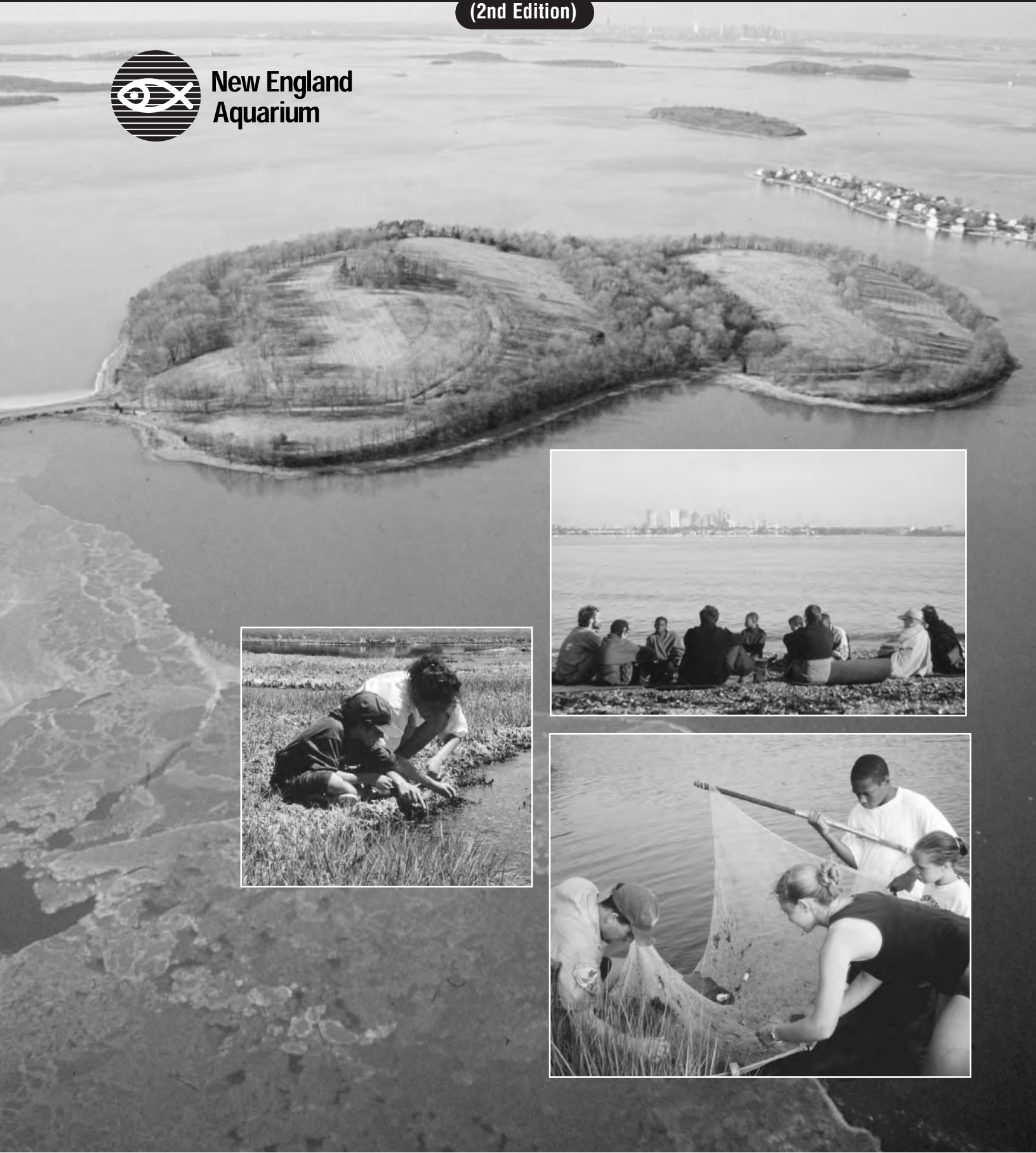


# ***BOSTON HARBOR*** **SEASIDE EDUCATOR'S GUIDE**

(2nd Edition)



**New England  
Aquarium**



## SECRETS FOR SEASIDE SUCCESS

1. **THINK ABOUT THE BIG PICTURE:** What are your objectives? How can you integrate your field trip into a larger inquiry? What frameworks and standards are you addressing?
2. **CHOOSE AND SURVEY A SITE:** Choose a habitat to match your learning objectives. Select a specific site. Consult a tide chart. Contact the site. Survey the site yourself. Determine travel logistics.
3. **SELECT ACTIVITIES AND EQUIPMENT:** Plan classroom and site visit activities. When selecting gear, “less is more.” Bring the basics: small buckets, hand lenses and field guides. Supplement with items chosen for specific activities.
4. **PLAN FOR GROUP SAFETY AND SITE STEWARDSHIP:** Have a group management and safety plan. Consider low-impact exploration policies.
5. **PREPARE STUDENTS AND CHAPERONES:** Incorporate pre-visit activities and skills into your curriculum. Create an itinerary for the day of the site visit.
6. **ORIENT THE GROUP TO THE SITE WHEN YOU ARRIVE:** Provide a habitat overview. Review safety, site stewardship and animal handling procedures. Set boundaries.
7. **IMPLEMENT IN-THE-FIELD TEACHING STRATEGIES:** Explore in small groups. Regroup and focus with stations or worksheets. Pay attention to group energy and needs.
8. **MODEL INQUIRY:** Share your excitement and curiosity, it's contagious! Foster close observation skills. Ask lots of questions. Be willing to admit that you don't know all the answers.



Photo / L. Fredrickson

Students explore our rocky coast.

9. **EXPECT THE UNEXPECTED:** Have a bag of tricks to fill time or deal with contingencies.
10. **CONCLUDE WITH A WRAP UP:** Allow time for closure and/or follow up. Inventory equipment, count heads and survey the site for gear and trash before you leave. Thank participants for their help!

Let the New England Aquarium Teacher Resource Center (TRC) help plan your trip!

Seaside study resources available: Aquakit (field equipment and guides), K-12 curricula, classroom kits, videos, artifacts, posters, in-the-field workshops and more. All available for loan or minimal fee.

Individual consultation by appointment also available.

Contact Joel Rubin, TRC Coordinator (617) 973-6590; e-mail: <jrubin@neaq.org>.

# ***BOSTON HARBOR*** **SEASIDE EDUCATOR'S GUIDE** (2nd Edition)



**New England  
Aquarium**

**This guide is based on a New England Aquarium  
“Bring It and Wing It” Workshop  
developed by  
Sukey Padawer  
and  
Lisa Fredrickson**

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## ACKNOWLEDGEMENTS

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**New England  
Aquarium**



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## TABLE OF CONTENTS

<i>Foreword</i> .....	4
<i>Introduction to the Boston Harbor Region</i> .....	5
Planning a Field Trip: Secrets for Seaside Success .....	10
1. Think About the Big Picture .....	10
2. Choose and Survey a Site .....	11
3. Select Activities and Equipment .....	16
4. Plan for Group Safety and Site Stewardship .....	16
5. Prepare Students and Chaperones .....	19
6. Orient the Group to the Site .....	20
7. Implement In-the-Field Strategies .....	20
8. Model Inquiry .....	22
9. Expect the Unexpected .....	22
10. Conclude With a Wrap-up .....	22
 <i>APPENDIX A: Activities</i> .....	 25
 <i>APPENDIX B: Habitat Primers</i> .....	 49
 <i>APPENDIX C: Site Guide</i> .....	 69
 <i>APPENDIX D: Resources</i> .....	 75

## THE BOSTON HARBOR SEASIDE EDUCATOR'S GUIDE

### ***Foreword***

*The Boston Harbor Seaside Educator's Guide* is an introduction to coastal field trips that offers a variety of creative ways to help students establish a connection to nature. From a graceful sweep of sand to the drama of surf crashing against time-worn boulders, New England's coasts are filled with uniquely-adapted animals and fascinating natural processes that spark our innate curiosity. These habitats can all be found throughout Boston Harbor. Through this guide, the New England Aquarium Education Department shares its collective years of experience in leading coastal field trips, summer camps and after-school programs.

By providing essential practical details, as well as a framework for how to use these resources as powerful learning experiences, *The Boston Harbor Seaside Educator's Guide* is designed to increase effective access to Boston's coastal resources. While this guide is for teachers, it can also be used by after-school program leaders, summer camp staff and community groups. Through this project, we hope that more of Boston's citizens will see the Harbor as a community resource that is accessible, valuable and important to preserve.

### ***Coastal Access***

Coastal access means simply the ways in which people reach the shoreline—physically, visually and, to some extent, psychologically. People gain access to coastal areas for many reasons: swimming, kite-flying, walking, horseback riding, picnicking, fishing, boat launching or class field trips.

Public coastal access is an issue in Massachusetts in particular because about three-quarters of the coastline is privately owned, including much of the intertidal zone. Some landowners tolerate informal public use of their coastal areas but, increasingly, many do not. Legally, access to the shoreline is only through publicly-owned pathways or lands. Once there, you can generally access publicly-owned parks, beaches, and other areas as well as “fish, fowl, or navigate” (our colonial-era public rights) on privately-owned intertidal land. But the rest of the coastline —hundreds and hundreds of miles — is legally off-limits for activities such as swimming or walking.

Despite this, there is still a wide variety of great rocky shores, sandy shores, tidal mudflats and salt marshes that are accessible and worth exploring in the Boston Harbor area.

The following are examples of recent developments in Boston Harbor that enhance coastal access:

- The National Park Service was assigned the task of designing a management plan to conserve Boston Harbor Islands and expand their public use. In 1996, Congress designated the Boston Harbor Islands, including the already established Boston Harbor Islands State Park, as a National Park Recreational Area, and in the coming years will host more recreational and educational facilities.
- The Metropolitan District Commission is transforming the area along the lower Neponset River estuary into a river side park, scheduled to be complete in Fall 2000. The park will include trails, a bike path and restored salt marsh areas.
- The Boston Harbor Association has been working with the city and state to create a 43-mile continuous walkway along Boston's waterfront known as the Harbor Walk, which will include public parks, seating areas, boat ramps and other amenities. New segments of the Harbor Walk are added each year.
- A multi-agency “Back to the Beaches” initiative is restoring natural elements and upgrading public facilities on beaches from Winthrop to Quincy, including some of the harbor islands.

A directory to some of our favorite public access sites to explore in Boston Harbor appears in ***Appendix C: Site Guide***.

## INTRODUCTION TO THE BOSTON HARBOR REGION

### Geologic History

What is currently known as Boston Harbor was formed millions of years ago as part of a geological feature created by a shift in the earth's crust. A large section of land sank, forming a lowland plain surrounded by a fault line now known as the Boston Basin. Today, Boston Harbor is part of Massachusetts Bay, an 800 square mile body of water that extends from Gloucester to the north, Marshfield to the south and Provincetown to the east. Boston Harbor itself is made up of three smaller bays, Dorchester Bay, Quincy Bay and Hingham Bay, containing 50 square miles of water and 1,200 square miles of land.

### Filling Boston Harbor

When European settlers came to Boston during the 17th century, Boston was only a small peninsula connected to the mainland by a thin causeway less than a quarter of a mile wide. During this time in history, Boston, South Boston and Charlestown were often separated from the mainland when the causeway was flooded by the high tide.

Over time, more space was needed for Boston's growing population. Starting in the early 1800s, tidal marshes were filled by leveling the many hills that made up the peninsula. Over the next hundred years, Boston Harbor was filled, built upon, dredged and channeled to accommodate a burgeoning shipping trade. By the end of the nineteenth century, Boston had become a major gateway to a vast continent with rich natural resources.

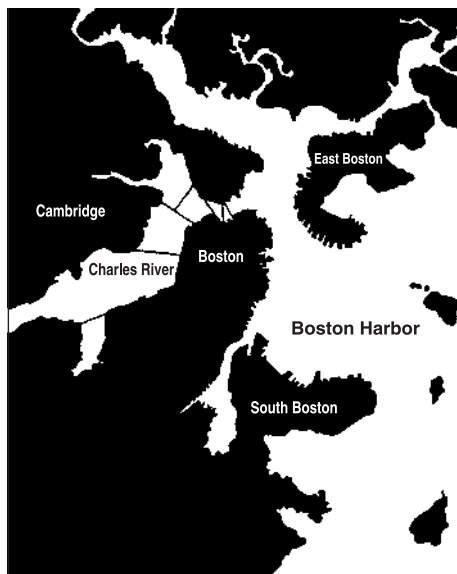
Where swaying marsh grasses, expansive tidal flats and sloping beaches once wove land into sea, people built concrete edges, stone piers and towering buildings. As a 1932 U.S. Geological Survey report noted, "Possibly nowhere else in the United States has the original extent and outline of a tidal harbor been so greatly modified artificially, chiefly through the filling of tidal flats."

### *Boston's Water Timeline*

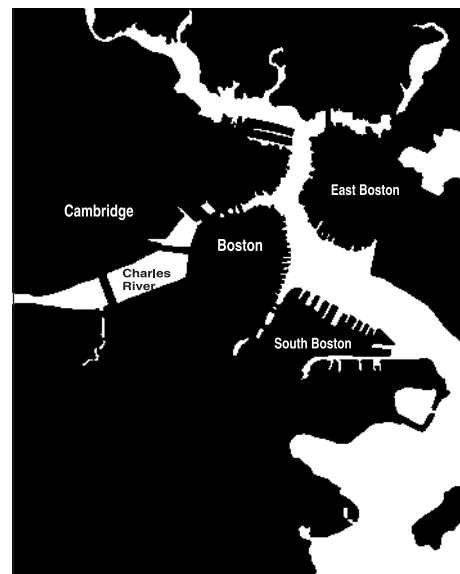
**1630**



**1870**



**1970**



## HISTORY OF THE BOSTON HARBOR ISLANDS

The islands in Boston Harbor are actually a submerged cluster of drumlins; smooth oval hills of sand and gravel left by moving glaciers. These drumlins were formed when glaciers covered New England during two distinct periods in the Pleistocene Era (1.6 million to 10,000 years ago). The lower parts of the drumlins were deposited during the Illinoian stage (350,000 – 170,000 years ago), and the upper portions were deposited during the Wisconsinan stage (75,000 – 10,000 years ago). Geologically, the Boston Harbor Islands are unique as part of the only drumlin field in the U.S. that intersects a coastline.

Boston Harbor's shoreline stabilized roughly three thousand years ago, establishing a rich estuarine zone with tidal mud flats. The harbor was filled with clam and mussel beds, as well as with cod, flounder, bass and seals. The islands were home to all kinds of waterfowl, including cormorants, ducks, loons, auks and some songbirds. Deer and some small mammals made the islands their homes as well.

Today, there are 30 islands in the harbor, ranging in size from less than an acre to 214 acres, all home to many species of plants and animals, both aquatic and terrestrial. The islands preserve unique areas, such as salt marshes, which have all but vanished in most urban areas. Some islands still provide valuable haul-out space for harbor seals to rest. Many of the islands are colonized by gulls, cormorants and shorebirds.

The Boston Harbor Islands show evidence of human settlement long before Europeans visited these shores. In the 1960s, a resident of one island uncovered a 4,100-year-old human skeleton, the oldest found in New England.

Archeologists have determined that people lived on or otherwise made use of the Boston Harbor Islands at least 8,000 years ago. Nearly all of the harbor islands have served some significant cultural purpose, including harbor protection, coastal defense, agriculture, commercial fishing, recreation, industry or social welfare.

Throughout recent history, the islands were used to house many different facilities. At various times they contained prisons; schools for juvenile delinquents; quarantine centers for victims of infectious diseases; hospitals for sailors, unwed mothers, alcoholics and paraplegic children; poorhouses; warehouses and waste treatment facilities.

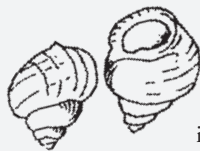
That the islands might be managed for recreational use wasn't truly articulated until the 1880s, when Frederick Law Olmsted suggested the islands should be preserved and protected. Olmsted envisioned an "emerald tiara" in the islands to complement the "emerald necklace," or string of green spaces, that he planned in Boston. Olmsted felt that urban parks and recreation areas were especially valuable to working families who could not afford the luxury of escaping the city.

In 1970 the Commonwealth of Massachusetts passed an act authorizing acquisition of the islands by the state. In 1996, Congress recognized the valuable recreational, cultural and natural resources of the islands by designating them as a National Parks Area. Managed cooperatively by federal, state and local agencies, the islands will continue to be preserved and enjoyed for generations to come.

See **Appendix D: Resources** for a listing of books, organizations and websites with more information about the Boston Harbor Islands. Be sure to check the *Boston Harbor Curriculum Guide: Bringing Boston Harbor into the Classroom*, published by the Boston Harbor Association, and *Boston Harbor Islands: A National Park Area*, published by Down East Books.

### *Did You Know?*

The common rough periwinkle (*Littorina littorea*) and the green crab (*Carcinus maenas*) are not native to Boston Harbor or New England. They are both species that were introduced to this area through human activities. They probably came from Europe in the ballast water of cargo ships in the late eighteenth to mid-nineteenth centuries. Both of these animals have dramatically changed many habitats along



the New England coast by preying upon animals and eating native plants. Invader species continue to change New England coastal ecology. Recent invaders that are now becoming dominant species in our shorelines include sea lace (a bryozoan that encrusts kelp) (*Membranipora membranacea*), codium or "dead man's fingers" seaweed (*Codium fragile tomentosoides*) and golden star tunicates (*Botryllus schlosseri*).



## BOSTON HARBOR WATER QUALITY

Water quality in Boston Harbor is better than it has been in decades. Today, the harbor is home to many healthy species of marine fish, birds and marine mammals, including harbor porpoises and seals. People are also coming back to Boston Harbor beaches for recreation. But the harbor has not always been so inviting.

In the mid-1800s, cholera epidemics were blamed on Boston's sewage problems. Underground sewers and wastewater drains were finished in 1884 and the Metropolitan District Commission (MDC) was established in 1919 to oversee water and sewer operations. The MDC finished state-of-the-art primary sewage treatment facilities in 1968, but without adequate funding, the facilities fell into neglect. By the early 1980s, barely-treated sewage was being directly discharged into the Boston Harbor, resulting in its reputation as the dirtiest harbor in the country. While the residents of Boston were not paying attention, Boston Harbor changed from being the nation's gateway to becoming the poster child of what can result from mismanagement of resources.

Going into the harbor on a daily basis were tons of sludge (solid material that settles out of sewage), barely-treated effluent (wastewater) and scum (oils, plastics and other floating materials). The sludge accumulated on the harbor floor, making it uninhabitable for marine life, and the scum washed up onto the beaches and islands. Another problem for Boston was the combined sewer overflows, or CSOs. During heavy rains, the same pipes that drain sewage from homes and businesses also drain stormwaters. To prevent flooding, CSOs release excess flow into the nearest harbor or river. This means that raw sewage is discharged directly into waterways, raising harmful bacterial levels.

In 1982, William Golden, a solicitor for the town of Quincy, noticed that on his morning run along Wollaston Beach, he was literally up to his sneakers in human excrement. Together with the Conservation Law Foundation, he sued the MDC, the Environmental Protection Agency and other defendants for violating the 1972 Clean Water Act. In 1985, Boston was ordered to improve its sewage treatment and the Massachusetts Water Resources Authority (MWRA) was created to take over management of water and sewer services for 43 communities. Driven by court-mandated schedules, the MWRA launched the Boston Harbor project, an 11-year, \$3.6 billion endeavor.

Key accomplishments of the Boston Harbor Project include:

- Demolishing the old Deer Island sewage treatment facility and building a new primary treatment plant that now removes 85% of pollution, as mandated by the Clean Water Act.
- Building a 5-mile tunnel between Nut and Deer Islands, ending more than 100 years of wastewater discharges into the shallow waters of Quincy Bay.
- Building a 9.5 mile tunnel bored through solid rock 450 feet below the ocean floor with 55 separate diffusers that release secondary treatment of wastewater at various points at depths up to 120 feet.
- Processing sludge from primary treatment in the 12 new egg-shaped sludge digesters on Deer Island. Instead of releasing the digested sludge into the harbor, the sludge is transported by barge to Quincy, where it is dehydrated and converted to pellet fertilizer for use in agriculture, forestry and land reclamation.
- Reducing CSO volumes by 84%, reducing untreated discharges to 4 or fewer per year and treating 95% of the remaining flow.

Thanks to this ambitious project, Boston Harbor is healthier than it has been in decades. Coastal ecosystems are amazingly resilient. Some remarkable changes have occurred in Boston Harbor since sludge dumping ended in 1991.

With a healthier, cleaner harbor, marine animals are again taking advantage of the rich ecosystems of the harbor. Salt marshes, tidal flats and bays are home to an increasing number of shellfish, fish, waterfowl and marine mammals. Harbor porpoises and seals have again been seen in the harbor, along with increased numbers of migratory fish, such as herring and striped bass. Mussels, kelp, sea urchins and anemones have begun to re-colonize the areas near former sludge outfalls.

Since 1995, when the new Deer Island primary treatment was completed, water clarity has increased and surface pollution has decreased. Scum has been almost completely eliminated. Beach closings due to high bacteria counts have been greatly reduced. Cases of liver lesions and tumors found on fish, often the result of toxic contamination, have also declined. Bluefish, striped bass and cod—fish that prefer healthy, clean water—are returning to the harbor. This turn around in the health of Boston Harbor has been dramatic, and overall improvement should continue for many years to come.

## CONSERVATION CONCERNS FOR BOSTON HARBOR

### Watersheds

Water flows into Boston Harbor from five rivers, Mystic, Charles, Neponset, Weymouth and Weir. The combined watersheds from these rivers encompass more than 50 communities, from as far away as the Rhode Island border.

Every water body has a land area from which water drains. This is known as a watershed. Rain that falls on land, even hundreds of miles inland, will eventually drain into streams and rivers that lead to the ocean. What occurs on land does impact the body of water into which it drains. Pollution that comes from land use within a watershed is known as non-point source pollution.

### Non-point source pollution

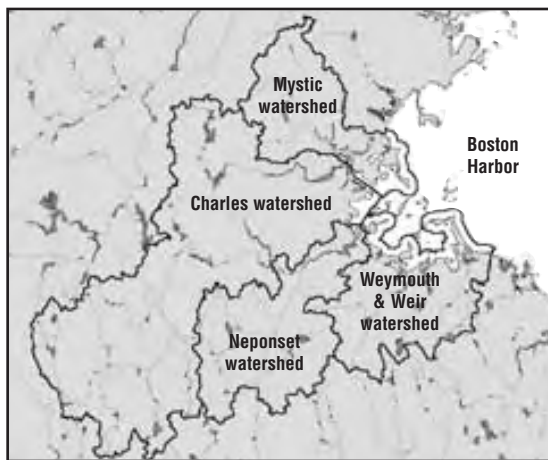
Thirty years ago, people in the environmental movement focused on industrial plants as the greatest threat to water quality. We have come a long way in regulating this type of pollution through legislation such as the Clean Water Act of 1972. Today, however, we are facing a different issue. Pollution that comes from lawn fertilizer used in homes and agricultural areas, oil and debris from roads and parking lots, and air pollution from vehicle exhaust are becoming a growing concern for the environment. These are all examples of non-point source pollution.

### Eutrophication

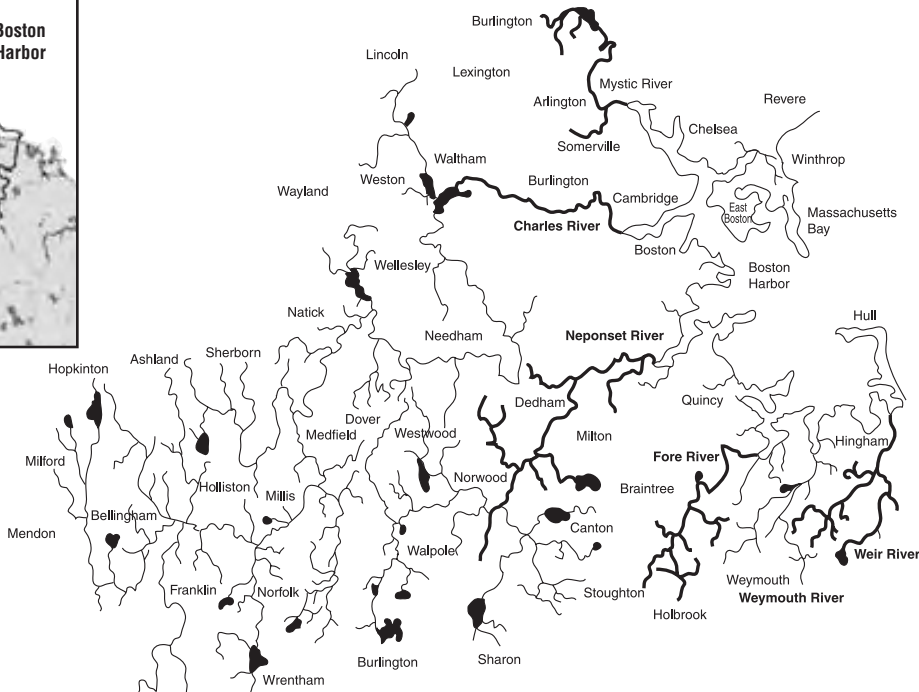
Eutrophication is one result of non-point source pollution. Nutrients such as phosphorous and nitrogen that flow from land into rivers and eventually to the ocean act as a fertilizer for aquatic plants. If nutrient levels are high, the result is an increase in aquatic plant growth. Too many plants in a water body can choke off sunlight to lower levels. Eventually the plants die. As bacteria begin to decompose the dead plant matter, they consume oxygen that is dissolved in the water. Fish and other animals that are dependent upon dissolved oxygen either leave the area or die.

### How does it relate to me?

Everyone creates non-point source pollution every day: through use of cars, trains and buses; by fertilizing lawns and gardens; by not cleaning up after pets; by using electricity and many other things in everyday life. Land use activities impact our coastal areas no matter how far inland we live. Runoff from streets into sewers carries with it all the pollution and trash that we leave behind. Every time it rains, the streets become a source of a surge of pollution that is washed into streams, rivers, and eventually the harbor and the ocean. Every city and town in the Boston Harbor watershed has some impact on the harbor.



### Boston Harbor Watershed



## What can I do to help?

Although we probably cannot stop causing non-point source pollution altogether, we all can make a big difference. Armed with information and encouragement, both adults and children can be empowered to do their part for the environment.

### Specific things **ADULTS** can do:

- ✓ Look for a place to live that is near work or school, so you don't have to travel a long distance every day.
- ✓ Walk, bicycle, take public transportation or carpool as much as possible rather than drive.
- ✓ If you have to drive, use the cleanest car you can. When buying a car, choose one that gets high gas mileage and the cleanest engine possible. Today, there are more options such as electric vehicles or hybrid vehicles that are part electric, part internal combustion engine.
- ✓ If you are buying a new home, keep in mind that smaller houses are more energy efficient to heat and cool.
- ✓ If you are buying a new large appliance like a refrigerator or washing machine, buy one that uses the least amount of energy.
- ✓ Install showers, toilets and household appliances that conserve water.
- ✓ Install efficient lights that use less electricity.
- ✓ Use the most efficient systems for supplying heat and hot water to your home.
- ✓ If you want a grass lawn, make it a small one and mow with a push-mower.
- ✓ Avoid pesticides, herbicides and chemical fertilizers. Let a few weeds grow.
- ✓ Visit Boston Harbor and enjoy it with your family and friends.
- ✓ Join a local watershed monitoring program.
- ✓ Volunteer as a New England Aquarium guide. For more information on how to volunteer, visit us online at <[www.neaq.org](http://www.neaq.org)>.
- ✓ Vote in local and national elections.

### Specific things **KIDS** can do:

- ✓ Talk to your parents about what they can do.
- ✓ Reduce, reuse and recycle materials. This includes plastic, aluminum, paper and cardboard.
- ✓ Inform others that it is not acceptable to throw trash on the ground. Tell them how it harms our environment. Plastics in the oceans can harm or even kill animals by entangling them, limiting their ability to eat, move and grow.
- ✓ Be careful with balloons. They can eventually end up in the ocean if you let them go accidentally. Many marine animals found dead have plastics in their stomachs. Since the plastic cannot be digested, the animal will feel full and not eat. This can lead to starvation.
- ✓ Conserve water when you shower or brush your teeth.
- ✓ Learn about environmental issues in your neighborhood. Start a neighborhood clean-up project. Adopt a stream or pond near you and keep it clean.
- ✓ Write to your local newspaper about environmental issues that concern you.
- ✓ Write to your local representatives. Tell them your concerns and remind them that you are a future voter.
- ✓ Participate in a beach clean-up.
- ✓ If you're 14 or older, volunteer at the New England Aquarium. Visit our website, [www.newenglandaquarium.com](http://www.newenglandaquarium.com), for more information and opportunities.

## SECRETS FOR SEASIDE SUCCESS

Based on years of experience planning and implementing coastal field trips, the New England Aquarium has come up with ten strategies for seaside success.

### 1. THINK ABOUT THE BIG PICTURE

#### Why a coastal field trip?

- Coastal field study promotes an understanding of ecosystems and connections in ecosystems that cannot be duplicated in any other way. Immersed in the field, students truly appreciate concepts such as the diversity of adaptations, the visual effects of human impact, or the flow of tidal rhythms. Through hands-on exploration, students learn to construct meaning and draw conclusions from first-hand investigation and research.
- Outdoor investigation capitalizes on the innate curiosity and fascination that both children and adults have for nature. It also fuels an interest and enthusiasm for scientific inquiry that they may not necessarily experience in a classroom setting.
- Formal and informal educational programs should include the resources of the community. Coastal field trips introduce students and their parents/guardians to local coastal habitats that they may not have known even existed. Together they learn not only about marine resources, but also about cultural and historical perspectives of the region.
- Outdoor exploration creates a personal connection to local coastal habitats, which in turn leads to active environmental stewardship. The first step in teaching environmental leadership is fostering appreciation for and raising awareness of how we interact with and depend upon ecosystems.
- Outdoor field trips link to learning standards set by the Massachusetts Curriculum Frameworks, that are the mandate of current education reform. A well-planned field trip expands upon and reinforces subject content and inquiry processes outlined in the guidelines.
- Your field trip should be an integral part of an ongoing curriculum or theme. Incorporate the inquiry “learning strand” into your curriculum with pre-trip and extension activities.

#### Links to Frameworks

The Massachusetts Curriculum Frameworks outlines the skills and knowledge students are expected to develop as they progress through grades K-12. The planners and activities in the Boston Harbor Seaside Educator’s Guide link directly with current learning standards as described in the Massachusetts Curriculum Frameworks (See **Appendix A: Links to Frameworks**). This guide is designed to fit into curricula for all ages, from helping students develop observation skills in their early years to helping high school students develop complex analytical skills.

Listed below are Massachusetts Curriculum Frameworks Science Learning Standards that are applicable to seaside study activities. Teachers planning outdoor field studies should not consider themselves limited to science learning standards. Language arts, social sciences, arts and math are all subjects that can and should be incorporated into an interdisciplinary curriculum.

#### ● Strand 1: **Inquiry**

Process skills such as: observing, describing, grouping by common characteristics, recognizing patterns, measuring, asking questions, communicating observations, planning and conducting an investigation, recording and analyzing data, making predictions, inferring and drawing conclusions.

- Strand 2: **Domains of Science**

**Life Science:** Characteristics of organisms, diversity and adaptations of organisms, classification, life cycles, food chains and webs, development and reproduction, energy in ecosystems, population growth, cooperation and competition in ecosystems.

**Earth Science:** Physical features and changes of earth's materials, weather phenomenon, daily and seasonal changes, geological observations, moon phases, tides, water cycle, reading and making maps, rock formation, erosion.

**Physical Science:** Properties of solids, liquids and gases; observable properties such as size, shape, color; physical and chemical properties of water; properties of sound; gravitational forces; waves.

**Technology/Engineering:** Use of simple and more complex scientific instruments, collecting and organizing quantitative and qualitative data; using appropriate science and technology terminology.

For more information about the Massachusetts Curriculum Frameworks, please write the Massachusetts Department of Education at 350 Main Street, Malden, Massachusetts 02148, or call (781) 388-3300 or visit their web site at <[www.doe.mass.edu](http://www.doe.mass.edu)>.

## 2. CHOOSE AND SURVEY A SITE

- **Choose a habitat** (e.g. sandy beach, tidal mudflats, salt marsh, rocky tidepools or floating docks and piers) to match your learning objectives. Once you have identified your overall curriculum, where should you go? Do you want to take an in-depth look at a salt marsh? Investigate a rocky intertidal zone and some neighboring mudflats? Visit a harbor island? Many students are surprised to learn that not everything in the ocean lives together. See **Appendix B: Habitat Primers** for more information about the types of habitats in Boston Harbor.
- **Select a specific site** for your field trip. Boston Harbor has a diverse array of accessible coastal habitats that you can choose from. See **Appendix C: Site Guide** for descriptions of suggested field trip sites with accompanying contact person and facilities information.
- **Consult a tide chart** to determine the optimal date and time for exploring your site. Full and new moon tides offer the lowest tides for the best intertidal exploration, so look for below-average low tides for the month. But, if your choices are limited, there is still plenty to do during a high tide visit. See **Appendix D: Resources** for a list of locations to obtain a tide table for Boston Harbor.
- **Survey the site.** For effective group management, we highly recommend that you visit your site in advance. Important considerations when surveying your site are:
  - Safety:** Consider hazards such as steep inclines, slippery rocks, razor-sharp barnacles, strong currents and deep mud. Determine what footwear to recommend on a “what to wear” list (open- or closed-toe wet shoes, sandals or mud boots).
  - Group management:** Choose an area of the site where group leaders can visually monitor the entire group. Plan where you will set up activity stations.
  - Facilities:** If there are no restrooms, locate nearest public restrooms. Other considerations: shelter from extreme sun or heavy rain, swimming area/lifeguards, areas to use for lunch or games, potential distractions.
- **Determine travel logistics.** Schedule arrangements for travel by bus, public transportation and/or boat. What is approximate travel time to and from the site?

## THINK ABOUT THE BIG PICTURE: CONCEPT LEARNING

### ***Why teach with concepts?***

In the past, instructors have found themselves answering “What’s this?” questions, often for the same student, about the same animal or plant. While there is nothing wrong with these questions, they tend to focus attention on the specific rather than drawing it to the larger picture of nature’s recurring themes.

The field of environmental education has increasingly moved away from the identification approach to concept learning which allows participants to think and explore for themselves and is adaptable to any environment. It connects students to the natural world by making them a part of that world as opposed to outsiders observing the life within. This personalized approach to “scientific” learning makes students aware of the vital role they play in any habitat, from salt marshes and rain forests to their own backyards.

The seven concepts listed below were developed to draw participants’ attention to how organisms fit into dynamic environmental systems. They are adapted to apply to the coastal habitat. “Questions for the Field” are to encourage on-site discussion and exploration for each concept.

### **ADAPTATION**

Animals and plants living in the coastal habitat have developed behaviors and/or structures which enable them to survive the harsh conditions of their environment. These adaptations may be seen in the morphology of the plant or animal (shells, spines, air bladders), in their physiology (the functioning of cells, organs or entire organisms), or in the animal’s behavior (hiding, defense tactics, feeding).

#### ***Questions for the Field***

- What is an example of a morphological adaptation that helps an animal or plant survive?
- How can an animal’s behavioral adaptations increase its chances for survival?

### **CHANGE**

The coast is a habitat subject to many changes. Animals and plants experience these changes continuously, both in short-term ecological time and in long-term geological time. Examples include salinity, temperature and access to water in the short-term, and changes in habitat structure in the long-term. These changes constantly affect the animals and plants of the habitat.

#### ***Questions for the Field***

- What changes may take place in the ecosystem on a daily, seasonal or geological basis? (Don’t forget ice!)
- How will these changes affect an animal in the habitat?

### **ECOSYSTEM**

Simply put, an ecosystem consists of the physical features of an area and the organisms living within it. Many physical factors such as salinity, wave action, temperature and oxygen content influence the ecosystem.

#### ***Questions for the Field***

- What are the basic elements of an ecosystem?
- What are ten animals and five plants unique to the habitat you are investigating?

### **ENERGY CYCLE**

Energy from the sun is the driving force of almost every ecosystem on earth. An energy cycle can be thought of as a process: the sun provides the energy for plants to grow, plants become food for animals and dead plants and animals decay into simple compounds that organisms absorb, continuing the cycle.

#### **Questions for the Field**

- What is the significance of the sun to the ecosystem you are investigating?
- Why is the death of any organism a necessary part of living in an ecosystem?

### **HABITAT**

A habitat is the place where a plant or animal lives. On a global scale, many ecosystems may be considered to be a single habitat, but as you explore the coastal area you will find them comprised of many “mini” habitats. There are zones within the marsh where certain organisms predominate, creating a “mini” habitat that is easy to see. Some organisms live attached to one another, in root systems or burrowed in mud.

#### **Questions for the Field**

- Identify two or three “mini” habitats and explain how they differ from one another.
- What are the organisms living in the “mini” habitat you just found?

### **HUMAN IMPACT**

Virtually no ecosystem on earth has been left untouched by humans. Humans impact the marsh directly (e.g. when students walk on marsh grasses while exploring) and indirectly (e.g. when development near a marsh changes tidal inflow and outflow). Human impact on any ecosystem can be either positive or negative.

#### **Questions for the Field**

- What are examples of positive and negative human impact on the habitat you are investigating?
- How can humans reduce negative or strengthen positive impacts on the coastal ecosystem?

### **INTERDEPENDENCE**

All coastal organisms have complex interrelationships. Animals and plants depend on one another for the necessities of life: food, shelter and protection. The links between the organisms are critical for survival and changing these links can determine if an organism lives or dies.

#### **Questions for the Field**

- What is an example of plant/animal interdependence?
- Can you find a part of the habitat you are exploring where an interdependence link has been broken?  
What is the cause of the break?

This **CONCEPT LEARNING** section was copied with permission from *The Salt Marsh: A Complete Guide to Conducting Successful Field Trips for Grades K-12*. 1994. Seacoast Science Center/Audubon Society of New Hampshire, Rye, New Hampshire 03870.

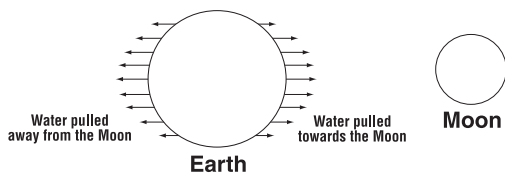
*Text adapted for general use in Boston Harbor.*

## TIDE BASICS

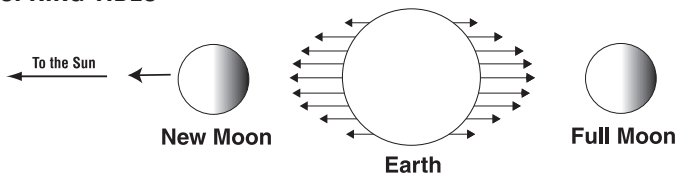
Tides are local variations in water depth due to the oceans' sloshing around in their basins under the gravitational pull of the Moon and (to a lesser degree) the more distant Sun.

In Boston Harbor, there are two high tides and two low tides each lunar day (24 hours and 50 minutes) with an interval of 12 hours and 25 minutes between successive high tides. So if the tide is high at 6 a.m. today, you can expect it to be high again at 6:25 p.m. this evening and then again at 6:50 a.m. tomorrow. On average, the water in Boston Harbor will be about 9.5 feet deeper at high tide than it is at low tide. But the strength of the tide varies throughout the lunar month (see "Spring Tides and Neap Tides," below). It is not unusual to see tides so strong that the difference in depth between a high and low tide is about 12 feet, or tides so weak that the difference is only about 8 feet. Storm surges can lead to even higher tides.

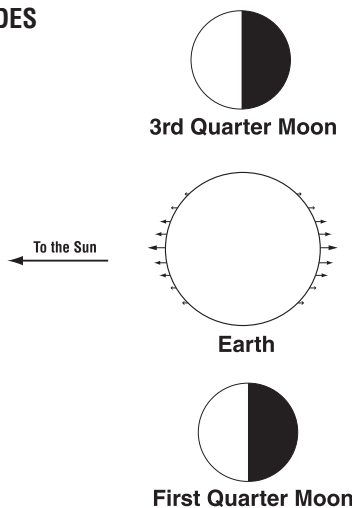
## FORCES CREATING THE TIDES



## SPRING TIDES



## NEAP TIDES



## FORCES CREATING THE TIDES

Earth and the Moon orbit one another around their common center of mass. (The center of mass is much closer to the center of Earth than it is to the Moon, so the common understanding that "the Moon orbits Earth" is good enough to aid in understanding most phenomena — but not tides.) They are held together in orbit by gravity: Earth is gravitationally attracted to the Moon, and the Moon is attracted to Earth. Without this attraction, the two bodies would fly away from each other. Gravitational attraction increases with closeness, so parts of Earth that are close to the Moon are subject to an extra attraction and are pulled towards it. Parts of Earth that are far from the Moon are subject to less gravitational attraction, so they are less constrained from flying away from it—in effect, they seem to be pulled away from the Moon. Thus, water closer to the Moon is pulled towards it and water farther from the Moon is pulled away.

## EARTH IS NOT AN EGG

If Earth's surface were completely covered with water, that water might take on an egg-like shape, with one mound of water pulled directly toward the Moon, and another mound rising away from Earth on the side directly opposite the Moon. Since Earth is spinning once per day on its axis, a point on Earth's surface would pass under each of these two mounds, one after the other, each day. In effect, it would experience two daily high tides (when the point is under a mound, so the water is high) and two daily low tides (when the water over the point is lowest).

The continents prevent the ocean from taking on that egg-like shape. Even so, water at points on Earth's surface close to the Moon is pulled towards it, and water at points on the opposite side is pulled away. Under the influence of those forces, the ocean waters slosh back and forth or around and around in their basins, causing high tides when the sloshing brings a lot of water over a point and low tides when the sloshing brings water away from that point. Many places on Earth (such as Boston Harbor) do experience two high tides a day, although in some locations one of those tides might be considerably stronger than the other tide. Other places effectively experience only one high tide per day. The nature of the tide at any given place depends on such details as the size and shape of the ocean basin near that place, the degree to which the Moon's orbit is tilted relative to Earth's Equator, and other phenomena.

## SPRING TIDES AND NEAP TIDES

The Sun's tidal influence on the ocean is similar to the Moon's, but the effect is much smaller because the Sun is much farther away than the Moon. Still, at times of New Moon (diagram A) and Full Moon, when the Sun and Moon are aligned with Earth, the Sun's influence adds a bit to the strength of the Moon's tidal pull, so the tide is stronger. High tides tend to be higher and low tides tend to be lower. This is called a "spring tide." Spring tides are the best times for seaside exploration: because the low tide is so low, a lot of the intertidal zone is exposed at low water. So if you have a choice, try to plan your trip for a low tide near the time of Full or New Moon.

Around the first and third quarters of each lunar month, the Moon looks like half a circle to us (diagram B). At those times, Earth, Sun and Moon form an approximate right angle and so the Sun's tidal influence reduces the strength of the lunar tides. This is called a "neap tide." Note that "spring" and "neap" do not refer to seasons. Every lunar month—roughly 29 days—there are two spring tides (at Full and New Moon) and two neap tides (halfway between Full and New Moons).



## HOW TO READ YOUR TIDE TABLE

**Time:** Times of high and low tide are often recorded in military time, using a 24 hour clock instead of a 12 hour clock. For example, 6:23 p.m. is written as 0623; 6:23 p.m. is written as 1823. Double-check to make sure your tide table is corrected for daylight saving/standard times.

**Height:** This is the vertical rise in feet between low and high tide.

- For tide tables that conveniently list heights of both high and low water: *look for the lowest tides with a minus sign*; this indicates below average tides. (0.00 height indicates average low tide).
- For tide tables that list only high tide heights: look for 10.5-12+ ft. high tide (exceeding the average 9.5 ft), the *following* low tide will be lower than average.

**Tide Chart for Boston, MA**  
**07/01/2000 to 7/31/2000**  
**Local Daylight Time**

Date	Day	HIGH		LOW		HIGH		LOW		HIGH	
		Time	ft	Time	ft	Time	ft	Time	ft	Time	ft
07/01/2000	SAT			05:14	-1.46	11:26	10.33	17:27	-0.44	23:39	12.22
07/02/2000	SUN			06:08	-1.79	12:21	10.54	18:20	-0.60		
07/03/2000	MON	00:33	12.34	07:00	-1.92	13:15	10.66	19:14	-0.62		
07/04/2000	TUE	01:27	12.24	07:53	-1.83	14:10	10.68	20:08	-0.51		
07/05/2000	WED	02:23	11.92	08:46	-1.54	15:05	10.60	21:04	-0.27		
07/06/2000	THU	03:19	11.42	09:40	-1.08	16:00	10.46	22:01	0.06		
07/07/2000	FRI	04:17	10.81	10:34	-0.54	16:57	10.28	23:01	0.39		
07/08/2000	SAT	05:16	10.18	11:30	0.03	17:54	10.11				
07/09/2000	SUN			00:02	0.67	06:17	9.61	12:26	0.55	18:51	9.98
07/10/2000	MON			01:04	0.84	07:19	9.17	13:22	0.96	19:46	9.90
07/11/2000	TUE			02:05	0.88	08:19	8.90	14:17	1.24	20:40	9.88
07/12/2000	WED			03:03	0.81	09:16	8.77	15:09	1.39	21:30	9.91
07/13/2000	THU			03:54	0.69	10:07	8.75	15:57	1.44	22:30	9.98

Scan the **LOW** tide column for the morning or afternoon times that best suit your program. "Minus" low tides are a bonus. Some examples of possible options:

◀ **Monday, July 3, 2000**  
 Low tide is at 7:00 a.m. and is -1.92 feet below average low tide. A good "spring tide," but too early in the morning!

◀ **Friday, July 7, 2000**  
 Low tide is at 10:34 a.m. and is -0.54 feet below average low tide.

◀ **Tuesday, July 11, 2000**  
 Low tide is at 2:17 p.m. and is 1.24 feet above average low tide.

See **Appendix D:** Resources for where you can get a tide chart.

### 3. SELECT ACTIVITIES AND EQUIPMENT

**Plan your classroom and on-site activities.** See **Appendix A: Activities** for a list of suggestions.

**Select Equipment.** Experience has shown that “less is more.” Too much gear is cumbersome and often goes unused. So we suggest that you plan to bring the basics: small buckets, hand lenses and field guides, and then select additional gear necessary for your chosen activities.

See **Appendix D: Resources** for information about where to purchase your own equipment and equipment available for loan from the New England Aquarium Teacher Resource Center.

### 4. PLAN FOR GROUP SAFETY AND SITE STEWARDSHIP

**Have a designated plan for group management and safety.**

For the safety of your group, you must be prepared for any emergency situation. While preventing injuries is always the goal, the following information will help to prepare you.

- **Health Forms:** Group leaders should have health forms in waterproof plastic with them on site. Review the health forms and note any unusual allergies or health needs before your trip. You must be able to reach a parent or guardian by phone in case an injury needs to be treated or hospitalization is required.
- **First Aid:** Group leaders and chaperones should know what to do in case of a minor injury or what course of action to take for a medical emergency. First aid kits should be stocked and easily available. If possible, a person certified in first aid training should be designated as a first responder.
- **Emergency vehicles:** One group leader should plan on driving a separate vehicle to the site rather than riding the school bus. A leader needs to be able to leave the site with an injured student and/or ambulance and have a way of returning to the site later.
- **Group management considerations:** Designate a meeting place in the event that anyone in the group becomes lost or separated. Agree upon a meeting place and time for lunch. If using a cellular phone or pager for communications, share this information with all chaperones.
- **Student comfort and safety:** Bring extra water, cups, insect repellent and sunscreen for students. Make sure participants have appropriate clothing and footwear.
- **Poison ivy:** Not usually found on well-worn trails. Ask site contact if there are problem areas to look out for. Rule of thumb: if you're not sure, don't touch it.
- **Ticks:** You won't find ticks in the intertidal zone. Stay on trails and avoid thick brush and high grass areas. Deer ticks, which carry Lyme disease, are mostly found in thick and brushy areas of high grass and are not at present a big problem in the Boston Harbor area. Check with site contact to see if there are any concerns.
- **Water safety:** No bare feet! Allow wading only up to below-knee level. Avoid fast-moving tidal currents. Make sure students do not get stranded in a rising tide. Swim (*if allowed by your program*) ONLY with lifeguard or certified Water Safety Instructor.

**Visiting a site with minimal environmental impact.**

Coastal field trips offer an irreplaceable opportunity for participants to connect with and learn to care for the natural world. Students learn to appreciate the fact that each of them is an interdependent part of the earth's ecosystem, that they are not "visitors" to the seashore, but rather participating members of the coastal ecosystem community. In keeping with this ethic, educators are responsible for teaching and modeling low-impact practices when visiting an outdoor area. Repeated visits by large groups of people can cause problems such as erosion, disturbed wildlife, littering and other types of habitat degradation. Listed below are ground rules to help you and your students reduce these kinds of stresses.

In teaching and discussing low-impact practices with students, consider emphasizing that even if we "leave only footprints," humans still do leave a trace. Actions in our households influence our watersheds. The school bus that brings us to the field site emits gases into the atmosphere. The manufacturing and packaging of the products and food we carry in our day packs has had far-reaching environmental effects. For better or worse, we affect the coastline in our daily lives.

We recommend a common-sense approach to teaching low-impact ethics. The outdoors is not an archival preserve that we tiptoe in and out of in order to leave it undisturbed for posterity. The coastline is a dynamic, resilient zone of energy and change. Winter storms rework miles of shoreline annually. Hungry shorebirds munch on the tidepool animals students so thoughtfully release after their research investigation. The concept to emphasize is that our individual actions are multiplied by the numbers of our ever-growing population, creating pressures that have a profound impact on the health of the coastline. Therefore commitment to low-impact exploration is exceedingly important.

**Preparing for your visit.**

National, state and city park services as well as town conservation commissions each have their own set of regulations to protect their sites. Request a brochure or inquire with the site contact person regarding park policies. See **Appendix C: Site Directory** for contact information.

Have students brainstorm and discuss ground rules for protecting the habitat they are exploring. What are they and why are they necessary? Discuss specific park regulations as well. Why are those regulations in place? Are there any changes or additions that the students would want to make if they could?

Pre-trip classroom curriculum activities should focus on human interconnection to ecosystems and incorporate topics such as point and non-point source pollution, food webs and energy in ecosystems. Group discussion topics should also include environmental stewardship practices and coastal watershed connections.

**Decide your policy on beachcombing.**

Beachcombing is the collection of organic non-living marine items such as empty shells, molts and empty egg cases, as well as live marine algae (seaweeds). In general, most park services and town conservation commissions in the Boston area adopt a general "no collecting" policy. However, many of these agencies, on request, will consider granting special permission to allow limited, responsible beachcombing for educational purposes. Check with the site before your trip.

## Beachcombing Ethics.

Members of the New England Aquarium's Education Department have taken a closer look at the issue of beachcombing in order for you to choose a protocol that balances sound environmental ethics with your educational objectives and personal philosophy.

We recommend that you incorporate beachcombing into your field trip only if you have a very clear motive and objective and have taken the time to discuss collection ethics with your students (this applies to all ages).

Limit beachcombing collecting to a minimum, choosing items for further study or for projects or displays to be shared with others. Collect only items that are in abundance. Try not to duplicate selections. We suggest a limit of one item per person (fewer is even better). If possible, return the items when projects are completed.

### Reasons for Choosing a “No Collecting” Policy

**Consistent with current trends:** A “no collecting under any circumstances” policy falls in line with the minimal-impact ethic that many environmental organizations and land management agencies are moving toward in the face of the growing number of visitors to even the most remote outdoor places. Even the smallest impact, when multiplied by the hundreds or thousands, could eventually degrade a habitat.

**Simplicity:** A “no collecting” policy provides the easiest and most reliable method of site protection management. The policy is clear, consistent and needs minimal explanation. It ensures that every group visiting the same site will have equal opportunity to appreciate all of the treasures each tide brings in.

**Encourage alternative interactions:** A “no collecting” policy encourages people to appreciate, interact with and connect to the coastline in creative ways, such as writing in a journal, taking pictures, sketching or writing poetry. Participants learn to visit a site without needing to possess a piece of it, exploiting it for selfish purposes—a positive shift in values.

### Reasons for Choosing a “Responsible Beachcombing” Policy

**Enhances educational experience:** Given careful and thoughtful planning, beachcombing has educational value. Individually selected items can reinforce a science, art or literacy curriculum.

**Extends learning opportunities beyond actual visit:** Collecting non-living beach specimens creates the opportunity for many others to have a valuable hands-on experience for days or years to come.

**Encourages a lasting connection:** Searching for and selecting a special item can nurture a meaningful personal connection to the coastline. In contrast, an antiseptic hands-off approach may create a sense of frustration and alienation, particularly for young children.

**Models the concept of renewable resources:** It is inevitable that we interact with and impact the coastline. Students and staff can participate together in responsible decision-making that complies with ecological supply and demand, choosing to select items that are available in abundance.

**Recognizing our impact on habitat:** Consider that the greatest impact on the harbor comes from hundreds of thousands of homes, schools and offices. You do not want to reinforce the myth: “If you don’t take something away, you have had no effect on the coastline.” You may end up enforcing a rule that diverts emphasis from more critical coastal issues.

## 5. PREPARE STUDENTS AND CHAPERONES

**Clear communications and task delegation.** Clarify the responsibilities for group leaders, chaperones and students before and during the trip. Make checklists for the weeks and days before your field trip as well as for the actual day of the trip itself.

### Prepare chaperones.

- Recruit your chaperones early. It is important that they know and understand just how essential they are to you and the success of the program.
- Plan to have at least one chaperone for every five to eight students, depending on the students' ages. Younger students require more.
- Invite chaperones to attend class when studying field trip topics. This will help them be better prepared.
- Chaperones, as well as students, should dress appropriately. See **Appendix D: Resources** for a list of what to bring and what to wear.

### Prepare students.

- *Incorporate pre-visit activities into your curriculum.* See **Appendix A: Activities** for a list of pre-trip activities.
- *Guide your students through open-ended questioning as they design their investigation:* What are their preconceived beliefs and ideas? What questions do they have? How can they find the answers? What kind of investigations should they conduct? For example, will they be observing individual animals, analyzing transects, comparing water temperatures, or looking for different shapes or colors? How should they record their findings?
- *Practice skills before going outside:* In the classroom, select activities that sharpen observation and descriptive skills. Draw and record observations, incorporate field journals and data sheets and use field guides, hand lenses and science equipment. The more familiar students are with using these practices, the more effective their use will be when applied in the field.
- *Set guidelines in advance:* Students should know what is expected of them. Journal topics, portfolio requirements, investigative teams and data sheets should be assigned and prepared as part of pre-trip planning. You may want also want to assign jobs and/or designate roles (examples: team leader, equipment inventory taker, group recorder, water quality specialist).
- *Transfer routines from your classroom or program into the field:* Being in a potentially over-stimulating environment without familiar boundaries can be anxiety producing for both staff and students. Reduce stress by using strategies that are already familiar to your group. Plan to bring worksheets or activities that reinforce or expand on what you have already done in the classroom. Before your trip, have your group review your school or program's conduct rules and/or have students brainstorm their own behavioral contract. Be clear about consequences of misbehavior.
- *"Student-centered" orientation:* The more information students have in advance about trip logistics, the more they will be able to focus on subject content during their field exploration. Questions you should answer in advance to avoid distraction later include: How long is the bus ride? Will there be swimming? What time is lunch? Is there a gift shop? Some research indicates that this type of "student-centered" planning can be a more effective tool for focused field trips than pre-trip academic curriculum.
- *Keep it simple:* Prepare a schedule in advance for the day of the field trip that students (and chaperones) will understand. Organize the day around clearly-defined themes and activities. Review the day's agenda and program objectives with students. Make sure they know what to bring and what to wear. Discuss safety concerns and appropriate behavior. Go over gear, journals or work sheets. Students should be prepared for a group wrap-up or follow-up project. See **Appendix A: Activities** for suggestions, and see **Appendix D: Sample Salt Marsh Itinerary** for an example.

### Sample In-the-Field Schedule

10:00	Arrival	11:40	Station II
10:15	Habitat Overview	12:00	Lunch
10:25	Habitat Exploration	12:40	Station III
11:00	Group Observations and Discussion	1:00	Station IV
11:20	Split into five groups & rotate through Focus Stations *	1:20	Station V
11:20	Station I	1:40	Group Game
		2:00	Wrap-up

\* Choose from **Appendix A: Activities**.

## 6. ORIENT THE GROUP TO THE SITE WHEN YOU ARRIVE

### Habitat overview

Once you have arrived at your site, we suggest that you bring your group to the highest point or a lookout tower to present a brief overview of the habitat. Use any available signage, charts or maps to help you.

### Review “site stewardship” rules with students.

- Read and respect all signs. Signs give important information about preventing erosion, protecting wildlife, respecting private property and ensuring safety.
- If there are marked trails, stay on them. In areas without a trail, stay in small groups and avoid single file lines to minimize compacting vegetation and creating new trails.
- Dispose of waste properly. Use restrooms.
- Leave nothing behind! Bring a garbage bag. Pick up your food crumbs and leftovers. Pick up any other litter. Carry out your trash.
- Be sensitive to wildlife. Avoid areas where birds and wildlife are nesting. Discuss why certain areas are cordoned off for nesting in spring and early summer.
- Report any stranded or injured marine animals to the New England Aquarium’s Stranding hotline at (617) 973-5247. Please keep your distance! Stranded animals can bite and attempts to help often do more harm than good.
- Use proper animal handling techniques when exploring the intertidal zone (see inset “Tips on Being an Intertidal Detective” on page 21).
- Bring no live animals home or back to the classroom. The exception to this is collecting invertebrates and small fish for a classroom saltwater aquarium, ONLY if you are properly equipped and trained to maintain one. In this case, be sure collecting is allowed at your site and you have a collecting permit from Massachusetts Division of Fish and Wildlife.
- Do not pick flowers or other vegetation. An exception to this is collecting seaweed for an herbarium, only with permission of site agency. Be clear about what the policy is about collecting non-living items.

### Set boundaries.

- Be sure to assign each chaperone to a small group of students for effective group management.
- Students should stay in small groups and always be within seeing and hearing distance of one another.
- Make sure students know who their group leader is.



Carefully handle crabs.

Photo / L. Fredrickson

### Tips for Intertidal Detectives

- Most tidepool invertebrates in and around Boston Harbor do not sting or bite. Their defenses typically come in the form of a hard shell or spiny skin. Many are safe to touch. If you are not sure, do not touch - use a bucket or other container to scoop them into for closer observation.
- Be sure to explore the lowest intertidal zone first if the tide is rising or it is near the turn of the tide. Don't just stop at the first point of interest near the top of the tideline.
- Look underneath seaweeds, a great place for animals to stay moist and hide while the tide is out. Shake the ends of a clump of seaweed into a bucket, a good way to collect small organisms such as amphipods.
- Look under rocks and in small crevices, making sure that they are returned to their original position in order to protect the animals that live there.
- Observe tidepools and shallow water carefully before reaching or stepping in to explore. Animals scoot away when the water is disturbed and sediment gets stirred up, decreasing visibility.
- Search carefully for clues that are evidence of intertidal life, such as snail trails in the mud, worm castings and clam holes in the sand, shells and molts in the wrackline.

### Observing and Handling Intertidal Animals

- Observe animals without disturbing them. You often see more interesting behavior if you look and don't touch, or wait and watch before handling.
- Handle animals properly. Most tidepool animals will not harm us, but we can harm them. Animals should be picked up gently and supported fully in the palm of the hand.
- Never pry or forcefully pull on an organism that is clinging to a rock or other surface. Some shells are easily broken; a sea star's tube feet can be torn. Try a slow gentle nudge. Sometimes sliding the animal sideways works. Leave the animal alone if more effort is required.
- Keep animals underwater as much as possible; it is much less stressful for them. Immersion in the water allows the animals to get oxygen and stay in a constant temperature. It's also the best way to observe their behavior.
- When collecting for close-up observation, use small buckets with fresh seawater. Keep containers in the shade and replenish frequently to maintain temperature. Limit the time you keep organisms in containers.
- Limit the number of duplicate organisms in containers. Be aware of what other people are collecting. Collect only one or a few of each species for group discussion or field guide research. Look for diversity, not quantity.
- Remember where each animal was collected. They should be returned to the same location where they were found. If you can't remember (it happens!), at least return to the proper intertidal zone area.
- If collecting algae, look for specimens that are already free-floating. If site policy allows, pick the minimal amount needed if you are making an herbarium (a collection of dried and mounted specimens.)

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## 7. IMPLEMENT IN-THE-FIELD STRATEGIES

### **Initial exploration.**

It usually works best to allow your group time for open-ended exploration in their small groups or pairs. After this initial exploration time, it is easier to regroup and re-focus the group. Pay attention to group's energy level and the objectives you've set for the trip. Regroup and focus by setting up stations and/or worksheets.

### **Inquiry-focused stations.**

After lunch (or snack) is a good time to set up inquiry-focused stations, now that the initial curiosity has been satisfied. Students react positively to choosing their preferred activity or to a rotating station format for specific experiments or research opportunities. See **Appendix A: Focus Stations** for suggestions.

### **Use playful activities that energize body and mind.**

There are any number of distractions that can prevent your group from becoming aware of their surroundings. Aside from cars, machinery and even human voices, students may be feeling cold, anxious or worried about a personal problem. Your goal is to excite, instill curiosity and, ideally, re-focus the group's attention so they can relax, have fun and enjoy the natural world. High energy games can distract students from personal worries and focus attention on new experiences.

See **Appendix A: Reinforcing Games**.

## 8. MODEL INQUIRY

### **Share your excitement and curiosity — it's contagious.**

Being enthusiastic and ready to get a little wet or muddy is contagious. Ask lots of questions. Focus less on "what is it?" and more on how the different parts of the ecosystem are interrelated. Foster close observation skills. Be willing to admit that you don't know all the answers.

## 9. EXPECT THE UNEXPECTED

It's guaranteed... Bus is late? Misread the tide chart? Forgot the scavenger hunt? Rainy day? Have a bag of tricks for time-fillers and for re-focusing the group. See **Appendix A: Activities** for examples.

## 10. CONCLUDE WITH A WRAP-UP

### **Allow time for closure and/or follow-up.**

The chances are good that *you* will wear out before your students, but it is important to allow time for some form of closure to your outdoor experience. The wrap-up could be as simple as sharing new knowledge, or made more challenging by asking the group to follow up on any remaining questions or issues not covered in the field and present their findings later.

See **Appendix A: Habitat-Based Wrap-ups** and **Classroom Follow-up Activities**.

### **Before departing the field trip site.**

Inventory equipment for missing items. Count heads and have the group check to make sure they have all their personal gear. Do a quick survey of site for trash or lost belongings. Check in with all group leaders regarding accidents or discipline issues. Be sure to thank all the volunteers and chaperones for their assistance!





Photo / A. E. Dines/NORTHSTAR

Allow time for self-discovery.



Photo / S. Padawer

Check to see if guided tours are available.

Photo / S. Padawer



Set up a home base for gear and field guides.



Photo / A. E. Dines/NORTHSTAR

Explore in small groups.



Photo / S. Padawer

Using a seine net.



Photo / L. Fredrikson

Students using public transportation to get to their field site.



Photo / L. Fredrikson

Using a Magiscope™ to investigate plankton.



Photo / L. Fredrikson

Beach clean-up graph.



Photo / New England Aquarium

Ask questions.



Photo / L. Fredrikson

Making a plankton net.

## APPENDIX A

Photo / L. Fredrickson



Use the Aquarium's TRC to help prepare.

### FOR MORE ACTIVITIES AND CONSULTATION

Let the New England Aquarium's Teacher Resource Center (TRC) help! Borrow a seine net or a secchi disk (see Aquakit Inventory in **Appendix D**). Ask TRC staff for instructions on using equipment. Come in for a visit and peruse the extensive aquatic science curricula available. Call Joel Rubin at (617) 973-6590 or e-mail [jrubin@neaq.org](mailto:jrubin@neaq.org) for an appointment.

### Pre-Trip Activities

- Concept Web
- Making a Plankton Net
- Making an Underwater Viewer
- Team Brainstorm
- The Watershed Activity

### Observation and Sensory Field Activities

- Human Tide Chain
- Personal Periwinkle
- Sound Inventory
- Submersible Mystery

### Focus Station Activities

- Investigating Transects
- Mounting Algae
- Plankton Investigation
- Sand Sampling
- Wrackline Sort

### Habitat-Based Wrap-Ups

- Beach Clean-Up
- Make a Field Guide
- Nature Journals
- Salt Marsh Metaphors
- Sharing Circle

### Reinforcing Games

- Habitat Relay
- Who Am I?

### Classroom Follow-Up Activities

- Invent an Invertebrate
- The Wave

### Worksheets

- Animal Observation Sheet
- Beach Clean-Up Data Card
- Coastal Scavenger Hunt
- Invent an Invertebrate
- Plankton Identification
- Tidepool Animal Chart
- The Wave Worksheet

# MASSACHUSETTS CURRICULUM FRAMEWORKS

## *Domains of Science*

### LIFE SCIENCE (LS)

- Characteristics and Diversity/Variation of Organisms
- Basic Classification/Grouping
- Adaptations/Structure and Function
- Life Cycles
- Energy for Ecosystems
- Food Chains and Webs
- Population Growth
- Cooperation and Competition in Ecosystems
- Predictable Changes in Ecosystems
- Inheritance/Natural Selection/Evolution

### EARTH SCIENCE (ES)

- Properties and Changes of Earth Material
- Atmosphere and Weather
- Cycles: Seasons, Weather, Water, Tides
- Physical Features and Earth History
- Reading and Making Maps

### PHYSICAL SCIENCE (PS)

- Properties of Materials/Matter/Objects
- Sound
- Energy
- Motion/Forces of Motion
- Waves
- Heat/Temperature

### TECHNOLOGY/ENGINEERING (T/E)

- Engineering: Design, Produce
- Engineering: Use, Manage, Assess
- Nature of Engineering and Systems of Technology

# LINKS TO CURRICULUM FRAMEWORK

Activities	Massachusetts Standard	LS: Characteristics and Diversity/Variation of Organisms	LS: Basic Classification/ Grouping	LS: Adaptations/ Structure and Function	LS: Life Cycles	LS: Energy for Ecosystems	LS: Food Chains and Webs	LS: Population Growth	LS: Cooperation and Competition in Ecosystems	LS: Predictable changes in Ecosystems	LS: Inheritance/Natural Selection/Evolution	ES: Properties and Changes of Earth Material	ES: Atmosphere and weather	ES: Cycles: Seasons, weather, water, tides	ES: Physical Features and Earth History	ES: Reading and Making Maps	PS: Properties of Materials/Matter/ Objects	PS: Sound	PS: Energy	PS: Motion/Forces and Motion	PS: Waves	PS: Heat/Temperature	T/E: Engineering: Design/Produce	T/E: Engineering: Use, Manage, Assess
Concept Web (p. 28)												●	●	●	●	●			●	●	●			
Underwater Viewer (p. 28)	●		●							●													●	●
Plankton Net (p. 29 & 43)	●	●				●	●	●															●	●
Team Brainstorm (p. 30)														●	●					●	●	●		
Watershed Activity (p. 30)												●	●	●	●	●				●				
Human Tide Chain (p. 31)													●	●	●				●	●				
Personal Periwinkle (p. 31)	●	●	●							●	●													
Sound Inventory (p. 31)	●		●								●							●			●			
Submersible Mystery (p. 32)	●	●	●								●													
Transects (p. 32)	●	●	●	●	●	●	●	●	●	●	●			●	●	●								
Mounting Marine Algae (p. 33)	●	●	●			●	●	●																
Plankton investigation (p. 33)	●	●	●	●	●	●	●	●																●
Sand Sampling (p. 34)												●			●		●				●			●
Wrackline Sort (p. 34)	●	●	●																					
Beach Cleanup (p. 35 & 40)																								
Field Guide (p. 35)	●	●	●	●			●		●	●	●			●	●									
Nature Journals (p. 36)	●	●	●	●			●			●				●	●									
Wetland I.Q. (p. 36)	●	●				●	●	●		●				●								●		
Sharing Circle (p. 36)																								
Habitat Relay (p. 37)	●	●	●	●				●														●		
Who Am I? (p. 37)	●	●	●	●	●	●	●		●	●	●			●							●	●		
Invent An Invertebrate (p. 38 & 42)	●	●	●	●	●	●	●		●	●	●			●										
The Wave (p. 38 & 48)	●	●	●	●	●	●				●	●	●	●	●	●			●	●	●				
Animal Observation Sheet (p. 39)	●	●	●	●	●	●			●	●	●			●										
Coastal Scavenger Hunt (p. 41)	●	●	●	●	●	●	●		●	●	●			●										
Tidepool Animal Worksheet (p. 44-47)	●	●	●	●	●	●	●		●	●	●													

# PRE-TRIP ACTIVITIES

## CONCEPT WEB

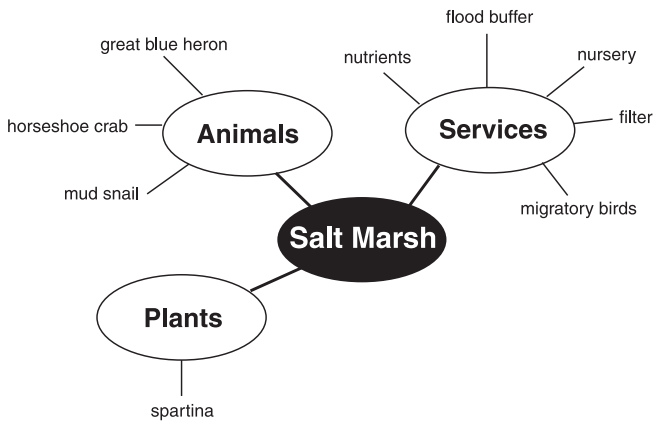
*Objective: To learn about the components that make up a coastline.*

*Materials:*

- Chart paper or chalkboard
- Chalk, pens, pencils or markers

*Directions:*

1. Write down a coastline concept such as "salt marsh" in the middle of a big piece of paper or chalkboard.
2. Draw a circle around it and have the students think of the main components that make up a coastline.
3. Then have the students consider additional features that come to mind.
4. Add those words and phrases connected by a line to the central idea.
5. Continue to add descriptions of features for each new phrase added until you feel it gives a comprehensive picture of all that salt marsh encompass.
6. Variation: Could be done after visiting a site.  
See example below:



## MAKING AN UNDERWATER VIEWER

*Objective: To make a viewer to observe the deeper parts of a tidepool.*

*Materials:*

- Milk carton or coffee can, open at both ends
- Strong, tight rubber band or duct tape
- Plastic wrap
- Tray or bucket

*Directions:*

1. Wrap a large piece of plastic wrap around the bottom of can or carton.
2. Pull it taut and secure with a rubber band or tape.
3. Practice using the underwater viewer with a tray or bucket of water and everyday objects.

*Discussion Topics*

- How are objects in the bucket different from what you expect to see in the field?
- What behaviors do you expect to observe?

## MAKING A PLANKTON NET

*Objective: To make a net for straining plankton.*

### *Materials:*

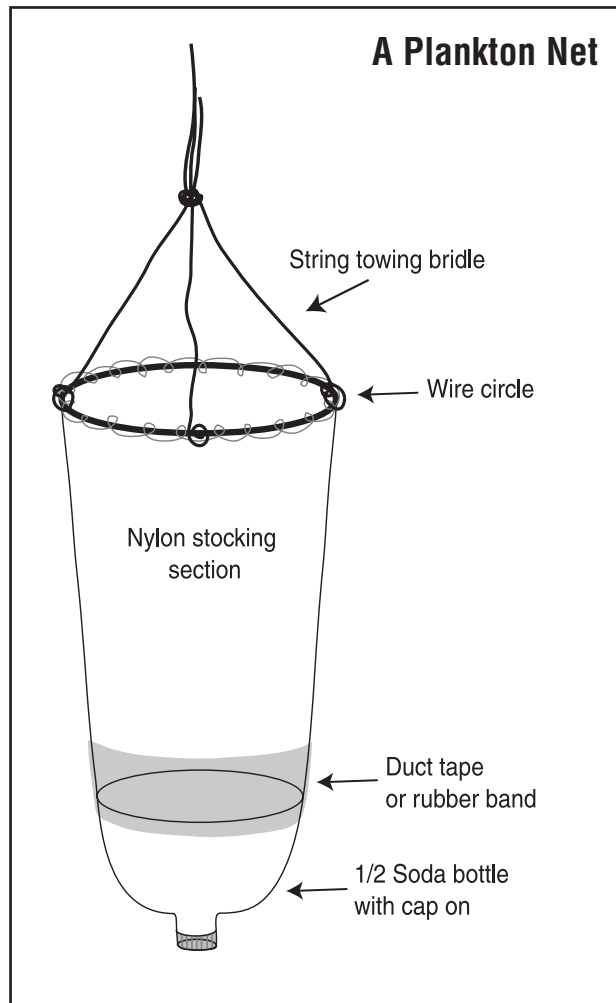
- A pair of nylon stockings
- Sturdy aluminum that can be formed into a loop (such as a wire coat hanger)
- wire cutters or pliers
- 3-4 feet of heavy-duty nylon string or crab line
- top half of 12-16 oz. clean empty plastic bottle
- needle and thread
- ruler
- rubber bands or duct tape
- magnifying glass

### *Directions:*

1. Using the coat hanger, create a circle approximately 6 inches in diameter.
2. Attach half of a stocking leg to the wire circle using a needle and thread. The stocking attached to the wire circle will be the opening of the net.
3. Cut off the toe of the stocking approximately an inch from the end and fit it over the opening of the soda bottle using a rubber band or duct tape.
4. Make a handle for the net by attaching the ends of three pieces of string to the wire circle and knotting the other ends together.
5. Use with Zooplankton Investigation (see Focus Station activities p. 43).

### *Discussion Topics:*

- How does the net strain the water?
- What do you expect to find?
- How do you identify phytoplankton and zooplankton?
- Why does the ocean look dark green or brown in New England?
- What is red tide?



### TEAM BRAINSTORM

*Objective: To have students identify the components that make up a specific habitat; to assess comprehension level of students to help set teaching objectives and strategies.*

*Materials:*

- Clipboard
- Paper and pencil for each group
- Chart paper or chalkboard

*Directions:*

1. Divide group into small teams.
2. Have each team think of and write down words that describe a specific habitat (such as rocky shore) for 2-5 minutes.
3. When the time period is over, have each team call out two words that they thought of and record the words on chalkboard or chart paper. Each word should be listed only once.
4. In the end, there will be a comprehensive list to describe the habitat.
5. Variation: Could be done before and after visiting a site.

*Discussion Topics:*

- Discuss the differences between specific habitats (rocky, sandy, climate, freshwater vs. marine).
- Revisit the original list upon returning from the field site. What misconceptions did you have? Did you find anything that you weren't expecting?

### THE WATERSHED ACTIVITY

*Objective: To demonstrate non-point source pollution and how actions on land affect the harbor.*

*Materials:*

- 2-3 sheets of newspaper
- Waterproof box, pan or tray
- Clear or light colored trash bag
- Spray bottle filled with water
- Assorted powdered drink mixes

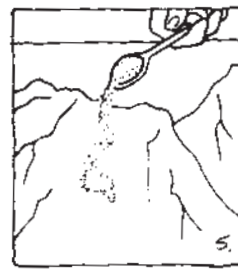
*Directions:*

1. Crumple the newspaper and place it into waterproof box.
2. Cut the trash bag to create a single sheet of plastic and cover the crumpled newspaper to form mountains and valleys. This is now your landscape.
3. Using the spray bottle, spray the landscape with a light mist to simulate rain.
4. Observe where the water goes. Find a large pool of water, or a bay, in your landscape. The whole area in your landscape that drains into this bay is called a watershed.
5. Sprinkle different colors of drink mix onto your landscape. This simulates sources of non-point source pollution: lawn fertilizers, pesticides, road salt and other pollutants. Such pollutants mix with rainwater and are carried into lakes, rivers, streams and oceans. Spray again, and watch the pollution run into the bay.
6. Separate the ridges that divide different watersheds in your model, and count them.

*Discussion Topics:*

- Where does the water drain when you spray it on top of a mountain?
- What happens to the drink mix? Where does it end up?
- How would this affect a real bay or lake?
- Which watershed do you live in? Where does the water you use end up?
- How has runoff from these areas affected the body of water near you?
- Discuss non-point source pollution as the biggest source of pollution in coastal areas.

### Watershed Activity





## OBSERVATION AND SENSORY FIELD ACTIVITIES

### HUMAN TIDE CHAIN

*Objective: To observe the change in incoming or outgoing tide.*

*Materials:*

- Long stick

*Directions:*

1. Identify a specific fixed object above the high tide line.
2. Have students form a line beginning at that point (the first student's foot should be placed directly next to the fixed object).
3. Have students take hands of the two people on either side of them, extending the line to the water's edge, with arms spread widely apart.
4. Count the number of students it takes to create a line between the fixed object and the edge of the water. Remember that number.
5. At the end of the day, repeat this activity to determine whether the tide has come in or gone out.
6. Variation: Use a long stick to mark the tide level and check it periodically to monitor the movement of the tide. Record times and distances.

*Discussion Topics:*

- What is a tide?
- Discuss number of tidal changes in a 24-hour cycle.
- What causes the tide to be high and low?
- What is a wrackline and how does it get there?
- What is the average difference between high and low tide in Boston Harbor?

### PERSONAL PERIWINKLE

*Objective: To encourage students to use their senses and develop meticulous observation skills.*

*Materials:*

- Bowl to hold periwinkle shells
- Periwinkle shells (a few more periwinkle shells than students)

*Directions:*

1. Distribute one periwinkle shell to each student.
2. Instruct each person to examine his/her periwinkle shell for 2 minutes and record specific details about the specimen using notes and/or drawings.
3. Collect all the periwinkle shells and add a few new periwinkle shells to the bowl.
4. Have the students try to pick out their own periwinkle shells.

*Variation:* Ask students to exchange descriptions and attempt to find their partners' periwinkle shell using these notes and drawings.

*Discussion Topics:*

- When trying to distinguish one periwinkle shell from another, what do you look for?
- What features of the shell did you notice that helped to identify a particular one?
- How does this activity foster the skills that scientists use to do their work?

### SOUND INVENTORY

*Objective: To become aware of surrounding noises.*

*Materials:*

- Index cards
- Pencils

*Directions:*

1. Have the students sit far enough apart to feel alone.
2. For one minute, have them sit with their eyes shut, and tell them to listen carefully and hold up one finger for every sound they hear.
3. Variation: Have students sit silently for one minute and mark the direction of the sounds they hear on an index card.

*Discussion Topics:*

- Could you identify each of the sounds you heard?
- Did you hear any animals in close proximity to you?
- Were there more natural sounds or human-made sounds?

## SUBMERSIBLE MYSTERY

*Objective: To develop listening, observation and description skills.*

### Materials:

- Container filled with miscellaneous wrackline artifacts (shells, crab molts, etc.)
- Clipboards
- Paper and pencils

### Directions:

1. Give students the following scenario:  
"Imagine you are in a research submersible with other scientists. You have just spotted what you believe to be an unidentified species. Since your colleagues are unable to turn around and look out your window because of the close quarters, you must describe what it looks like to the others."
2. Have one student sit so his/her back is facing the group.
3. That student, the Chief Scientist, chooses an object from the container without allowing anyone else to see it.
4. The other students hold a clipboard with paper and a pencil.
5. Have the Chief Scientist describe the object to the others without naming actual parts (*i.e. claw, shell, twig*), but rather by making analogies (*i.e. it is shaped like a teardrop, it looks like a worm*). The Chief Scientist may use measurements and may compare the object to other objects.
6. The others sketch as the Chief Scientist describes the object.
7. When a student thinks he/she knows what the object is, he/she can make a guess.
8. If the student is correct, the Chief Scientist will show the object and the artist can compare it to his/her drawing.
9. Variation: Have the students pair up and sit back to back. One student can describe the object while the other one draws it.

### Discussion Topics:

- Discuss parts of the mystery object.
- How did the Chief Scientist come up with descriptions without giving away its identity to the others?
- What did you learn about the challenges of listening to drawing directions without any visual guidance?

## FOCUS STATION ACTIVITIES

### INVESTIGATING TRANSECTS

*Objective: To survey populations and zonation in the intertidal community.*

### Materials:

- Journals
- Pencils
- Rope loops (1 ft. diameter) or hula hoops
- Hand lenses
- Thermometers
- String

### Directions:

1. Demonstrate how to set up transects before going out in the field.
2. Once in the field, divide students into small working groups.
3. Give each group a loop of rope, journals and pencils.
4. Run several transect lines from low to high tide with string, marking each at every 10 feet (3 m). Be careful not to hurt the animals along the way.
5. Find an area to lay the rope loop or hula hoop down in one of the designated habitat zones.
6. Count the distribution of organisms and conditions, focusing on just the section within the rope circle.
7. Record data on plants, animals and the conditions found within the survey area.
8. If time allows, have students sample different areas in the habitat. Take temperature readings at the different areas and make comparisons.
9. *Variation:* Have students draw a map to record information about the plant and animal populations.

### Discussion Topics:

- What organisms inhabit each zone?
- How are the organisms adapted differently?
- Discuss the distribution changes over the tide zones.
- Can you identify zones by color or by the types of organisms found there?
- Did you see any signs of competition for space?
- What was common to two different areas? Different? Why?
- Did you find anything surprising?
- Did you find anything human-made? If so, where did it come from?
- What would happen if you moved animals and algae from one area to another?
- As a wrap-up, present your data to the group using a graph, map or mural.

**MOUNTING MARINE ALGAE (SEAWEEDS)*****Be sure to check site collection policies first!***

*Objective: To observe, preserve and identify species of algae to make a herbarium (a collection of pressed and mounted specimens, used by botanists).*

***Materials:***

- Marine algae (seaweeds)
- Tray or lid
- 4x6 index cards
- Toothpicks
- Eyedroppers
- Pencils

***Directions:***

1. Have students collect samples of various types of marine algae.
2. Float them in a shallow tray or lid.
3. Spread the algae as thin as possible. Ideally you want one layer of thickness without overlapping.
4. Have each student write his/her name on the back of an index card.
5. Slide the cards underneath the algae.
6. Use toothpicks to help slide the algae onto the card to spread it out.
7. Carefully tilt or lift the card to let the water run off.
8. The algae should stick to the card.
9. *Variation:* Take a closer look by classifying algae by shape, size and color categories.
10. Use field guides to identify the type of algae and seaweed. Include additional information on the index card such as species name, type, date and place collected.
11. Have students research products made with seaweed and share information with one another.

*Note:* Seaweeds are covered with natural glue called "mucin" and will stick to index cards without glue. Lay the card flat, algae side up, so it can air dry.

Thick seaweeds, such as rockweed (*Fucus* sp.) must be pressed and weighted to dry. After the seaweed is on the index card, cover it with a thin cloth, then sandwich it between layers of folded newspaper. Flatten with a plant press or under bricks for several days.

***Discussion Topics:***

- Are these species of algae found year round or only seasonally?
- Where else could they be found geographically?
- What are some adaptations that allow seaweed to survive?
- How does its shape help it to survive/adapt?
- How do we use seaweed in our daily lives?

**PLANKTON INVESTIGATION**

*Objectives: Collect, observe and identify zooplankton; to understand ocean food webs and life cycles.*

***Materials:***

- Plankton net (see **Making a Plankton Net Pre-Trip Activity** p. 29)
- Microscopes
- Microscope slides
- Transfer pipette
- Plankton Identification Sheet (p. 43) or other plankton guide

***Directions:***

1. Tow plankton net by hand off of a dock or pier, in a tidal creek or while wading in shallow water. The fine mesh strains tiny zooplankton into the bottle at the end of net.
2. Use a pipette to transfer specimens to slides.
3. Using the Plankton Identification Sheet, identify what you found.

***Discussion Topics:***

- What types of zooplankton did you find?
- Which ones are a larval stage of a fish or invertebrate?
- What adaptations do plankton have to stay afloat?
- What does zooplankton eat?
- What animals feed on zooplankton?

**INVESTIGATING PHYSICAL AND CHEMICAL PROPERTIES OF WATER**

Coastal field trips offer the opportunity for hands-on water investigation. Water quality investigations in the field are best applied within the framework of an ongoing classroom curriculum unit. For more information on water testing, including teacher workshops and test kit loans, contact the Massachusetts Water Resources Authority (School Education Programs) at (617) 788-4643.

## SAND SAMPLING

*Objectives: To observe sand particles and identify their origins; to understand the process of beach formation.*

### *Materials:*

- Sieves of different sizes
- Magnifying glasses
- Small containers
- Field guides
- Clipboards and pencils
- Glue or double-sided tape
- Index cards

### *Directions:*

1. Have students brainstorm about how sand is made. Talk about the two different types of sand, abiogenic (from erosion of rocks) and biogenic (from animal and plant remains).
2. Divide the students into pairs.
3. Give each student a magnifying glass.
4. Have students record observations in their journals, particularly documenting the different-shaped sand particles.
5. Students can collect sand samples by using glue or double-sided tape on index cards.

### *Discussion Topics:*

- What shapes of sand did you find?
- What was the most common type of sand?
- How many different components of sand did you find (mica, quartz, sea urchin, barnacle fragments)?
- How much of your sand sample is biogenic and how much is abiogenic?

## WRACKLINE SORT

*Objectives: To learn about sorting and categorizing items found in the wrackline by similarities and differences; to introduce concepts of taxonomic classification and identification.*

### *Materials:*

- Small items scavenged from the wrackline such as shells, molts, plastic debris, driftwood, algae, grasses, etc.

### *Directions:*

1. Have students collect an assortment of wrackline items.
2. Divide students into small teams, and challenge each team to arrange their items into two sub-groups in 45 seconds.
3. Share results and criteria used.
4. Now ask students to divide each sub-group of wrackline items into as many categories as they choose in 60 seconds.
5. Share results and criteria used.
6. *Variations:*
  - Phylum Search:* Have students organize wrackline items by phylum.
  - Alphabet Museum:* Have students find and present their collection of items collected alphabetically; i.e. algae, barnacle, crab, dog whelk, etc.
  - Head of the Class:* Challenge students to quickly brainstorm and divide themselves into two groups based on similarities and differences (example: "boys and girls"). Now three ("brown, blue, hazel eyes"). Now four (blonde, brown, black, red hair), etc.

### *Discussion Topics:*

- How did the group choose their criteria for sorting?
- What were shared similarities for each subgroup? Differences?
- Is there more than one way to categorize?
- How do scientists compare and classify organisms?

## HABITAT BASED WRAP-UPS

### BEACH CLEAN-UP

*Objective: To learn about different types of marine debris found at the beach and the threats that this type of pollution has on marine life.*

*Materials:*

- Beach clean-up data sheet (see p. 40)
- Latex gloves
- Garbage bags
- Clipboards and pencils

*Directions:*

1. Divide the students into pairs.
2. Hand out a beach clean-up data sheet to each pair.
3. Have one person record data and the other person collect debris (using latex gloves).
4. Remind students that certain things should not be picked up, such as sharp metal objects, needles and other medical waste, sharp glass and dead animals.
5. Gather the students and discuss findings.

*Note: Be sure to make arrangements to dispose of trash with the site manager, or be prepared to bring it home with you.*

*Discussion Topics:*

- What types of debris did you find?
- What was the most commonly found item?
- How much debris did the group collect?
- Did the amount you collected surprise you?
- Do you think a beach clean-up is an effective way to solve pollution and contamination problems? List more effective ways to address pollution and contamination issues.
- Discuss pollution sources.

### MAKE A FIELD GUIDE

*Objective: To encourage students to use their observation, research, writing and artistic skills to create a field guide representing a specific habitat.*

*Materials:*

- Clipboards
- Paper
- Pencils
- Construction paper
- Stapler
- Colored pencils and markers
- Field guides

*Directions:*

1. Focusing on a specific habitat, have students choose an organism from that habitat to study.
2. Find an example at the site.
3. Observe and sketch the organism.
4. Research interesting facts about the organism using field guides. Use multiple resources to verify the information is accurate.
5. Have students use this information to create their pages in the field guide.
6. Copy and distribute all the pages to each student.
7. Make construction paper covers and use colored pencils and markers to complete the guide.

*Discussion Topics:*

- How did you represent different organisms?
- Did you learn anything new by observing and researching?
- If you had chosen only to research or only to observe, how would the field guide be different?
- Could you share the information in the guide with another audience? Who?

The Massachusetts Coastal Zone Management (CZM) Office coordinates an annual "Coastsweep" event focused on cleaning up our beaches. The primary clean-up day is usually a Saturday in mid-September. However, CZM will support school beach clean-up projects anytime during the Coastweeks period (third Saturday in September through Columbus Day). Supplies include data collection cards, latex gloves, garbage bags and background information. If you are interested in participating, contact the CZM Coastsweep Coordinator, 100 Cambridge Street, Boston, MA 20022 or call (617) 727-9530.

## NATURE JOURNALS

*Objectives: To gain an understanding of the importance of using a journal to record observations, sketch or reflect; to integrate literacy and fine arts with life science study, enhance appreciation for nature, reflection and self-expression.*

*Materials:*

- Paper or notebook
- Pen or pencil

*Directions:*

1. Explain the use of journals to practice observation, writing and drawing skills.
2. Emphasize that the goal of drawing is to look closely.
3. Establish a format for recording observations to include: date, place, time of day, weather conditions, observations, sketches, field guide research entries.
4. Have students use their journals in the field to record observations on topics such as tidepool organisms, shore bird behaviors, beach botany and poetry.

*Discussion Topics:*

- What methods do scientists use to observe plants and animals in their habitats?
- What did you particularly notice as the result of being a good observer?
- What will you most remember about this day?

## WHAT IS YOUR WETLAND I.Q.?\*

*Objective: To understand the useful services salt marshes provide by using symbolic objects.*

*Materials:*

- Sponge: absorbs excess water caused by runoff; retains moisture for a long time and helps control flooding
- Pillow: resting place for migratory birds
- Eggbeater: mixes nutrients and oxygen into the water
- Cradle: provides a nursery that shelters, protects, and feeds juveniles
- Strainer: strains silt and debris from the water
- Filter: salt marsh vegetation filters small impurities from the water
- Antacid: neutralizes toxic substances
- Cereal: provides nutrient-rich foods

*Directions:*

1. Divide students into groups.
2. Give each group a box filled with the items above (or with pictures of the items). Ask the students to relate these items to the functions of the salt marsh. Give them a time limit.
3. Gather the students together and review their findings.

*Discussion Topics:*

- What are the major functions of a salt marsh?
- How does a salt marsh perform these functions?
- Why are these functions important?
- How are salt marshes threatened?
- What are we doing to protect salt marshes?

\* Used with permission from Wetlands, Wildlife and You!  
U.S. Government Printing Office, Pub # 1990-700-753

## SHARING CIRCLE

*Objectives: To allow the students the opportunity to share information with each other; to find out what activities the students liked and didn't like to help with future planning.*

*Directions:*

1. Have the students sit in a circle.
2. Have one person start by sharing what he/she learned, observed, collected or would like to do next time.

*Discussion Topics:*

- What was your favorite part of the day?

## REINFORCING GAMES

### HABITAT RELAY

*Objective: To reinforce the information learned about habitats.*

*Materials:*

- Animal ID cards for sandy beach, rocky shore and salt marsh
- 6 buckets

*Method:*

1. Label two buckets "sandy shore," two "rocky shore" and two "salt marsh."
2. Divide the students into two groups and have them form two lines, and place three buckets for each team a few yards in front of the lines.
3. Have the first two people in line pick up animal cards and run to drop the cards in the appropriate buckets (sandy beach, rocky shore or salt marsh).
4. The winning team will have matched the most animals to the correct habitats in the least amount of time. Accuracy is more important than speed.

*Discussion Topics:*

- While reviewing card placement after the relay, ask students why each animal can survive in that particular habitat.
- Why can some live in all three habitats and some can only live in one?

### WHO AM I?

*Objective: To encourage creative thinking among the students when trying to identify animals that belong in a particular habitat.*

*Materials:*

- Index cards for each student
- Tape or safety pins
- Marker

*Directions:*

1. Label each index card with an organism.
2. Tape or pin an organism card to each student's back.
3. Divide students into pairs and have them stand face to face.
4. Discuss questions that will help to determine what is pinned to their backs.
5. Have students try to guess what organism is pinned to their backs by asking their partner questions about their organism.
6. Questions can only be answered by "yes," "no," or "it doesn't matter" responses.

*Discussion Topics:*

- What are the basic features of living organisms?
- What enables them to survive in their habitats?
- What are some characteristics that distinguish organisms from one another?

## CLASSROOM FOLLOW-UP ACTIVITIES

### INVENT AN INVERTEBRATE\*

*Objective: To design and create an animal out of various materials (recycled, arts & crafts) that has special adaptations to survive the demands posed by their intertidal habitat.*

*Materials:*

- Miscellaneous art, craft or recycled materials, (i.e. pipe cleaners, toothpicks, foam packing, colored paper, cotton swabs, yarn, tubes, egg cartons etc).
- Invent-an-Invertebrate worksheet
- Markers and pencils

*Method:*

1. Have the class brainstorm a list of the challenges an organism faces living in a coastal habitat. You may want to distinguish between challenges faced in any coastal habitat and challenges unique to specific habitats; for example: "avoiding being eaten—all habitats," "avoiding being washed away by waves—rocky and sandy coast habitats."
2. Challenge students to design and construct (with the materials provided) a never-before-seen animal or plant that is adapted to the conditions and challenges of the specific habitat recently visited (sandy, rocky, salt marsh or tidal mudflat).
3. Use the Invent-an-Invertebrate worksheet (see p. 42) to describe the organism and its adaptations.

*Discussion Topics:*

- Why are adaptations important?
- How do animals use adaptations?
- What adaptations did you create for the new organisms?
- How did you decide what to create?
- What factors did you consider?

\* Adapted from New England Coastlines, New England Aquarium Education Department Curriculum Guide (1996).

### THE WAVE\*

*Objective: To gain an understanding of how rocky shore animals are adapted to withstand the physical impact of waves.*

*Materials:*

- Small plastic bag filled with 4 lbs of birdseed (or rice)
- String
- Index cards or card stock
- Scissors
- Masking tape
- The Wave worksheet (p. 48)

*Directions:*

1. Have students invent a new rocky coast organism with the materials provided.
2. Explain that their organism should be able to withstand "the wave" (i.e., the plastic bag filled with 4 pounds of birds seed being dropped on them).
3. Have students think about different animals and plants that live on the rocky coast to get ideas about how to build their organism.
4. Before they start building, have students write down their ideas on The Wave worksheet (see p. 48).
5. Working in pairs or individually, have students design and build their own organisms.
6. Gather the students together after they have completed their organisms.
7. Test each organism by dropping "the wave" bag from a height of 5ft. on it. Record the results on the worksheet.
8. This activity can be used to extend the Invent-an-Invertebrate activity – after they have invented their invertebrates, have students subject them to The Wave.

*Discussion Topics:*

- What are the challenges of living in a high energy wave zone?
- What organisms did you find during the field trip that share the same adaptations as your invented organism?

\* Adapted from New England Coastlines, New England Aquarium Education Department Curriculum Guide (1996).



# ANIMAL OBSERVATION SHEET

Your Name: \_\_\_\_\_

Name of Animal: \_\_\_\_\_

What habitat does this animal live in? \_\_\_\_\_

**1** Observe your animal for two minutes and record three behaviors.

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_

**2** List three favorite facts about your animal based on field guide research.

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_

**3** List your questions for further investigation about your animal based on your observations.

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_

**Items Collected** You may find it helpful to work with a buddy as you clean the beach, one of you picking up trash and the other taking notes. An easy way to keep track of the items you find is by making tick marks. The box is for total items. See example below.

**Example:** egg cartons |||| |||| |||| || 17 cups |||| |||| |||| 15

**BEACH CLEAN-UP DATA SHEET**

**PLASTIC**

<p><b>Bags</b></p> <p>foodbags/wrappers <input type="checkbox"/></p> <p>trash <input type="checkbox"/></p> <p>salt <input type="checkbox"/></p> <p>other bags <input type="checkbox"/></p> <p><b>Bottles</b></p> <p>beverage, soda <input type="checkbox"/></p> <p>bleach, cleaner <input type="checkbox"/></p> <p>milk/water gal. jug <input type="checkbox"/></p> <p>oil lube <input type="checkbox"/></p> <p>other bottles <input type="checkbox"/></p> <p>buckets <input type="checkbox"/></p> <p>caps, lids <input type="checkbox"/></p>	<p>cigarette filters <input type="checkbox"/></p> <p>cigarette lighters <input type="checkbox"/></p> <p>cups, utensils <input type="checkbox"/></p> <p>diapers <input type="checkbox"/></p> <p>fishingline <input type="checkbox"/></p> <p>fishing lures, floats <input type="checkbox"/></p> <p>fishing nets <input type="checkbox"/></p> <p>hard hats <input type="checkbox"/></p> <p>light sticks <input type="checkbox"/></p> <p>pieces <input type="checkbox"/></p> <p>Pipe thread protector <input type="checkbox"/></p> <p>rope <input type="checkbox"/></p>	<p>sheeting <input type="checkbox"/></p> <p>longer than 2 feet <input type="checkbox"/></p> <p>2 feet or shorter <input type="checkbox"/></p> <p>6-pack holder <input type="checkbox"/></p> <p>strapping bands <input type="checkbox"/></p> <p>straws <input type="checkbox"/></p> <p>syringes <input type="checkbox"/></p> <p>tampon applicators <input type="checkbox"/></p> <p>toys <input type="checkbox"/></p> <p>vegetable sacks <input type="checkbox"/></p> <p>"writing protection" rings <input type="checkbox"/></p> <p>Other plastic (specify) <input type="checkbox"/></p>
---	---	--

**STYROFOAM® (or other plastic foam)**

<p>buoys <input type="checkbox"/></p> <p>cups <input type="checkbox"/></p> <p>egg cartons <input type="checkbox"/></p> <p>fast food containers <input type="checkbox"/></p>	<p>meat trays <input type="checkbox"/></p> <p>packaging materials <input type="checkbox"/></p> <p>pieces <input type="checkbox"/></p> <p>plates <input type="checkbox"/></p>	<p>other Styrofoam® (specify) <input type="checkbox"/></p> <p>_____</p> <p>_____</p> <p>_____</p>
---	--	---

**GLASS**

<p><b>Bottles</b></p> <p>beverage, soda <input type="checkbox"/></p> <p>food jars <input type="checkbox"/></p> <p>other bottles/jars <input type="checkbox"/></p>	<p>fluorescent light tubes <input type="checkbox"/></p> <p>light bulbs <input type="checkbox"/></p> <p>pieces <input type="checkbox"/></p>	<p>other glass (specify) <input type="checkbox"/></p> <p>_____</p> <p>_____</p>
---	--	---

**RUBBER**

<p>balloons <input type="checkbox"/></p> <p>condoms <input type="checkbox"/></p>	<p>gloves <input type="checkbox"/></p> <p>tires <input type="checkbox"/></p>	<p>other rubber (specify) <input type="checkbox"/></p> <p>_____</p> <p>_____</p>
--	--	--

**METAL**

<p>bottle caps <input type="checkbox"/></p> <p>cans</p> <p>aerosol <input type="checkbox"/></p> <p>beverage <input type="checkbox"/></p> <p>food <input type="checkbox"/></p> <p>other <input type="checkbox"/></p>	<p>crab/fish traps <input type="checkbox"/></p> <p>55 Gallon drums <input type="checkbox"/></p> <p>rusty <input type="checkbox"/></p> <p>new <input type="checkbox"/></p> <p>pieces <input type="checkbox"/></p> <p>pull tabs <input type="checkbox"/></p>	<p>wire <input type="checkbox"/></p> <p>other metal (specify) <input type="checkbox"/></p> <p>_____</p> <p>_____</p>
---	--	--

**PAPER**

<p>bags <input type="checkbox"/></p> <p>cardboard <input type="checkbox"/></p> <p>cartons <input type="checkbox"/></p>	<p>cups <input type="checkbox"/></p> <p>newspaper/magazines <input type="checkbox"/></p> <p>pieces <input type="checkbox"/></p>	<p>plates <input type="checkbox"/></p> <p>other metal (specify) <input type="checkbox"/></p> <p>_____</p>
--	---	---

**WOOD (leave driftwood on the beach)**

<p>crabs/lobster traps <input type="checkbox"/></p> <p>crates <input type="checkbox"/></p>	<p>lumber pieces <input type="checkbox"/></p> <p>pallets <input type="checkbox"/></p>	<p>other metal (specify) <input type="checkbox"/></p> <p>_____</p>
--	---	--

**CLOTH**

clothing/pieces

## COASTAL SCAVENGER HUNT

Find the items listed below. You may use the same answer more than once. Please find your items by recording and observing, rather than collecting. If you do pick up an animal or other object, be sure to return it to where you found it. Do not pick any plants or leaves. Ask your group leader before picking up any object you can't identify.

### ON THE SHORE FIND:

Six different types of human litter and explain how it got here (example: Balloon: floated over)

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_

- |   |   |
|---|---|
| <input type="radio"/> Part of an egg or egg case  | <input type="radio"/> A red algae   |
| <input type="radio"/> Three bivalves _____, _____, _____  | <input type="radio"/> A holdfast attached to a rock or shell                    |
| <input type="radio"/> A living crustacean   | <input type="radio"/> A living dog whelk  |
| <input type="radio"/> An animal that spends part of its time in the water and part of its time on land  | <input type="radio"/> A piece of driftwood shaped like an animal                |
| <input type="radio"/> An animal (or parts) found on the beach that was/were tossed in from deeper water | <input type="radio"/> An animal that blends into its surroundings               |
| <input type="radio"/> An animal that uses another animal's empty shell for protection                   | <input type="radio"/> An animal that can regenerate (grow back) missing limbs.  |
| <input type="radio"/> A rock with a white line all the way around it                                    | <input type="radio"/> An animal that might be on the menu at a local restaurant |
| <input type="radio"/> A crab molt   | <input type="radio"/> An animal with spiny skin                                 |
| <input type="radio"/> A sea urchin  | <input type="radio"/> An animal whose mouth is on the underside of its body     |
| <input type="radio"/> A living sea star   | <input type="radio"/> An animal that spends most of its time on the bottom      |
| <input type="radio"/> A living periwinkle   | <input type="radio"/> An animal that is attached to something else              |
| <input type="radio"/> A slipper shell   | <input type="radio"/> An animal that has no bones                               |
| <input type="radio"/> A seaweed with air bladders   | <input type="radio"/> An animal that eats other animals                         |
| <input type="radio"/> Sea lettuce   | <input type="radio"/> An animal that is a scavenger                             |
| <input type="radio"/> The biggest piece of kelp that you can find                                       | <input type="radio"/> An animal that is a filter feeder                         |

## INVENT AN INVERTEBRATE

Draw your organism here:



*I am called a:* \_\_\_\_\_

*My habitat is:* \_\_\_\_\_

*I was discovered by a scientist named:*  
\_\_\_\_\_

*I get my food by:* \_\_\_\_\_  
\_\_\_\_\_

Here is a picture of my food:



### ***Other adaptations I have are:***

*To avoid being eaten* → \_\_\_\_\_  
\_\_\_\_\_ → \_\_\_\_\_  
\_\_\_\_\_ → \_\_\_\_\_  
\_\_\_\_\_ → \_\_\_\_\_



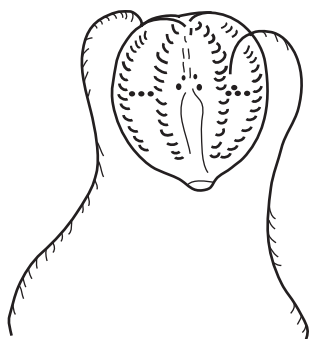


## PLANKTON IDENTIFICATION

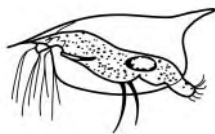
Planktonic organisms are floating or weakly-swimming plant-like organisms (**phytoplankton**) and animals (**zooplankton**) that drift at the mercy of the ocean's currents. Plankton are not necessarily tiny. Drifters such as sea jellies and sunfish are examples of large plankton (**megaplankton**).

Holoplankton are zooplankton that remain planktonic (free-floating) throughout their lives. Meroplankton are larval animal stages that develop into non-planktonic adults.

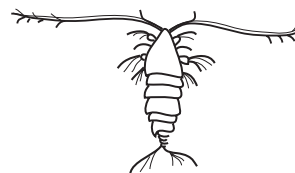
### HOLOPLANKTON



Ctenophore

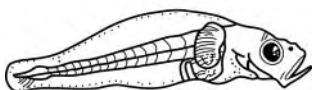


Ostracod



Copepod

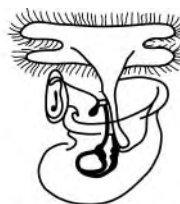
### MEROPLANKTON



Fish larva



Ephyra larva  
of Moon Jelly



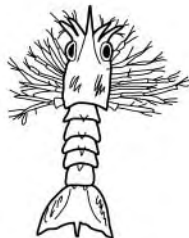
Veliger larva  
of gastropod



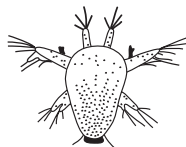
Zoea larva of crab



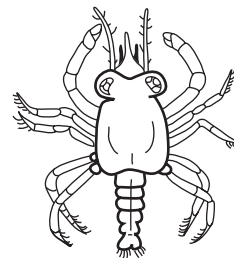
Echinopluteus larva  
of sea urchin



Mysis larva  
of lobster



Nauplius larva  
of barnacle



Megalops larva of crab

*Illustrations are not to scale, adapted with permission from Martek Instruments Inc., P.O. Box 97067, Raleigh, North Carolina 27624-7067. May be reproduced for educational purposes.*

**TIDEPOL ANIMAL WORKSHEET (p. 1)**

<b>ANIMAL NAME</b>	<b>How Does It Move?</b>	<b>What Does It Eat?</b>	<b>How Does It Grow?</b>	<b>Where Is It Found?</b>	<b>Does It Have Eyes? Where?</b>	<b>How Does It Protect Itself?</b>
<b>HERMIT CRAB</b>						
<b>HORSESHOE CRAB</b>						
<b>BLUE MUSSEL</b>						
<b>MOON SNAIL</b>						
<b>PERIWINKLE SNAIL</b>						
<b>DOG WHELK</b>						



ANIMAL NAME	How Does It Move?	What Does It Eat?	How Does It Grow?	Where Is It Found?	Does It Have Eyes? Where?	How Does It Protect Itself?
MUD WHELK						
NORTHERN ROCK BARNACLE						
SOFT SHELL CLAM						
QUAHOG						
ROCK CRAB						
GREEN CRAB						

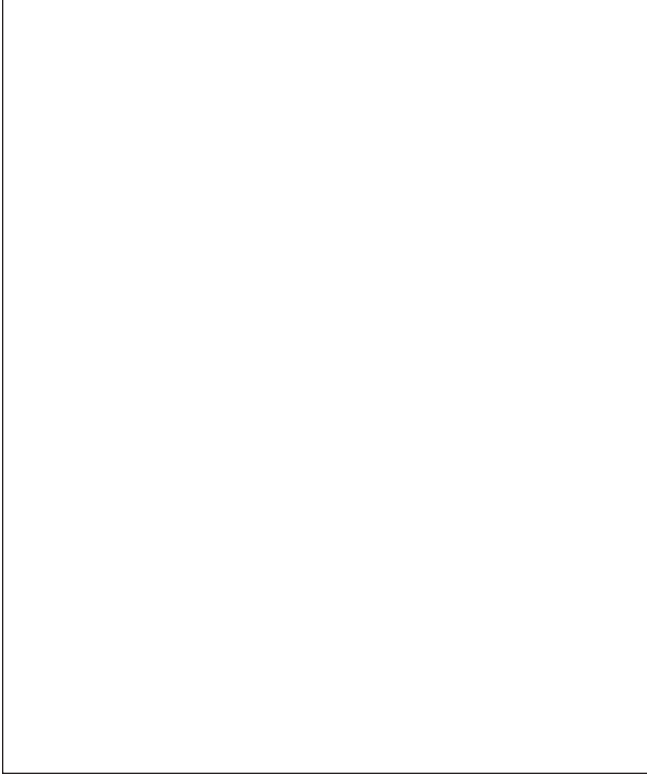
**TIDEPOL ANIMAL ANSWER SHEET (p. 1)**

<b>ANIMAL NAME</b>	<b>How Does It Move?</b>	<b>What Does It Eat?</b>	<b>How Does It Grow?</b>	<b>Where Is It Found?</b>	<b>Does it Have Eyes? Where?</b>	<b>How Does It Protect Itself?</b>
<b>HERMIT CRAB</b>	4 jointed legs and 4 grasping legs in shell	scavenger, feeds on dead flesh, uses mouth parts	molt exoskeleton, find new shells as they grow	shallow water, sandy or rocky, deep subtidal, too	yes, blue eyes on stalks	hides, claws, exoskeleton
<b>HORSESHOE CRAB</b>	jointed legs, uses tail to flip, turns upside-down to swim, waves gills	scavenger, uses front feet (chellicera) to transfer, grind and pass food to mouth	all arthropods molt exoskeleton	summer: shallow waters winter: deeper offshore	4 eyes on top (2 compound, 2 light sensitive)	hard shell, burrows in
<b>BLUE MUSSEL</b>	sedentary but has muscular foot	filter feeds 2 liters/hour	mantle produces annual rings, shows yearly growth	dense colonies or beds intertidally & subtidally	does not seem to respond to light	shell, clusters with other mussels, holds on with byssal threads
<b>MOON SNAIL</b>	large, slimy foot	acidic secretions, drill w/radula; proboscis is inserted, eat various snails	mantle secretes the limy shell	sandy or mud bottom	base of eye stalks, light sensitive	foot covers entire shell, secretes excessive mucus
<b>PERIWINKLE SNAIL</b>	muscular foot	eats algae; radula to scrape algae off rocks	mantle enlarges, shell secretes calcium carbonate	colonies in intertidal zone, rocky and mud flats	simple eyes detect light: base of tentacles	shell, operculum holds on
<b>DOG WHELK</b>	suctioned foot	carnivorous, feeds by drilling holes with proboscis	mantle secretes the limy shell	mostly intertidal zone	two eyes spots	shell, operculum holds on

<b>ANIMAL NAME</b>	<b>How Does It Move?</b>	<b>What Does It Eat?</b>	<b>How Does It Grow?</b>	<b>Where Is It Found?</b>	<b>Does It Have Eyes? Where?</b>	<b>How Does It Protect Itself?</b>
<b>MUD WHELK</b>	suctioned foot	detritus-feeder	mantle secretes the limy shell	muddy bottoms both intertidally & subtidally	two eye spots	shell, burrows in mud, camouflages w/bottom
<b>NORTHERN ROCK BARNACLE</b>	stationary, secretes strong glue	sweeps water w/jointed feet (cirri) to catch plankton	molt exoskeleton inside & secretes limy shell outside	colonies in intertidal zone	does not seem to respond to light	hard shell closes up, cement holds in place
<b>SOFT SHELL CLAM</b>	hatchet-shaped muscular foot	siphon tubes filter water, gills trap and transport food to mouth w/cilia	mantle secretes the limy shell, ridges on shell show yearly growth	intertidally and subtidally	does not seem to respond to light	burrows into mud or sand
<b>QUAHOG</b>	uses anterior foot	filter feeds; traps food with mucous-covered gills	grows quickly, can live for several decades	sandy or mud bottoms from intertidal to 60 ft.	does not seem to respond to light	hard shell, digs or burrows in sand or mud
<b>ROCK CRAB</b>	sideways manner using legs	scavenges, feeds on dead animals	molts exoskeleton	intertidal and subtidal rocky areas preferred	two eyes	hard shell, claws, camouflage
<b>GREEN CRAB</b>	sideways manner using legs	soft-shelled clams, claws capture and tear apart	molts exoskeleton	most common shore crab intertidally & subtidally	two eyes	hard shell, claws

## THE WAVE WORKSHEET

Draw your shape here:



**Before**



**After**

**Predict:**

Do you think this shape will survive? Why or why not?

*(What adaptations does your organism have to keep it from being crushed by waves?)*

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---

---

**Results:**

What happened when the wave was dropped on your shape? Why?

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## **APPENDIX B**

**1 ROCKY SHORE**

**2 SANDY BEACH AND WRACKLINES**

**3 SALT MARSH**

**4 TIDAL FLATS**

**5 FOULING ORGANISMS**



Photo / S. Padaver

**Investigating fouling organisms on a float.**

## THE ROCKY SHORE

Rocky shores include wave-battered boulders, grapefruit-sized cobbles and exposed bedrock. Rocky shores are common throughout New England, wherever bedrock outcrops at the shoreline or high energy waves remove the local glacial veneer. The mixture of mud, boulders, pebbles and cobble on the rocky shores of the Harbor Islands are the result of glacially-deposited landforms.

### PHYSICAL FEATURES

Rocks offer algae and animals a hard substrate on which to attach. This means that organisms with some method of attaching to hard surfaces find a ready home on the rocks. Many species of algae and animals are well-adapted to the constant variation in submergence, temperature, oxygen and salinity they experience as members of a rocky shore intertidal community. However, rather than a random arrangement of organisms in intertidal areas, we find the community organized into zones.

The average tidal exchange in Boston is 9.5 feet (3 m). Extreme spring tides exceed 12 feet (4 m). The diurnal rise and fall of the tides means that each part of the intertidal zone is covered with water for different lengths of time.

In addition to the variable living conditions of this zone, high energy waves are often part of the physical characteristics of a rocky shore. The waves challenge the animals' and algae's ability to hang on while providing oxygen and nutrients.

### IMPORTANCE OF ROCKY SHORE HABITATS

Habitats include the bare face of rocks, cracks and crevices, intertidal spaces between the algae and animals and tidepools. Micro-habitats on the hard rock surfaces are further modified by their exposure to the sun. Community composition may differ depending on amount of exposure to the sun. In addition to the communities living on the surface of rocks, where cobbles and boulders are the rule, different communities live under the rocks.

Tidepools, pools of water left in rocky crevices and depressions, can be found from the supratidal region (highest tide) down to the low water line. Tidepools are extremely variable environments. In the supratidal region, they are subject to evaporation, rainfall, temperature variation and contamination from seabirds and runoff. Pools at lower levels are subjected to much less variation but are still accessible to predators during low tide. As a general rule, the lower a tidepool occurs in the intertidal region, the more its inhabitants resemble the immediate subtidal communities.

### ZONATION OF THE ROCKY SHORE

The organisms of the rocky shore distribute themselves naturally according to their abilities to withstand desiccation and tolerate the variability of the habitat. This distribution of organisms results in wide horizontal bands, or zones, readily distinguished by the colors of the organisms living in them.

#### The Spray Zone

The spray zone is also called the black, supratidal or supralittoral zone. Just beyond the reach of the highest high tide is a slippery, gray-black zone that receives moisture only from the splash of waves at the highest tides, during storms or from rainfall. Its dark color is due to black patches of the Cyanobacteria (*Calothrix sp.*), also known as blue-green algae, although it is a bacteria not an algae. When dry, these colonies resemble oil splotches stuck to the rocks. But when wet they are very slippery, as they become physiologically active. Periwinkles venture into the lower parts of the spray zone. In this zone, we also find a few barnacles that eke out a living in the spray that falls there.

#### The Intertidal Zone

This encompasses the entire area between high, high water and low, low water lines, and contains several sub-zones: upper, middle and lower.

#### The Upper Intertidal/Periwinkle Zone

Also known as the periwinkle zone, the upper intertidal zone is located near the high tide line. This area is submerged regularly at high tide. The animals and algae that live here must be able to survive without water for ten to eleven hours at a stretch. Often the zone contains animals that can trap sea water and close out rain water while the tide is below them. Common species include: periwinkles, dog whelks, small blue mussels and a thin algal film. Where tidepools occur, there are often bright green colonies of *Cladophora sp.*, a filamentous green alga and *Enteromorpha sp.*, a tubular green alga. The green algae respond well to high levels of nitrogen and often signal waste pollution leaching into the intertidal region.

#### The Middle Intertidal/Barnacle-Rockweed Zone

Also known as the barnacle or rockweed zone, this band comprises the greatest part of the intertidal zone. In the Boston area it is dominated by two genera of brown algae, common rockweed (*Fucus sp.*) and knotted wrack (*Ascophylum nodosum*), also often called rockweed. *Fucus* is a flattened drab green color with a midrib running down the thallus. It often has swellings that may function as floats or reproductive structures. *Ascophylum* also is drab green but lacks the midrib and has regular swellings that always act as

floats. Common species aside from the dominant seaweeds include: common periwinkles (*Littorina sp.*), barnacles (*Balanus sp.*) blue mussels (*Mytilus edulus*), limpets (*Acmaea sp.*), slipper shells (*Crepidula fornicata*), sea stars (*Asterias vulgaris*) and a few worms living in mussel beds and seaweed turfs. Living on the algae we often find a tiny, coiled polychaete worm called Spirobis. When submerged, this worm has brightly-colored gills which project out into the water and disappear instantly when disturbed. Observe with a hand lens.

### The Lower Intertidal Zone/Irish Moss Zone

This area is just above the low tide mark. Here, the rockweeds are replaced by the red algae, Irish moss (*Chondrus crispus*). This area is exposed only at very low tides. Here we find well-developed beds of blue mussels and organisms that live in association with the mussels. Gently pry apart a few mussels and note the many worms and arthropods using the mussels for protection. Diversity here is greater than in the zones above. This is typical of a more stable and less stressed habitat. Low diversity and high density usually denote a highly-stressed environment.

### The Subtidal Zone/Kelp Zone

Except for the extreme spring tides of winter, this area is always underwater and is therefore much more stable than the rest of the rocky shore. The subtidal zone extends downward as far as sunlight can penetrate. This varies with the clarity of the water (turbidity). Large leathery kelps, soft filamentous red algae, red crustose algae, sea stars and sea urchins are commonly found here along with the typical fauna of New England nearshore waters.

### SPECIAL ADAPTATIONS/WHAT TO LOOK FOR

Whether rocky shore inhabitants live in tidepools or on exposed rocks, they all have to contend with waves, air exposure, and fluctuating temperatures and salinity. Periwinkles have hard, pointed shells to minimize the impact of crashing waves. A periwinkle's foot can hold tightly to the rock surface. They glue themselves to the rock with a sticky substance that seals them off from the dry air. Barnacles glue themselves to the rocks and other barnacles with an extremely strong glue. They, too, can close the plates that cover their opening to hold water while they are high and dry. Sea stars and sea urchins use their tube feet for suction. Seaweeds have special structures called holdfasts by which they attach to the rocks. A mussel has a special gland on its foot that secretes a protein that sticks to the rocks and forms the byssal threads by which they remain attached to the rocks and tether themselves together.

### NATURALIST NOTES

Among the many things to observe in the rocky intertidal zone are the algae that form the base of the food chain. The large seaweeds are conspicuous, however much less obvious are the splotches of red and pink on the rocks that represent encrusting red algae. Most of the gastropods (snails, limpets and chitons) graze on these films with a modified mouth structure called a radula. Look for grazing marks on the rocks. With a hand lens note the many smaller algae growing on the seaweeds. These are epiphytes and come from several phyla of algae. Along with algae, hydrazoans and bryozoans may live as epiphytes on the seaweeds. These are very beautiful when viewed with a 10x lens.

Slipper shells are frequently piled three and four deep on top of one another. Note that only the animal living in the bottom shell is female. All of the others are male. Should the female die, the first male changes sex to become a female (yes, slipper shells are hermaphroditic). Remove a pile of slippers from a rock and you may see clusters of eggs under the shell.

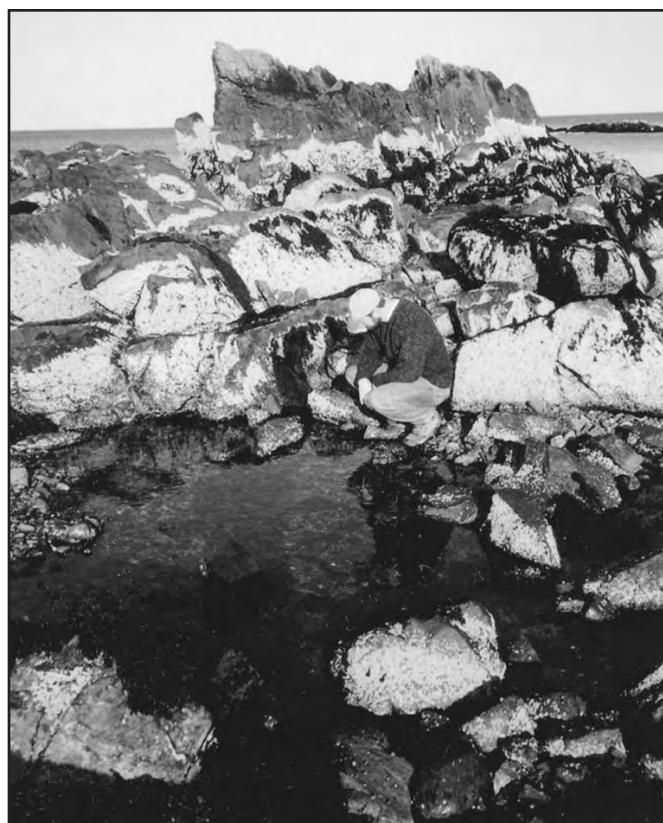
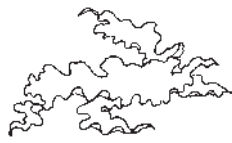


Photo / S. Paclaver

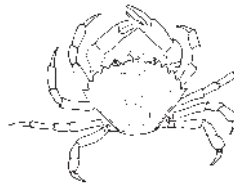
Rocky tidepools, Nantasket Beach, Hull, MA



**2,3** Rock Barnacle  
(*Balanus balanoides*)



**2** Sea Lettuce  
(*Ulva lactuca*)



**2,3,4** Green Crab  
(*Carcinus maenas*)



**2,3,4** Blue Mussel  
(*Mytilus edulis*)



**4** Irish Moss  
(*Chondrus crispus*)

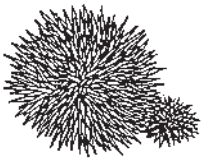


**2,3,4** Dog Whelk  
(*Thais lapillus*)

Egg Case



**2,3** Periwinkle  
(*Littorina Sp.*)

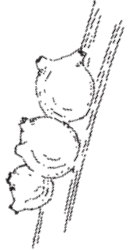


**5** Green Sea Urchin  
(*Strongylocentrotus droebachiensis*)

**1** spray or black zone

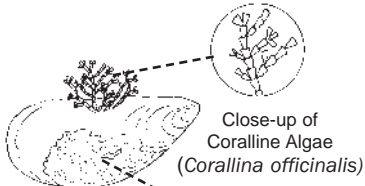
**2** upper intertidal or periwinkle zone

**3** middle intertidal or barnacle/rockweed zone



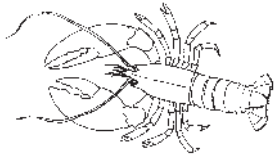
**5** Sea Grapes (*Molgula Sp.*)  
on Piling

**4** lower intertidal or Irish moss zone



**5** Bubblegum Algae  
(*Lithothamnium*)  
on Blue Mussel (*Mytilus edulis*)

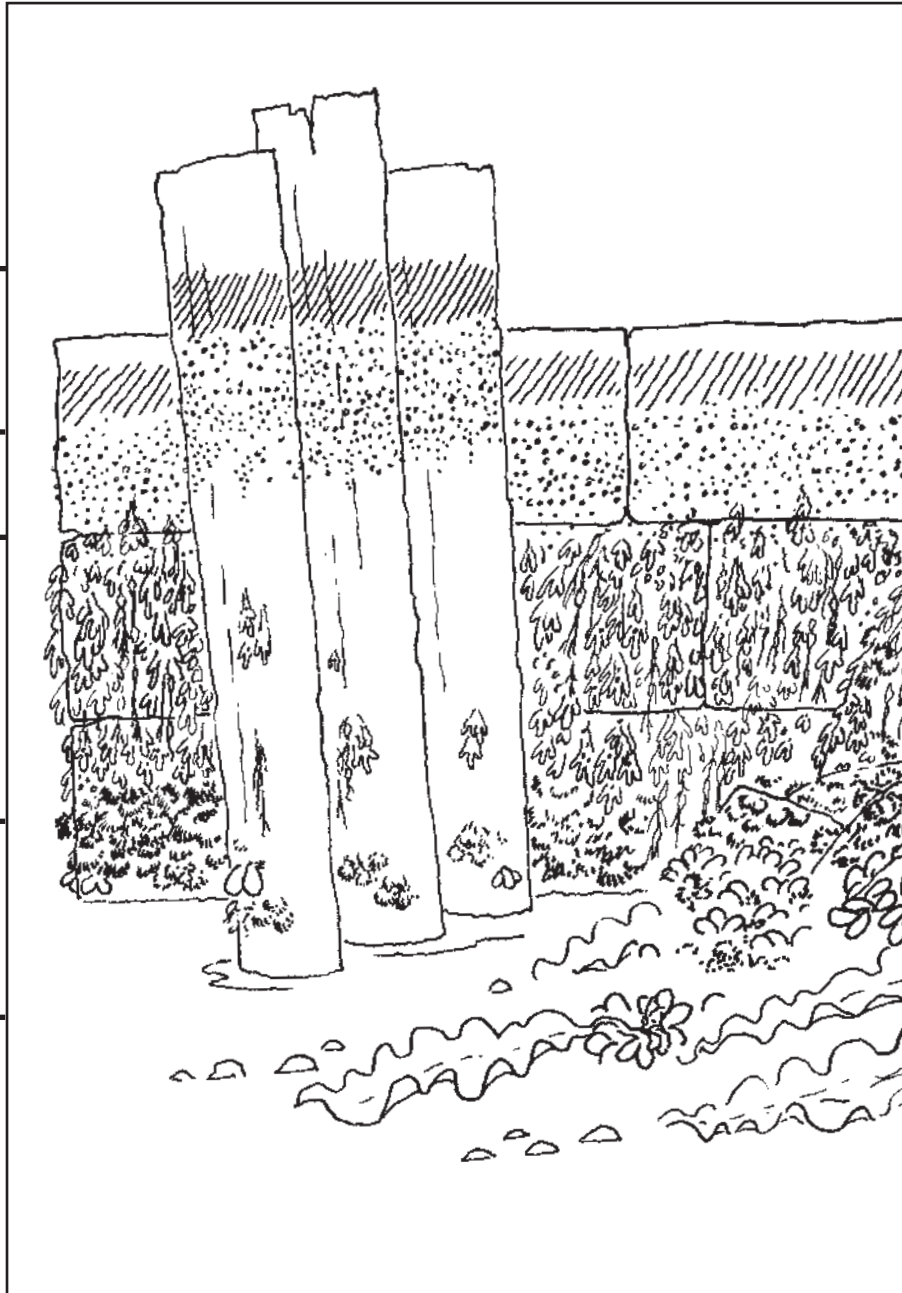
**5** subtidal or kelp zone



**5** American Lobster  
(*Homarus americanus*)



**5** Stalked Sea Squirt  
(*Botlenia ovifera*)



**5** Crumb of Bread Sponge  
(*Halichondria panicea*)



**5** Brown Kelp  
(*Laminana agardhii*)



**5** Sea Colander  
(*Agarum cribrosum*)



**5** Sea Vase  
(*Ciona intestinalis*)



**5** Northern Sea Star  
(*Asterias vulgaris*)

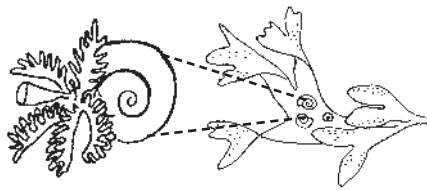




**3** Knotted Wrack  
(*Ascophyllum nodosum*)



**3** Left-coiled Tubeworm  
(*Spirobis borealis*)



**3** Right-coiled Tube Worm on Rockweed  
(*Spirobis spirillum*)



**3,4** Rock Crab  
(*Cancer irroratus*)



**3,4** Common Slipper Shell  
(*Crepidula fornicata*)



**3,4** Limpet  
(*Acmaea testudinalis*)



**3,4** Amphipod  
(*Gammarus sp.*)



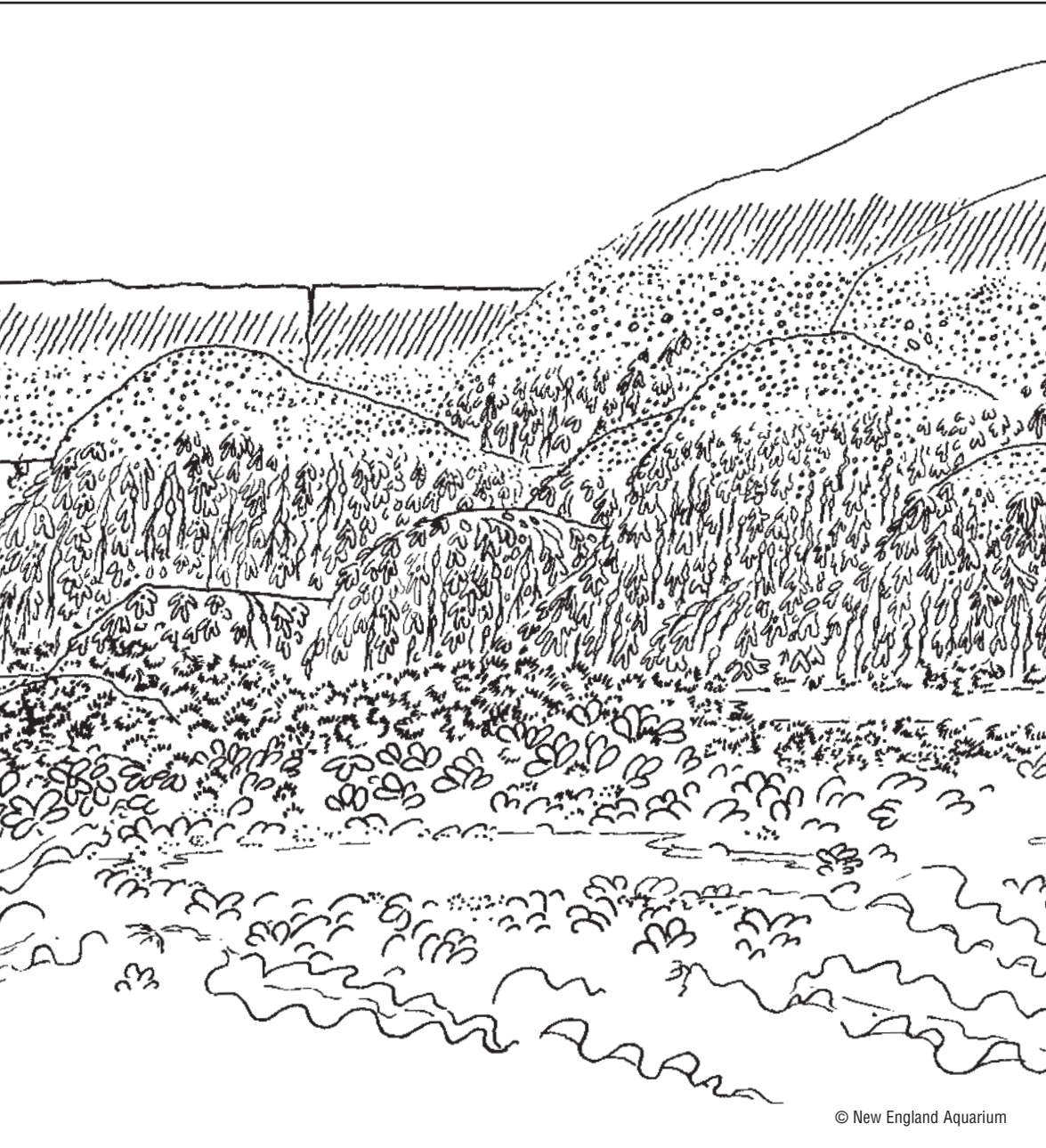
**3,4** Hermit Crab  
(*Pagurus sp.*)



**3** Rockweed  
(*Fucus sp.*)



**5** Club Tunicate or  
Rough Sea Squirt  
(*Styela partita*)



© New England Aquarium



**5** Golden Star Tunicate  
on Irish Moss



**5** Golden Star Tunicate  
(*Botryllus scholsseri*)



**5** Frilled Anemone  
(*Metridium senile*)



**5** Bushy Bryozoan  
(*Bugula turrita*)



**5** Sea Lace or Lacy Crust on Kelp  
(*Membranipora sp.*)



## SANDY BEACH AND WRACKLINES

### WHAT IS A BEACH?

A coastal beach is the zone of unconsolidated material extending from the lowest low water landward to the point of permanent vegetation or change in topography. Unconsolidated means "not cemented together." The beach is a constantly shifting, dynamic area.

Many of the beaches around Boston Harbor, particularly in East and South Boston, are artificially nourished with sand-sized sediment from sand and gravel quarries.

### ORIGINS

The beaches of Boston Harbor are composed of loose, broken rock material. Their color and composition varies depending on whether the material is delivered by streams or erosion of the coastal rocks nearby. In New England, the sand is mainly quartz, but also contains bits of most minerals found in the till brought here by the glaciers. Look carefully at a handful of sand with a hand lens and you will see black, green, red and brown grains in with the white or clear grains of quartz. As the sand ages, more of the colored grains dissolve and leave the quartz behind.

Our sands are very young. None is more than about 15,000 years old. The sands of the Caribbean are white because they are made of calcium carbonate pieces of algal and animal skeletons. In Hawaii some beaches are made of black volcanic sand. Beaches everywhere reflect the sediment of the area.

### BEACH STRUCTURE

The size of the particles of rock influence the structure of the beach. The zone from the lowest low water to the highest high water is called the beach face. This zone is controlled by the energy of the waves that attack the beach. In the high energy areas of the outer islands and headlands the beaches tend to be made up of gravel, pebbles and cobbles. On some islands with slate or schist bedrock the beaches are made of flat rocks called shingles. However, in the quiet inlets and bays the sediment is finer sand and mud. There is a relationship between sediment size and the slope of the beach face. The coarser the sand, the steeper the face angle. Watch for this effect from a distance, then check it out close up.

There is usually a change in slope at the top of the beach face. This is called the beach berm. It marks the beginning of the back beach. The back beach extends to the permanent vegetation or to the sea scarps (a cliff or steep slope) so common to New England. It is the width of this zone that changes throughout the year. As winter begins, the storm

waves excavate the beach and store the sand in near shore bars. This makes the beach narrow or even disappear completely. When the wave energy drops between storms or as summer comes on, these bars migrate onto the beach, making it wider. This process can be observed especially well at Revere Beach, Wollaston Beach and Nantasket Beach.

### LIFE ON THE BEACH

Most people think nothing lives on the beach, but this is far from true. The animals that live on the beach include the many birds that feed there and the very small animals that live burrowed into the sand or between the sand grains. Look at any beach and you will see lines of dead seaweed and other flotsam, called wracklines. Under and within these there is a microcosm of animals feeding on the decaying seaweed. Most common is the beach flea, or beach hopper (*Americhor, chestia sp.*). In the lower parts of the beach, soft-shelled clams (*Mya arenaria*) and Atlantic razor clams (*Ensis directus*) burrow into the substrate. Feeding on these are a number of birds including the great black-backed gull, the herring gull, the ring-necked plover, the sanderling, as well as various terns and sandpipers. Raccoons, skunks, white-footed mice, rats and possums also venture onto the beach to scavenge.

While the beach face and back beach are so dynamic that few plants can grow there, the dunes a few meters landward and above the highest storm waves are the home of pioneer plants such as dune grass (*Ammophila*), dusty miller (*Artemisia stelleriana*), beach pea (*Lathyrus japonicus var. glaber*) and cocklebur (*Xanthium echinatum*). These plants stabilize the dunes and enrich the sand base, making possible the typical coastal communities of salt spray rose (*Rosa rugosa*), bayberry (*Myrica pensylvanica*), seaside goldenrod (*Solidago sempervirens*), beach plum (*Prunus maritima*) and poison ivy (*Rhus radicans*). If undisturbed, the dunes will often become covered with poverty grass (*Hudsonia sp.*), which is actually not a grass but a heather. As soil develops on the dunes, ecological succession tends to produce the typical Eastern deciduous hardwood forest of the mature climax communities of New England.

### SPECIAL ADAPTATIONS/WHAT TO LOOK FOR

Animals that live in sandy shores have adaptations that allow them to live in this ever-shifting, unstable environment. Some animals, like the bivalves, have a foot that can be inserted in the sand and inflated with body fluids to secure them in the sand. To allow them to breathe while buried, they have a set of siphons or tubes that extend up into the water column when they are submerged. Many beach-dwellers are camouflaged to look like sand, such as crabs and small

crustaceans. Birds that nest on the beach such as plovers and sandpipers have protective coloration. Their nests are little more than depressions in the sand and their eggs are the color of sand. Between the grains of sand live a group of tiny worms called interstitial fauna. These are largely microscopic. Mole crabs (*Emerita talpoida*) and ghost crabs (*Ocypode sp.*) are active burrowers on the beaches south of Cape Cod.

Sandy soil does not hold moisture well, and the salt spray in the air can draw out the fresh water in plants. Beach peas curl their leaves during intense sun exposure to retain moisture. Beach grasses have adapted to these low moisture conditions by developing deep roots that tap into fresh water, and rhizomes that hold the sand in place when winds come, stabilizing the beach. Some plants, like beach peas, are legumes and “fix” their own nitrogen.

### Conservation Notes

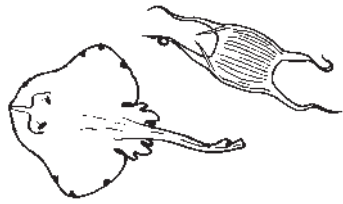
Explore the wrackline for shells, molts, algae and one evidence of intertidal life left behind the receding tide. The popularity of beaches for recreation can interfere with many of a beach's natural functions. Cars, trucks, dog-walkers and joggers can kill areas of beach grass, contributing to erosion. Trash and plastic can threaten beach habitats and wildlife. Development and foot traffic can force nesting shorebirds, including the threatened piping plover and least tern, out of their habitats. Certain areas are now cordoned off during nesting season.

Beaches cycle through seasonal changes, often losing sand in harsh winter storms, and rebuilding in the summers. This natural, periodic waxing and waning of beaches is at odds with the human desire to build permanent structures. So, to stabilize beaches, people have built jetties and groins out of rocks and concrete. Instead of solving the problems, these armored beaches cause adjacent beaches to lose sand. Neighboring beaches then build up protections, too, resulting in miles and miles of armored beaches. Instead of providing a solution, these artificial structures interfere with the natural equilibrium of these environments and prevent the sand that would naturally nourish the beaches from reaching them.



Photo / L. Fredrickson

Wrackline, Webb State Park, Hingham, MA



Skate and Egg Case  
(*Raja* sp.)



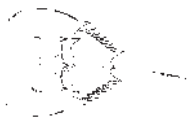
Moon Jelly  
(*Aurelia aurita*)



Soft-Shell or Steamer Clam  
(*Mya arenaria*)



Common Slipper Shell  
(*Crepidula fornicata*)



Atlantic Horseshoe Crab (molt)  
(*Limulus polyphemus*)



Atlantic Razor Clam  
(*Ensis directus*)



Shell of Horse Mussel  
(*Modiolus modiolus*)



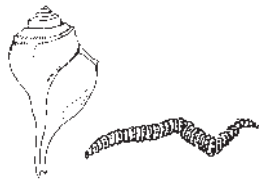
Moon Shell with Egg Case  
(*Lunatia heros*)



Herring Gull  
(*Larus argentatus*)



Semipalmated Sandpiper  
(*Calidris pusilla*)



Channeled Whelk and Egg Case  
(*Busycon canaliculatum*)



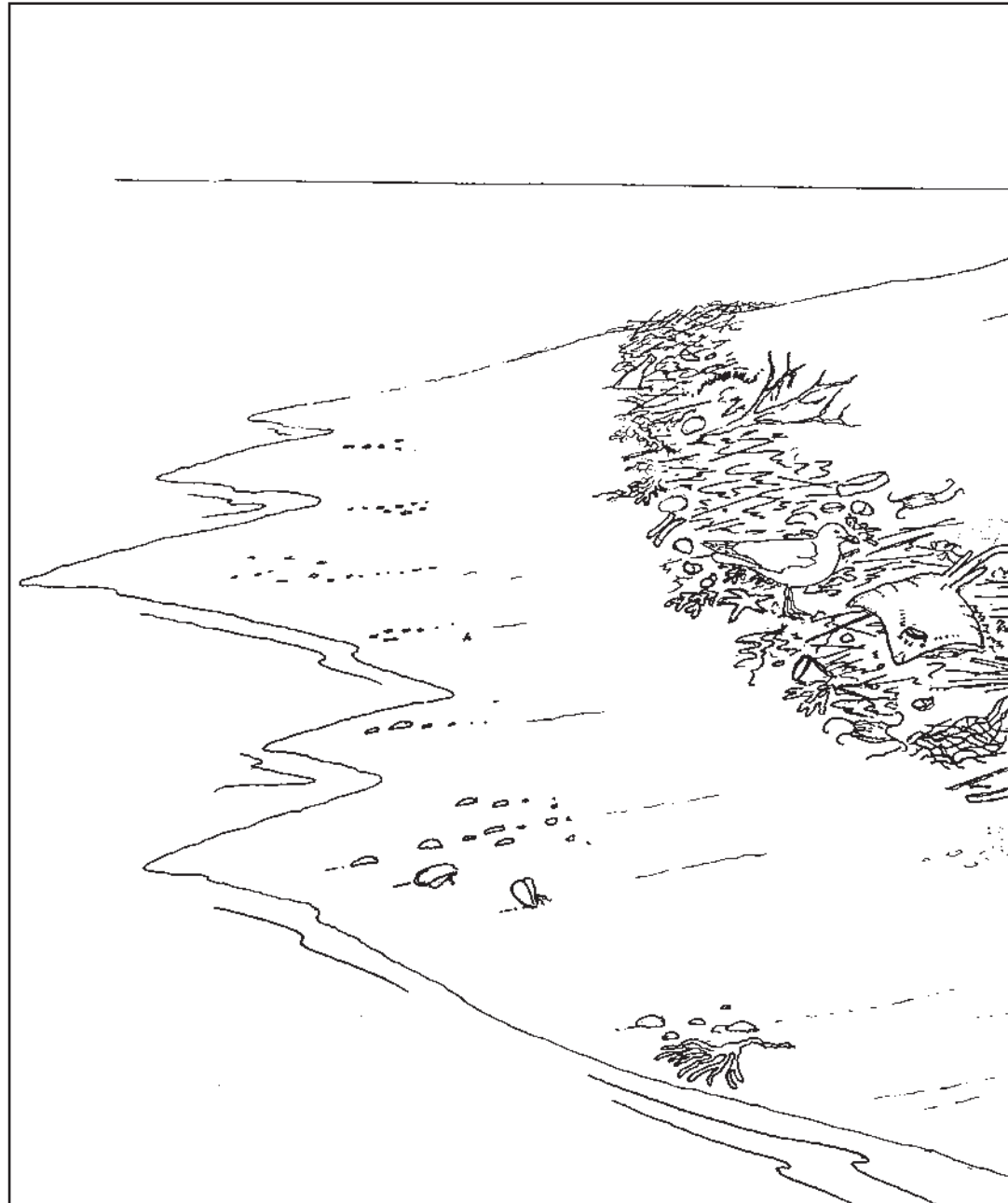
Knobbed Whelk  
(*Busycon carica*)



Atlantic Surfclam  
(*Spisula solidissima*)



Green Sea Urchin Test (shell)  
(*Strongylocentrotus droebachiensis*)

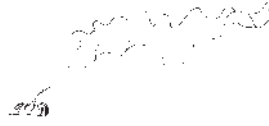




Beach Flea or Sand Hopper  
(*Americhorchestia* sp.)



Eelgrass  
(*Zostera marina*)



Kelp  
(*Laminaria agardhii*)



Green Fleece  
(*Codium fragile*)

# SANDY BEACH/WRACKLINES



Bayberry  
(*Myrica pensylvanica*)



Seaside Rose  
(*Rosa rugosa*)



American Beach Grass  
(*Ammophila* sp.)



Smooth Sumac  
(*Rhus glabra*)

© New England Aquarium



Beach Pea  
(*Lathyrus* sp.)



Dusty Miller  
(*Artemisia stelleriana*)



Poison Ivy  
(*Rhus radicans*)



Goldenrod  
(*Solidago* sp.)

## SALT MARSH

### WHAT IS A SALT MARSH?

Salt marshes form in estuaries and protected areas or bays where freshwater streams empty into the sea. This zone of mixing between fresh and salt water (known as brackish water) produces a rich and highly productive ecosystem. The dominant grasses in a salt marsh are of the genus *Spartina*. The large amount of food produced by both living and decaying plants provides nutrients for many young fish and crustaceans. Salt marshes are considered the nurseries of the sea.

### PHYSICAL FEATURES

New England salt marshes owe their structure to the glaciers of the last ice age. As the glaciers melted, the outwash water eroded numerous valleys as it flowed towards the rising sea. As sea level rose, these valleys were swamped and slowly filled with sand and gravel from the streams. Eventually the characteristic plants and animals of the salt marsh found a fertile place to settle. Salt marshes form in shallow inlets, where tidal flooding and stream currents deposit suspended sediments, gradually forming the base of the marsh. In the zone that is regularly exposed at low water, salt marsh meadow grass gains a foothold and stabilizes the shifting substrate. The roots and stems slow and trap more sediment. As the annual growth dies back in the fall, the plant bodies become partially decomposed and form a bed of peat. In well-developed marshes this peat may be several feet thick.

### IMPORTANCE OF SALT MARSH HABITATS

Scientists have determined that salt marshes are among the world's most productive ecosystems in terms of the sheer amount of nutrient-rich decaying plant material (detritus) they produce. With added nutrients from the ocean, salt marshes are important habitats for shellfish and coastal birds. Salt marshes are critical nursery areas for many fish, such as winter flounder, that migrate into deeper water as they get older. Nearly 70 percent of all commercially harvested fish and shellfish use estuaries at some point in the life cycles. Salt marshes also provide food and nesting sites for many species of migratory birds.

In addition to the services salt marshes provide marine plants and animals, they also positively impact human life. Salt marsh bacteria clean up the environment by breaking down waste and decaying organisms. Salt marsh grasses provide natural filtration of debris and impurities that helps to neutralize and balance the ecosystem. The peat base of a salt marsh, which is quite porous, acts like a giant sponge, absorbing water during floods and storms, and thus protecting homes and property from damage.

### SALT MARSH ZONES

The plants in a salt marsh tend to grow in specific zones. These zones are characterized by the proportion of each tidal cycle during which they are submerged in salt water. Plants growing toward the landward side of the marsh tend to be less tolerant of salt or brackish water. Low tide exposes the tidal channels through which the sea water journeys, flooding the marsh twice a day. These marshes may have some water in them continuously. In contrast, the upper marsh may flood only during spring tides and storm tides.

#### The Marsh Edge

The marsh edge is the most landward zone. In many New England marshes, this zone is easy to recognize by the very large reed, *Phragmites communis*, that grows to be 10 feet high. This grass sports a flower plume resembling a feather duster that cannot tolerate much salt water. In many marshes, *Phragmites* is encroaching on the marsh flat as a result of the restricted circulation of sea water. *Phragmites* is considered a nuisance species because it out-competes other salt marsh grasses. Fresh groundwater will push back the salt water and allow the reed to grow out onto the marsh. In the landward part of this zone, we often find beach plums (*Prunus maritima*), staghorn sumac (*Rhus glabra*), sea spray rose (*Rosa rugosa*), bayberry (*Myrica pensylvanica*) and a multitude of plants that live in open or disturbed areas. This zone has the highest diversity of any in the marsh.

#### The Upper Marsh

The upper marsh is submerged only by spring tides and storm tides. The plants that live here do best in fresh water, but can tolerate the occasional dose of brackish water. The flooding by brackish water eliminates other exclusively freshwater plants. This zone is dominated by marsh elder (*Iva frutescens*), a shrub growing to about 3 feet tall. True grasses like spike grass (*Distichlis spicata*) and black grass (*Juncus gerardi*) and other flowering plants like seaside lavender (*Limonium carolinianum*), goldenrod (*Solidago sp.*) and aster (*Aster tenuifolius*) also have a strong presence in this zone. Note that only a slight elevation drop (about 6 inches) marks the change to the middle marsh.

#### The Middle Marsh

The middle marsh is often called a salt meadow. This zone is conspicuous because of the nearly total dominance of the short, stiff salt meadow grass (*Spartina patens*). The marsh flat has no more than 6 inches of relief. The meadow grass turf is broken by shallow depressions in the flat called pannes. Pannes are recognizable by their thick growths of glasswort (*Salicornia sp.*). Glasswort removes salt from the

water, storing it in special cells until the plant dies at the end of the season. This plant is often used in salads. It has a strong salty taste and is sometimes called "pickleweed." In the fall, the plant turns a brilliant red as it dies. Algae are an important part of the food chain in the marsh. Note the algae growing around the base of the grass stems. Look in the mud at the base of the grass plants. Look carefully at the stems of the grass and you may see the coffee bean snails (*Melampus bidentatus*). These snails have lungs and must climb the grass stems to avoid submergence.

### The Lower Marsh

As the elevation drops toward the tidal channels, the grass changes to salt marsh cordgrass (*Spartina alterniflora*). Cordgrass can grow to heights of 3-6 feet. This grass is submerged during more than half of the tidal cycle. Living at the base of the grass is a stringy green algae, called mermaid's hair (*Chaetomorpha* sp.). Often, the mud here has films of algae that make the surface appear greenish or golden colored. Attached to the mud by byssal threads are Atlantic ribbed mussels (*Modiolus demissus*). The banks of the tidal channels expose the peat base that lies under the grass beds. Look for mud snails (*Nassarius obsoletus*) plowing through the mud. You may see mummichogs (*Fundulus heteroclitus*), mosquito-larvae-eating fish, that are common to the channels.

Looking out over a marsh for the first time, you may not be able to distinguish one grass from another. Two clues to identification are knowing where the grass is located in relation to amount of time it stays in the water and color. At the water's edge salt marsh cordgrass forms a dark green border, up to 6 feet tall in favorable conditions. The salt meadow grass and nearby spike grass are 1-2 feet high and form a lighter green carpet. By late summer the salt meadow grasses have bent at their bases to form flattened cowlicks.

### NATURALIST NOTES

Mosquitoes and greenhead flies do breed in salt marshes, and can make visiting quite challenging. But fish called mummichogs that live in the marshes eat mosquito larvae, keeping the populations somewhat in check. Attempts at draining marshes to eliminate mosquitoes have been unsuccessful, probably because the natural predators are cut off from the larvae.

Native Americans foraged and hunted in salt marshes. Early New England settlers grazed cattle on productive salt marshes and harvested the grasses (particularly *Spartina patens*) for hay. Salt marshes lost their economic importance in the early 19th century when seed supplies and improved technology

made upland farming more practical. Salt marshes became the neglected coastal habitat—ignored, undervalued and unappreciated. Marshes were filled, dredged, drained and sprayed with pesticides in order to build roads, houses and dumps.

### SALT MARSH CONSERVATION AND RESTORATION

Only now that we have destroyed many of our salt marshes have we realized what valuable services they provide for us, for the health of the world's oceans and for a variety of aquatic life. Our state and federal governments have enacted legislation to protect existing wetlands and to improve and restore degraded salt marshes. Wetlands restoration projects restore critical tidal flow, remove fill, replace wetland soils, replant native species, remove invader species (such as *Phragmites*), remove pollution sources and stabilize erosion.

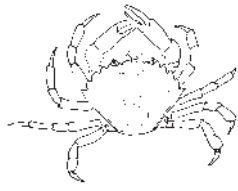


Photo / S. Paclawer

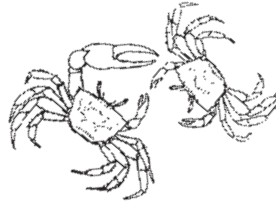
Salt marsh, Peddock's Island, Boston Harbor



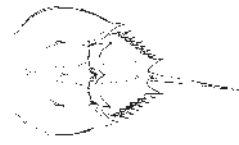
Black Grass  
(*Juncus gerardi*)



Green Crab  
(*Carcinus maenas*)



Fiddler Crab  
(*Uca sp.*)



Atlantic Horseshoe Crab  
(*Limulus polyphemus*)



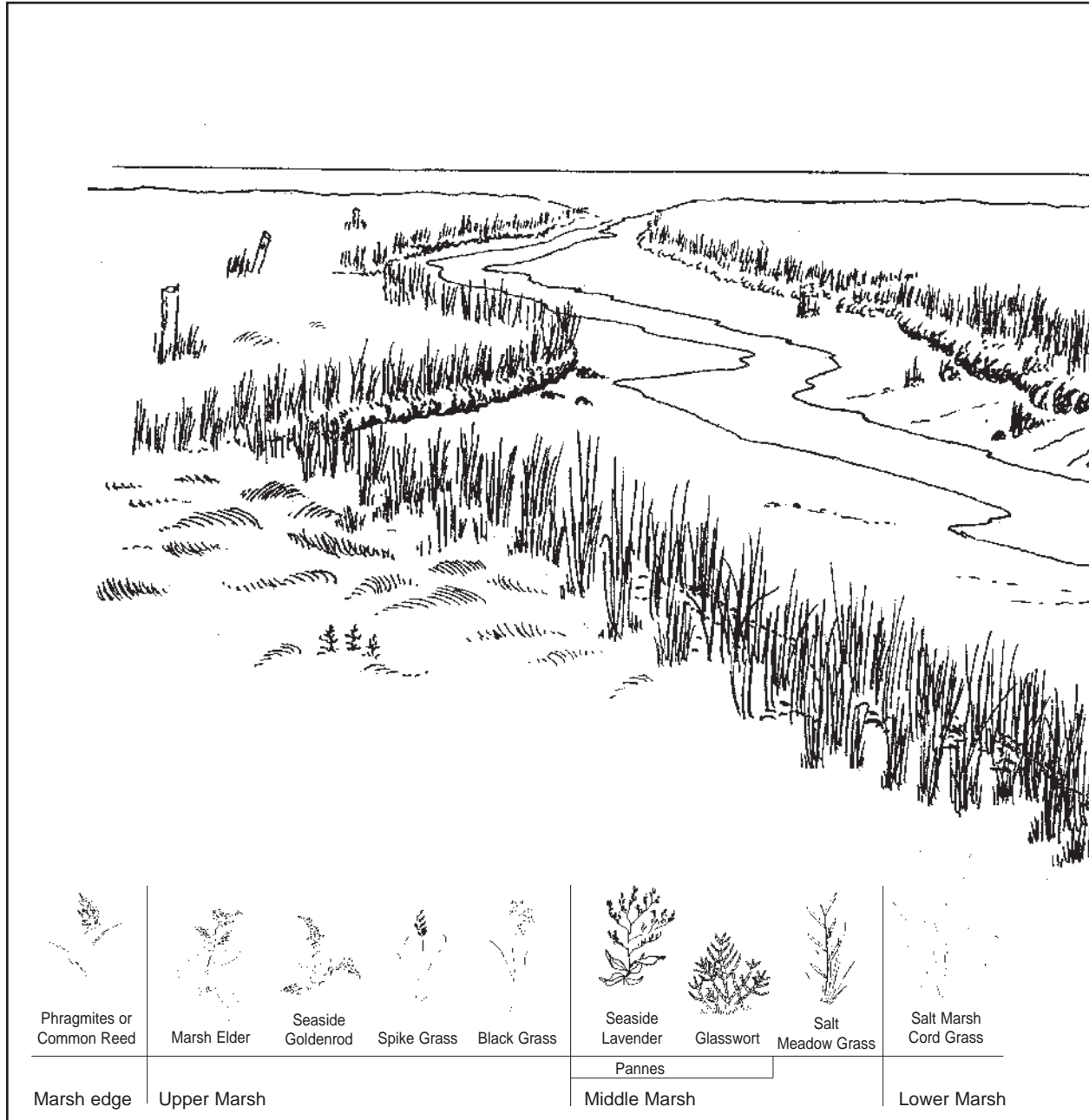
Phragmites or  
Common Reed  
(*Phragmites communis*)



Spike Grass  
(*Distichlis spicata*)



Marsh Elder  
(*Iva frutescens*)



Salt Marsh Cord Grass  
(*Spartina alterniflora*)



Salt Meadow Grass  
(*Spartina Patens*)



Seaside Goldenrod  
(*Sempevirens sp.*)



Glasswort  
(*Salicornia sp.*)



Sea Lavender  
(*Patens*)

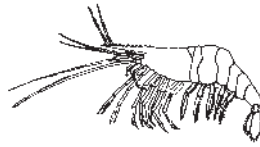




Brown Salt Marsh Mosquito  
(*Aedes cantator*)



Greenhead Fly  
(*Tabanus sp.*)

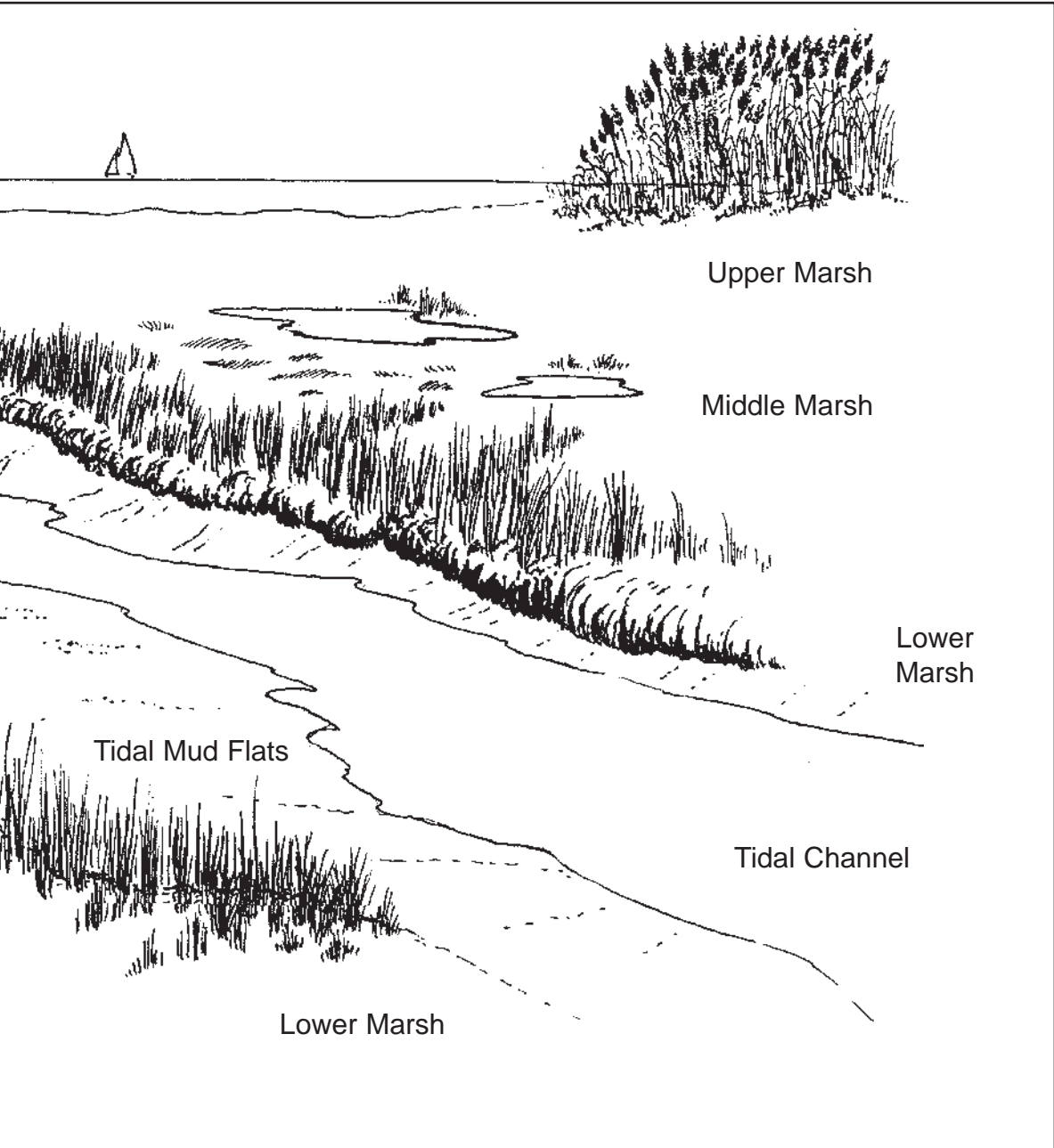


Glass Shrimp  
(*Palaemonetes sp.*)



Great Blue Heron  
(*Ardea herodias*)

# SALT MARSH



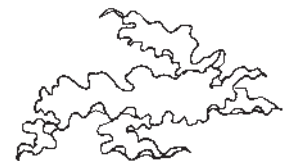
Ribbed Mussel  
(*Modiolus demissus*)



Mud Snail  
(*Nassarius obsoletus*)

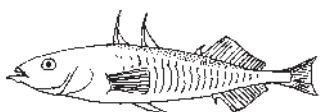


Muskrat  
(*Ondatra zibethicus*)

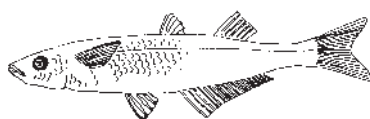


Sea Lettuce  
(*Ulva lactuca*)

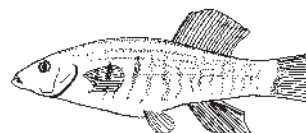
© New England Aquarium



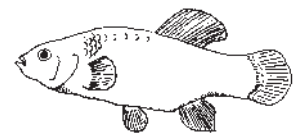
Three-spined Stickleback  
(*Gasterosteus aculeatus*)



Atlantic Silverside  
(*Menidia menidia*)



Striped Killifish  
(*Fundulus majalis*)



Mummichog  
(*Fundulus heteroclitus*)

## TIDAL FLATS

### WHAT ARE TIDAL FLATS?

In Boston Harbor there are large expanses of sand and mud that are exposed at low tide—these are called tidal flats. They are formed as a result of low-wave energy in estuaries and harbors, which allows sand and mud to collect into shallow deposits or banks. These banks are composed of rather fine sediment which was brought here first by the glaciers of the last ice age and then redistributed by waves and running water. Where wave energy is high, such as on headlands and the windward sides of islands, the sand has been removed and boulders and cobbles are left to form a rocky shore. However, in the quiet corners of the harbor, in the lee of islands and in estuaries where waves do not reach, the sand and mud accumulates into the characteristic flats we see (and smell) exposed at low tide. Since tidal exchange in Boston Harbor is a hefty 9.5 feet (3 m), the low slope and flat relief of the banks makes for large areas of tidal flats.

### PHYSICAL FEATURES

The particle size in a given tidal flat is a function of how the sediment deposit was created. In areas where rivers and streams deliver extremely fine sediments and decomposed organic matter, there are true mud flats. Where the flats are formed by waves redistributing glacial till, the flats may be more sandy than muddy. Flats are just that, flat. Relief is usually confined to the adjacent beach face and to tidal channels that dissect the flat. They have a typical slope of about 1:500. Occasionally, we see large boulders protruding from the surface of the sand or mud.

Characteristic of all flats is the fact that the sediments are loose and unconsolidated. They shift with every storm. This lack of a firm substrate makes it impossible for most organisms of the rocky shore to find a footing.

### CONDITIONS FOR LIFE

As noted above, the substrate in the flats is constantly shifting. Thus the algae which so easily attaches to rocks and floats cannot grow here. Instead the area is bathed by a mixture of microscopic planktonic (free floating) algae brought in with the incoming tide. When conditions are calm we see a greenish-yellow sheen on the surface of the mud. This sheen is caused by algae growing on the sand surface. Diatoms and dinoflagellates (two phyla of algae) dominate these films. They disappear with the next storm and reestablish when conditions allow. The only other photosynthesizer is eel grass (*Zostera marina*), a true flowering plant that grows in thick beds in the subtidal areas adjacent to some exposed flats.

As with other intertidal habitats, tidal flats experience the stress of daily variation in temperature, desiccation and salinity. Animals who live in them are equipped with adaptations for burrowing or anchoring themselves in the mud. Most clams have an inflatable foot which can be inserted into the mud, inflated and used to anchor the clam in place. The soft-shelled clam (*Mya arenaria*) is one of the most common burrowing clams. The Atlantic razor clam (*Ensis directus*) burrows even deeper and faster. These clams breathe and ingest nutrients through a set of siphons, long tubes that extend through the mud up to the water. When the tide is out these siphons store water to keep the clam moist while exposed. Look carefully at the surface of the sand and you may see the holes through which these siphons extend at high water. Step close to them and a squirt of water tells you the clam is retracting its siphon deeper into the hole.

Many other holes are formed by worms of the polychaete group. These are segmented worms that feed actively at high tide, sticking their heads out of the holes. A worm's gut constantly processes food from the grains of sand and sediment that it ingests. The indigestible sand grains pass out of the animal's anal opening to the surface forming the coils of sand, mud castings or mounds. For this reason, many of the marine worms live in a vertical U-shaped position.

Worms may be either sedentary or mobile. The mobile worms leave their burrows at high water to hunt other small worms, fish and crustaceans. These often have large paddle-like "legs" or parapodia on the sides of their bodies. They have small simple eyes and large well-formed jaws that can give a painful bite. The sedentary worms tend to have smaller parapodia that are modified for anchoring the worm in its burrow. Some of these worms, like the bamboo worm (*Clymenella torquata*) and the parchment worm, construct linings for their burrows that stick out of the mud.

While the water cover changes dramatically over tidal flats, the composition of the soil remains relatively stable. The sediments retain moisture and buffer temperature and salinity fluctuations, making the flats an easier place for burrowers to live. Many of the mud flat worms are deposit feeders, eating organic material (detritus) and single-celled algae in the sediments. Worms are constantly eating and eliminating waste, which can look like mounds of sand at the surface or straw-size sand grain chimneys. Three strange denizens of the flats include the ribbon worm (*Cerebratulus lacteus*) a strap-like worm that can grow to 3 feet long and an inch wide. This worm catches its food with a modified proboscis. In sandier flats, you can find peanut worms (*Golfingia gouldii*) and glass worms (*Leptosynaptera sp.*), the latter of which are not true worms, but sea cucumbers. In addition to worms,

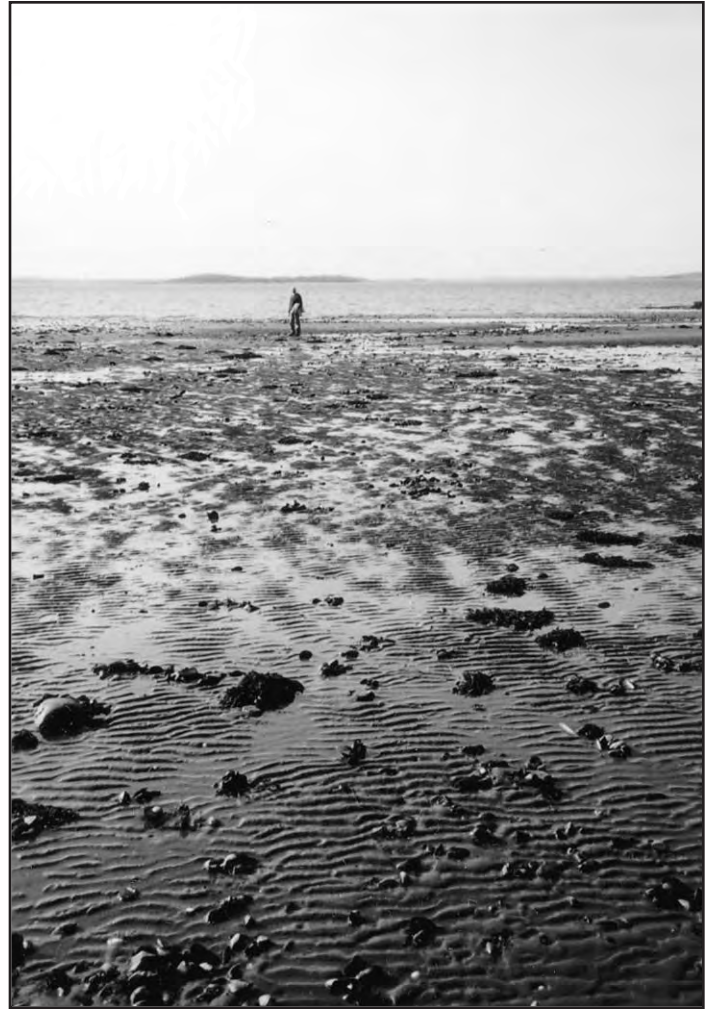
tidal flats are also home to small crustaceans, crabs, snails and a variety of other mollusks. Although the tidal flats may look relatively uninhabited, a little digging will prove that the density of life is tremendous. In Barnstable (on Cape Cod), studies indicate that between 7,000 and 355,000 animals live in each square meter of flat.

### EELGRASS

Eelgrass is a submerged aquatic plant from the seagrass family that inhabits the shores of most of the world's north temperate and arctic coastlines. It is very productive, growing up to a couple meters in length, and provides a valuable nursery habitat for many animals, including commercially important species such as shellfish and cod. Common in Boston Harbor, eelgrass will occasionally be exposed on intertidal flats during extremely low tides. Eelgrass beds provide important habitat for a wide variety of fish such as juvenile winter flounder and cod that use the sea grass for a nursery. Invertebrates such as isopods, amphipods and small crustaceans also forage in the eelgrass on organic material that settles between the blades of grass. Predatory fish, such as the striped bass, also use eelgrass beds as hunting grounds.\*

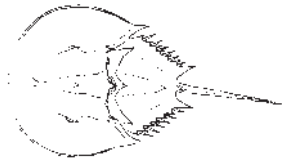
To grow and thrive, eelgrass requires shallow protected waters, good water quality and abundant light. Historical records show that at one time eelgrass beds in Boston Harbor were widespread. However, with development, pollution and disease, fewer than 100 acres remain. With the recent improvements in water quality, due mainly to the new sewage treatment plant on Deer Island and other pollution control initiatives, environmental conditions may favor the return of eelgrass beds to Boston Harbor.\*

The New England Aquarium has been working on eelgrass in Massachusetts since 1993, investigating the importance of eelgrass beds to local fisheries. More recently, Aquarium researchers have focused on the relationship between lobsters and eelgrass.



Tidal flats, Worlds End, Hingham, MA

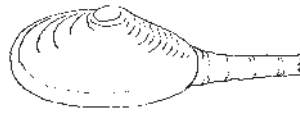
\* From Save the Harbor, Save the Bay. *Feathers and Fins, Boston Harbor's Habitat*.



Horseshoe Crab  
(*Limulus polyphemus*)



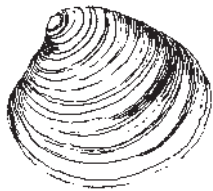
Peanut Worm  
(*Phascolopsis gouldii* or  
*Golfingia gouldii*)



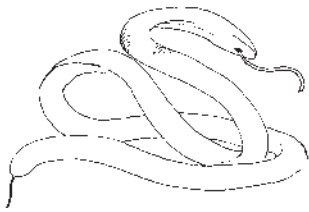
Soft-Shell or Steamer Clam  
(*Mya arenaria*)



Mud snail  
(*Nassarius obsoletus*)



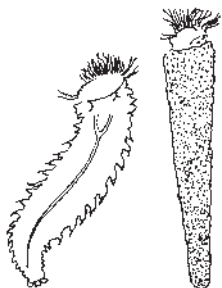
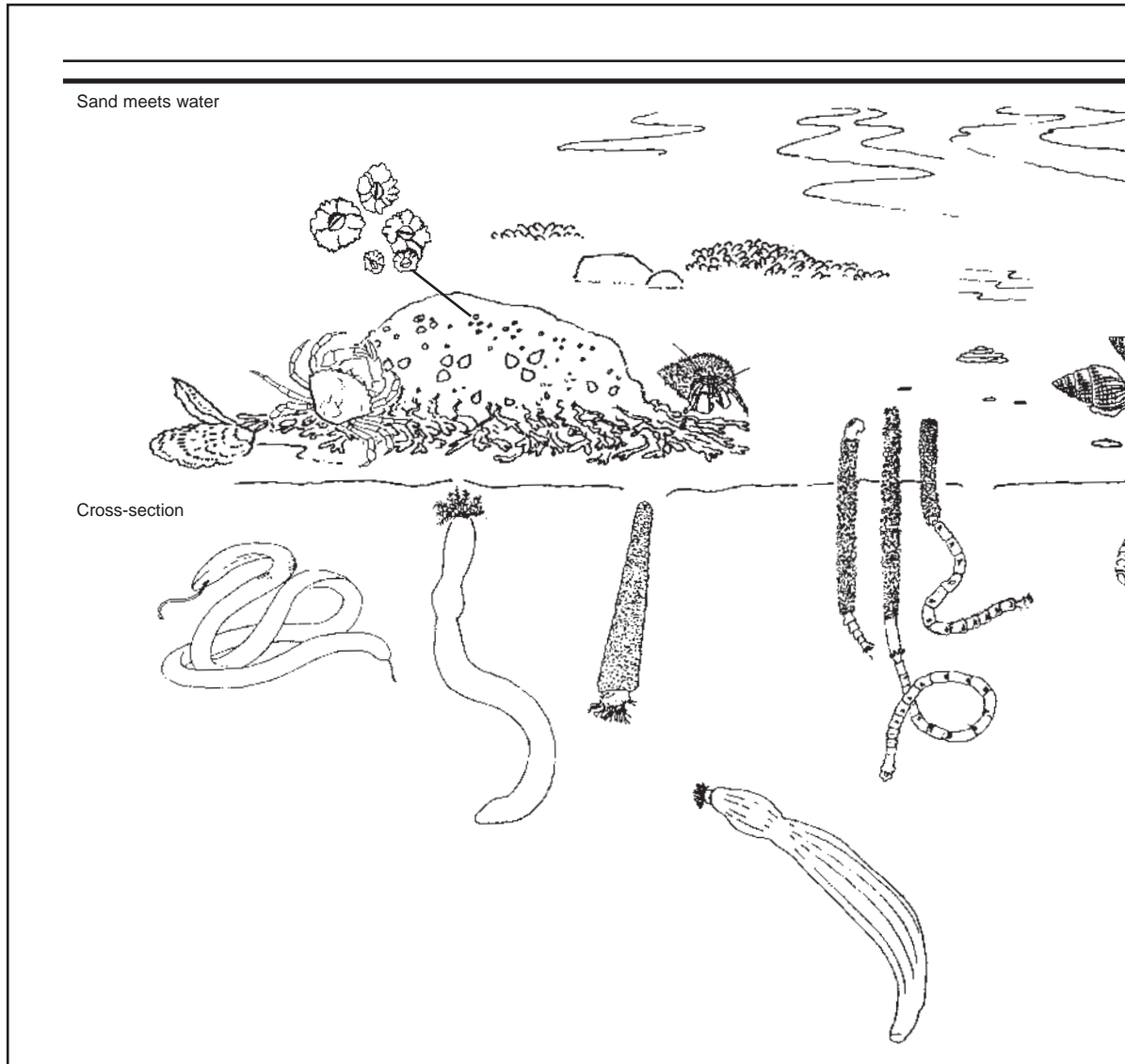
Northern Quahog  
(*Mercenaria mercenaria*)



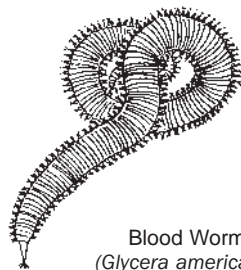
Ribbon Worm  
(*Cerebratulus lacteus*)



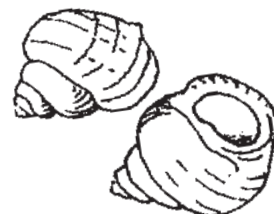
Glass worm Sea Cucumber  
(*Leptosynapta sp.*)



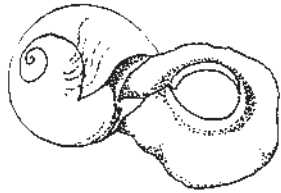
Trumpet Worm or Cone Worm  
(*Pectinaria gouldii*)



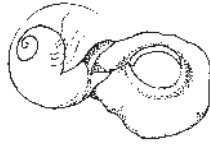
Blood Worm  
(*Glycera americana*)



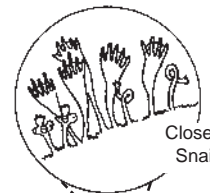
Common Periwinkle  
(*Littorina littorea*)



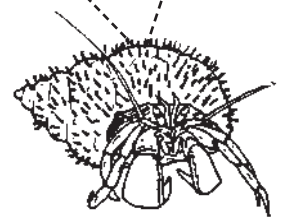
Moon Snail with Egg Collar  
(*Lunatia heros*)



Lugworm  
(*Arenicola marina*)

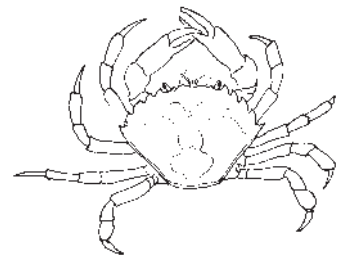
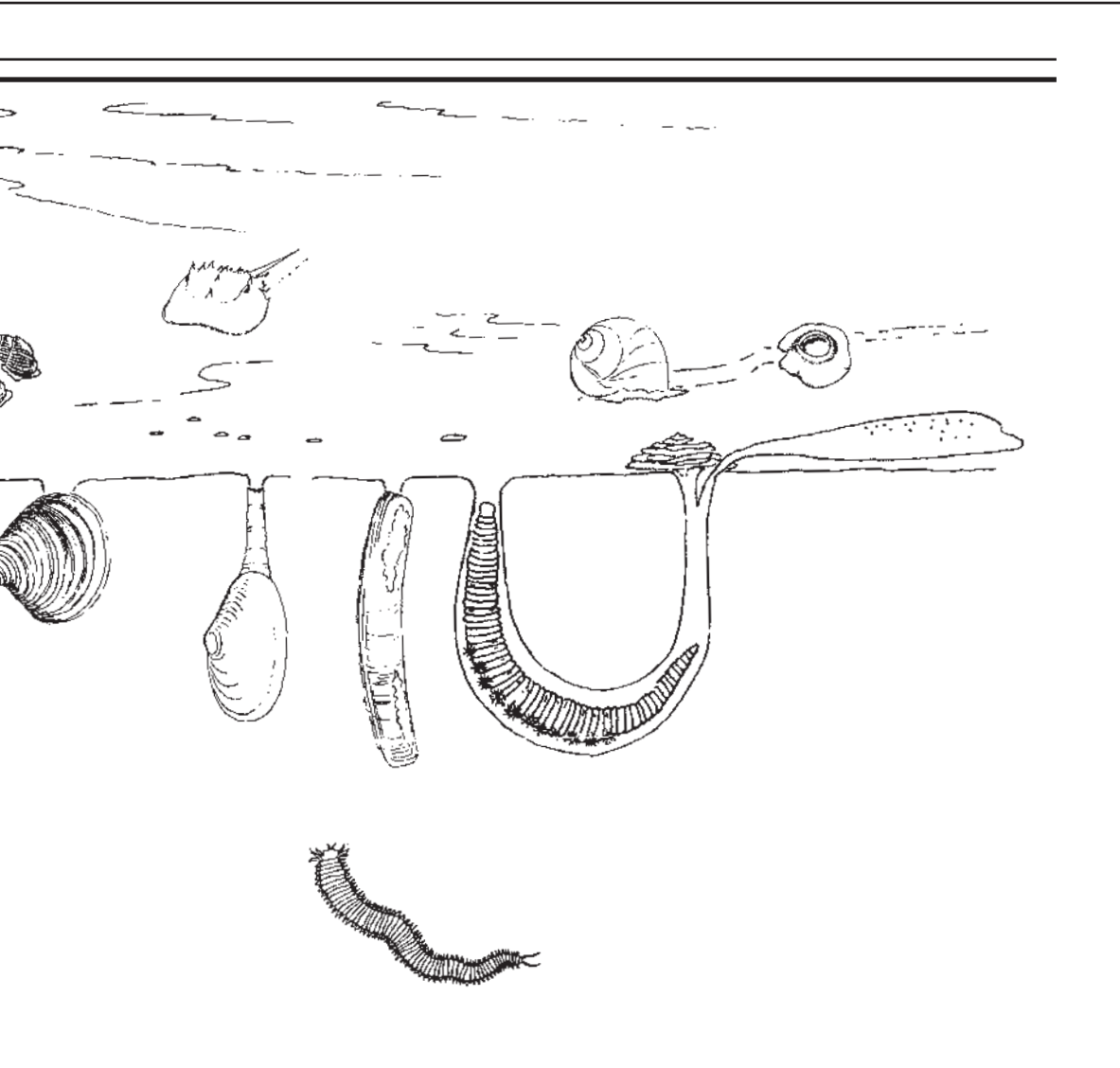


Close-up of  
Snail Fur



Hermit Crab  
(*Pagarus sp.*) with  
Rough-spined Snail Fur  
(*Hydractinia echinata*)

# TIDAL FLATS



Green Crab  
(*Carcinus maenas*)

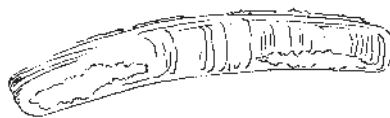


Rock Barnacle  
(*Balanus balanoides*)

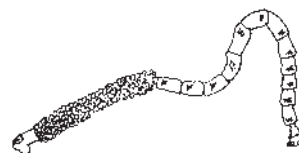
© New England Aquarium



Common Clam Worm  
(*Nereis virens*)



Atlantic Razor Clam  
(*Ensis directus*)



Common Bamboo Worm  
(*Clymenella torquata*)



Eastern Oyster  
(*Crassostrea virginica*)

## FOULING ORGANISMS

### PHYSICAL CONDITIONS

Floats on docks, such as those at marinas, support an amazing variety of organisms. Organisms that attach to floating objects in the ocean are called "fouling organisms." This negative term originated as a reference to the way they slow the speed of a ship when they build up on the bottom of a hull.

The obvious difference between this habitat and a rocky shore is that it is never exposed to the air. Although the tide rises and falls, these organisms never face the problem of desiccation. They do, however, face changes in salinity. Most marinas are in estuaries. These river mouths are frequently flooded with fresh water. The organisms living here must be able to withstand at least short exposure to reduced salinity during rain storms. Sea water in New England averages a salinity of about 32 parts per thousand (ppt). In estuaries, salinity is often much lower and in flood conditions may reach 0 ppt.

Floats provide a solid substrate to which animals and algae attach. Since this zone is rarely disturbed by natural forces apart from ice, a highly diverse yet stable community forms. Another physical characteristic of this zone is the wide temperature variations it experiences through the year. The organisms that live here must tolerate temperatures that range from 23° Celsius or more in the summer to winter ice conditions with the temperature reaching -1.9° Celsius, the temperature at which sea water freezes. The community may then be subjected to the grinding and scouring of sea ice as it moves.

These organisms are also subject to pollution. Oil spills from fueling operations, bilge discharge and highway runoff all contribute to the floating chemical pollution of this habitat. Serious spills of lightweight hydrocarbons (like gasoline and fuel oils) may wipe out the communities on floats near the source of the spill. Add to this the chemical poisons leaching from antifouling paints used on boat hulls and the chemical load in the water may limit the development of a vigorous community.

### CHARACTERISTICS OF LIFE

Since the substrate is solid, animals and algae with the capability of attaching to a solid surface settle on the floats. Diatoms, green algae and red algae often settle first, forming a pale green film on the floats. Then come the larger green algae such as *Enteromorpha*, a long green tube-like algae, *Ulva*, known as sea lettuce, and *Chladophora*, a tangled mass of green filaments. Along with the green algae, both red and brown algae find a home here. With the exception of rock

weed, either *Fucus* or *Ascophyllum*, these do not have common names. Each of these algae has a holdfast, a structure that attaches the organism to the float.

Along with the algae a host of animals settle here. Juvenile barnacles settle in May and June, often forming solid banks of tiny volcano-shaped tests. Blue mussels (*Mytilus edulus*), attached by byssal threads, often form thick beds that appear to shut out all other organisms. In these beds you may find a strange creature called a sea squirt or sea grape (*Molgula sp.*), one of several tunicates that grow well on floats. Sea grapes resemble small pale white grapes with two siphon openings. When handled roughly they contract, squirting out the water they contain, hence the name sea squirt. A long wrinkled club-shaped tunicate (*Styela sp.*) is also common here. It resembles an elongate prune, again with two siphon openings on top. These are the solitary tunicates. There are also colonial or social tunicates, like the star tunicate (*Botryllus schlosseri*). Star tunicates form thin flat colonies that appears to have star-shaped arrangements of individuals in a common matrix or tunic.

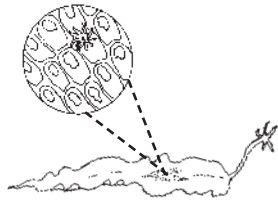
As summer begins, the community changes as various algae and animals reach their maximum growth. Among these is a bright pink hydrozoan (*Tubularia crocea*), which looks like a bunch of small pink flowers. Other hydrozoans found in summer include the squirrel tail hydrozoan (*Sertularia pumila*) and *Companularia sp.* Examine these with a hand lens and you will see tiny individuals resembling sea anemones. Encrusting the algae you may find *Obelia*, a hydrozoan used in biology classes as an example of the typical hydrozoan.

Sponges are common on floats. Nearly all of these are small and encrusting. They help glue the community together. Most are beige or yellow-colored. An exception is the red beard or fire sponge (*Microcionia prolifera*). Handle this one with care since it can cause a burning irritation.

A number of animals live among the attached organisms. Numerous worms of the polychaete class crawl among the mussels and algae. Examine the algae carefully and you may get a glimpse of sea spiders, class *pycnogonida*, and strange little skeleton shrimp (*Caprella sp.*) Sliding across the algae you will find sea slugs, called nudibranchs because they have naked gills. Some of these feed on hydrozoans and recycle the stinging cells for their own defense. They can be recognized by the frilly gills on their backs. Examine the algae carefully and you will find many algae growing on other algae. These are called epiphytes since they use another algae as a substrate on which to grow. They are not parasites, but only use their host as a home.



Bubblegum Algae  
(*Lithothamnium officinalis*)  
on Blue Mussel (*Mytilus edulis*)



Sea Lace or Lacy Crust on Kelp  
(*Membranipora* sp.)

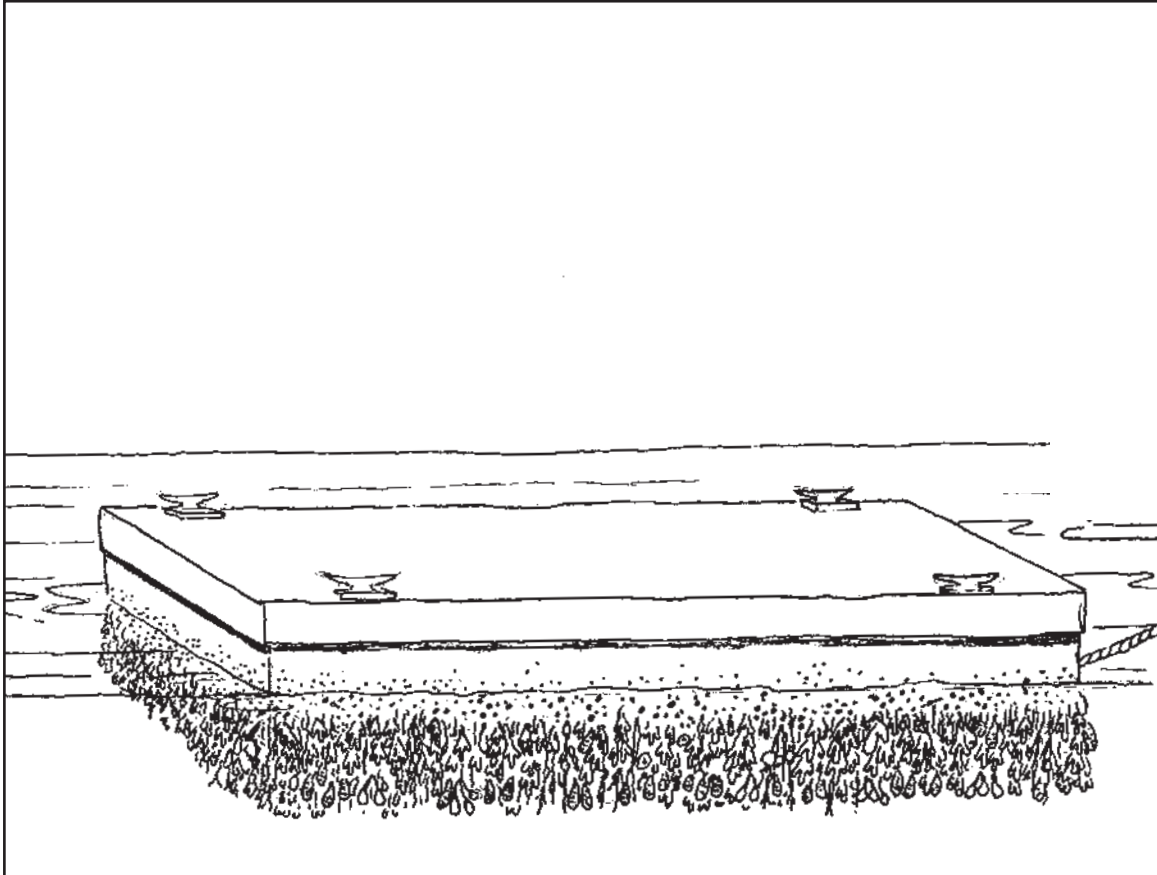


Skeleton Shrimp  
(*Caprella* sp.)



Blue Mussel  
(*Mytilus edulis*)

# FOULING ORGANISMS



Club Tunicate or  
Rough Sea Squirt  
(*Styela clava*)



Golden Star Tunicate  
on Irish Moss



Golden Star Tunicate  
(*Botryllus scholsseri*)



Frilled Anemone  
(*Metridium senile*)



Redbeard Sponge  
(*Microciona prolifera*)



Bushy Bryozoan  
(*Bugula turrita*)



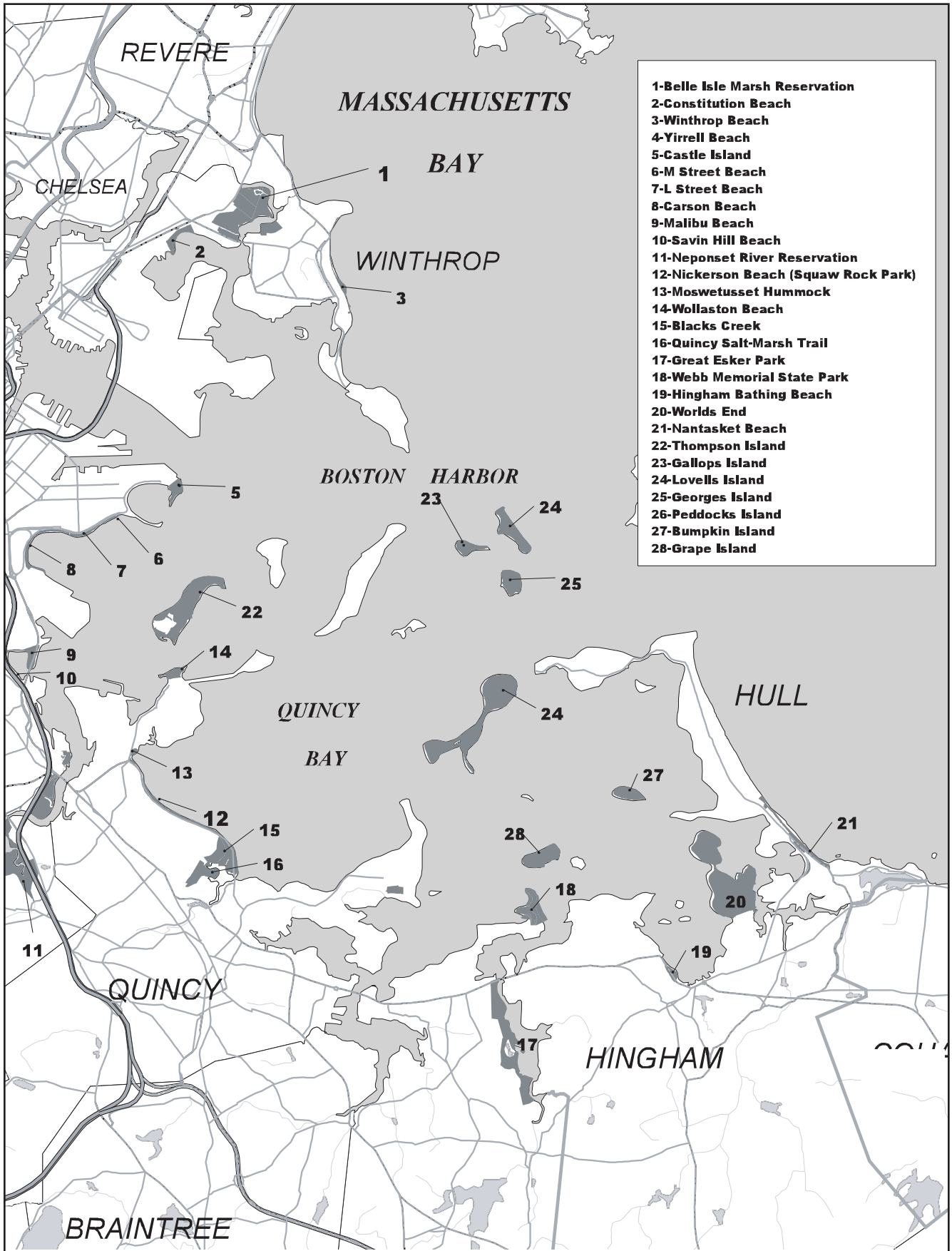
Stalked Sea Squirt  
(*Boltenia ovifera*)



Sea Grapes (*Molgula* sp.)



Orange Sheath Tunicate  
(*Botrylloides* sp.)



Map courtesy of CZM.



## APPENDIX C: Site Guide

To the uninitiated, there are a surprising number of Boston Harbor seaside habitats with public access. The following is a selection of recommended sites to explore near Boston Massachusetts, with background information and comments provided by the New England Aquarium Education Department. Please note that site accessibility is subject to change.

This is by no means a complete list. The map and site descriptions are adapted from the working draft of the *Massachusetts Coast Guide, Greater Boston Harbor and the North Shore, 2001 edition*, which includes all public access sites in those areas (not all of them, however, are appropriate for intertidal exploration). Final copies will be available in Spring 2001. For information on ordering the 2001 edition of the Coast Guide, contact Massachusetts Coastal Zone Management, 251 Causeway Street, Suite 900, Boston, MA 02114-2136.

### WINTHROP/EAST BOSTON

- 1**  
**Site:** Belle Isle Marsh Reservation  
**Location:** Bennington Street, East Boston  
**Description:** 152 acres of the Belle Isle Salt Marsh are protected in the reservation, one of the last remaining true salt marshes in Boston. Open 9:00 a.m. to dusk.  
**Facilities:** No restrooms or drinking water available at the site. Walking paths, boardwalk, benches, observation tower. Free parking off Bennington Street.  
**Special interest:** Self-guided trail map is available in English and Spanish. Easily accessible salt marsh pannes, channels and salt marsh zones; birdwatching.  
**Agency:** Metropolitan District Commission, Belle Isle Reservation  
**Contact:** (617) 727-5350  
**Website:** [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
**T:** Blue Line T to Suffolk Downs, turn left onto Bennington St., entrance 500 yards to right.

- 2**  
**Site:** Constitution Beach  
**Location:** Barnes Street, Orient Heights, East Boston  
**Description:** Recreation area with a sandy beach and swimming area.  
**Facilities:** Restrooms, sports fields and courts, ice skating rink, picnic tables, lifeguard June-

- September free parking.  
**Special Interest:** Tidal flats, patches of salt marsh grasses, wracklines, view of Logan Airport.  
**Agency:** Metropolitan District Commission  
**Contact:** (617) 727-4708  
**Website:** [www.magnet.state.ma.us/mdc/bchplan.html](http://www.magnet.state.ma.us/mdc/bchplan.html)  
**T:** Blue Line T to Orient Heights.

- 3**  
**Site:** Winthrop Beach  
**Location:** Winthrop Shore Drive, Winthrop  
**Description:** Sandy beach with adjacent rocky tidepools; long seawall. Popular swimming beach.  
**Facilities:** Restrooms, lifeguard June-Sept, free parking. Handicapped access.  
**Special interest:** Tidepooling near rocky breakwaters at low tide.  
**Agency:** Metropolitan District Commission  
**Contact:** (617) 727-4708  
**Web site:** [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
**T:** Blue Line to T to Orient Heights, Point Shirley or Winthrop Beach buses.

- 4**  
**Site:** Yirrell Beach  
**Location:** Shirley Street, Winthrop  
**Description:** Yirrell Beach is a sand and cobble beach with extensive wracklines.  
**Facilities:** Free limited parking along the beach route.  
**Special Interest:** Small tidepools and abundant beachcombing; view of Deer Island wastewater treatment facility and harbor islands.  
**Agency:** Town of Winthrop  
**T:** Blue Line T to Orient Heights, Point Shirley bus.

### DORCHESTER BAY

- 5**  
**Site:** Castle Island  
**Location:** William J. Day Boulevard, South Boston  
**Description:** 22 acres of largely grassy areas with a sandy beach, pier and rocky shore. Fort Independence, built between 1834 -1851, is open from Memorial Day to Columbus Day, hours vary.  
**Facilities:** Signage for self-guided tours. Handicap accessible bathrooms, picnic areas, food service, walking and biking paths, lifeguard June-Sept., playground, pier, free parking.  
**Special Interest:** Artificial rocky shore habitat (granite blocks).

Agency: Metropolitan District Commission, Boston Harbor Islands Reservation  
 Contact: (617) 727-5290  
 Website: [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
 T: Red Line T to Broadway, City Point buses #9 or #11 to end of line.

**6**  
 Site: **M Street Beach**  
 Location: M Street and Marine Boulevard, South Boston  
 Description: Sandy beach  
 Facilities: Walking and biking paths, lifeguard, June-Sept., on-street parking.  
 Special Interest: Harbor view, wracklines.  
 Agency: Metropolitan District Commission  
 Contact: (617) 727-8865  
 Website: [www.magnet.state.ma.us/mdc/bchplan.html](http://www.magnet.state.ma.us/mdc/bchplan.html)  
 T: Green line T to Copley, City Point bus #9 or #10; Orange Line to Back Bay, City Point bus #10; Red line to Andrew, City Point bus # 10.

**7**  
 Site: **L Street Beach**  
 Location: William J. Day Boulevard and L Street, South Boston  
 Description: Sandy beach  
 Facilities: Bathhouse, lifeguard June-Sept., on-street parking.  
 Special Interest: Harbor view, wracklines.  
 Agency: City of Boston  
 T: Green line T to Copley, City Point bus #9 or 10; Orange Line to Back Bay, City Point bus #10; Red line to Andrew, City Point bus #10.

**8**  
 Site: **Carson Beach**  
 Location: William J. Day Boulevard, South Boston  
 Description: Crecent shaped sandy beach.  
 Facilities: Restrooms, bathhouse, concession stand, gazebo, promenade, lifeguard June- Sept, free parking. Handicap access.  
 Special Interest: Harbor view, wracklines  
 Agency: Metropolitan District Commission  
 Contact: (617) 727-8865  
 Website: [www.magnet.state.ma.us/mdc/bchplan.html](http://www.magnet.state.ma.us/mdc/bchplan.html)  
 T: Green line T to Copley, City Point bus #9 or 10; Orange Line to Back Bay, City Point bus #10; Red line to Andrew, bus # 10.

**9**  
 Site: **Malibu Beach**  
 Location: Morissey Boulevard, Dorchester  
 Description: Rocky/sandy beach with a wrackline. Protected swimming.  
 Facilities: Parking at Savin Hill Beach, bathhouse and a nearby playground.  
 Special Interest: Part of a planned continuous green path extending from Castle Island to the Neponset River.  
 Agency: Metropolitan District Commission, Dorchester Shores Reservation  
 Contact: (617) 727-6034  
 Website: [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
 T: Red Line T stop to Savin Hill; follow Savin Hill Ave. for one quarter mile.

**10**  
 Site: **Savin Hill Beach**  
 Location: Southview Street  
 Description: Sandy beach for swimming, adjacent to McConnell Park.  
 Facilities: Playground, benches, restrooms, walking trails, sport fields, free parking.  
 Agency: Metropolitan District Commission/City of Boston  
 Contact: (617) 727-6034  
 Website: [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
 T: Red Line T stop to Savin Hill; follow Savin Hill Ave. for one quarter mile.

**11**  
 Site: **Neponset River Reservation**  
 Location: Salt marsh section near Butler T stop.  
 Description: Salt marsh and estuary wetlands at the mouth of the Neponset River.  
 Facilities: Trails (entrance to trail not well marked), future plans for urban bikeway and walkway, canoe launch nearby.  
 Special Interest: Site of the Neponset River Salt Marshes Restoration Project, restoring areas degraded by filling, ditching, and urban development; also development of new riverfront parks and trails.  
 Agency: Metropolitan District Commission, Neponset River Reservation  
 Contact: (617) 727-9693 x265  
 Also contact Boston Natural Areas Fund (617) 542-7696 for information about tours for school and camp groups.  
 Website: [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
 T: Red Line to Ashmont, then to Butler trolley.

**12**

**Site:** **Squaw Rock Conservation Area (Nickerson Beach)**  
**Location:** Dorchester Street, Squantum, Quincy  
**Description:** Rocky shore, tidal flats, sand and slate cobble beach.  
**Facilities:** Walkways, small on-street parking space.  
**Special Interest:** Puddingstone cliffs, scenic overlook.  
**Agency:** Quincy Conservation Commission  
**Contact:** (617) 376-1254  
**T:** Red Line to Quincy Center, Bus #221.

**13**

**Site:** **Moswetuset Hummock**  
**Location:** East Squantum Street, Quincy  
**Description:** Small wooded area surrounded by salt marsh, located near the northern end of Wollaston Beach. Short loop trail with views.  
**Facilities:** Walking paths, scenic overlook, picnic areas, free parking.  
**Special Interest:** Was Native American summer campground in 1600s.  
**Agency:** Metropolitan District Commission, Quincy Shore Reservation  
**Contact:** (617) 698-1802 x307  
**Website:** [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
**T:** Red Line to Quincy Station, MBTA Bus #211 to Squantum.

**14**

**Site:** **Wollaston Beach**  
**Location:** Quincy Shore Drive, Quincy  
**Description:** Long sandy beach, popular for jogging, biking, walking and swimming, observation tower with salt marsh sites adjacent on either end.  
**Facilities:** Restrooms, bathhouse open July- Sept., lifeguards, benches, free parking (crowded in summer)  
**Special Interest:** Tidal flat invertebrates, birds. Salt marsh habitats on either end.  
**Agency:** Metropolitan District Commission, Quincy Shore Reservation  
**Contact:** (617) 698-1802 x307  
**Website:** [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)  
**T:** Red Line to Wollaston Station, walk east on Beale Street.

**15**

**Sites:** **Caddy Park and Black's Creek Salt Marsh**  
**Locations:** Quincy Shore Drive  
**Description:** Salt marsh area at southern end of Wollaston beach.

**Facilities:** Playground, picnic site, free parking (Caddy Park)  
**Special Interest:** Salt marsh habitats.  
**Agency:** Metropolitan District Commission, Quincy Shore Reservation  
**Contact:** (617) 698-1802 x307

**16**

**Sites:** **Quincy Salt Marsh Trail**  
**Location:** Entrance to Quincy Salt Marsh Trail is on Fenno Street, Quincy.  
**Description:** Salt marsh trail adjacent to the other side of Black's Creek salt marsh area.  
**Facilities:** Trails, numbered trail signs.  
**Special Interest:** Quincy Salt Marsh Trail is a self-guided walk highlighting salt marsh plants and ecology, maintained by the Beechwood Knoll Elementary School community.  
**Agency:** Quincy Conservation Commission (Quincy Salt Marsh Trail)  
**Contact:** Dave Murphy, (617) 376-1254

## WEYMOUTH

**17**

**Site:** **Great Esker Park**  
**Location:** End of Elva Road (off Green Street) in North Weymouth.  
**Description:** 237 acres of woods and extensive marshland along the Weymouth Back River, a tidal river. Eskers (serpentine ridges) up to 90 feet high were formed by melting glaciers during the last ice age.  
**Facilities:** Restrooms by appointment, trails, ball fields, playgrounds and canoe rental, special events, free parking.  
**Special Interest:** Extensive mudflats and salt marsh, good for "mudwalks," osprey nests, herring run, reversing falls, kettle holes.  
**Agency:** Weymouth Parks Department  
**Contact:** (781) 682-6124  
**Website:** <http://members.aol.com/GreatEsker/>

**18**

**Site:** **Webb Memorial State Park**  
**Location:** End of River Street, Weymouth  
**Description:** 36 acres of rolling hills, sand beach, mussel beds, freshwater marsh, salt marsh and rocky shores.  
**Facilities:** Restrooms, hiking trails, picnic areas, boating area, playground, free parking.

Special Interest: Self-guided trail map (45 minute walking tour). An area that was heavily used by Native Americans for shellfishing. Nike missiles were once based on this property.

Agency: Department of Environmental Management  
 Contact: (781) 740-1605 x204  
 Website: [www.state.ma.us/dem/bhis.html](http://www.state.ma.us/dem/bhis.html)  
 T: Red Line to Quincy Center, Bus #221.

## HINGHAM

19

**Site:** Hingham Bathing Beach  
**Location:** Route 3A, Hingham  
**Description:** Tidal flats overlooking Hingham Bay harbor islands.  
**Facilities:** Restrooms (June-Sept only), free parking.  
**Special interest:** Tidal mudflats; intertidal zonation on seawall.  
**Agency:** Town of Hingham  
**Contact:** (781) 741-1400  
**T:** Red Line to Quincy Center, Bus #220.

20

**Site:** Worlds End (Hingham Bay)  
**Location:** End of Martin's Lane, Hingham (Worlds End is a peninsula, not an island, and is part of the Boston Harbor Islands National Parks Area).  
**Description:** Scenic World's End is 251 acres, with two large grassy drumlins connected by a narrow spit (tombolo), as well as the Rocky Neck peninsula, with steep granite cliffs and rocky outcrops. Woods, meadows, diverse coastal habitats include rocky shores, tidal flats, salt marsh and freshwater marsh.  
**Facilities:** Restrooms (portable toilets), walking trails, small parking lots, ranger at entrance.  
**Special Interest:** A representation of coastal habitats all on one site. Compare rocky shore, mussel and tidal flats, salt marsh along Weir River shore, as well as tidal flats between the two drumlins. Originally a private farm and estate landscaped by Frederick Law Olmsted.  
**Agency:** The Trustees of Reservations  
**Contact:** (781) 821-2977 (Members and children 12 and under free; call for other rates)  
**Website:** [www.thetrustees.org](http://www.thetrustees.org)  
[www.bostonislands.com](http://www.bostonislands.com)

## HULL

21

**Site:** Nantasket Beach Reservation  
**Location:** Nantasket Avenue, Hull  
**Description:** Nantasket Beach is a long public sandy beach with adjacent large glacial boulder/cobble rocky shore area on southern end of beach. Open year round, dawn to dusk.  
**Facilities:** Restrooms, bathhouse, showers, food concession, picnic area, benches, parking lots (fee in summer), lifeguard June-Sept. Handicapped access to paths and bathhouse.  
**Special Interest:** Use south end of beach for comparison of rocky and sandy shore habitats. Crowded in summer.  
**Agency:** Metropolitan District Commission, Nantasket Beach Reservation  
**Contact:** (617) 727-8865 or (781) 925-1894  
**Website:** [www.magnet.state.ma.us/mdc/reserv.html](http://www.magnet.state.ma.us/mdc/reserv.html)

## BOSTON HARBOR ISLANDS NATIONAL PARKS AREA

In 1996, the Boston Harbor Islands were officially designated as a National Parks Recreation Area. Unlike most National Park Areas, this park is administered by a partnership of national, state and local agencies. For general information and help with trip planning, please contact:

### Boston Harbor Islands National Parks Area

Phone: (617) 223-8666

Website: [www.bostonislands.com](http://www.bostonislands.com)

**For group visits and programs, you must also contact the agency that manages each island as described below.**

Public ferry service to most of the Boston Harbor Islands listed departs seasonally from Long Wharf (next to the New England Aquarium) and Hingham Shipyard. Call Boston Harbor Cruises (BHC) for fare and schedule information at either (617) 227-4320 or 227-4321, or visit their website <http://www.bostonharborcruises.com>

**22**

**Site:** **Thompson Island** (Dorchester Bay)  
**Ferry:** Private ferry service; visitors must schedule in advance.  
**Description:** 157 acres includes a drumlin, moraine and esker; open meadows, wooded areas, rocky and sandy beaches, tidal flats, also a 50 acre salt marsh.  
**Facilities:** Restrooms, trails, picnic areas, office and school buildings, school house and library for a private middle school, conference and events facilities. Year-round Outward Bound Education facilities include challenge courses, sailing program as well as customized programs.  
**Special Interest:** Self-guided trail map available. Salt marsh and beach habitat explorations, abundant bird life. Landscape and architectural features bear evidence of the former Farm and Trade school established in 1833.  
**Agency:** Thompson Island Outward Bound Education Center  
**Contact:** Main number (617) 328-3900  
x135 - Boston Public School groups only  
x161 - other school groups  
x918 - Public access Saturdays only, June-August  
**Website:** [www.thompsonisland.org](http://www.thompsonisland.org)  
[www.bostonislands.com](http://www.bostonislands.com)

**23**

**Site:** **Gallops Island** (Boston Harbor)  
**Ferry:** Water shuttle from Georges Island  
**Description:** Gallops Island is one of the smallest islands in the harbor at 16 acres. Meadows, flowering trees, foundations from former quarantine hospital and military radio operators' school.  
**Facilities:** Self-guided trail map available. Restrooms, picnic areas, hiking trails, benches, seasonal rangers, special events. No running water or electricity. No camping.  
**Special Interest:** Explore beach habitat east of dock. Small size and well-groomed trails allow for easy circumnavigation. Scenic overlook on north side.  
**Agency:** Massachusetts Department of Environmental Management, Boston Harbor Islands State Park  
**Contact:** Group visits: (781) 740-1605 x205  
Group reservations and permits: (877) 422-6762  
**Website:** [www.state.ma.us/dem/bhis.html](http://www.state.ma.us/dem/bhis.html)  
[www.bostonislands.com](http://www.bostonislands.com)

**24**

**Site:** **Lovells Island** (Boston Harbor)  
**Ferry:** Free water shuttle from Georges Island.  
**Description:** Lovells Island is 62 acres of woodland, grassland, with long stony beaches and fortifications that are remnants of historic Fort Standish.  
**Facilities:** Restrooms, visitor center, trails, Fort Andrews tours, seasonal rangers, special events, picnic area. No running water or electricity. Individual and group camping available. Swimming beach with lifeguard in summer.  
**Special Interest:** Explore rocky tidepools and flats on north end of island near old pilings. Scenic views of Boston and Graves Light from Fort Standish and eastern side of island; abundant rabbit population. Site of "Lover's Rock."  
**Agency:** Metropolitan District Commission, Boston Harbor Islands Reservation  
**Contact:** (617) 727-7676 or (617) 726-5293 for group visits and camping permits.  
**Website:** [www.magnet.state.ma.us/mdc/harbor.html](http://www.magnet.state.ma.us/mdc/harbor.html)  
[www.bostonislands.com](http://www.bostonislands.com)

**25**

**Site:** **Georges Island** (Boston Harbor)  
**Ferry:** Boston Harbor Cruises ferry from Long Wharf, Hingham, and Salem.  
**Description:** This 28-acre island is currently the hub for the Boston Harbor Islands ferry and water shuttle services. It features historic Fort Warren, which has extensive intact casemates and a large parade ground.  
**Facilities:** Restrooms, trails, tours, picnic areas, seasonal snack bar, lookout points, annual special events. Limited handicap assistance on or off the ferry. No camping.  
**Special Interest:** Explore beach on south side of island for intertidal investigation. Slide show and tours of the fort feature its time as a prison during the Civil War.  
**Agency:** Metropolitan District Commission, Boston Harbor Islands Reservation  
**Contact:** (617) 727-7676 or (617) 726-5293. A permit is required for a group of 25 people or more.  
**Website:** [www.magnet.state.ma.us/mdc/harbor.html](http://www.magnet.state.ma.us/mdc/harbor.html)  
[www.bostonislands.com](http://www.bostonislands.com)

**26**

**Site:** **Peddocks Island** (Boston Harbor)  
**Ferry:** Free water shuttle from Georges Island or BHC Ferry from Hingham.  
**Description:** 188 acres includes woodlands, fields, salt marsh, freshwater marsh, and rock/cobble beaches and sand spits. One of the largest harbor islands, Peddock's is made up of four drumlins connected by long spits of sand and gravel (tombolos). Buildings and gun batteries of historic Fort Andrews.  
**Facilities:** Restrooms, visitor center, trails, Fort Andrews tours, seasonal rangers, special events, picnic area. No running water or electricity. Individual and group camping available.  
**Special Interest:** Good sites for exploring and comparing diverse habitats, need walking time to get to them. Private homes, mostly summer cottages, on island. Fort Andrews tours.  
**Agency:** Metropolitan District Commission, Boston Harbor Islands Reservation  
**Contact:** (617) 727-7676 or (617) 726-5293 for group visits and camping permits.  
**Website:** [www.magnet.state.ma.us/mdc/harbor.html](http://www.magnet.state.ma.us/mdc/harbor.html)  
[www.bostonislands.com](http://www.bostonislands.com)

**27**

**Site:** **Bumpkin Island** (Hingham Bay)  
**Ferry:** BHC Ferry from Hingham or Lynn; or free water shuttle from Georges Island.  
**Description:** At 35 acres, this is one of the smaller Boston Harbor Islands. There are rocky beaches, tidal flats, wooded areas and open areas.  
**Facilities:** Self-guided trail map available. Restrooms, picnic areas, hiking trails, benches, seasonal rangers, special events. Individual and group camping. No running water or electricity.  
**Special Interest:** Old foundations and paved walkways of former site of school for disabled children. Good site for group camping and habitat exploration.  
**Agency:** Massachusetts Department of Environmental Management, Boston Harbor Islands State Park  
**Contact:** Group visits: (781) 740-1605 x205  
 Camping reservations and permits: (877) 422-6762  
**Website:** [www.state.ma.us/dem/bhis.html](http://www.state.ma.us/dem/bhis.html)  
[www.bostonislands.com](http://www.bostonislands.com)

**28**

**Site:** **Grape Island** (Hingham Bay)  
**Ferry:** BHC Ferry from Hingham or Lynn; or free water shuttle from Georges Island.  
**Description:** 50 acres of wood and marshland. The island itself is actually made up of two drumlins that are connected by a marshy lowland.  
**Facilities:** Self-guided trail map available. Restrooms, picnic areas, hiking trails, benches, seasonal rangers, special events. Individual and group camping. No running water or electricity.  
**Special Interest:** Grape Island is known for its pastoral woods and trails. Rocky shores and tidal flats, salt marsh area, shell beaches, herring run. Native Americans used it extensively for shellfishing.  
**Agency:** Massachusetts Department of Environmental Management, Boston Harbor Islands State Park  
**Contact:** Group visits: (781) 740-1605 x205  
 Camping reservations and permits: (877) 422-6762  
**Website:** [www.state.ma.us/dem/bhis.html](http://www.state.ma.us/dem/bhis.html)  
[www.bostonislands.com](http://www.bostonislands.com)

## **APPENDIX D: Resources**

1. **Equipment Available from New England Aquarium Teacher Resource Center**
2. **Where to Purchase Your Own Equipment**
3. **Where to Get A Tide Table for Boston Harbor**
4. **Reminders for Group Leaders**
5. **Sample Salt Marsh Field Trip Itinerary: Belle Isle Salt Marsh**
6. **What to Wear and Bring**
7. **Favorite Field Guides**
8. **Recommended Reading**
9. **Recommended Coastline Curricula**
10. **Organizations and Websites**

**Select Bibliography**

**Aquarium Programs and Services**

Photo / S. Padawer



**Bring the basics: small buckets, field guides, hand lenses...and your curiosity.**

## 1. EQUIPMENT FOR LOAN FROM THE NEW ENGLAND AQUARIUM TEACHER RESOURCE CENTER

### *New England Aquarium AquaKit*

- 1 large-plastic tarp for "home base"
- 15 one-gallon buckets
- 15 hand lenses
- 2 clear plastic aquaria
- 6 bug boxes, 4X
- 2 trowels
- Assorted field guides appropriate for habitat and grade level

### **Additional Equipment Available for Loan**

- plankton nets (funnel-shaped net with collecting bottle, used for straining zooplankton)
- Brock Magiscopes #60™ (field-tested, durable 20x microscopes; no batteries or bulbs required)
- plasticware for Magiscopes™
- plastic pipettes
- small plastic vials with lids
- plastic petri dishes
- plastic round well slides
- dip nets (assorted sizes)
- seine net (to collect and release fish and invertebrates found in tidal creeks and shallow waters)
- minnow trap with retrieving line (to catch and release crabs, small fish)
- sand sieves (to sort sand and gravel particles or strain out small organisms from mud)
- core sampler (for observing layers of mud, sand, peat and other sedimentation)
- transect line (100+ ft. rope or clothesline for studying zonation)
- thermometers
- secchi disk (for measuring water turbidity)
- knot-tying rope and instruction book
- cloud chart or cards (for weather forecasting)
- compasses

### **Consider Bringing (Supply Your Own)**

- Student worksheets and journals
- Laminated focus station write-ups and habitat field guide sheets
- Clipboards and pencils, index cards, colored markers
- Clothespins for securing loose papers
- Ziplock™ bags
- Chart of Boston Harbor and islands
- Trash bags, data sheets and rubber gloves for beach clean-up
- Tennis balls and bandanas for games and icebreakers

## 2. WHERE TO PURCHASE YOUR OWN EQUIPMENT

The New England Aquarium Education Department uses the following sources for ordering field equipment. Some items are listed in more than one catalog. We are providing this information as a convenience, and not as an endorsement of these products or companies. We are not responsible for any inaccuracies, omissions or equipment failures. Feel free to contact the New England Aquarium Teacher Resource Center, <jrubin@neaq.org>, (617) 973-6590 with suggestions for other items or sources.

### **Carolina Biological Supply Company/Science and Math Catalog**

P.O. Box 6010, Burlington, NC 27216

Phone: 800-334-5551 x6409

Fax: 800-222-7112

Web: [www.carolina.com](http://www.carolina.com)

- 3.5 and 5 gallon buckets
- minnow seine, dip nets, minnow trap
- plankton net
- eye protection goggles
- pipettes, small plastic vials, plastic labware, petri dishes
- books, curricula and field guides

### **Connecticut Valley Biological/Science Catalog**

82 Valley Rd., Southamptn, MA 01073

Phone: 800-628-7748

Fax: 800-355-6813

- Brock Magiscope™ #60 with accessory lenses
- binoculars
- magnifiers
- latex gloves, soil sieves
- water sampling gear and testing kits
- plastic aquarium, pipettes and droppers, plastic slides and cover slips
- books, curricula and field guides

### **Delta Education/Hands-On Science Catalog**

P.O. Box 3000, Nashua, NH 03061-3000

Phone: 800-442-5444

Fax: 800-282-9560

Web: [www.delta-ed.com](http://www.delta-ed.com)

- Brock Magiscope #60™
- bug boxes and magnifiers
- sorting sieves
- plastic aquarium/terrarium with lid
- thermometers
- cloud chart
- plastic slides and cover slips
- coiled tape measure for transect study



**LaMotte Environmental Science Education**

P.O. Box 329, Chestertown, MD 21620

Phone: 800-344-3100

Fax: 410-778-6394

Web: [www.lamotte.com](http://www.lamotte.com)

- extensive assortment of water-quality testing kits and equipment
- core sampler
- plankton net, seine net
- secchi disk
- thermometer
- refractometer

**Learning Things, Inc.**

68A Broadway, P.O. Box 436, Arlington, MA 02476

Phone: 800-284-5688

Fax: 781-646-0135

- plastic tweezers and dissecting instruments
- plastic slides
- student thermometers
- assorted magnifiers

**Massachusetts Audubon Society/Educational Resources**

208 South Great Road, Lincoln, MA 01773

Phone: 800-AUDUBON x7255

Web: [www.massaudubon.org](http://www.massaudubon.org)

- Laminated Habitat Guides: Beachcombers, Backyard Birds, Pond Watchers, Whale Watchers (*note: Bind edges with strong clear tape to keep waterproof.*)

**Museum Products Company**

84 Route 27, Mystic, CT 06355

Phone: 800-395-5400

Fax: 860-572-9589

Web: [www.museumproductsco.com](http://www.museumproductsco.com)

- dip nets with durable handles
- knot-tying rope and instruction book
- assorted field guides: Life on Intertidal Rocks, Peterson Field Guides, Golden Guides
- binoculars
- trowels
- rock and mineral set
- compasses
- assorted field guides
- bug boxes and magnifiers

**Nasco**

901 Janesville Ave, Ft. Atkinson, WI 53538-0901

Phone: 800-558-9595

Fax: 920-563-8296

Web: [www.nasco.com](http://www.nasco.com)

- Two way microscope/viewer

**3. WHERE TO GET A TIDE TABLE FOR BOSTON HARBOR**

## 1. Websites:

<http://bostonharbor.com/><http://maineharbors.com/ma/tidemab.html><http://www2.shore.net/~mcmorran/tide/tideform.html><http://tidesonline.com/>

## 2. Local marinas and marine supply stores often supply complementary tidetables. Call Boxell's Chandlery, 12 B Street, South Boston, MA. (617) 241-2800.

3. Libraries and bookstores carry *The Farmer's Almanac*, *Eldridge Tide and Pilot Book* or *Reed's Nautical Almanac*, as well as calendars that include tides.4. *The Boston Globe* lists each day's high tides in the top corner of the front page, but that doesn't help you plan in advance!

## 4. REMINDERS FOR GROUP LEADERS

### **SEVERAL WEEKS BEFORE TRIP**

- Consult tide table.
- Pick a date, time and place.
- Conduct site survey.
- Make necessary reservations and travel arrangements.
- Identify resources to help design objectives.
- Recruit chaperones.
- Select activities and equipment.
- Integrate trip into ongoing curriculum with pre-trip activities and student preparation.
- Distribute permission/health forms with adequate time for return.
- Send home "What to Wear and Bring List" to students and chaperones.
- Mail out chaperone packets at least one week before trip, including schedule for the day.

### **SEVERAL DAYS BEFORE YOUR TRIP**

- Listen to weather forecast and double-check tide table.
- Confirm all reservations and travel arrangements.
- Predetermine student groups and assign chaperones (minimum 8:1 ratio).
- Chaperones should be assigned the same group all day for continuity. Consider color-coded name tags for easy identification.
- Collect all health and permission forms and store in waterproof pouch.
- Inventory field equipment, first aid kits, extra sunscreen, cups.
- Review theme, expectations, activities and low impact policies with students.
- Discuss lunch packaging and waste disposal. Perhaps offer an incentive to the student with the least amount of packaging?
- Have focus station write-ups for chaperones and materials for activities ready to go.
- Have icebreakers, time-fillers, bus activities and bag of tricks ready.
- Make sure all participants have directions and know meeting time and location.
- Designate "emergency driver" with additional vehicle.

### **DAY OF TRIP UPON ARRIVAL**

- Check in with your contact and deal with payments, permits, tour arrangements.

### **BRIEF CHAPERONES**

- Be sure chaperones understand and feel comfortable about all the plans and expectations for the day.
- Let them know they do not have to know all the answers but instead model inquiry through their own interest and enthusiasm.

- Run through all activities the chaperones will do with the class during the field trip.
- Explain what is expected of students and what the educational goals are for the trip.
- Explain safety concerns and review emergency procedures.
- Agree upon a meeting place and time for lunch.
- Determine who will carry the cellular phone and who will carry the pager and share this information with all chaperones.
- Thank the chaperones for all they are doing to help make the trip a success.
- Tell chaperones about future trips and, if you can, give them dates.

### **BRIEF STUDENTS**

- Review boundaries, rules and the agenda with the group.
- Review low impact exploration, animal handling and responsible beachcombing protocols.
- Determine a meeting place in case anyone gets lost or separated.
- Make sure everyone in group "greases up," "bugs off" and "fills 'er up" when necessary (applies sunscreen, applies insect repellent, drinks water) and is warm enough in cold weather.
- Set clear boundaries and establish "home base" area for gear and rendezvous.
- Use pre-determined hand or voice signals for group communication (Example: Everybody circle up when you hear the word "Echinoderm!").

### **DURING SNACK/LUNCH TIME**

- Assess group energy and needs.
- Group leaders may need time to regroup and troubleshoot, so chaperones should be prepared to supervise the group.

### **FOCUS STATIONS**

- Delegate specific roles to group leaders and chaperones.

### **BEFORE DEPARTING FROM YOUR FIELD TRIP SITE**

- Determine what type of wrap-up you will do. Always allow time for closure!
- Do a gear check and quick inventory for missing items.
- Do a head count and have the group check to make sure they have all their personal gear.
- Do a quick survey of site for trash.
- Check in with all group leaders re: accidents or discipline issues.
- Be sure to thank all the volunteers and chaperones for their assistance!

## 5. SAMPLE FIELD TRIP ITINERARY: BELLE ISLE SALT MARSH

*Basic Equipment:* Collecting buckets, magnifiers, field guides, journals or worksheets with clipboards, pencils. *Select for focus stations:* Plankton nets, Magiscopes® (with plastic slides, pipettes, small jars), seine net, string or rope loops, core sampler, tide charts, dry erase board, index cards, tape, markers.

### 10:00 a.m.

Group arrives. Overview of the day's agenda. Review group safety and site stewardship policies.

### 10:15 a.m.

Walk the entire group to the observation tower for a habitat overview.

Sample discussion topics and questions:

Use sight, sound and smell to make observations.

How will this marsh look six hours from now?

Do you notice any plant zones? Look for low, middle and high marsh zones.

How do you think the salt marsh was formed?

Discuss the history and vital functions provided by salt marshes.

### 10:30 a.m.

Morning snack. Groups split up to explore the marsh (no gear, low impact). Examples of guided interpretation: Compare low and high marsh vegetation; observe *Spartina* adaptations; feel and smell the detritus (nutrient rich decaying plant material) and spongy layers of peat; stand still and carefully observe plant and animal life.

### 11:00 a.m.

Regroup to review findings. Discuss proper collecting and animal handling methods. Group leaders supervise collecting of organisms - only one of each.

### 11:30 a.m.

Animal Interviews. Student pairs or teams select an animal that they will observe, sketch, identify and research with field guides using "Animal Observation" worksheet. Each team then presents their findings to the rest of the group. Animals are carefully returned to their habitats.

### 12:00 noon Lunch

### 12:30 p.m.

Reinforcing Game: Who Am I?

Tape index card with picture or name of salt marsh organism onto each student's back. In pairs, students ask each other questions to guess the name of the organism pinned to their backs. Questions can only be answered by "yes," "no," or "it doesn't matter."

### 12:45 p.m.

Select from these suggested Focus Station Rotations (15-20 mins. each)

Each group starts their field data sheets or journal entries with: date, time, cloud cover, air temp, time and height of low and high tides.

- Plankton tow: Collect plankton and observe using Magiscopes© and Zooplankton Identification Sheet
- Seine net: Students take turns using the seine net in different locations. Group observes samples and records what is found.
- Salt marsh census: Designate study areas with string or rope loops; record number and species of all the organisms found within the circle.
- Bird finders: Use bird field guide, binoculars and journals to distinguish identifying characteristics and observe feeding behaviors. Do a bird census.
- Core sampler: Take a sample of the peat with a corer in different zones and study the samples. Sketch what the sample make-up was at each site.
- Underwater viewers : Identify what was observed, draw or make field notes.

### 2:00 p.m.

Wrap-up. Gather all groups to review station research, findings, data sheets. Suggestions for salt marsh wrap-ups: Wetland IQ: Students review the importance of salt marsh services. Concept web of the salt marsh: On dry erase board, students map a web of all the living components of the ecosystem and how they are connected.

## 6. WHAT TO WEAR AND BRING

### *For Students and Chaperones*

- Insect repellent (lotions are best!)
- Sunscreen (SPF 15 or higher)
- Sweatshirt, jacket or windbreaker
- Hat or visor
- Sunglasses with UV protection
- Backpack or small duffel bag (with closures)
- Small, nutritional snack
- Water bottle (with closure)
- Water shoes or old shoes that can get wet or muddy
- A set of clean dry clothes
- Plastic bag for wet clothing
- Old hand towel
- Any special or personal necessities
- Rain jacket or poncho for wet weather
- Journal and pencil in plastic bag

#### *Optional:*

- Lunch in a reusable bag or lunch box (must be transportable and not need refrigeration)
- Swimsuit (seasonal)
- Snorkel and dive mask (seasonal)
- Wool or fleece hat, gloves, sweater or jacket (seasonal)
- Binoculars
- Inexpensive camera

#### **Things to Leave at Home**

- Personal stereo and headphones
- Video games
- Jewelry such as necklaces, earrings and watches (unless water proof)
- Money (no purchases of food or souvenirs will be allowed during programs)
- Candy and gum
- Pagers or beeping watches
- Cellular phones (group leaders will have means of communication)

#### **Chaperones/Staff**

- Personal identification (i.e. drivers license, medical insurance card)

## 7. FAVORITE FIELD GUIDES

### **Seashore**

- Coulombe, Deborah A. *The Seaside Naturalist*. New York: Prentice Hall Press, 1984.
- Day, Cherie Hunter. *Life on Intertidal Rocks*. Berkeley, CA: Nature Study Guild.
- Fitzsimons, Cecilia. *An Instant Guide to Seashore Life*. New York: Bonanza Books, 1989.
- Gosner, Kenneth L. *A Field Guide to the Atlantic Seashore*. Boston: Houghton Mifflin, 1978.
- Martinez, Andrew J. *Marine Life of the North Atlantic*. Camden, ME: Down East Books, 1999.
- Massachusetts Audubon Society. *Beachcomber's Guide to the North Atlantic Seashore*. Lincoln, MA.
- Pollack, Leland W. *A Practical Guide to the Marine Animals of Northeastern North America*. New Brunswick, NJ: Rutgers University Press, 1998. (dichotomous identification key)
- Weiss, Howard M. *Marine Animals of Southern New England and New York*. Connecticut: State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, 1995. (dichotomous identification key)
- Zim, Herbert S. and Lester Ingle. *Seashores: A Guide to Animals and Plants along the Beaches*. New York: Golden Press, 1989.

### **Salt Marsh**

- Neiring, William A., and Scott R. Wareen. *Salt Marsh Plants of Connecticut*. The Connecticut Arboretum Bulletin No. 25, June, 1980.
- Olmstead, Nancy C. *Plants and Animals of the Estuary*. The Connecticut Arboretum Bulletin No. 23, June, 1978.
- Olmstead, Nancy C., and Paul E. Fell. *Tidal Marsh Invertebrates of Connecticut*. The Connecticut Arboretum Bulletin No. 20, October, 1974.

### **Seaweeds**

- Lee, Thomas F. *The Seaweed Handbook: An Illustrated Guide to Seaweeds from North Carolina to the Arctic*. New York: Dover Publications, 1977.
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- Villalard-Bohnsack, Martine. *Illustrated Key to the Seaweeds of New England*. Kingston, RI: The Rhode Island Natural History Survey, 1995.

### **Plankton**

- Smith, DeBoyd L., and Kevin B. Johnson. *A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae*. 2d ed. Dubuque, IA: Kendall/Hunt, 1996.
- Gerber, Ray P. *An Identification Manual to the Coastal and Estuarine Zooplankton of the Gulf of Maine Region*. Brunswick, ME: Acadia Productions, 2000.

### Seaside Botany

- Duncan, Marion B., and Wilbur H. Duncan. *Seaside Plants of the Gulf and Atlantic Coasts*. Washington, DC: Smithsonian Institution Press, 1987.
- Petry, Loren C. *A Beachcomber's Botany*. Old Greenwich, CT: Chatham Press, 1968.
- Levering, Dale. *Illustrated Flora of the Boston Harbor Islands*. Boston: Northeastern University Press, 1978.
- Perkins, William D. *Chestnuts, Galls and Dandelion Wine, Useful Wild Plants of the Boston Harbor Islands*. Halifax, MA: The Plant Press, 1982.

### Natural History Field Guide Series

- Alden, Peter, et al. *National Audubon Society Field Guide to New England*. Chanticleer Press ed. Alfred A. Knopf, 1998.
- *Golden Guides*
- *National Audubon Society Field Guides*
- *Nature Study Guides*
- *Peterson Field Guides*

## 8. RECOMMENDED READING

### Methods of Environmental Education

- Caduto, Michael J. and Joseph Bruchac. *Keepers of the Earth: Native American Stories and Environmental Activities for Children*. Golden, CO: Fulcrum Publishing, 1989.
- Cornell, Joseph. *Journey to the Heart of Nature*. Nevada City, NV: Dawn Publications, 1994.
- Doris, Ellen. *Doing What Scientists Do*. Portsmouth, NH: Heinemann Educational Books, 1991.
- Leslie, Clare Walker. *Nature Drawing: A Tool for Learning*. Dubuque, IA: Kendall/Hunt, 1980.
- Leslie, Clare Walker and Charles E. Roth. *Nature Journaling: Learning to Observe and Connect with the World Around You*. Pownal, ME: Storey Books, 1998.
- Hogan, Kathleen. *Eco-Inquiry: A Guide to Ecological Learning Experiences for the Upper Elementary/Middle Grades*. Dubuque, IA: Kendall/Hunt, 1994.
- Roth, Charles E. *Beyond the Classroom: Exploration of Schoolground and Backyard*. Lincoln MA: Massachusetts Audubon Society, 1991.

### Marine Biology/Oceanography

- Castro, Peter and Michael E. Huber. *Marine Biology*. 2d ed. Dubuque, IA: Times Mirror Higher Education Group, 1997.
- Doris, Ellen. *Marine Biology*. New York: Thames and Hudson, 1993.
- Fox, William T. *At the Sea's Edge: An Introduction to Coastal Oceanography for the Amateur Naturalist*. New York: Prentice Hall Press, 1983.
- Greene, Thomas F. *Marine Science: Marine Biology and Oceanography*. New York: Amsco School Publications, 1998.
- Goodman, Susan E. *Ultimate Field Trips 3: Wading into Marine Biology*. New York: Atheneum Books for Young Readers, 1999.
- Niesen, Thomas M. *Marine Biology Coloring Book*. New York: Barnes and Noble Books, 1982.

### Coastlines/Seashores

- Amos, William H., and Stephen H. Amos. *Audubon Society Nature Guides: Atlantic & Gulf Coasts*. New York: Alfred A. Knopf, Inc., 1985.
- Berrill, Michael and Deborah Berrill. *A Sierra Club Naturalist Guide to the North Atlantic Coast: Cape Cod to Newfoundland*. San Francisco: Sierra Club Books, 1981.
- Hansen, Judith. *Seashells In My Pocket: A Child's Guide to Exploring the Atlantic Coastline*. Boston: Appalachian Mountain Club Books, 1992.
- Kochanoff, Peggy. *Beachcombing the Atlantic Coast*. Missoula, MT: Mountain Press Publishing Company, 1997.
- Lawlor, Elizabeth P. *Discover Nature at the Seashore*. Harrisburg, PA: Stackpole Books, 1992.
- Rood, Ron. *Beachcombers All: Exploring the New England Seashore*. Shelburne, VT: New England Press, 1990.
- Silver, Donald M. *One Small Square, Seashore*. New York: Learning Triangle Press, 1993.
- Teal, Mildred and John Teal. *Life and Death in the Salt Marsh*. Boston: Little, Brown, 1969.

- Zinn, Donald. *The Handbook for Beach Strollers from Maine to Cape Hatteras*. 2d ed. Chester, CT: Globe Pequot Press, 1985.

### **Boston Harbor and Islands**

- Cooke, Ian, Nina Danforth and Mark Mirsky. *The Explorer's Guide to the Neponset River Watershed*. Canton, MA: Neponset River Watershed Association, 1997.
- Kales, Emily and David Kales. *All About the Boston Harbor Islands*. Boston: Herman Publishing, 1976.
- Mallory, K. (Ed.), *Boston Harbor Islands: A National Park Area*. Down East Books, Camden, Maine, 2003.
- Sammarco, Anthony Mitchell. *Images of America: Boston's Harbor Islands*. Charleston, SC: Arcadia Publishing, 1998.
- Snow, Edward Rowe. *Islands of Boston Harbor*. New York: Dodd, Mead & Company, 1971.
- Sweetser, M.F. *King's Handbook of Boston Harbor*. Boston: Applewood Book for Friends of the Boston Harbor Islands, reprint of 1888 edition.
- The Boston Harbor Association. *Boston Harbor Curriculum Guide: Bringing Boston Harbor into the Classroom*, 2003. Written by: Kristin Forkeutis, Johanna Mendillo, Vivien Li, Brian Palm.

## **9. RECOMMENDED COASTLINE CURRICULA** *(Available in the Teacher Resource Center)*

- *Aquatic: Project Wild*. Boulder, CO: Western Regional Environmental Council, 1987.
- *Charting Our Course: The Massachusetts Coast at an Environmental Crossroads*. Massachusetts Coastal Zone Management and Massachusetts Marine Educators.
- *Coastal Wetlands... More than Muck and Mire, a Salt Marsh Guide for Educators*. Essex County Green Belt Association.
- *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools*. 11th. ed. Dubuque, IA: Kendall/Hunt, 1997.
- *Go with the Flow, A Boston Harbor Curriculum*. Boston: New England Aquarium Education Department, 1994.
- *Investigating Aquatic Ecosystems*. Ontario: Prentice-Hall Canada, 1987.
- *Investigating the Marine Environment*, Vol. 1 (Field Studies), Vol.2 (Laboratory and Classroom Studies), Vol. 3 (Teacher's Manual). Groton, CT: Project Oceanography, 1979.
- *Island Explorations: A Boston Harbor Islands Curriculum*. Boston: New England Aquarium Education Department, 1996.
- *Living in Water, an Aquatic Science Curriculum for Grades 5-7*. National Aquarium in Baltimore Department of Education. Dubuque, IA: Kendall/Hunt, 1997.
- *Massachusetts Bays Watershed Stewardship Guide: An Education Resource*. Boston: Massachusetts Bays Program, University of Massachusetts Extension, 1996.
- *New England Coastlines*. Boston: New England Aquarium Education Department, 1991.
- *On Sandy Shores: Teacher's Guide*. Berkeley, CA: LHS Gems, 1996.
- *Project WET Curriculum and Activity Guide*. Bozeman, MT: Montana State University, 1996.
- *Ranger Rick's Nature Scope: Wading into Wetlands*. Washington, DC: National Wildlife Federation, 1989.
- *The Rocky Shore: A Complete Guide to Conducting Educational Field Trips*. Rye, NH: Seacoast Science Center, 1997.
- *The Salt Marsh: A Complete Guide to Conducting Successful Field Trips for Grades K-12*. Rye, NH: Seacoast Science Center, 1994.
- *Sea Soup, Discovering the Watery World of Phytoplankton and Zooplankton*. Gardiner ME: Tilbury House, 1999.
- *A Teacher's Guide to Marine Life of the Gulf of Maine*. Augusta, ME: Maine Department of Marine Resources, 1993.
- *WOW! The Wonders of Wetlands*. St. Michaels: Environmental Concern, Inc. & Bozeman: The Watercourse, 1995.

## 10. ORGANIZATIONS AND WEBSITES

### **The Boston Harbor Association**

(617) 482-1722

Website: <http://www.tbha.org>

### **City Archaeology Program**

Phone: (617) 635-3850

e-mail: <ellen.berkland@ci.boston.ma.us>

### **Harbor Explorations (EnviroLab)**

University of Massachusetts Boston

Phone: (617) 287-7666

Website: <http://harborex.gcoe.umb.edu>

### **Hull Lifesaving Museum**

Phone: (781) 925-5433

Website: <http://www.bostonharborheritage.com>

### **Island Alliance**

Phone: (617) 223-8326

Website: <http://www.bostonislands.com/learn>

### **Massachusetts Bay Education Alliance**

Phone: (781) 740-4913

Website: <http://k12s.phast.umass.edu/~masag/massbays.html>

### **Massachusetts Coastal Zone Management**

Phone: (617) 626-1200

CoastswEEP (annual beach clean-up): (617) 727-9530

Website: <http://magnet.state.ma.us/czm>

### **Massachusetts Department of Environmental Management**

Boston Harbor Island State Park

Phone: (781) 740-1605 x205

Website: <http://www.state.ma.us/dem/bhis.html>

### **Metropolitan District Commission (MDC)**

Harbor Region

Phone: (617) 727-7676

Website: <http://www.magnet.state.ma.us/mdc/reserv.html>

### **Massachusetts Executive Office of Environmental Affairs**

Watershed and Environmental Education

Phone: (617) 626-1200 x1114

Website: <http://www.state.ma.us/envir/>

### **Massachusetts Marine Educators**

Phone: (617) 287-7666

Website: <http://www.capecod.net/~mme>

### **Massachusetts Water Resources Authority**

School Education Programs

Phone: (617) 788-4643 (water); (617) 689-8150 (wastewater)

Website: <http://www.mwra.com>

### **MIT Sea Grant Program**

Phone: (617) 252-1741

Website: <http://massbay.mit.edu>

### **National Park Service**

Boston Harbor Islands – A National Park Area

Phone: (617) 223-8666

Website: <http://www.bostonislands.com>

### **National Park Service**

Boston National Historical Park

Charlestown Navy Yard

Phone: (617) 242-5689

Website: <http://nps.gov/bost>

### **New England Aquarium**

Teacher Resource Center

Phone: (617) 973-6590

Website: <http://www.neaq.org>

### **Save the Harbor/Save the Bay**

Phone: (617) 451-2860

Website: <http://www.savetheharbor.com>

### **The Trustees of Reservations**

Phone: (781) 821-2977

Website: <http://www.thetrustees.org>

### **Thompson Island Outward Bound**

Education Center

Phone: (617) 328-3900

Website: <http://www.thompsonisland.org>

### **University of Massachusetts**

#### **Mass Studies Project Curriculum Database**

Website: <http://k12s.phast.umass.edu/~masag/highlights/html>

### **Volunteers and Friends of the Boston Harbor Islands**

Phone: (781) 740-4290

Website: <http://www.fbhi.org>

### **Other Recommended Websites**

<http://coast-enviro.er.gov/boseco>

<http://www.boston-online.com/harbor.html>

<http://bostonharbor.com>

<http://www.vims.edu/bridge>

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- Massachusetts Water Resources Authority. <http://www.mwra.com/>
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- National Park Service. *Boston Harbor Islands, Report of a Special Resource Study*. National Park Service, North Atlantic Region, 1994.
- Save the Harbor, Save the Bay. *Feathers and Fins, Boston Harbor's Habitat*.
- Sommers, George. *Boston Harbor and Massachusetts Bay: Ten Years of Change*. Boston, MA: Save The Harbor, Save The Bay, 1996.
- Waters, Barbara. Field Guide Sheets for Eastern Shore Marine Environments.



## New England Aquarium Programs and Services

### **Free subscription to *Schooling*** (617) 973-0280

*Schooling* is our yearly teachers' newsletter describing the New England Aquarium's educational programs. For the latest information on professional development courses, special events and new programs, sign up for our *Schooling* news listserv for e-mail updates at <http://www.neaq.org/special/teachers.html>

### **Teacher Resource Center** (617) 973-6590

**e-mail:** <[jrubin@neaq.org](mailto:jrubin@neaq.org)>

We offer loan materials (activity kits, equipment, videos, puppets, artifacts, posters and books), curriculum consultation, teacher workshops, and field trip planning assistance. Open by appointment, 8:30 a.m.- 5 p.m. Monday-Thursday; weekend appointments also available. An on-line catalog of TRC loan materials is at <http://www.neaq.org/learn/trc/index.html>. COD shipping can be arranged.

### **Library** (617) 973-5237

**e-mail** <[dwensink@neaq.org](mailto:dwensink@neaq.org)>

Open to the public by appointment. Students are invited to forward questions to "Librarian, New England Aquarium, Central Wharf, Boston, MA 02110-3399." E-mail requests for information must include postal mailing address in order to receive an answer.

### **Boat Programs Reservations** (617) 973-5281

**"Science At Sea" Harbor Tours** (grades K-12)  
**Whale Watches**

### **Reservations Center** (617) 973-5206

Please call the Reservations Center for information or to register for:

**Field Trips**

**Outreach Programs**

**Explorers' Classes**

**Behind-The-Scenes Programs**

**Overnight Programs**

### **Summer Programs**

**Harbor Discoveries** (617) 973-5206

**Duxbury Bay Maritime School** (781) 934-7555

**Outward Bound Environmental Leadership**

(617) 328-3900 ext 142

## Other Phone Numbers

**Youth Programs** (617) 973-6745

**Volunteer Office** (617) 973-5235

**Visitor Education** (617) 973-5297

**Marine Animal Stranding Hotline** (617) 973-5247

**Membership Office** (617) 973- 6555

**Proud Parent** (617) 573-0746

**Adopt-a-Right-Whale** (617) 973-6582

**General Information** (617) 973-5200

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