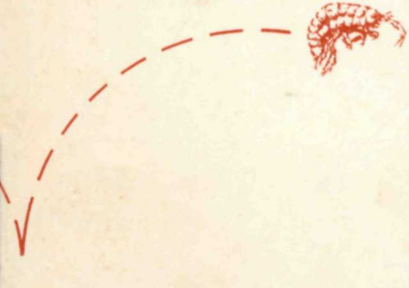
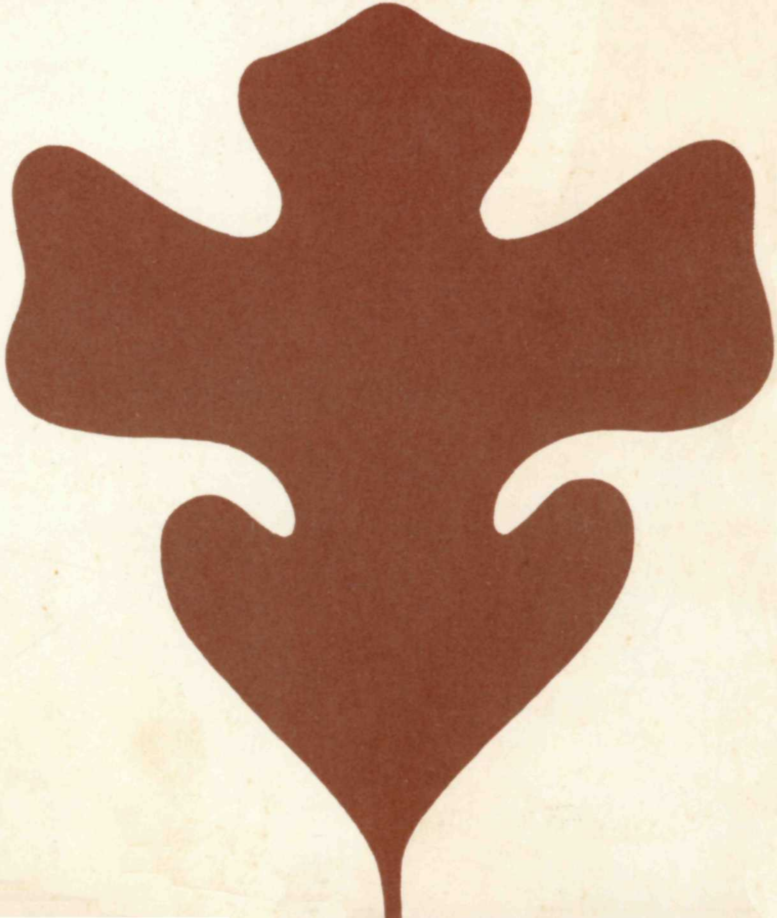
Discovering Fire Island

The Young Naturalist's Guide to the World of the Barrier Beach





Fire Island National Seashore was established to preserve the plant-and-animal communities of one of the few relatively unspoiled barrier beaches on our Atlantic coast. Within the boundaries of the National Seashore, the National Park Service not only provides for a variety of recreational activities but protects the natural resource as an outdoor laboratory for the study of geology, biology, and ecology. Except for those living things officially authorized for harvesting (fish, clams, etc.), and nonliving things such as shells and other beach wrack, do not remove anything from the park without permission.

Discovering Fire Island

The Young Naturalist's Guide to the World of the Barrier Beach

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Explorations Key:

- **A:** *For advanced ecology students*
- **I:** *Individual explorations*
- **G:** *Group explorations—direct supervision of a teacher or leader required for beginners or younger students.*
- **T:** *Team explorations—2 to 6 students or a family*
- **Y:** *Investigations to be carried on at intervals over a period of at least one year, or during the same season in successive years.*

Acknowledgements

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Photo Credits

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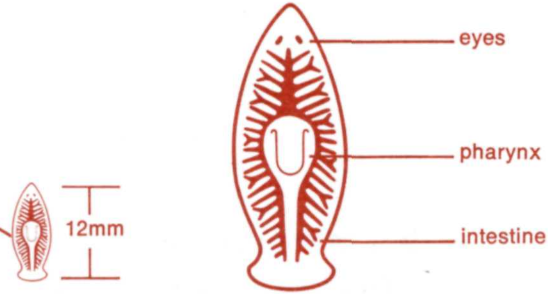
A Ramble Across the Barrier Island

Across Great South Bay, the sun appears about to sink into the low mass of Long Island. You are wading among patches of eelgrass in the warm, shallow water off the north shore of Fire Island. Dipnet in hand, you are seeking whatever kind of animal life you can capture. The fingersize fish darting about your legs are too fast. But wouldn't it be a thrill to see a sea horse? Your chances are slim. This animal is a slow swimmer, but it is not abundant, and it is well camouflaged in its eelgrass-jungle habitat. You do manage to catch a few crabs, dig up one clam with your toes, and scoop a number of small crustaceans into your fine-mesh net.

Suddenly an enormous horseshoe-crab comes right toward you, swimming just under the surface and veering to one side as it is about to bump your legs. Excitedly, you grab it by the long tail spine, drag it to the beach, and turn it over for a close look. What a curious creature! As it attempts to right itself with its tail, you probe between the leaflike "book gills" on its underside. There you find just what you're looking for: a large white flatworm, a permanent guest of the horseshoe-crab, living on the gills with no evident harm to the host. Turning the big invertebrate right-side up, you watch it return to the water. How does it find its way so easily? You didn't notice any eyes.



The flatworm, Bdelloura *(don't pronounce the "B"), lives on the gills of the horseshoe-crab.*

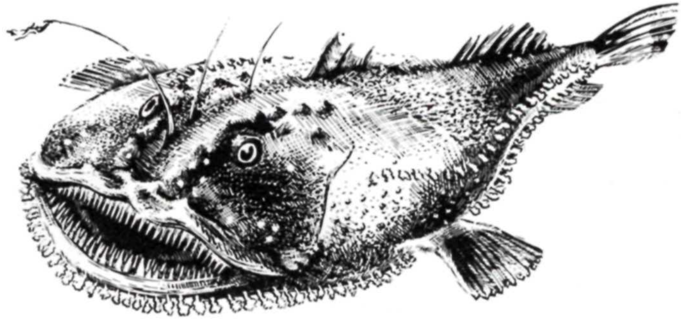
The horseshoe-crab, Limulus polyphemus, *is actually an arachnid, related to spiders, ticks, scorpions, and daddy-long-legs. This non-crab plows the muddy and sandy bottoms in search of the burrowing animals upon which it feeds. In early summer it lays its eggs in the sand along the shore. Horseshoe-crabs often carry a bevy of passengers—permanent guests, not hitchhikers—including sea lettuce, barnacles, boat snails, tube worms, limpets, and flatworms.* Limulus *is valuable to science: blood is drawn from living specimens (without killing them) and used in medical diagnosis. Return the horseshoe-crab unharmed to its habitat.*

As the horseshoe-crab swims away, your thoughts wander back in time—for you have just had a brush with the world of 200 million years ago, when such marine monsters as *Ichthyosaurus* ruled the seas, long before the great predatory dinosaur, *Tyrannosaurus,* appeared on land. This horseshoe-shaped animal without a backbone but with a tanklike outside armor has lived in Earth's seas virtually unchanged since that era. No wonder it is called a living fossil!

On the narrow beach you discover that the tide, receding while you foraged in the bay, has deposited a wealth of beachcomber's treasure on the sand. Here's an assortment of flotsam, jetsam, and beach wrack that could occupy you for hours. Besides a few dead horseshoe-crabs and many shed exoskeletons, there are scallop shells, seaweeds of various shades of brown and red, assorted driftwood, various items discarded from boats, and an abundance of plastic bottles and other ugly reminders that civilization is close by.

More interesting to you right now is a set of hoofprints running along the high-tide line. A deer has chosen the easy travel route; passage down the middle of this long, narrow, roadless island is made difficult by dense thickets of trees and shrubs. You decide to follow the deer tracks to see if they'll lead to an island crossing.

The American goosefish, Lophius americanus, *is so soft-bodied that when it is stranded on the shore its flat body becomes even flatter. It is one of the angler fishes, and although it preys on a wide variety of marine animal life it sometimes lies in wait in the eelgrass and gulps down fish that approach its lure—a flap of skin at the tip of the spine over its great mouth.*



A Living Fossil: I

Examine the external anatomy of Limulus, *the horseshoe-crab. You will notice that it resembles the hoof of a horse rather than a horseshoe; probably it was originally named "horsefoot-crab." Locate the eyes. How many are there? How does their position relate to* Limulus' *feeding habits? Study the book gills and swimming appendages. (Later, find a diagram of the gillbooks of a spider for comparison. And see if you can find out how* Limulus, *which has no jaws, chews its food.)*

Examine the exoskeleton. Can you find the opening through which the horseshoe-crab emerged from its outgrown armor? Except for this slit around the front margin, your specimen will be a complete and accurate representation of the exterior of the animal.

A little way along the beach you come to the skeleton of a goosefish, more than a meter long and almost as wide. You can well believe the account of a goosefish that was found to contain the bodies of seven ducks! Nearly all gaping mouth, with a formidable array of teeth, it seems a monster indeed. But there is a natural function for each of its parts, including the great mouth. Perhaps to a goosefish you would appear as grotesque.

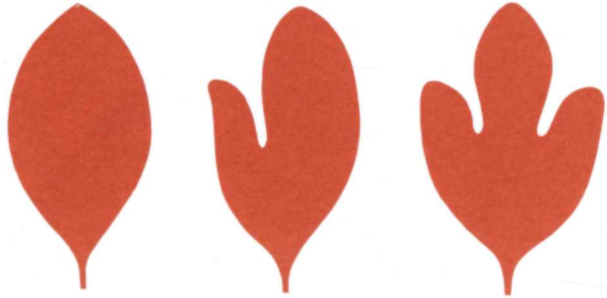
There is still flesh and skin adhering to the bones and skull of the goosefish, and it emits a putrid odor. But thinking that the skeleton would make a great conversation piece for your bedroom, you drag it to the upper beach to leave for the gulls, grackles, and scavenging invertebrates to clean up. You can return for your specimen in a few days.

Now the deer tracks turn inland, following a path through the salt marsh that separates the bay and the forest. Perhaps this will lead to the ocean beach. Following the trail, you pass first through a ten-meter-wide forest of reeds that tower high above you with large, feathery tips waving gracefully in the evening breeze. Beyond this zone of tall grasses is a band of ankle-high, odd-looking plants with fleshy stalks and without noticeable leaves or flowers. They look much like the primitive horsetails—the plants your pioneer forebears called "scouring rushes" and used for cleaning pots.

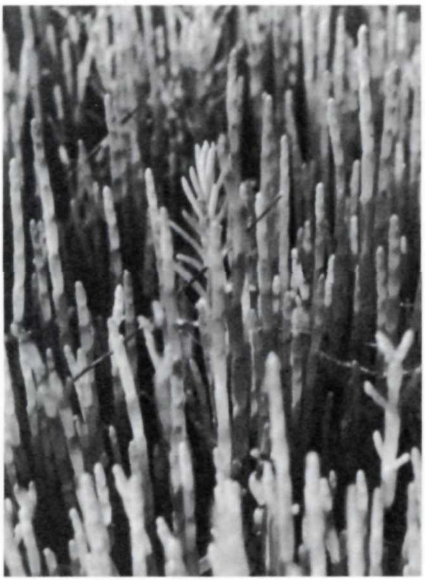
The glasswort zone merges eventually into a growth of head-high bullrushes; a little farther on the bullrushes mix with high shrubs whose big, pinkish blossoms remind you of the hibiscus growing back home in the front yard. Perched on the swaying tip of one of the tallest of these plants is a male red-winged blackbird, calling "konk-la-ree! konk-la-ree!"

Your nose wrinkles, and you stop. What is that odor that reminds you of a disagreeable medicine? It seems to be coming from some hip-high plants with purplish flower clusters. You think, "stinkweed" would be a good name for them.

Phragmites *is perhaps the tallest of the grasses, with the exception of the bamboos. It grows in both fresh and brackish water, normally to a height of 3 or more meters; sometimes it towers to almost 6 meters. It adds picturesque beauty to the lagoons and estuaries, and its strong root system helps control erosion on barrier islands and estuaries; but it encroaches on good wildlife habitat.*



Indians taught us to make a beverage from sassafras. It is more important ecologically as a "pioneer" tree: in some areas it is one of the first species to come into a burned or abandoned field.



Glasswort (Salicornia europaea), *despite its resemblance to the horsetails, is actually a member of the goosefoot family. Glasswort grows in coastal marshes over most of the world. Like spinach and the common garden pest, pigweed, which are members of the same family, it is quite edible.*

The forest is now only a few steps away. At the border of forest and marsh you see the plant you've been warned to watch for: poison ivy. Tracks and droppings indicate that the deer lingered here, as if to feed. Could it be that this plant, so troublesome to humans, actually provides nourishment for wild animals?

In the diminishing light of early evening, you move into the forest on a boardwalk trail. You stop, turn down the legs of your jeans, and apply insect repellent to your exposed skin; for there is little breeze here to discourage the mosquitos. As they fly about your head, you wonder what possible good there can be in these pesky creatures. True, they are food for swallows and dragonflies. If only they'd leave you out of the food chain!

What an unusual forest this is. There are no tall trees; you estimate that the biggest in sight is only seven meters high, although at the level of your eyes the trunk is almost as big around as your body. Another tree here has a very familiar look—it's the leaves, shaped like mittens, some with no thumb, some with one, some with two. You crush one of the leaves and hold it to your nose. Sure enough, there's no mistaking the fragrance of sassafras.

Hippocampus

Imagine a fish with a tubelike mouth through which it sucks its food as through a straw, a pouch in the male's abdomen in which the young hatch and remain until they are ready to make it on their own, an armor of interlocking bony plates instead of scales, and the ability to change color to blend with its surroundings; an animal that swims in a rigid upright position with no body movement and just a faint fanning of the delicate fins, uses its prehensile tail like a South American monkey's to cling to its slippery eelgrass perch, and resembles some mythical creature, half-horse, half-mermaid. Such a creature is the sea horse, Hippocampus. *Though its appearance and behavior wouldn't make you think so, it is a true fish, having a bony skeleton and occupying a rung on the evolutionary ladder about halfway between the primitive lungfishes and the highly advanced flounders and mackerel.*

Irresistible is the word for this quaint creature. Lacking the streamlining of most fishes, it seems to defy the laws of hydrodynamics as it swims stiffly upright. No wonder it depends upon camouflage instead of speed for protection from its enemies. It captures its prey, which is chiefly small crustaceans and crustacean larvae, not so much by pursuit as by vigorously sucking in what comes close. It apparently spends most of its time clinging to underwater rooted or free-floating plants, where its visibility is low and the food supply good. Look for it on the bay side of Fire Island in the eelgrass meadows under a meter or more of water. Finding one will be largely a matter of luck, for these animals apparently disappeared from these coastal waters with the decline of the eelgrass beds in the early 1930s *(see p. 86)* *and are just now on the comeback road long after the eelgrass returned.*

Would sea possum or sea kangaroo be a better name for it?

The forest is alive with birds. You see such fruit-eating species as robins, towhees, catbirds, and thrashers. You recognize the juneberry trees, having enjoyed their fruit on many a hike in the countryside. Here there are also the abundant fruits of black cherry, holly, chokeberry, and sassafras.

Poison-ivy is scattered through the forest, making you thankful for the elevated trail. Eventually the winding boardwalk leads out of the dimness to the top of a high dune. You can now hear the surf. You are at the border of the dune-and-swale community. Beyond the foredune a hundred meters away will be the ocean beach zone.

Turning around, you get a tern's-eye view of the forest you've just left. Looking down on the roof of the densely shaded community, one might think, "Why, it's almost like a green carpet I could walk across!" The foliage is so thick that you can see nothing under the top layer, and for all one could tell from this viewpoint, it might be no taller than your knees. What pruning tool has kept this forest leveled to the height of the dunes that separate it from the ocean beach?

Rhus toxicodendron, *poison-ivy, related to cashew and pistachio but not to English ivy, grows as a woody shrub or vine. Its three-parted leaves are borne* alternately *on the stem. It is common on Fire Island—so know it, use established trails, and keep alert.*

Everybody's favorite reptile, the box turtle (Terrapene carolina) *ranges as far north as Maine and Michigan, as far south as Florida, and west of the Mississippi as far as central Kansas. It's as wide-ranging in its diet, which includes mushrooms, snails, insects, berries, and earthworms. The female's eyes are normally brown; if you see a red-eyed box turtle, it's most likely a male. The plastron (lower shell) of the male is concave.*

Glancing down, you see a box turtle on the sand by a poison-ivy plant. It's a surprising place to see a turtle, even a land species. You'd have expected it in the damper low spots of the forest—but here, on the sun-baked top of the dune?

Before you a broad hollow, extending to your right and left as far as you can see, separates your dune from the dune that borders the beach. The vegetation in this zone is neither as dense nor as tall as that in the forest you've just left. Junipers, hollies, and pitch pines, pruned to the contours of the dune, cover the top of the dune; but as you go down the face these give way to a variety of plants growing in low clumps separated by bare sand. One shrub, with dense clusters of small, white flowers like wild roses, catches your eye; it's the same plant from which, on a September weekend, you gathered beach plums for home-made jelly. It has two growth forms here—sprawling on the ground and standing upright. A few meters away a cottontail is nibbling on one of these shrubs.

Suddenly a mallard duck zooms in over your head and makes a landing in the midst of the brushy vegetation. This is a strange habitat for waterfowl, you think. On the other hand, there would certainly be good hiding places for a nest under the thick clumps of shrubs and sprawling pitch pines.

Continuing on the boardwalk across the swale, you reach the top of the dune bordering the beach— the primary dune, or foredune. It slopes steeply to the high-water mark, and here the woody plants have given way almost entirely to clumps of beach grass.

The breeze is stronger than it was on the bay side of the island, and you can feel salt spray on your face. The cries of wheeling gulls and terns pierce the rhythmic roar of the surf. Two herring gulls are foraging for food at the line of wave upwash. What is the sea bringing to them? The graceful, hovering terns drop at intervals to the surface beyond the breakers; whatever they're fishing for must be small, for you can't see anything in their beaks.

You, too, are lured to the beach. Removing your shoes and again rolling up your jeans, you run down the broad slope toward the water. Suddenly three small, sand-colored birds you hadn't noticed fly up in front of you and settle again on the sand about 30 meters down the beach. As the waves wash up the beach, the little birds dash back and forth almost as if playing tag with the water; but as they follow each receding wave they jab their bills repeatedly into the sand. You walk toward them, hoping to get close enough to see what they're picking up. Again they fly up, white wing-bars flashing, to land a safe distance away and resume their game of catch-me-if-you-can with the waves.

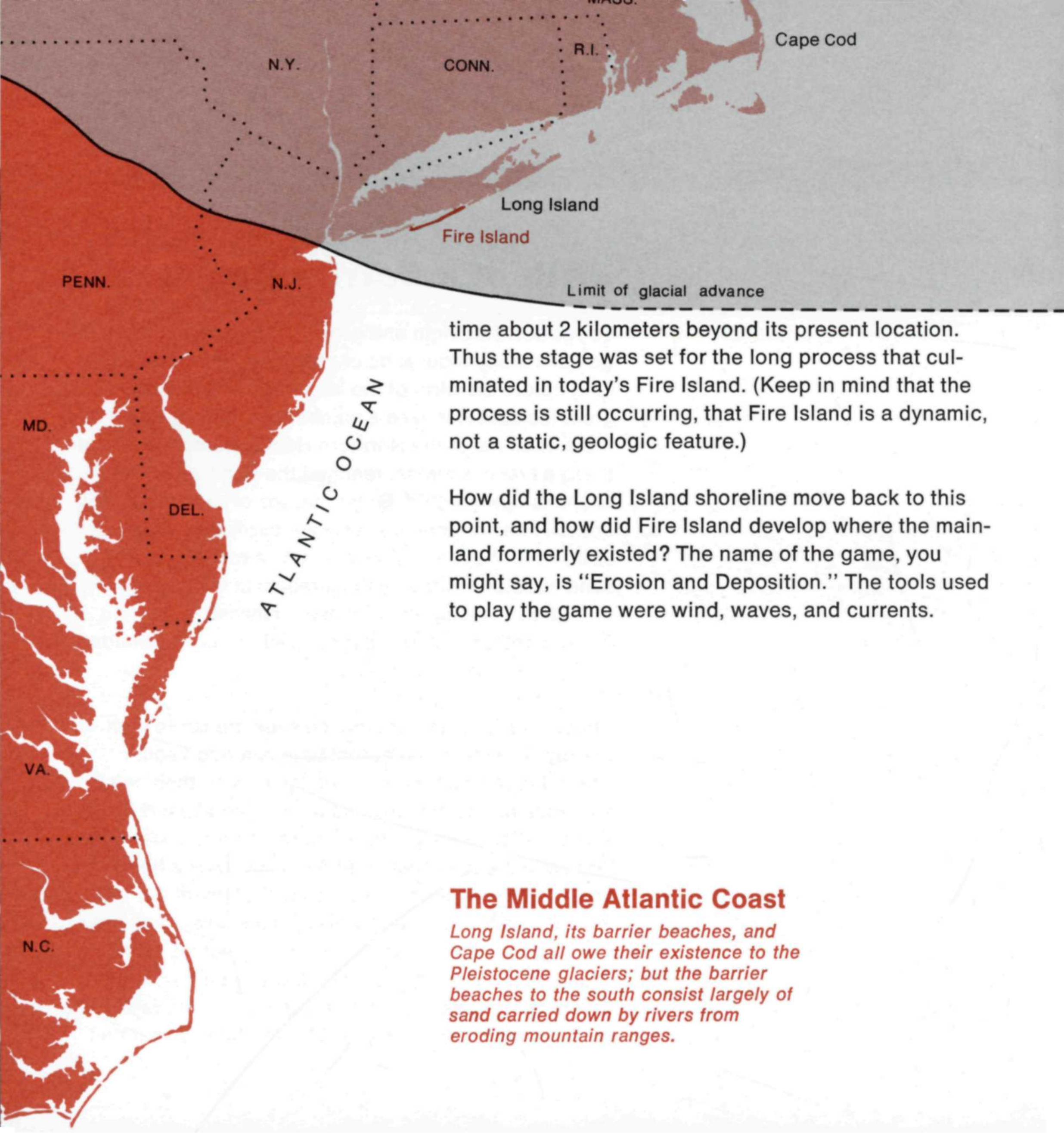
For a while you try the same sport; you soon discover that it's impossible to predict how far each wave will run up the beach. Standing still, you enjoy the sensation of having the receding waves wash the sand out from under your feet. Would you sink out of sight if you stayed long enough? How quickly your footprints disappear when you walk away! This must be a difficult environment for animals. You wonder how the birds can expect to find living things in these shifting sands. With such questions in mind, you decide to come back tomorrow with a digging tool. But now the sky is darkening rapidly, for the sun is well below the horizon. Buttoning your windbreaker, you gather up shoes and equipment and walk along the beach toward camp.

Birth of a Barrier Beach

To retrace the origin and growth of Fire Island, we must go back many thousands of years—to the Pleistocene, long before the birth of the island. During that epoch great ice sheets moved a number of times far down into the continents of the Northern Hemisphere. The last of these advances almost reached the point where Fire Island is now located. Great masses of rock material borne in and on that glacier were carried by glacial streams far beyond its terminus. The rocks, silt, and sand were deposited by the streams in fan-shaped formations. A long row of these "outwash fans"—so close together that they overlapped—was the foundation for most of Long Island.

About 11,000 years ago, the ice sheet began to melt rapidly. The mainland at that time extended south beyond today's beaches; Long Island was then only a low ridge on the outwash plain, and Long Island Sound a river valley in the plain. So much of Earth's water was tied up in the ice sheets that the ocean was a hundred or so meters lower than it is today. But as the ice melted, sea levels rose. By about 4,000 years ago they reached the level of today. The ridge became Long Island as the sea moved into the valley and separated it from the mainland. The south shore of Long Island between Montauk Point and Southampton was at this time about 2 kilometers beyond its present location. Thus the stage was set for the long process that culminated in today's Fire Island. (Keep in mind that the process is still occurring, that Fire Island is a dynamic, not a static, geologic feature.)

How did the Long Island shoreline move back to this point, and how did Fire Island develop where the mainland formerly existed? The name of the game, you might say, is "Erosion and Deposition." The tools used to play the game were wind, waves, and currents.



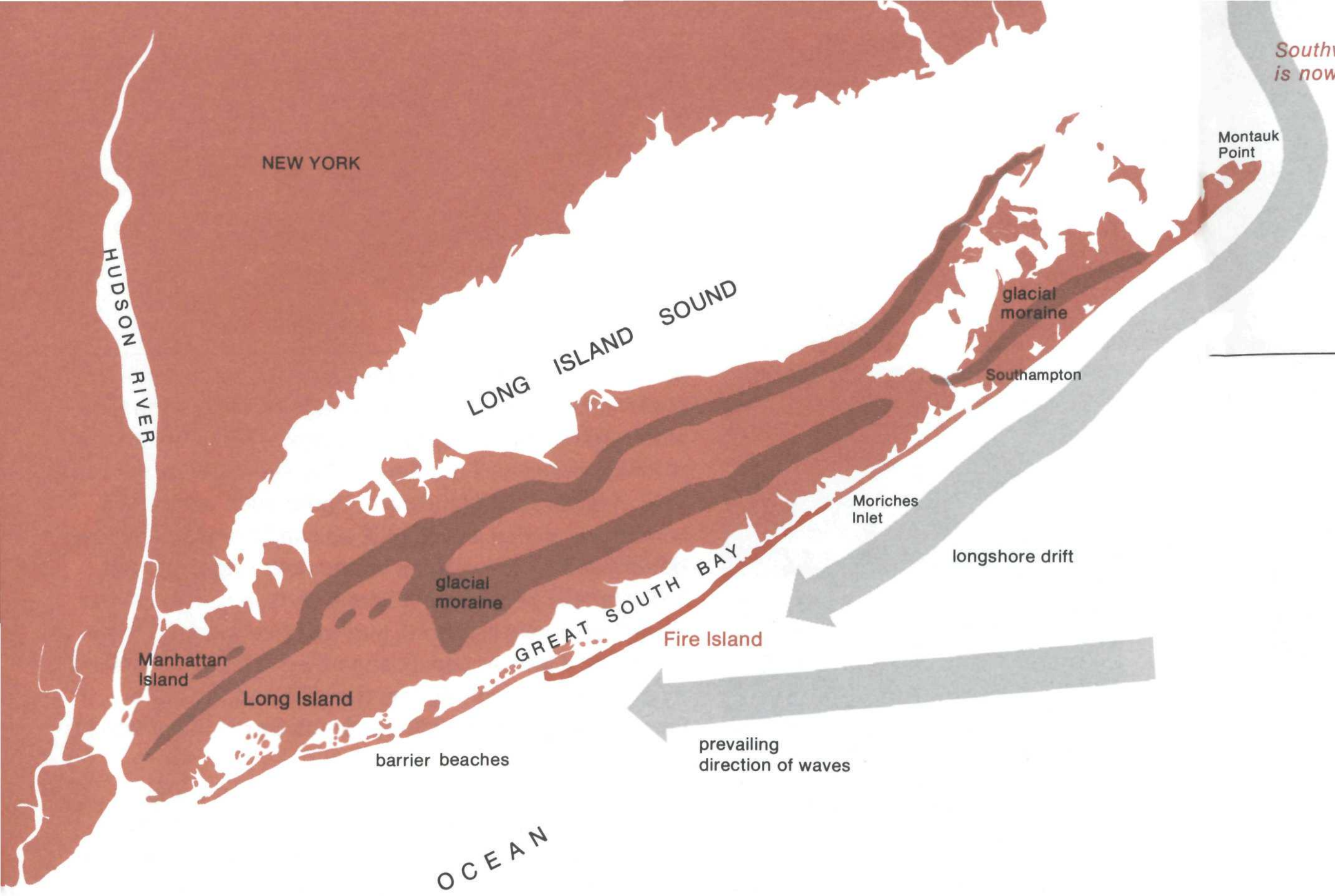
The Middle Atlantic Coast

Long Island, its barrier beaches, and Cape Cod all owe their existence to the Pleistocene glaciers; but the barrier beaches to the south consist largely of sand carried down by rivers from eroding mountain ranges.

Barrier islands, as we call these wave-and-current-built, linear islands, are developed only where the land slopes gently beneath the sea. Here the glacial outwash plain extended well out beyond the shoreline as the sea rose and advanced landward. Under such conditions, winddriven ocean waves pick up sand from the shallow bottom and build it into an underwater ridge, or sand bar. With the help of longshore drift (see p. 16), the bar is built up above sea level, and we have what we sometimes call a barrier beach, separated from the mainland by a shallow bay, or lagoon. (Long Island is Fire Island's "mainland," and Great South Bay is its lagoon.)

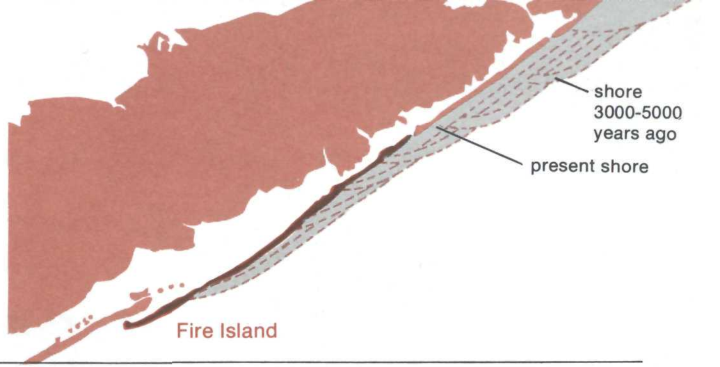
But Fire Island is not a typical barrier island, and its story doesn't quite conform to the pattern. The island began its development perhaps 3,000 years ago as the sea carved away at the headlands between Montauk and Southampton. Sand carried by the longshore currents (see diagram) built up a spit that grew westward at an average rate of some 25 meters per year. Wind and waves built the spit higher and wider, forming the dunes and the "sand apron" behind them.

In those 30 or so centuries, the sand spit has grown to a total length of about 80 kilometers; but its average width has never exceeded 300 meters. Sometime in



The Origins of Fire Island

Long Island is a part of an outwash plain that remains above sea level, which today is about 100 meters higher than it was during the Pleistocene. Long Island Sound is an inundated part of that outwash plain. Fire Island and other barrier beaches are made up of sand eroded by the waves from the post-glacial shores and carried southwest-ward by longshore drift.



Southwestward migration of the spit that is now Fire Island.

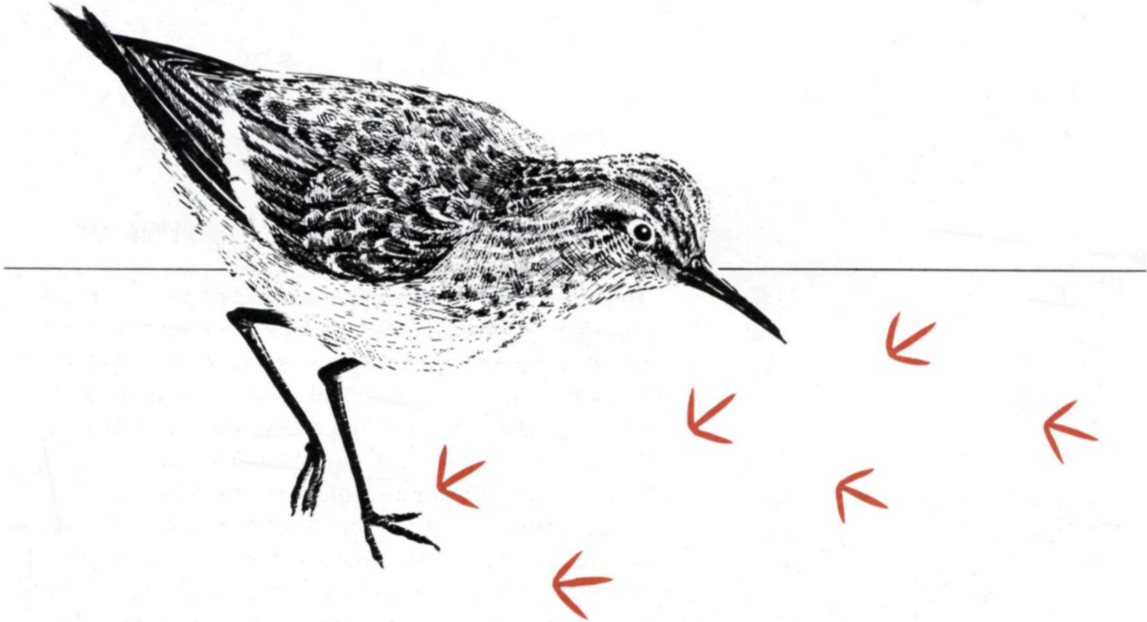
recent centuries storms breached the spit at two points, and the section farthest west is now Fire Island, which is separated from the middle section by Moriches Inlet. It is still a child of its "mainland," getting its growth from sand eroded from the Montauk-Southampton shore. Fire Island today is a little more than 50 kilometers long.

As the diagram shows, Fire Island is not only growing longer year by year; it is moving toward the mainland. This migration occurs because wind, waves, and currents are removing more sand from the ocean side of the island than is being deposited there. Much of the sand is piled up on the beach by wind, tide, and waves and is blown landward, extending the sand apron and the marshland and encroaching on Great South Bay. Some sand is carried into the lagoon through Moriches and Fire Island inlets, and this helps to extend the marshland, build islands, and fill in the lagoon. It is entirely possible that this landward migration will continue until Fire Island becomes a part of Long Island. Perhaps ocean waves will then build up new sand bars that with the help of the wind will develop into new barrier islands occupying almost the same locations as do the present chain of islands. But none of these developments will come to pass in your lifetime.

How to Be a Beachcomber

The sprightly shore bird you saw playing tag with the waves on your early evening walk from the bay is the beachcombing champion of Fire Island, the sanderling. It is well named, because it likes sand beaches, and because its coloration blends well with the beach sand. But it could just as aptly have been named "wanderling," for it is a champion globetrotter, too, known to lands around the Earth from the Arctic almost to the Antarctic. A sanderling that summers on the northern shore of Greenland may fly in winter to the south coast of Australia. And it's not even as large as a robin.

You can see these birds from fall through spring and sometimes in summer; and you can learn from them some valuable lessons in beachcombing. Observe carefully as they forage for food. Watch a sanderling dash on slender legs up and down the beach slope with the advancing and retreating waves at its heels. When a wave seems about to overtake it, the little shore bird may just flutter above the beach for a moment, then alight and follow the receding wave back downslope. This game of tag is actually a most efficient way of getting food, for small organisms living in the sand are closest to the surface when it is being washed by incoming and receding waves; and the waves deposit other organisms carried in from the offshore waters.

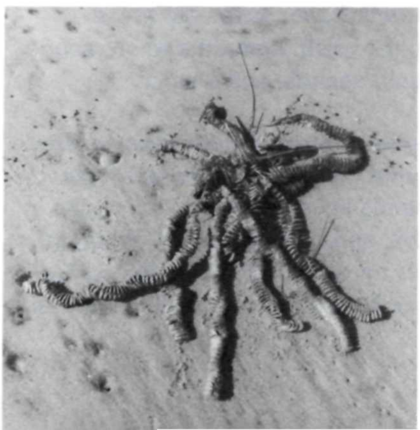


Notice that as the sanderling's twinkling legs carry it over the wet surface, it makes repeated downward thrusts of its awl-like bill. If you were able to examine this operation closely, you'd find that, probing the sand with slightly opened bill, it is extracting tiny animals—shrimp and other crustaceans, marine worms, mollusks, and invertebrate larvae.

So here's your first lesson: look along the water's edge for small animals. But they are not usually abundant in this severe environment, and you'll need a magnifying glass—10-power or more. And unless you're as nimble as a sanderling, plan on getting wet feet.

Your Beachcombing Kit

At little expense, you can make up a kit of handy beach-study aids that can be carried in a plastic shopping bag. Some useful items are 10-power magnifying glass, thermometer, binoculars, wide-mouth glass jar or clear plastic container, magnet, sieve or sifting box, trowel, metric ruler, and collecting bag. You may want field guides for bird or shell identification. A camera (with close-up lens) is a good record-keeping tool and a means of "collecting" specimens of living animals that you're not allowed to remove from the beach. And don't forget notebook and pencil!



These chains of papery, hollow discs found on ocean and tidewater beaches are the empty egg capsules of large, carnivorous marine snails called whelks. As many as 200 eggs are enclosed in each capsule.

There are certain clues that will help you find life in the sand. Most of the small holes you see are "percolation holes" made by air escaping from the sand; a few may be the entrances of burrows. Footprints indicate where birds have been foraging. Look for smaller creatures living in the spaces between sand grains; for this you'll need a strong lens or even a microscope. Digging and sifting will bring forth such animals as razor clams, soft-shelled clams, and the burrowing amphipod, *Haustorius,* a relative of the beach hoppers that is more closely tied to the sea.

Donax, the active little coquina, or bean clam, normally found on southern beaches, arrives at Fire Island as a larva carried in the Gulf Stream. It moves up- and downslope with the tides. When a wave reaches the point where it lies buried, *Donax* leaps out of the sand and rides up on the wash. When the wash recedes, it quickly anchors itself, upends, and digs in.

Actually, most of the life of the intertidal zone consists of fish and plankton that come in with the tide. Few animals and fewer plants have adapted to existence in this unstable, abrasive, and difficult habitat. When the tide is out, the sand is hard-packed. When the surf is washing it, the sand is subjected to violent motion. As

Beachcombers All: I
Compare the feeding habits of animal visitors to the ocean beach. Examine such questions as:

Do you ever see terns feeding on the beach?

Do such shore birds as sanderlings and sandpipers use the same techniques for getting food as do the gulls?

Which birds depend on the waves to bring fresh food?

What songbirds do you find visiting the beach, and what are they seeking?

What information can you get from tracking mammals on the beach?

Which visitors are scavengers?

you will discover if you visit the beach the day before and the day after a storm, it can change dramatically overnight. Where you saw a 100-meter-wide beach, there may remain only a 50-meter strip between the foredune and the sea. A storm may remove the entire population of an animal such as the mole crab, which might not recover for years. Even after a long spell of moderate weather, you will do well to find a half-dozen species of animals below the surface of the sand.

But with the lack of variety of life forms in this environment, those species that have adapted to its stresses occasionally reach enormous numbers. The sea brings an unlimited supply of food to this zone, and populations can build up rapidly.

Can you explain why in the intertidal zone of Great South Bay you'll find a much greater variety of forms than you will find on this exposed ocean beach?

Each kind of animal in the intertidal beach occupies a zone that is strictly limited by the physical conditions. For example, the mole crab's feeding techniques require that it remain in a narrow zone that moves back and forth with the tide; the crab does not ascend as far as the upper intertidal zone.

Amphipods

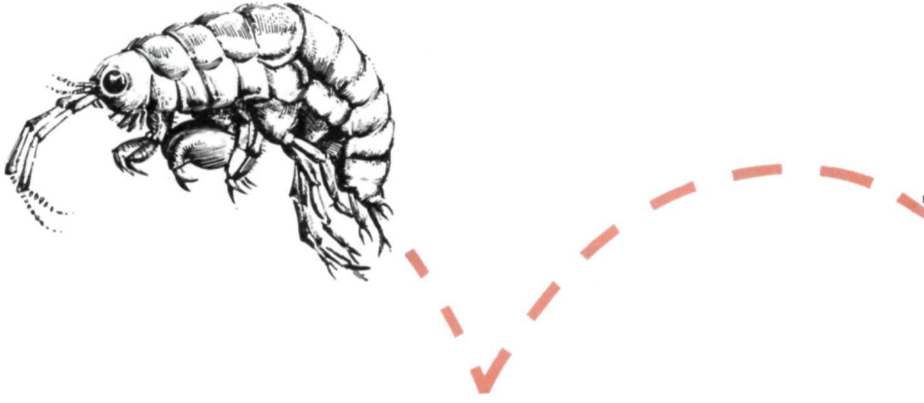
Anyone interested in seashore life should become acquainted with the group of small crustaceans called amphipods. There are more than a thousand species, and all are flattened sideways, which makes them easy to distinguish from other crustaceans. They range in size from near-microscopic to about 30 millimeters long. Because of their abundance and because many animals eat them, they are important ecologically.

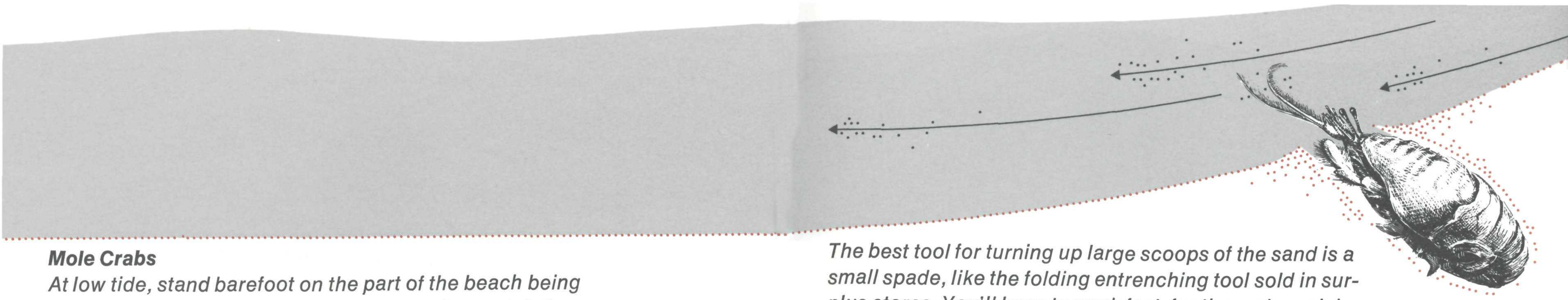
The sand hoppers of the ocean beach are gilled air breathers. Their three hind pairs of abdominal feet are adapted for jumping, and the three front pairs for swimming. As though these animals were on the evolutionary road from a marine habitat to a dry-land existence, the jumping feet are much the larger. But the usual route from sea to land is not direct; rather, it is via estuaries and fresh water. No crustaceans, moreover, have entirely adapted to dry-land existence—not even the sowbugs you find under boards in your back yard.

Apparently the small amount of moisture under the driftwood and seaweed is enough for the upper-beach amphipods. They feed upon the seaweed and upon dead animals, and in turn are fed upon by a host of predators: sandpipers, sanderlings, insects, centipedes, and many others.

At the shore on the bay side of the island, you'll find other amphipods, as well as the distantly related isopods, *which are flattened from top to bottom.*

Amphipods can swim, walk, or jump, and would be inconspicuous except for their activity.





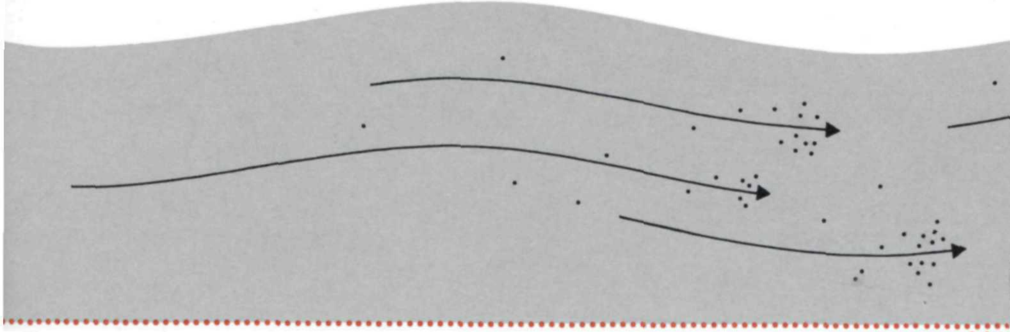
Mole Crabs

At low tide, stand barefoot on the part of the beach being washed by the waves. As each wave recedes, watch the sand where the water is flowing down the slope of the beach. If you're sharp-eyed, you may see a pair of tiny, featherlike objects project from the sand only to disappear when an incoming wave washes up the slope. Dig quickly into the sand where you saw the "feathers;" with luck you'll find a small, smooth, egg-shaped animal. This is the mole crab, which buries itself head up just beneath the surface of the sand in the lower part of the intertidal zone. When the waves are receding—not advancing—it extends its plumelike antennae to strain food particles from the water. As the tide ebbs and flows the mole crabs, which can swim, move with it so as to remain in the feeding zone. The females, as much as 40 millimeters long, may be too big for the sanderling to swallow; but the much smaller males are probably taken by this bird.

The best tool for turning up large scoops of the sand is a small spade, like the folding entrenching tool sold in surplus stores. You'll have to work fast, for the mole crab is an amazingly adept burrower. One of its predators, the swimming crab, has developed an efficient means of capture: it shoves its large claw downward into a bed of sand crabs. If it manages to grab one, it begins running in a circle, all the time holding onto its victim. The twisting motion enables it to pull the sand crab out of the tightly packed sand much as you'd pull the cork out of a bottle of wine.

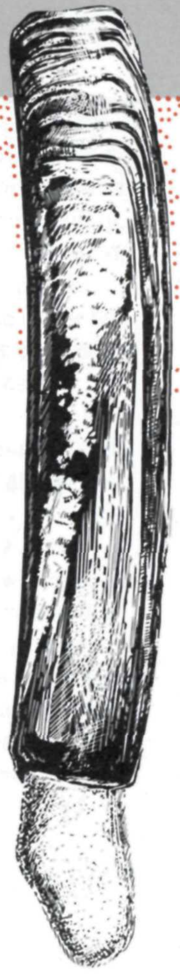
If you get one, put your specimen into a wide jar filled with sea water and with about 50 millimeters depth of sand in the bottom. Then drop the mole crab into the jar. It will burrow into the sand so quickly you'll miss it if you blink! This ability, an adaptation to life at the edge of the ocean, is due partly to its streamlined shape. Examine the crab *with a magnifying glass; you'll see the several pairs of short, stout legs that enable it to dig in backwards. Study the branched breathing antennae, the feathery feeding antennae, and the eyes on very long movable stalks.*

To learn more about this remarkable crustacean's adaptations, life history, and behavior, read The Life of the Seashore.



Razor Clams

The razor clam, so named because it is shaped like an old-fashioned straight razor, shares the mole crab's reputation as a fast burrower. But it lives in quieter sandy intertidal areas, where there is not the active surf so necessary to the mole crab's existence. Like the mole crab it cannot burrow in dry sand; but in the watery lower intertidal habitat it is a wizard at the disappearing act.



The razor clam, which may reach 25 centimeters in length, occupies a vertical hole without any sand piled around the opening. It feeds when its burrow is covered with water, with part of its shell sticking above the surface of the sand. When the tide is out, you may be able to dig up a razor clam—but you'll have to move fast, for it has a muscular "foot" that enables it to descend quickly beyond your reach. Try to get it with the first fast spadeful of sand; if you miss, you might as well move on to another clam hole.

Like the sanderling, you shouldn't limit your beachcombing to the intertidal zone. You'll find the pickings less slim and the foraging easier on the upper beach. This is the zone between normal high-tide mark and the "toe" of the primary dune (see p. 46). It's good for sunbathing and play, and also has lots of animal visitors. But when you consider the prevailing conditions—sands being shifted constantly in the wind and removed wholesale by storm waves; so much salt that the surface of the sand is often crusty with it; a lack of organic matter to provide food for burrowing animals; and extremely dry conditions near the surface—you can understand why few animals are permanent residents. If you've walked barefoot across the upper beach on a midsummer day, you can also understand why animal visitors might be scarce at midday.

On the upper beach as in the intertidal zone, the sanderling's favored food is crustaceans. These include sand hoppers ("beach fleas"), abundant animals hardly more than a centimeter long that hide in vertical burrows in damp sand or live under the windrows of driftwood, fish remains, shells, dead seaweed, and other debris at high-tide mark. Kick over some of this "beach wrack" and watch the little crustaceans jump like the fleas for which they have been named. There are also

Be a Scavenger: G, I, T

Make a bulletin-board display, or a mobile sculpture, of things found on the beach. Try to have a specimen representing each of the major animal groups of the marine ecosystem—a fish skull, a horseshoe-crab shell, bird feathers, and a mollusc shell—as well as driftwood, dried seaweed, and other plant material.

predatory and scavenging beetles, and flies and (on dead fish or birds) fly maggots. Together with gulls and visiting scavengers from the island's interior, these are nature's garbage collectors for the beach community, keeping dead plants and animal carcasses from piling up. (The gulls are also efficient removers of picnic scraps, and prey upon horseshoe-crabs and other live animals cast up by the waves.) Carnivorous centipedes and herbivorous millipedes are also found here.

You can learn much about the beach community and the life of the sea by combing this zone for skeletons, shells, egg cases, and other animal remains. At high-tide mark and in the storm-wave zone look for the shells or dead bodies of horseshoe-crabs, which live in the ocean as well as the bay; for those necklace-like chains of whelk egg cases that mystify many a visitor to the beach; and for fish skeletons, which are more varied than you'd guess. Some of your discoveries will have a tragic note; too often, today, the beachcomber finds a sea bird, its feathers soaked with heavy, black oil, cast dead or dying upon the shore.

If you keep a record of where you discover each living thing–above high-tide mark; in the intertidal zone; in the sand being washed by the waves; above or below

Want to enjoy wildlife-watching the year around? Learn to identify gulls, terns, and shorebirds, the most conspicuous animals of the seashore. Observe their feeding behavior, plumage patterns, manner of flight, and calls. The sandpipers, including the sanderling, are a big family that will require a lot of practice on your part. A bird guide and binoculars are essential. The bird in the picture is a herring gull.

the surface–you'll gradually piece together an ecological jigsaw puzzle: the pattern of life communities and the habitat requirements of different species. You'll observe that some animals, such as the sanderling, are not restricted to a single community or habitat. Others, such as the mole crab, because of their food requirements and special adaptations to the environment, are never found beyond their special narrow zone, except by accident. Each of the life forms of the ocean beach has developed structural adaptations and behavior patterns that enable it to cope with physical hazards, find food, and protect itself from its enemies. It is this great variety of life styles that makes even this austere environment—almost a desert when compared with the rich bay community—an interesting place to explore.

As your observations and examinations accumulate, you will begin to see emerging a pattern of seashore life—a structure much like that of a human community, in which each organism has a function, or "niche" in the ecosystem.

After the Storm

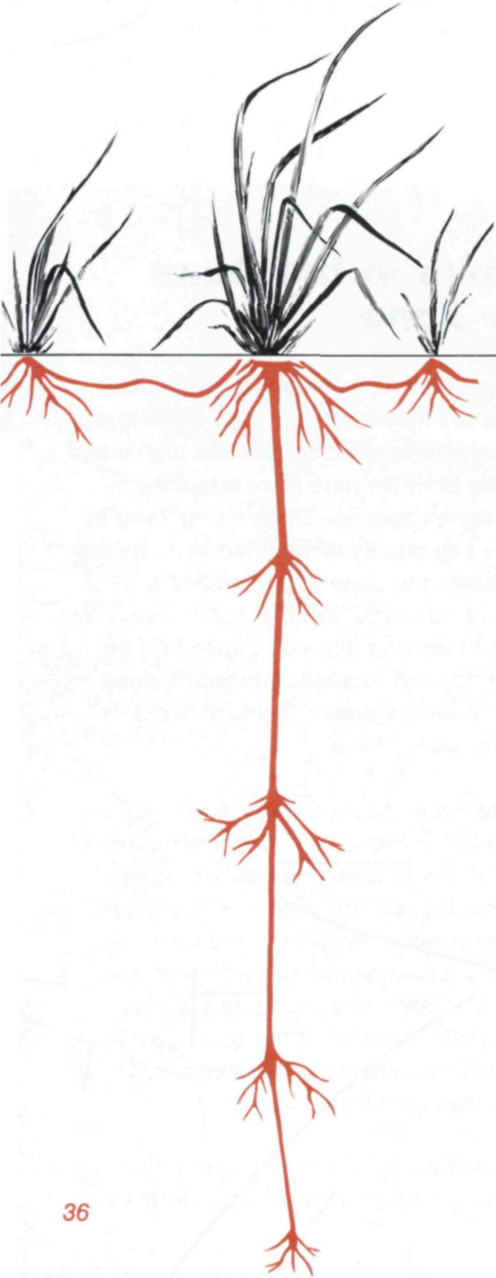
The most productive time for beach exploration is the day after a storm; the bigger the blow the better the beach-combing. But stay well above the dangerous surf that persists after the wind abates. Probe the windrows of jetsam, driftwood, and dead plants for animals cast up by the storm waves. You will find the valves of many molluscs, including such forms as the sea butterfly, knobbed whelk, shark's-eye, transverse ark, jingle shell, and false angel wing; dead sand sharks and sea robins; and perhaps living specimens of surf clam, starfish, blue mussel, large hermit-crab, Tubularia *and other hydroids, bryozoans, and sponges.*

Up and Down in the Dune and Swale Zone

The zone behind the beach is in some ways the most severe environment of Fire Island. It is very close to a desert in its physical characteristics; and the plants and animals that are able to thrive here have adaptations similar to those of desert species. Every living thing in the dune-and-swale community is modified in its habits, structure, and life history to cope with heat and dryness. And any part of this zone is subjected to heavy doses of salt spray, in varying degrees depending on whether it is on a windward (ocean) or leeward slope and on how far it is from the ocean. Thus, only plants tolerant of salt can succeed here.

It is true that the dune-and-swale zone gets as much rain as the other island communities. But the porous nature of the sand allows rainfall to percolate rapidly down beyond the reach of ordinary plant root systems. This means that plants either must produce a root system that reaches to unusual depths or must have special adaptations to conserve what moisture they can capture during the rains. Animals either must go outside the zone for water or must have the capacity to survive on moisture obtained from food.

Let's explore this community by starting at the "toe" of the foredune—the upper edge of the beach. Here, even



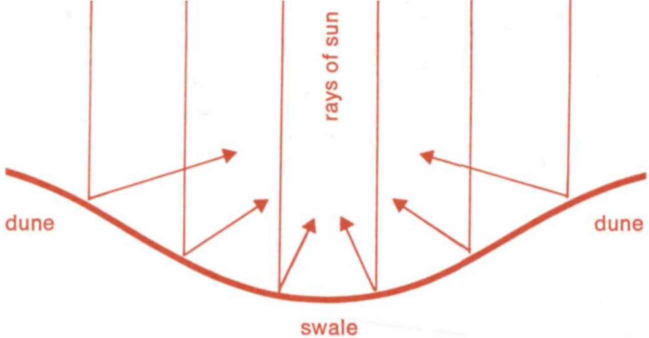
Beach grass, Ammophila breviligulata, *a most important plant ecologically, is found on the coast from Newfoundland southward and on sandy shores of the Great Lakes. It spreads mainly by sending up shoots from the joints of creeping rhizomes, or horizontal underground stems.*

on the beach itself, you may see an intriguing plant with an intriguing name, "dusty miller." You'll know it because it looks as though it had been dusted with a white powder—much as an oldtime flour miller might be. Its floury appearance is due to a dense matting of white fibers that insulates the plant against light and heat and probably provides some barrier to evaporation of moisture. Obviously, a plant growing in such a location must be very tolerant of salt spray.

Now let's go up the face of the foredune—via a boardwalk or other designated crossing. Here the dominant plant is beachgrass *(Ammophila breviligulata).* This plant is so effective in stabilizing the dune with its spreading roots that it is often planted in dune-restoration work where human traffic has trampled the vegetation or a heavy storm has caused damage. The prevalence of beachgrass on the ocean side of the foredune suggests that, like dusty miller, it has great tolerance for salt spray. Patches of beach-plum and bayberry shrubs occur among the beachgrass.

At the top of the dune another shrub, bearberry, appears. As you go downslope, the shrubs become dominant and beachgrass diminishes. In the more open areas where there is much bare sand, woolly beach-

"Lens Effect"
In hollows (including the swale itself, which is a large hollow), the sloping sides reflect sunlight and radiate heat toward the center, raising temperatures to levels as high as 50° C.



Artemisia Stelleriana *is the scientific name of beach wormwood, popularly known as "dusty miller"—a name applied to at least four other plants.* Artemisia *is most conspicuous on the windward side of the foredune, and a few plants even grow on the upper beach. It is too scattered to be of importance as a dune-holding plant. Like saltspray rose, it is an Asian plant that escaped from American gardens and spread along our Atlantic coast.*

heather and seaside goldenrod are common. Look closely at the beachheather; notice its heavy, scalelike leaves—an adaptation against water loss and heat.

The dip between the primary dune and the secondary dune is called a *swale*. You'll find changes in the vegetation here that reflect the changed conditions. Does it seem hotter here than it was at the top of the dune? Of course the swale is shielded from cooling sea breezes. But as shown in the diagram, there is a further reason: when the sun is high the slopes of a swale or hollow in the dunes act much like a lens or reflector to concentrate the sun's rays. So plants growing in the bottom of the swale have to contend with greater heat. On the other hand, being closer to the water table (see diagram), they may have less difficulty reaching moisture with their root systems. Animals, being mobile, cope by remaining in burrows or escaping to other parts of the zone during the hottest part of the day.

And what animals can you expect to find in this community? You found that the beach and intertidal zones, unlike most natural communities, were populated primarily by animal forms. The green plants that are the base of the food web in these communities are the algae and plankton plants of the sea. The living animals

What's in a Name?

Why do we use Latin names such as Ammophila breviligulata *or* Artemisia Stelleriana *when it's so much simpler to call the former "beachgrass" or to use the more interesting name of "dusty miller" for the latter? For one thing, most of the 1,000,000-plus known species of animals and 375,000 species of plants have no names other than the Latin binomials ("two names") given to them by the scientists who classified them. Secondly, "beachgrass," for example, would be used only by English-speaking people; its Latin name is universal. Moreover, there are other species of grasses that can quite properly be called beachgrass—and some persons might refer to* any *grassy plant growing on the beach as "beachgrass." And to confuse matters further, there are other acceptable English names for beachgrass: sand-reed, psamma, dunegrass, and marram. One name might be used in one locality, another in the next county.* Ammophila breviligulata, *on the other hand, refers to one species, or kind, of plant, wherever it grows. Another "beachgrass,"* Ammophila arenaria, *belongs to the same* genus *(plural: genera), or closely related group of species,* Ammophila. *Their different specific names,* breviligulata *and* arenaria, *reflect the fact that the seeds of each will reproduce only that kind of plant.* Ammophila breviligulata *seeds will not produce* Ammophila arenaria *plants, and the pollen of one will not fertilize the ovary of the other.*

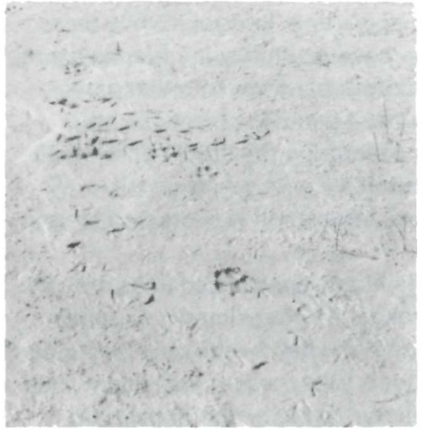
If you were to mention "beachgrass" to a European scientist who did not speak your language he would not know what plant you meant. But Ammophila *is a genus with species on both sides of the Atlantic, and the Latin name of each would not only be spelled the same everywhere, but would have basically the same pronunciation.*

The generic name is always capitalized. The specific name is not—except when it applies to a plant named for a person. (Artemisia Stelleriana *was named in honor of the great 18th-century German explorer-naturalist Georg W. Steller.)*

of beach and intertidal zones depend mostly on food brought in by the waves. But here in the dune-and-swale the situation is normal—a variety of rooted green plants is the food base. In crossing this zone, you will see as many as two dozen plant species.

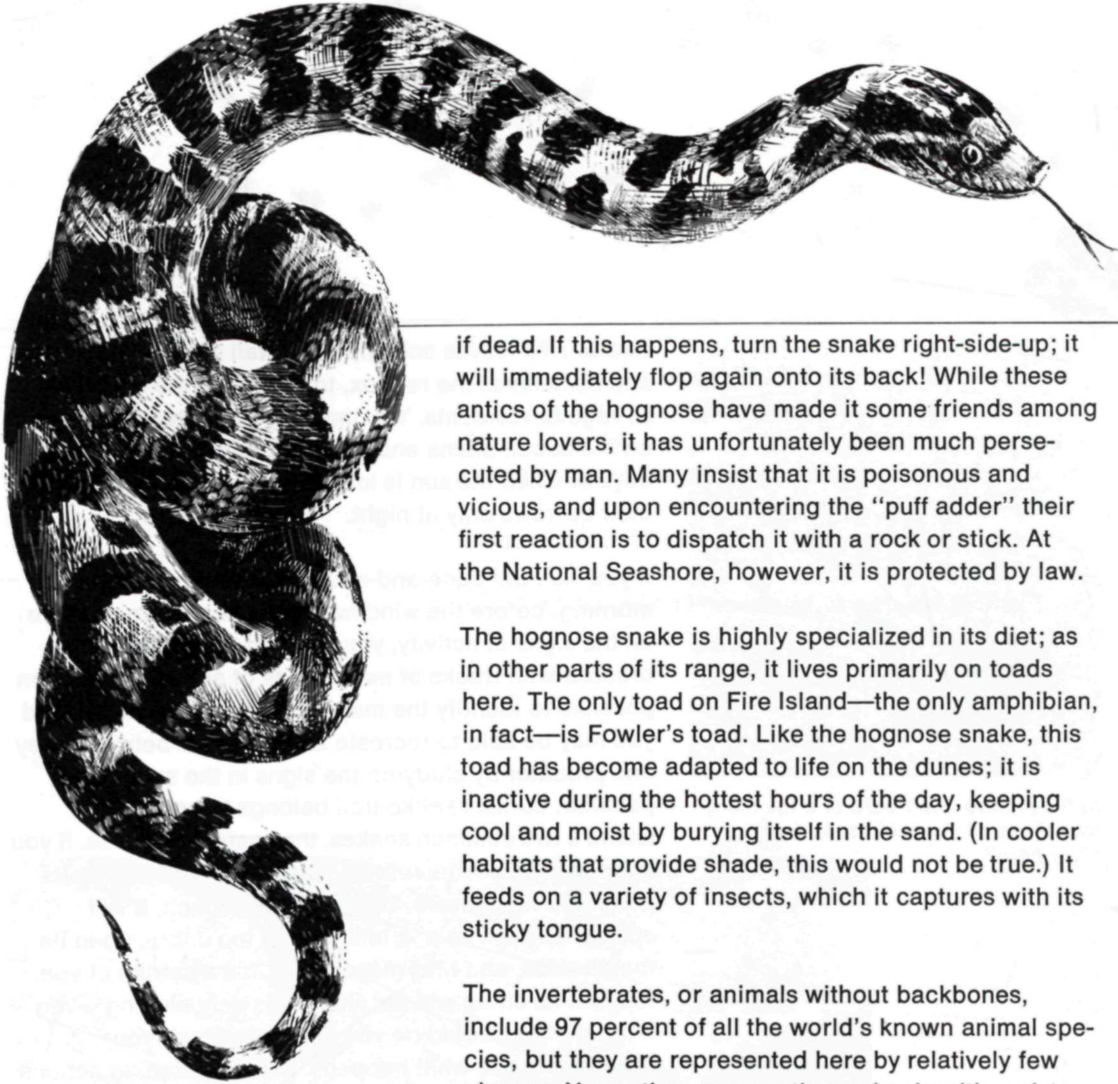
Except for birds that visit the dunes to feed on berries, there are few vertebrates here. The white-tailed deer, which roams over all the island, is a visitor to the swale. This leaves only the cottontail and meadow vole, and sometimes the red fox, to represent the mammals as regular residents. You may see cottontails nibbling on the beach plums and other shrubby plants on cooler days or when the sun is low. But the voles come out of their burrows only at night.

Beach-heath (Hudsonia tomentosa) is not found on the windward face of the primary dune; but in the swale it is more prominent than beachgrass.



In the picture, the tracks of a fox merge with those of shore birds. Is there a story here?

If you visit the dune-and-swale community in early morning, before the wind has had a chance to obscure all the signs of activity, you will find the surface criss-crossed with tracks of many kinds of animals. It is often possible to identify the maker of a particular track; and you may be able to recreate an encounter between prey and predator by studying the signs in the sand. One peculiar, corkscrewlike trail belongs to one of Fire Island's two common snakes, the eastern hognose. If you happen to meet this reptile, you may be startled by its defensive maneuvers. Upon your approach, it will spread its neck as if in imitation of the cobra, open its mouth wide, and hiss menacingly. It may strike at you, too, but its strike will fall short. It is only bluffing; even if it did bite it would do you no harm. Stand your ground and see what happens. If its threatening actions don't drive you off, it may suddenly roll onto its back as



if dead. If this happens, turn the snake right-side-up; it will immediately flop again onto its back! While these antics of the hognose have made it some friends among nature lovers, it has unfortunately been much persecuted by man. Many insist that it is poisonous and vicious, and upon encountering the "puff adder" their first reaction is to dispatch it with a rock or stick. At the National Seashore, however, it is protected by law.

The hognose snake is highly specialized in its diet; as in other parts of its range, it lives primarily on toads here. The only toad on Fire Island—the only amphibian, in fact—is Fowler's toad. Like the hognose snake, this toad has become adapted to life on the dunes; it is inactive during the hottest hours of the day, keeping cool and moist by burying itself in the sand. (In cooler habitats that provide shade, this would not be true.) It feeds on a variety of insects, which it captures with its sticky tongue.

The invertebrates, or animals without backbones, include 97 percent of all the world's known animal species, but they are represented here by relatively few classes. No earthworms or other animals with moist skins can tolerate the hot, dry sands. Insects are the dominant group of invertebrates here as in other land

The hognose snake, Heterodon platyrhinos, *inhabits sandy areas throughout eastern United States except in Maine. On Fire Island its chief prey is Fowler's toad,* Bufo woodhousei fowleri. *Unlike frogs, toads generally have dry, warty skins and hop rather than leap. They are not as much bound to water as most frogs, but return to water to breed and occasionally to soak. Fowler's toad is a late breeder, laying eggs until mid-August.*

Sunlight and Sand: I

During early afternoon make a series of temperature readings at a spot on the foredune or secondary dune that is fully exposed to sunlight. Read the temperature one meter above the sand (be careful to shade your thermometer from the sun to be sure of getting the air *temperature); 5 centimeters above the sand; just under the surface of the sand; and 5 and 15 centimeters under the surface. How does this relate to the egg-laying behavior of the bembecid, or digger wasp, and to the daily schedule of activity of the Fowler's toad?*

environments. Special structural adaptations or behavior patterns enable many of them to survive in desert-like conditions. Some beetles move up and down the plant stems, varying their distance from the hot sand as its temperature changes. Some insects burrow underneath by day and come out at night. Some are light-colored, like many desert species, and absorb the heat of the sun less readily than do darker animals.

Successfully coping with the heat and dryness of the dune environment are the abundant ants of various kinds. Dune ants are burrowers; some have special sand-carrying apparatuses on their heads that make it easier for them to dig deep into the sand to a level where it is cool and humid. The ants avoid activity on the surface during the hot part of the day.

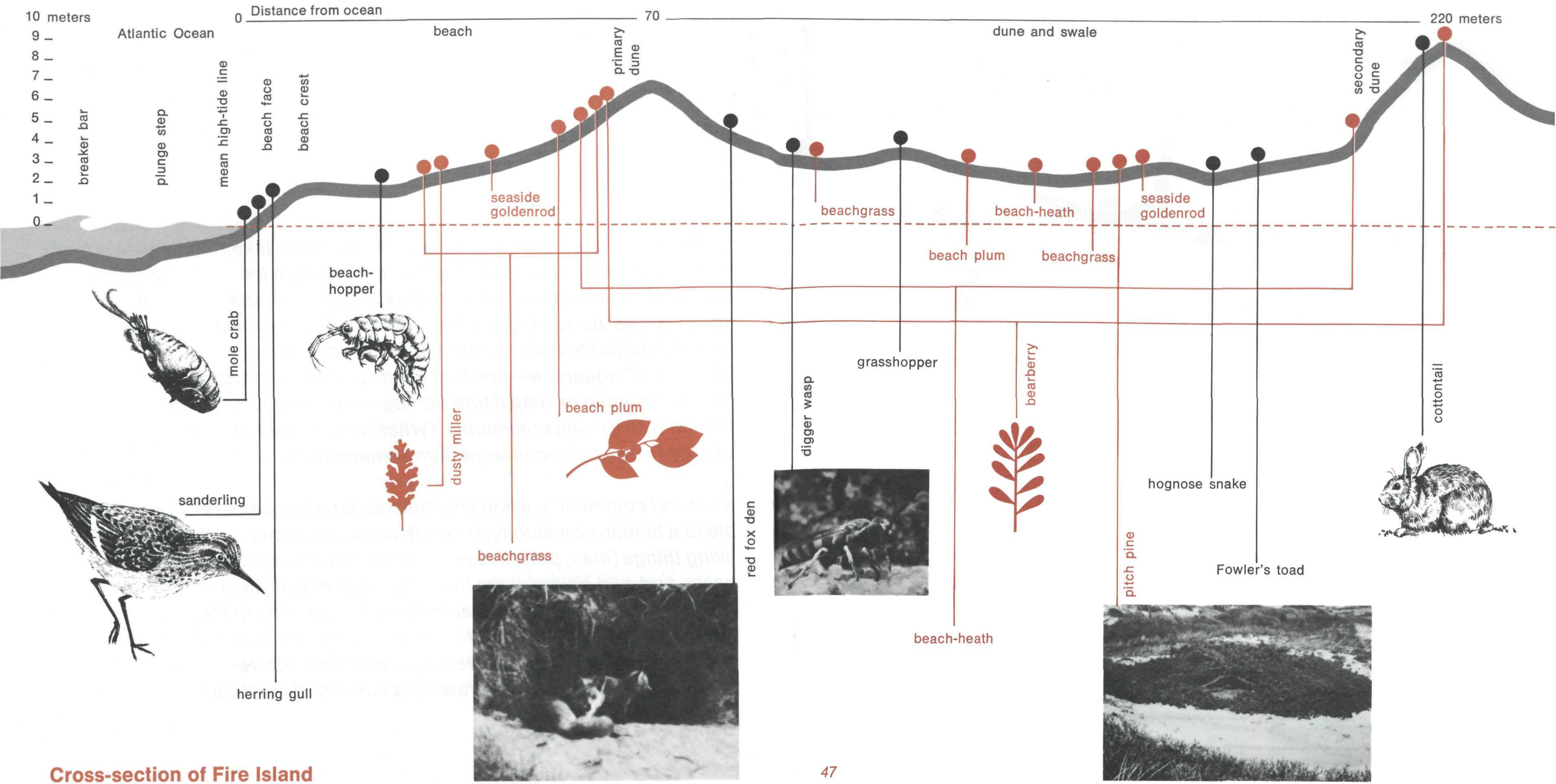
Mammals are less conspicuous than birds on Fire Island, but if you keep your eyes sharp you're sure to see the cottontail. Take a walk at daybreak; the red foxes are particularly active then. Watch for a fox den in the side of a dune. In spring you may see several cubs playing about the entrance. Without these predators, the plant-eating cottontails might become so abundant as to cause severe damage to the environment.

Natural Communities

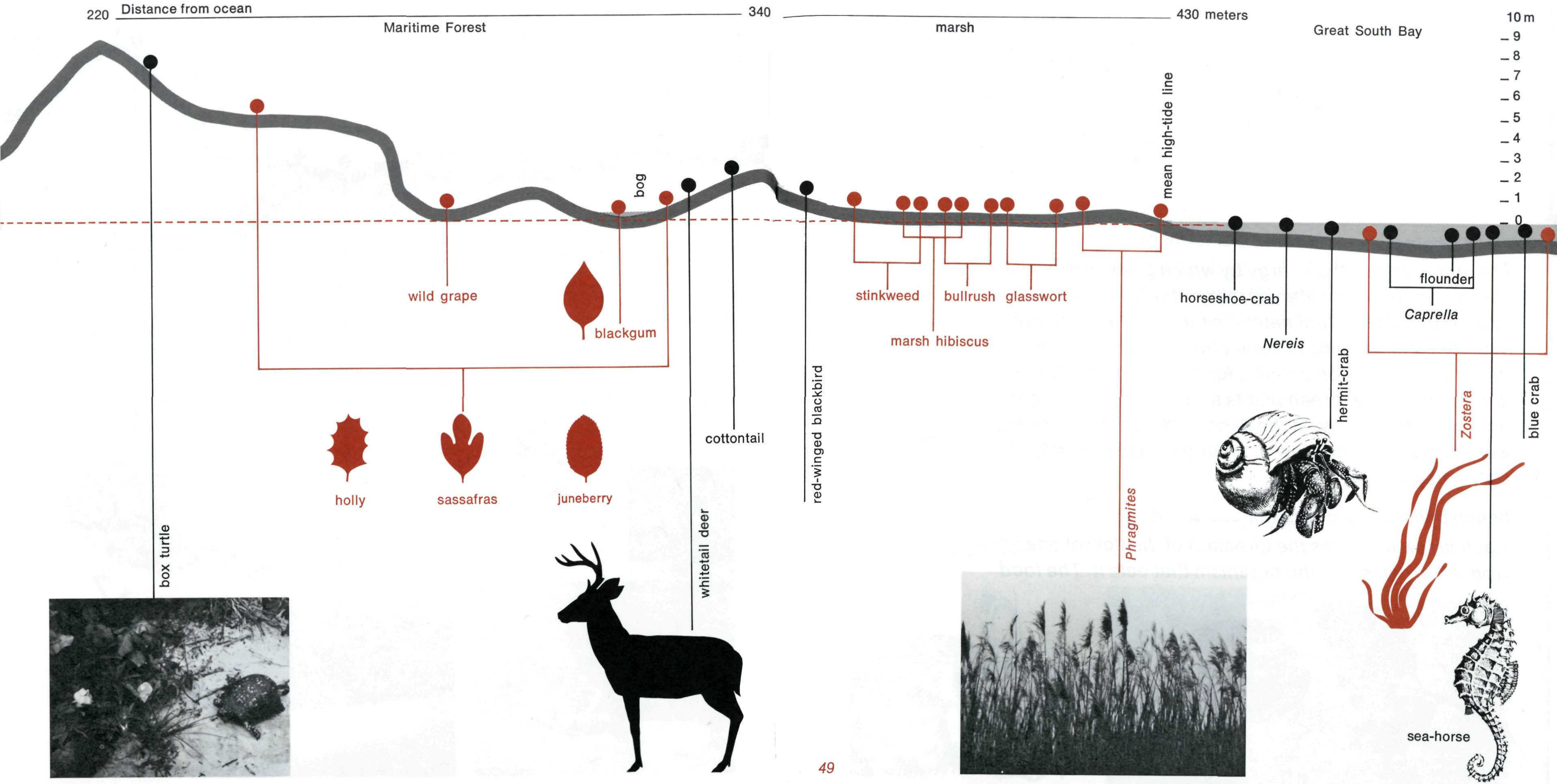
A community in nature can be defined as the living part of an ecosystem—that is, the association of plants and animals living in a particular physical habitat. An example: all the organisms in a pond, including, at particular times of the day or during particular seasons, those visiting it from other habitats. Plants growing around the edge because of conditions of moisture deriving from the pond might be considered part of the pond community; or, if a large area adjacent to the pond is vegetated by cattails and other rooted emergent plants, it would be called a marsh community. The two may overlap, and many animal forms might belong to both. (Such a transition zone is called an ecotone.) *Study of the living things in any habitat will soon convince you that all are interrelated and interdependent, through such factors as competition, (for living space, food, etc.), predation, parasitism, commensalism, and habitat modification (as in the building of beaver dams).*

A community need not be as large as a forest or a lake. It can be as small as a decaying log or stump with its myriad of organisms including mosses, fungi, bacteria, insect larvae, burrowing beetles, ants, etc. The log itself can be referred to as a "microhabitat." If you have a "balanced" aquarium—one that needs addition of neither food nor oxygen to keep it functioning—this is a microhabitat with a living community. (What is the source of energy for the balanced-aquarium community?)

A natural community, when you think about it, is comparable to a human community, in which an association of living things (man, pets, livestock, trees and other plants, pests, and wild animals) are living together in a physical habitat altered or largely created by man. Just think of the many ways in which all the plant and animal inhabitants of the human community are interdependent and interrelated, and it will be easy to draw parallels with the natural community.



Cross-section of Fire Island


220 Distance from ocean
340
430 meters
Maritime Forest
marsh
Great South Bay
10 m
9
8
7
6
5
4
3
2
1
0
bog
mean high-tide line
wild grape
blackgum
holly
sassafras
juneberry
box turtle
whitetail deer
cottontail
red-winged blackbird
stinkweed
bullrush
glasswort
marsh hibiscus
Phragmites
horseshoe-crab
Nereis
hermit-crab
flounder
Caprella
Zostera
blue crab
sea-horse

Food Chains

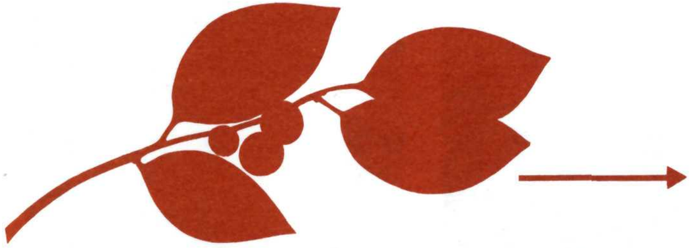
The sun provides the energy by which green plants convert raw materials (water, carbon dioxide, and minerals) into living matter. Plant eaters in turn convert the carbohydrates and proteins of vegetation into animal tissue. Predators, relying on animals for their food, are just as dependent on the green plants as are animals that eat green plants directly. In the dune-and-swale community, we can illustrate this flow of energy with a simple food-chain diagram:

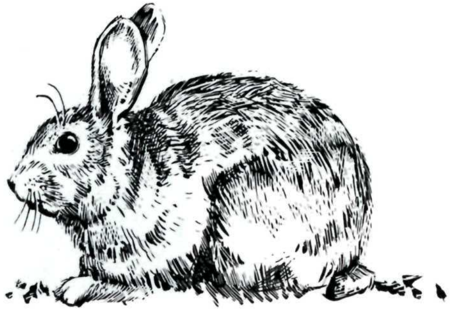
beach plum ⟶ cottontail ⟶ red fox

Each arrow indicates the direction of the flow of energy from an organism to the organism that eats it. The food chain ends with an animal that is not normally preyed upon. (There are no predators on the red foxes of Fire Island.) At each level of the food chain, about 90 percent of the energy is lost. It requires at least 10 kilos of beach-plum food to produce one kilo of cottontail, and that kilo of cottontail will produce only 1/10 kilo of red fox. Sometimes the red fox eats the fruit of the beach plum, and then we have a shorter food chain and a more direct process for converting plant food into fox flesh:

beach plum ⟶ red fox

A food web, made up of many interlinking food chains, is shown in the chapter on the salt-marsh community.





Mysteries of the Maritime Forest

How did this strange woodland with the peculiarly cropped appearance come about? It looks as though a giant with a hedge clipper had tried to level it off even with the dune crest. And from your viewpoint on the top of the secondary dune the roof of the forest seems as dense as a hedge. The trees appear to be filling a great hollow, but this is somewhat deceptive. As you walk through the forest toward the bay, you will be gradually descending, with some ups and downs, to near sea level, where the northern edge of the forest borders the salt marsh. You will discover that the trees do not fill a deep hollow at all, and that the tallest of them does not exceed 8 or 10 meters in height.

Now let's return to the crest of the secondary dune. If the wind, which is almost always present, is coming from the ocean, notice that it is strongest at this point. It is somewhat more gentle as you move down to the beach; and going in the other direction—into the forest—it diminishes almost entirely.

If this is a particularly windy day you may be able to feel some of the salt spray that the wind has picked up from the crests of the waves. This salt-laden wind is the clue to the trimmed-hedge appearance of the forest. It

Osmosis: G, I

Devise an experiment to demonstrate the process by which salt removes the water from leaves. (A science teacher can help.) This interaction is the reason the maritime forest trees do not grow to their "normal" height and the reason that plants intolerant of salt spray cannot grow at all in the dune-and-swale community.

does not really have a shearing action, like a hedge-clipper, though the effect is the same.

All the plants in the dune-and swale community are of necessity tolerant of salt, for they are directly exposed to the salty ocean breezes. And what happens when the wind sweeps over the secondary dune? Salt is deposited on the highest branches and leaves of the forest trees. These are much less tolerant of salt than the dune-and-swale plants, and the new buds and leaves at the top are killed. So the forest cannot grow higher than the secondary dune, and once they have reached the critical level the trees can grow sideways only. The spreading branches at the top thus form a dense canopy that from the dune crest looks almost solid enough to walk on. The vegetation below this dense cover is affected little by the salt-laden wind; but as you can see it is deprived of most of the sunlight that falls on the forest. So only plants that are tolerant of shade can survive in the understory and on the forest floor. You will not find any beach grass here, though a few of the sun-loving pines grow in the edges of the forest on the secondary dune and near the marsh.

Most of the trees of the maritime forest can be identified from the shapes of their leaves. Shown are (1) juneberry, (2) sassafras, and (3) holly.

In Fire Island's largest stand of maritime forest, three species of trees are clearly dominant. An examination of the canopy will show that it is made up mostly of American holly, sassafras, and juneberry. Where conditions vary, you'll find other species. In boggy places there are sour-gums (swamp tupelo) and swamp azalea (a tall shrub rather than a tree). There are scattered black cherries, and here and there a big oak (big for the maritime forest, that is). Only where an opening in the canopy admits enough sunlight can you find a pitch pine.

It won't take you long to learn all the tree species in this forest. And since the vegetation of the forest floor is not greatly diverse, you should be able to identify the common shrubs and herbaceous plants with a little work. Why do you think so few species grow here? It is not entirely a matter of available sunlight; consider also such factors as the sandy soil and the salt that rainstorms wash from the uppermost foliage onto the forest floor.

Detailed studies of the plantlife in the maritime forest at Sailors Haven have enabled scientists to trace the history of this unique community quite accurately. Careful observation will enable you to discover some of the

Profiling a Community: I, G
Stake out a 10-meter-square plot of maritime forest (get permission from the ranger) or a narrow strip of the forest or thicket bordering the boardwalk, and make a profile diagram of the habitat. Be sure to include any birds, insects, and other animals you observe. The generalized maritime forest diagram on p. 60 can serve as a guide. To get a greater variety of plant species, you might pick a plot that includes a boggy spot or a forest opening.

clues yourself. Notice, for example, that the dominant forest trees—holly, sassafras, juneberry—are vigorous and healthy. There are very few dead specimens of these trees. On the other hand, there are a number of dead oaks, redcedars, and pitch pines—some standing and some on the ground—but very few living specimens. This *suggests* that the forest has undergone a fairly recent change; that the pines, oaks, and redcedars are on the way out; and that the holly, juneberry, and sassafras are here to stay.

If climatic changes, severe storms, or other events do not occur to upset the present balance, the forest may remain for the foreseeable future in its present state. We call such a stabilized forest a "climax community." Climax communities come about through a process of natural succession, which may require a hundred or a thousand years to run its course. In the case of the maritime forest here, it appears to have required about 250 years. But barrier islands, creations of the winds and currents, are subject to sudden drastic alteration, or even destruction, by these same forces. So the concept of a climax community doesn't mean quite the same here as it would in a mountain forest—where even a fire or an unusually violent storm generally does no more than cause a setback to an earlier stage in succession. One winter storm could cut Fire Island in half at this point, eliminating the forest. Also, the migration of the barrier island toward the mainland might remove the habitat. At Assateague Island National Seashore in Maryland and Virginia, cedar stumps on the beach mark the location of a former swamp.

Sometime between 200 and 300 years ago the site of this forest was an area of bare, windblown sand. But it was not to remain barren for long. It was soon invaded by the seeds of pioneering dune plants. First, while sand was still being deposited on the dunes, came beach grass. This is the same plant now dominant on the windward side of the primary dune. In spots where the wind was *removing* sand, it was probably woolly beachheather and seaside goldenrod that first gained a foothold. Woolly beachheather not only pioneered, but helped stabilize the habitat by trapping blowing sand. But how did these pioneering plants get the nourishment all living things need for growth and reproduction? There are virtually no nutrients to be derived from sea sands; so they had to get their food from the air—minerals borne on the winds both from sea and from land. As the plant communities developed, they added

Comparing Communities: A, I, T
Make a comparative study of the maritime forest and a high thicket community. Chart the species of woody plants and their heights, height of protective dune, distance from ocean, and species of herbaceous plants and birds and other animals. If you have a camera you can take pictures to show differences and similarities. If you can draw even a little bit, make profile diagrams of the two habitats. It is best for comparative purposes if you choose two locations at approximately the same distance from the ocean. This will eliminate distance from the ocean as a cause of differences you discover between the two forests. Because of the prevalence of poison-ivy in the thicket, you should make most of your observations at the edge, or along established trails and boardwalks.

organic material to the sand, and gradually an environment was created that enabled increasingly diverse plant associations to grow.

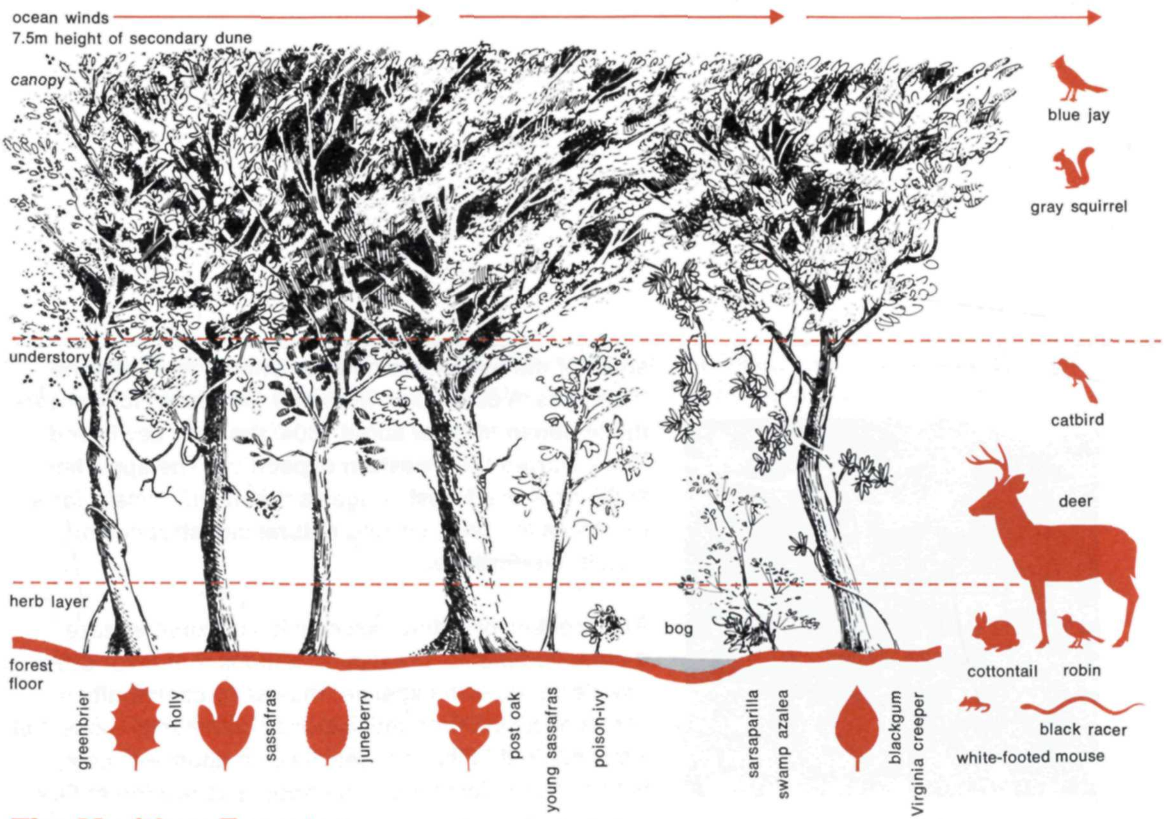
As the pioneer plants spread over the dunes, they created conditions favorable to such plants as bearberry, bayberry, poison-ivy, Virginia creeper, and beach-plum. In the more stable places, pitch pine and redcedar were able to get a foothold. These woody plants—shrubs, vines, and small trees—then created an environment that permitted the development of still another plant community, which was dominated by blackcherry, post oak and other oaks, and highbush blueberry, and by pitch pines and redcedars persisting from the previous community. The other early plants, from beachgrass to beach-plum, had by this time either disappeared or declined, because conditions were no longer favorable for them or because they could not successfully compete with the new plants for the available food, moisture, living space, and sunlight.

This blackcherry-oak-blueberry-redcedar-pitchpine community has by now been almost entirely replaced by the holly-sassafras-juneberry maritime forest. We can't pinpoint the time when this transition began, but

some of the trees have been examined to determine their ages. A core taken from one American Holly shows that it began to grow about 1804, the year Lewis and Clark started their western expedition. The apparent stability of this forest suggests that it will remain for a long time to come, barring natural catastrophes or man's interference.

The process of natural succession occurs because a plant community creates conditions that favor other species at its own expense; thus each community is replaced by another until a climax community—one that does *not* in this manner seal its own doom—is established. The fascinating thing about succession at Fire Island is that you can retrace it, in a sense, by walking from the beach to the maritime forest; you move from bare sand through a beachgrass-dominated zone to the shrubs of the swale to the forest hiding behind the protective secondary dune. You can find all the plants mentioned above, if not in clearly demarked communities at least roughly in the same order of occurrence as the order in which they became established in the succession cycle.

It is not only plants that follow a successional pattern. As you pass through the various zones from beach to



The Maritime Forest

Maritime forests typically develop through the process of natural succession in areas first supporting such soft-stemmed plants as beachgrass or sea-oats, and usually have canopies deformed by wind and salt spray. Like other plant communities, they have characteristic associations of animals. About 11 species of mammals and twice as many birds breed in the Fire Island forest; many others forage in it or pass through on migration. In earlier times it probably sheltered otter, gray fox, bobcat, and black bear, as well as the red fox and deer we see today.

forest, make a note of what animals you see, and what plants they are feeding on or using for perches, shade, or other purposes. If you make such observations over a long enough period of time, you should be able to develop a distribution pattern that will roughly parallel the changes that took place in the animal populations during the succession from bare sand to maritime forest.

You will learn more about the concept of natural succession in plant-and-animal communities in the chapter on salt marshes.

Ecosystem

An ecosystem is a plant-and-animal community and its physical environment. For example, when we speak of the salt marsh ecosystem we mean, along with the living sedges, grasses, algae, and other plants, the mud or sand in which they are rooted, the invertebrate and vertebrate animal life, the dead plant and animal material, and the water, minerals, atmosphere, and incoming solar energy.

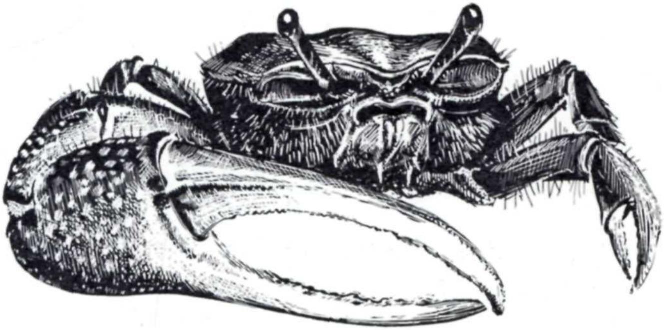
The salt marsh can be considered part of a larger ecosystem, the estuary; on the other hand, two well defined zones of the salt marsh ecosystem with distinctly different plant associations can be treated as separate ecosystems.

When you encounter any new word beginning with "eco-", keep in mind that it is taken from the Greek word eko, *meaning "home."* Ecology *is the science of the home (-logy = science)—that is, the study of the relationships between the living things in an environment.*

Wet Your Feet in the Salt Marsh

At low tide, walk out onto one of the expanses of flat terrain on the island's north shore between low- and high-tide marks. If you're in a zone that is covered and uncovered by each day's tides, you're probably in the salt-marsh cordgrass community. In thousands of hectares of our coastal wetlands, cordgrass is the only rooted plant growing. It thrives best in soil that is inundated about half the time. Along tidal creeks, it may be as tall as a man.

This is probably the most rewarding of Fire Island's life communities for the wildlife watcher. And don't make the mistake of thinking that the animal life consists of the ducks, shore birds, and wading birds that fly off at your approach. Look down as well as up—and look carefully. If you're not making too much disturbance, you may spot the fiddler, an important citizen of the wet marsh. It's only a crab—and a small one at that. But this crab looks as though its growth hormones have gone awry; it is waving an oversize foreclaw back and forth like a huge fiddle. As you approach, the crab will scurry toward one of the holes in the mud, apparently unhindered by the burden of the claw it carries before it. The fiddler may reach the entrance to a burrow, quite likely not its own, before you can catch it. But with patience you should get a specimen to examine. It won't harm



The fiddler crab, Uca pugnax, *with a 25-millimeter-long shell, is Fire Island's smallest crab. The related* Uca musica*—a noisy creature—has a shell only 8 mm long!*

you. Look at its other foreclaw—the normal-sized one. It is spoonlike and is used, logically enough, in feeding upon minute plants scraped from the mud. This comical little show-off is the male of the species; the female fiddler has two spoon-claws, which suggests that she can feed more efficiently than the male. Perhaps this is a necessary difference, for she must produce the eggs that maintain the species. The male's big claw, used in mating and territorial displays, is useless for feeding.

The fiddler crab and saltmarsh cordgrass are well adapted to a half-land, half-water existence. The crab can breathe quite well out of the water, so long as its gills remain moist. The cordgrass is one of the few flowering plants that will grow in the lower intertidal zone; another species, saltmeadow cordgrass, grows on the drier flats where only the highest tides reach. Low cordgrass marsh is the more productive; one hectare can produce 10 tons per year of green plant material, dry weight—more, in fact, than any other natural land community. This is a bountiful base not only for this zone but for the adjacent estuary that is enriched by it. The saltmarsh cordgrass community is an ideal place to study Earth's natural rhythms and life processes.

What Good Is a Salt Marsh?

This question reflects our historic indifference to and abuse of a priceless natural resource. Much of our extensive coastal marshland has been drained for farming or mosquito control; filled in for housing, industry, highways, and recreation; used as a handy place to dump refuse; and badly polluted by sewage and factory effluents. Yet the salt marsh is the most productive of all natural communities, exceeded only by fertilized sugar cane fields.

The abundant growth of green marsh plants provides the base of a food pyramid unsurpassed in variety and richness. The animals that feed on the marsh plants are in turn eaten by predatory animals. Besides the profusion of vertebrate and invertebrate animals that spend all or most of their life cycles in the tidal marsh, there are many marine species that use them as nurseries.

Though you may not have realized it when eating seafood such as fish sticks and crab cakes, many of the animals that are important food for man are caught in the marsh.

Many hatch and spend their early lives there, or live in estuarine or offshore waters on nutrients that flow from the rich marsh ecosystem. Marshes offer protective cover and abundant food for fishes, molluscs, and crustaceans.

The marsh is also a valuable habitat for nonaquatic forms. Most of these are rodents, such as the meadow vole, that feed upon the vegetation, or predators that feed both on rodents and upon fish and other aquatic life. Eagles, ospreys, marsh hawks, owls, ducks and geese, shore birds, gulls and terns, rails, herons of many kinds, diamondback terrapins and snapping turtles, raccoons, mink . . . the list is almost endless. Not every one of them is found in the Fire Island marshland; but if you're a bird watcher or nature photographer you'll do well to spend some of your time in this habitat.

The existence of much of our coastal lowland derives from salt marshes. The vegetation slows the movement of water and traps sediments, building up the land. It also helps *prevent shoreline erosion by breaking the force of waves, currents, and wakes of vessels.*

The value of salt marshes for recreation is recognized by many, especially waterfowl hunters and wildlife watchers. As for educational and scientific benefits, marshes are excellent laboratories for ecological studies, and a knowledge of salt-marsh ecology is absolutely essential in marine fisheries research.

The black-crowned night heron has a thicker neck, heavier body, and shorter legs than most of the heron-and-egret family; and its habits are somewhat nocturnal. Look for it early and late in the day.

Coastal marshland is called "wasteland" by many who, ignoring its value, wish to convert it to "useful" purposes. Yet a cordgrass marsh produces four times as much plant growth as a cornfield—without artificial fertilizer or cultivation!

As cordgrass plants break up or die, fragments of decaying plant material, called *detritus,* are washed by the receding tides into the bay, where they furnish food for amphipods, ostracods, isopods, polychaete worms, and other animals. These detritus feeders are eaten by small predators such as pipefish and sticklebacks; the small predators in turn are fed upon by flounders and other fish that provide food for man and larger predators.

The marsh itself is rich in variety and abundance of animal life. Many burrowing animals feed on green plants—cordgrass and algae—or on fine particles of organic matter contained in the mud. These and all the other animals of the broad marsh-bay ecosystem are dependent upon a group of organisms we call *decomposers:* the fungi and bacteria that begin the process of breaking down the cordgrass and other green plants, and the small crustaceans, worms of various types, and other invertebrates that feed on the detritus and convert it to animal protein that feeds the host of predators. Even direct feeders on green plants, such as the purple marsh and fiddler crabs, can be considered decomposers, since their digestive processes only partially utilize the plant material, and their fecal pellets contain fine particles that become part of the detritus.

Natural Succession

The salt marsh is an excellent field for the study of the process by which one natural community replaces another and then creates conditions that bring about its own replacement by a third community. It would require more than your own lifetime to follow the series of stages in the succession process that leads from an abandoned farm field to a mature broadleaf forest. But on Fire Island you can observe the creation of new land from the sea and can see the pattern of the successive stages that lead eventually to thicket, maritime forest, or other relatively stable community. On the bay side of the barrier island, the first stage in the succession story is the creation of a new low-water marsh.

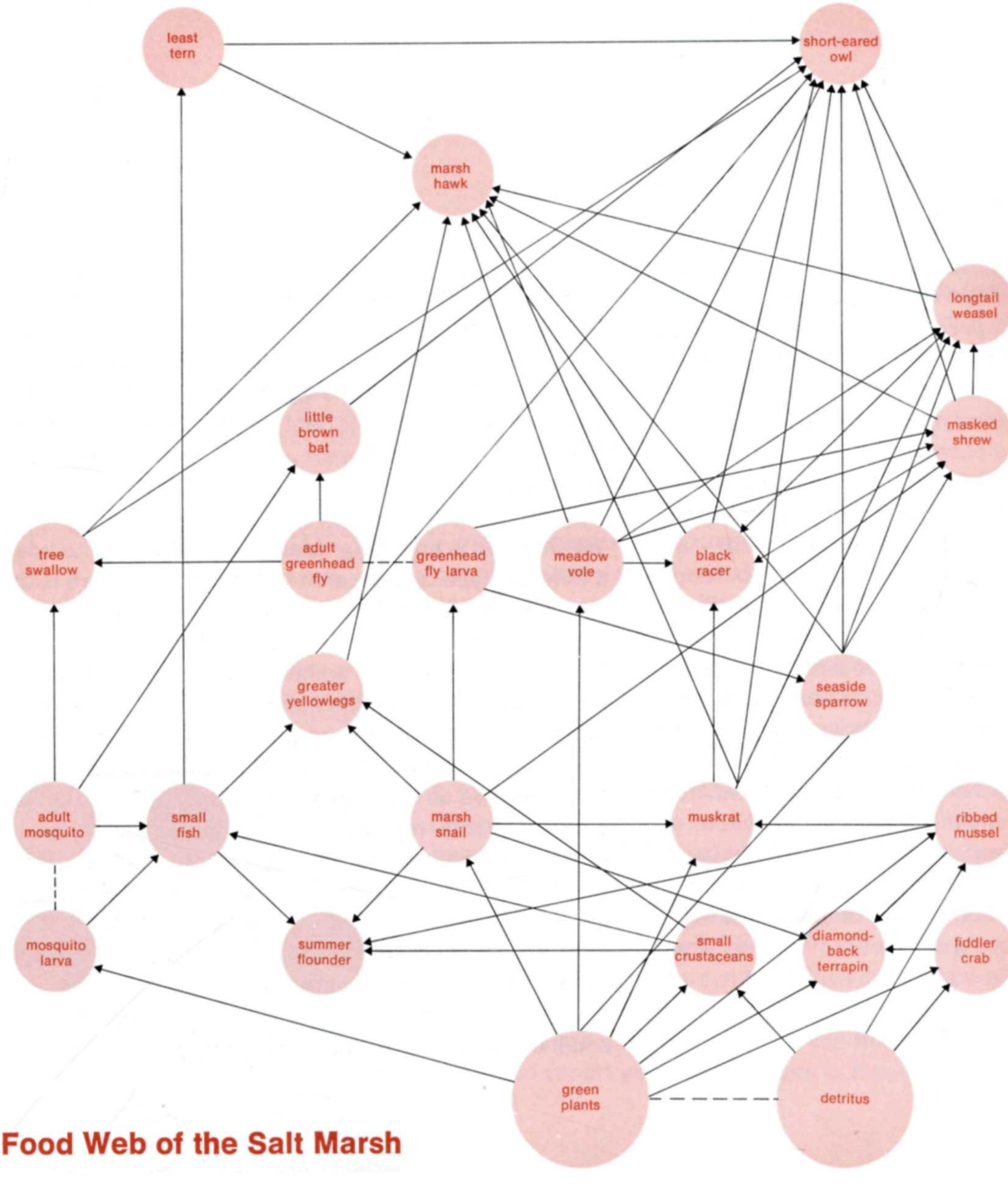
Look for a place in an inlet or tidal creek where mud has built up above the low-tide mark and enabled a clump or two of salt-marsh cordgrass to take root. The underground stems of this plant spread rapidly, sending up new tufts of grass that trap more sediment and form an island, or build *out from the existing marsh. As the tides deposit more silt and the dead grass stems and leaves accumulate along with windblown sand and shells and other remains of dead animals, the marsh becomes higher—and the tides cover it for fewer hours of the day. Eventually, after many years, a level beyond all but the highest tides is reached; by this time the saltmarsh cordgrass has been replaced by salt-meadow cordgrass, and we have a high-water marsh. The low-water marsh, by its own success, has eliminated the conditions that favored it and has thus paved the way for its replacement by a plant community adapted to the new conditions.*

Salicornia, *or glasswort, which has become established in the later stages of the low-water cordgrass marsh, remains in the new marsh community, where along with black grass, three-square rush, and spike rush it mixes with the salt-meadow cordgrass. As the marsh builds up still higher, the cordgrass disappears, leaving a stand of the* *other three plants. These eventually give way to a borderline community between marsh and upland, such as* Phragmites *(reed) grassland. When the soil base has built up to the point where it is no longer affected by even the highest tides, it supports an upland community. This might be beachgrass grassland, low thicket, or any one of several other types, depending upon such factors as deposits of windblown sand and proximity of the water table to the soil surface.*

By walking from the bay across the marshland to the upland, you can see the same succession of communities that has occurred in one locality over a long period of time. The pattern may not exactly parallel what has been described above; it will vary, depending upon what part of the barrier island you are exploring.

On the mainland, natural succession generally proceeds until a community develops that does not *create conditions leading to its replacement by another. This is called a* climax *community; it will prevail until fire, flood, other natural catastrophe, or the activities of man either eliminate the plant community or alter it so drastically as to set it back to an earlier stage of succession. On Fire Island, however, the dynamics of barrier-beach ecology are such that a climax community in the usual sense does not exist. The island itself is migrating toward the mainland as the ocean eats away at its south shore and new marshland builds up on the bay side. Perhaps the nearest thing to a climax community on the island is the holly-juneberry-sassafras Sunken Forest, which has developed from bare sand over a period of two centuries.*

For a fuller understanding of natural succession, refer to some of the books in the Reading List.



Food Web of the Salt Marsh

Backyard Ecology: I, G, T, Y
The process of natural succession is so slow that the changes leading to a climax community may span several human lifetimes. But you can observe the early stages by watching a newly abandoned farm field, an empty lot, or a corner of your backyard or schoolyard allowed to return to nature. Record the changes in plant and animal life as one community creates conditions that enable another to replace it. During the first year the grass is not mowed, a piece of lawn will be converted to a patch of wildflowers. The increase in numbers and kinds of animals will be noticeable as the "weeds" grow high and shrubs and tree seedlings gain a foothold. Keep a photographic record of the succession process for as many years as you can.

The diagram of the saltmarsh food web shows how intricately all these animals are interrelated and how all are totally dependent upon the green plants and ultimately on the sun's energy. Because the saltmarsh provides much of the nutrient for the adjacent estuary, the diagram includes part of the Great South Bay community.

Where there is no regular (daily) inundation by the tides, a different type of saltmarsh will develop. On Fire Island you will find several kinds of high, or dry, marsh. There are solid stands of *Phragmites,* the towering reed grass. This plant is utilized by so few organisms that it is almost valueless as wildlife habitat. There are also expanses of saltmeadow cordgrass, in the zone flooded only by occasional tides. Saltmeadow cordgrass is not so productive as saltmarsh cordgrass. Here the fiddler crab is largely replaced by the purple marsh crab, though the zones of the two overlap and the latter, primarily a vegetarian, sometimes preys upon the smaller fiddler. Among shore birds, the greater yellowlegs is often seen fishing for minnows in the marsh waterways, while the lesser yellowlegs prefers the short-grass marshes where it hunts its food, mainly insects and small crustaceans, in wet places and shallow pools.

The Peregrine, an Endangered Species
Some of the birds and mammals once common on our barrier islands and in our offshore waters have been brought close to extinction by man's greed and carelessness. Destruction of habitats, environmental pollution, and ruthless hunting have all contributed to the decline of such species as the noble peregrine falcon, which is perilously close to disappearing but can still occasionally be seen hunting rodents in the salt marshes and other coastal habitats. In the middle decades of this century the peregrine suffered enormous losses from such pesticides as DDT. Stricter environmental controls and better protection may bring the population back to a level that will assure its survival.

Knowledge of any animal's habits and familiarity with its preferred haunts will make wildlife finding more rewarding for you. Keeping records of your observations—times, habitats, behavior, etc.—will enhance your experience and build your skills.

The wild animals of Fire Island do not always conform to the standard behavior of their species as described in the field books. For example, the muskrat, whose lodges dot coastal and inland marshes on the mainland, doesn't even seem to build a mound of vegetation as a home here. Instead, it digs burrows in the walls of mosquito-drainage ditches or in the sandy banks of small ponds. It will take some searching to get so much as a sight of this rodent. The muskrat ordinarily is preyed upon by many birds and mammals. But here it is probably not an important link in the saltmarsh food chain. Snapping turtles are not abundant. Still, the muskrat must be on guard against other regular enemies, such as red foxes and large hawks. If you're going muskrat-watching, be sure you know how to recognize this rodent's tracks. Watch for them in muddy spots along the ditches and the edges of small ponds and cattail marshes. The records of wild mammals on Fire Island are quite sketchy. You can help fill the gaps—so report your observations to the park rangers.

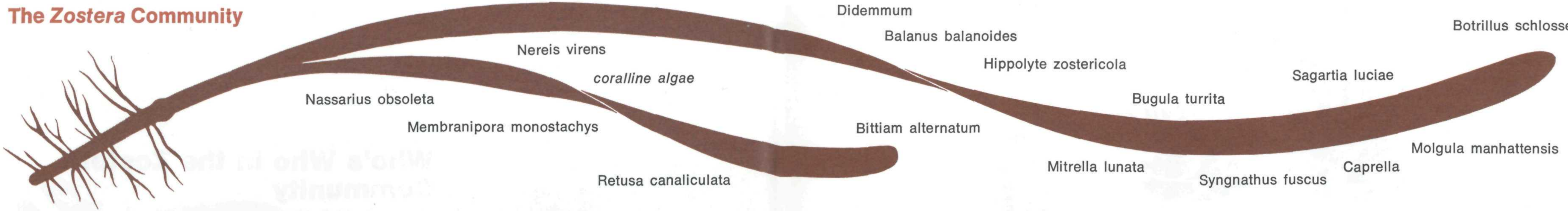
Who's Who in the Zostera Community

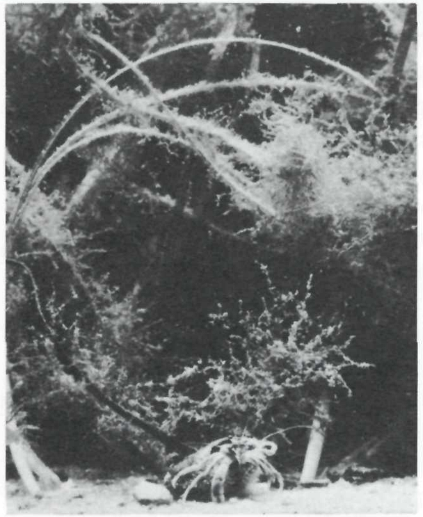
You don't need a boat to get on close terms with the life community of Great South Bay. This shallow coastal lagoon, as much as 8 kilometers wide and many times as long, slopes so gradually from the shore that you can wade out hundreds of meters from the narrow beach. Simple collecting gear, most of which you can salvage or make yourself, will enable you to sample the fascinating array of living things. At the base of this community is a plant called eelgrass.

A freshwater plant, not at all related to *Zostera,* also goes by the name "eelgrass." To confuse the matter further, neither of these plants is a member of the grass family. The name that definitely distinguishes Fire Island's eelgrass from other plants is *Zostera marina* (pronounced zoss-TARE-uh ma-REE-na).

You'll find *Zostera* growing thickly in much of the shallow offshore water on the lagoon side of Fire Island. It grows in mud or soft sand bottoms, generally in brackish waters but also sometimes in highly saline areas. It is one of only a few flowering plants that have gone back to the sea from the land, where that branch of the plant kingdom evolved. Almost all of the green plants in the sea are nonflowering, and are loosely grouped under the term "algae."

The *Zostera* Community

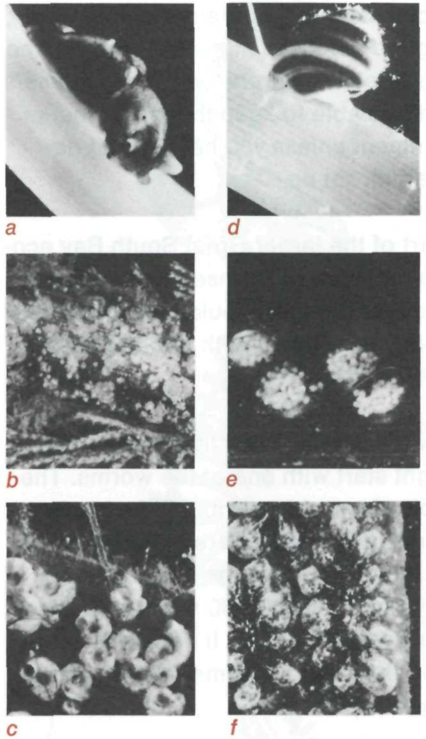




Hermit-crabs, the clowns of the eelgrass jungle, walk about with their snailshell homes on their backs, scavenging for bits of animal matter on the bottom. Shown on the facing page are a few of the animals and plants that live not on the floor of the eelgrass community but on the Zostera plants themselves.

Examine *Zostera* closely. You'll see that it does indeed resemble grass, even to having jointed stems. With a hand lens you'll be able to see its tiny green flowers, which develop in grooves on a leaflike spike. Unlike algae, it has true leaves, which are ribbonlike and flexible and grow to a meter in length. The beds of *Zostera* are extensive, and most of the beach wrack on the shore of Great South Bay consists of dead leaves of this plant.

Why is this plain-looking saltwater weed so important? Certainly, few of the animals in this community eat it, though it is the staple diet of the American brant, a small goose that you may see in winter along this coast; and several ducks are known to eat small quantities of it. But look at the plant through your hand lens. Feel its texture. That slippery coating is a growth of algae—and it is on this that a great variety of organisms feed. Snails, including the centimeter-long *Lacuna* and the iridescent *Margarita,* are the most abundant of these algae feeders.



a Elysia
b bryozoan, algae
c Spirorbis
d snail (Lacuna vincia)
e snail eggs
f Didemmum

Also found in enormous numbers on and amongst the *Zostera* plants is *Nassa,* a predaceous snail that feeds on other molluscs. *Nassa* itself is devoured by the hermit-crab, which adds insult to injury by taking its victim's shell as its home. Examine *Zostera* leaves for small, gelatinous masses of bright yellow eggs of *Nassa.* Your search may reveal another animal that you first take to be a snail but is actually a worm, *Spirorbis.* Its home is a minute, limy tube coiled in such a way as to resemble the shell of a snail, and cemented to one spot on the *Zostera* blade. It has even developed its own version of the operculum, the horny plate that serves to close the entrance to a snail's shell: in *Spirorbis,* one gill is modified to form an operculum that closes the end of its tube!

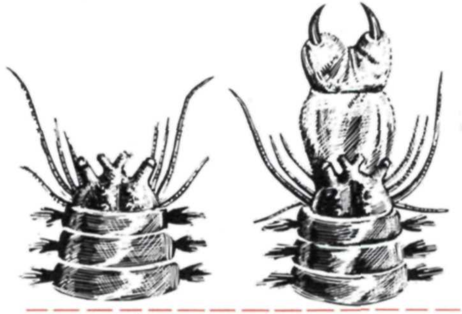
Besides these and other tube worms and snails, inhabitants of the *Zostera* beds include clams, small fishes, edible crabs, horseshoe-crabs, and smaller crustaceans. With a few sweeps of a fine-mesh net you should be able to capture many of these organisms. With luck you'll get a sea horse or its close relative the pipefish.

The Eelgrass Microhabitat: I
Examine some eelgrass plants (Zostera) *with a hand lens and, if it is available, a low-power microscope. See how many kinds of organisms you can find and identify, using books listed in the Appendix. Don't overlook the roots. Do any of the organisms appear to be feeding on* Zostera *itself? Put your sample into a jar or larger container of bay water, and examine it at intervals to see if eggs hatch or other changes occur. Keep it out of the sun, to prevent warming and loss of oxygen. Replenish frequently with fresh sea water. These water changes may introduce new organisms into your sample.*

Put your living specimens into a container of bay water; a white basin is good because it makes seeing the smaller forms easier. *Be sure to return all living animals to the bay;* you won't be able to keep them alive out of their natural environment unless you have a well designed marine aquarium set up .

Though they are part of the larger Great South Bay ecosystem, the *Zostera* beds are in themselves a dynamic plant-and-animal community. You could easily spend a whole summer getting acquainted with the inhabitants of this shallow offshore zone.

Let's see how a few of these animals fit into the *Zostera* community. We might start with one of the worms. The word "worm" is a bit of a problem, though, because many unrelated forms of animal life are called worms. *Nereis virens,* the clam worm, belongs to the phylum Annelida, which, with more than 6,000 species, is the best known of the "worm" phyla. It includes earthworms, leeches, and the *Tubifex* worms you buy at the pet shop to feed your tropical fishes.



Nereis virens (left) and detail drawings showing the head of Nereis with its pharynx retracted and extended.

Nereis belongs to the class of segmented worms sometimes called "paddle-footed annelids." During the day it burrows in the mud and sand; at night it emerges and swims about like an eel. It is a voracious predator, feeding on invertebrates, including other worms, and employing an unusual device for capturing and eating its prey. Its two horny, notched jaws are well back inside its body. Suppose it comes upon a small crustacean such as the skeleton shrimp, only two centimeters long. The clam worm turns its pharynx inside out, everting it right through its mouth and bringing the jaws into position for action. Seizing the crustacean in its jaws, the worm pulls its pharynx back inside its body, where the jaws tear the shrimp to pieces.

Predator though it is, the clam worm is not at the top of the food chain. When swimming about at night it often falls prey to fishes. In fact, large numbers of clam worms are dug from tidal flats to be sold to fishermen for use as bait.

The Web of Life: G, I, A, T

Individually or as a team, capture or observe and identify as many animals of the Zostera community as you can. Draw a food web showing how each fits into the community—as predator, scavenger, browser, or filter feeder—and be sure to include plankton and algae, as well as any birds you see feeding in the zone. You will need to use reference works to determine the food habits of the animals. The food web can be constructed at home or school from your field notes.

If you should capture a specimen of *Nereis virens,* use a bit of caution. You're in no danger from this 30- or 40-centimeter-long worm; but those jaws can give you a painful nip. Unless you can seize it behind the head as experienced fishermen do, use a net to scoop it up.

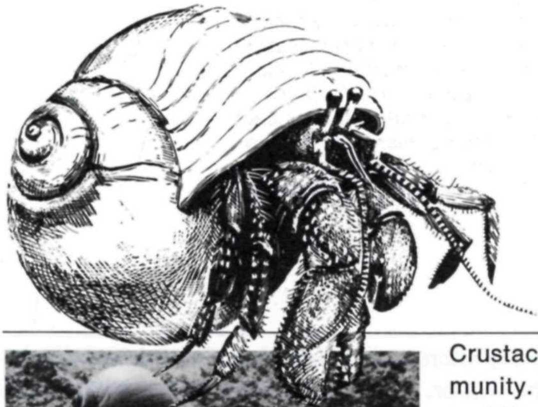
With your captive in a container of water, notice how it swims, snakelike, with the help of the paddle-like appendages on each body segment. Notice its metallic iridescence and its sense organs—eyes, palps, tentacles, and cirri.

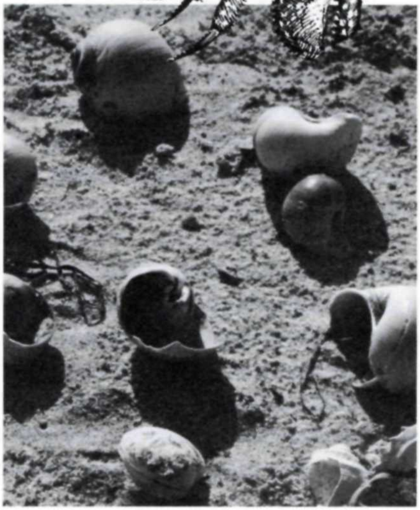
Since the molluscs of the *Zostera* community include filter feeders, browsers on algae, and predators, we can't place them as a group in any level of the food chain. The hardshell clam is one of the most interesting to us, since it is a favorite food of man. If you can borrow a clam rake, it shouldn't take you long to get a specimen or two. You might even be able to excavate one with your toes as you wade in the shallows; for although the hardshell is a burrower, it usually remains just below the surface of the sand. It feeds by extending its siphon, or "neck"—which is actually a part of the posterior end of the clam's mantle. Through the siphon it draws water, using its gills as internal filtering devices

The oyster drill, which rarely reaches 2.5 centimeters in length, bores neat round holes in the shells of its victims and sucks out the soft parts of their bodies. You will find shells on the beach that show that their owners perished in this way. Such shells with holes ready-drilled can be easily strung into necklaces.

to extract any microscopic organisms (plankton) taken in with the water. Then the water, along with waste products, is discharged through the same opening. Many molluscs, including oysters, mussels, and scallops, and many other invertebrate animals of the bay are filter feeders–reflecting the importance of small plankton in the food web.

The hardshell clam, like most organisms in the *Zostera* community, is itself food for other animals. Small clams are eaten by the abundant horseshoe-crabs, which burrow under the surface of the sand in search of prey. The oyster drill, a carnivorous snail, is able to cut a hole through the shell of a clam and devour it. And the clam worm, true to its name, is a predator on the hardshell.





All crustaceans breathe with gills and have two pairs of antennae. True crabs are crustaceans with a reduced abdomen that is folded under the body and cannot be seen from above. The hermit-crab's abdomen is long—and it is invisible only because it is coiled into a snail shell. Also included in the Crustacea are barnacles, amphipods, isopods, copepods, shrimp, lobsters, crayfish, sowbugs, and water fleas.

Crustaceans are well represented in the *Zostera* community. The members of this class are so varied in form and life style that we can't choose one that is typical. Perhaps we can have the most fun with *Pagurus longicarpus,* the small hermit-crab. (The last word is hyphenated because these curious animals are not true crabs.) Their posterior parts lack the hard, crusty exoskeleton (outside skeleton) of most larger crustaceans; they protect themselves by inserting their soft abdomens into a hollow object, generally the shell of a snail. This protection is not complete; predatory fish swallow them shell and all.

You can spend fascinating hours observing these engaging creatures as they scurry over the bottom, dragging their portable homes with them. You may see two hermit-crabs fight over an empty shell, or watch one trying to dispossess another—for as the hermit grows it must seek larger quarters. Especially amusing are its antics as it tries out a series of empty shells; but its movements are so quick you won't be able to see just how it's done. Naturally, it does not want to remain defenseless for long. Notice when you pick up a hermit-crab that it closes the shell opening with its larger pincer. Different species utilize the shells of different snails;

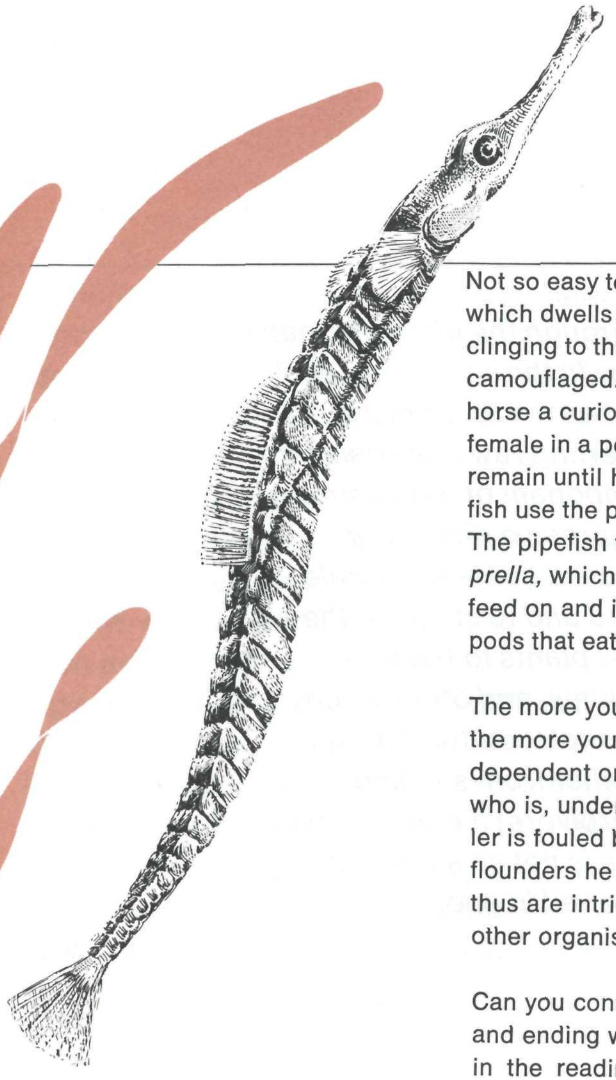
in each case the anterior end of the occupant is modified to fit the particular house doorway. For example, some West Coast hermits inhabit tooth-shells; their right claws are cylindrical in form, snugly fitting the circular openings of the shells. Even when they are stranded on land between tides, they are closed up so tightly that they are in no danger of drying out.

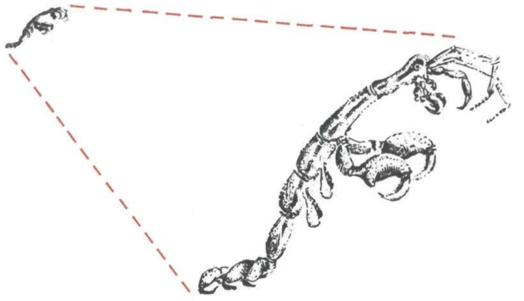
With the aid of your hand lens, you'll be able to see tiny eyes at the ends of *Pagurus'* eye-stalks. When the hermit is closed up in his home, notice how its small left claw neatly fills in the part of the shell opening not closed by the large claw. If you chance to see a hermit-crab out of its shell, examine the posterior end of its abdomen; you'll see that the last pair of abdominal appendages have been modified into hooks, which serve to fasten the crab in its shell. Place it next to an empty snail shell in a container of cool bay water and watch it back in—or better yet, give it a choice of two or three empty shells and observe the selection process.

The skeleton shrimp, Caprella, is actually an amphipod. Although tiny (males 2 cm, females smaller), it is a voracious predator. Besides devouring smaller crustaceans, it feeds on algae and other minute plants growing on Zostera. The 20-cm pipefish—as curious a creature as the related seahorse, preys on Caprella.

The Eelgrass Blight

What do you suppose would happen to Pagurus and the many other animals in this habitat if Zostera should disappear? In the early 1930s the abundant eelgrass beds on the east coast were hit by a disease that almost wiped them out. The effects were far-reaching. Flounder fishing declined; clams became scarce; pipefish almost disappeared. The American brant, whose diet before 1932 had been about 90 percent eelgrass, had much difficulty adapting to other plant foods, and many of the birds starved to death. But Zostera came back during the 1940s and is now abundant enough to support and shelter a rich natural community.





Not so easy to find as *Pagurus* is the northern pipefish, which dwells in the *Zostera* beds, much of the time clinging to the plant's leaves and stems where it is well camouflaged. It shares with its close relative the seahorse a curious habit: the eggs are deposited by the female in a pouch in the male's underside, where they remain until hatching. After hatching, the young pipefish use the pouch as a retreat in time of danger.
The pipefish feeds extensively on the amphipod, *Caprella,* which preys on the larvae of invertebrates that feed on and in the Zostera beds, including some amphipods that eat the decaying remains of *Zostera* itself.

The more you learn about the creatures in this habitat, the more you realize that all are interrelated and all are dependent on *Zostera.* But what about the fisherman who is, understandably, annoyed when his boat propeller is fouled by eelgrass? Is he aware that the summer flounders he is angling for feed on the pipefish, and thus are intricately linked with the plant and all the other organisms in the community?

Can you construct a food chain beginning with *Zostera* and ending with man? (You will find good references in the reading list in the back of this booklet.) *Tip*: flounders eat blue crabs.

Niches

Your own community functions through the efforts of many persons doing many different jobs. In the same way, each organism in a natural community has a role, or niche. *All green plants are producers, converting raw materials into food that supports the animal component of the community; but each plant species has a precise niche. For example, beach grass functions in the dune-and-swale community to capture moving sand and to stabilize the dunes, making it possible for other plants to become established. Pitch pines, beach plums, and other woody plants not only provide food for insects, cottontails, and whitetail deer, but also furnish shelter from sun and wind. The cottontail's niche is that of herbivore; it converts plant food into flesh. The red fox's niche is not so simple; it is predator, herbivore, and scavenger all in one.*

Sometimes two animals seem to be performing the same function. But investigation shows that their niches are not identical. The long-eared owl and the short-eared owl, Asio wilsonianus *and* Asio flammeus, *are a good illustration. These closely related birds have almost identical diets, the bulk of their food being small rodents. But their habits separate their functions in the island's ecology. The long-eared owl prefers dense woodland and thicket growth, and the short-eared owl prefers more open areas such as sand dunes and marshes. Even where their hunting ranges overlap they play a different ecological role, for the short-eared owl is most active by day and the long-eared owl by night. Thus the former feeds on diurnal species, the latter on nocturnal. How do the niches of the greater yellowlegs and the lesser yellowlegs differ in the Fire Island environment? Compare the roles of the white-footed mouse and the meadow vole ("field mouse").*

Glossary

Adaptation: An inherited structural, functional, or behavioral characteristic that improves an organism's chances for survival in a particular habitat.

Algae (pronounced "AL-jee"): A group of plants (singular, alga, pronounced "AL-ga"), one-celled or many-celled, having chlorophyll, without roots, and living in damp places or in water.

Brackish Water: Mixed fresh and salt water, as in estuaries and lagoons where water from streams mixes with tidal waters.

Carnivore: An animal that feeds upon the bodies of other animals. (Parasites are not included in this definition.) Animals that feed chiefly upon insects are more often referred to as *insectivores*.

Commensalism: The relationship between a host plant or animal and its "guest," a species that shares the host's food without harming it. The flatworm, *Bdelloura,* is commensal, not parasitic, on the horseshoe-crab.

Deposition: The laying down of rock particles, by wind or in water.

Dune: A hill or ridge of wind-deposited sand. The windward side slopes gently, while the lee side is steep.

Environment: All the external conditions—such as soil, water, air, and organisms—surrounding a living thing.

Erosion: Any process by which materials of the earth's crust are worn away or removed from the surface. Water, wind, and gravity are the usual agents.

Estuary: The portion of a river or coastal wetland affected by the rise and fall of the tide, containing a graded mixture of fresh and salt water.

Habitat: The place where an organism lives; the immediate surroundings, living and unliving, of an organism.

Herbivore: An animal that feeds upon plants.

Invertebrate: An animal that lacks a vertebral column and internal bones.

Marsh: A wetland, salt or fresh, where few if any trees and shrubs grow, characterized by grasses and sedges; in fresh-water marshes, cattails are common.

Phylum (plural phyla): The largest divisions in classification of either the plant or the animal kingdom. Man belongs to the Phylum Chordata. *Zostera* belongs to the Phylum Embryophta of the plant kingdom.

Plankton: The small plants and animals of fresh and salt waters that, lacking swimming ability, drift more or less at the mercy of currents and form the base of the food web in most aquatic ecosystems.

Predator: An animal that lives by capturing other animals for food.

Scavenger: An animal that feeds upon dead animals.

Swamp: A wetland characterized by mosses, shrubs, and trees. Usually not covered by water the year around.

Reading List

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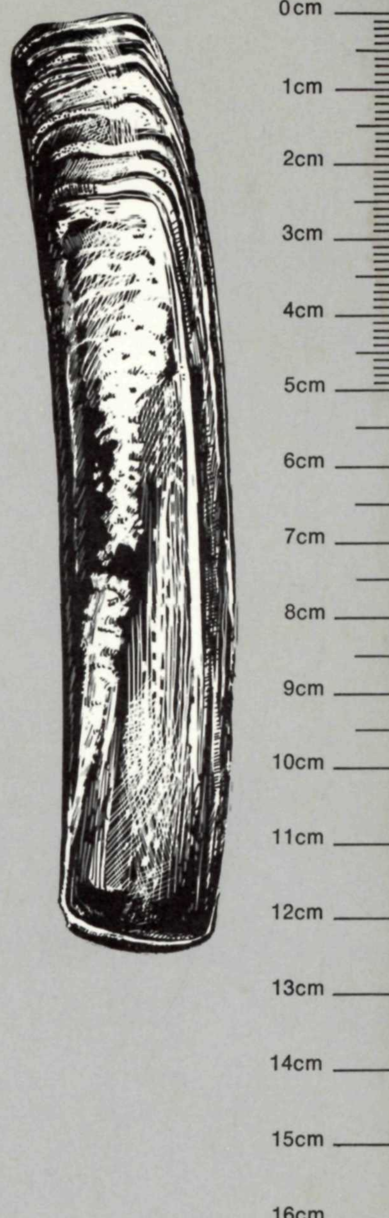
Using Metrics

As we go to press with this book, the United States is in the early stages of conversion to the metric system of measurement. Though we urge you to think metric—for most of the world does—we provide this table to help you understand the measurements given in the book.

Conversion Table

Millimeters	x	0.6301	=	Sixteenth-inches
Centimeters	x	0.3937	=	Inches
Meters	x	3.2808	=	Feet
Kilometers	x	0.6214	=	Miles
Hectares	x	2.4711	=	Acres
Hectares	x	0.00386	=	Square Miles
Grams	x	0.0322	=	Troy Ounces
Kilograms	x	2.2046	=	Pounds
Degrees Celsius	x	1.8 and add 32	=	Degrees Fahrenheit



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