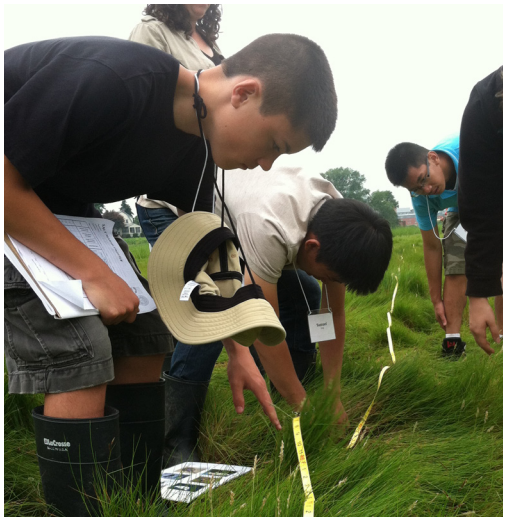
Coastal Habitats Curriculum

“From School to Sea: Linking Middle School Students to the Sea Next Door”

Developed by **Northeastern University Marine Science Center** & **Lynn Public Schools**
Made possible by a grant from the Lincoln and Therese Filene Foundation |

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About the Project

The Northeastern University Marine Science Center Outreach Program collaborates with Lynn Public Schools to deliver STEM programming in marine & environmental sciences to middle schoolers. Funded by the Lincoln and Therese Filene Foundation, the "From School to Sea: Linking Middle Schoolers to the Sea Next Door" project has been working since 2012 to achieve the following goals and objectives:

1. Improve environmental literacy of middle school students
   - Improve middle school student knowledge of New England coastal habitats
   - Enhance student skills and confidence in investigating the natural environment
   - Improve student attitudes and perceptions about the environment and their connection to it
2. Improve middle school teachers' capacity to engage students in meaningful field-based learning experiences

The "From School to Sea" project engages 6th grade students in three outdoor field studies each year, at a rocky shore, sandy beach, and salt marsh. This curriculum has been developed to provide teachers with "wrap-around" lesson plans and other resources to prepare students for outdoor learning, engage in field activities, and to debrief, reinforce content, and assess impact at the end of each module.

About the Curriculum

There are three modules, one for each of three coastal habitats: the rocky shore, salt marsh, and sandy beach. Also included is a chart that references the relevant Massachusetts curriculum standard for science, reading, and writing that are covered in each module. Each module contains the following components:

- Habitat Description
- Pre-visit activities
- Field activities
- Post-visit and assessment activities
- Duration, learning objectives, and materials needed for each activity
- Vocabulary

Reproducible data sheets, worksheets, and species identification cards may be found at the end of the pack. Lessons also reference videos and slide presentations that can be found online at the Northeastern University Marine Science Center's website at www.northeastern.edu/marinescience.

Background Information for Teachers

This program will focus on three coastal habitats found in New England. These habitats are the sandy beach, rocky shore, and salt marsh. One major factor that shapes and affects coastal habitats are tides, which are closely tied to cycles of the moon. Local tides are semi-diurnal, meaning that there are two low and two high tides per day, with a tidal range of anywhere from 8-12 feet between low and high tides. Tide times and heights fluctuate, and are related to geography, cycles of the moon and time of year. Other factors affecting the form of these coastal habitats are ocean currents and geographic location, particularly proximity to rivers and wetlands and the presence of headlands.

Life in coastal habitats can be challenged by abiotic factors such as exposure (wind, sun, precipitation), competition for space, and fluctuating water levels (due to tides, waves, storm surge, precipitation), as well as biotic factors such as competition for food and the presence of predators. Species living in coastal environments have developed many adaptations in order to survive. These adaptations include characteristics related to body form, such as having a hard shell, claws and camouflage. Other adaptations include tolerances and/or abilities to cope with things such as changes in water level, water quality, ability to move or stay put, and specific feeding and breeding strategies.

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The **ROCKY INTERTIDAL** is a zone of rocky coastline that falls between high tide and low tide. Below the rocky shore is the subtidal zone, and above it is uplands. These rocky shores generally occur in relatively exposed waters, and are generally comprised of bedrock and other large glacial rocks and cobble. The rocky shore has several distinct zones that are defined by elevation relative to the water's edge and distinct geologic features. These include a low, mid, and high zone, and the splash zone above. Signature pools of seawater, called tidepools, can form at any elevation where geographic terrain allows, and these tidepools host a diversity of life. Life across the rocky shore is dominated by invertebrates (e.g., mollusks, crustaceans, echinoderms) and algae (i.e., brown, red, green).

ROCKY INTERTIDAL

2

The **SALT MARSH** is a type of wetland that is inundated with salt water at high tide. Even at low tide, it can retain pools (called pannes), channels, or rivulets of salty or brackish water. Salt marshes have distinct soil types and plants that are salt and/or water-tolerant. he marshes tend to form behind barrier beaches in areas where rivers and streams flow out, causing the accumulation of soft sediments that are ideal for wetland plant growth. They are important in coastal flood control, groundwater recharge, and provide valuable habitat for many species, including some that are commercially important. The nutrient-rich waters and grass flats of a salt marsh provide critical habitat for birds, fish, small mammals, a number of grass and shrub species, and a variety of invertebrates. Worms, snails, crustaceans, and insects are among the many types of animals that call the salt marsh home.

SALT MARSH

3

The **SANDY BEACH** is an area where loose particles cover all or part of the shore, and are generally found in less exposed coastal areas. Beaches in New England are generally made up of heavily eroded shells of marine animals and rock (quartz, feldspar, basalt). In addition to tides and currents, beaches are heavily influenced by wave action, and can change in shape and size drastically between seasons or even before/after a storm event. Compared to other local coastal habitats, there are relatively few animals living in sandy beaches because of the pressures of wave action and absence of abundant food within the sand. However, the wrack lines on a beach – those accumulations of organic debris that wash up at high tide lines – can support micro-communities of life. Living things generally dwell in the sand (e.g., worms, clams, some snails) and/or on the sand (e.g., horseshoe crabs, shorebirds, and some marine mammals.)

SANDY BEACH

CONNECTION TO MASSACHUSETTS STATE STANDARDS

	Rocky Shore	Salt Marsh	Sandy Beach
Life Science			
1 - Classify organisms into all kingdoms according to characteristics that they share. Be familiar with organisms from each kingdom.	✔	✔	✔
2 - Recognize that all organisms are composed of cells, and that many organisms are single-celled (unicellular), e.g., bacteria, yeast. In these single-celled organisms, one cell must carry out all of the basic functions of life.			✔
5 - Describe the hierarchical organization of multicellular organisms from cells to tissues to organs to systems to organisms.			✔
13 - Give examples of ways in which organisms interact and have different functions within an ecosystem that enable the ecosystem to survive.	✔	✔	✔
14 - Explain the roles and relationships among producers, consumers and decomposers in the process of energy transfer in a food web.	✔	✔	
15 - Explain how dead plants and animals are broken down by other living organisms and how this process contributes to the system as a whole.	✔	✔	
16 - Recognize that producers (plants that contain chlorophyll) use the energy from the sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.		✔	✔
Physical Science			
3 - Recognize that the measurement of volume and mass requires understanding of the sensitivity of measurement tools (e.g., rulers, graduated cylinders, balances) and knowledge and appropriate use of significant digits.	✔	✔	✔
Earth Science			
1 - Recognize, interpret, and be able to create models of Earth's common physical features in various mapping representations, including contour maps.			✔
Reading Standards for Literacy in Science and Technical Subjects			
1 - Cite specific textual evidence to support analysis of science and technical texts	✔	✔	✔
3 - Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks	✔	✔	✔
7 - Integrate quantitate or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table.)	✔	✔	
Writing Standards for Literacy in Science and Technical Subjects			
3 - Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments or technical processes.	✔	✔	✔
10 - Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline- specific tasks, purposes, and audiences.	✔	✔	✔

Field Trip Etiquette

PREPARING STUDENTS

Before your outdoor field trip, brainstorm with students about how everyone should conduct themselves. Below are some general themes to guide your discussion. If desired, the teacher can document the rules on a board or flip-chart paper.

Established rules of the site

- Challenge students to think about who lives in the habitat they are exploring
- How should students behave to ensure they respect these inhabitants?
- What rules are in place to protect these inhabitants?
- General discussion on proper handling/respect of living things

School rules

- Students should conduct themselves as they would in school
- Reminders about any field-trip specific rules
- Students are responsible for representing their school via good behavior

Safety

- Ask students to brainstorm any dangers or hazards at the field trip site
- How should students avoid these dangers?
- What rules are in place to avoid dangers or respond to potential hazards?

Logistics

- Allow students to ask questions about field trip logistics. This will help to avoid distraction during the field trip.
- Give them all the details such as: how long is the bus ride, what will we be doing, is there a gift shop, when will we eat lunch?
- Discuss what students should wear/bring, and what they should not. Send home a handout with this information before the field trip.

Taking Care of the Environment

If the students don't think of everything while brainstorming, be sure to mention these general rules regarding visiting coastal habitats:

- Remind students that they shouldn't take anything home and to be sure not to leave any equipment, personal belongings or trash.
- It's ok to get your feet wet, but no one should be more than ankle deep in the water.
- On the rocky beach, no one should climb on high rocks above where seaweed grows.
- On the sandy beach no one should walk on the dunes. The dune grass stabilizes the sand, keeping the beach in place.
- At the salt marsh, participants should stay on marked path and try not to disturb the vegetation – these plants are very important to the health of the marsh.

PREPARING CHAPERONES

Invite chaperones to attend the in-class discussion of field trip etiquette and even the pre-visit educational activities that you do to prepare students for the field trip.The more information that the chaperones are familiar with, the more they can help students get the most out of the experience. Share resources with chaperones such as the field trip etiquette document, a schedule of activities for the day, procedures for activities, what to bring handout, site map or website where they can find out more information about the site.

Module 1

ROCKY SHORE

Learning Objectives

1. Use a field guide to identify rocky shore organisms and their biological classification.
2. Construct a field guide specific to the rocky shore.
3. Give examples of organismal adaptations specific to the habitat.
4. Conduct a population study.
5. Document weather conditions and explain how weather impacts life in this habitat.

Vocabulary

- Intertidal
- Tidepool
- Salinity
- Temperature
- Tide
- Adaptation
- Elevation
- Quadrat
- Transect
- Kingdom
- Phylum
- Class
- Order
- Family
- Genus
- Species

HABITAT DESCRIPTION

The rocky intertidal is rocky coastline that falls between the high and low tide line. The rise and fall of the tides creates an area that is covered by water part of the day and exposed to air for part of the day. Below the rocky shore is the subtidal zone, which is always submerged in water, and above the rocky shore are uplands, which waves rarely reach. These rocky shores generally occur in relatively exposed waters, and are generally comprised of bedrock and other large glacial rocks and cobble.

These rocks provide a hard substrate for a variety of sessile (non-moving) organisms to settle. Additionally, many mobile organisms dwell in the cracks, crevices and tidal pools left behind as the water retreats to the low tide line. Due to the habitat provided by the rocks, the tide pools, and the foundations species living here, the rocky shore hosts variety of life that is much more apparent at first glance compared to the sandy beach. Invertebrates and seaweeds (red, green and brown) dominate life on the rocky shore. Large, brown seaweeds form dense canopies that trap water and provide relief from the stressful conditions experienced by organisms during low tide. Cooperation between organisms is important for survival in this stressful environment.

The rocky shore has distinct zones that are defined by elevation relative to the water's edge and distinct geologic features. These include a low, mid, and high zone, and the splash zone above. The intertidal is not uniform. These distinct zones are submerged in water and exposed to air for different lengths of time, resulting in increasing physical stress associated with higher tidal elevations. This physical stress includes drastic changes in temperature, salinity, dissolved oxygen levels, and pH in high tidepools during low tide when they are separated from the flow of seawater. Additionally, organisms living directly on the rocks outside of tidepools must deal with desiccation stress. Organisms have adapted to these stressors by developing high tolerances for changes in abiotic conditions. For instance, a periwinkle in a high tide pool is able to survive in temperatures ranging from below freezing to over 90°F, and salinities ranging from 15 to 45ppt. Wave action is another abiotic stressor on the rocky shore. Large waves can dislodge organisms from the rocks, washing them into deeper waters, or to the uplands beyond the intertidal. As a result many intertidal organisms have adaptations that allow them stick to rocks such as tube feet in sea stars and byssal threads in mussels.

In addition to abiotic stressors, biotic stressors include competition and predation. Isolated tidepools contain limited quantities of food and oxygen, leading to competition for these essential resources. Space is at a premium on rocky shores, and organisms complete for a spot on the rocks to settle. Competition is so intense that organisms even settle on top of one another. Like land plants, seaweeds that grow on other seaweeds are known as epiphytes. Sessile animals such as mussels, barnacles and tunicates settle on each other as well as on larger organisms such as crabs and snails, and are referred to as epibionts. Intertidal organisms are subject to predation from both land and sea. At high tide large subtidal crabs and fish can venture into the intertidal for a snack. Similarly, at low tide, terrestrial predators such as seabirds, rodents and raccoons might make a meal out of tidepool creatures.

PRE-VISIT ACTIVITIES

To prepare your students for a rocky shore field experience, conduct several or all of the activities detailed below, before your rocky shore visit.

Duration: 1 class period

Learning Objectives: Build on prior knowledge to learn about the rocky shore

Materials: Rocky Shore Slide Presentation

Introduction to the Rocky Shore

As an introduction to classification & field etiquette/safety, the teacher will display a picture of the rocky shore and ask students if they have ever been to such a place. Students will be invited to share their experiences of the rocky shore in a whole group discussion. An overview of the on-site study will be presented to the students. Students will be introduced to vocabulary related to the rocky shore and site etiquette. The teacher will present the Rocky Shore slide presentation, which can be found at www.northeastern.edu/marinescience.

Duration: 1 class period

Learning Objectives: Classify animals based on shared characteristics

Materials: Variety of sea-shells, Field guides (books and/or online)

Animal Classification

Students will be organized into groups of 4 to classify different types of shells based on characteristics observed. Groups will share and discuss their classification schemes with the whole group. The teacher will then show students how to use a field guide to identify organisms, shells in particular. Students will use the field guides to identify the types of shells they have been given.

Duration: 10-20 minutes

Learning Objectives: Review recently learned vocabulary

Materials: Printed vocabulary terms and associated photos in envelopes

Vocabulary Picture Matching

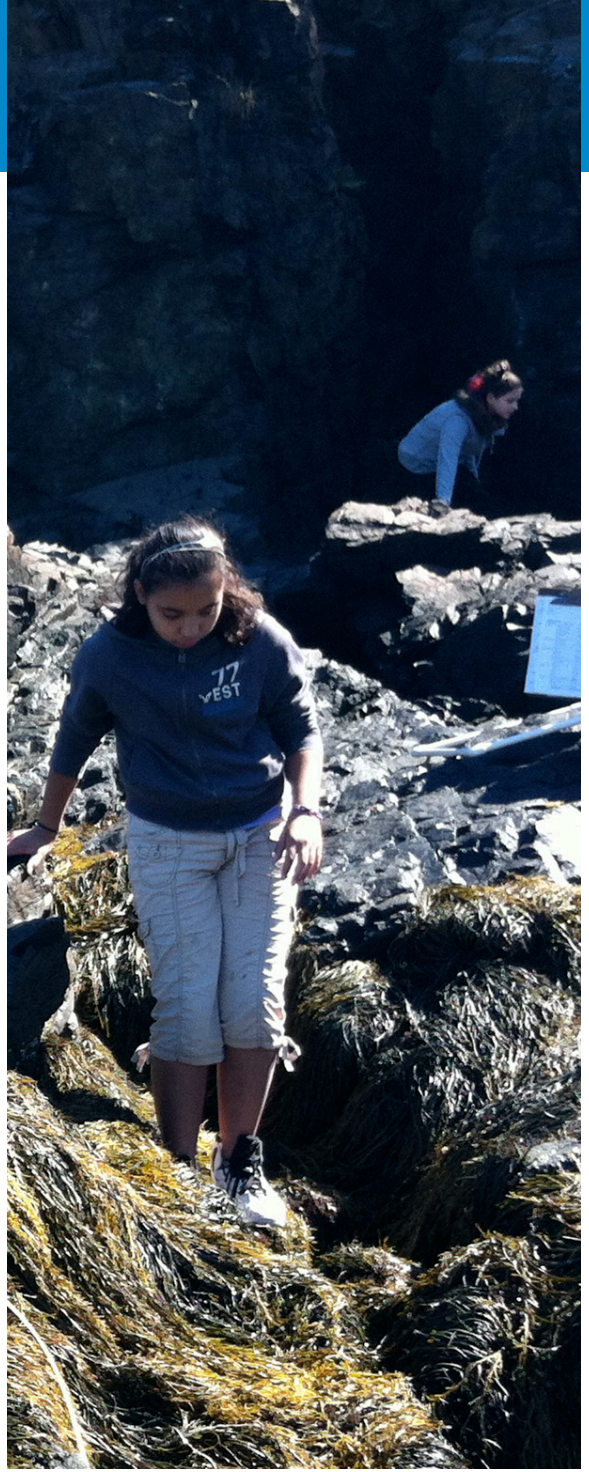
Pairs of students will be given an envelope containing the vocabulary terms addressed in the PowerPoint presentation and images representing those terms. Students will work together to sort the images with the correct term.

Why Study The Rocky Shore?

The rocky shore hosts a large amount of marine biodiversity and is easier to access than other ocean habitats such as the open ocean or seafloor, which might require a boat or scuba gear to explore. The stress gradient and zones created by the rise and fall of the tides inspires easily testable questions, such as why does one organism live in one zone versus another? Is it due to competition? Or heat stress? Lets do an experiment to figure it out!

Did You Know?

Competition for space is very intense on rocky shores and this leads to seaweed and animals living right on top of each other. When one species of seaweed grows on another, it is called an epiphyte and when an animal grows on another animal, it is called an epibiont.



ROCKY SHORE

PRE-VISIT ACTIVITIES (continued)

Duration: 1 class period

Learning Objectives: Practice field sampling procedures

Materials: Quadrats or hula hoops, pompoms, various sizes and colors, yarn, various colors of pipe cleaners, Practice Quadrat Data Sheet

Practice Quadrats

In a large room with ample floor space or outdoors, scatter pom poms, felt, pipe cleaners etc. on the ground. Break students into groups and give each group a quadrat/hula hoop and a clipboard, pencil and the Practice Quadrats Data Sheet. Instruct students to survey the practice “beach” recording everything in their quadrat. Once students record everything, they can move the quadrat and do a second or third survey, if time allows.

Duration: 1 class period

Learning Objectives: Practice field sampling procedures

Materials: Thermometer, Cloud Types Chart, Beaufort Scale Chart, Practice Weather Observation Data Sheet

Weather Observation Practice

Teacher will lead a discussion on weather and how it impacts all the living things on our planet. When scientists collect data in nature, they need to consider how the weather might impact the natural world which they are studying. Teacher will introduce several tools that scientists use to study the weather and how they work. Teachers will lead students outside to use the tools to make and record observations about the weather on their Practice Weather Observation Data Sheet.

ROCKY SHORE FIELD EXPERIENCE

Students will visit the Northeastern University Marine Science Center for the rocky shore experience. Students will be divided into three groups and will rotate between three activities: (1) Historical Tour, (2) Classroom Discussion, and (3) Rocky Shore Survey.

Historical Tour

Students will be guided around the MSC property, while learning about the geology, scientific and military history, and local wildlife of the area.

Classroom Discussion

Students will be guided in hypothesizing water temperature, salinity, etc. of the low and high intertidal zones before students collect data.

Rocky Shore Survey

In small groups, students will conduct rocky shore survey and collect water quality data in the tidal pools at the rocky shore. Data and observations will be recorded on the Rocky Shore Data Sheets.

Duration:

2-3 hours; with travel time, could be half or full day field trip

Materials:

- Rocky Shore Data Sheets
- Species ID Guides
- Clip boards, one per group
- Hydrometer, one per group
- Thermometer, one per group
- 3 x 30 m tape measures
- Cloud/wind charts
- Pencils, one per group

Don’t Forget...

On your trip to the rocky shore, don’t forget to wear shoes with a good grip that can get wet and dirty. An extra layer is a must have, and for hot, sunny days don’t forget a hat, sunscreen, and a water bottle!

ROCKY SHORE

POST-VISIT ACTIVITIES AND ASSESSMENT

To help your students get the most out of a rocky shore field experience, conduct several or all of the activities detailed below, after your rocky shore visit. Students successful completion of these activities serves as assessment, as students must recall knowledge gained during prior activities and field study.

Duration: 1-2 class periods; could be assigned as homework

Learning Objectives: Become familiar with organisms by identification and illustration

Materials: Field guide template, Species ID Guides, any other print or digital resources

Construct Field Guides and Present to Class

In small groups, students will create field guide pages using a template for selected organisms observed at the rocky shore. Field guide pages will be presented, compiled, organized and bound as a whole group.

Duration: 10-20 minutes

Learning Objectives: Use prior knowledge to identify organisms

Materials: Pictures of rocky shore organisms (don't forget to remove names!)

Name That Organism

Ten images of rocky shore organisms will be displayed one at a time to the whole group. Students are given 3 minutes to individually use their field guide to identify and record the displayed organisms on a piece of paper, mini white board, or SMART Response transponders.

Duration: 1 class period

Learning Objectives: Recall prior knowledge to identify organisms and their classification

Materials: Touch Tank Visit Checklist

Classroom Touch Tank Visit

Prior to touch tank visit, students will review rocky shore vocabulary and field trip etiquette. MSC staff will bring specimens from the rocky shore. A classroom discussion will focus on classification of rocky shore organisms. Students will then use their self-constructed field guides to rotate around 4 stations of rocky shore organisms to identify them. Students will check off organisms on the Touch Tank Checklist as they identify them.

POST-VISIT ACTIVITIES AND ASSESSMENT (continued)

Duration: 1 class period

Learning Objectives: Use prior knowledge to predict which organisms eat each other on the rocky shore

Materials: Food Web Worksheet, Food Web Student Template, Food Web Teacher Key

Construct a Food Web

Students will use the knowledge they have gained from field experiences and classroom activities to construct a food web with yarn and pictures of animals on a poster or white/chalkboard, identifying animals at different trophic levels (consumers, producers etc.) As students work together to create the large class food web, they can fill their food web template worksheet.

Duration: 1 class period

Learning Objectives: Recall prior knowledge to illustrate and label organisms

Materials: Paper, colored pencils

Field Guide Cover Illustration

Students will pick four organisms (one from each of four different phyla/classes) present in touch tanks. Illustrate and label each for cover of field guide.

SALT MARSH

Learning Objectives

1. Use a field guide to identify and classify salt marsh organisms.
2. Create a profile of vegetation found at the salt marsh.
3. Give examples of organismal adaptations specific to the salt marsh.
4. Conduct a population study of the salt marsh.
5. Measure and document water quality at the salt marsh.
6. Document weather conditions and explain how weather impacts life in this habitat.

Vocabulary

- Salt marsh
- Estuary
- Brackish
- Sediment
- Vegetation
- Salinity
- Temperature
- Dissolved oxygen
- Refractometer

HABITAT DESCRIPTION

The salt marsh is type of wetland that is inundated with salt water at high tide. Even at low tide, it can retain pools (called pannes), channels, or rivulets of salty or brackish water. This salt-water inundation rone can see a lush diversity of vegetation. These specialized plants have adaptations to tolerate the salt water that fills their habitat at each high tide and thrive in the salty soil that is left behind.

Like the rocky shore, the salt marsh is organized into distinct zones, as a result of the stressful conditions created by the rise and fall of the tides. Unlike the rocky shore however, many of the organisms living in the salt marsh are terrestrial flowering plants (angiosperms), and therefore the physical stress gradient is reversed, with increasing physical stress at lower tidal elevations. Zonation of marsh plants is related to the salt tolerance of the plants as well as their competitive abilities. The tall, green grass in the low marsh, closest to the water's edge is known as salt-water cord grass. It has special adaptations that allow it to tolerate the salt water that covers it everyday at high tide. One of these adaptations is the ability to secrete salt from special glands in its leaves. Visit a marsh on a hot summer day and you might see salt crystals on the leaves of cord grass in the low marsh.

In the mid-marsh, another type of cord grass thrives, however this one is shorter and forms tufts reminiscent of cowlicks on a head of hair needing to be brushed. This mid-marsh cord grass is less salt tolerant than the salt-water cord grass, as it is submerged in salt water only once a month or so during the especially high spring tides. The mid-marsh is also home to an interesting succulent plant know as glasswort or pickle weed. This plant is able to store ample water in its tissues to deal with salty soil that might cause dehydration in other plants. Visit the marsh in the summer and this plant will be a beautiful light green, but in the fall, like deciduous tree, it turns a deep red as its light-gathering pigments change and it prepares for winter. The high marsh is the least stressful zone and is therefore home to more species than the low and mid-marsh. Species must compete to live in the high marsh, and one strategy is emerging early in the growing season.

Salt marshes are known for the many Ecosystem Services they provide to humans and other local species. The marshes tend to form behind barrier beaches in areas where rivers and streams flow out, causing the accumulation of soft sediments that are ideal for wetland plant growth. Marsh plants stabilize this sediment, playing an important role in protecting coastal development from erosion and other damage caused by storms. Marshes are important in coastal flood control, groundwater recharge, carbon sequestration and provide an essential nursery habitat for many species, including some that are commercially important. The nutrient-rich waters and grass flats of a salt marsh provide critical habitat for birds, fish, small mammals, a number of grass and shrub species, and a variety of invertebrates. Worms, snails, crustaceans, and insects are among the many types of animals that call the salt marsh home.

PRE-VISIT ACTIVITIES

To prepare your students for a salt marsh field experience, conduct several or all of the activities detailed below, before your salt marsh visit.

Duration: 1 class period

Learning Objectives: Build on prior knowledge to learn about the Salt Marsh

Materials: Salt Marsh Slide Presentation

Introduction to the Salt Marsh

As an introduction to the salt marsh, the teacher will ask students if they know of any other places that contain salt water aside from the ocean. The teacher will lead students into a discussion of the salt marsh with an image a local salt marsh, introduce students to vocabulary related to salt marsh, and site etiquette. Teacher will present salt marsh Slide Presentation.

Duration: 1 class period

Learning Objectives: Learn and practice field-sampling procedures

Materials: Hydrometer/ refractometer, thermometer, dissolved oxygen meter, turbidity tube, Practice Water Quality Data Sheet, pencils, soil saturation tubes, trowels/corers, colored water, soil color chart, water color chart

Introduction to Water Quality Testing

Teacher wil pre-collect salt water samples prior to class. Teacher will lead a discussion of water quality and how we can measure different properties of water. Teacher will challenge students to think about how water quality might impact a habitat and the organisms that live there. Students will be broken up into groups of four. Each group will be given a local water sample. With guidance from teacher, each group will test the temperature, salinity, turbidity and dissolved oxygen within their sample. Students will record results on the Practice Water Quality Data Sheet.

Why Study The Salt Marsh?

These habitats form natural barriers between the ocean and coastal development, preventing erosion and other damaging impacts of storms. Salt Marshes also provide other essential Ecosystem Services; they filter water and serve as a carbon sink as well as an important nursery habitat for many commercially valuable marine animals.

Did You Know?

Salt marsh grasses are angiosperms (flowering plants) with special adaptations to deal with the salt water that would kill most other flowering plants. One such adaptation is the ability to get rid of excess salt by secreting salt through special glands on the leaves. On a hot day you can see these excess salt crystals on the leaves of plants in the low marsh.

SALT MARSH

Duration:

2-3 hours; with travel time, could be half or full day field trip

Materials:

- Quadrats
- 3 x 5 gallon buckets, at least one on a rope for collecting from bridge
- Clip boards, one per group
- 3 x 30 m tape measures
- Elevation rod
- Cloud/wind charts
- Salt Marsh Data Sheets
- Salt Marsh Field Guide (NUMSC will provide)
- Hydrometer, one per group
- Thermometer, one per group
- Refractometer
- Dissolved oxygen meter
- Turbidity tube
- Pencils, one per group

SALT MARSH FIELD EXPERIENCE

Students will visit a local Salt Marsh. Students will be divided into 2 groups and will rotate between two activities: (1) Water Quality Testing, (2) Vegetation and Soil Profile

Water Quality Testing

Students will record weather data. Students will collect water at two sites and conduct tests of temperature, salinity, turbidity and dissolved oxygen. Data will be recorded on Salt Marsh Data Sheets.

Vegetation and Soil Profile

Students will collect vegetation data across a transect of the salt marsh every 5 meters. Students will measure the absorbance of the soil and record soil characteristics in three locations. Students will measure depth of marsh using elevation rod. Data will be collected on Salt Marsh Data Sheets.

Don’t Forget...

On your trip to the Salt Marsh, rain boots are the best footwear as the ground is wet and muddy. In the summer, bug spray is a must have and long pants will help avoid any scrapes from the marsh plants!

POST-VISIT ACTIVITIES AND ASSESSMENT

To help your students get the most out of a salt marsh field experience, conduct several or all of the activities detailed below, after your rocky shore visit. Students successful completion of these activities serves as assessment, as students must recall knowledge gained during prior activities and field study.

Duration: 1 class period

Learning Objectives: Use data collected and recall knowledge learned during salt marsh visit to illustrate the distribution of organisms in the salt marsh

Materials: Large format paper or poster board, vegetation profile data, colored pencils/ markers/crayons, field guides (or other materials for research)

Graph a Salt Marsh Profile

Students will graph the profile of the salt marsh guided by the teacher, using data collected during the salt marsh visit. Using field guides and colored pencils, students will draw and label the different types of vegetation along the profile they graphed. Students will research, using field guides, the adaptations of the vegetation they found in the marsh and discuss why the adaptations are necessary at specific locations along the marsh profile.

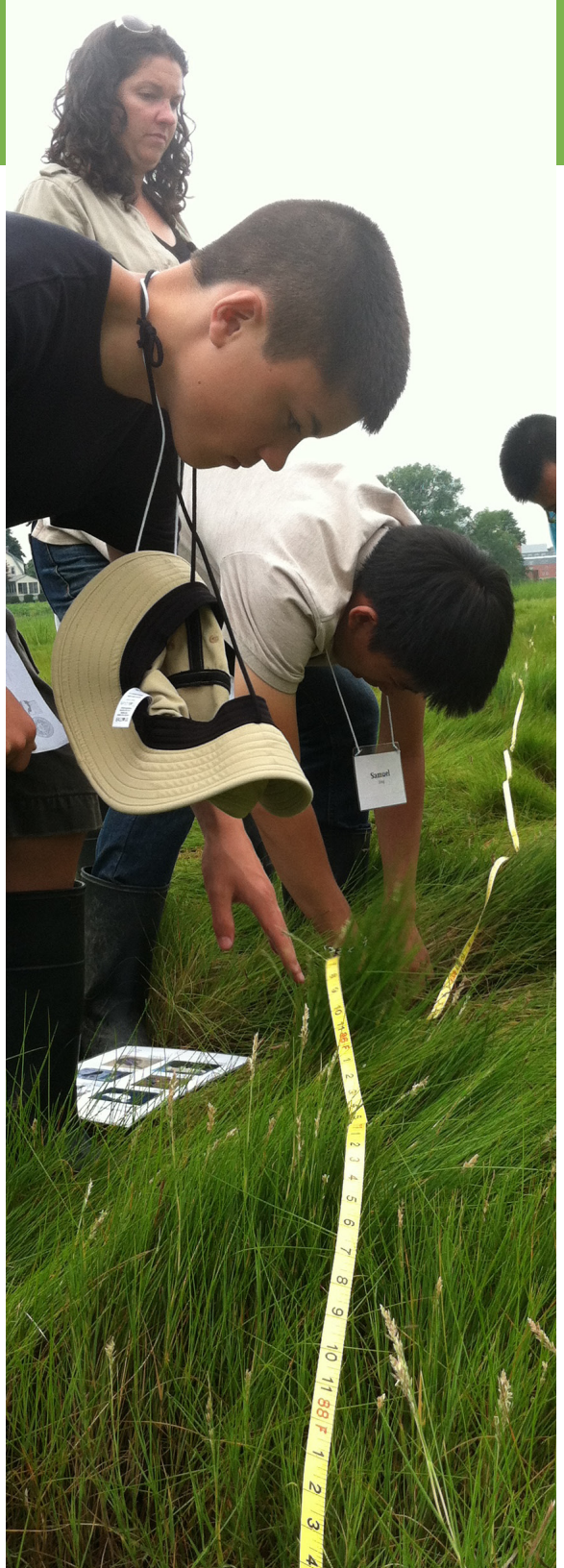
Duration: 1 class period

Learning Objectives: Use experimental data to compare the soil characteristics in different locations of the salt marsh and illustrate the results graphically.

Materials: Large format paper or poster board, water quality data, colored pencils/markers/ crayons

Soil Saturation Comparison

Students will create a bar graph to compare their measurements of soil saturation in the Low Marsh, the High Marsh, and the Forest. The graph will depict the change in water level in the Saturation Tubes from the beginning to the end of the experiment. Students will discuss their soil observations, which can also be displayed on the graph or in a list on the board or poster. How does the data differ between locations? Why?



SANDY BEACH

Learning Objectives

1. Use a field guide to identify and classify sandy beach organisms.
2. Give examples of organismal adaptations specific to the sandy beach.
3. Conduct a survey of life in the wrack line.
4. Conduct a survey of, and collect, marine debris in the wrack line.
5. Create a beach elevation profile.
6. Document weather conditions.

Vocabulary

- Wrack lines
- Tides
- Vegetation
- Sandy Beach
- Ecosystem
- Food web
- Elevation
- Marine debris

HABITAT DESCRIPTION

The sandy beach is an area where loose particles cover all or part of the shore, and are generally found in less exposed coastal areas. Beaches in New England are generally made up of heavily eroded shells of marine animals and rock (quartz, feldspar, basalt). The composition of the sand on a New England beach may vary depending on the sand's source, such as sediment expelled from a nearby river, or coastal erosion of rocks. Using a hand lens or microscope, you can see the many different types of rock that make up the sand, which appear as different colored grains scattered among the white quartz.

In addition to tides and currents, beaches are heavily influenced by wave action, and can change in shape and size drastically between seasons or even before/after a storm event. Wave action wears away the coast, creating more sand and changing the shape of the beach. At exposed sandy beaches with more intense wave action there will be more erosion and the slope of the beach will be steeper. Also, sand particles will be larger at more exposed beaches, because large waves are able to move larger particles up and down the beach, and smaller particles are swept away. More protected beaches will be more gradually sloped, and the grains of sand will be smaller. Similarly, winter storms of New England that create intense wave action can lead to steeper beaches in the winter and more gradually sloped beaches in the summer. On sandy beaches, the sand near the low tide line is more impacted by wave action since it is in the water for a longer amount of time compared to the high tide line. Therefore, sand particles at the low tide line will be smaller and more uniform that those at the high tide line.

Compared to other local coastal habitats, there are relatively few animals living on sandy beaches, at first glance. This apparent lack of life arises for two main reasons. First, the pressures of wave action in combination with the absence of structure/shelter such as rocks or vegetation create an inhospitable habitat. Second, there is an absence of abundant food within the sand. However, the wrack lines on a beach can support micro-communities of life. Wrack lines are the accumulations of organic debris such as seaweed that washes up at high tide lines. In these, crabs and other small crustaceans can be found feeding on the seaweed and other organic material. Unfortunately, these wrack lines are also usually filled with marine debris, or trash, that makes its way into the ocean via human activities.

Another reason that the sandy beach does not appear to be brimming with life is that many of the organisms live buried in the sand. These animals, know as infaunal organisms, include worms, clams, snails and other invertebrates, some so tiny they live between the grains of sand! Animals living atop the sand are less abundant, but include prehistoric looking horseshoe crabs as well as a variety of seabirds such as gulls, plovers and sandpipers. Along with the birds, raccoons and skunks occasionally venture down to the beach to make a meal out of all the life hiding in the sand. Sandy beaches can also provide a stopping ground for migrating marine mammals; lucky beachgoers might see a harbor seal taking a rest on the sand before venturing back out to the ocean on a long journey.

PRE-VISIT ACTIVITIES

To prepare your students for a salt marsh field experience, conduct several or all of the activities detailed below, before your sandy beach visit.

Duration: 1 class period

Learning Objectives: Build on prior knowledge to learn about the Sandy Beach

Materials: Sandy Beach Slide Presentation

Introduction to the Sandy Beach

As an introduction to the sandy beach, the teacher will ask students about their beach experiences. The discussion will then be led into sandy beach vocabulary. The teacher will present the Sandy Beach slide presentation, which can be found at www.northeastern.edu/marinescience.

Duration: 1 class period

Learning Objectives: Learn and practice field-sampling procedures

Materials: Elevation profiling rods, Sandy Beach Data Sheets, pencils

Elevation Profile Practice

Teacher will lead students into using elevation gear to measure the elevation of the schoolyard or other location close to the school. Students will collect data and create a profile on graph paper.

Why Study The Sandy Beach?

These habitats are unique in that they change shape throughout the year, due to transport of sand by wind, water and other weathering forces. Transport of sand on a beach changes the shape of coastlines through time, and these changes are important to consider when building homes and businesses along the coast. Due to their recreational value, sandy beaches see much more human activity. What evidence of human activity can you think of?

Did You Know?

While the sandy beach may not seem to support much life at first glance, there are actually many organisms living in the sand. These infaunal organisms include worms, clams, and even animals so tiny that they live in between the grains of sand!

SANDY BEACH

Duration:

2-3 hours; with travel time, could be half or full day field trip

Materials:

- Elevation profiling gear (4 or 5 sets)
- Surveyor flags
- Collection containers
- Quadrats
- Tape measures
- Cloud/wind charts
- Field guides
- Sandy Beach Data Sheets
- Clipboards
- Pencils
- Buckets
- Trowels
- Trash bags

SANDY BEACH FIELD EXPERIENCE

Students will be divided into 2 groups to complete 2 major activities: (1) wrack line study/beach cleanup and (2) beach profile.

Wrack Line Study And Beach Cleanup

In pairs, students will lay down quadrats in 5 locations, 10 paces apart, along the wrack line and collect data recording the animals and classifying animals by phylum/class. Additionally, students will record marine debris found in the quadrats and decide whether not it is recyclable. Students will record a tally mark for each animal or marine debris found in the quadrats so that they have a total for all 5 quadrats for later analysis. Data will be recorded on the Sandy Beach Field Trip data collection sheets. Each pair will have a trash bag to collect debris as they count.

Beach Elevation Profile And Sand Collection

In groups of 4-5, students will collect elevation data across a transect of the sandy beach every 3 meters and record elevation change on Sandy Beach Data Sheets. If possible, there should be one teacher/chaperone guiding each group. Each group will collect a sample of sand at both high and low tide for in-class sand sorting exercise. Teachers: Make sure to dry both samples back in the classroom prior to conducting any sand sorting.

Don’t Forget...

On your trip to the Sandy Beach, an extra layer is always a good idea. Check the weather before any outdoor trip to make sure you are extra prepared. For hot sunny days don’t forget a hat, sunscreen and water bottle!

POST-VISIT ACTIVITIES AND ASSESSMENT

To help your students get the most out of a sandy beach field experience, conduct several or all of the activities detailed below, after your rocky shore visit. Students successful completion of these activities serves as assessment, as students must recall knowledge gained during prior activities and field study.

Duration: 1-2 class periods

Learning Objectives: How does the movement of wind and water change the shape of the beach and sand particle size at various locations on the beach

Materials: Dried sand samples, sand sorting sieve with at least 3 different mesh sizes, scales, hand lens/microscopes, graph paper, pencils, Sandy Beach Data Sheets

Sand Sorting

Students will use sand sorters and scales to compare sand composition (particle size and organic vs. inorganic constituents) between a low and a high tide collection. They will weigh each sample, calculate percentages of each sample compared to the whole, and complete a pie chart depicting distribution of particle size between sites. Students will record their results on the Sady Beach Data Sheets.

Duration: 1 class period

Learning Objectives: Analyze and interpret beach elevation data in order to draw conclusions about the shape of the beach

Materials: Beach elevation data, graph paper, pencils

Graph a Beach Profile

Students will graph the profile of the sandy beach guided by the teacher. Students will discuss and then summarize their data, hypothesizing why the beach profile is different at different sites, and what causes these differences.

Appendices

- Data Sheets
  - Practice Quality Data Sheets
  - Practice Quadrat Data Sheet
  - Practice Weather Observation Data Sheet
  - Rocky Shore Data Sheets
  - Touch Tank Checklist
  - Salt Marsh Data Sheet
  - Sandy Beach Data Sheet
  - Food web worksheets and answer key
- Species identification guides
- Cloud types and Beaufort Scale

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PRACTICE QUADRATS DATA SHEET

Today's date _____

Team members _____

Algae species

Phylum/Class	Common name	% Cover
Green	Yarn	
	Pipecleaner	
	Felt	
Red	Yarn	
	Pipecleaner	
	Felt	
Brown	Yarn	
	Pipecleaner	
	Felt	

Animal species

Phylum/Class	Common name	Number
Pom-Poms	Red	
	Purple	
	Pink	
	Yellow	
	Blue	
	White	
	Other _____	
Snails	Gray	
	White	
	Yellow	
	Other _____	
Other	Other _____	
	Other _____	
	Other _____	

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PRACTICE WEATHER OBSERVATIONS DATA SHEET

Today's date: _____ **Time:** _____

Team members: _____

Location: _____

Weather (circle one)

Sunny Partly Cloudy Mostly Cloudy Overcast Rainy

Use the chart to identify the cloud types in the sky and write them here:

_____

Estimate the wind speed (circle one)

<5 mph 1-5 mph 6-10 mph 11-20 mph > 20 mph

Estimate the wind speed using the Beaufort scale (circle one)

0 1 2 3 4 5 6 7 8 9 10 11 12

Air temperature _____ °F *(sit thermometer in shade for at least 30 seconds)*

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ROCKY SHORE DATA SHEETS

Today's date _____ **Time** _____

Time of low tide _____ **Time of high tide**_____

Location _____

Team members _____

Weather (circle one) Sunny Partly Cloudy Mostly Cloudy Overcast Rainy

Cloud Types _____

Wind speed <5 mph 1-5 mph 6-10 mph 11-20 mph > 20 mph

Beaufort scale (circle one) 0 1 2 3 4 5 6 7 8 9 10 11 12

Air temp _____ °F *(sit thermometer in shade for at least 30 seconds)*

Tidepool physical characteristics

Parameter	Low tidepool	High tidepool
Water temperature	**°F**	**°F**
Salinity	**ppt**	**ppt**
Dissolved oxygen	**ppm**	**ppm**
pH		

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Algae species

Phylum/Class	Common name	Scientific name	% Cover in Low	% Cover in High
Brown algae	Kelp	Various species		
	Knotted wrack	*Ascophyllum nodosum*		
	Rockweed	*Fucus vesiculosus*		
	Other _____			
	Other _____			
	Other _____			
Red algae	Dulse	*Palmaria palmata*		
	False Irish moss	*Mastocarpus stellatus*		
	Irish moss	*Chondrus crispus*		
	Filamentous red algae	Various species		
	Coralline algae (branching or crusting)	Various species		
	Red stain algae	*Hildenbrandia rubra*		
	Other _____			
	Other _____			
	Other _____			
Green algae	Dead man's fingers	*Codium fragile*		
	Sea lettuce	*Ulva lactuca*		
	Filamentous green algae	Various species		
	Hollow green algae	*Ulva intestinalis*		
	Other _____			
	Other _____			
	Other _____			

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Animal species

Phylum/Class	Common name	Scientific name	# in Low	# in High
Mollusks	Smooth periwinkle	*Littorina obtusata*		
	Common periwinkle	*Littorina littorea*		
	Rough periwinkle	*Littorina saxatilis*		
	Atlantic dog whelk	*Nucella lapillus*		
	Common slipper shell	*Crepidula fornicata*		
	Blue mussel	*Mytilus edulis*		
	Atlantic plate limpet	*Tectura testudinalis*		
	Other _____			
Echinoderms	Sea star	*Asterias* (various species)		
	Blood star	*Henricia sanguienolenta*		
	Green sea urchin	*Strongylocentrotus drobachiensis*		
	Other _____			
Crustaceans	European rock shrimp	*Palaemon elegans*		
	Green crab	*Carcinus maenas*		
	Rock crab	*Cancer irroratus*		
	Jonah crab	*Cancer borealis*		
	Asian shore crab	*Hemigrapsus sanguineus*		
	Spider crab	*Libinia emarginata*		
	Long-clawed hermit crab	*Pagurus longicarpus*		
	Acorn barnacle	*Semibalanus balanoides*		
	American lobster	*Homarus americanus*		
	Amphipods, copepods, isopods	Various species		
	Other _____			
Other	Crusting bryozoans	*Membranipora* (various species)		
	Sheath tunicate (sea squirt)	*Botrylloides violaceus*		
	Springtails	*Anurida maritima*		
	Sponges	Various species		
	Stalked hydroid	*Dynamena pumila*		
	Anemone	Various species		
	Other _____			
	Other _____			

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TOUCHTANK CHECKLIST

Name: _____ **Date:** _____

Animal Species

Phylum/Class	Common name	Present?
Molluscs	Smooth periwinkle	
	Common periwinkle	
	Rough periwinkle	
	Dog whelk	
	Slipper shell	
	Mussel	
	Moon snail	
	Limpet	
	Other: _____	
Echinoderms	Sea star	
	Green sea urchin	
	Blood star	
	Othe_____	
Crustaceans	Green crab	
	Rock crab	
	Jonah crab	
	Asian shore crab	
	Hermit crab	
	Lobster	
	Barnacle	
	Spider crab	
	Shrimp	
	Other: _____	
Other	Bryozoan	
	Sea squirt	
	Sponge	
	Anemone	
	Hydroid	
	Other: _____	

Algae Species

Phylum	Common name	Present?
Brown algae	Kelp	
	Knotted wrack	
	Rockweed	
	Other: _____	
	Other: _____	
Red algae	Irish moss	
	Filamentous red algae	
	Coralline algae	
	Dulse	
	Red stain algae	
	Other: _____	
	Other: _____	
Green algae	Dead man's fingers	
	Sea lettuce	
	Filamentous green algae	
	Gut weed	
	Other: _____	
	Other: _____	

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PRACTICE WATER QUALITY DATA SHEET

Today's date: _____ **Time**: _____

Team members: _____

Location(s) where water was collected:

Sample 1 _____

Sample 2 _____

Parameter	Instrument	Units	Sample 1	Sample 2
Water temperature	Thermometer	°F or °C (circle one)		
Salinity	Refractometer Hydrometer	ppt (g/kg) ppt (g/kg)		
Dissolved oxygen	Digital meter	ppm (mg/L)		
Tubidity	Turbidity tube	Level of water, color	Level:_____cm Color:_____	Level: _____cm Color:_____

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SALT MARSH SURVEY

Name _____ **Today's date**_____

Time of low tide _____ **Time of high tide** _____

Location _____

Weather (circle one) Sunny Partly Cloudy Mostly Cloudy Overcast Rainy

Cloud Types _____

Measure Wind speed (anemometer) _____ Miles Per Hour (MPH)

Estimate Wind Speed
Beaufort scale (circle one) 0 1 2 3 4 5 6 7 8 9 10 11 12

Air temperature in the shade _____ **°F** _____ **°C**

SALT MARSH PROFILE

Site #	Distance along transect (m)	Height of tallest vegetation (m)	Vegetation (check what you found)				Signs of animals within quadrat	Other observations within quadrat
			Commmon Reed *Phragmites*	Salt Marsh Grass *Spartina alterniflora*	Salt Meadow Hay *S. patens*	Glasswort *Salicornia.*		
1	0 m							
2	5 m							
3	10 m							
4	15 m							
5	20 m							
6	25 m							

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WATER AND SOIL CHARACTERISTICS

Today's date: _____ **Time:** _____
Team members: _____

Location where water was collected:
Sample 1 _____
Sample 2 _____

Parameter	Instrument	Units	Sample 1	Sample 2
Water temperature	Thermometer	°F or °C		
Salinity	Refractometer Hydrometer	ppt (g/kg) ppt (g/kg)		
Dissolved oxygen	Digital meter	ppm (mg/L)		
Tubidity	Turbidity tube	Level of water, color	Level: Color:	Level: Color:

SOIL CHARACTERISTICS

Soil Absorbance

	Forest	High Marsh	Low Marsh
Starting water level (mL)			
Ending water level (mL)			

Soil Observations

	Forest	High Marsh	Low Marsh
Number of Soil Layers			
Color(s)			
Smell			
Texture (rocky, sandy, muddy)			
Living organisms			
Other observations			

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SANDY BEACH DATA SHEETS

Today's date _____ **Time** _____

Time of low tide _____ **Time of high tide** _____

Location _____

Team members _____

Weather (circle one) Sunny Partly Cloudy Mostly Cloudy Overcast Rainy

Cloud Types _____

Wind speed <5 mph 1-5 mph 6-10 mph 11-20 mph > 20 mph

Beaufort scale (circle one) 0 1 2 3 4 5 6 7 8 9 10 11 12

Air temp _____ °F *(sit thermometer in shade for at least 30 seconds)*

Animals around the wrack line

Phylum/Class	Common name	# found
Molluscs	Clam	
	Moon snail	
	Periwinkle	
	Whelk	
	Slipper shell	
Echinoderms	Green sea urchin	
Other	Skate egg case	
	Other _____	

Phylum/Class	Common name	# found
Crustaceans	Green crab	
	Rock crab	
	Asian shore crab	
	Lobster	
Seabirds	Cormorant	
	Seagull	
	Plover	
	Sandpiper	

Marine debris

Item	How many pieces did you find?	Is it trash?	Is it recyclable?
Plastic bag			
Paper bag			
Plastic bottle			
Glass bottle			
Can			
Napkin/plate/cup			
Food wrapper			
Fishing gear			
Cigarette			

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Beach elevation profile

	Horizontal Distance (m)	*Change in Elevation (cm)*	*Cumulative Change in Elevation*
Site 1	*0*		
Site 2	*3*		
Site 3	*6*		
Site 4	*9*		
Site 5	*12*		
Site 6	*15*		
Site 7	*18*		
Site 8	*21*		
Site 9	*24*		
Site 10	*27*		
Site 11	*30*		
Site 12	*33*		
Site 13	*36*		
Site 14	*39*		
Site 15	*42*		
Site 16	*45*		
Site 17	*48*		
Site 18	*51*		
Site 19	*54*		
Site 20	*57*		
Site 21	*60*		
Site 22	*63*		
Site 23	*66*		
Site 24	*69*		
Site 25	*72*		

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FOOD WEB WORKSHEET

Name: _____ **Date:** _____

Use the list of organisms below and the template to identify who eats whom on and near the rocky shore.

- Using the template provided, work together with your classmates and use resources like textbooks or the Internet to determine who eats whom and whether each organism is a primary producer, primary consumer, secondary consumer or tertiary consumer. Write the organisms name or draw that organism at the correct level on the food web template.
- Next draw arrows up the food web from the organism that gets eaten, to the organism that eats it. Example: common periwinkle→green crab, because the crab eats the snail.
- Remember that since this is a food web, not a linear food chain, organisms can eat multiple things and get eaten by multiple things, allowing for many connections.

Rocky and Nearshore Organisms

Common periwinkle	Smooth periwinkle	Rock crab
Asian shore crab	Sea urchin	Blue mussel
Sea gull	Phytoplankton	Dog whelk
Barnacle	Seaweed	Zooplankton
Atlantic salmon	Sea star	Harbor seal

Once you have created your food web, answer the following questions:

1. Why do the arrows point from something that gets eaten to something that eats it? What does the predator/herbivore get from its prey?

2. Why is the food web shaped like a pyramid? Why are bottom levels (primary producers and primary consumers) larger than the higher levels (secondary consumers and tertiary consumers)?

3. Decomposers complete the food web by breaking down organic material (such as dead plants and animals) and convert it into nutrients, which are used by primary producers. Go back to your food web and draw arrows from food web levels (such as primary producers, secondary consumers) to the decomposers that show which levels provide organic material for decomposers to break down. (Hint: you should draw more than just one arrow)

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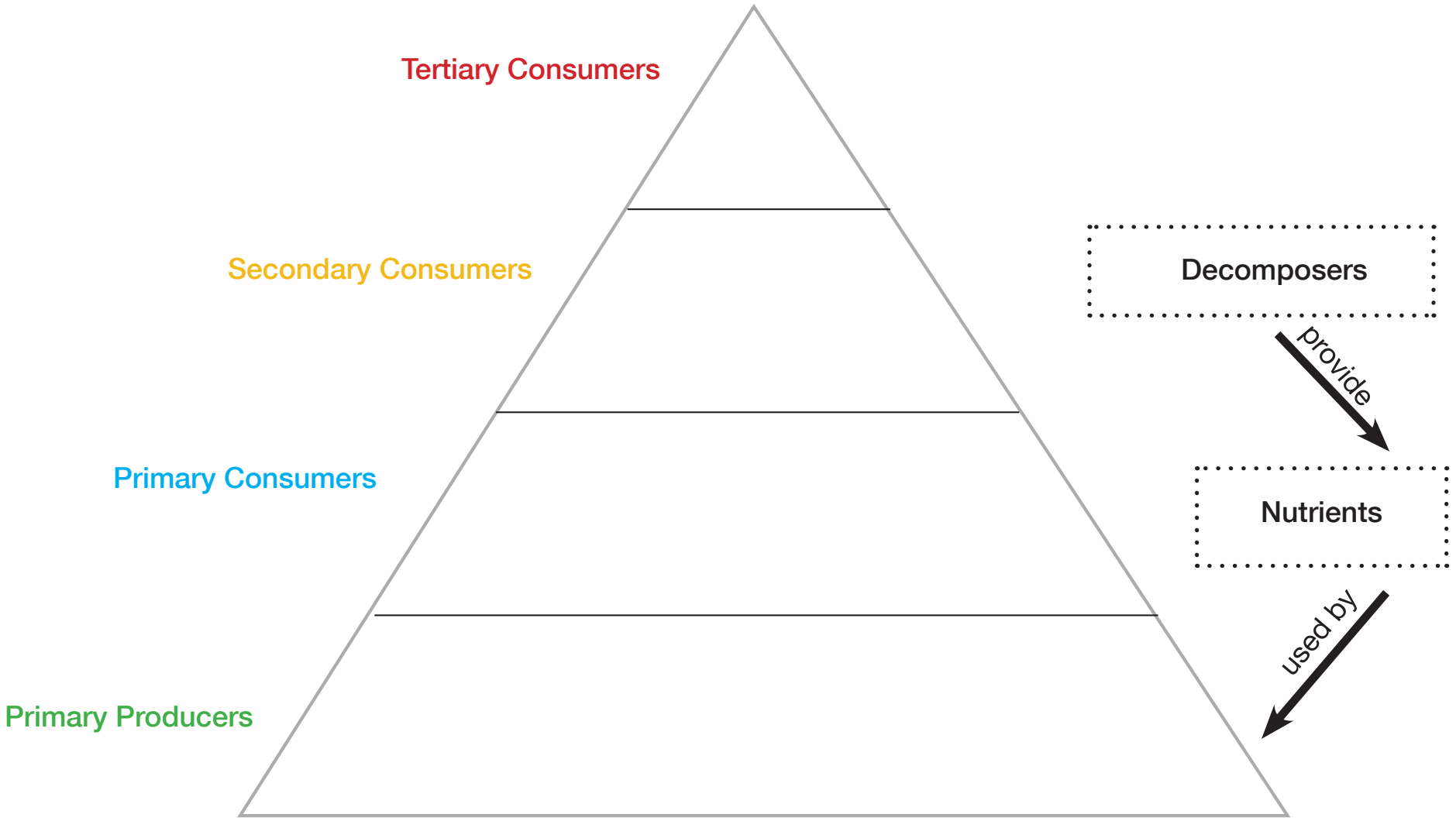
Student Worksheet Name: _____ Date: _____

CREATE A ROCKY SHORE FOOD WEB



Rocky Shore Food Web
Teacher Answer Key

Tertiary Consumers
Primary Consumers
Secondary Consumers
Primary Producers


Sea Gull


Sea Star


Rock Crab

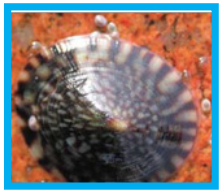

Green Crab


Nudibranch


Dog Whelk


Smooth Periwinkle


Barnacle

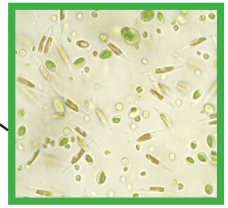

Limpet


Sea Urchin


Sea Anemone


Blue Mussel


Zooplankton


Phytoplankton


Seaweed

A Guide to the Rocky Intertidal: Crustaceans

Asian Shore Crab
hemigrapsus sanguineous

Green Crab
Carcinus maenas

Long Clawed Hermit Crab
Papurus longicarpus

Jonah Crab
Cancer borealis

Acorn Barnacle
Semibalanus balanoides

Rock Crab
Cancer irroratus

American Lobster
Homarus americanus

Spider Crab
Libinia emarginata

European Rock Shrimp
Palaemon elegans

Various Amphipods
Copepods, & Isopods

Crustaceans

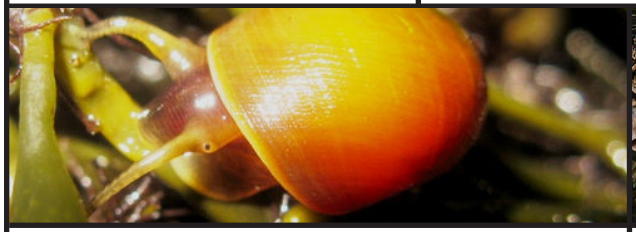
A Guide to the Rocky Intertidal: Mollusks

Rough Periwinkle
Littorina sazatilis

Common Periwinkle
Littorina littorea

Blue Mussel
Mytilus edulis

Lady Slipper Snail
Crepidula fornicata



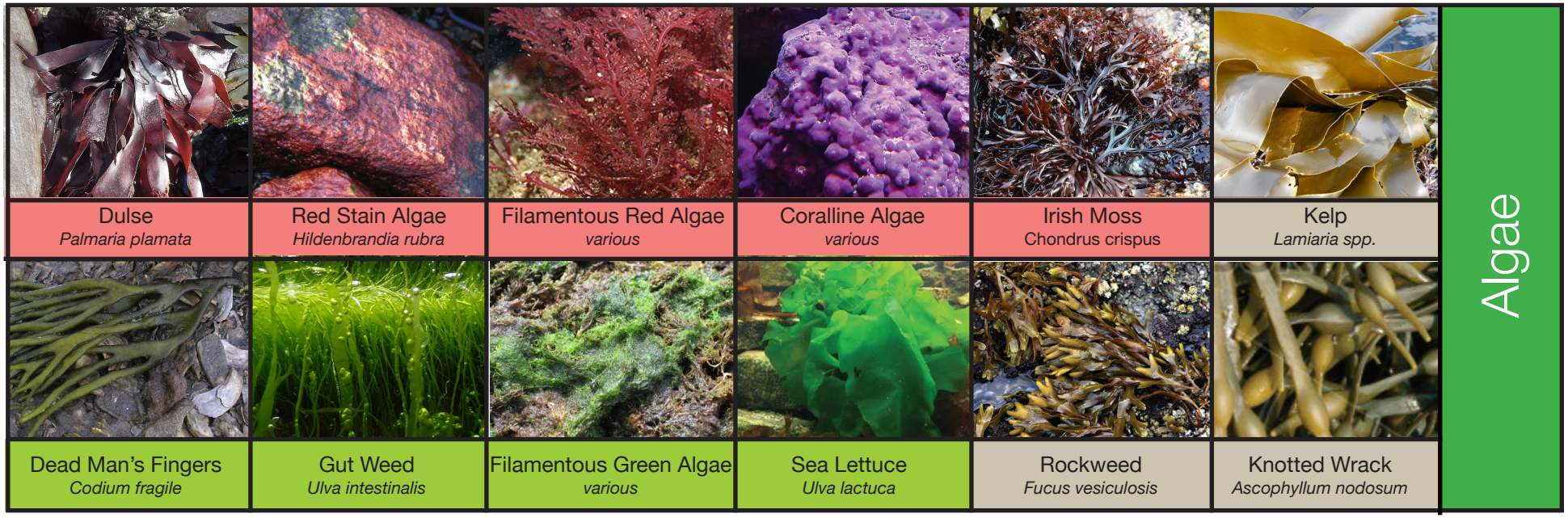
Smooth Periwinkle
Littorina sbtusata

Atlantic Dog Whelk
Nucella lapillus

Atlantic Plate Limpet
Tectra testudinalis

Mollusks

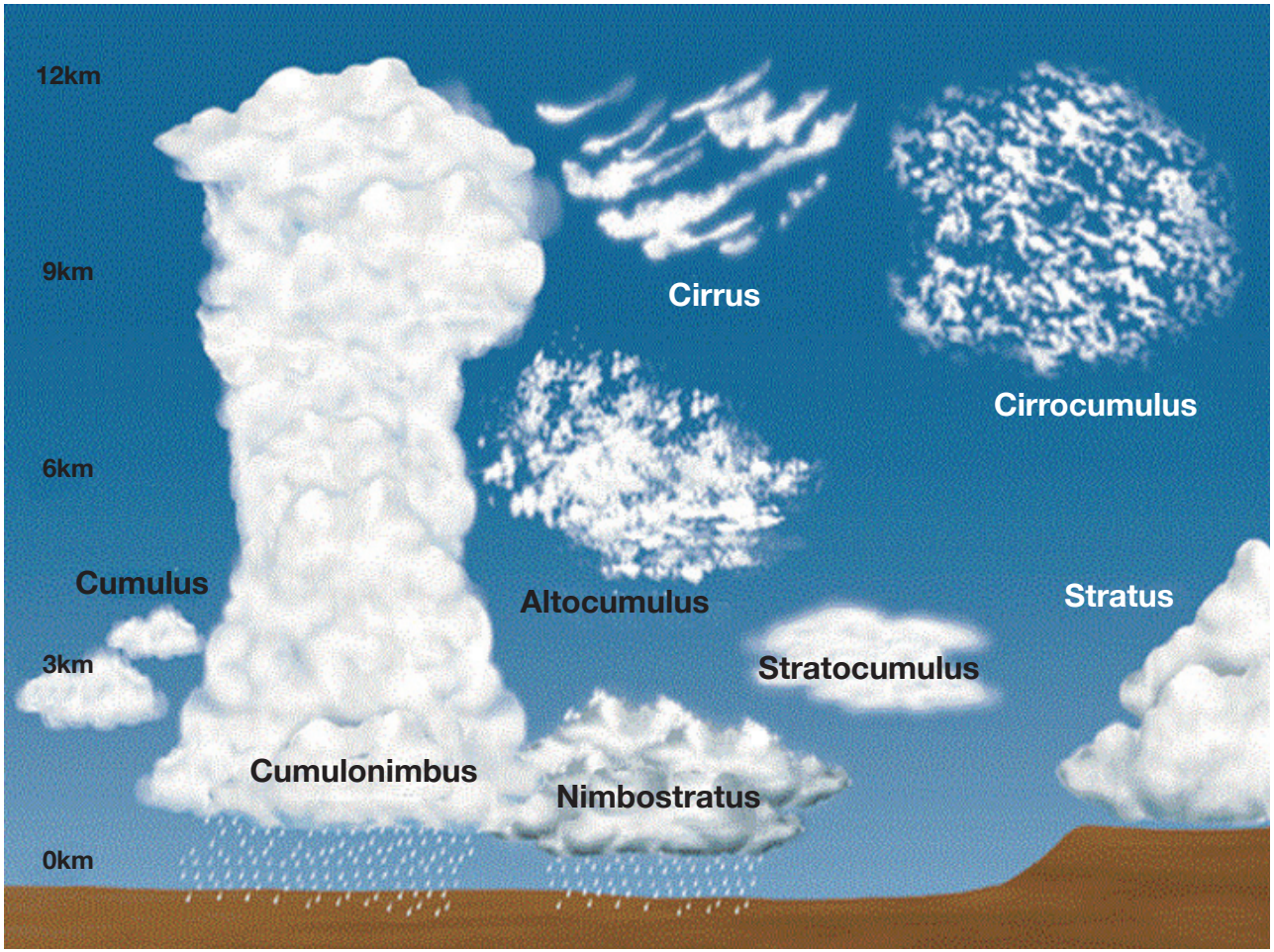
A Guide to the Rocky Intertidal: Algae



A Guide to the Rocky Intertidal: Echinoderms & Other species

Cloud Types

Cirra-means ‘high-level’
Cirrostratus clouds are more like a thin veil high in the sky
Cirrocumulus clouds are layered with little lumps
Cirrus clouds are thin and wispy and made of ice crystals
Alto-means ‘mid-level’
Altostratus clouds are flat and may thicken and lower into rain or snow
Altocumulus clouds are heaped up and may form rows
Stratus clouds are flat and make a low grey layer of clouds make light rain
Stratocumus clouds form a layer of cloud lums with thick and thin areas
Nimbus-mean ‘rain or snow’
Cumulonimbus clouds produce large storms



BEAUFORT SCALE

Beufort Scale	Description	feels like/looks like:
0	Calm, wind less than 1 mph, water is flat.	Calm, smoke rises straight up
1	Light air; wind 1-3 mph, water has ripples without crests.	Smoke drifts in direction of wind
2	Light breeze; wind 4-7 mph, water has small wavelets, glassy crests, not breaking	Wind felt on skin, leaves rustle.
3	Gentle breeze; wind 8-12 mph, water has large wavelets, scattered whitecaps and crests begin to break	Leaves small twigs constantly moving, flags fluttering.
4	Moderate breeze; wind 13-17 mph, water has small waves with breaking crests, whitecaps.	Dust blowing, small branches moving.
5	Fresh breeze; wind 18-24 mph, water has moderate waves, many whitecaps, a little spray.	Medium sized branches move small trees start to sway
6	Strong breeze; wind 25-30 mph, water has many white foam crests, some airborne spray.	Large branches move, wires whistle, umbrellas are hard to use.
7	High wind; wind 31-38 mph, water heaps up, foam from breaking waves blown in streaks along wind direction, moderate airborne spray.	Whole trees moving, hard to walk against the wind..
8	Gale, wind 39-46 mph, Moderately high waves, well marked streaks foam in wind direction, considerable airborne spray	Twigs breaking off of trees, cars swerving from wind, can’t walk against the wind.
9	Strong gale; wind 47-54 mph, water has high waves whose crests sometimes roll, dense foam, spray may reduce visability	Some branches break off trees, small trees blown over, traffic cones blow over.
10	Storm; wind 55-63 mph, water has very high waves, large patches of foam make sea look white, spray reduces visability	Trees are broken or uprooted, shingles on roofs peel off and blow away.
11	Violent storm; wind 64-72 mph, water has exceptionally high waves, very large patches of foam cover most of sea surface, poor visability from spray.	Lots of damage to plants, many roofs damages.
12	Hurricane; wind greater than 73 mph, high waves, sea completely white, air filled with spray.	Lots of damage to plants, windows break, flying debris.

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