this region is probably more imperfectly known than that of other kinds of bottom. This is mainly owing to the difficulties encountered in dredging upon rough rocks.

Rocky bottoms are very favorable for many kinds of Crustacea, both for those that swim free and conceal themselves among the sea-weeds that grow on rocks in shallow water, and for those that take refuge beneath the rocks. Consequently rocky bottoms are the favorite feeding-grounds for certain kinds of fish, especially tautog, striped bass, black bass, cunners, &c., in this region.

The common crab, *Cancer irroratus*, (p. 312,) *Panopeus Sayi*, (p. 312,) *P. depressus*, (p. 312,) the larger hermit-crab, *Eupagurus pollicaris*, (p. 313,) and the smaller hermit, *E. longicarpus*, (p. 313,) are common species on the rocky bottoms. A small species of spider-crab, *Pelia mutica*, occasionally occurs. The *Cancer borealis* has hitherto been a rare species, and little is known concerning its habits or distribution; it appears to frequent rocky bottoms chiefly, but most of the specimens obtained in this region were found thrown up by the waves on the shores of Cuttyhunk Island, No Man's Land, and near Gay Head.

The lobster, *Homarus Americanus*, frequents rocky bottoms, concealing itself under and among the rocks while watching for its prey, but it is much less abundant in this region than on the coast of Maine and in the Bay of Fundy, and does not usually grow to so large a size as in the northern waters. It also occurs on the sandy and gravelly bottoms of Vineyard Sound, where most of those sent to the markets from this region are obtained. The young, free-swimming larvæ of the lobster, in the stages represented in Plate IX, figs. 38, 39, were often taken at the surface in great abundance, during June and July, in the towing-nets. The young lobsters were also found swimming actively at the surface by Mr. S. I. Smith, even after they had acquired the true lobster-like form and structure, and were nearly three-quarters of an inch long. In this stage they swim and act much like shrimp. While young, therefore, the lobster must be devoured in immense numbers by many kinds of fishes, and even when of considerable size they are still preyed upon by the tautog and black bass, and especially by sharks, skates, and rays, and doubtless by other fishes. We found the lobsters very abundant off Menemsha on a sandy and weedy bottom in shallow water. At this place over one hundred were taken at a single haul, by the trawl. The lobsters caught for the market are nearly all caught in "lobster-pots," baited with refuse fish of various kinds.

In addition to the common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10,) another quite different species (*Hippolyte pusiola*) was often met with on the rocky bottoms. This is a smaller species, about an inch long, of a pale gray, salmon, or flesh-color, often specked with red; there is usually a white stripe along the middle of the back, and sometimes transverse bands of red or white; the antennæ are annulated with flesh-color and light red, and the legs are sometimes specked with

brown, and often annulated with brown, or with gray and white. It differs from all the other American species in having a short, acute rostrum, scarcely projecting beyond the eyes, with three or four sharp teeth on its upper edge and none below. In form and general appearance it somewhat resembles the *Virbius* represented in Plate III, fig. 11, but is stouter and quite different in color. It is a northern species, extending to Greenland and Northern Europe, and is more common on the coast of Maine, where it is usually associated with several other larger species of the same genus, all of which are remarkable for their brilliant colors, the various shades of red usually predominating. Their bright colors are no doubt directly connected with their habit of living among the bright red algæ, so abundant in the shallow waters on rocky bottoms.

A beautiful little shrimp-like Crustacean, *Mysis Americana* SMITH, sometimes occurs in immense numbers among the algæ growing on the rocks just below low-water mark, especially in spring. This is an important species, as it is one of the principal kinds of food for the shad and other fishes. The full grown specimens are only about an inch long. It is almost transparent, whitish, with conspicuous black eyes; there is a row of more or less conspicuous, dark stellate spots along the body, both above and below, and similar specks often occur on the tail; a spot of dark brown or blackish often occurs on each side of the carapax. The intestine shows through as a greenish or brownish line.

Another small, shrimp-like species belonging to an interesting new genus, the *Heteromysis formosa* SMITH, often occurred in small colonies, sometimes hid away in the dead shell of some large bivalve or gastropod. The females of this species are of a beautiful light rose color, but the males have the pale color and translucency common to most of the species of *Mysis*.

Numerous Amphipods also occur, most of which are also found in the pools or under stones at low water, and have, consequently, been mentioned on former pages. One of the most curious Amphipods was a small species, found living among the large compound ascidians, which is probably *Cerapus tubularis* SAY. This species constructs a little, slender, free tube, which it inhabits and carries about upon its back when it travels, very much as the larvæ of caddis-flies, common in fresh waters, carry about their tubes. One species of barnacle, the *Balanus crenatus*, was abundant, often completely covering small stones and shells. This has not been met with, as yet, at low-water, although it occurs on the bottoms of vessels.

Of Annelids a large number inhabit rocky bottoms, but as most of them live beneath the rocks, or in tubes attached to rocks and stones, it is difficult to obtain an accurate knowledge of them. Many of the species seem, however, to be found also in pools and beneath the stones on rocky shores, and have already been mentioned.

Perhaps the most characteristic Annelids of rocky bottoms are the scaly worms, of which three species are common in this region, viz.:

Lepidonotus squamatus, (p. 320, Plate X, figs. 40, 41;) *L. sublevis* V., (p. 320, Plate X, fig. 42;) and *Harmothoë imbricata*, all of which cling close to the rough surfaces of the stones, or hide away in the cracks and crevices, or conceal themselves in the interstices between the ascidians, barnacles, roots of algæ, or in the cavities of sponges, &c. Several long, slender, and active species, belonging to the genera *Phyllodoce*, *Eulalia*, *Eumidia*, and *Eteone*, are of frequent occurrence; most of them are bright green or yellowish green in color, and all have small, leaf-like branchiæ along the sides.

The *Nereis pelagica* (p. 319, Plate XI, figs. 52–55) is very common, living beneath the stones, and especially in the interstices between the lobes of a large, sand-covered, compound ascidian, *Amarœcium pellucidum*, in company with the species of *Phyllodoce*, &c., just named. This species of *Nereis* is remarkable for its brilliant iridescence. It is a northern species, extending to the Arctic Ocean and northern coast of Europe. It is very abundant on the coast of Maine, under stones at low-water mark.

Associated with the preceding species among the sandy compound ascidians, occurring both on rocky and gravelly bottoms, were large numbers of the *Lumbriconereis opalina*, (p. 320, Plate XIII, figs. 69, 70,) conspicuous on account of the brilliant iridescent colors. Several other Annelids also occurred among these ascidians. The *Cirrinereis fragilis*, which is a small and delicate species, furnished with conspicuous eyes, and related to the large *Cirratulus*, occurs beneath the stones. The singular *Naraganseta coralii* occurs burrowing in the coral, *Astrangia Danæ*, and in this respect is similar in its habits to the allied genus *Dodecacerea*, which excavates its galleries in the solid shells of *Cyprina Islandica*, *Pecten tenuicostatus*, &c., in the Bay of Fundy. The *Sabellaria vulgaris*, (p. 321, Plate XVII, figs. 88, 88*a*;) *Nicolea simplex*, (p. 321;) *Scionopsis palmata*, (p. 321;) *Potamilla oculifera*, (p. 322,) Plate XVII, fig. 86;) *Sabella microphthalma*, (p. 323;) *Serpula dianthus*, (p 322;) and *Fabricia Leidyi*, (p. 323,) all occur in tubes attached to the rocks and stones.

A species of *Spirorbis*, which forms a small, white, calcareous shell, coiled up in an open spiral, is commonly attached to the algæ and hydroids. The *Autolytus cornutus* (Plate XIII, figs. 65, 66) constructs cylindrical tubes, which are attached to sea-weeds and the branches of hydroids. This is a small flesh-colored species, with conspicuous brown eyes; the ends of the body are often tinged with green, and the dark, greenish intestine shows through as a median line. The males and females are widely different in appearance and structure, and there are also asexual individuals (fig. 65) very different from both. The asexual ones construct the tubes referred to, but do not remain in them constantly, for they are also often taken swimming at the surface. The males and females are also taken at the surface, especially in the evening, but they also occur creeping over and among the hydroids. This worm is partic-

ularly interesting on account of its remarkable mode of reproduction, for, like several other marine annelids, it presents the phenomena of alternate generation. Its history has been well given by Mr. A. Agassiz.* The very numerous eggs of the female (fig. 66, *e*) are at first contained in the general cavity of the body, between the intestine and the outer wall, along the whole length of the body; afterwards they pass into a pouch on the lower side of the body, extending from the twelfth to about the twenty-sixth segment; in the pouch they hatch into young worms, and soon after the sac bursts and they escape into the water. The females apparently die after discharging the young. The eggs do not develop into males and females, but into the asexual or neuter individuals, (fig. 65,) which differ widely from the others in form and in the eyes and other appendages of the head, as well as in the internal anatomy and lateral appendages. After these neuter individuals become nearly full-grown, having forty to forty-five segments, a median dorsal swelling arises at about the thirteenth or fourteenth segment, most commonly on the thirteenth, and soon after two others arise from the sides of the same segment and develop rapidly; these swellings finally become the three front tentacles of a new head, (*a*, *a*, *a*, fig. 65;) soon a pair of eyes appears on the upper side of the segment, than a pair of tentacular cirri; then the second pair of eyes; then other appendages of the head, until finally a complete head is formed, having the structure belonging to the head of a male or female, as the case may be. As the new head, with its appendages, becomes more completely organized, the segments posterior to it, which are to become the body of the new individual, become more highly developed, and the lateral appendages more complicated, those back of the fifth in the male, or the sixth in the female, acquire dorsal fascicles of long setæ, and the dorsal cirris becomes longer; at the same time some additional segments are developed; and the ova in the female, or spermatazoa in the male, are formed. Finally the new sexual individual, thus formed out of the posterior segments of the original neuter, breaks its connection and swims off by itself, and becomes a perfectly developed male or female. The head of the female is represented in fig. 66; a male individual is represented as developing from an asexual individual in fig. 65. The male can be easily distinguished from the female by the pair of large antennæ, which are forked in the male, but simple in the female. Farther details concerning this curious mode of reproduction may be found in the memoir of Mr. Agassiz, together with numerous excellent illustrations, in addition to those here copied.

Associated with the preceding species a few specimens were found which probably belong to another species of *Autolytus*. These were quite slender, light-red in color, with paler annulations, but only the asexual individuals were observed. Another species of larger size also occurs among the hydroids, near New Haven, which belongs to *Autolytus* or

* On Alternate Generation in Annelids, and the Embryology of Autolytus cornutus; Boston Journal of Natural History, Vol. VII, p. 384, 1863.

some closely allied genus, but of this only the asexual form has occurred, and it has not yet been carefully studied. This becomes nearly an inch long and quite slender. The body is white, with about fifty annulations of bright purplish red between the segments, but sometimes a red ring is absent, leaving wider white bands; the lateral appendages are simple, and each has a dot of red on the anterior side; the head is orange, with four dark red eyes.

Of Mollusks there are but few species among the higher groups which do not also occur on the rocky shores at low-water, but of the Ascidians and Bryozoa we find numerous additional species. The Gastropods are represented by the large *Fulgur carica* (p. 355, Plate XXII, fig. 124) and *Sycotypus canaliculatus*, (p. 355;) also by the "drill," *Urosalpinx cinerea*, (p. 306, Plate XXI, fig. 116,) which is usually abundant in shallow water; *Astyris lunata* (p. 106, Plate XXI, fig. 110) is abundant on the hydroids and algæ; *A. zonalis*, (Plate XXI, fig. 111,) which is an allied species, of larger size and with plainer colors, is sometimes met with, but is rare in this region. It takes its name from two narrow spiral zones of white that usually surround the whorls. The *Crucibulum striatum* (Plate XVIII, figs. 125, 126) is often met with clinging firmly to the rocks and stones.

The *Leptochiton apiculatus* (Plate XXV, fig. 167) is one of the most characteristic and common species on rocky and gravelly bottoms; this also adheres firmly to the stones and dead shells, and its grayish or dirty whitish shell, often more or less stained, blends its color with that of its surroundings in a way that might deceive the fishes themselves. The back is covered with a series of movable plates, so that when removed the animal can curl itself into a ball, like a "pill-bug," (*Oniscus*,) or like an armadillo, a habit that it shares in common with the scaly annelids, *Lepidonotus* and *Harmothoë*, which live in the same places with it. The flexibility of the shell also enables the chitons to adapt themselves more closely to the uneven surfaces of the rocks than they otherwise could. More rarely the *Leptochiton ruber* (Plate XXV, fig. 166) is met with, though farther north, as in the Bay of Fundy, this is a very common species, while the *apiculatus* is quite unknown there, being decidedly southern in its range. The *ruber* is, as its name implies, a red species, and its colors are usually bright and beautifully varied with lighter and darker. Its bright color would seem at first a fatal gift, calculated to attract the attention of passing fishes, which are always fond of such food, but when we examine its habits more closely we find that it lives almost exclusively on and among rocks that are incrusted by the curious stony algæ, known as "nullipores," (*Lithothamnion polymorphum*,) which are red in color, but of various shades, and often completely cover the rocks with irregular red incrustations, over large areas in shallow water, especially on the coasts farther north, so that this shell and a larger species, (*C. marmoreus*,) usually associated with it, are admirably adapted by their colors for living and concealing them-

selves on such bottoms, while many other species, frequenting the same localities, have a similar coloration, though belonging to very different groups. As examples we may mention the beautifully variegated starfish, *Ophiopholis aculeata*, (Plate XXXV, fig. 270,) rare in this region, but very abundant in the Bay of Fundy; *Crangon boreas*, common on the same bottoms in the Bay of Fundy; several species of shrimp belonging to the genera *Hippolyte*, *Pandalus*, &c. The bright red colors of all these animals would certainly be very fatal to them were there no red algæ among which they could conceal themselves and thus escape, to a considerable extent, from the voracious fishes, which are nearly always ready to pounce upon them whenever they expose themselves. One or two handsome species of *Æolis* (similar to fig. 174) were taken, but for lack of opportunity they were not identified while living, and these soft and delicate creatures cannot be preserved in alcohol so as to be identified afterwards with certainty. The handsome little *Doto coronata* (Plate XXV, fig. 170) occurs occasionally on the hydroids, upon the animals of which it feeds. This species is generally less than half an inch in length. The body is pale yellowish, or salmon-color, or rosy, specked with pink, light red, or dark red, which often forms a median dorsal line toward the head; the curious papillose branchiæ along the back are pale orange, the lateral and terminal papillæ being tipped with bright purplish red, dark red, or carmine, with a ring of flake-white below the tip; the head and tentacles are pale and translucent. The eggs are laid upon the hydroids, in long, flattened, and convoluted gelatinous strings, at various times during the early summer.

Another curious and beautifully colored naked mollusk, the *Polycera Lessonii*, also occurs occasionally on rocky bottoms, among hydroids and bryozoa. In this species the body is pale flesh-color, or sometimes pale orange, and thickly covered with bright, deep green specks, giving the whole surface a green color; along the back is a median line of tubercles or papillæ, and there are two other rows on each side, which extend as far as the gills or a little beyond; all these tubercles are tipped with bright sulphur-yellow, except that the last ones of the lateral rows, posterior to the gills, are usually tipped with flake-white, but these have two or three irregular, lateral lobes, which are tipped with yellow; other smaller, yellow tubercles are scattered over the back, sides, head, and tail; the tentacles are also bright yellow, but sometimes specked with green and yellow, with yellow tips. The gills are three in number, in a cluster on the middle line of the back, posteriorly; each one is bipinnate and delicately plumose; they are colored similar to the back, generally more or less specked with bright yellow, and often with flake-white; the tips are usually bright yellow.

Another small but singular species, which also occurs among the hydroids, as well as among dead shells, is the *Doridella obscura*, (Plate XXV, fig. 173;) in this the colors are not conspicuous, but seem rather intended for its concealment. The back is sometimes light, yellowish

brown, finely mottled with white, and specked with darker brown; dorsal tentacles white and retractile; lower surface white or light yellowish, a three-lobed yellowish or brownish internal organ showing through in the middle of the foot. Other specimens are very dark-brown or almost black above, finely mottled with whitish. The anterior angles of the head are prolonged into tentacle-like organs or palpi. The gills are situated beneath, in the groove between the edge of the foot and the mantle, on the left side, and near the posterior end of the foot; they consist of a tuft of slender filaments.

Of Lamellibranchs certain species occur on rocky bottoms, which attach themselves firmly to the rocks, either by the side of one valve, like the oyster, *Ostræa Virginiana*, (p. 310,) and the *Anomia glabra*, (p. 311, Plate XXXII, figs. 241, 242;) or by threads of byssus, which they spin and use as cables for anchoring themselves, like the common muscle, *Mytilus edulis*, (p. 307, Plate XXXI, fig. 234,) the "horse-muscle," *Modiola modiolus*, (p. 309, Plate XXXI, fig. 237,) the *Argina pexata*, (Plate XXX, fig. 227,) and *Scapharca transversa*, (Plate XXX, fig. 228,) all of which are common in this region; but certain other species occur, which burrow beneath the stones, like the *Saxicava arctica* (p. 309, Plate XXVII, fig. 192) and *Mya arenaria* (p. 463, Plate XXVI, fig. 179,) and several other less common species.

The Ascidians are usually very abundant on the rocks and stones at all depths. The *Cynthia partita* (p. 311, Plate XXXIII, fig. 246,) is very common, often forming large, rough clusters, much overgrown with hydroids, bryozoa, and algæ. The specimens mostly belong to the erect variety, and in form are quite unlike the one figured. The body is more or less cylindrical, oblong, or urn-shaped, about twice as high as broad when expanded, and with a wide base; the branchial orifice is largest, and situated at the summit of a broad, terminal tube, swollen at base; the anal orifice is smaller, on a short lateral or subterminal tube. Both orifices are usually squarish, and open widely, but, when fully expanded, they sometimes become nearly circular; they are often surrounded at the edge with a narrow circle of red, and each tube has eight longitudinal stripes of white, narrowing downward to a point at the base of the tubes, and alternating with purplish brown ones, which are usually specked with flake-white. The exterior of the test is more or less rough and wrinkled, and generally yellowish or rusty, often tinged with deep purplish brown on the upper parts or throughout. The tubes are usually roughened by small, wart-like papillæ. Unpromising as this species looks, it is devoured by the tautog. The *Molgula Manhattensis* (p. 311, Plate XXXIII, fig. 250) is generally associated with the former. The *Perophora viridis* (p. 388) is often very abundant, creeping over and covering up the two preceding, as well as other ascidians, algæ, hydroids, &c. The most conspicuous species, however, are the massive compound ascidians, which sometimes completely cover the bottom. One of the most abundant of these is the *Amaræcium pel-*

lucidum, which forms large, hemispherical or irregular masses, often six or eight inches, or even more, in diameter, with the surface more or less completely covered by adhering sand. These masses consist of a large number of lobes or basal branches, which come out from a common base as elongated, stolon-like processes, and enlarge upward to the end, which is obtusely rounded, and variable in size, but usually from a quarter to half an inch, while the length may be from one to six inches; these lobes often coalesce, more or less completely, at the upper surface, which is sometimes naked and smooth, translucent, and of a gelatinous appearance. Each of these lobes contains a central cloacal orifice, around which a colony of minute ascidians, or zoöids, are grouped, in a manner analogous to the arrangement in *Botryllus*, already described, (p. 389,) but in the present case the zoöids are very long and slender; the lower end of each, containing the ovaries, with the heart at its extremity, extends down toward the base of the lobe in which they are contained to various distances, varying according to the age and state of development of each zoöid, but the full-grown ones are often nearly an inch long. Each zoöid has its own branchial orifice opening at the surface, as in *Botryllus*, while all the anal tubes discharge the refuse water, fæces, and eggs into the common cloacal ducts.

The *Amarœcium stellatum* is another related species, which is nearly as abundant as the last, and likewise grows to a very large size. It forms large, smooth, irregular plates, or crest-like lobes and masses, which are attached by one edge to the stones and gravel. These plates are sometimes one to two feet long, six inches high, and about an inch thick, and, owing to their smooth surface and whitish color, look something like great slices of salt-pork, and in fact it is often called "sea-pork" by the fishermen. Other specimens will be four or five inches high, and only one or two inches broad at the base, and perhaps half an inch in thickness, and the summit often divides into broad, flat, blunt lobes; various other shapes also occur, some of them very irregular. The larger specimens of this species are generally of a pale-bluish or sea-green color by reflected light when first taken from the water, but pale salmon or flesh-color by transmitted light. The zoöids are much elongated and arranged in more or less regular circular groups over the whole surface, with a small cloacal orifice in the center of each circle. If kept in water, when they grow sickly the zoöids will be forced partially or wholly out of their cavities by the contraction of the tissues around them—a peculiarity seen also in other species of this genus. These zoöids have the branchial tube prominently six-lobed, and of a bright orange-color, this color also extending over the upper or outer end of the body, between the tubes, and more or less over the branchial sac, which is pale yellow or whitish below. The stomach is longitudinally sulcated, with bright orange-red ribs or glands; intestine bright orange or yellow.

This species is devoured by sharks, skates, and the tautog, although

it would seem difficult for them to digest it, or get much nutriment from it. The supply is certainly sufficiently abundant.

A third species of this genus, and much more beautiful than either of the preceding, is also common on rocky bottoms. This is the *Amarœcium constellatum* V. (p. 388,) which has already been described as occurring on the piles of the wharves. In deeper water, attached to rocks, it grows to a larger size, forming thick, hemispherical or cake-shaped masses or crusts, sometimes becoming somewhat mushroom-like by the upper parts growing out beyond the central attached portion, which then becomes a short and broad peduncle. It can be easily distinguished from the last on account of its brighter colors, the general color inclining to orange, and by the more irregular and complicated clusters of zoöids. It is less abundant than either of the two preceding.

Two other species of compound Ascidians are also abundant in this region, as well as farther north. These belong to the genus *Leptoclinum;* they form thin, irregular, often broad, white, or salmon-colored incrustations over the surfaces of the rocks, shells, and other ascidians; these crusts are of a firm, coriaceous or gritty texture, and have a finely granulous surface. Under the microscope they are seen to be filled with small, nearly globular particles of carbonate of lime, from which points project in every direction. The zoöids are very minute and are scattered over the surface in large and scarcely distinct groups, which have, however, a common cloacal orifice in the middle, but the several cloacal tubes or channels leading to each central orifice are long, with many crooked branches, reminding one of miniature rivers, and the zoöids are arranged along these ducts and their branches. One of these species, the *Leptoclinum albidum*, is easily distinguished by its chalky white color; the other, *L. luteolum*, is buff or salmon-color. It is possible that the last may even prove to be only a colored variety of the former, but the very numerous specimens that I have collected and examined, in the living state, both in the Bay of Fundy and Vineyard Sound, do no not warrant their union. In these localities both forms are about equally common, but near New Haven the *L. luteolum* has not yet been met with, though the other is not uncommon.

The Bryozoa are very abundant on rocky bottoms at all depths. Some of these incrust the rocks directly, like the *Escharella variabilis*, (p. 312, Plate XXXIII, fig. 256;) *Alcyonidium hirsutum; Escharipora punctata*, &c.; but even these seem to prefer other locations, and by far the greater number occur attached to algæ, hydroids, ascidians, and dead shells. A large part of the species occur also in rocky pools at low-water mark, or attached to the *Fuci* and other sea-weeds between tides, or to the under sides of stones laid bare by low tides, and have, consequently, been previously mentioned. Others which have not yet been detected on the shore will doubtless be found there by more thorough search.

The *Alcyonidium ramosum* (Plate XXXIV, fig. 257) is one of the most conspicuous species, and is often very abundant, attached to rocks in shallow water. In such situations we have often found arborescently branched specimens, twelve to fifteen inches high, with smooth, cylindrical branches about a third of an inch in diameter.

The *Alcyonidium hispidum* (p. 312) does not appear to have been recorded as from our coast, by previous writers, but it is one of our most common species, and may almost always be found incrusting the stems of *Fucus* at low-water mark, as well as the under surfaces of rocks; below low-water mark it is less abundant, generally incrusting *Phyllophora*, and other stout, palmate algæ. It is easily distinguished by the slender, acute, reddish spines, of horn-like texture, which surround each of the cells. It forms soft crusts of moderate thickness, gradually extending over the surface of the sea-weeds to which it becomes attached.

The *A. hirsutum* has also been hitherto overlooked on our coast, but is common, living under the same circumstances as the last, and sometimes associated with it, both above and below low-water mark. I have found it in the greatest abundance in some of the large, rocky tide-pools on the outermost of the Thimble Islands, east of New Haven. It was there growing chiefly upon *Phyllophora membranifolia*, in some cases entirely covering and concealing the plant, from the base of the stem to the tips of the fronds. It also often grows on the "Irish moss," *Chondrus crispus*, on rocky bottoms in shallow water. It forms rather thin, soft crusts, which have small, soft papillæ scattered over the surface; from the summit of each of these papillæa zoöid protrudes, when they expand, and displays an elegant little wreath of tentacles, much as in *A. ramosum*, (see fig. 257.) The *A. parasiticum* is also a species hitherto neglected on our coasts. It forms thin crusts on algæ and hydroids, which generally become coated with a layer of fine sand or dirt. I have not observed it at low-water, but have found it at the depth of a few fathoms on rocky bottoms in Vineyard Sound.

The *Vesicularia dichotoma* V. is a very common species, both on rocky shores, in pools and on the under side of stones; and in shallow water on rocky and shelly bottoms. It is also capable of living in brackish water, and is frequent on the oyster-beds. It usually forms cæspitose clusters of many crowded, slender, white stems, each of which is repeatedly forked, branching in a somewhat arborescent manner. There is a little crowded cluster of small, dark-colored, oval or pear-shaped cells just below each fork, the cells being sessile and arranged in two somewhat spiral rows in each cluster. It generally grows about an inch high, but sometimes two or three inches. When expanded each of the zoöids protrudes from its cell-like body a delicate wreath of eight slender tentacles.

The *Vesicularia cuscuta* is a delicate, creeping species, which resembles, in miniature, the "dodder-plant," (*Cuscuta*,) and creeps over other bryozoa and hydroids, very much as the dodder creeps over other

plants. The stem is very delicate, filiform, jointed, and at intervals gives off two very slender, opposite branches, which diverge at right angles, and in their turn branch at intervals in the same way. The cells are small and oval or elliptical, mostly arranged in clusters at or near the branchings of the stems, but some are often scattered on the branches; they are attached by a narrow base. It occurs both at low-water in pools and in shallow water among rocks. The *V. armata* is also a creeping species, but the cells are terminated by four conical prominences, each of which bears a slender spine when perfect. This also occurs both between tides and in shallow water, on hydroids and bryozoa.

With these species of *Vesicularia*, and often attached to them and creeping over them, as well as on other kinds of bryozoa, hydroids, and algæ, a very curious little species often occurs, in which the cells are small, campanulate, and raised on slender pedicels, which rise from slender, white, creeping stems. This is the *Pedicellina Americana*. The zoöids, when expanded, display a wreath of twelve or more tentacles; in contraction and when young they are often clavate.

The *Ætea anguinea* has not been recorded as from our coast, but is very common on rocky and shelly bottoms, creeping over various hydroids, algæ, ascidians, broyozoa, &c.; it also frequently occurs on floating eel-grass and algæ, in company with many hydroids. It consists of delicate, white, creeping, calcareous stolons, from which arise elongated, slender, clavate, white, rigid, erect cells, with the aperture at the end; the narrower, pedicel-like portion of the cell is surrounded by fine, circular, punctate striæ.

The *Eucrate chelata* is also a slender, creeping species, and has somewhat similar habits, but is much less common, and has been met with only in the deeper parts of Vineyard Sound on ascidians and hydroids. In this species each cell arises from the back of the preceding one, near the end, and bends upward and forward obliquely, the cell expanding from a narrow, pedicel-like, basal portion to a more or less oval upper part, with the aperture oblique and subterminal. This, also, is a new addition to the fauna of our coast, although, like the last, long well known on the coast of Europe.

The *Diastopora patina* grows attached to algæ and eel-grass; it forms little circular disks, with tubular cells arising from the upper surface, those in the middle being longest.

The *Tubulipora flabellaris* frequently occurs attached to various kinds of slender-branched algæ, such as *Ahnfeltia plicata*, &c. It forms small, blunt-lobed, coral-like masses, composed of long, crooked, tubular cells, united by a porous mass at base. Toward the borders of the lobes the cells are crowded and polygonal. In the central parts they are more cylindrical and form groups or radiating rows. Associated with the preceding on the algæ, *Crisia eburnea*, (p. 311;) *Mollia hyalina*, (Plate XXXIV, fig. 264;) *Cellepora ramulosa*, (p. 312;) and other species oc-

cur. The *Membranipora pilvsa* (Plate XXXIV, figs. 262, 263) is frequent on rocky bottoms, growing chiefly upon *Phyllophora* and other algæ. It may be known by the oval cells, bordered by erect, bristle-like processes, of which the one at the proximal end of the cell is much longer than the rest.

Another species, *M. lineata*, is also common, incrusting rocks and shells in broad, thin, radiating patches. In this the cells are oblong, crowded, and separated only by the linear margins. In the most common variety there are eight or ten slender spinules on each side of the cells, which bend over so as to meet or interlock across the open cells. The cells are much smaller as well as narrower than those of the preceding species.

Of Echinoderms only a few species occur in this region, on rocky bottoms, which causes this fauna to contrast very strongly with that of the rocky bottoms farther north, as in the Bay of Fundy or on the coast of Maine, where numerous other fine species of star-fishes and several additional Holothurians are common. The common green sea-urchin, *Strongylocentrotus Dröbachiensis*, (Plate XXXV, fig. 268,) so very abundant farther north, and especially in the Bay of Fundy, where it occurs in abundance at low-water mark, and on rocky bottoms at all depths down to 110 fathoms, and off St. George's Bank even down to 450 fathoms, is comparatively rare in this region and chiefly confined to the outside colder waters, as off Gay Head and No Man's Land, where it was quite common. But a few specimens were dredged at several localities in Vineyard Sound. The largest occured on the rocky bottoms off West Chop, and off Menemsha. It has been found occasionally in Long Island Sound, as off New Haven and Stratford, Connecticut, but is there quite rare and small. It feeds partly on diatoms and other small algæ, &c., which it cuts from the rocks with the sharp points of its teeth, but it is also fond of dead fishes, which are soon devoured, bones and all, by it in the Bay of Fundy. In return it is swallowed whole in large quantities by the wolf-fish and by other large fishes. The purple sea-urchin, *Arbacia punctulata*, is much more abundant in Vineyard Sound and similar waters, in this region. This is a southern species which is here near its northern limit. It is easily distinguished by its rather stout, unusually long, purple spines; by its ambulacral pores in two simple rows; by the upper surface of the shell being partly destitute of spines; and by the anal region, at the summit of the shell, which is formed of only four rather large plates. It occurred of large size, associated with the preceding species, off West Chop and Holmes's Hole; it was quite abundant in the passage at Wood's Hole, especially on shelly and gravelly bottoms north of Naushawena Island, and it was met with at many other localities.

The common green star-fish, *Asterias arenicola*, (p. 326, Plate XXXV, fig. 269,) is very common on all the rocky bottoms in this region. A smaller and more beautiful northern star-fish was occasionally met with

in Wood's Hole passage and several other localities on rocky or gravelly bottoms. This was the *Cribrella sanguinolenta;* it is much more common north of Cape Cod, and is abundant in the Bay of Fundy and northward to Greenland; it is also found on the northern coasts of Europe. It has not been found much south of Vineyard Sound on this coast. It can easily be distinguished by its five round, tapering rays, covered with small spinules, and by having only two rows of locomotive suckers in the grooves on the under side of the rays, instead of four rows, as in the common star-fishes belonging to the genus *Asterias*. Its color is quite variable. It is often orange, or purple, or rose-color, or cream-color, and sometimes mottled with red and purple, &c. Unlike the preceding, and most other species of our star-fishes, this does not have free-swimming young. Its eggs are deposited around the mouth, and retained by the mother until they develop into little star-fishes capable of taking care of themselves.

The Hydroids are very numerous on rocky bottoms. A few species, like *Hydractinia polyclina* (p. 328) and the *Thamnocnida tenella*, attach themselves directly to the rocks, but the greater number adhere to ascidians, algæ, or to other hydroids. Many of the species are also to be found on the rocky shores in tide-pools, and have already been mentioned. Among those not yet detected at low water is a delicate species of *Plumularia*, with slender, alternately pinnate branches, which was found growing upon rocks in company with *Hydractinia*. The *Thamnocnida tenella* is a Tubularian which grows in clusters, two or three inches high, consisting of long, slender, somewhat branched stems, which are more or less crooked, and usually irregularly and distantly annulated, with beautiful pink heads at the top. The general appearance is like that of the *Parypha*, (Plate XXXVI, fig. 274.) The *Obelia dichotoma* was found growing upon ascidians (*Cynthia partita*, &c.) in 8 or 10 fathoms, among rocks. It is a well-known European species, but has not hitherto been established as an inhabitant of our coast. It has dark, horn-colored, slender stems, with pretty long and rather erect, slender, alternate branches, which branch again in the same way. The hydroid cells are deeply campanulate, with the margin slightly sinuous or scolloped, the slight notches corresponding with faint angular ridges which run down on the upper parts of the cells, giving the upper half a slightly polygonal form. In this respect this species closely resembles the *Obelia commisuralis*. The reproducsive capsules are elongated, urn-shaped, with a narrow, raised, sub-conical neck.

The *Obelia geniculata* is often very abundant on the fronds of *Laminaria* and other algæ having flat fronds. Its creeping tubular stolons often thickly cover the surface with a complete net-work; from these the erect stems rise to the height of about an inch. This species may be known by the prominent geniculation at the origin of the hydroid pedicels. The *Obelia fusiformis* has a similar mode of growth, but is

much less common. Its hydroid cells are comparatively small and their pedicels very short.

Several very delicate and beautiful creeping hydroids, belonging to the Campanularians, also occur attached to larger hydroids, and the algæ. Among these are *Clytia Johnstoni*, having comparatively large, bell-shaped cups, with a notched rim, each borne on a long, slender, generally simple pedicel, ringed at each end, and arising from the creeping stems. The reproductive capsules are urn-shaped and annulated. The *C. intermedia* is quite similar in its growth, but has smaller and deeper cups, with smaller notches around the rim. The *Orthopyxis caliculata* grows in the same manner; it has beautiful little bell-shaped or cup-shaped cells, with an even rim, each borne on a long, slender, annulated pedicel with one of the rings, just below the cup, very prominent. Its reproductive capsules are large, oblong, smooth, and obtuse at the end. The *Platypyxis cylindrica* has small, very deep, somewhat cylindrical cups, with the rim divided into sharp teeth or notches; each one is borne on a small, slender pedicel, generally less than an eighth of an inch high, feebly annulated at each end. The reproductive capsules are elongated, compressed, flaring slightly at the end. The *Campanularia volubilis*, is also a very small, but elegant species; it has deep cylindrical cups, which have a regularly scolloped rim, the scollops being small and evenly rounded. The pedicels are very slender, and are annulated *spirally* throughout their whole length, so as to appear as if twisted; just below the cup there is one prominent rounded annulation, or bead, the whole resembling in miniature the stem of certain wine-glasses and glass vases. The reproductive capsules are vase-shaped, attached by short pedicels, and have the neck elongated and gradually narrowed to the end, which flares slightly.

The *Lafoëa calcarata* is also a small creeping hydroid, belonging to another family. It has curved tubular cells. It nearly always grows on *Sertularia cornicina*, which is a small species, resembling *S. pumila*, (Plate XXXVII, fig. 279.) The *Sertularia argentea* (Plate XXXVII, fig. 280) is a large, profusely branched species, often growing to the length of a foot or more. It is very abundant in this region. *S. cupressina* is closely related, but much less common. The *Hydrallmania falcata* is also a large species very common on these bottoms. It can be easily distinguished by the spiral arrangement of its branches and the unilateral arrangement of its jug-shaped cells along the branches.

The *Eudendrium ramosum* and *E. dispar* are not uncommon on rocky bottoms, and are both beautiful species, somewhat resembling the *Pennaria*, (Plate XXXVII, fig. 277.)

The species of Polyps are the same as those found on rocky shores at low-water mark. The coral, *Astrangia Danæ*, (p. 329,) is much more common than on the shores, and grows larger, some of the specimens becoming four or five inches across, and rising up in the middle into

lobes or irregular branches, sometimes nearly two inches high, making very elegant specimens.

Numerous sponges also occur, but they have not yet been carefully studied. One of the most abundant is a species of *Chalina*, which grows up in clusters of slender, soft, smooth branches, five or six inches high, and from a quarter to half an inch in diameter, of a pale yellowish or buff-color while living. It makes very delicate, white, and beautiful specimens when the animal matter has been thoroughly washed out and the sponge dried in the sun, which can be best done by hanging them up in a reversed position, owing to the flexibility of the branches when wet. This species is closely related to the *Chalina oculata*, which also occurs in this region, in the outside cold waters, as off Gay Head, and is abundant farther north and on the coast of Europe; but the present species is much more delicate, with more slender and rounder branches, and it seems to be a southern form, for it is common all along our coast as far, at least, as North Carolina.

The common, irregularly branched, red sponge is found in abundance, and also several light yellow, irregular, soft, massive species of *Tedania*, and the firm, massive, sulphur-yellow *Cliona sulphurea*.

List of species ordinarily found on the rocky bottoms of the bays and sounds.

ARTICULATA.

Insects.

Crustacea.

Annelids.

Nemerteans.

MOLLUSCA.

Gastropods.

Lamellibranchs.

Ascidians.

Bryozoa.

RADIATA.

Echinoderms.

Acalephs.

Polyps.

PROTOZOA.

Sponges.

Foraminifera.

6. FAUNA OF THE GRAVELLY AND SHELLY BOTTOMS OF THE BAYS AND SOUNDS.

Bottoms composed of gravel or pebbles, often with small stones, and generally with a considerable proportion of dead and usually broken shells, were of frequent occurence in Vineyard Sound, and a few such localities were found in Buzzard's Bay. Similar bottoms of small extent have also been examined in Long Island Sound, near New Haven. These bottoms are generally the most productive and agreeable for the dredger, for they are the favorite abodes of large numbers of animals of all classes, and the contents of the dredge are often so clean that they require little if any washing in the sieves. They vary much, however, in character, some of them consisting mostly of gravel, with pebbles and perhaps small scattered boulders; others consist largely of broken shells, especially those of *Mactra solidissima* and *Crepidula fornicata*, mixed with more or less gravel, sand, and mud. Others are so completely overgrown with the various large compound ascidians described above, that they might well be called "ascidian bottoms." In many places, however, there are patches of mud or sand, scattered here and there over a bottom which is mostly of gravel and shells, so that the dredge will often bring up more or less mud or sand, with some of the animals peculiar to such patches, mixed with those peculiar to the gravelly bottoms, thus augmenting the number and variety of animals. In other cases more or less mud and sand may be mixed with the gravel throughout, or the bottom may be in process of changing from mud or sand to gravel, or the contrary, owing to frequent changes in the directions of the currents, produced chiefly by the action of storms upon the shoals and bars of sand. Hence it is often difficult to

distinguish with certainty the animals properly inhabiting the gravelly and shelly bottoms from those that pertain to the muddy and sandy bottoms, but for our present purposes it is not necessary to make a very sharp distinction between the different lists, for many species are common to all, and the areas of the different kinds of bottom are generally small in this region, and evidently may change their character from time to time.

After a single storm the character of the bottom, in some localities, was found to be greatly altered over wide areas, sometimes several miles in extent, at depths of two to ten fathoms, and the animal life at the bottom was always found to have changed very quickly, when the physical character of the bottom had been modified. The most frequent cause of change was the accumulation of immense quantities of dead sea-weeds and eel-grass over bottoms that, a few days before, had been perfectly free from it. Such accumulations must either kill the majority of the animals inhabiting gravelly, sandy, or rocky bottoms, or else cause them to migrate. In all probability the majority of them perish, at such times, beneath the accumulations. In other cases one or two storms sufficed to change gravelly and shelly bottoms to sandy ones, causing, undoubtedly, great destruction of life and a great change in its character over particular areas. These changes in the character of the deposits accumulating on the bottom, attended with extermination of life and changes in its character in particular localities, illustrate on a small scale similar phenomena that have constantly occurred on a grander scale in the history of the past life of the globe, during all the geological ages, from the first commencement of life. Practically it was found quite difficult to find, in this region, large areas of gravelly and shelly bottoms, without some admixture with mud or sand, and it very seldom happened that a continuous series of dredgings could be made on such bottoms without encountering patches of mud and sand. Therefore the accompanying list of species undoubtedly contains many that belong rather to muddy or sandy bottoms than to those now under discussion, for species have not been excluded unless well known, from many observations, to be peculiar, or nearly so, to mud or sand and rarely met with on true hard bottoms.

The following are the principal localities where this kind of bottom was explored in Vineyard Sound and vicinity, but those belonging to the outside cold area are not included:

First. An extensive area extending from off Nobska Point eastward, nearly parallel with the shore, with some interruptions of sandy bottom, as far as Suconesset Shoal, mostly in three to eight fathoms of water; on this bottom were the dredgings of line 6, *a*, *b*, *c*, *d*, *e*, *f*; 21, *a*, *b*, *c*, *d*; 22, *a*, *b*, *c*, *d*; 23, *a*, *b*, *e*, *f*; 25, *b*, *c*, *d*; 26, *a*, *b*, *c*, *d*, *e*; 34, *a*, *b*, *c*, *d*, *e*, *f*; 35, *a*, *b*, *c*, *d*, *e*.

Second. Another similar region nearly parallel with the southeastern shores of Naushon and Nonamesset Island and extending out into mid-

channel; dredgings on line 5, *a*, *b*; 7, *b*, *c*, *d*; 8, *c*, *d*, *e*, *f*, *g*; 42, *a*, *b*; 43, *a*, *b*, *c*, *d*, *e*, were made on the shallower portion of this ground, mostly in three to eight fathoms; 38, *a*, *b*, *c*; 39, *a*, *b*; 40, *a*, *b*, *c*, *d*; 41, *b*; 44, *a*, *b*, *c*, *d*, *e*; 46, *e*, were made in the deeper parts of the channel, in eight to fifteen fathoms.

Third. Several areas, in the deeper waters of the sound, north and northeast of Holme's Hole, and doubtless continuous with the last area; dredgings, at line 28, *a*, *b*, *c*, *d*, *e*, *f*; 29, *a*, *b*, *c*; 31, *a*, *b*, *c*, *d*, *e*; 32, *a*, *b*, *c*; 33, *a*, *b*, *c*, *d*, were made on these bottoms.

Fourth. A narrow strip of clean gravelly bottom, swept by the strong currents passing around West Chop, and situated between the "Middle Ground" Shoals and Martha's Vineyard, and extending around to East Chop, with an interruption of rocky bottom just opposite West Chop; dredgings on line 37, *a*, *b*, *c*, *d*, *g*, *h*; 47, *a*, and 48, *a*, *b*, *c*, *d*, were made on this area.

Fifth. In the channel, at the entrance to Great Harbor, off Nonamesset Island, and partially extending into the harbor, there is more or less gravelly and shelly bottom, frequently alternating with rocks and often composed chiefly of dead shells, (mainly *Crepidula fornicata*.) This place is swept by the powerful tidal currents running through Wood's Hole Passage; dredgings at line 3, *d*, *e*; 5, *e*, *f*, *g*; 13, *a*, *b*; 18, *a*, *b*, *c*, *d*; 19, *a*; 20, *a*, *b*, and many others not indicated on the chart, were made here.

Sixth. Another area at the other end of Wood's Hole Passage, north of Hadley Harbor, and extending out into Buzzard's Bay a short distance; some parts of this region had a smooth hard bottom of fine gravel and sand, or coarse sand; in other places it was more or less stony; dredgings on line 10, *e*, *f*; 11, *a*, *b*, *c*, *d*, *e*, *g*; 12, *b*, *c*; 70, *a*, *b*, *c*, *d*; 71, *a*, *b*, were on these gravelly bottoms.

Seventh. A shallow region off Cataumet Harbor, in Buzzard's Bay; the bottom here was hard gravel and shells, much overgrown with algæ; dredgings at line 65, *a*, *b*, and others not indicated, were made here.

Eighth. At Quick's Hole, in the channel between Nashawena and Pasque Islands, good gravelly bottom was found; dredgings at line 45, *a*, *b*; 76, *a*, *b*, *c*; 77, *c*, *d*, *e*, *f*, were on this area.

Similar bottoms of small extent were also met with in other places. There are also gravelly bottoms in the southwestern part of Vineyard Sound, near its mouth, as off Menemsha, but as these are inhabited by the more northern species of animals, they will be grouped with those of the outside waters.

The animals of gravelly and shelly bottoms may be burrowing or tube-dwelling species, like many annelids, amphipods, bivalve-shells, &c.; they may be species that adhere directly to the shells and pebbles, like certain hydroids, bryozoa, bivalve-shells, and the numerous ascidians; the latter are quite as numerous here as upon the rocky bottoms, and for the most part of the same species; they may be species that hide among