ART. LII.—*Notice of the remarkable Marine Fauna occupying the outer banks off the Southern Coast of New England, No.* 8; by A. E. VERRILL. (Brief Contributions to Zoology from the Museum of Yale College: No. LIV.)

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Nature and origin of the sediments. Occurrence of fossiliferous Limestone-nodules.

A LIST of most of the stations occupied this season by the U. S. Fish Commission steamer "Fish Hawk" has been given in a previous article. After that article was in type, another trip was made to the Gulf Stream slope by the Fish Hawk. A list of these additional stations is now given, together with those occupied by the "Josie Reeves," while fishing for the "tile-fish." In the lists the general character of the bottom is indicated, as well as the depth and temperature.

A detailed description of the materials covering the bottom, in this region, cannot be given, at this time, but certain facts, observed by us, are of sufficient geological interest to justify a brief notice. At several localities, but especially at stations 1121, 1122 and 1124, in 234, 351 and 640 fathoms, respectively, we dredged fragments and nodular masses, or concretions, of a peculiar calcareous rock, evidently of deep-sea origin, and doubtless formed at or near the places where it was obtained. These specimens varied in size from a few inches in diameter up to one irregular nodular or concretionary mass, taken at station 1124, in 640 fathoms, which was 29 inches long, 14 broad, and 6 thick, with all parts well rounded. This probably weighed 60 pounds or more. The masses differ much in appearance, color, texture, and fineness of grain, but they are all composed of

grains of siliceous sand, often very fine, cemented by more or less abundant calcareous matter. In some, the grains of sand are large enough to be easily seen by the naked eye, and small quartz pebbles often occur in them, but in others the sand-grains are so fine that a microscopic examination is needed to distinguish them. These fine-grained varieties of the rock are often exceedingly compact, heavy, hard and tough, usually grayish or greenish in color. They usually weather brown, from the presence of iron (probably as carbonate). The sand consists mainly of rounded grains of quartz, with some feldspar, mica, garnet and magnetite. It is like the loose sand dredged from the bottom in the same region. The calcareous cementing material seems to have been derived mainly from the shells of foraminifera abundantly disseminated through the sand, just as we find the recent foraminifera, in the same region. In some cases I was able to identify distinct casts of foraminifera, in the rock. In some pieces of the rock distinct fossil shells were found, apparently of recent species (*Astarte*, etc.). The larger masses appear to have been, originally, concretions in a softer deposit, which has been more or less worn away, leaving the hard nodules so exposed that the trawl could pick them up. The age of these rocks may, however, be as great as the pleistocene, or even the pliocene, so far as the evidence goes. Moreover, it is probable that they belong to a part of the same formation as the masses of fossiliferous sandy limestone and calcareous sandstone, often brought up by the Gloucester fishermen, from deep water, on all the fishing banks, from George's to the Grand Bank, as I have formerly recorded in this Journal. No rocks of this kind are found on the dry land of this coast.

Throughout the Gulf-stream slope examined by us, the bottom, in 70 to 300 fathoms, 60 to 120 miles from the shore, is composed mainly of very fine sand, largely quartz, with grains of feldspar, mica, magnetite, etc.; with it there is always a considerable percentage of shells of foraminifera, and other calcareous organisms, and also spherical, rod-like, and stellate, sand-covered rhizopods, often in large quantities. In the deeper localities there is usually more or less genuine mud, or clay, but this is often almost entirely absent, even in 300 to 500 fathoms. The sand, however, is often so fine as to resemble mud, and is frequently so reported, when the preliminary soundings are made and recorded. In many instances, even in our deepest dredgings (over 700 fathoms), and throughout the belt examined, we have taken numerous pebbles and small rounded boulders, of all sizes, up to several pounds in weight, consisting of granite, syenite, mica-schist, etc. These are sometimes abundant and covered with *Actiniæ*, etc. Probably

these have been recently floated out to this region, while frozen into the shore-ice, in winter and spring, from our shores and rivers, and dropped in this region, where the ice melts rapidly under the influence of the warmer Gulf-stream water. Possibly much of the sand, especially the coarser portions, may have been transported by the same agency. Another way, generally overlooked, in which fine beach-sand may be transported long distances, is by reason of its floating on the surface of the water after it has been exposed to the air on the beaches and dried. The rising tide always carries off a certain amount of fine dry sand floating in this way. In our fine towing-nets we always take more or less fine siliceous sand, which evidently was floating on the surface, even at considerable distances from the shore.

The prevalence of fine sand, along the Gulf-stream slope, in this region, and the remarkable absence of actual mud or clay deposits indicate that there is here, at the bottom, sufficient current to prevent, for the most part, the deposition of fine argillaceous sediments over the upper portion of the slope, in 65 to 150 fathoms. Such materials are probably carried along till they eventually sink into the greater depths nearer the base of the slope, or beyond, in the ocean basin itself, where the currents are less active. It is probable that such a movement of the water may be partly due to tidal currents, as well as to the actual northward flow of the Gulf Stream, which is here slow, even at the surface.* It is not probable, however, that the bottom currents are strong enough to move even the fine sand, after it has once actually reached the bottom; nor is it strong enough to prevent the general deposition of oceanic foraminifera, pteropods, etc. I have, above, suggested that the loose nodules of limestone may have been derived from softer rocks or unconsolidated materials by the removal or wearing away of the latter. The existence of actual currents sufficiently powerful to directly effect such erosion is hardly supposable. I believe, however, that such a result may be due directly to the habits of certain fishes and crustacea that so abound on these bottoms. Many fishes, like the "hake" (*Phycis*), of which two species are common here, have the habit of rooting in the mud, like pigs, for their food, which consists largely of Annelida and other

* Our observations fully demonstrate that the western edge of the Gulf Stream is nearer the coast than it has hitherto been located on the charts. In summer, as is well known, it is nearer the coast than in winter, but this doubtless applies strictly to the *surface-water*. Our researches show that the warm-belt, in 65 to 125 fathoms, is inhabited by a peculiar southern fauna, that could not exist there if the Gulf Stream did not flow along this area, *at the bottom*, both in winter and summer. But it is evident that what many of these species require is not a very *high*, but a *nearly uniform* temperature. Such an equable temperature cannot exist in this region except under the direct and constant influence of the Gulf Stream.

mud-dwelling creatures. Other fishes, those with sharp tails especially, burrow actively into the mud or sand, tail first, and in all probability *Macrurus*, abundant in this region, has this habit. Several species of eels and eel-like fishes are very abundant on these bottoms. These are all burrowers. The "slime-eel" or hag (*Myxine glutinosa*) was also taken in large numbers, both in the trawl and in traps. Many crabs and allied forms are active burrowers. Such creatures, by stirring up the bottom-sediments continually, would give the currents a chance to carry away the finer and lighter materials, leaving the coarser behind.

In many localities, in the region under consideration, there are great quantities of dead shells, both broken and entire. A small proportion of the bivalves have been drilled by carnivorous gastropods, but there are large numbers that show no injury whatever. There is no doubt, in my mind, but that these have, for the most part, served as food for the star-fishes, so abundant on these grounds, and from which I have often taken entire shells, of many kinds, including pteropods. Many fishes, like the cod, haddock, hake, etc., have the habit of swallowing shells entire, and after digesting the contents, they disgorge the uninjured shells, and such fishes abound here. The broken shells have probably been preyed upon by the crabs and other crustacea, having claws strong enough to crack the shells. The large species of *Cancer* and *Geryon*, and the larger Paguroids, abundant in this region, have strength sufficient to break most of the bivalve shells. Although I have often seen such crustacea break open bivalves for food, I am well aware that they also feed on other things.* Many fishes that feed on mollusca break the shells before swallowing them, so that both fishes and crabs have doubtless helped to accumulate the broken shells that are very often scattered abundantly over the bottom, both in deep and in shallow water. Such accumulations of shells would soon become far more extensive if they were not attacked by boring sponges and annelids. Certain common sponges belonging to the genus *Cliona* very rapidly perforate the hardest shells, in every direction, making irregular galleries, and finally utterly destroying them. In our shallower waters the most destructive species is *C. sulphurea* (Desor), which burrows in shells and limestone when young, but later grows into large, rounded, sulphur-yellow masses,

*I have observed that, when in aquaria, many different species of the larger crustacea, such as the crabs, *Libinia emarginata*, *Cancer irroratus*, *Panopeus Sayi*, *Carcinus mænas*, *Platyonicus occellatus*; the hermit-crabs, *Eupagurus pollicaris*, *E. longicarpus* and *Catapagurus socialis*; the shrimp, *Palæmonetes vulgaris* and *Virbius zostericola*; and *Limulus polyphemus*, are all extravagantly fond of the masses of diatoms and other fine algæ, intermingled with copeopods, etc., which we often collect in our surface-nets. When a mass of such materials is thrown into an aquarium containing these crustacea they seize and devour it with great avidity.

often a foot in diameter. In deep water other species occur. Rarely, we dredge up, on the outer grounds, fragments of wood, but these are generally perforated by the borings of bivalves (usually *Xylophaga dorsalis*) and other creatures, and are evidently thus soon destroyed. Very rarely do we meet with the bones of vertebrates at a distance from the coast. Although these waters swarm with vast schools of fishes, while sharks, and a large sea-porpoise or dolphin (*Delphinus*, sp.) occur in large numbers, we have, very rarely indeed, dredged up any of their bones, or, in fact, remains of any other vertebrate animals. In a few instances we have dredged a single example of a shark's tooth, and occasionally the hard otoliths of fishes. It is certain that not merely the flesh, but most of the bones, also, of all vertebrates that die in this region are very speedily devoured by the various animals that inhabit the bottom. Echini are very fond of fish-bones, which they rapidly consume. Relics of man and his works are of extremely rare occurrence, at a distance from the coast, or outside of harbors, with the exception of the clinkers and fragments of coal thrown overboard from steamers with the ashes. As our dredgings are in the track of European steamers, such materials are not rare. A few years ago even these would not have occurred. A rock forming on this sea-bottom would, therefore, contain little evidence of the existence of man, or even of the existence of the commonest fishes and cetaceans inhabiting the same waters.

Additional Stations occupied in 1882.

Stat.	Locality.	Fathoms.	Bottom.	Date.	Temp'rature.		Hour.
					Bottom.	Surface.	
	Off Martha's Vineyard. *Sch. "Josie Reeves."*						
	N. Lat. W. Long.			Sept.			
1145	40° 03′ 00″; 70° 28′ 00″	135	fine sand	20			
1146	40 02 00; 70 41 00	140	fine sand	21			
1147	40 01 00; 70 54 00	125	--------	22			
1148	39 54 00; 71 22 00	110	hard sand, sponges	23			
1149	.		hard sand, sponges				
	Off Martha's Vineyard. *"Fish Hawk."*			Oct.			
1150	39° 58′ 00″; 70° 37′ 00″	140	sand	4	47°	62°	6·35 A.M.
1151	39 58 30; 70 37 00	125	sand	4	48	62	7·45 "
1152	39 58 00; 70 35 00	115	sand	4	48	62	8·42 "
1153	39 54 00; 70 37 00	225	sand. mud	4	44	62·5	10·45 "
1154	39 55 31; 70 39 00	193	sand, mud	4		62·5	12·10 P.M.
1155	39 52 00; 70 30 00	554	v'y fine sand, soft m.	4	40	63	4·06 "

NOTE.—In the last article of this series, I referred to the adoption of steel wire rope, since 1880, for dredging on the Fish Hawk, as having greatly expedited our work. This great improvement, first introduced by Lieut. Com. C. D. Sigsbee,

on the Coast Survey steamer Blake, in 1877–8, was suggested by Mr. A. Agassiz, who used it during that cruise, and also on subsequent ones on the Blake, when commanded by Lieut. Bartlett. Its introduction and use has been described by Mr. Agassiz in his reports, and also, in detail, by Captain Sigsbee, in his extended work on Deep Sea Sounding and Dredging. Our arrangements, on the Fish Hawk, for reeling in the wire rope were unlike those on the Blake, for we used only one drum, with 1000 fathoms of rope on it. The use of steel wire for sounding goes back to an earlier date than is commonly supposed. It was extensively used by Lieut. J. C. Walsh, U. S. N., on the schooner "Taney," in his survey of the Gulf Stream in 1849 (see Maury's Winds and Currents of the Sea, p. 56, 1851). Important improvements have since then been made in the reels for winding it in, by Sir Wm. Thomson, Captain Sigsbee, and others.