues as well broad populations of ELL students (English Language Learners). Furthermore, students vary widely in reading, mathematics, and science skills, and this range amplifies as grade levels increase. As educators, our ability to engage such a vast breadth of diverse abilities is a constant challenge. One strategy of instruction used to reach this diverse population has been through our tiered levels of questioning guided by Bloom's Taxonomy. Recently, however, Dan Rothstein and Luz Santana have proposed a simple, but far more complex and effective use of questioning; an approach that they argue will change the face of classroom instruction. This change is simply to teach our students to ask their own questions. [1]

One's ability to question not only activates one's thinking; it engages one on a path of discovery through evolving knowledge. The relationship between the subject matter and the student develops through one's ability to question. Fearless, curious, thoughtful, critical; the ability to learn from one's own questions and answers is a characteristic that I seek to strengthen in my students. Furthermore, it is my hope to create a culture, which cultivates academic inquiry, collaboration, and confidence - strengthening investigative skill. As a result, I believe students will learn to ask their own questions and strive to find answers with purpose, wonder and an eye for the unexpected.

The aquatic life of the LIS will be our focus of study because of its relevance to my students and academic goals of this unit. The LIS is approximately two miles from our school and is an integral part of my student's lives, frequently visited and enjoyed. The subject matter, by nature is of high interest inspiring a sense of wonder and question asking. Marine life offers a venue through which students are able to experience a journey of discovery, driven by curiosity and wonder. Marine ecology provides an ocean of information for students to explore. Fully engaged, students will approach topics in their own way, in their own direction, at their own pace, as their own questions carve a personal path of discovery. This approach empowers students to drive their own learning, experiencing the joy and love for learning in its purest form.

Why Question?

Imagine a classroom where every student is excited and fully engaged in a personal quest to explore, asking questions, and designing ways to seek out answers. Where the teacher is a resource and facilitator as students are empowered by curiosity and a sense of purpose. Imagine a classroom where students are learning from their evolving questions, enthusiastically creating a path of growing knowledge, discovering a plethora of possibilities for the mind to explore, owning their learning. I want to create a classroom like this. Student-driven learning embodies the best of instruction, student engagement, ownership, and differentiation. The day I introduced this activity into my classroom, my students were excited, highly focused, and actually thanked me!

Questioning is not a new strategy used to explore a topic. The Socratic Method, scientific inquiry, comprehension strategies, and Blooms Taxonomy are familiar questioning-strategies used by most educators. Questions have led the greatest of minds to profound discoveries. When asked why he became a scientist, Nobel Laureate Isidor Rabi attributed his success to his mother. Every day, she would ask him the same question about his school day: "'Did you ask a good question today?' Asking good questions – made me become a scientist!" Rabi said. [2] One's questions can help one to look beyond, stretching one's thinking and extending the possibilities that lie before us. Learning how to question may just be the catalyst to our future.

The Biology of Thinking

In studies in 2009 and 2011, Sharon Thompson-Schill a neuroscientist at the University of Pennsylvania, showed that the brain behaves differently when thinking creatively. Normally, the prefrontal cortex is engaged in focused, rule-guided cognitive activity. However, this area of the brain acts differently in a creative mental state when novel ideas are generated. As original ideas are being created, there is a lower state of cognitive control in the prefrontal cortex. In this state, rules and assumptions are not "boxing in". It was discovered that the prefrontal cortex became electrically "quiet" when the human subject thought with fewer restrictions. The prefrontal cortex was in a state of "blurred" attentional focus. The Thompson- Schiller team gave this state a name, they called it *hypofrontality* . [3] This kind of thinking is very different from the mental state of cognitive control and focus with perimeters such as guidelines or criteria, as when one is analyzing or evaluating. Earlier studies, in the mid 1990's, supported *hypofrontality* when brain waves were measured over the prefrontal cortex. While participants generated novel ideas, alpha waves (8 to 12 cycles per second) were recorded. The synchronized firing of the neurons in the state of defused attention and relaxed wakefulness is a state of lower cognitive control. [4] Alpha waves denote a synchronized firing of the neurons. Further support for the theory of " *hypofrontality* " was found in Thompson- Schill's most recent study. In this study, participants were asked to find uses for objects. The most creative participants showed minimal activity in their prefrontal cortex but also showed activity in the posterior brain regions, areas of visuospatial skills.

[5]

These studies suggest that when there is lower cognitive control, less filtering of information, one is able to think more creatively. The state of hypofrontality allows one to be more open to possibilities without preconceived notions and assumptions that could stifle thought. In conclusion, these two mental states offer uniquely different outcomes. The mental state needed to generate novel ideas and facilitate creative thinking, is characterized as relaxed, with less cognitive control, and defused attention. In contrast, the mental state necessary to think critically is characterized as highly focused attention with cognitive control, such as in synthesizing and evaluating.

This research clearly demonstrates the importance of the mental state of hypofrontality when creative thought is needed to generate innovative ideas and since creative thinking is the highest level of cognition, there is value in teaching our students this skill and structuring learning for this opportunity. Equally important, however, is the controlled state of thinking, but this is already a common approach in education today; synthesizing, analyzing, and evaluating information. Together, however, the combination of these dual styles of thinking just might be the key to better student learning.

Furthermore, one's ability to move back and forth between these two cognitive states, from a mental state with high cognitive control to a relaxed state of diffused attention of lower cognitive control, is one's ability to be cognitively flexible; hence the term cognitive flexibility. [6] In a 2010 study by Zabelia and Robinson, it was discovered that the more innovative and creative thinkers showed greater cognitive flexibility in a Stroop test when measuring results of their ability " to switch from matching combinations (for instance, the word " red" appearing in red type) to a clashing one ("red" showing up in blue letters)" [7] on the test. The Stroop test is a test that measures cognitive control using words for colors written in the same and different colored fonts as the actual color. [8] However, the ability of one to switch back and for between these two states, matching combinations, and clashing ones demonstrated cognitive flexibility: flexible and controlled thought; creative and focused thought; innovation and application. Moreover, it is suggest that the most innovative and creative outcomes are when one demonstrates cognitive flexibility; able to shift between thinking modes, exercising one's ability to think outside the " box" and then build the " box," generate an ideas and then make it happen. [9]

The implications of this research are exciting! Teaching students these two styles of thinking and their specific purposes along with the metacognitive skills to discriminate between each state, shifting from wonder to analysis, using both convergent and divergently thinking is worth exercising in our classrooms. I believe this would empower our students with an understand of their thinking well enough to adjust and change it according to the needs of the specific problem or topic, ultimately teaching independent cognitive flexibility, the ability to adapt one's thinking according to the required needs of the problems to be solved, purposefully.

The Question Formulation Technique

In 2011, Dan Rothstein and Luz Santana applied cognitive flexibility in their groundbreaking Question Formulation Technique published in, Make Just One Change, which proposes a simple and effective use of questioning; an approach that they argue that will change the face of classroom instruction. [10] In this work, they explain the profound effect that the shift to teaching students to ask their own questions rather than responding to ours can make in the classroom. [11] Rothstein and Santana introduce this in the formation created a Question Formulation Technique that offers three different ways of thinking about a subject: divert, convergent, and metacognitive thinking. They developed a systematic process which teaches students specific skills and techniques in order to develop their thinking and questioning skills. Divergent thinking, they explain, encourages students to wonder, generating a wide range of ideas, unfiltered, or judged. [12] This style of thinking is associated with creativity and innovation. Convergent thinking, on the other hand, is a way of thinking that synthesizes information, summarizing, seeing common threads, themes, and an ability to evaluate ideas. Metacognition is the ability of one to know and be aware of how one is thinking. The Question Formulation Technique employs each of these strategies. [13]

The explicit instruction of cognitive flexibility is exactly what Dan Rothstein and Luz Santana accomplished in their Question Formulation Technique. In this technique, they have applied the theory of cognitive flexibility along with metacognition. It is brilliantly simple, reorganizing instruction, in a process that moves students back a forth between convergent and divergent thinking, exercising cognitive flexibility and control of it. By design, the Question Formulation Technique is achievable to every student, embodies choice, differentiation, and engagement. [14]

The Question Formulation Technique is a six-step process to teach your students to ask their own questions. First, the teacher names a focus. Then, students generate questions using four important rules. The first and second rules are, to generate as many questions as possible and to do this without stopping to judge, discuss, or answer any of the generated questions; surprisingly difficult as it represents a huge change in academic culture. The third rule is to write down each question exactly as it is said and the fourth is to change any statement into a question. [15] Next, closed and open-ended questions are prioritized. After that, a plan is made for the use of questions. Finally, students reflect on their work and decide the next steps. [16] In this way, students are exercising cognitive flexibility, highly engaged in the process, and taking ownership for learning to think, develop, and refine their learning.

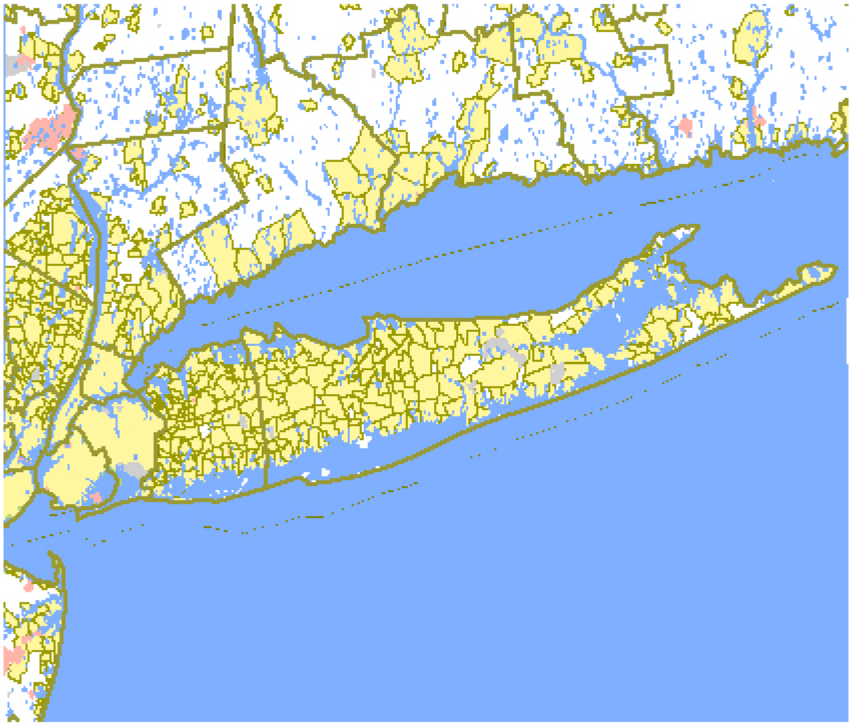
Learning to Love the Marine Life of Long Island Sound

This unit is designed to motivate and engage students through hands on activities and thought provoking questions that will ignite curiosity while creating a culture that develops critical, analytical, and investigative thinkers. Reaching across the curriculum, this unit wraps reading, writing, and mathematics around the science of marine ecology of the Long Island Sound. Students will be immersed in the topic through field study, observation, experimentation, simulations, models, and research. Skillful questioning techniques will encourage deeper thinking as well as improved exploration of the subject matter. The study of relationships within the system will lead to an appreciation for the fragile nature and respect for its function. Discovery of the complex interdependency of living systems would become clear, as each student becomes an expert in their marine creature studying its physical characteristics, habitat, predators and prey, food webs and chain in each ecosystem.

Students will keep daily journals of learning and would be encouraged to draw visual explanations of concepts as well as thinking maps to illustrate their pathways of questioning. As students learn information about their creature, they will illustrate and describe this information on a huge classroom wall mural. This collective expression of shared knowledge of individual subject study will reveal the connections between creatures, their environments, and other ecosystems. As a result, students will discover the diversity and interdependence between ecosystems of this beautiful body of water. In this study, students would cooperatively create a multifaceted visual illustration of the complex interdependent ecosystems as a vehicle to share information and learn about marine life and their habitats. The mural would be an ongoing pictorial expression demonstrating the collective information gathered, serving as a concrete expression of complex ideas/concepts helping students deepen their understanding of this multilayered system. In addition to illustrations, students will add captions, headings, text boxes, life cycles, timelines, as well as other text features in order to present the rich deep layers of information they are discovering. This will allow for reflection on the ecosystems within the Long Island Sound. As students learn about their creature, they will make connections to other creatures in their food web, prey, food sources, and specific characteristics of each habitat. Ultimately, it is my hope that my students would come to understand the fragile nature of each ecosystem, the interdependence of all life systems, as well as the catastrophic effects to a system if interrupted, broken, or disturbed. Through these activities, students will learn to question with confidence, skillfully drawing upon knowledge gained and driven by curiosity to notice and marvel about the world around them with an understanding that they are part of this vast, complex, interdependent living system and have an ability to affect it.

Let your students go. You don't have to know everything about their subject. Let them take the lead. Step back, guide and watch them succeed, enjoy, and grow, learning to find their way, steering their own learning. Their excitement will build as they discover answers to their questions; propelling, empowering your students as learners. The process by nature is engaging because it allows students to seek answers for their own questions developing their own interests, igniting their curiosity, as they become fully invested in asking and finding answers to their own questions.

The Long Island Sound



http://en.wikipedia.org/wiki/File:Long_Island_US_map.gif

The Long Island Sound was born 15,000 years ago in Pleistocene Ice Age when a two-mile high glacier inched its way across the earth across what is now the coast of Connecticut where its journey ended. With a climate shift, the glacier began to melt. As this two-mile-high glacier melted, the debris it had collected formed a mass we now call Long Island. [17] The melted waters covered what is now the Long Island Sound at a depth of 300ft. However continued melt water from the glacier swept approximately 200ft of sediment into the lake which resulted in the depth of the Long Island Sound of today [18]

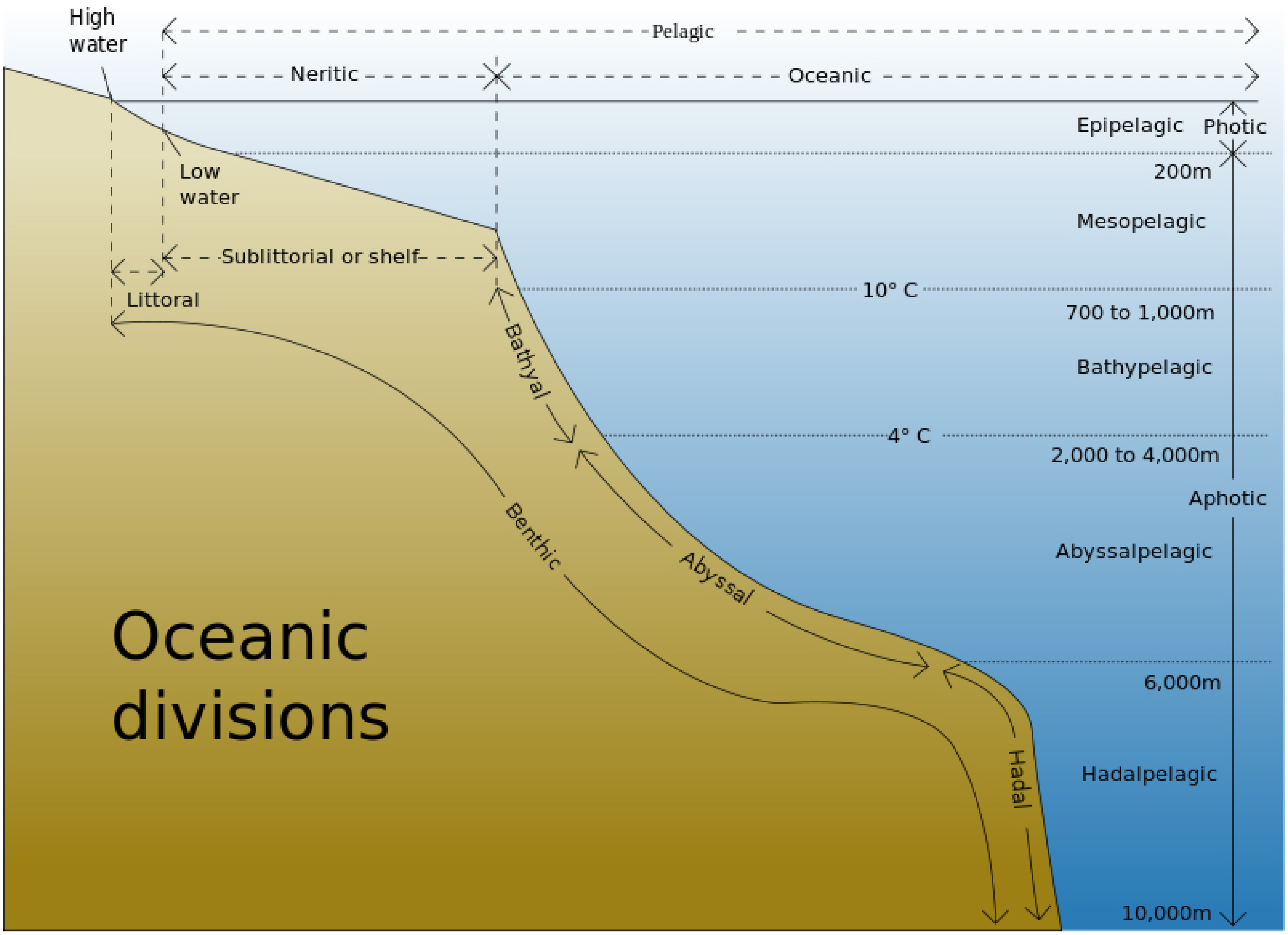
Today the Long Island Sound is 113 miles long, 21 miles wide (at its widest) and holds about 18 trillion gallons of water. Its average depth is 63 feet. [19] It is an estuary. An estuary has unique characteristics, which define its aquatic system. An estuary can be defined as a body of water that is semi-enclosed with a free connection to the open sea as well as freshwater drainage. [20] The Long Island Sound is a body of water where the Atlantic Ocean spills around and behind Long Island, mixing with the outflow of the freshwater from Connecticut rivers. These conditions form our Long Island Sound estuary. The tides, salinity, temperature, and water movement are the main features, which define this highly complex ecosystem. The tides and river flows are continuously moving the water, mixing the salt and fresh water. Changing winds and tidal movement from the ocean and seasonal precipitation affecting river flow create daily variations that characterize an estuary by a constant state of flux in terms of chemical and physical characteristics. [21] A variety of ecosystems function these conditions. Specifically, The Long Island Sound is an enclosed and well-protected, shallow body of water where salt water from the Atlantic Ocean mixes with the fresh water fed by rivers. In addition, the land mass of Long Island functions as a barrier from high seas and strong currents, softening wave height and strength resulting in calmer water movement. It is bordered by Connecticut to the north, Long Island to the south, and New York to the west creating a sheltered "tub" where strong ocean currents are escaped and rough seas of the open waters are calmed. The Long Island Sound is a safe, gentle backyard and nursery for the young. The shallow conditions create warmer waters as well as contribute to the calmer waters. The mixing of fresh and salt waters creates variable salt levels for which animals and plants uniquely adapt. These qualities create a unique environment for the spawning, mating and rearing of young sea creatures. An estuary is one of the most important habitats on our planet because it is able to provide the life-sustaining systems for nourishing, protecting, and housing vast numbers of species during their early lives, supporting the fragile infants of the sea; it is the ocean's nursery.

The Long Island Sound estuary is one of the most valuable and productive ecosystems. One reason it is so productive is that the water filtering into it from the watershed brings a rich supply of nutrients that provide nourishment to the diverse inhabitants. The Long Island Sound also serves as feeding, breeding, and nursery area for many species that spend most of their adult lives in the ocean. The LIS estuary is home to more than 1,200 species of invertebrates, and170 species of fish, and dozens of species of migratory birds live there at least part of the year. [22] The LIS serves a variety of purposes for sea creatures. Some creatures live their entire lives in the estuary, while others begin their lives in the estuary then move to other habitats. Other creatures move in and out of the estuary while others migrate through the estuary destined for other waters. [23] The movement of sea creatures in, out, and through the LIS, adds another layer complexity to this vibrant ecosystem.

Marine Zones: Pelagic Epipelagic Benthic

The Pelagic and Epipelagic Zones

Marine organisms can be studied according to where they live. The pelagic and benthic are two sub- tidal zones within the water column. These habitats stay completely submerged. The pelagic zone is the area in the water column that extends from the surface of the water to on or near the floor of the LIS and the benthic zone is the region at or just below the sea floor. The epipelagic zone is the top layer within the pelagic zone and is characterized by the depth of penetrating light. The Epipelagic zone is home to plankton, particularly phytoplankton that are plants able to photosynthesize with enough sunlight.



http://en.wikipedia.org/wiki/Oceanic_zone

The epipelagic or photic zone in the sunlit area of the pelagic zone. It is called the sunlit zone because the sunlight is able to penetrate the water. This area is the habitat for ninety percent of all ocean life because of the warm temperature and sunlight. Since this is the only zone in the water column that is able to fuel photosynthesis, it is home to all plant life. This plant life supports all other life in the marine system. The value of aquatic plant life is highly significant because it is the very base of the food chain. Furthermore, aquatic plants contribute significantly to the oxygen of the atmosphere as well as the dissolved oxygen in the water needed by aquatic life. The depth of this zone depends on the clarity of the water allowing the transfer of light energy needed for fueling photosynthesis. Water turbulence, sediment, and climate can have an effect on the ability of light to filter through the water affecting the depth of this zone, however, this it can reach the depth of 660 feet because the sunlight is able to penetrate to this level. Since this zone is richly packed with food, plants and plankton, many sea creatures inhabit this zone. Some sea creatures living in this zone in the LIS include the shark, sea turtles, jellies, bluefish, and salmon to name a few. The light which characterizes this zone has resulted in an adaptation called counter shading. Counter shading in a method of camouflage. Fish have lighter colored belly than their top so when a predator looks down form above the fish will blend in appearing darker like the depths. In contrast, when looking from below a fish, the belly is light like the sky making it more difficult to see. [24]

The Benthic Zone

The Benthic Zone is the ecological region of the sea floor with a vast array of diverse plants and animals. Organisms that live in the benthic zone are called benthos. The Long Island Sound floor is made up of sand, mud, silt, decomposing organic matter, as well as rocky reefs, which contribute to the character of this unique habitat. Organic matter from higher in the pelagic zone sinks to the sea floor. Decomposing organic material such as dead fish and animal feces is an energy source for the benthic zone providing bottom dwellers with needed nutrients. Dead marine creatures, feces of sea life, and decomposing plant material provide food for these bottom dwellers and their dissolved nutrients are recycled. This group of sea creatures is different from other creatures because of their adaptation to life on the sea floor. Some adaptations include the need for less light, food, response to water movement and ground movement. Some creatures in the benthic zone attach themselves to rocks, boulders, or the sea floor. Other creatures burrow into the flooring while still other benthic creatures crawl freely along the seabed. The benthic zone provides a habitat for spawning, foraging, and refuge for a variety of fish. The sizes of benthic organisms have a broad array ranging from microscopic bacteria to large flounder. Sponges, coral, starfish, mollusks, lobster, crab, and sea anemones are some of the creatures that live in this habitat. Benthic organisms are divided into two categories based on were they make their home. The ocean floor is one habitat and an inch or two into the ocean floor is another. Those living on the surface of the sea floor are called epifauna. Creatures that burrow into the ocean floor are called infauna.

Marine Life of the Long Island Sound

Marine Animals of the Epipelagic and Pelagic Zones

Plankton

Planktonic organisms are large and small as well as plant and animal. There are several varieties of plant and animal within this species, however, the one characteristic that have in common is that they are all drifters. The word plankton comes from the Greek word "planktos" which means drift hence their name, defining their common trait, organisms that drift or swim weakly in the pelagic zone near the surface of the water. Phytoplankton are unable to propel themselves through the water against currents, therefore drift along with the surface currents, their destination determined by the water movement. Although most plankton are microscopic, plankton come in a wide range of sizes, ranging from microscopic bacteria to large jelly fish and seaweed several feet long. However, most plankton are small, microscopic, single-celled organisms less than a quarter inch -6mm across [25] . Plankton can be grouped into five categories. These classifications are: bacterioplankton, phytoplankton, zooplankton, mereoplankton, and holoplankton. Bacterioplakton are simple cellular bacteria organisms, phytoplankton are photosynthetic plants, zooplankton are animal plankton that feed on phytoplankton, mereoplankton are larval stages of marine zooplankton and holoplankton are zooplankton that remain as zooplankton throughout their life. [26] These surface creatures play a fundamental role in marine life, pillars of the aquatic ecosystem forming the life sustaining base of the food chain. [27]

Phytoplankton

Phytoplankton are single celled plant plankton that are able to photosynthesize. Photosynthesis is the process phytoplankton use to make their own food by trapping sunlight and combining water and carbon dioxide with other substances to make carbohydrates (sugar and starch), proteins and fats. Photosynthesis is the ability of a plant to convert light energy and carbon dioxide into food, then oxygen is released as a byproduct of this chemical reaction. [28] The oxygen produced by photosynthesis of phytoplankton contributes greatly to our oxygen rich atmosphere [29] producing over half of the world's oxygen. In fact, these tiny ocean plants called phytoplankton contribute 50 to 85 percent of the oxygen in Earth's atmosphere. [30] Phytoplankton are at the base of the ocean food chain, a primary producer, harvesting energy directly from the Sun and feeding most ocean life along with those that live off them. [31] The skeletal structures of phytoplankton are diverse with dynamic geometric spirals, cubes, and cylinders whose purpose is to keep the phytoplankton floating in the photic zone (top 30 meters) where the phytoplankton is able to absorb enough sunlight energy to photosynthesize. Their complex shapes have large surface-areas in relation to their body size, with spiny extensions increasing surface area and friction enabling the phytoplankton to float on the surface of the open water. These microscopic plants, phytoplankton, come in a variety of types. [32] A variety of diatoms and dinoflagellates live in the Long Island Sound. Diatoms have a skeleton made of silica with a box like structure, which is perforated with holes to allow chemicals to enter and leave. Depending on the species, diatom silica skeletons vary widely. The silica that makes up their skeleton is also the major ingredient in sand and glass. [33] During the summer in the Long Island Sound, diatom abundance declines to 30% of the phytoplankton mass, as other species, such as the dinoflagellates increase. [34]

Zooplankton

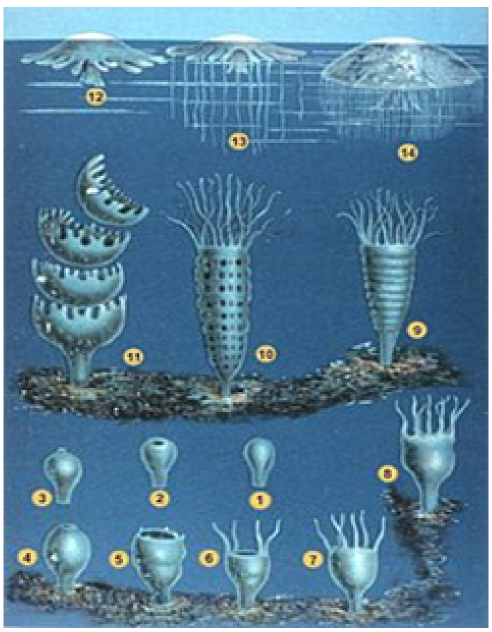
Zooplanktons are animal plankton that float and drift with the current. Unlike phytoplankton, they are able to swim. The appendages of zooplankton enable them to move within this abundant food zone. Their sizes range from a microscopic one-tenth of a millimeter to four millimeters. Some zooplankton eat phytoplankton and others prey on smaller zooplankton. In addition, zooplankton are able to eat bacteria, algae, and other fine particles in the water by using their appendages as strainers. Zooplankton that are able to propel themselves are able to move vertically, up and down the water column, eating and avoiding predators. Zooplankton are the primary food source for almost all fish larvae. Zooplankton can reproduce rapidly, and populations can increase by about 30 percent a day under favorable conditions. Zooplankton reach maturity quickly and live short, but productive lives. For example, adult females of a zooplankter called *Daphnia* can produce their body mass in eggs every two to three days. *Daphnia* live an average of one month. One kind of zooplankton that lives in the Long Island Sound is called the copepod. They are tiny crustaceans related to shrimp and are an important food source for larger fish. Adult copepods have long, cylindrical or torpedo-shaped bodies with a single eye and a pair of long antenna at the front, five pairs of legs along the middle and a paddle-like tail at the end. They use their legs for swimming. Copepods use small appendages near their mouths to capture food. Copepods lay eggs that hatch into tiny nauplii that have only three pairs of appendages. Nauplii gain legs and change form as they grow. [35] Ciliates are another species of zooplankton found in the LIS that feed on phytoplankton such as dinoflagellates. Ciliates have hair like structures called cilia that help them to move, eat and breathe. Other zooplankton that live in the Long Island Sound are Comb Jellies, Moon Jellies, and Sea Gooseberry. Jellies are transparent gelatinous creatures that have adapted to survive. Jellies feed on copepods. Although jellies are a poor food source for most sea creatures, turtles consider them a favorite meal. [36] Crustaceans also prey on jellies. [37] Some zooplankton, pump heavy positive ions, positive atoms, out of their bodies, which makes them lighter, enabling them to float. [38] The organic materials from living and dying plankton sink to the bottom and become food for bottom feeders such as lobsters.

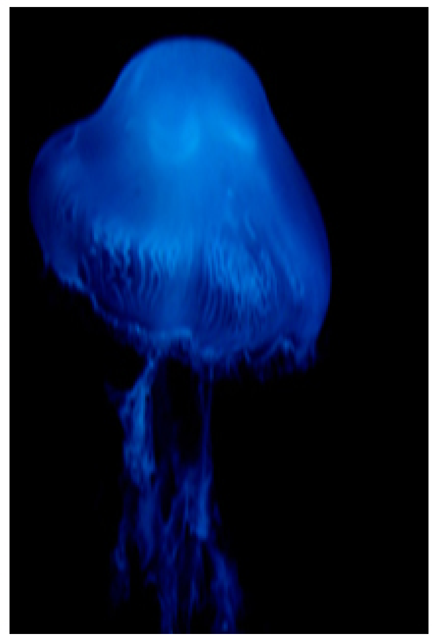
Lions Mane Jelly

The Lions Mane jelly is another very common jelly in the waters on the LIS during the summer months. The dark reddish color makes them easy to recognize. Diameters of six to twelve inches are common sizes for these jellies in southern New England. They have many stinging cells, nematocysts, which are mildly toxic. [39]

Moon Jellies

Moon Jellies are intriguing zooplankton found in the brackish waters of the Long Island Sound. They live in waters with temperatures between 48? -66? F and ranges in size from 2-15 inches. The moon jelly is a carnivore. Its prey is small plankton, larval crab, shrimp and fish eggs. Although they are considered drifters, which move with the current, moon jellies can propel themselves by pulsing their bell. One way moon jellies catch prey is when it becomes entangled in its outer mucous layer, the food is moved along eight canals and is deposited into the stomach. The moon jellyfish doesn't have any respiratory organs, e.g. lungs, trachea or gills. It breathes by diffusing oxygen from the surrounding water through its thin membranes. Well oxygenated water enters the gastrovascular cavity and low oxygenated water is expelled. Adults can live for a year but polyps can live for up to 25 years! [40]





https://en.wikipedia.org/wiki/Jellyfish#Anatomy

The developmental stages of scyphozoan jellyfish's life cycle: **1–3** Larva searches for site **4–8** Polyp grows **9–11** Polyp strobilates **12–14** Medusa grows

Moon jellies have a most unusual life cycle. A male releases sperm in the water to fertilize the female's eggs, which resemble purple popcorn. After hatching, the larvae attach to a solid surface and develop into polyps. For years, even decades, the polyp can alternate between feeding, budding into more polyps and spreading. At some point, it produces stacked cuplike sections that launch off as young adults. These finally change into the familiar bell-shaped adults we recognize. What a surprisingly complex life cycle for such an ancient organism! [41]

Green Sea Turtles

Green sea turtles have a unique heart shaped shells, the top shell is smooth with shades of grey, yellow, green , brown, and green. The bottom shell is yellowish white. Adult turtles are herbivores. Green sea turtles pass through in the LIS during the summer eating sea grass and algae. The green turtle is the largest of all the hard-shelled turtles growing up to 4 feet and weighing as much as 400 pounds. Baby sea turtles are extremely vulnerable and are food for large fish, and crabs. Sharks also prey on adult sea turtles. Sea turtles have oxygen reserves that allow them to sleep underwater for more than two hours and dive without surfacing for 30 minutes. The green turtles are now endangered from suffocation and strangulation as a result of discarded trash bags, fishing lines, and balloons mistaken for their favorite meal, jellies. [42]

Blue Fish

Blue fish are greenish blue in color, with strong bodies and sharp conical teeth. They are very aggressive finned fish and can grow up to twenty pounds and forty inches long. Their prey includes squid, crabs, shad, herring and smaller blue fish and are known to leave partially prey behind. Predators of the blue fish include shark, tuna, striped bass, and humans. [43]

Cownose Ray

The cownose ray is a pelagic swimmer and benthic feeder, grey on top and white on the bottom serving as camouflage from predators above and below. It has a sharp venomous stinger at the base of its long thin tail, can weigh up to 50 pounds, and can have a wingspan of 45 inches. They have a skeletal frame made up of cartilage like their relatives the shark and skate. Their habitat is the soft sandy bottom of the LIS floor where prey of clams, invertebrates, and oysters are plentiful. The cownose ray is found at depths between 0 to 22 meters. Mature females give birth to usually one pup. Sharks and humans are this ray's main predator. Humans use them as bait and imitation scallops. [44] [45]

Seahorse

The northern lined seahorse is a fascinating creature who's shape inspired the naming of a part of our brain's anatomy because of its similarity in shape, our hippocampus (Latin for sea horse), responsible for the consolidation of memory. They inhabit the shallow waters of the sound among the grasses ranging up to five inches in length. Seahorses prey are shrimp and other zooplankton. Their predators include crabs, skates and rays. Seahorses have evolved to be masters of camouflage and excellent hunters. They have no teeth, instead a long snout for sucking in food and a tail for an anchor. Other specialized characteristic include, a horse like head, up right stance, independently moving eyes, the ability to grow appendages and change color. Probably one of the most unusual features of this fish is that the male seahorses becomes pregnant after the female deposits her eggs into the male's pouch. The male seahorse then fertilizes the eggs, incubates them for three weeks and then gives birth to their young, miniature half inch perfect duplicates of their parents. [46] [47]

Atlantic Salmon

The Atlantic salmon has a long body, its top brownish and silvery sides with black spots. When breeding, the salmon's lower jaw looks like an upward hook in breeding males along with their red side areas. The Atlantic salmon spawns in fresh water, but spends most of its life at sea. They can grow up to four and a half feet and weigh up to eighty pounds. It inhabits the coastal waters of the Atlantic and finds its way into the LIS. Its prey is herring, capelin, sand eel and large plankton and is hunted by seals, sharks, pollack, tuna, skates, halibut, cod, striped bass, bluefish and humans. [48]

Sand Tiger Shark

The Sand Tiger Sharks pups practice in vitro cannibalism, one of the most surprising characteristics of marine creatures. This means that when the "pup" are still inside their mother, they consume each other and any unhatched eggs, resulting in just one pup born at a time. A process of "survival of the fittest" in utero! Once born, the sand tiger shark can grow up to eleven feet long and weigh up to 350 pounds. They live in warmer ocean waters including the Long Island Sound. Sand tiger sharks are slow moving sharks, and eat just about anything. Their predators are other sharks and humans. Sand tiger sharks are colored light brown to grey on top and lighter shading on their undersides, called countershading, which serves to camouflage it from predator. Other unique features of this creature, is that unlike most other sharks, the sand tiger shark's two dorsal fins are about the same size and its teeth are always visible. [49]

Marine Creatures of the Benthic Zone

Sponges

Sponges and sea anemone are called epifauna because they can attach themselves to the sea floor. These sea creatures are called filter feeders because they are able to strain out food particles as water passes through their bodies. Much of their diet consists of plankton, although anemone can catch small fish. Finger sponges are common in the LIS, an epifauna, providing shelter to young lobsters and crabs. [50]

Lobsters

The LIS is a habitat for the American lobsters. These lobsters are a greenish brown, but can also be red, albino or blue. They have two large front claws. The larger claw is used for grabbing , crushing and fighting while the smaller claw is used for ripping and tearing. They have eight legs that extend from their abdomen and a wide tail that is used as a powerful thruster in a fight, propelling an enemy backwards offering needed escape time for the lobster. Lobsters molt frequently in the first year of their life because it is growing so quickly, but as an adult it slows down to once every six months to two years. Molting contributes to the lobster's remarkable ability to regenerate their limbs as well as voluntarily release a limb if injured or held captive by an enemy. Regeneration can take up to two-years for an adult, but much less for a juvenile. The lobster is a nocturnal creature spending most of the day hiding in the cracks of rocky regions with its antennae protruding, however when no shelter is available, they burrow into the muddy sea floor. Lobsters are territorial and will aggressively fight to defend their shelters. Lobsters are scavengers, feeding at night and combing the bottom of the water for mollusks, fish and other crustaceans. Their predators include shark, cod, wolfish, goosefish and striped bass in addition to people. When a female lobster carries an egg mass attached to her underside, she is called "berried." One brood produces 8,000- 10,000 lobster larvae. After the larvae hatch, they become part of zooplankton community in the water column living near the surface and drift with the current. After about a month the larval lobster looks more like a miniature adult, is ¾ inch long and moves to the bottom to live as a true benthic creature. [51] [52]

Sea Stars

The Common Sea Stars grow to approximately five inches in diameter. They live on the sea floor in rock, gravel or sand. They can be found on the between the low tide line to depths of 160 feet. A sea star eats clams, scallops, and oysters. The sea star has an everted stomach which means it is able to extend its stomach outward and puts its into the tissue of their prey to digests it. The predators of a sea star are spider crabs, and sometimes lobsters. Sea Stars have a water vascular system that carries water and food the its extremities. A fascinating feature of the sea star is that it has an eye at the end of each of its five arms that radiate from its center. These arms can also be regenerated when injured or severed. The underside of each arm has tiny tube feet and a stomach / mouth in the center. Sea stars outer skin it hard, tough and spiny colored brownish red or orange. [53]

Horseshoe crab

A horseshoe crab is one of the most primitive ocean creatures, surviving for almost 300 million years. The horseshoe crab is actually not a crab, but an arachnid a class of arthropods that includes the spider. Horseshoe crabs grow up to 24 inches long and 12 inches wide and 3 or 4 pounds. The horseshoe crab has two main eyes, two light sensitive eyes and a mouth on the bottom. It has a hard brown-segmented helmet-like shell that protects it. The pointed tail helps the horseshoe crab to right itself. Horseshoe crab's preys are worms and bivalves as well as other creatures of the sea floor. They come to shore to spawn in May and June. As adults, their predators include shorebirds and humans; however, their crab eggs are an important source of nourishment for migrating shore birds and their larvae is consumed by a variety of fish . The abundance of horseshoe crabs are reflective of the environmental health of the intertidal area for which they spawn. [54] Most recently, they have become extremely valuable for their blood because it has blood proteins, which are extremely sensitive to bacteria. The blood of the horseshoe crab is extremely unusual, hemocyanins carry the oxygen in their blood, not hemoglobin. Hemocyarin is comprised of two copper molecules, which give the blood its blue color. In addition, important proteins in the horseshoe crab's blood, a result of their primitive immune system's ability to stop bacterial invasion by clotting, have proved extremely significant. Their sensitivity to bacteria which cause clotting in the presence of bacteria has resulted in every implanted biomedical device, drug , and vaccine certified by the FDA being tested using LAL, (limulus Amebocyte derived from horseshoe crab blood) for bacterial contamination. [55] [56] [57]

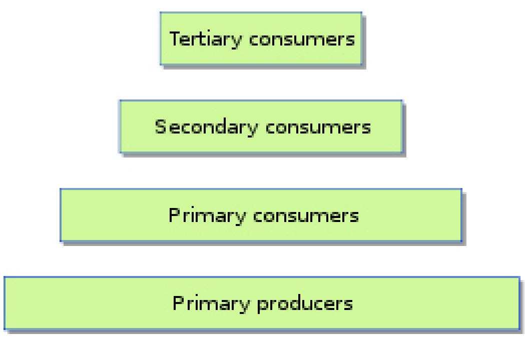
Mollusks

Mollusks are a category of sea creatures characterized by a soft bodied animal covered with a hard protective shell. They include clams, oysters, mussels, oysters , whelks and snails and are abundant in the sound. Mollusks are classified by shell type. "Bi" is Latin for two, thus bivalve means two shelled animals such as clams, mussels, and oysters. "Uni" means one in Latin, thus one shelled animals are called univalves like snails and whelks. The two shells of a bivalve is connected with a hinge. Univalves have one whole shell often carried on the back of the animal. Bivalves feed on algae. Sea slug, nudibranch, squid are mollusks too, but are exceptions to the existing classifications. Due to adaptations, the shell is these creatures are missing or strongly reduced. [58]

Food Chains and Food Webs: Predator and Prey

A food chain and food web are two expressions of the way in which energy is transferred from one organism to the next The food chain is a linear path that can be used to follow one particular creature and the food web is a visual illustration that explains the integral relationships between the many food chains in an ecosystem. However, both the food web and a food chain begin with the energy provided by the sun because it is this energy that is transferred and sustains all life on our planet. The next trophic level is a common link in both web and chain and then more diversion occurs according to habitat and ecosystem.

Beginning with the energy from the sun collected in phytoplankton through photo synthesis, each step in a food chain is called a trophic level. Phytoplankton are green plants that manufacture their own food through photosynthesis . These single celled microorganisms form the base of the food chain. Phytoplankton are called primary producers because they are able to produce their own energy, forming the pillar of the food chain. All food chains start with plants. Zooplankton occupy the second trophic layer because they eat phytoplankton. As a result, zooplankton are called primary consumers because they eat primary producers. Marine life that eats primary consumers occupy the third trophic level. Energy is lost as it is passed from one trophic level to the next. About 10% of energy is converted to body tissue from one trophic level to the next. Although energy is lost through the food chain as it is passed from prey to predator, material is not. Material from waste products and dead organisms are decomposed by bacteria and thus recycled back into the food chain as nutrients for phytoplankton. [59]



Phytoplankton

Creatures of the Long Island Sound

Marine Creature	Prey	Predators	Facts	Habitat
Phytoplankton	Makes own food – photosynthesis	zooplankton	Photosynthetic, Drifters	Epipelagic Photic zone
Zooplankton: Comb jelly	Phytoplankton	Fish	Drifters, weak swimmer	Near surface, able to move vertically in the water column
Moon Jellies	Small plankton, fish eggs	Sea turtles, sunfish	Does not sting	Drifter-Float near the surface
Atlantic Salmon	Herring, capelin, sand eels and large plankton.	Seals, sharks, pollack, tuna, skates, halibut, cod, striped bass, bluefish; humans.		Coastal waters, as well as freshwater rivers and lakes.
Atlantic Shad				Migration: Anadramous fish-Adult life at sea-return to LIS to spawn returning to river

Striped Bass	Squid, finfish		Do not spawn in the LIS, nekton	Pelagic Zone
Horseshoe crabs	Worms, bivalves and other bottom dwelling creatures.	Migratory shorebirds, humans (fishing bait).	Copper based blue blood , sensitive to bacteria-clots,	Benthic zone
Sponges	Filter feeders, plankton		Provide habitats for small fish, crab and lobsters	Benthic zone anchored to sea floor or rocks
Sea Star	Clams, scallops, and oysters.	Spider crabs and, occasionally, lobsters.	Stomach is everted into the prey animal, where it digests the tissue. Can regenerate severed arms.	Low tide line to depths of 160 feet; rock, gravel or sandy bottom.
American Lobster	Fish, crabs, snails, mussels,clams,worms,	shark, cod, wolfish, goosefish and striped bass	Regenerates limbs, molt, nocturnal	Benthic Zone, rocky reefs, sea floor, temperature sensitive

LIS Study

Classroom Activities

The Mural: As students learn new information about their marine creature, they will display it visually along with the words that explain it using labels, captions, text box explanations, headings, or timelines. The mural will offer support for new vocabulary, complex concepts, and serve as a catalyst for discussions. Opportunities to practice the language of marine science should be imbedded frequently. The mural will express the growing collective learning of the class, connecting sea animals to predator, prey, and habitats. As students share what they have learned, they will come to understand how incredibly interesting, unique, and interdependent marine life of the Long Island Sound.

Lesson 1: What is an Estuary? Long Island Sound is an estuary.

Objective: Students will understand the location and characteristics that make the Long Island Sound an estuary.

Activity: Students will write a question web before the lesson and then illustrate and describe in writing the characteristics that make Long Island Sound an estuary in their journal. Students will construct and label a map of the Long Island Sound including the bordering landmasses as well as the Atlantic Ocean and freshwater rivers that feed into it. (Housatonic, Hammonasset, Connecticut, Quinnipiac, and Thames Rivers)

Field Trip to Hammonasset State Park: Field Study

Lesson 2 : Marine Life of the Long Island

Objective: Students use evidence (shells, egg casing, sea weed) from the shore as a question focus and to make predictions about the sea creatures that may live in the Long Island Sound. Then students will carry out research and investigations to answer their questions and verify predictions. In the end, students will share their learning to develop a list of sea life in the Long Island Sound. From this list, student will each choose a marine creature to become the expert of through this unit.

Lesson 3: Exploring Marine Life in the Sound

Objective: Students will develop questions related to the unique physical characteristics of their sea animal and then search for the answers with particular interest in how and why the physical features help them survive.

Activity: Students will illustrate and label the parts of their sea creature in their journal then build a model of their creature to be placed on the wall mural.

Lesson 4: Marine Zones: Pelagic, Epipelagic, and Benthic Zones

Objective: Students will understand that the water column is divided into zones and these zones have unique characteristics suited to life within it.

Activity: Students will illustrate, define, and label ocean zones in their science journal and then find out where their creature lives and why.

Mural: Create water zones by hanging blue paper. Ask students to mark and label marine zones; pelagic, epipelagic, and benthic zones.

Mural: Each student will place their marine creature in its zone.

Lesson 5: Life Cycles

Objective: Students will learn that each creature has unique stages of their life cycle that contribute to the balance of the ecosystem.

Activity: Students will research, illustrate, and write about the life cycle of their creature, in their journal as well as on the wall mural to include the birth, infancy, juvenile and adult stages.

Wall Mural: Students will post the different stages of their marine animal's life cycle in action and label it.

Lesson 6: Predator and Prey: Food Webs and Food Chains

Objective: Students will understand that the food chain and web are ways of transferring energy from one creature to the next through what a creature eats(prey) and what eats it(predator). Producer (plants) and then levels of consumer in trophic levels will be discussed. Students will understand that a food chain illustrates the line of dependence from one animal to the next, whereas, the food web illustrates the broader interdependence of the marine life in relation to their prey and predators.

Activity: Students will develop their own questions about their sea creature's prey and predators and then illustrate the food chain and web in their science journal.

Mural: Survival in action: In addition to the food chain and web, students will add their creature eating its prey and hiding from or being eaten by its predators in action on mural. Colored ribbon can be used to connect predators and prey in food chains, which students will see develop into the creation of the ecosystem's food web.

Lesson 7: Ecosystems: Function and Structure

Objective: Students will understand that an ecosystem is the relationship between the animal(s) and the environment. Specific environmental characteristics of an estuary will be discussed such as, salinity, water temperature, depth, light, oxygen, and water movement.

Activity: Students will apply the fundamental elements of an ecosystem to their individual sea creature including the specific characteristic of the water and environment needed for the creature survival. Questions will be generated from this focus. Students will construct a visual description of their marine creature's ecosystem in their journal and then add new information to the class mural.

Mural: Each student will illustrate and label additional elements of the ecosystem.

Lesson 8: The Big Picture- Connecting the Dots

Objective: Students will share the unique qualities of their marine animal and how it fits into the ecosystem. This will connect all the marine life (the individual parts) to the whole ecosystem, revealing the complex interdependence of marine life and the waters of the Long Island Sound.

Activity: What If Game. Student will explore scenarios of change within the ecosystem, and predict outcomes.

Activity: Who Am I? Students will take turns being "It." Each student will ask one question at a time about the sea creature of the chosen student until someone is able to guess its name.

Activity 9: Class Book: Marine Life of Long Island Sound: Each student will have a page to illustrate, label and describe their marine animal in its habitat including its life cycle, predators, and prey.

Schooner Trip: Exploring marine life on the water of the Long Island Sound

Unit Extensions: Adaptations, Evasive Species, Conservation

Common Core Content Standards addresses in this unit:

Scientific Inquiry: Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain, and predict natural phenomena.

Scientific Literacy: Scientific literacy includes speaking, listening, presenting, interpreting, reading, and writing about science.

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