ROCKY SHORE ZONES: THE LOWER INTERTIDAL ZONE

Topic
Zones, Adaptations

Duration
Two sessions

Vocabulary
adaptation
challenge
feature
lower intertidal zone
zone

STANDARDS

Practices
Analyzing and Interpreting Data

Core Ideas
Adaptation

Crosscutting Concepts
Systems and System Models

OCEAN LITERACY PRINCIPLES

OLP 5

Focus Question

What is the Lower Intertidal Zone?

Overview

Students recall that the rocky shore has been divided into zones by marine biologists based on the average water and air exposure of each area. Students discuss what they learned about the splash zone, upper and middle intertidal zones. Students record information about the lower intertidal zone's names, characteristics, common algae life and common animal life. Students continue to construct a bulletin board diagram or individual rocky shore zone diagram by creating the lower intertidal zone using art supplies.

Objectives

Students will be able to:

- Indicate that the rocky shore can be divided into zones
- Identify the lower intertidal zone and its features
- Recognize the challenges living organisms encounter in the lower intertidal zone and the different adaptations of organisms living in the lower intertidal zone
- Create a lower intertidal zone using art supplies.

Materials Needed

If doing bulletin diagram activity:

- Rocky Shore Zones Table (one per student, page 126)
- Atlantic Ocean Rocky Shore Guide (one per student, pages 18–20)
- Rocky Shore Zones Table Answer Key (for teacher reference, page 127)
- Life at the Rocky Shore Fact Sheet (for teacher reference, pages 14–15)
- A large bulletin board or blank wall
- White bulletin board art paper
- White paper/index cards for each student
- Coloring utensils for each student

Teacher Tips

- Have students use the Atlantic Ocean Rocky Shore Guide as a reference while they draw their rocky shore organisms. Use book illustrations or other printed resources if you need more examples.
- While instructing students about the lower intertidal zone using the Rocky Shore Zones Table, either project a copy of the table on the board or draw a table on a whiteboard to record information for all students to see.
- Make copies of the Rocky Shore Zones Table Answer Key for students with special needs to use at their own desks to either copy or highlight.

Materials Needed (continued)

- Scissors for each student
- Stapler (for teacher)

If doing individual diagram activity:

- Rocky Shore Zones Table (one per student, page 126)
- Atlantic Ocean Rocky Shore Guide (one per student, pages 18–20)
- My Rocky Shore Diagram (one per student, page 70)
- Rocky Shore Zones Table Answer Key (for teacher reference, page 127)
- Life at the Rocky Shore Fact Sheet (for teacher reference, pages 14–15)
- Coloring utensils for each student

Teacher Preparation

For the large classroom diagram:

1. Make sure all students have copies of the Rocky Shore Zones Table and Atlantic Ocean Rocky Shore Guide.
2. Thoroughly review the Rocky Shore Zones Table Answer Key and Life at the Rocky Shore Fact Sheet.
3. Prep scissors, drawing utensils, and white paper/index cards for each student.

For the individual student diagram:

1. Make sure all students have copies of My Rocky Shore Diagram, Rocky Shore Zones Table and Atlantic Ocean Rocky Shore Guide.
2. Thoroughly review the Rocky Shore Zones Table Answer Key and Life at the Rocky Shore Fact Sheet.
3. Prep drawing utensils for each student.

Background

The rocky shore ecosystem is naturally divided into zones by the tidal movement of the ocean. These zones are mainly defined by the amount of time they are exposed to water and air. Specific organisms can often be found inhabiting particular zones.

Although types of living organisms are often found in one specific zone, they can be located in different zones depending on their ability to survive in various regions of the rocky shore. Zones are not restrictive, and will vary tremendously by slope, exposure, size of loose rocks, etc. While using the term "zone" is common and helpful, it can also mislead if students think that barnacles can only exist in the "barnacle zone."

Extension Suggestions

★ Provide students with the following facts: Green crabs were introduced to the Atlantic coast more than 250 years ago. Asian shore crabs were first seen on the Atlantic coast in 1988. Both types of crabs are considered invasive species—organisms that are not native to an ecosystem and are likely to cause harm to the ecosystem they have entered. Green crabs are the most abundant predators along New Hampshire's coastline. Asian shore crabs are also fierce predators. Both crabs have a large impact on their prey's population. Provide the following writing prompt to students, having them discuss their answers after the writing prompt is complete: 1) Do you think an invasive species should ever be considered a native species? Why or why not? Refer to *New Hampshire Wildlife Journal*'s article "Hitchhikers and Stowaways: Invasive Species Threaten New Hampshire's Coastal Ecosystems" by Ethan Nedeau.

Background (continued)

Each rocky shore zone presents living organisms with challenges that risk their survival. These living organisms have adaptations that enable them to overcome these challenges and thrive in the rocky shore ecosystem conditions.

The rocky shore ecosystem is frequently divided into three zones: the upper intertidal zone, the middle intertidal zone, and the lower intertidal zone. This ecosystem can be divided more precisely into five zones: the splash zone, the upper intertidal zone, the middle intertidal zone, the lower intertidal zone, and the subtidal zone.

Procedure

Part One

1. Ask students if they can recall how the rocky shore is divided into zones.
2. Inform students that a zone can be an area of land that has particular features. Each zone of the rocky shore has particular features, including specific amounts of time they are exposed to air and water, specific living organisms, and specific challenges to an organism's survival.
3. Have students discuss what they have learned about the splash zone, upper and middle intertidal zones by referring to their Rocky Shore Zones Table.
4. Inform students that they are going to be learning about the lower intertidal zone.
5. Instruct students on the names, features, algae, and animal life of the lower intertidal zone, having each student record facts you provide them with in their Rocky Shore Zones Table.
6. Emphasize the challenges to life in the lower intertidal zone, specifically citing the organisms' adaptations that allow them to survive these challenges.

Part Two

7. Inform students that they are going to continue to work on their rocky shore diagram, either as a class or individually.
8. *If as a class:*
    a. Have students access their Atlantic Ocean Rocky Shore Guide.
    b. Provide each student with white paper or index cards, scissors, and drawing utensils.
    c. Divide students into groups and designate each group specific organisms to draw and color for the lower intertidal zone.
    d. When finished, have students cut out their organisms, and the teacher will attach them to the bulletin board or wall diagram.

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Books

- *Invasive Species Underwater* by Richard Spilsbury
- *Keep Out! Invasive Species* by Sara L. Latta

Websites

- Watch O'Chang Studios' YouTube episode titled "Attack of the Green Crabs" and discuss invasive species.
- Watch the Seacoast Science Center's YouTube Channel episode titled "Anemones in Time Lapse."

Scientist Notebook

- Students can record the challenges and adaptations of organisms found at the lower intertidal zone.

Procedure (continued)

If individually:

a. Have students access their Atlantic Ocean Rocky Shore Guide and My Rocky Shore Diagram.
b. Inform students that they are going to draw the specific organisms of the lower intertidal zone onto their My Rocky Shore Diagram.

Wrap-up

- Have students store their Rocky Shore Zones Table, Atlantic Ocean Rocky Shore Guide, and My Rocky Shore Diagram (if applicable) in a secure place to refer to in upcoming lessons.
- Have students recall the features of the lower intertidal zone and its living organisms.
- Have students recall the specific adaptations of the lower intertidal zone organisms.

ROCKY SHORE ZONES TABLE

Name: _____

Date: _____

Name of Rocky Shore Zone: _____

Zone Name	
Zone Features	
Zone Algae	
Zone Animals	

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ROCKY SHORE ZONES TABLE

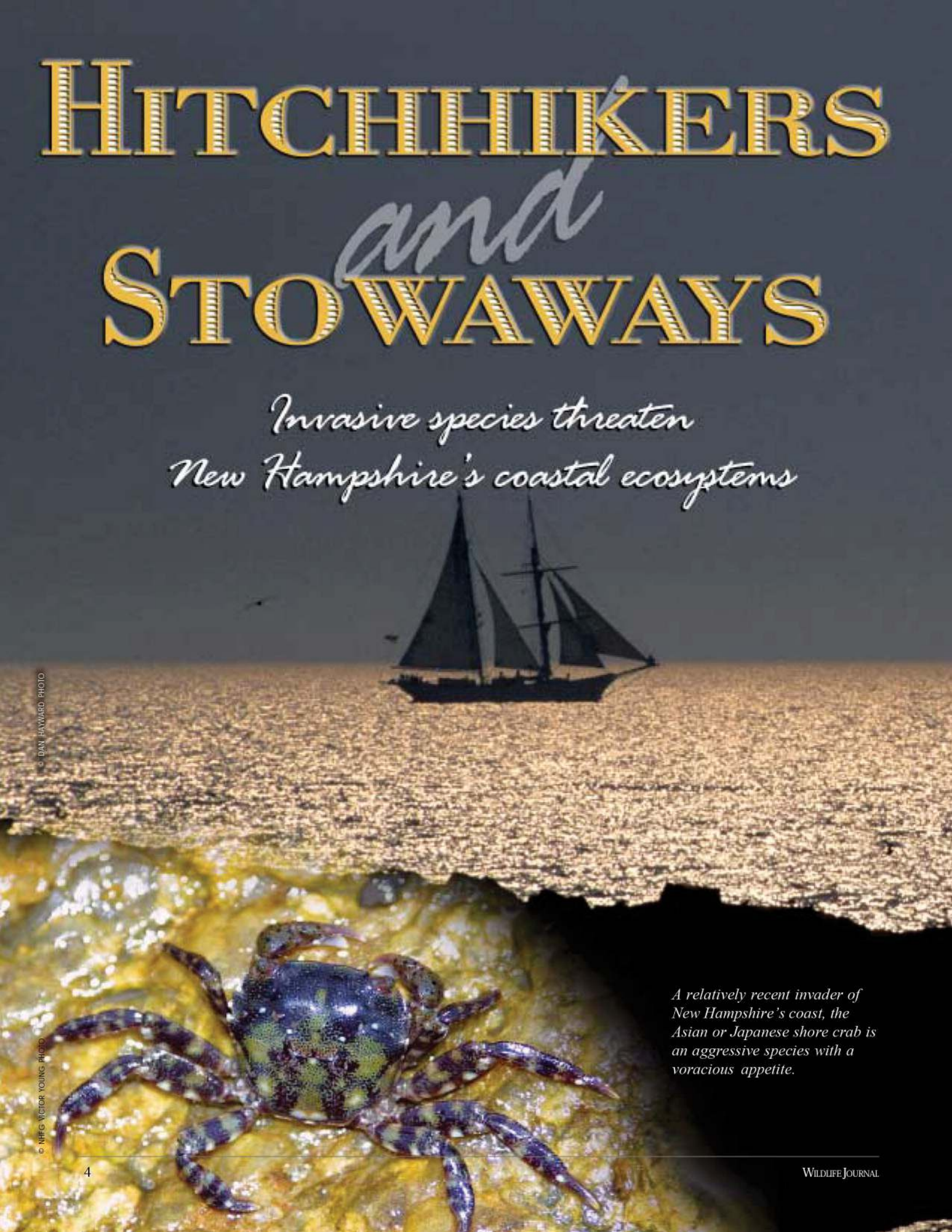
Answer Key

Name of Rocky Shore Zone: Lower intertidal zone

Zone Name	Lower intertidal zone
Zone Features	This zone is almost always exposed to water except for at extreme low tides.
Zone Algae	Sea Lettuce, Maiden Hair Algae, Coralline Algae
Zone Animals	Smooth Periwinkle, Atlantic Rock Crab, Common Slipper Shell, Northern Sea Star, Blood Star, Brittle Star, Frilled Sea Anemone, Bread Crumb Sponge, Clam Worm, Speckled Flatworm, Left-coiled Tubeworm, Red Chiton

Hitchhikers and Stowaways

Invasive species threaten New Hampshire's coastal ecosystems



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A relatively recent invader of New Hampshire's coast, the Asian or Japanese shore crab is an aggressive species with a voracious appetite.

Invasive, exotic, introduced, non-native, alien.....these are fighting words! People consider themselves native to the place of their birth—regardless of their family history—and carry that honor proudly. "A New Hampshire native? Well, pull up a chair and have a cup of coffee!" Plants and animals are not given that same birthright, especially ones that are economically or ecologically destructive. It doesn't matter if a species arrived in New Hampshire 200 years ago or two years ago—if they cause trouble, they are forever scorned. Hemlock woolly adelgids, gypsy moths, Dutch elm disease, Eurasian water milfoil and purple loosestrife are just a handful of species that will always raise the ire of New Hampshire's citizens. Sure, we brought them all here, but that is beside the point (right?). We also brought countless species that we embrace warmly. Earthworms, honeybees, apple trees and rainbow trout do not belong in New Hampshire, but what kid doesn't like to search for nightcrawlers on the evening before a fishing trip? What family doesn't enjoy an autumn Sunday in the apple orchards?

By Ethan Nedeau

Unwitting Voyageurs

When sailing ships began to bring Europeans to the New World, they not only carried the people and supplies to create a paradise in the image of the motherland, but they also carried plant and animal "hitchhikers" that—like the people—would forever change North American ecosystems. Thousands of hitchhiking marine species have been brought to North America, beginning more than 500 years ago.

Wooden ships moored in European seaports were colonized by shipworms (which are actually molluscs) and gribbles (isopods); these two species have voracious appetites for wood. They bored into boat hulls, creating a labyrinth of holes and tunnels that weakened the wood. This created an ideal living situation for creatures specialized to attach to surfaces or live within spaces, including algae, sponges, barnacles, anemones, bryozoans, tunicates, molluscs and tube-building crustaceans. Collectively, we call these "fouling organisms" because they foul surfaces that we would like to keep clean. Crabs, fish and snails are among the species that take refuge in the shelter that fouling communities provide. A single ship setting sail for America could have carried dozens or even hundreds of species in or on its hull: unwitting voyageurs.

Ships carrying an unusually light load were unstable in the water, so ballast (weight) was added to fix the problem. At first, sailors used dry ballast consisting of materials they could scrape from near the docking area. This was usually sand, rock or other debris that was chock-full of tiny marine and terrestrial animals and plants. Once the ship reached its destination, dry ballast was unloaded along with the creatures that survived the journey. Hundreds of years later, ships began using water ballast instead of dry ballast. Seawater—along with phytoplankton, zooplankton, larval fish and invertebrates—was pumped into ballast tanks. Once a boat reached its destination, thousands of miles away, the water was released and millions of organisms were poured into the local ecosystem to start a new home.

Commercial fisheries and aquaculture became a very effective vector for invasive species. By the late 1800s, adult oysters were being transported all across the world. Oysters were packed in crates with mud, vegetation and water from their native habitat. American oysters from New England were sent to far corners of the world and oysters from other oceans were sent here. Today, commercial shipping, fisheries, aquaculture and oil platforms continue to play a role in the spread of marine invasive species.

Invaders on New Hampshire's Shores

Ships from Europe arrived in New Hampshire's waters by the early 1600s, and years later, from all across the world. These ships carried thousands of foreign species to coastal waters and estuaries. Most of these species failed to become established—perhaps too few individuals were released to reproduce and sustain a population; or they might not have found New Hampshire's waters to their liking; or they could not compete with the natives. Others may have gained a foothold very early on and by the time scientists began doing careful surveys—two or three centuries later—the species might have become so widely distributed and harmonious with the native community that scientists may have mistaken them for native. A few species—the worst of the worst—shook the foundation of our native ecosystems and threatened the prosperity of our coastal communities.

Some of New Hampshire's marine invasive species are obvious. Most people admire or study the ocean from the shore—standing in salt marshes, gathering crabs and snails among boulders at low tide or strolling along the beach. Green crabs and periwinkles are two of the most common species in these habitats, allowing people to see first-hand how dominant non-native species can become. But most never witness the ecological damage that some invasive species are causing further offshore.

New Hampshire's Least Wanted

Crabs

Some invaders eat their way into an ecosystem by outmuscling native competitors and eating almost everything. Green crabs (*Carcinus maenas*) were introduced to the mid-Atlantic more than 250 years ago. They scuttled up the coast, spreading through New England and into the St. Lawrence region by the 1950s. They are now one of the most abundant predators along our coastline, feasting among eelgrass, shellfish beds and rocky intertidal areas. Their strong claws can crush shells of small clams, scallops, mussels and oysters.

Though green crabs have held reign as the toughest thugs in the neighborhood, there are new contenders that may soon take over. Asian shore crabs (*Hemigrapsus sanguineus*) have rapidly eaten their way northward to Maine since being first seen in New

continued on next page

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Sea Squirts Slime Seabed

Recent news reports document the alarming spread of *Didemnum sp.* or "sea squirt" infesting waters off New Hampshire. Late last year, researchers found dense, slimy colonies present in an area of at least 40 square miles on the Georges Bank seabed. Sea squirts reproduce rapidly and have no known predators, making them a potential threat to marine habitats, aquaculture and commercial and recreational marine fisheries. Scientists are rushing to learn more about the current and future impact of the species on our marine resources and what can be done to stop the spread. When you're on the coast, be on the lookout for *Didemnum* (a Google search for *Didemnum* will lead you to the U.S. Geological Survey's Woods Hole Science Center, which has lots of pictures for accurate identification of the species in its various forms), and report sightings to e-mail address *pvalentine@usgs.gov*.

Jersey in 1988. In the lab, a single Asian shore crab ate 150 juvenile snails and 170 juvenile mussels in one day! The eating contest between green crabs and Asian shore crabs in New Hampshire's coastal waters will certainly have a profound effect on their hapless prey.

Algae

With a name like deadman's fingers, you know the invasive green algae means trouble. Originally from Japan, it was brought to North America—and eventually New England—on shells of transplanted oysters. This species (*Codium fragile tomentosoides*) has tightened its grip on shallow subtidal and intertidal marine habitats in the Gulf of Maine in the last thirty years. It thrives in shallow water and often outgrows native kelp and eelgrass—two irreplaceable native species that provide habitat for countless others. To make matters worse, our champion native herbivores, green sea urchins, prefer to eat tastier foods. Other herbivores have taken up the fight, including snails and sea slugs, but *Codium* is definitely winning. Even though you may never go snorkeling to witness its abundance, you can still get an inkling of what is happening offshore from the enormous amounts of *Codium* that storms tear from the ocean bottom and deposit on beaches and shorelines.

Diseases

Not all invasive species can be plucked from the water. Several diseases have been introduced into New Hampshire's waters, causing sickness and death among our wildlife that is difficult to chronicle. Three oyster diseases—Dermo disease, MSX and Bonamia oyster disease—exist in New Hampshire and have wreaked havoc on most populations (keep in mind that oyster populations were mainly non-native to begin with). These parasitic protozoans were introduced to New Hampshire's waters with infected oysters transported from the mid-Atlantic or southeast coast. They flourish in the summer when water temperatures are warmest. Oysters had enough troubles with coastal pollution and overfishing, so these diseases only added insult to injury. New Hampshire is working to improve conditions for oysters, but may have to import strains with disease resistance because ridding an ecosystem of a disease is nearly impossible. Thus, the cycle of species introductions and reintroductions will likely continue.

Fouling Species

This ragtag group of hitchhikers and stowaways has crossed the high seas ever since humans first built boats and began exploring the globe. While these species are certainly adaptable and have good dispersal abilities, most would not have had the wherewithal to cross oceans on their own, and thus they cemented or encrusted themselves to our vessels. Blue mussels, barnacles, bryozoans, tunicates, sponges and worms are the most common types of fouling species. The easiest way to find them is to visit ports and harbors at low tide—piers, docks and wharves (as well as natural habitats) are often smothered with fouling communities and many of the species are not native. While many are innocuous, some may have profound effects on ecosystems, fisheries and marine industries. The white lace bryozoan

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Introduced to the Atlantic coast centuries ago, green crabs (left) are being threatened by a new invader, the ravenous Asian crab. Deadman's fingers, an invasive green algae (right), is taking over tidal habitats in the Gulf of Maine.

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Smooth periwinkle. A prized food in northern Europe, periwinkles were introduced in Canada for food, then spread throughout New England in the 1800s bringing a disease harmful to fisheries.

(*Membranipora membanacea*) smothers and kills native plants and has devastated native kelp forests in the Gulf of Maine. The colonial tunicate *Didemnum sp.* forms large, gruesome colonies that cover rocks, docks, gravel bottoms, mussels, oysters, or any other firm substrate; they have even been found offshore in Georges Bank *(see sidebar on page 6)*.

Forever Changed

Before you go off with your scoop and pail to "do your part" by making garden compost out of green crabs, periwinkles or other well-known invasive species, be aware that—unfortunately—your efforts are likely to have no effect on the ecosystem. Once species become firmly established, it is nearly impossible to get rid of them. Mother Nature sometimes finds clever ways to shift the balance and keep species from eating everything or carpeting the ocean, but often not before species go extinct and ecosystems are forever changed.

We have made so many mistakes that we should have learned at least one important lesson: keep out invasive species. Sure, accidents happen, but often because of ignorance, laziness or misguided efforts to make things better. There are several species in southern New England creeping toward New Hampshire to join ranks with other invasives. Carefully regulating the use of ballast water, cleaning boats before entering our waters, and closely regulating fisheries and aquaculture industries will help stop their spread. Monitoring programs—using New Hampshire's citizens armed with knowledge and a watchful eye—may help detect invasives early enough to eradicate them. Residents and visitors come to New Hampshire's seacoast area for the high quality of life; we must do our best to thwart those invasive species that threaten to spoil it. WJ

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Visit harbors at low tide to see stowaways like blue mussels and barnacles (right), fouling species that disperse with the shipping trade.

What Can I Do?

STOP AQUATIC HITCHHIKERS!™

Yes, it's a big ocean, but there *are* things you can do—or avoid doing—that can help prevent or reduce new introductions.

- Always discard unused fishing bait and packing material in the trash bin; live bait species may be invasive.
- Clean off all boats and boat trailers, canoes, kayaks, and diving and fishing gear of all plants and animals before going into a body of water.
- Never discard fish or aquatic pets or plants in the wild *(see page 19)*.
- Contact your elected officials to let them know you care, and encourage them to act to prevent and reduce invasives from various pathways.

www.protectyourwaters.net