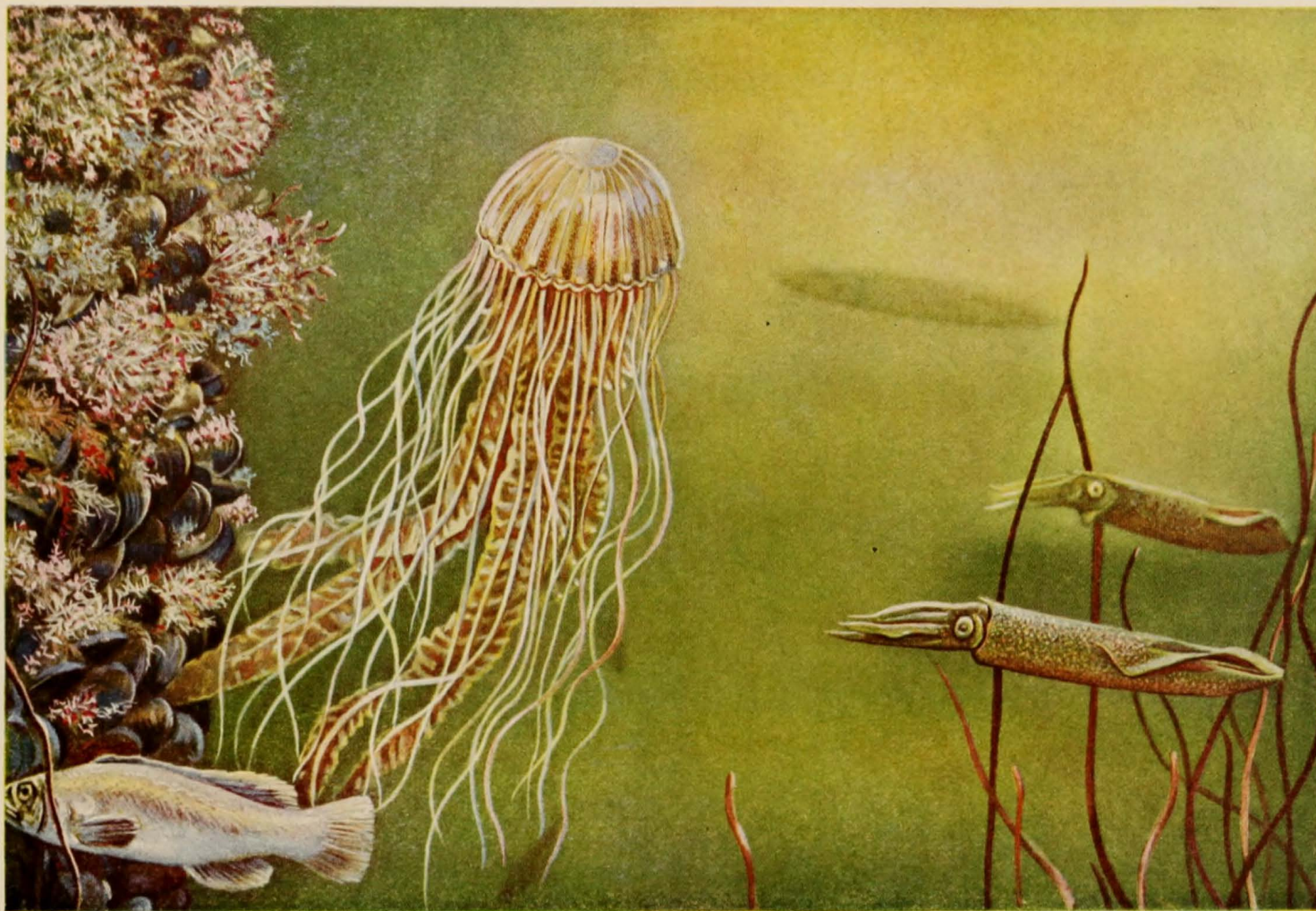


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A STUDY IN LOCOMOTION AMONG MARINE ANIMALS

Detail of Wharf-Pile Group in the Darwin Hall of the American Museum

The stationary animals of the wharf piles are contrasted, on the one hand, with the jellyfish (*Dactylometra quinquecirra*), which swims aimlessly without power of direction, and on the other, with the squid (*Loligo pealii*) and cunner (*Tautoglabrus adspersus*), both of which possess highly coordinated and efficiently controlled swimming organs

The Kingdom of the Tides

By

Roy Waldo Miner

Curator, Living Invertebrates
American Museum

Some of the Creatures One May Find
along the Shore Line of New England

WHEN we look at maps and charts, we see the boundary between land and sea marked by a definite line, but if we search for its exact location as we stroll along the beach, we cannot find it. The incoming waves rush up over the sands until they flatten out, lose their momentum, hesitate, and stream back into the flood whence they came. As the tide rises, the sea gradually advances farther inshore, but finally a limit is reached at high water. At certain seasons, and at times of storm, a greater area of land is covered, but the recession always takes place and the territory won by the ocean is abandoned, until, at the very lowest ebb, a strip of sea-bottom, in turn, is conquered by the land.

The strand slides under water at the same general slope, and, though diversified by sand bars and shoals, the sea-bottom sinks at a uniform rate, until, at a greater or less distance offshore, at a depth of about six hundred feet, it dives at a more rapid gradient into the depths of the sea. Here, at the edge of this steep slope, is the first indication of a line of separation. It is said that, ages ago, the real boundary of the land was to be found here, and the continents were much larger. Now the seas have flooded over the edges of this ancient land, forming a comparatively shallow border or rim, varying in width from thirty to one hundred miles, which we call the continental shelf.

This shallow area, well lighted by the sun, and warmer than the oceanic deeps, is the real theater of the life of the sea-bottom. In the sunlight the sea-plants, or algæ, abound, and feeding among them are myriads of small oceanic creatures,

which, in turn, form the food of the larger inhabitants of the sea.

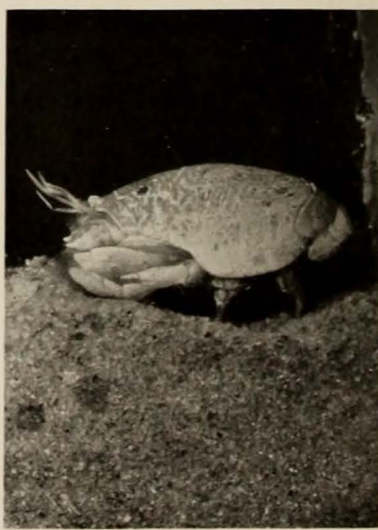
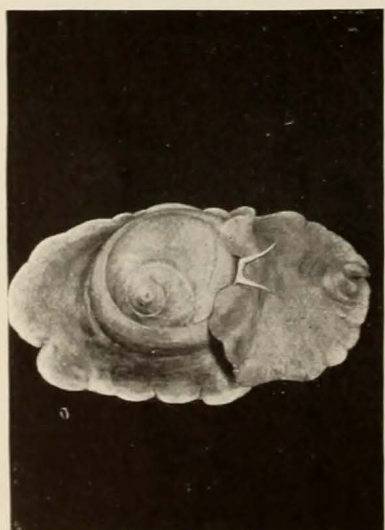
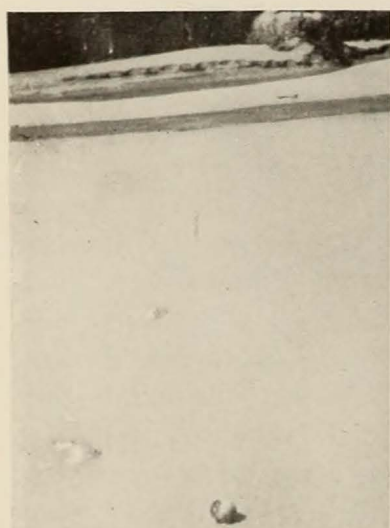
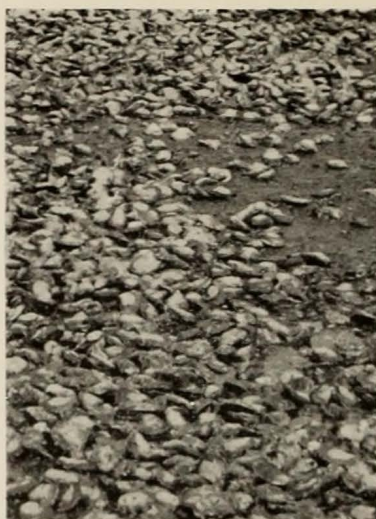
Here are gathered living hordes of fishes, mollusks, crustaceans, sea-worms, echinoderms, and the lower forms of life. From this shallow zone, in the course of time, many species have invaded the deeper waters and have become adapted for the dark abysses beyond the edge of the continental shelf. Myriads of others have crowded into the warm, sun-lit shallows near the shore and have even sought the intertidal stretch which is laid bare twice daily by the ebbing tide.

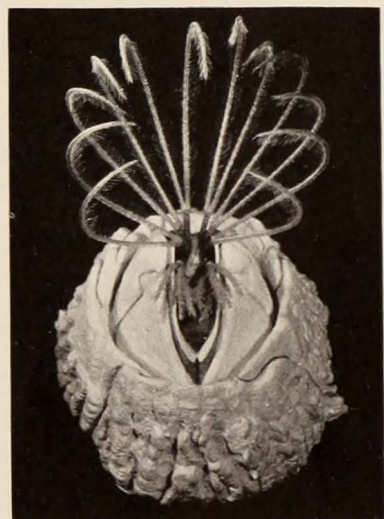
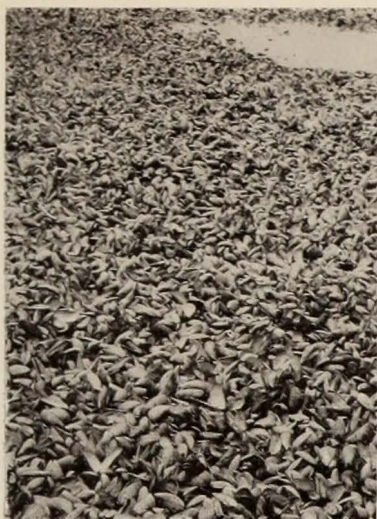
As we walk along the shore at low tide or wade in the shallows, we invade the edge of this teeming world of sea-creatures and see many signs of their activities. Along our coast from New York to the Bay of Fundy, the aspect of the ocean margin presents many contrasts. Long Island and Connecticut are characterized by stretches of exposed sand beaches, sheltered mud flats and sand spits. Here and there may be found out-croppings of rocks or tide-rips where glacial boulders have been laid bare, but the chief character of the coast is low and free from rock. This condition becomes intensified as we reach and round the curving arm of Cape Cod, which is nothing but a huge sand spit. North of Massachusetts Bay and Boston, bold headlands of rocky cliff jut out into the sea, as at Nahant, Marblehead, Gloucester, and Cape Ann generally. Along the coast of Maine, high, rocky cliffs become the rule, lining and limiting deep bays, sown with jagged islands, and hemming in the estuaries of great rivers.

The height to which the tide may flow

Sea Shore Warfare

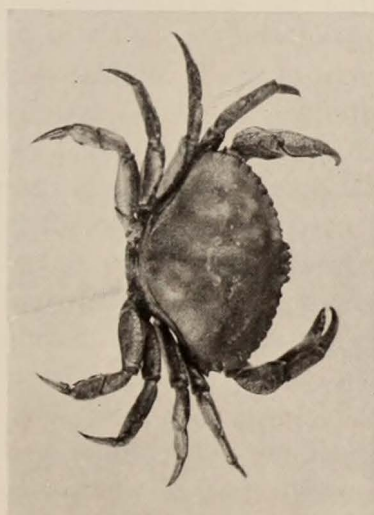
The five pictures at the right show, first, a colony of oysters on a mud flat. The second picture shows a mass of invading mussels which, in the third photograph, are pictured after they have overwhelmed the oysters. The fourth view depicts the mussel colony being invaded, in turn, by barnacles which, in the fifth view, are shown completely victorious





A barnacle extending its feathery feet from its limestone wigwam

Creatures of the Sandy Beach



At the left on the opposite page are two pictures of *Natica*, the sand collar snail, which hides in mound-shaped burrows or crawls over the sand, pushing its fleshy apron before it. Next comes a lady crab up to her eyes in sand; a "sand bug" preparing to "dig in"; a rock crab, and finally another lady crab showing its paddle-shaped hind legs

shows great variation. Along the exposed sandy shores of southern New England it ranges from two to five feet in height, except where the incoming seas are forced into narrowing bodies of water like Long Island Sound, where it rises six to seven feet, as at New Haven and Bridgeport.

HIGH TIDES AND LOW

On the outer side of Cape Cod, the rise is but two feet, but the masses of water that crowd into Cape Cod Bay reach nine feet at Plymouth. North of Boston this height continues, becoming gradually increased along the Maine coast. The Gulf of Maine is a huge, curving and tapering funnel, guarded by Cape Cod to the southward and the peninsula of Nova Scotia to the northeast.

The tides entering this huge gulf are shunted along the hollow curve of the Maine shore line and Bay of Fundy, rising at high water eighteen feet at Bar Harbor, twenty-eight feet at St. Andrews, New Brunswick, and the enormous height of forty-five feet during spring tides at Amherst and Truro, where, at the double apex of the funnel-shaped Bay, the Nova Scotian isthmus ties the peninsula of that name to the mainland of North America.

Naturally the combination of high, swift-running tides and rocky coasts has a far-reaching effect on the animal and plant life inhabiting the impetuous waters of northern New England, compared with the low-lying, quiet, sandy and muddy coasts of the more southerly portions.

The temperature of the waters in the two regions also is of great influence. Southern New England is washed by spurs from the warm waters of the Gulf Stream, especially in the Cape Cod region which, with the outlying Elizabeth Islands, as well as Marthas Vineyard and Nantucket, juts boldly out into the sea. But farther north, the cold Arctic Current pushes its way in close to the shore, and creatures which, in southerly waters, are

found only in the deeper, colder seas, here occur near the surface and are able to live in shallow waters near the rocky shore.

If we could stroll along the entire New England coast in a few hours, we should find ourselves passing over regions continually changing in character, and the species of animals populating the shallow waters around the low-tide limit also would be seen to vary in harmony with the changing environment. The forces of inanimate nature sift out all individuals that invade regions to which their bodily structures and habits are not adapted.

As it is out of the question to cover so much territory in one journey, let us transport ourselves in imagination from place to place and sample a number of contrasting typical localities to become acquainted with the shallow-water animals characteristic of them.

AN EXPOSED SANDY BEACH

The white sand stretches out before us for miles, heaped high into dunes at our left or extending over into broad flats covered with beach grass and low shrubbery. At our right, the surf breaks thundering on the shore, washing to our very feet and bringing quantities of loose sand along with it. Here and there, with a rattle and a roar, the waves bombard the coast with masses of rounded pebbles, spreading them over the strand in assorted sizes ranging from gravel to boulders.

We pick up dead and empty shells on the beach, many of them broken and beach-worn. Ruffled fronds of kelp are washed up and other flotsam from the sea, but, for the most part, life is conspicuous by its absence, and the sandy shore seems barren indeed. This is not to be wondered at. The shifting sand gives little opportunity for harboring animal life which otherwise might burrow within it, and the force of the waves transforms into grindstones the pebbles and rocks which, in quieter waters, would give

shelter to all sorts of sea-creatures. The siliceous sand grains are barren of food material and could support no life even if any could find foothold among them.

Nevertheless, at the upper tide limit, long lines of beach wrack mark the boundary of the ocean's surge, and as we stir up the decaying and drying fragments of seaweed, swarms of beach-fleas (*Orchestia agilis*) come to life and jump hither and thither in clouds. If we are quick, we can capture them and put them into a glass jar, where we can examine them at leisure. They are olive green in color. Now, as we look closely at the sand not far from the high-tide mark, struggling forms emerge from tiny little holes that are almost invisible, and go leaping about, their grayish, sand-colored bodies closely resembling their environment. They, too, are sand-fleas of two different species (*Talorchestia megalophthalma* and *longicornis*) somewhat larger than their green brethren and distinguished by unusually large eyes and long feelers, respectively.

THE LADY CRAB

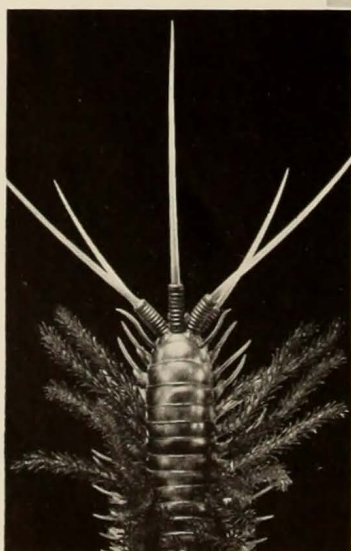
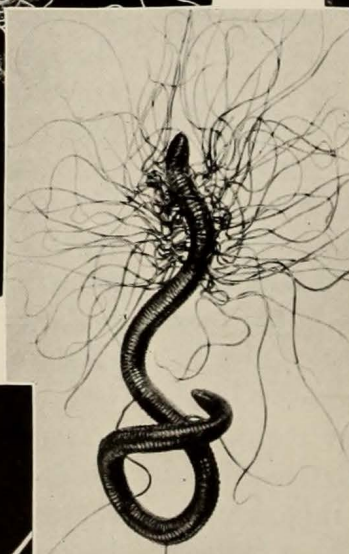
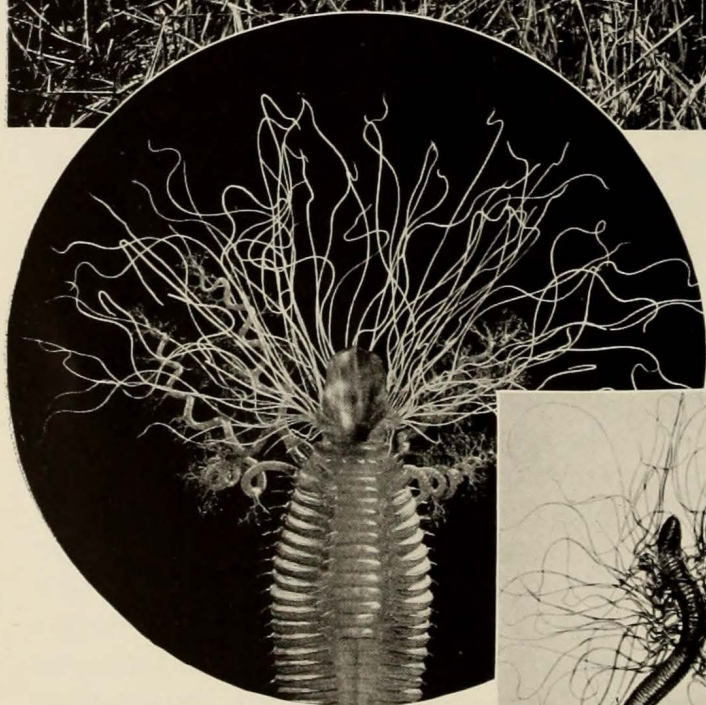
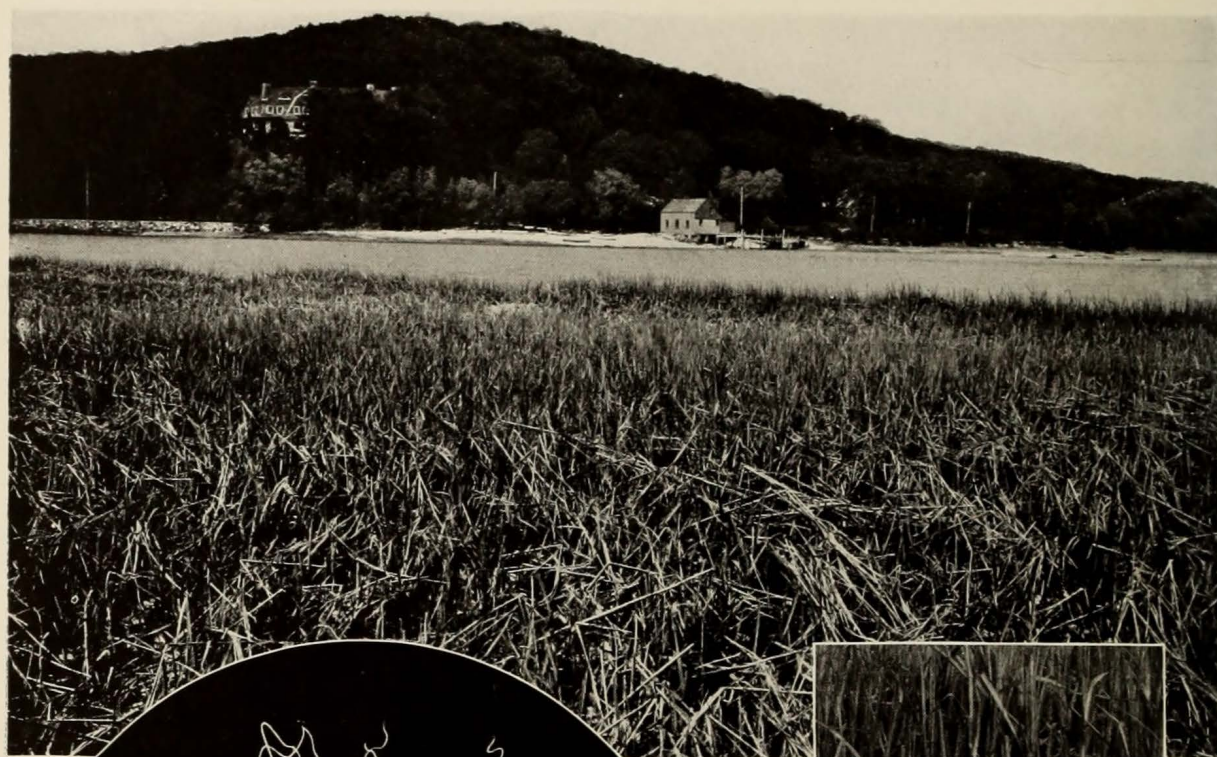
At low tide, when the sea is calm, one may wade in the shallows with a water glass and find other evidences of life. Yonder a lady crab (*Ovalipes ocellatus*) goes swimming by sidewise, waving its paddle-shaped hind legs over its back as a means of propulsion. A short distance away it settles down on the sea-bottom, raises its stalked eyes, and regards us warily. We approach with stealth, to get a good view of its carapace gayly spotted with irregular purplish pink dots, and the sharp pincer-like claws, striped also in purple and pink, which wave menacingly toward us. It is all a bluff! For as we cautiously wade nearer, the crab shoves the hinder margin of its carapace down into the sand, and rapidly digs itself under till only the frontal edge, the ends of the stalked eyes, and the waving, threadlike antennæ are visible.

The rock crab (*Cancer irroratus*) is also abundant here, scuttling over the sandy floor, as it has no paddles to swim with like its more fortunate cousin. We catch glimpses of the slender almost transparent boatlike bodies of the common shrimp (*Crangon vulgaris*) darting here and there like phantoms.

SAND-COLLAR SNAILS

A number of sand-collar snails of two species (*Natica heros* and *duplicata*) have started a settlement yonder where the sandy floor is nearly level and is laid bare only at the lowest tide. Low, rounded mounds scattered over the wet sand betray their habitat, and, as we watch, there is a disturbance in one of them which is still under water, and we see a round, almost globular shell, about as large as a tennis ball, break through. A fleshy foot protrudes itself from the shell opening and extends forward and back over the sand until it seems impossible that so much animal could be packed so tightly within the spire of the shell. Now it begins to travel forward, pushing before it an apron-like flap, above which waves a pair of antennæ, each with an eye-spot at its base.

As the creature slowly progresses, a transparent, jelly-like ribbon emerges from under the right side of the apron and is slowly pushed around the lower margin of the shell, where it is overlapped by a fold of the broad, fleshy body. Soon it completely surrounds the shell like a border. The snail continues to creep forward and leaves the transparent ribbon behind it on the sandy sea-floor. The sand washes against it and sticks to it. We pick it up and find it is a delicate little collar-shaped arrangement, open in front and slightly ruffled at the lower margin. The sand which has stuck to the outer surface covers it in a single layer, giving it an appearance of fine sandpaper. If we examine the under side with a hand lens, we find that it is entirely lined with a



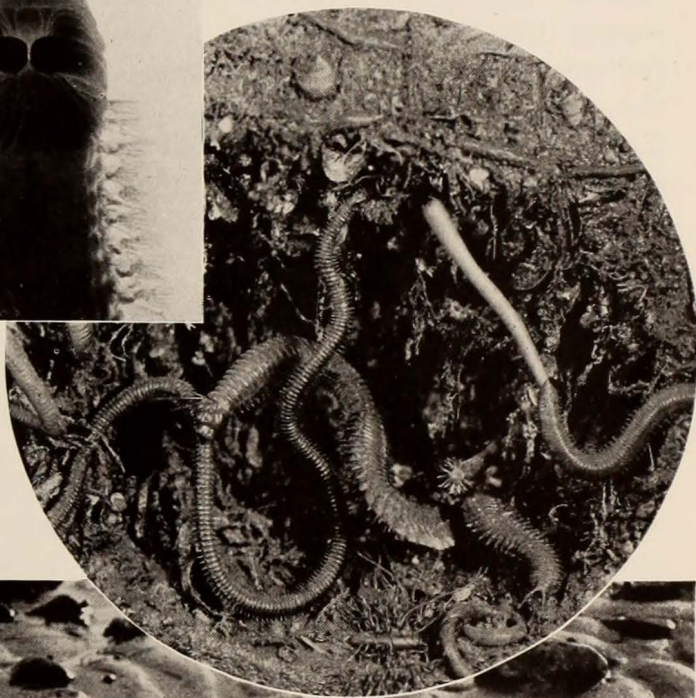
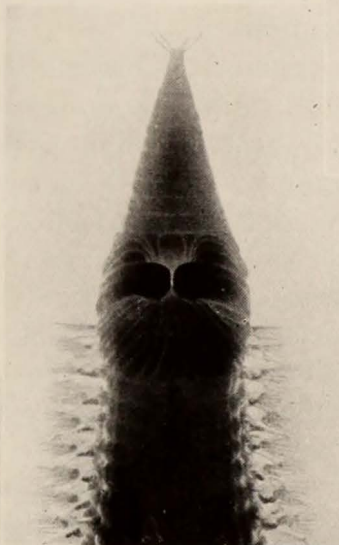
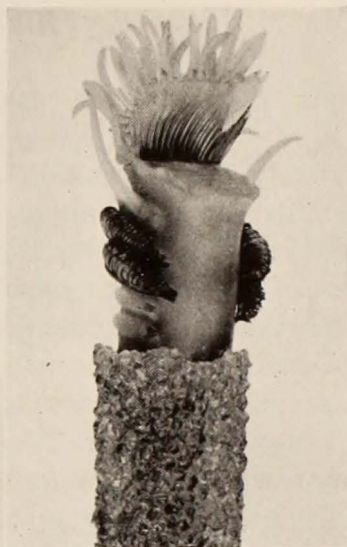
Tidal Water and Marsh Grass

In settings such as the one shown at the top of the page, fiddler crabs dig burrows among the grass roots.

The sectional view above at the right shows a fiddler-crab burrow, together with a starfish preparing to feed on an oyster. Marvelously adorned seaworms dig in the mud, as well. In the circle the ornate worm (*Amphitrite ornata*) spreads its delicate tentacles; in the center rectangle a fringed worm (*Cirratulus grandis*) extends its threadlike filaments; at the left is pictured the head of a plumed worm (*Diopatra cuprea*). Except for the view at the top, these photographs are of models at the American Museum

A Ripple-Marked Mud Flat

Prolific sea worms make their homes and dig their subways in the tide-washed mud. In the circle, a clam worm (*Nereis*) appears to be attacking an opal worm. At the upper right a trumpet-worm model is shown, surrounded by the sand grains that it has built into a home. The center rectangle shows a model of the head of a "beak thrower," pictured also in the circle "throwing its beak." Below at the left the head of an opal worm is shown, gleaming with iridescent hues. The tracks shown crossing the ripple marks in the bottom picture have been made by black mud-snails



delicate layer of transparent eggs, each like a tiny bead of jelly, all closely set together in a finely wrought mosaic. As the collar dries in the sun, it becomes so fragile that it crumbles to sand in our fingers.

We now turn our attention to the snail itself and see that it is rapidly creeping through the shallow water toward a group of little flattened sticks standing up from the sand at an abrupt angle. The snail seems much interested in them. As we examine them with attention we see that their sides are formed of two long, narrow, slightly curving shells which somewhat suggest the size and shape of the old-fashioned razor handle. We recognize the razor-shell clam (*Ensis directus*). The shells stand half-buried in the sand, showing the ends of their short siphon-tubes at the top bordered with fringelike papillæ. Apparently they are aware either of us or of the approaching snail, for suddenly first one, then another, shoots down into the sand until the siphon-openings are barely even with the surface. They are great diggers, for their lower end is equipped with a powerful curved and tapering foot, which is used as a very efficient digging organ.

These inhabitants of the exposed sandy beaches, together with certain others, such as the soft clam (*Mya arenaria*), the surf clam (*Spisula solidissima*), the "sand bug" (*Hippa talpoida*), the sand dollar (*Echinarachnius parma*), and a few sea-worms, are able to endure the difficult conditions of exposure to the open sea. Most of them also occur in the more sheltered regions described below, but they are the hardy explorers of the shallow seas, and form the scattered population of a region which is otherwise without abundant visible life.

SHELTERED SAND AND MUD FLATS

As we walk along the beach, we may find our progress stopped by an inlet through which the tide flows into more

sheltered waters. In such places the currents wash the sand and mud away from the boulders embedded therein and much of the mud is carried into the sheltered waters of the bay, to be deposited upon its floor, mingled with sand to a greater or less degree.

AMONG THE EELGRASS

This mud is filled with nutritive material in which eelgrass grows readily and which also provides sustenance for all sorts of burrowing sea animals, and many others which lurk among the weed. Hosts of tiny creatures grow on the eelgrass blades, hide under the stones in the bottom and edges of the tidal channel, and cling to the seaweeds growing in such places.

Depending on the amount of exposure to the open sea, the soil grades from gravel, through sand, sandy mud of various degrees of admixture, and pure mud, abounding in inhabitants which thrive best in each special environment as well as those ubiquitous creatures which range over the whole field.

The little hermit crabs (*Pagurus longicarpus*) are among the latter. These may be seen scuttling back and forth in shallow water. They are small shrimplike creatures with a pair of heavily armored, formidable claws and four spiny walking legs, but with a soft, tapering abdomen which is their weak point and is entirely unprotected. Attached to this are a few pairs of small holding claws. To make good their deficiency, the hermit crabs appropriate abandoned snail shells, backing their soft abdomen into the spiral chamber of the shell, into which it neatly fits. They hold the shell in place by gripping the central columella of the spire with their weak abdominal claws, and then boldly run around with their castles on their backs. If assailed by an enemy, they retreat within the shell, closing the opening with one of their large claws. However, certain species of fish eat them, shell

and all. The hermits are the scavengers of the shallow seas and always gather together in great numbers to feast upon dead and decaying plants and animals. On muddy bottoms they are joined by the black mud snails (*Nassa obsoleta*), whose progress over the mud can be traced by their undulating groove-like trails.

A POPULOUS CITY ON A SHELL

The hermit crab is also interesting, because, in many cases, the dead shell that it carries may become covered with a soft substance appearing at first glance like the pile of coarse velvet. If we place such a crab in a small dish of sea water and look at it under a magnifying glass, this covering resolves itself into a city of tiny hydroids (*Hydractinia echinata*), little flower-like creatures with slender tube-shaped bodies, some of them with terminal mouths surrounded with grasping tentacles; others with no mouths but carrying quantities of egg-producing organs looking like tiny clusters of grapes; and still others near the edge of the shell with no mouths, but with their heads crowned with beadlike batteries of sting cells. Obviously this is a community of specialists, some members of which are the feeders for the colony, others, the reproducers and nursemaids, and the rest the fighters. Each has its special work to do. All the individuals are connected by a network of tubes, so that food may be supplied to the members that have no mouths by those which secure and digest it.

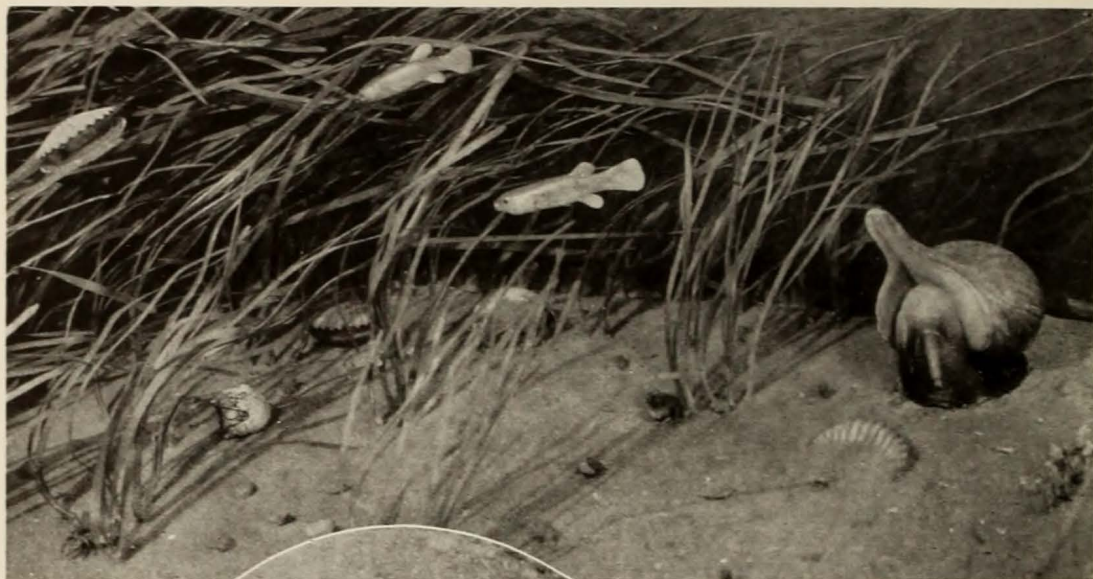
Larger species of hermits (*Pagurus bernhardus* and *pollicaris*) hide in the eelgrass, where also may be found the great whelks (*Fulgur canaliculata* and *carica*), which bear large, coiled shells on their backs with a pointed siphon in front. The females of these whelks manufacture egg-strings, two or more feet in length, looking like strings of spiny, yellow pill boxes, in which the eggs hatch into baby snails with tiny shells like those of their

parents. After a time the little snails emerge from a hole in the edge of each pill box and take up an independent life. The whelks prowl around, in the hope of capturing one of the scallops (*Pecten gibbus*) which abound in the eelgrass. This is a game of stalking, for the latter possess a hundred or more gleaming, steely blue eyes around the edge of the mantles, and, when alarmed by a shadow, will spring up in the water and flit out of the way, opening and closing their shells rapidly as a means of locomotion.

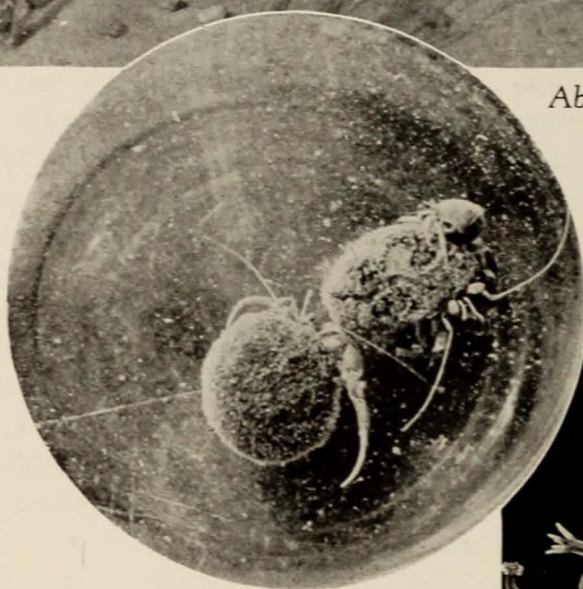
The green crab (*Carcinides mænas*), conspicuous with its bright green, yellow, and black markings, and the blue crab (*Callinectes sapidus*), familiar to us in the markets, frequent the sheltered mud flats in shallow water, while the small mud crabs (*Panopeus herbstii* and *sayi*) with their black-fingered claws are everywhere at the water's edge. The large spider crabs (*Libinia emarginata* and *dubia*), with their long legs and small, spiny, rounded carapaces, hide in the eelgrass and are hard to see on muddy bottoms.

OYSTERS AND MUSSELS

On mud-flats laid bare at low tides one may chance upon occasional oyster beds, though these are usually cultivated at some depth. More frequently huge flats may be covered with edible mussels (*Mytilus edulis*). These black mussels are a potential article of food, now much neglected, but, when properly prepared, they rival the succulent oyster and little-neck clam in delicacy of flavor and nutritious value. On Marthas Vineyard Island, literally acres of mussels are laid bare at low tide. They multiply so rapidly that, if by chance they come in contact with a bed of oysters, they will overspread it and completely smother it. The rock barnacles, in turn, reproduce even faster than the mussels, and, by sheer force of numbers, given an opportunity, will invade a mussel colony and overwhelm it,

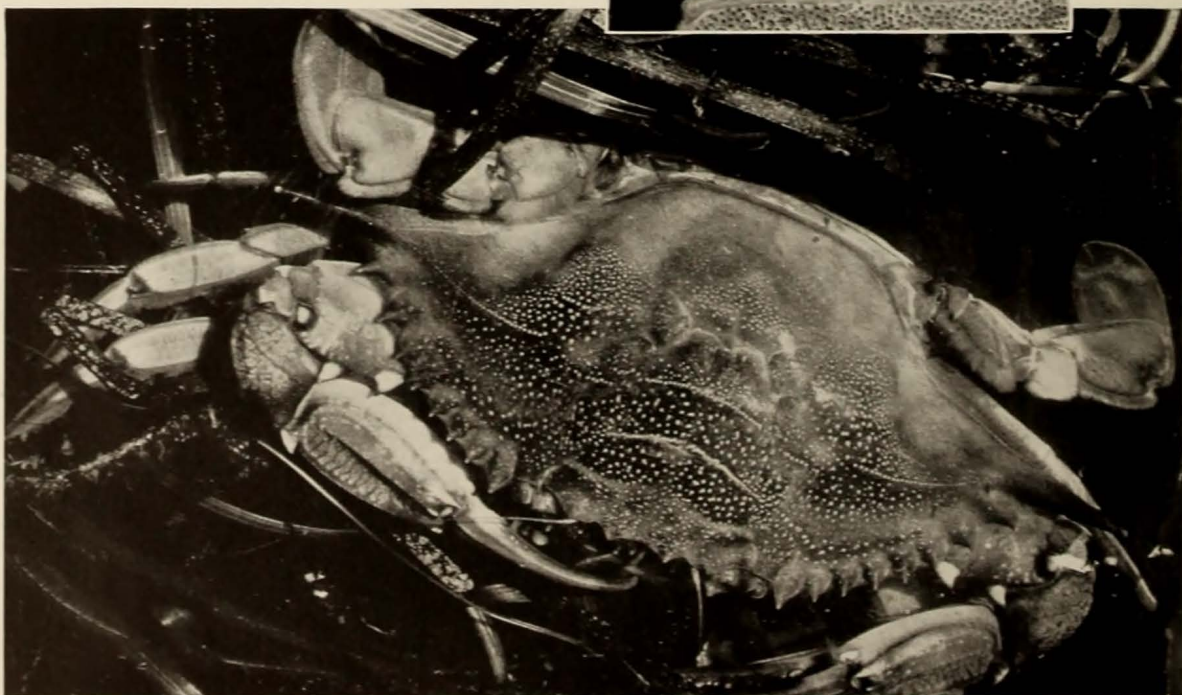


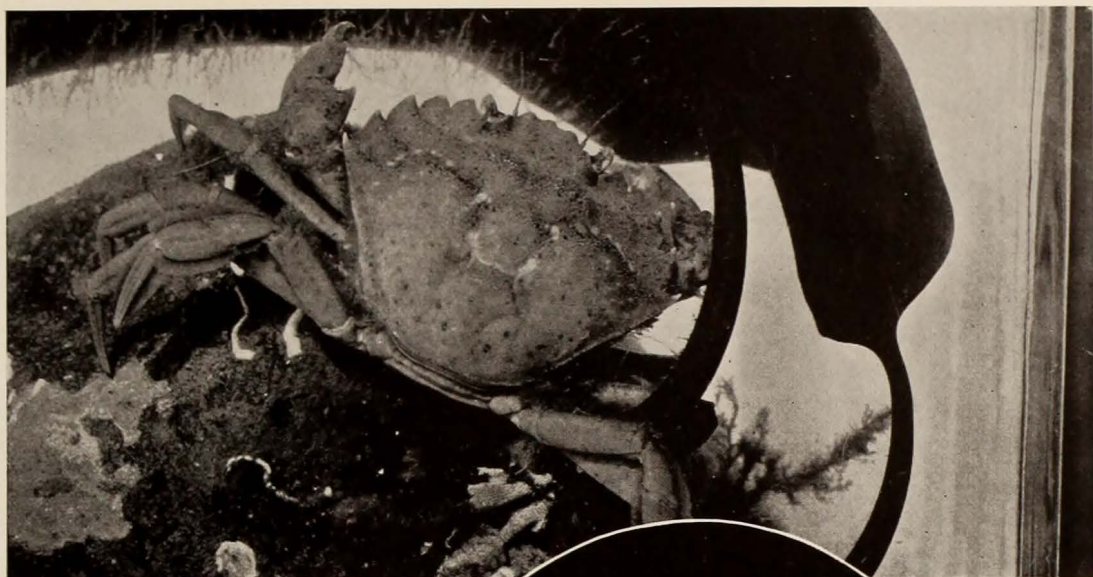
Above: A giant whelk pursues a scallop, which swims by opening and closing its shell



Above: A hermit crab in his borrowed and "velvet"-covered shell

Below: The familiar edible blue crab



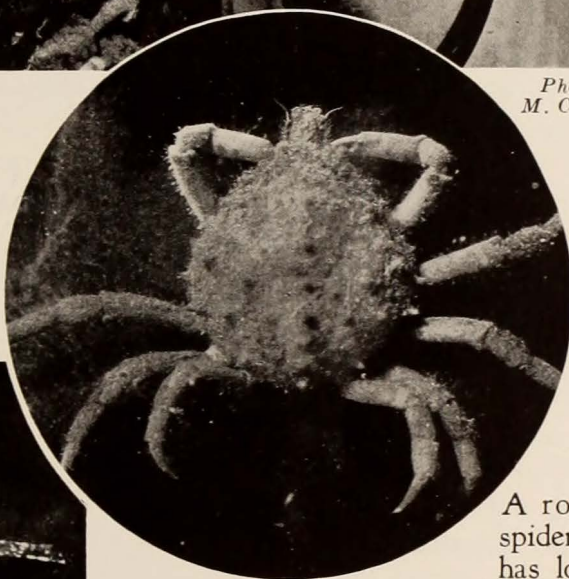


Above: The green crab above is not edible, but is a pugnacious fighter

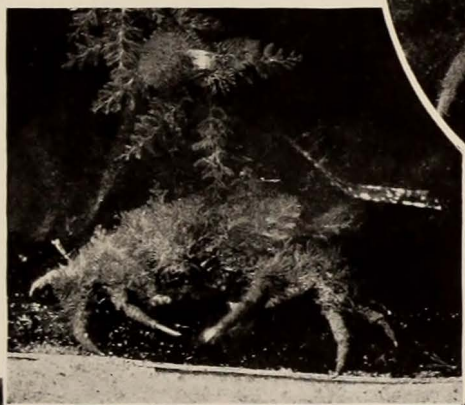
*Photographs,
M. C. Dickerson*

Below:

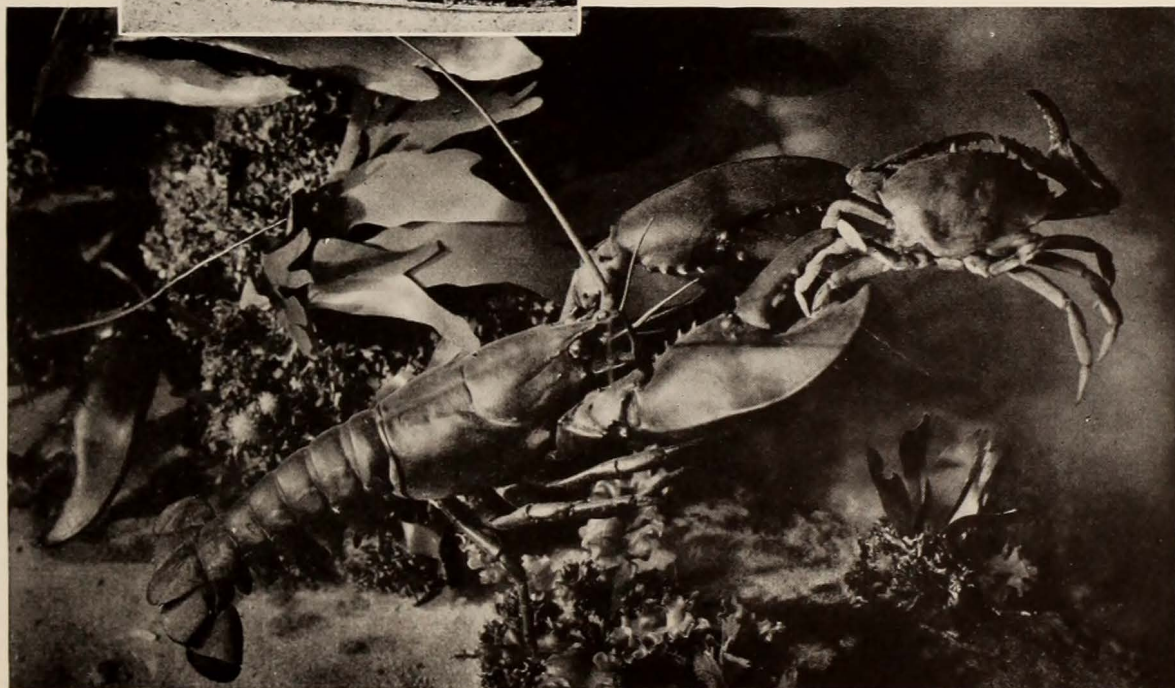
A spider crab, which has camouflaged himself by plucking tufts of *Bugula* and placing them on his back



A rough-spined spider crab, which has lost one claw



Below: A lady crab is shown swimming vigorously in an attempt to escape from a lobster



thus rendering poetic justice to the former conquering horde.

ENEMIES OF MOLLUSKS

These beds of shellfish, of course, attract the enemies of bivalve mollusks in great abundance. The most important of these are the oyster drill (*Urosalpinx cinerea*) and the common sea stars (*Asterias vulgaris* and *forbesi*). The former bores neat little pinholes in an oyster shell, and sucks out the contents, while the latter mounts the oyster, applies the pneumatic disks of its tube-feet to the two valves, and, bracing the tips of its arms against surrounding objects, pulls the shells open by main force and proceeds to devour their contents.

The oysters are not naturally found in muddy localities, but have been transplanted there by man, by spreading shells to form a "clutch." They belong more properly on a rocky bottom.

The animals most typically associated with more or less muddy regions are the sea worms. Burrowing in the soil everywhere, they construct tubes of greater or less consistency, or, in some cases, no tubes at all. They hide under flat stones, or dig among the roots of eelgrass. In localities rich in mud the fringed worm (*Cirratulus grandis*) burrows in great abundance, its reddish body adorned with a multiplicity of long, threadlike, breathing organs on the forward third of its body, each filament of golden yellow with a brilliant red thread of blood showing through the translucent walls. The plumed worm (*Diopatra cupræa*) constructs tough, parchment-like tubes in sandy mud, showing like chimneys above the sea-bottom, to which bits of shell and seaweed are cemented. The worm has a bluish iridescent body equipped on the forward part with marvelous blood-red plumes with spirally arranged branches. The ornate worm (*Amphitrite ornata*) builds tubes of sand and mud. It is a

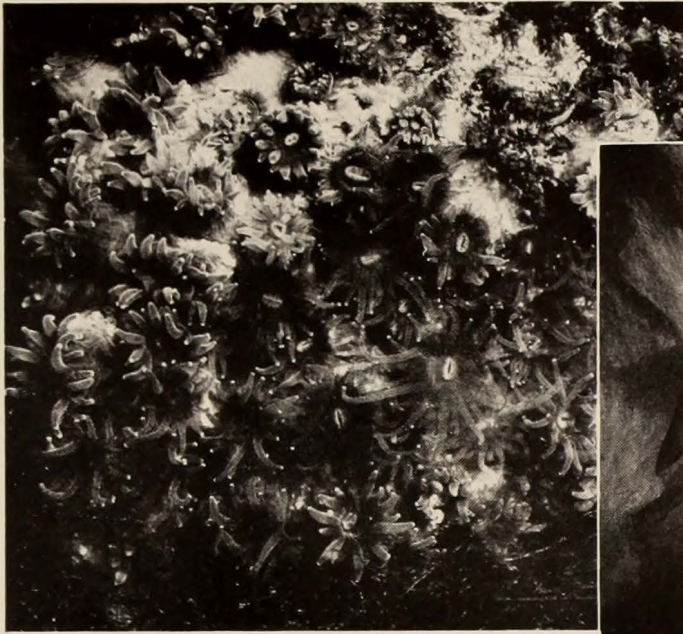
wonderful creature with three pairs of intricately branched gill-plumes on its shoulders and numerous flesh-colored tentacles extending in all directions from its head. Its body is beautifully marked with reddish brown, and a broadly tapering upper lip is colored from rich rose to violet. The opal worm (*Arabella opalina*) has an orange head with four eyes, and a long, slender body composed of brilliantly opalescent rings. The trumpet worm (*Pectinaria belgica*) digs with a pair of golden combs and constructs a trumpet-shaped tube of neatly matched sand grains arranged in a delicate mosaic.

Scores of other species occur, all remarkable for beauty, grotesqueness, or strange habits, but it is impossible to mention them all here. Needless to say, the sheltered mud- and sand-flat is one of the most fruitful fields for the study of the strange creatures of the sea.

ROCKY SHORES AND HIGH TIDES

Let us now transport ourselves to the north shore of Massachusetts or the coast of Maine. We are on a rock-bound coast, hemmed in by high cliffs, against the base of which the incoming tide breaks in masses of foam, which scour through every crevice and rush back into the sea. The tide rises and falls nine feet or more, according to the locality, and, farther north, several times that distance.

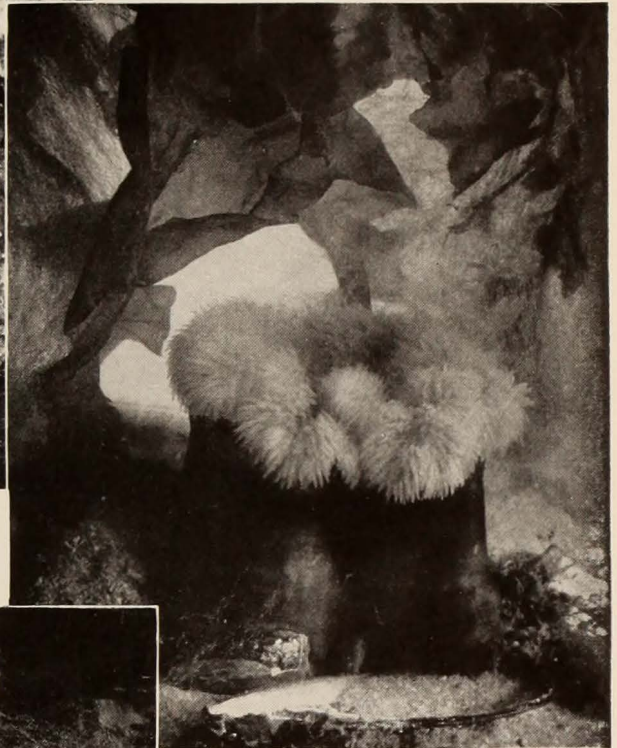
At low tide the vertical walls of the cliffs are seen to be broken into shelving terraces, draped and festooned with rock-weed, bordered above with a long frieze of white barnacles. The basin-like hollows on the rocky terraces are filled with water, even when the tide is at its lowest, and each one glows with submerged colors like an aquatic sea-garden. There is no soil for burrowing like that on sand- and mud-flats, and all animals having no adequate clinging organs, or requiring a soft substratum for burrowing are eliminated here by the force of the elements, and yet



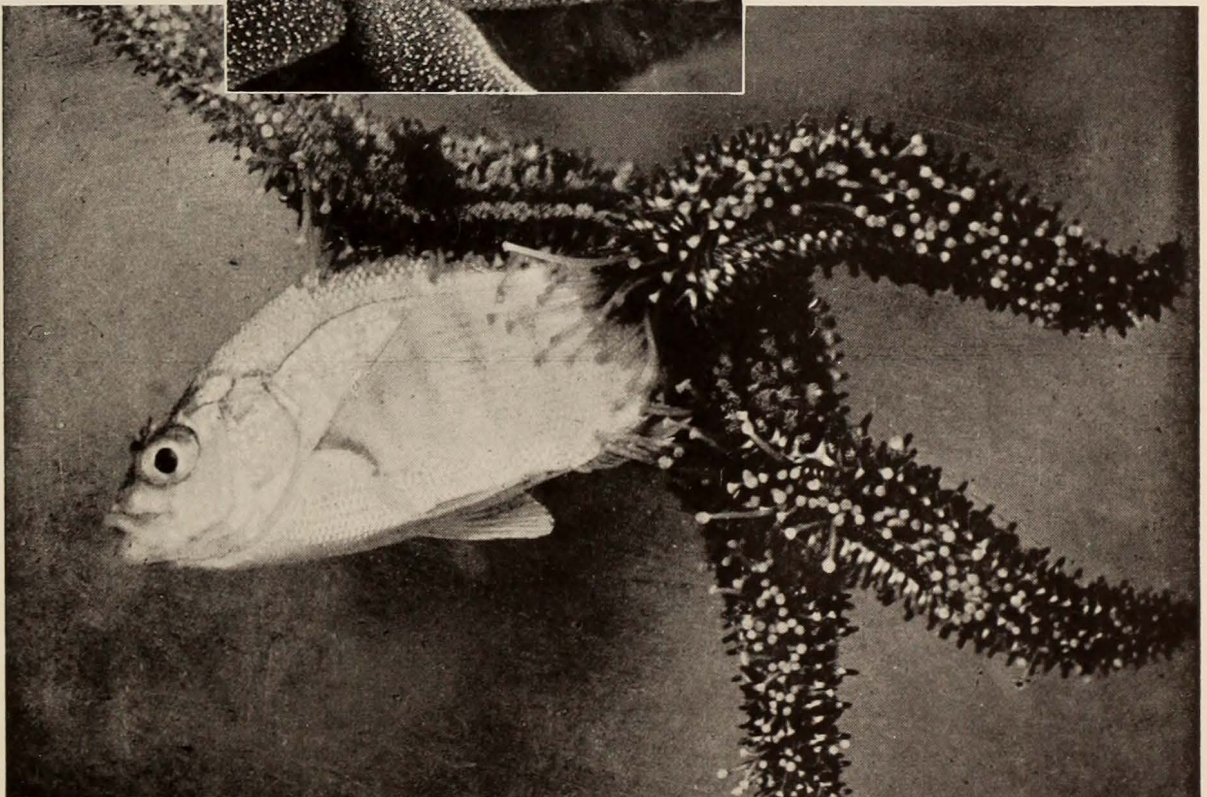
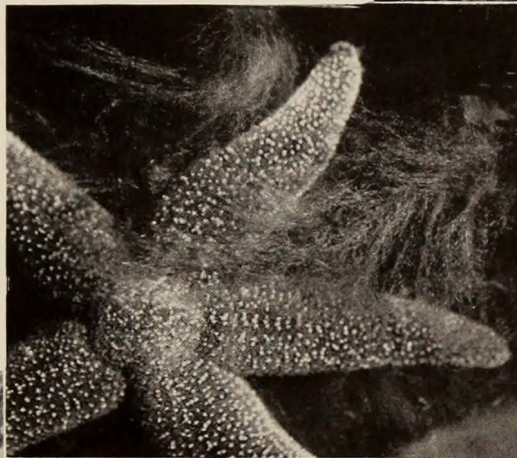
Left: The only coral (*Astrangia danae*) of the New England coast is shown growing over a rocky bottom

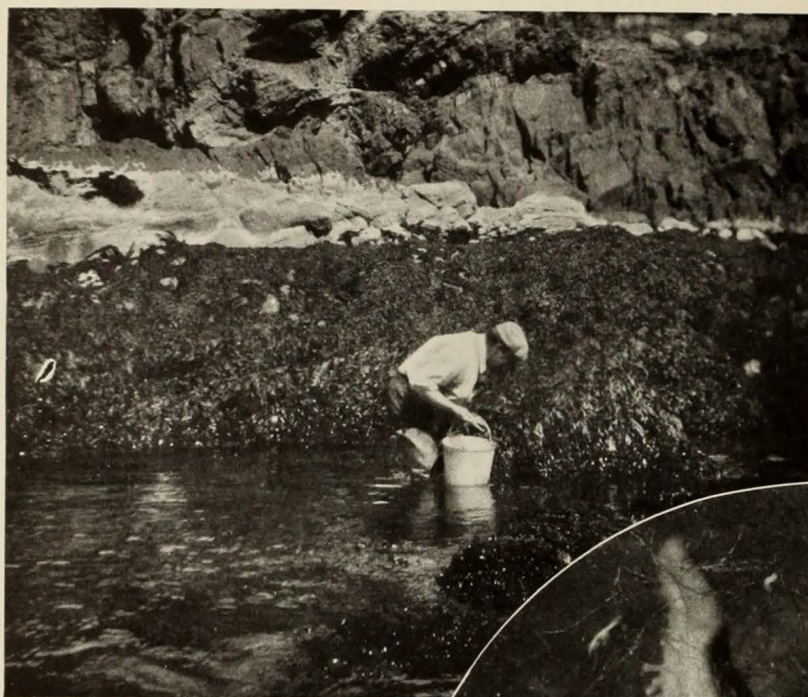
Photographs, M. C. Dickerson

In the small rectangle a common starfish (*Asterias vulgaris*) is portrayed. Below: A starfish is shown attacking a small fish. The "tube-feet" are equipped with sucking discs by means of which the fish is dragged into its attacker's central mouth



Above: A sea anemone (*Metridium marginatum*) expands its feathery crown, which is armed with sting-cells with which it slays small fish for food

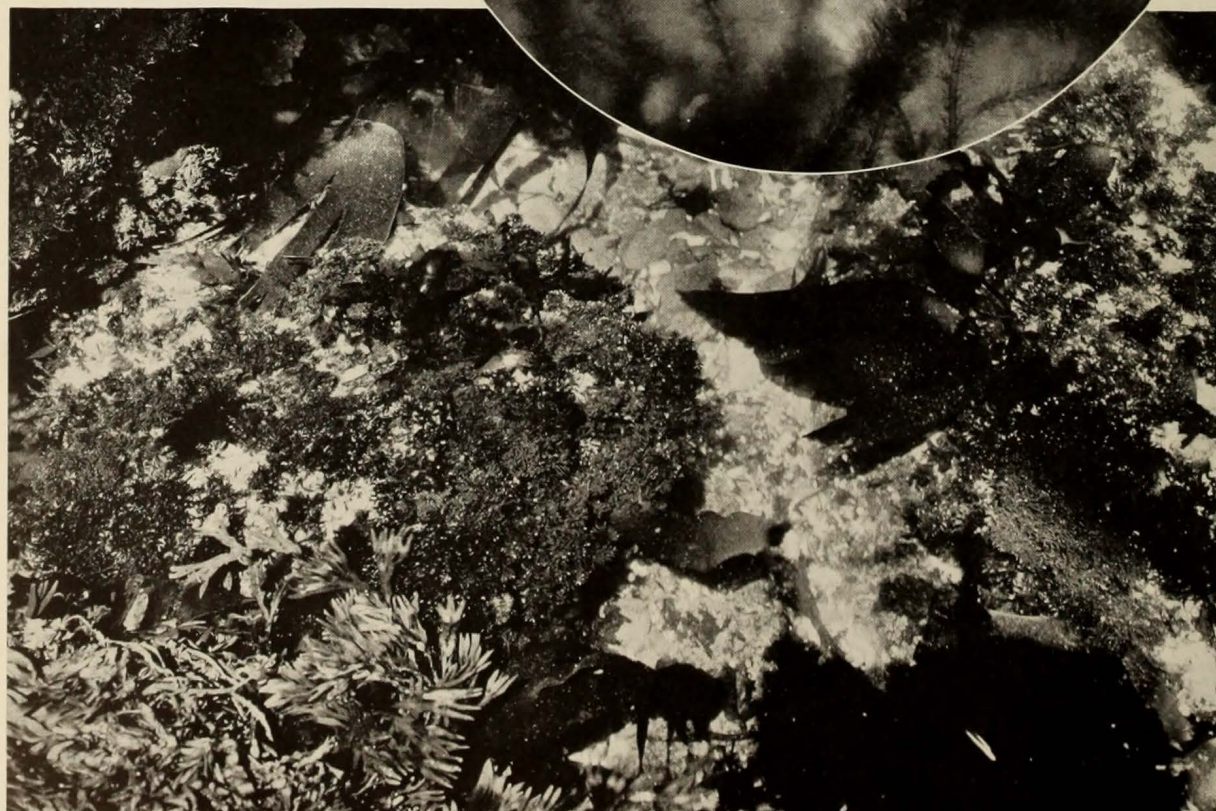
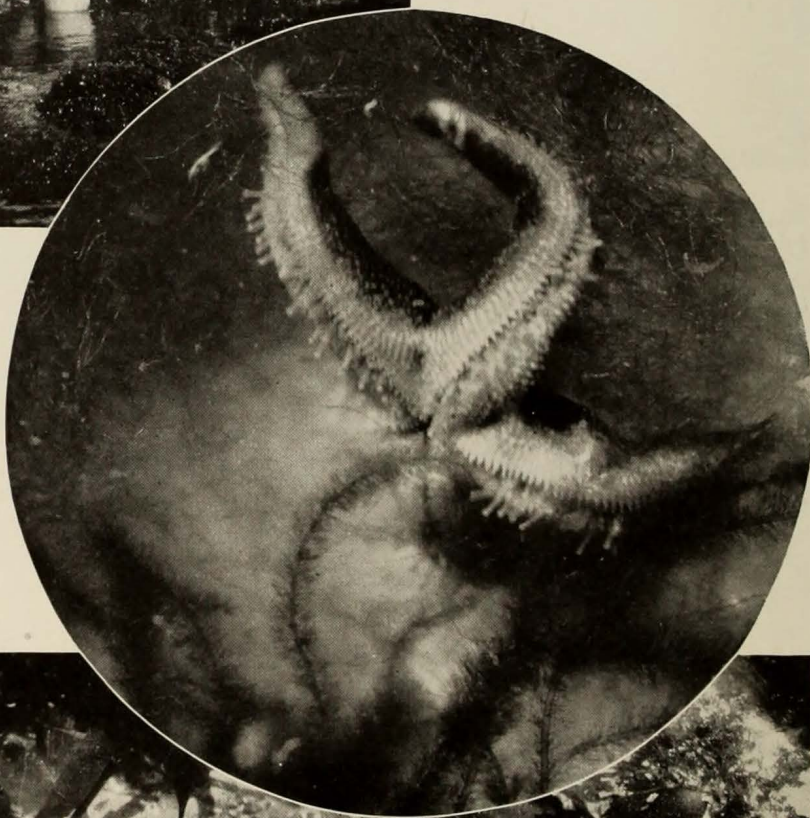




The rocky coast at low tide. The white band is made up of barnacles. Below these, festoons of rock weed partly cover crowded masses of mussels. In the water, starfish and green sea urchins abound

Right: The little red sea star (*Henricia sanguinolenta*), which is abundant in the tide pools of rocky coasts. Photograph by M. C. Dickerson

Below: A view looking through the clear water of a pool replete with Irish moss, coralline dulse, kelp, rockweed, and sponges

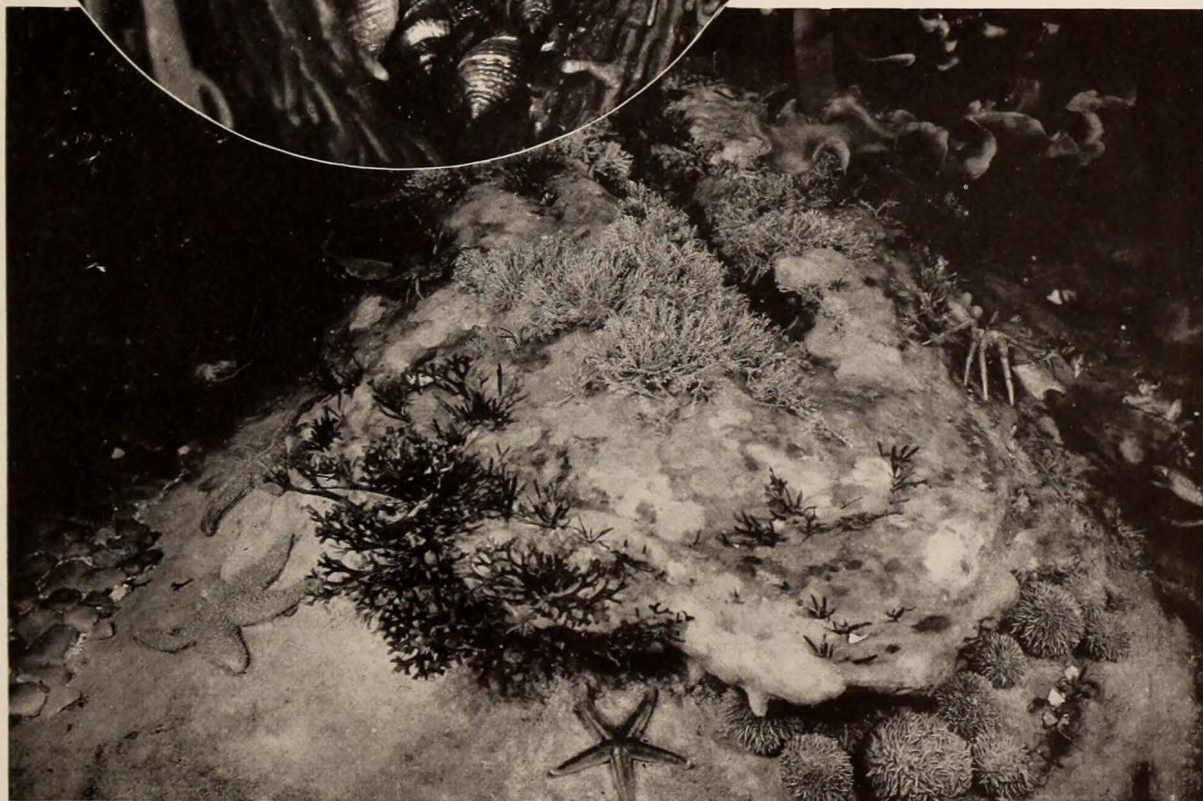


Seaweed drapes the rocks of a beautiful pool at Nahant, Massachusetts. In these clear, quiet waters are displayed a magnificent sea garden in which the observer may find a rich field for observation



Left: Purple snails (*Thais lapillus*) are shown feasting on mussels. These snails produce a beautiful purple dye similar to the ancient Tyrian purple. A cluster of eggs is also visible

Below: A corner of the Nahant pool showing green sea urchins, sea stars, and green crabs on the coralline covered rocks



certain creatures familiar to the southern shores adapt themselves to these trying conditions and survive.

BLACK MUSSELS AND PURPLE SNAILS

The same kind of black mussel (*Mytilus edulis*) that covers the mud-flats of the southern coast to so great an extent, clings to the rocks in broad bands below the barnacle zone and underneath the rockweed, but, in exposed situations, the shells are always very small, for when they reach a size to present resistance to the force of the waves, the silken strands of their tough byssus threads give way and they are stripped from their anchorage by the rushing water. They also must dispute their territory with the purple snails (*Thais lapillus*), which cluster in numerous colonies and feed on the little mussels. These snails derive their name from the fact that they exude a purple fluid, allied to the Tyrian purple of Mediterranean snails. Their shells, however, are gayly banded with red or yellow spirals, or the entire shell may vary from white, through orange, red, and brown. They lay their eggs in little pink or yellowish vase-shaped capsules, which stand on slender stems and are grouped together in small patches in the crevices of the rocks.

At low tide multitudes of sea stars familiar to the southern shore (*Asterias vulgaris*) but varying greatly in color from purple, through blue, crimson, and yellow, feed on the mussels and on the little green sea urchin with the long scientific name (*Strongylocentrotus droehbachiensis*), which is very abundant here. Another sea star characteristic of rocky coasts is a small, deep-red species (*Henricia sanguinolenta*), bright yellow beneath and at the tips of its curving arms. The Jonah crab (*Cancer borealis*) is very common, crouching and hiding in rocky dens. It is larger and with much rougher carapace than the rock crab of Southern New England (*Cancer irroratus*), which also is

found on the northern coast, but more sparingly.

The tide pools on the terraces show remarkable concentrations of sea life. As the sun slants through one of these flooded basins at low tide, it lights up tangles of rich brown, brilliant green, purple, pink, and red algæ, their graceful fronds clustering and overarching miniature vistas, in which acorn snails (*Littorina litorea*), green crabs (*Carcinides mænas*), and tiny red or variegated chitons (*Chiton ruber* and *apiculatus*) creep about amid fairy clusters of pink-hearted hydroids (*Tubularia crocea*), gray-green chimney sponges (*Hali-chondria panicea*), and pink finger sponges (*Chalina oculata*).

SEA ANEMONES AND SEAWEEDS

Sea anemones (*Metridium dianthus*) expand their broad, flower-like, fringed disks, and cylindrical bodies, brown, pink and white, and bright orange in color. Even the rocky basin itself is enameled with encrustations of red-purple *Melobesia* and brick-red *Lithothamnion*,—calcareous seaweeds, that spread thin, stony layers of color over the underlying rock. Clusters of huge horse-mussels (*Modiola modiola*) covered with purple and red bryozoa, open their shells slightly, exposing their orange-colored mantles.

It seems impossible that there should be such an abundant association of living forms in so small a space, but the secret lies in the flood of aerated and food-laden waters that twice a day overwhelms these tidal pools and brings the inhabitants everything on which their life depends.

These associations of the animal life of the seas, whether on sandy shore, mud-flat, or rock-bound coast, are but glimpses of an almost infinite kingdom of creatures under the rule of the tide, which sweeps over the great oceanic shelf, bringing life or death to its subjects, depending upon how they adapt themselves to its laws.

