Science

Stonington Public Schools

Physical Oceanography

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BOE Approved: May 11, 2023

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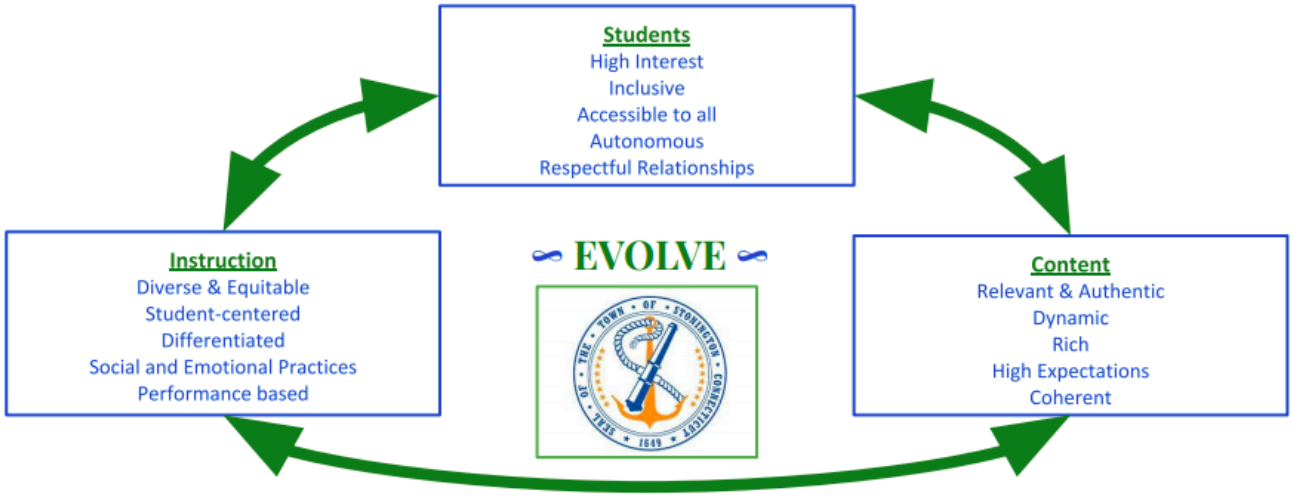
Science Vision Statement

The Stonington K-12 Science curriculum provides a comprehensive, problem-based education focused on the Next Generation Science Standards. The curriculum fosters

- High-quality authentic science education for every student
- Fluency in the Science and Engineering practices
- A recognition of the full implications of the scientific world
- The utilization of scientific concepts and phenomena to consider, connect, communicate and convince
- Rigorous and relevant learning environments

Students will become scientifically literate citizens able to contribute to a rapidly advancing, STEM-driven world, taking action in local, national and global issues.

District Curriculum Philosophy



Curriculum Philosophy from a Student Perspective

Students in Stonington Public Schools will experience and engage with an inclusive curriculum. The curriculum will encompass a variety of experiences and will be accessible to all students while providing a strong foundation for students to have a voice and make a positive impact in the modern world. The curriculum will be a living entity, ever evolving to meet the students' needs in a changing society.

Curriculum Philosophy from an Instructional Perspective

Instruction in Stonington Public Schools will be responsive and students will feel represented through culturally, socially, and emotionally conscious practices. It will be meaningful to students by incorporating multifaceted pedagogical approaches including inquiry, collaboration, and reflection. Instruction will provide all students opportunities to respond, equitable assessments, and positive feedback. Teachers will engage in dynamic and reflective practices to advance their craft.

Curriculum Philosophy from a Content Perspective

Content in Stonington Public Schools will be constantly adapting to reflect current and relevant information along with the state and national standards for each discipline. Through a rich, authentic, and coherent curriculum, students will learn that the past informs the future. The curriculum will be complex and will provide optimum challenges for all students with the goal of preparing knowledgeable, problem solving, productive citizens who are career and college ready and prepared for the diverse global community.

We Believe In You

1. **Convince:** Use critical thinking skills and a variety of relevant evidence to solve a problem, support a position, or present an idea.
2. **Communicate:** Use content area language clearly to convey ideas as an individual. Communicate with others in a way that facilitates a collaborative process.
3. **Consider:** Use all learning to develop innovative and/or creative options to solve challenging situations and/or problems.
4. **Connect:** Use technology to find, evaluate, create and/or share information, ethically and legally. Connect all learning to become a participative member in the social and civic community.

Physical Oceanography

Critical Areas of Focus (Course Description)
The major objectives of the course are to develop an appreciation for and a sound understanding of the "World Ocean" from a chemical, physical, and geological standpoint. Particular areas of study include hurricanes and water, the chemical nature of the water, navigation, waves, tides, currents, climate change, plate tectonics, and the ocean floor. Human impact on the oceans will also be discussed. Concept reinforcement will be accomplished utilizing a variety of methods including computer models, online/interactive activities, audiovisual materials, class discussion, demonstration, hands-on activities and guest speakers. Field trips often include: Mystic Marinelife Aquarium, Barn Island Field Study, USCGA Research & Development Center and the International Ice Patrol. Prerequisite: Completion of Biology & Physical Science. Length ½ year, Credit ½

Pacing Guide	
Unit 1	Unit 2
Ocean Exploration (weather, plate tectonics, zonation)	Ocean Circulation & Motion (tides, waves, currents) 4C Assignment: Consider
~22 classes @ 76 minutes	~23 classes @ 76 minutes

Unit 1

Name of Unit:	**Length of unit: (number of classes/minutes per meeting)**
Ocean Exploration	~22 classes @ 75 minutes

Content Standards Addressed in the Unit:

[Next Generation Science Standards]

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that causes changes to other Earth systems.

HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

[Ocean Literacy Framework]

1. **The Earth has one big ocean with many features.**
   A. The ocean is the defining physical feature on our planet Earth—covering approximately 70% of the planet's surface. There is one ocean with many ocean basins, such as the North Pacific, South Pacific, North Atlantic, South Atlantic, Indian, Southern, and Arctic.
   B. Ocean basins are composed of the seafloor and all of its geological features (such as islands, trenches, mid-ocean ridges, and rift valleys) and vary in size, shape and features due to the movement of Earth's crust (lithosphere). Earth's highest peaks, deepest valleys and flattest plains are all in the ocean.
   D. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change.

2. The ocean and life in the ocean shape the features of Earth.

B. Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

E. Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.

3. The ocean is a major influence on weather and climate

B. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and ocean atmospheric circulation.

D. Condensation of water that evaporates from warm seas provides the energy for hurricanes and cyclones.

F. The ocean has had and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water.

4. The ocean supports a great diversity of life and ecosystems.

H. Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast; density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms' distribution and diversity.

7. The ocean is largely unexplored.

A. The ocean is the largest unexplored place on Earth-- less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.

B.Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.

C. Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

D. New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.

E.Use of mathematical models is an essential part of understanding the ocean system. Models help us understand the complexity of the ocean and its interactions with Earth's interior, atmosphere, climate and land masses.

Big Ideas:	**Essential Question(s):**
● Oceanography is the important study of the ocean and its features.	● What is oceanography and why is it important? ● How has ocean exploration changed over time?
Students will know:	**Students will be able to:**
● Scientists who study the oceans have many different scientific backgrounds. ● The history of Oceanography is one of changing perspectives based on interpretation of historical and contemporary research and has shaped modern science and its applications. ● Less than 5% of the oceans volume has been explored to date. ● Marine exploration has had 4 distinct periods of growth. ● Ocean covers ~70% of Earth's surface ● Names of the ocean basins ● The difference between hurricanes, cyclones and typhoons. ○ Causes/formations ○ Characteristics ○ Locations ● Names of hurricanes ● Classification of storm categories ● The history of oceanography is part of understanding how the oceans shaped the past and may shape the future. ● The concepts of continental drift and sea floor spreading have been combined to form a single unified theory of plate tectonics.	● Create a timeline of ocean exploration. ● Describe technological advances that have led to oceanic discoveries. ● Identify ocean basins and describe the formation and ecological importance of the geologic structures similar to each. ● Identify the differences between hurricanes, cyclones and typhoons ● Plot and analyze data to plot the trajectory path of a hurricane ● Trace the development of the theory of plate tectonics. ● Create a 3D model of the sea floor ● Identify sea floor structures ● Create a diorama or other model of the Oceanic zones

● The sea floor is not a static environment but is in motion as new sea floor is created at oceanic ridges and an equal volume is destroyed at deep trenches. ● Our ability to accurately map the features of the sea floor has been acquired only recently and continues to improve with advancing technology ● The ocean water column is made up of five zones: the sunlight zone (epipelagic), the twilight zone (mesopelagic), the midnight zone (bathypelagic), the abyssal zone (abyssopelagic) and the hadal zone (trenches). ● The ocean is directly or indirectly responsible for the majority of the food on the planet.	

Significant tasks:

Significant task 1: Ocean Exploration

Students can brainstorm and discuss what they know about the ocean through their personal experiences and prior learning. Then, they can research to discover some of the important aspects of oceanography such as important events in history, inventions, technology, exploration, and resources. This task will introduce students to some common terminology and information relating to navigation. Students can present their information in a format of choice.

*Semester 1: Teacher choice: This content activity can occur during this task as a real-time study. During Semester 2: This can occur during Unit 2 Waves.
Students can answer the question: “Why should we study hurricanes?”. They can then research the different categories, historical events (Hurricane of 38), and retired names. Plot points from historical hurricanes and/or recent hurricanes can be plotted on a map after a review of latitude and longitude. Students should discover why hurricanes occur and compare and contrast them with typhoons, tsunamis, and cyclones.

Timeline: 8 classes @ 76 minutes*

Significant task 2: Plate Tectonics

Students can be introduced to geological oceanography by analyzing the basic structure of the Earth and its layers and a map or video of Pangaea or from a video source such as History Channel's How did the Earth Form or PBS's Where did Water Come From?. Mapping the tectonic plates, participating in a webquest or a similar activity allows students to learn the structure and composition of oceanic and continental crust and the theory of plate tectonics. Students can demonstrate the movement of the plates and seafloor spreading by creating a model and/or analyzing data. Students can also create a slideshow or similar presentation on the ocean's geologic features. Each student could choose or be assigned to two features and then create slides that show and explain the formation of each feature. The slides can be combined for a whole class presentation. After analyzing Earth's topography and bathymetry, students can make a claim about how natural processes shape our coasts and ocean floors.

Timeline: 6 classes @ 76 minutes

Significant task 3 : Zonation

Students can begin with an activity such as watching a movie such as Mariana Trench - David Attenborough's Documentary on the deepest sea floor or Robert Ballard's The Astonishing Hidden World of the Deep Ocean. This learning can serve as a segue from geology to ocean zones. Students can select a specific oceanic zone to research. Collected information should include location, name, depth, animals/food sources, and unique characteristics. There should be a focus on the diversity of sea life in the zone. A visual model, such as a diorama, of the zonation area should be made. Students can share their models with the class.

Timeline: 5 classes @ 75 minutes

Common Learning Experiences:

- Weekly Personal Field Trip- show and tell with an ocean artifact
- Opportunities to Respond: Active Engagement
- Culturally Responsive Pedagogy
- Frequent Formative Assessments/Check Ins
- Current Events as applicable

- Cooperative Grouping
- Scientific Discourse
- Science and Engineering practices
- Computer simulations
- Developing a Driving Question Board
- Systems and system modeling
- Form claims based on evidence and reasoning
- Mathematical calculations
- Exit Tickets
- Concept Quizzes

Key vocabulary:

Active coasts, adaptation, anoxic, asthenosphere, benthic zone, biogenous sediment, continental rise, continental shelf, continental slope, Coriolis Effect, dead zone, estuary, fathom, hypoxic, intertidal zone, land-deposition coasts, lithogenous sediment, lithosphere, marine-deposition coasts, neritic zone, oceanic zone, pelagic zone, primary coasts, secondary coasts, latitude, longitude

Evidence of Understanding - Common Assessments

- Concept Quizzes
- Oceanography exploration timeline
- Hurricane Tracking Map
- Map of the Sea Floor model
- Ocean Geological Features Slides (or similar presentation)
- Oceanic Zones model
- Unit Test

Teacher notes:

- Resources:
    - Marine Ecosystems & Biodiversity: National Geographic
    - https://www.shapeoflife.org/ The Story of the Animal Kingdom

- Possible Field Trips: Mystic Aquarium: Career explorations, deep sea exploration, ROV design, climate change and ocean acidification

- Anticipated Student Misconceptions:
  - All marine ecosystems are similar and face the same issues.
- Differentiation Strategies:
  - NGSS Appendix D - "All Standards, All Students":
    Making the Next Generation Science Standards Accessible to All Students
  - Tier 1 Universal Strategies
  - Tier 2 Targeted Strategies
  - Tier 3 Intensive Strategies

- Safety Considerations:
  - *Note: Each teacher will identify the safety considerations that occur in each individual activity.*
  - *See ACS Chemical Hygiene Plan for specific safety precautions.*

- Prior Knowledge:
  - 7th grade science: Spring semester studies ecosystems exclusively
  - Middle School Encore Wonders of Water (about ⅛ of the students): studies water quality & human impact
  - Biology freshman year: discusses populations
  - Environmental Science: studies various ecosystems, some including marine environments.

- Interdisciplinary Connections:
  - Common Core State Standards Connections:

    ELA/Literacy -
    - RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
    - RST-11.12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
    - WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

- WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research.
- SL.11-12.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

Mathematics -

- MP.2 Reason abstractly and quantitatively.
- MP.4 Model with mathematics.

U.S Conservation & Preservation: Definition of conservation and discussion of preserved areas.

Social Emotional Learning: CASEL 5

- Responsible Decision Making
  - Identifying Problems
  - Analyzing Situations
  - Solving Problems
  - Evaluating
  - Ethical Responsibility
- Social Awareness
  - Respect for Others
- Self Management
  - Self-Motivation
  - Goal Setting
- Relationship Skills
  - Communication
  - Teamwork

Unit 2

Name of Unit:	**Length of unit: (number of classes/minutes per meeting)**
Ocean Circulation and Motion	~23 classes @ 75 minutes

Content Standards Addressed in the Unit:

Next Generation Science Standards

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. (moon)

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

Ocean Literacy

1. The Earth has one big ocean with many features.

C. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of Earth's rotation (Coriolis effect), the Sun and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation. This "global ocean conveyor belt" moves water throughout all of the ocean basins, transporting energy (heat), matter, and organisms around the ocean. Changes in ocean circulation have a large impact on the climate and cause changes in ecosystems.

E. Most of Earth's water (97%) is in the ocean. Seawater has unique properties. It is salty, its freezing point is slightly lower than fresh water, its density is slightly higher, its electrical conductivity is much higher, and it is slightly basic. Balance of pH is vital for the health of marine ecosystems, and important in controlling the rate at which the ocean will absorb and buffer changes in atmospheric carbon dioxide.

F. The ocean is an integral part of the water cycle and is connected to all of Earth's water reservoirs via evaporation and precipitation processes.

G. The ocean is connected to major lakes, watersheds, and waterways because all major watersheds on Earth drain to the ocean. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to coastal estuaries and to the ocean.

4. The ocean is a major influence on weather and climate

B. The ocean moderates global weather and climate by absorbing most of the solar radiation reaching Earth. Heat exchange between the ocean and atmosphere drives the water cycle and ocean atmospheric circulation.

D. Condensation of water that evaporates from warm seas provides the energy for hurricanes and cyclones.

F. The ocean has had and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon, and water.

5. The ocean supports a great diversity of life and ecosystems.

H. Tides, waves, predation, substrate, and/or other factors cause vertical zonation patterns along the coast; density, pressure, and light levels cause vertical zonation patterns in the open ocean. Zonation patterns influence organisms' distribution and diversity.

7. The ocean is largely unexplored.

A. The ocean is the largest unexplored place on Earth-- less than 5% of it has been explored. The next generation of explorers and researchers will find great opportunities for discovery, innovation, and investigation.

B.Understanding the ocean is more than a matter of curiosity. Exploration, experimentation, and discovery are required to better understand ocean systems and processes. Our very survival hinges upon it.

C. Over the last 50 years, use of ocean resources has increased significantly; the future sustainability of ocean resources depends on our understanding of those resources and their potential.

D. New technologies, sensors, and tools are expanding our ability to explore the ocean. Scientists are relying more and more on satellites, drifters, buoys, subsea observatories, and unmanned submersibles.

Big Ideas:	**Essential Question(s):**
● The ocean's movement and circulation is a major influence on the planet's weather, climate, and surface.	● How does the ocean's water affect weather and climate? ● What is the relationship of the world's oceans to our planet?
Students will know: ● There are three major patterns of tides- diurnal, semidiurnal and mixed. ● Tides are influenced by the moon, Sun, Earth's rotation and local geography. ● There are many different types of waves and the type and characteristics are influenced by fetch, geology and physical processes. ● Waves transfer energy from one place to another. ● When current's twist and close on themselves they can trap water from one side of the current on the opposite side. ● Surface circulation is a response to the long-term average atmospheric circulation. ● Prevailing winds in the atmosphere drive surface currents in the oceans in predictable patterns. ● Temperature changes affect the density of water more than changes in salinity.	**Students will be able to:** ● Predict the tide cycle based on patterns and factors. ● Graph tidal cycles from different areas of the world. ● Analyze tidal data. ● Calculate wave speed, height and frequency. ● Create and measure wave patterns in a lab simulation. ● Determine circulation patterns and their effect on regional climates. ● Model the major oceanic currents. ● Analyze properties of ocean water. ● Compare the relationship of temperature and salinity to the density of water.

Significant tasks:

Significant task 1: Tides

Students can be asked; What Causes the Tides in the Ocean?. They can then read a short article (Newsela:), watch a video, or research to find the answer. A class discussion should occur to review the forces that affect tides including the moon cycle and the Coriolis effect. Students can observe tidal charts and name the tide cycles and describe reasons tides are important to humans and marine life. They can then practice analyzing tidal information from various harbors. Using vocabulary and fundamental terminology, students can categorize and characterize tides. Students can construct a marigram, which is a graph of the tidal fluctuations. As an assessment, students can be given a tidal set and then graph the data and determine its location. Students can compare all of the different locations across the globe to see the difference between a semi-diurnal, diurnal and mixed semi-diurnal tide in graphic form.

Timeline: ~4 classes @ 75 minutes

Significant task 2: Waves

The NOAA video: Ocean Wave can be watched as an introduction to waves. Students can learn about coastal waves by completing a constructive and destructive Waves activity. A guest speaker that is a surfer (Mr. Dan Rahl) can speak about waves, how to determine when to go surfing, which areas have really BIG waves, and why, and some of the dangers of waves or a video from a source such as Discovery News can be used to emphasize waves. Students should pay attention to wavelength and wave period. In an ocean wave lab, students can make a model and simulate the pattern of waves as they come into shore using a cardboard tube from a roll of paper towels to wrap the "data collector" around. Following the activities directions, students can measure wavelength and wave period, and then calculate the wave speed and answer follow-up questions about the characteristics of waves and their behavior. Students can also define tsunamis and describe ways that scientists predict and prepare for tsunamis. Students can apply equations they have learned to predict when tsunamis are triggered by earthquakes at given depths and how they affect specified locations.

Timeline: ~4 classes @ 75 minutes

Significant task 3: Currents

Students can learn (pictures, article, video) about the Giant Pacific Garbage Patch as an anchoring phenomena. After learning about currents, students can create a model of the major currents across the globe such as El Niño. A lab such as Ocean Currents and Coastal Temperatures allows students to collect data to see how different temperatures affect bodies of water and climate. They can graph the data and compare and contrast the East and West coast.

Timeline: 4 classes @ 75 minutes

Significant task 4: Sea Water

Students can discover water chemistry and properties in activities that measure the pH, turbidity, and salinity using numerous samples. They can learn that salinity and temperature vary throughout the ocean and they affect the density of water, which results in layers of water within the ocean. Students can then perform density experiments with different types of water (freshwater vs. saltwater) and different temperatures of water. A second lab should allow students to create their own experiment to test different parameters. After the labs, students can answer; Were you able to prove how density works in the ocean? Was anything different?, in a CER format using the Consider rubric.

Timeline: ~4 classes @ 75 minutes

Common Learning Experiences:

- Daily Warm Ups
- Weekly Personal Field Trip- show and tell with an ocean artifact
- Opportunities to Respond: Active Engagement
- Current Events as applicable
- Culturally Responsive Pedagogy
- Frequent Formative Assessments/Check Ins
- Cooperative Grouping
- Scientific Discourse
- Science and Engineering practices
- Computer simulations
- Developing a Driving Question Board
- Systems and system modeling

- Form claims based on evidence and reasoning
- Mathematical calculations
- Exit Tickets
- Concept Quizzes

Key vocabulary:

Boundary currents, crest, current, diurnal tide, duration, fetch, halocline, latitude, longitude, mixed tide, neap tides, period, pycnocline, salinity, semidiurnal tide, turbidity, pH, solute, solvent, spring tides, thermohaline circulation, tidal range, tide, trough, wave, wavelength, Gravity, High tide, Low tide, Neap tide, Range, Spring tide, thermocline, halocline

Evidence of Understanding - Common Assessments

- Concept Quizzes
- Various Labs/Activities
    - Tide Marigram
    - Tidal Set Assessment
    - Wave Simulation Lab
    - Current Graph Analysis
- Density Box lab or similar Water property labs (Consider Rubric)

Teacher notes:

- Resources:
    - NOAA Enrichment in Marine Sciences and Oceanography (NEMO) Curriculum
    - Possible Field Trips: Mystic Aquarium: Career explorations, deep sea exploration, ROV design, climate change and ocean acidification
- Anticipated Student Misconceptions:
    - All marine ecosystems are similar and face the same issues.
- Differentiation Strategies:
    - NGSS Appendix D - "All Standards, All Students”: Making the Next Generation Science Standards Accessible to All Students

- Tier 1 Universal Strategies
- Tier 2 Targeted Strategies
- Tier 3 Intensive Strategies

- Safety Considerations:
  - *Note: Each teacher will identify the safety considerations that occur in each individual activity.*
  - *See ACS Chemical Hygiene Plan for specific safety precautions.*

- Prior Knowledge:
  - Middle School Encore Wonders of Water (about ⅛ of the students): Water quality & human impact
  - Physical Science (core science class): Study of waves & geographical features
  - Chemistry: water properties

- Interdisciplinary Connections:
  - Common Core State Standards Connections:

    ELA/Literacy -
    - RST-11.12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
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    Mathematics -
    - MP.2 Reason abstractly and quantitatively.
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