AN INTENSIVE STUDY OF THE FAUNA AND FLORA OF A RESTRICTED AREA OF SEA BOTTOM

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The preparation of detailed lists of the animals and plants occupying regions of greater or less extent has long been the favorite occupation of a certain class of naturalists. Such lists abound in the annals of botany and zoology. And it is only thus, indeed, that we have learned how our planet is populated. The cumulative labors, first of individuals, then of scientific organizations and of governments, have given us the data from which to formulate the laws of geographical distribution. In the beginning we have the bare facts of occurrence; then correlations are established between given conditions of environment and the presence of given species or varieties; finally, we are brought within striking distance of the great central problem of the origin of species. So much for the scientific aspect of the case. On the practical side, faunistic studies need offer no apology for their existence. They have, indeed, formed a part of the established policy of our government for many years. The Department of Agriculture has long maintained a biological survey of the land animals and plants of this continent, while our Bureau of Fisheries has slowly but steadily been conducting a census of the inhabitants of our seas and lakes. Truly, these creatures are not all fit for food, nor indeed for any commercial purpose whatever—though we must add that there are probably many more animals and plants of economic value than we now realize. But the life of the sea is an interrelated whole. One species stands in relation to another as its enemy, prey, food, parasite, host, messmate, or the like, and intimate chemical relations may exist, as we find between the animal kingdom and the plant kingdom as a whole.

Moreover, as we now view the case, all these multitudinous living creatures are, so to speak, related by "blood." What we learn of one is commonly applicable to its nearer relatives and frequently to a long series of other forms.

Hence the futility of endeavoring, even on economic grounds, to restrict our investigations to food fishes or other animals of obvious commercial importance. What we discover from the study of a "minnow" is, in the great majority of cases, quite as applicable to a mackerel or a cod. But the minnow is easier to obtain and easier to manipulate. A few years ago an expert in the employ of the Bureau of Fisheries investigated the hearing of fishes. His experiments were concerned chiefly with a little fish of no seeming importance whatever. He cut its nerves and, worse yet, played musical notes at the helpless creature! Could anything seem less practical or less worthy of the attention of serious-minded persons? Recently the fishermen of certain sections of our coast have been stirred up by the alleged effects of naval target practice and of the noise produced by motor boats in driving away fishes from their customary haunts. To whom does the Bureau appeal to settle this problem? Naturally to the man who knows most about the hearing of fishes. The matter is tested, and the problem—or one phase of it, at least—is settled very briefly. The motor boats are found to be innocuous—at any rate to the fishes. Regarding the cannon, a decisive answer is likewise hoped for soon. But this is taking us a long way from the biological survey of the Woods Hole region.

Years ago Woods Hole was selected by Professor Baird as the most promising spot upon our coast for the commencement of a scientific study of fisheries problems. From the very outset he gathered about him a staff of naturalists of the type that was dominant in that generation—men eager to seek out every living thing concealed beneath the waves, to describe and figure and name. Accordingly, the first volume published by Baird as Commissioner of Fish and Fisheries contains not only a catalogue of the fishes of the east coast of North America, but an extended report upon the invertebrate animals of Vineyard Sound and adjacent waters and a list of the marine algæ found in this same region. In spite of the previous labors of Desor and Adams and Gould and Leidy and Stimpson and Perkins and the two Agassiz, who had already made essays into the waters of southern New England, Verrill and Smith found in Vineyard Sound and Buzzards Bay a practically virgin field. We begin to realize the pioneer nature of much of their work when we recall that even some of our most abundant and familiar species—e. g., the sponge *Chalina arbuscula*, the tube-worm *Hydroides dianthus*, the shrimp *Virbius zostericola*, and the beach flea *Orchestia agilis*—were first described in the Report upon the Invertebrate Animals of Vineyard Sound. And, indeed, this report, hasty and ill-digested as it was, remains to this time our chief single reference work upon the fauna of this section of our coast. That first inclusive list of local species has been much extended, it is true, partly by the original authors, partly by a more recent group of naturalists, who have prepared for the Bureau of Fisheries a series of monographic reports upon certain phyla or classes of animals.

The undertaking of which it is my privilege to speak to you was commenced in the summer of 1903.[a] The project was twofold: First to make as complete a census as possible of the marine fauna and flora of an arbitrarily limited region within the vicinity of Woods Hole, Mass. (fig. 1);[b] and secondly, to carry on systematic dredging operations throughout that portion of this region comprising Vineyard Sound and Buzzards Bay. For the former division of the work we have resorted for data to all previous published reports, to copious manuscript notes which have been furnished us by various investigators, to the wealth of information accumulated during many years past by the veteran collector of the Bureau of Fisheries, Mr. Vinal N. Edwards, as well as to original records from our own operations. The final product, a much elaborated check list, is nearly ready for press. But it is the second part of this project to which I shall invite your attention. The method of procedure here employed was to dredge at rather frequent intervals throughout the entire extent of Vineyard Sound and Buzzards Bay. Each of these dredging stations was numbered, and was definitely located upon our charts, and the total "array" of animals and plants from each point was determined. From such records it was of course possible to plot out the distribution of every animal and plant encountered, granting, of course, the thoroughness and reliability of our methods and the accuracy of our determinations of species. It will be impossible here to enter into a discussion of the methods employed or of the trustworthiness of our data. It is sufficient to state that a full report upon this entire undertaking is nearly ready for press, and that due allowance has been made for all possible sources of error. It is my present purpose merely to give a brief statement of a few of the more interesting results.

To begin with, the waters which have been explored are exclusively shallow ones, at no point exceeding 25 fathoms in depth. Accordingly, none of the characteristic deep-sea deposits and none of the abyssal types of animals have been encountered. Within the limits stated, however, we have dealt with a wide diversity of conditions. Among these are to be mentioned differences in the character of the bottom, in the temperature, salinity, depth, and purity of the water, and in the tidal currents. Foremost among the conditions determining the distribution of the bottom-dwelling organisms we have found to be the character of the bottom, considered chiefly in relation to its physical texture. It is a mere platitude to state that fixed animals require a solid basis for attachment, and burrowing ones a suitable medium for excavation. Drifting sand is of course unfavorable to the growth of many forms, and soft mud

[a] This work has been conducted for the Bureau of Fisheries by the present author in cooperation with R. C. Osburn and L. J. Cole (zoology), and B. M. Davis (botany). A large number of specialists have likewise rendered assistance in identifying specimens, revising terminology, etc.

[b] Roughly, from Newport to Monomoy, and from the mainland of Massachusetts to the 20-fathom line.

doubtless interferes with the respiratory currents of many others. Since Vineyard Sound and Buzzards Bay are rather sharply distinguished from one another by the presence or absence of mud on the one hand and of clean sand and gravel on the other (pl. CXXIV), it is natural that the most obvious distinction in distribution should be that between the predominantly sound-dwelling species and the predominantly bay-dwelling ones. The former, it must be added, greatly preponderate over the latter numerically. Within each of these large bodies of water the local distribution of many forms is very obviously determined by the occurrence of one or another variety of bottom. Thus it happens that many species whose occurrence in Vineyard Sound is general are found in Buzzards Bay only in the adlittoral zone, particularly along the Elizabeth Islands (fig. 6). Here the mud is less prevalent, and bottoms of clear sand and gravel are frequently met with.

A type of distribution which is almost the converse of the last is encountered in the case of certain mud-dwelling species which are of general occurrence throughout the bottom of Buzzards Bay, but which in Vineyard Sound are confined to a few definite areas where mud is known to be present (e. g., the annelid *Clymenella torquata* and the bivalve mollusk *Yoldia limatula*, figure 7 and 8). Furthermore, Vineyard Sound is roughly divisible into an eastern half, in which the bottom is predominantly stony and gravelly, and a western half, in which the bottom is mainly of sand. Accordingly, many species, particularly attached forms (fig. 9), are scarce or absent in the western half of the Sound, except in the littoral and sublittoral zones, while certain sand-dwelling forms, among which we may name the rays and the flounders among the fishes (fig. 10, 11), and the lady-crab (*Ovalipes ocellatus*), are especially common in that very region. The lower end of Buzzards Bay is comparatively free from deposits of mud, and accordingly we often meet with species here which are generally distributed in the sound, but which are scarce or absent from the more central parts of the bay. The scarcity or apparent total absence in Buzzards Bay of many local species of animals representing every phylum, is, we believe, due chiefly, if not entirely, to the character of the bottom.

The temperature factor, with little doubt, is a controlling one in determining the distribution of many species within the limits of our chosen region. We encounter a large number of animals, belonging to practically all the subkingdoms, and likewise certain plants, whose distribution in local waters is confined to the western end of Vineyard Sound and the mouth of Buzzards Bay (fig. 13, 14, 15, 17, 27). Here the water temperature at the bottom averages during the summer months about 10° F. (5.6° C.) lower than at Woods Hole and in the less exposed waters of the region. (Fig. 2.) The mean bottom temperature at 14 stations in the western third of Vineyard Sound and just without the latter, at a time when it was probably near its maximum, was found by us to be 60.2° F. (15.7° C.).

This temperature is exceeded at Woods Hole during that portion of the year between June 3 and October 12 (diag., pl. CXXIII). It thus appears that the summer conditions of temperature, such as obtain in the vicinity of Woods Hole during the months of June, July, August, and September, do not directly affect the western half of Vineyard Sound, and in only a limited degree the lower end of Buzzards Bay.

A few words are necessary here regarding the hydrography of this section of the New England coast. As is well known, the Gulf Stream courses in an approximately northeasterly direction, at a distance of about 100 miles south of Long Island, Marthas Vineyard, and Nantucket (fig. 1). That this great body of warm water must affect the temperature of the surface strata, at least in Vineyard Sound and Buzzards Bay, is rendered probable by the fact that large masses of the floating *Sargassum*, or "gulf weed," with their attendant animal life, are driven thither nearly every season by prolonged southerly gales. It is likewise generally believed that between the Gulf Stream and the southern coast of New England there passes another more or less well-defined current, having its origin in the far north. That the water of this colder current is diffused by the tides along its coastward margin and affects the temperature of the outlying waters of our region, especially at the bottom, can hardly be doubted.[a]

With few exceptions, those species whose occurrence locally is confined to these colder waters are known to be primarily northward-ranging types, which are here near the southern limit of their distribution, so far, at least, as such shallow waters are concerned. Many of these same species have likewise been encountered by us at Crab Ledge, off the southeastern bend of Cape Cod, and some of them likewise on the shoals to the eastward of Nantucket. Certain other forms (fig. 18, 26), though elsewhere of general distribution, are absent from just those waters to which these northern types are restricted. Such appear to be, for the most part, southward-ranging types, which find their northern limit in Cape Cod. The numerous species (fig. 5 and many of the others) which are of general distribution throughout the waters of the region, or which, at least, do not appear to be restricted as regards the temperature of their medium, are more commonly either species with an extended range in both directions up and down the coast or with a southward range only. The truly northern types are less likely to show such a general distribution in Vineyard Sound and Buzzards Bay. It is impossible to state at present how the temperature factor is effective in limiting the distribution of species locally. Our thermometric determinations seem to show that the temperature of those waters which immediately join the ocean is lower than elsewhere for probably not much more than half of the year, the difference being greatest during the summer

[a] See report by Libby in Bulletin of the U. S. Fish Commission, vol. IX, 1889 (1891) p. 391–459; also address before the Fourth International Geographical Congress, London, 1895. It must be added, however, that the existence of such a cold current off the New England coast is now questioned by some authorities.

months. It is likely that all the waters of the region approach very nearly to the freezing point of salt water for a longer or shorter period nearly every winter. It may be that the rule which has been formulated by Verrill[a] and Allen for birds, and by Merriam[b] for terrestial animals and plants in general, applies here—namely, that the limits of distribution are determined by the temperature at the breeding season only. If this be true it would follow that adult animals and plants might survive temperatures in which propagation could not occur.

It is certain, however, that an actual destruction of adult organisms may occur as the result of a too high or too low temperature. The case of the common sea urchin (*Arbacia punctulata*), which, as our records show, was almost exterminated in Vineyard Sound during the particularly cold winter of 1903–4[c] is a good illustration of this point; and it is a matter of common observation among fishermen that great numbers of dead fishes of certain species are frequently found during the thaw following a particularly hard spell of cold weather.[d] Conversely, certain members of our local fauna (e. g. the noncolonial hydroid *Tubularia couthouyi*) are known to be able to grow and maintain an active existence only at a low temperature. It is manifestly impossible, therefore, to make any single, all inclusive statement as to mode of operation of temperature in restricting the distribution of species in the Woods Hole region.

As regards the depth factor, we can find little evidence of actual bathymetric distribution in the waters under consideration. It is true that certain species, according to our dredging records, seem to be restricted to the sublittoral zone (e. g. *Crepidula convexa*, fig. 23), but these are probably also littoral in their habitat, and it is possible that proximity to shore rather than depth proper may be the determining factor in such cases.

Salinity, likewise, though undoubtedly a potent factor in determining the distribution of species in or near the mouths of streams, seems to play a negligible part in the explanation of our dredging records. The only point in the region covered where the dilution of the sea water is at all considerable is near the head of Buzzards Bay (fig. 4); but we have recorded hardly a single species which was dredged here exclusively or even predominantly.

One question which will naturally present itself to the student of geographical distribution is this: What is the position of the Woods Hole fauna in the fauna of our American coast? To which of the larger zoogeographical regions does it belong? And is it situated in the middle of that region or close to one of its

[a] American Journal of Science, March, 1866, p. 249.

[b] North American Fauna, no. 3, p. 26; Proceedings of the Biological Society of Washington, April, 1892, p. 45.

[c] The mean water temperature at the Woods Hole station for January and February, 1904, was 29.3° F., that for the same months during the other four years of the period 1902 to 1906 being 32.3°.

[d] Gould cites a case of the wholesale destruction of oysters by "ground frost" (see Boston Journal of Science, 1840, p. 492).

limits? In other words, do the majority of species have a range which extends mainly to the northward along this coast, or do the majority have, on the whole, a southward range; or is there no appreciable preponderance of one sort over the other? Simple as these questions may seem, it is difficult to give an answer that is at all satisfactory. The known range, as distinguished from the actual range, of a species, is very frequently determined by historical accident. Thus the Bay of Fundy, Massachusetts Bay, Woods Hole, New Haven, Charleston, etc., frequently figure in our literature as limits of distribution, and this for obvious reasons. Similarly, Cape Cod has taken a conspicuous place as a limit of distribution in all the accounts of our Atlantic Coast fauna and flora. In fact, it has been pretty generally assumed that Cape Cod forms a rather definite boundary between the fauna and flora inhabiting the regions above and below it. This was urged by Gould[a] as early as 1840, and has been maintained by Dana, Verrill, S. I. Smith, and others for the animal kingdom, and by Harvey and Farlow for plants. The faunal region extending to the southward of this barrier has been termed the Virginian, that to the northward the Acadian,[b] Woods Hole and the adjacent waters being assigned to the former. While it would be vain to dispute the importance of the barrier formed by Cape Cod and the outlying islands and shoals, together with the temperature conditions associated with them, it seems probable that its significance has often been exaggerated, owing to the historical prominence of this region of the coast in the annals of American zoology and botany. Some facts are herewith offered in support of this opinion.

Of the 202 species of animals which have been taken at 10 or more of our dredging stations, and which, therefore, may be regarded as representative of our local marine fauna, 100, or almost exactly 50 per cent, are reputed to have a range on our coast which is predominantly southward. By this it is meant that the extent of their known range to the southward is at least twice that of their known range to the northward. On the other hand, 48 of the species (24 per cent) have a range which is predominantly northward, while 29 of them (14 per cent) have a range of approximately equal extent (so far as known) in both directions. The remaining 25 species have been relegated to the doubtful column, owing to the unsatisfactory nature of the data at our disposal; some of these forms having been found only in the vicinity of Woods Hole. The fact to be emphasized is that the ratio of southward-ranging species (as thus defined) to northward-ranging species is approximately two to one, while about 14 per cent of them do not seem to be thus restricted in latitude.

Viewing these 202 species in another way, it is to be noted that 129, or about 63 per cent of them, are known to have a range extending north of Cape Cod,

[a] Boston Journal of Natural History, vol. III.

[b] See particularly Verrill, in Proceedings of the Boston Society of Natural History, vol. X, 1866, p. 333–357.

leaving only 37 per cent which, so far as reported, have not transcended this barrier. Doubtless more complete information will reduce the latter figure. As has already been pointed out, any locality where extensive collecting has been done is sure to figure as the reputed limit of distribution—whether northern or southern—for many species. It is significant, therefore, that only 40 of the species under consideration (20 per cent) have not yet been recorded from points south of Woods Hole.[a] Comparing this figure with the 37 per cent which are not known to occur north of Cape Cod, it may be that we have some measure of the real effectiveness of the last as a barrier to distribution.

It must be conceded at once that it is impossible to form a just estimate of the geographical range of a species from any mere statement, however correct in itself, of the extreme limits of its distribution. The bathymetric range and other factors of its habitat at various latitudes must be taken into consideration. It is obvious, likewise, that the same importance must not be attributed to the isolated and occasional occurrence of a given species as to its occurrence at points where it is widespread and abundant. But in most of the published tables which are available for consultation no distinction is made between the two.

Crude in the extreme, therefore, as any such computations must be, the conclusions seem to be fairly well grounded (1) that Cape Cod does have an appreciable influence as a barrier to distribution, and (2) that the southern types preponderate considerably over the northern ones in our Woods Hole fauna, or at least such of it as is accessible to the dredge. These generalizations may not be true of each individual group (e. g., coelenterates and amphipods); and in general it must be remembered that a considerable minority of northern forms are included in our local fauna, while more than 60 per cent of our species are known to occur north of Cape Cod. On the other hand, it is well to add that our local fish fauna, which is but sparingly represented in our dredging records, and consequently plays little part in the foregoing tabulation, is overwhelmingly southern, 75 per cent being southward-ranging in the foregoing sense of the term, while nearly 50 per cent of the total number of recorded species are such as are reputed to find in Cape Cod their northern limit of distribution. And, lastly, we must bear in mind that we are here dealing only with the *benthos* of the region, the plankton, as well as the littoral fauna, being left out of consideration.[b]

Turning now to another phase of our results, the comparative distributions of different species of the same genus are presented by us in a large number of cases (e. g., *Pecten*, *Asterias*, *Crepidula*, *Pagurus*, fig. 16, 17, 20–27). In some cases, two such species have a practically coincident distribution, as regards both

[a] More strictly, south of Vineyard Sound and Buzzards Bay.

[b] Of the total number of 1,600 (±) species of animals recorded for this region, only 500 (+) have been taken during our dredging, and of these less than half have been employed in the above computations.

extent and frequency; in other cases, one is of much greater abundance than the other, though their range of distribution is practically the same; in others still, one has a much more restricted range than the other. As instances of the last condition we may mention the two common starfishes, *Asterias forbesi* and *A. vulgaris* (fig. 20, 21), or the two chestnut shells, *Astarte castanea* and *A. undata*. In each of these examples the two related species overlap throughout a part of their range, but the range of one is more restricted than that of the other.

Whether or not the specific differentiation preceded or followed such a change of habitat is not even suggested by any of the facts which we have encountered. Who can say, for example, whether the tendency to restrict itself to muddy bottoms preceded or followed the differentiation of the amphipod crustacean *Ampelisca macrocephala* as a species distinct from *A. spinipes?* Yet this is the kind of data with which we have to deal. Nevertheless, the bare fact that various closely related species do show decidedly different distribution patterns is one of great interest, for it shows that the slight morphological differences by which the species are distinguished from one another are oftentimes correlated with marked physiological differences, sufficient to adapt the two to differing habitats. Thus the assertion so often made that the slight structural differences by which we distinguish one species from another are commonly of no conceivable utility, and therefore can never have arisen through the action of natural selection, loses much of its force. While it may be true that these slight structural differences in themselves can play no significant rôle in the life of the organisms concerned, it is likewise evident that there are certain correlative physiological changes sufficient to adapt the organisms to somewhat different modes of life. That natural selection has been the controlling factor in the origination and perpetuation of such specific differences, whether morphological or physiological, is far from certain. But that the characters concerned are in most cases too insignificant to be of selective value is also far from certain.

To the reader who would demand an exact economic equivalent for the labor and money here expended our answer must be a more general one. Science and industry move together. Industry is helpless without the aid of science, and the greatest industrial progress is at present being made by those countries which realize this fact most fully. But science can never prosper if forced to play the rôle of a servant. She must be free to pursue her own ends without being halted at every step by the challenge: *cui bono?* The attempt to restrict our scientific experts to problems of obvious economic importance would be equivalent to depriving ourselves of their services altogether. It is to-day accepted as a commonplace that all the great discoveries of practical value have rested ultimately upon principles first brought to light by the student

of nature. The enlightened manufacturer of Germany looks upon a well-paid scientific investigator as a good investment. As a result of this policy the rest of the world is looking on uneasily while its own industries pass into the hands of this far-sighted competitor. Great Britain and the Scandinavian countries, the great fishing nations of Europe, have long been leaders in the scientific investigation of the sea. And in recent years we have witnessed the formation of an international council, representing all of those nations having an immediate interest in the fisheries of the North Sea, and organized for the study of hydrographic and biological problems as well as of purely economic ones. To Americans there should be no novelty in all this. Let us keep in mind the oft-quoted words of the distinguished founder of our Fish Commission in outlining the policy adopted by him:

> As the history of the fishes themselves would not be complete without a thorough knowledge of their associaties in the sea, especially such as prey upon them or in turn constitute their food, it was considered necessary to prosecute searching inquiries on these points, especially as one supposed cause of the diminution of the fishes was the alleged decrease or displacement of the objects upon which they subsist.
>
> Furthermore, it was thought likely that peculiarities in the temperature of the water at different depths, its chemical constitution, the percentage of carbonic-acid gas and of ordinary air, its currents, etc., might all bear an important part in the general sum of influences upon the fisheries; and the inquiry, therefore, ultimately resolved itself into an investigation of the chemical and physical character of the water and of the natural history of its inhabitants, whether animal or vegetable. It was considered expedient to omit nothing, however trivial or obscure, that might tend to throw light upon the subject of inquiry, especially as without such exhaustive investigation it would be impossible to determine what were the agencies which exercised the predominant influences upon the economy of the fisheries.

So that if we can not, from our present labors, offer any suggestions of direct value to the practical fisherman, we trust that we have at least added to the intelligent understanding of the marine life of our coast. And we likewise trust that the ultimate benefit to the practical fisherman will be as great as that to the man of science.

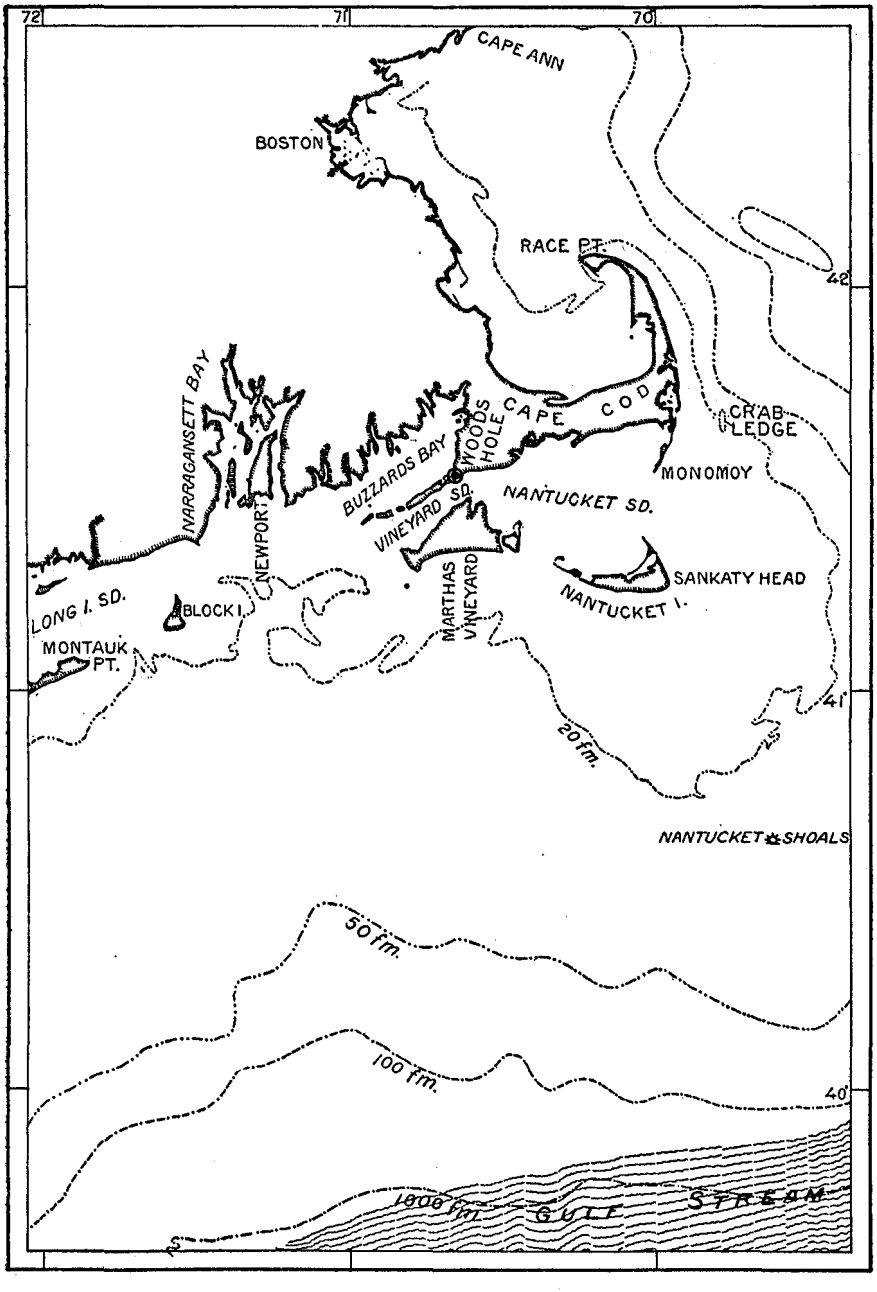

FIG. 1.—Map showing Woods Hole region and adjacent portions of the New England coast.

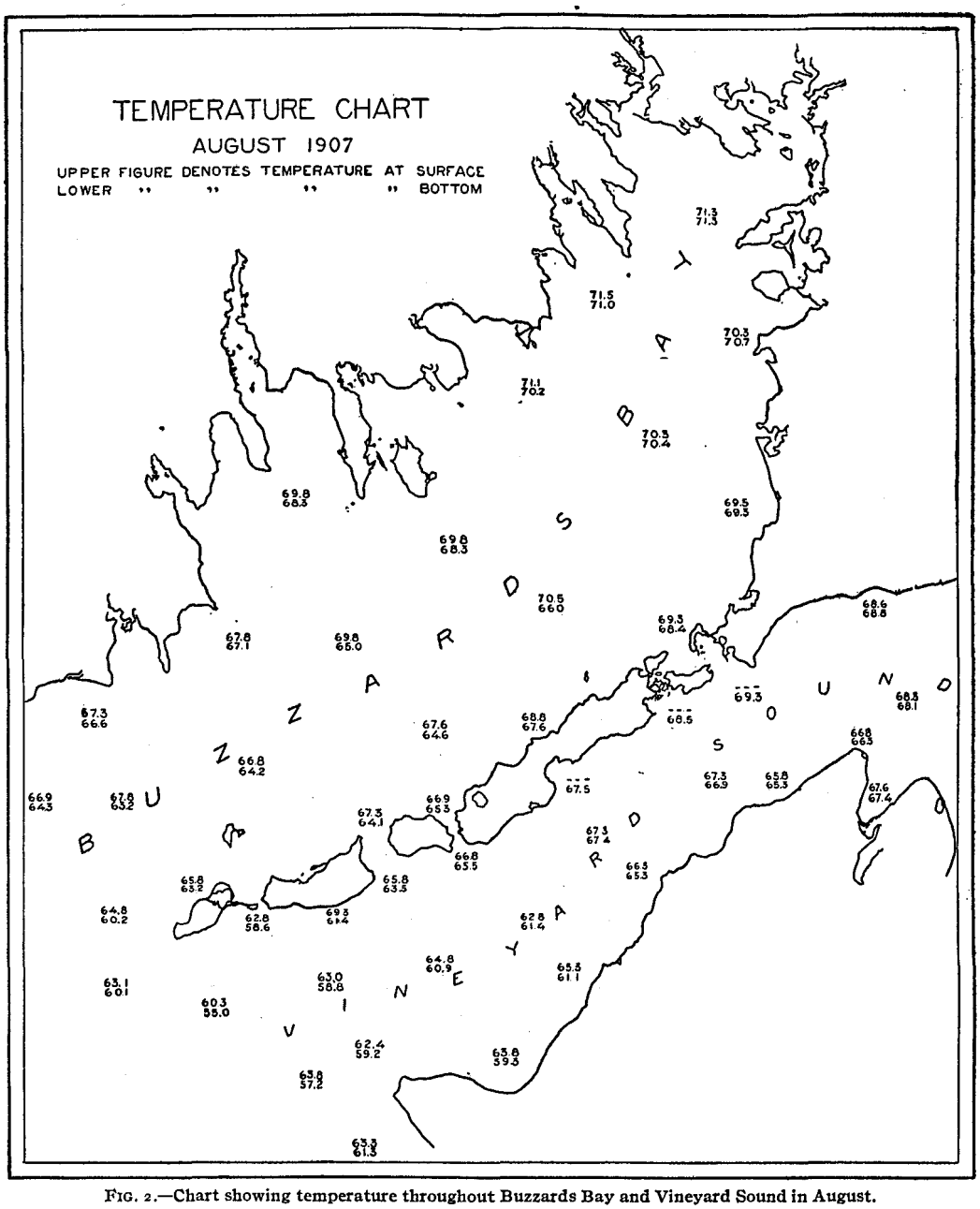

FIG. 2.—Chart showing temperature throughout Buzzards Bay and Vineyard Sound in August.

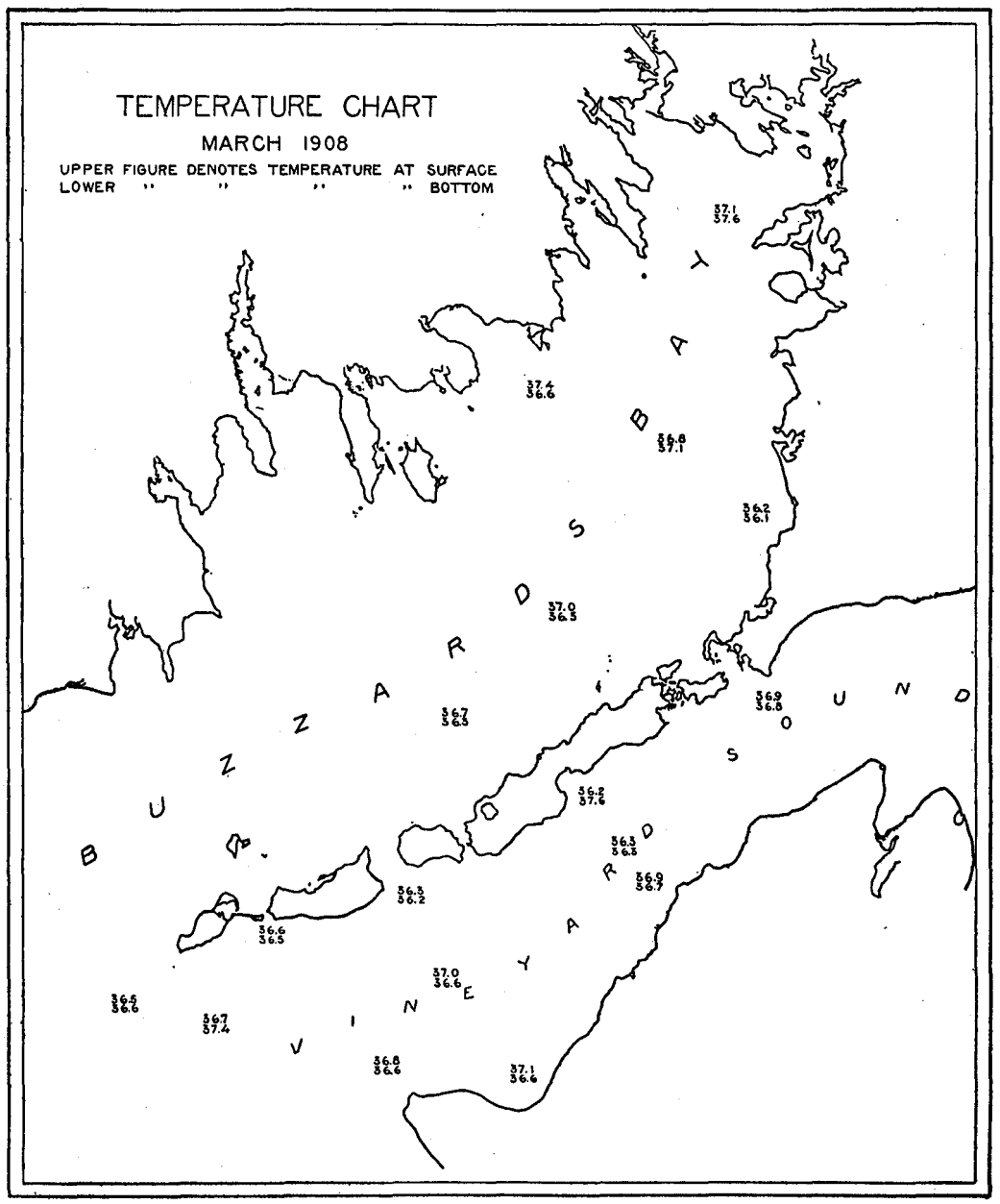

FIG. 3.—Chart showing temperature throughout Buzzards Bay and Vineyard Sound in March.

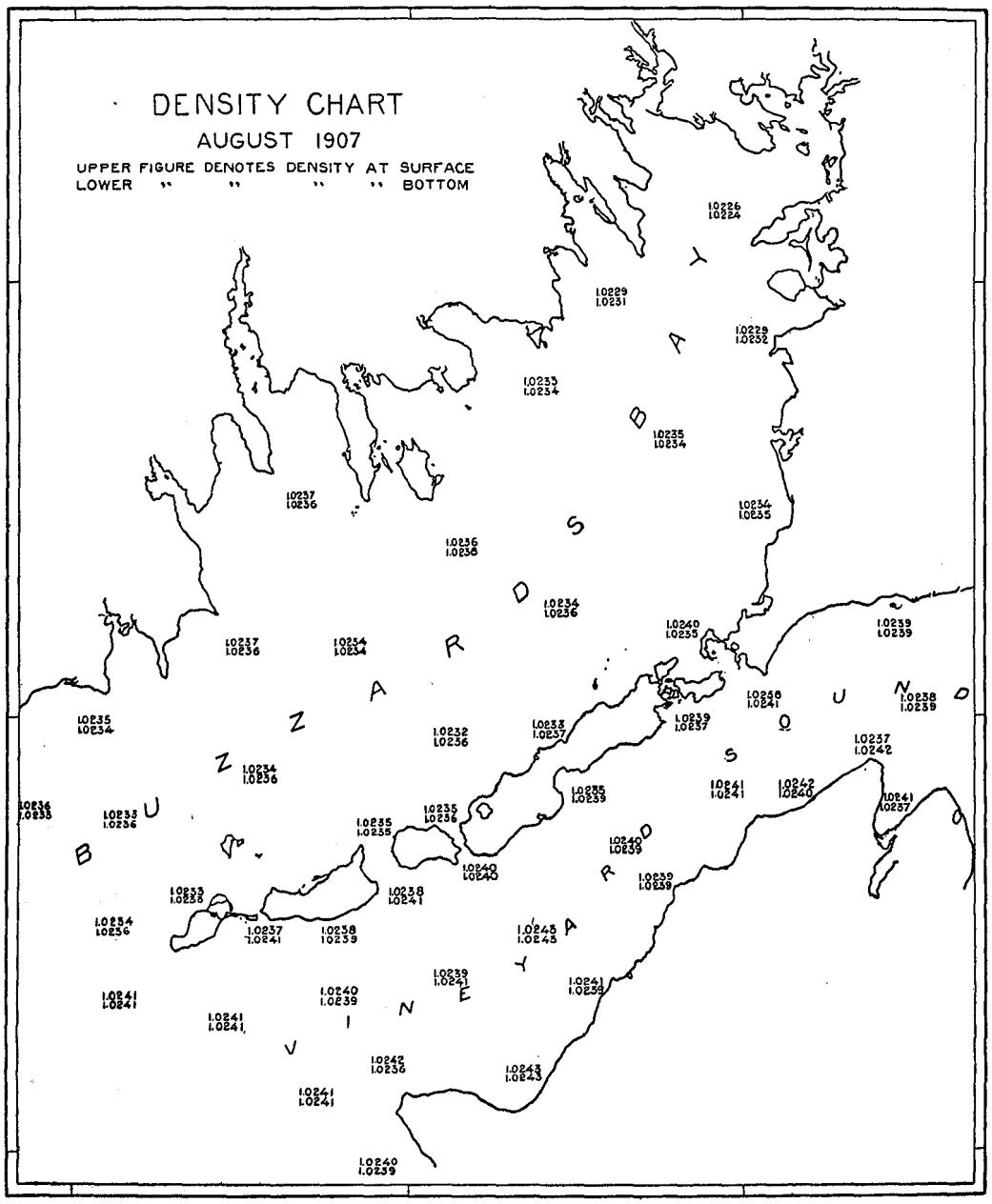

FIG. 4.—Chart showing density throughout Buzzards Bay and Vineyard Sound in August.

FIG. 5[a].—Local distribution of the gastropod mollusk *Tritia trivittata*. This species was recorded from 353 stations out of the total of 417 comprised within the limits of the map. It has thus the most general distribution of any species of animal dredged within these waters.

[a] The circle around the star, here and elsewhere among the mollusks, denotes the known occurrence of *living* specimens. Where the circle is wanting, either dead shells only were present or the point is not indicated in the records. This symbol has, however, been employed only in the case of shell-bearing animals.

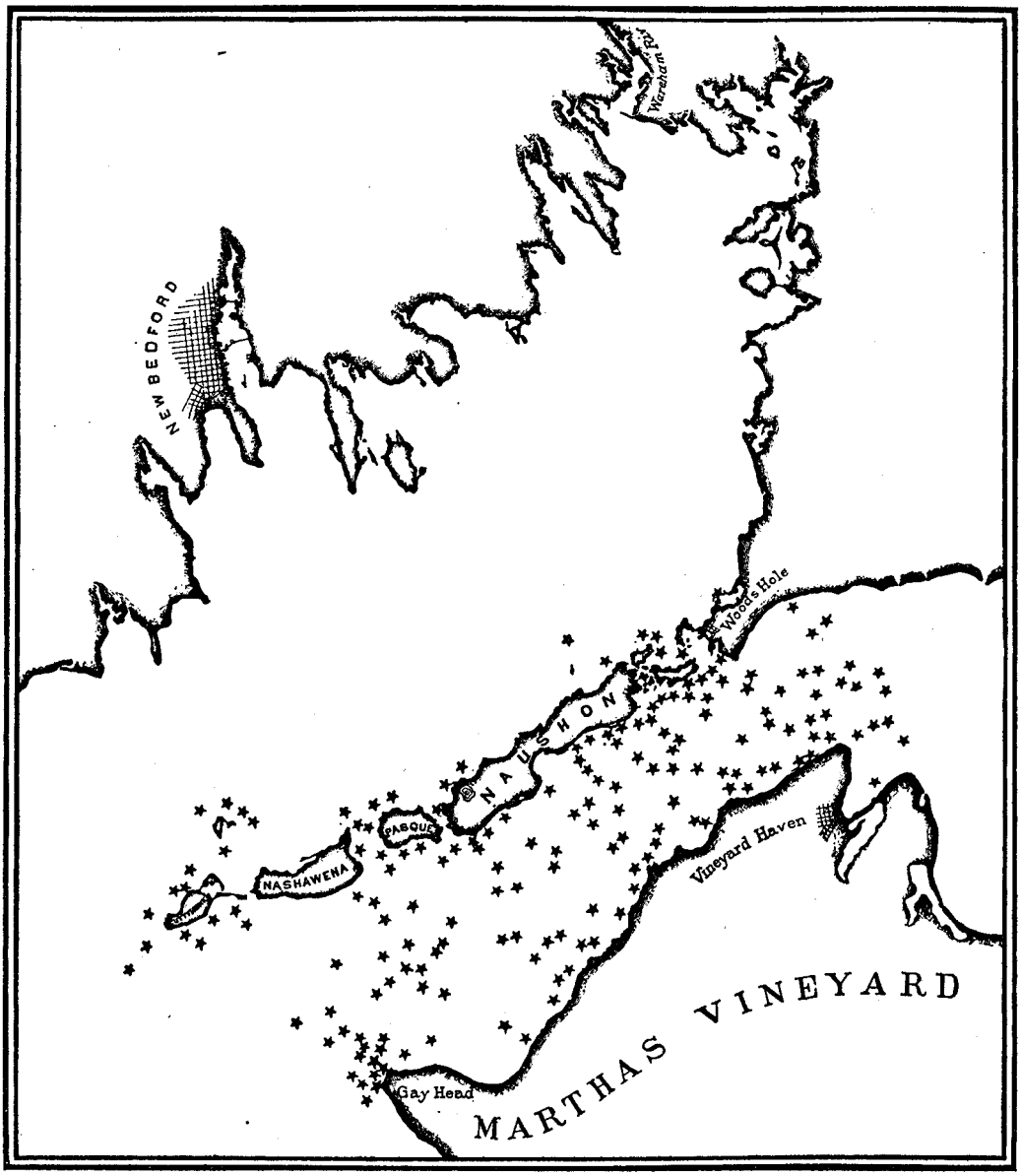

FIG. 6.—Local distribution of the polychaetous worm *Nereis pelagica*. Of general occurrence in Vineyard Sound; in Buzzards Bay mainly restricted to adlittoral zone, along the Elizabeth Islands. An example of distribution determined by the character of the bottom.

FIG. 7.—Local distribution of the polychaetous worm *Clymenella torquata*. This is likewise determined by the character of the bottom, but is almost the converse of that of *Nereis pelagica*, the present species being in a large degree restricted to a muddy habitat.

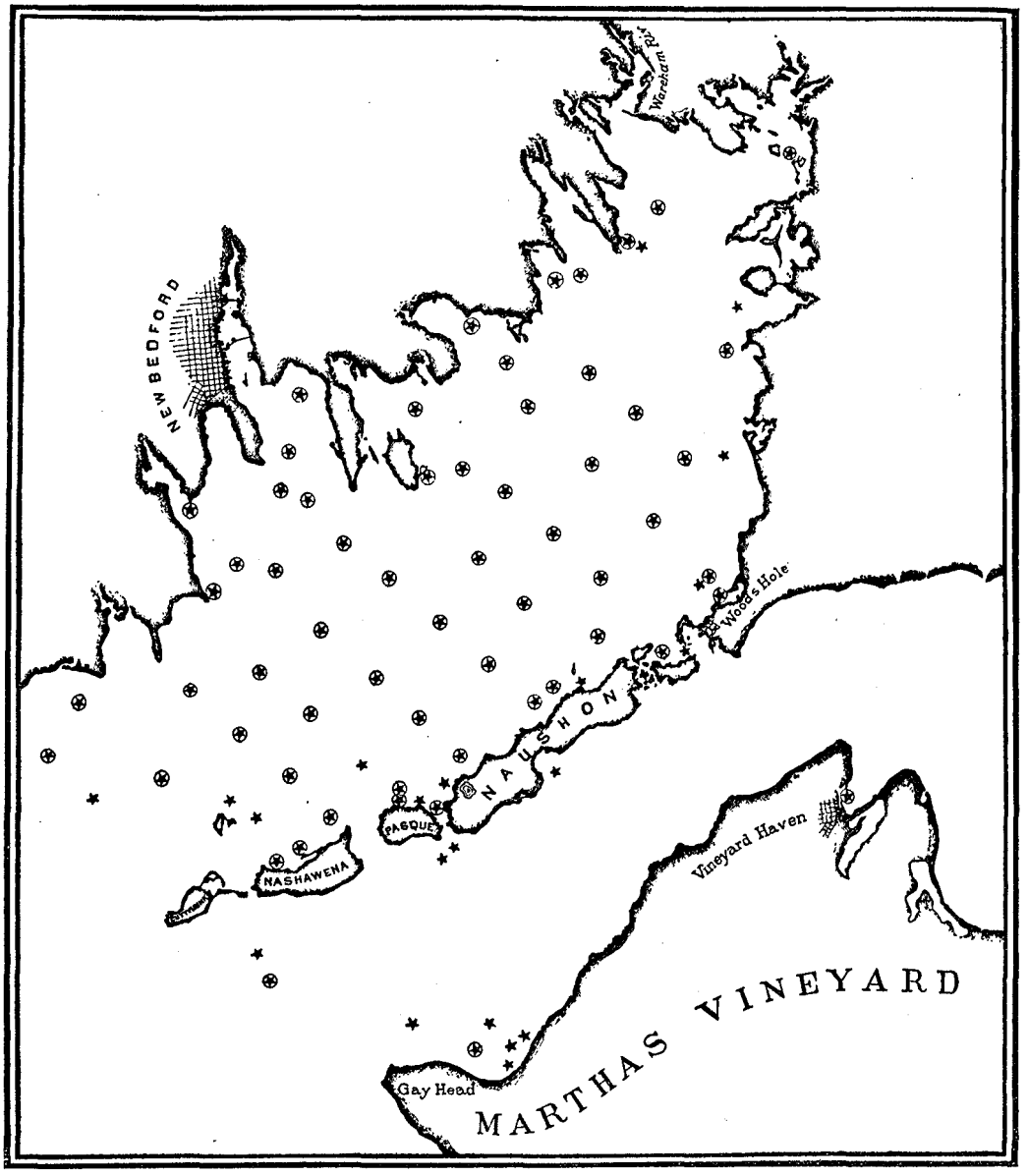

FIG. 8.—Local distribution of the bivalve mollusk *Yoldia limatula*, another mud-dwelling species, chiefly restricted to Buzzards Bay.

FIG. 9.—Local distribution of the sertularian hydroid *Thuiaria argentea*. The colonies of this species are almost invariably attached to stones and shells; hence the distribution is determined by the character of the bottom.

FIG. 10.—Local distribution of the common skate, *Raja erinacea*, a fish adapted to life upon sandy bottoms.

FIG. 11.—Local distribution of the "window-pane" flounder, *Lophopsetta maculata*. This is likewise a bottom-dwelling fish restricted to sandy places.

FIG. 12.—Showing localities at which the oyster, *Ostrea virginica*, or its shells, were taken. This is a good example of a spurious distribution pattern, since the shells in the main channel of Vineyard Sound were doubtless thrown overboard from passing vessels.

FIG. 13.—Local distribution of the bivalve mollusk *Venericardia borealis*. Here it is almost wholly restricted to the colder waters at the outer ends of Vineyard Sound and Buzzards Bay. Its range along our coast extends from the Arctic Ocean to off Cape Hatteras.

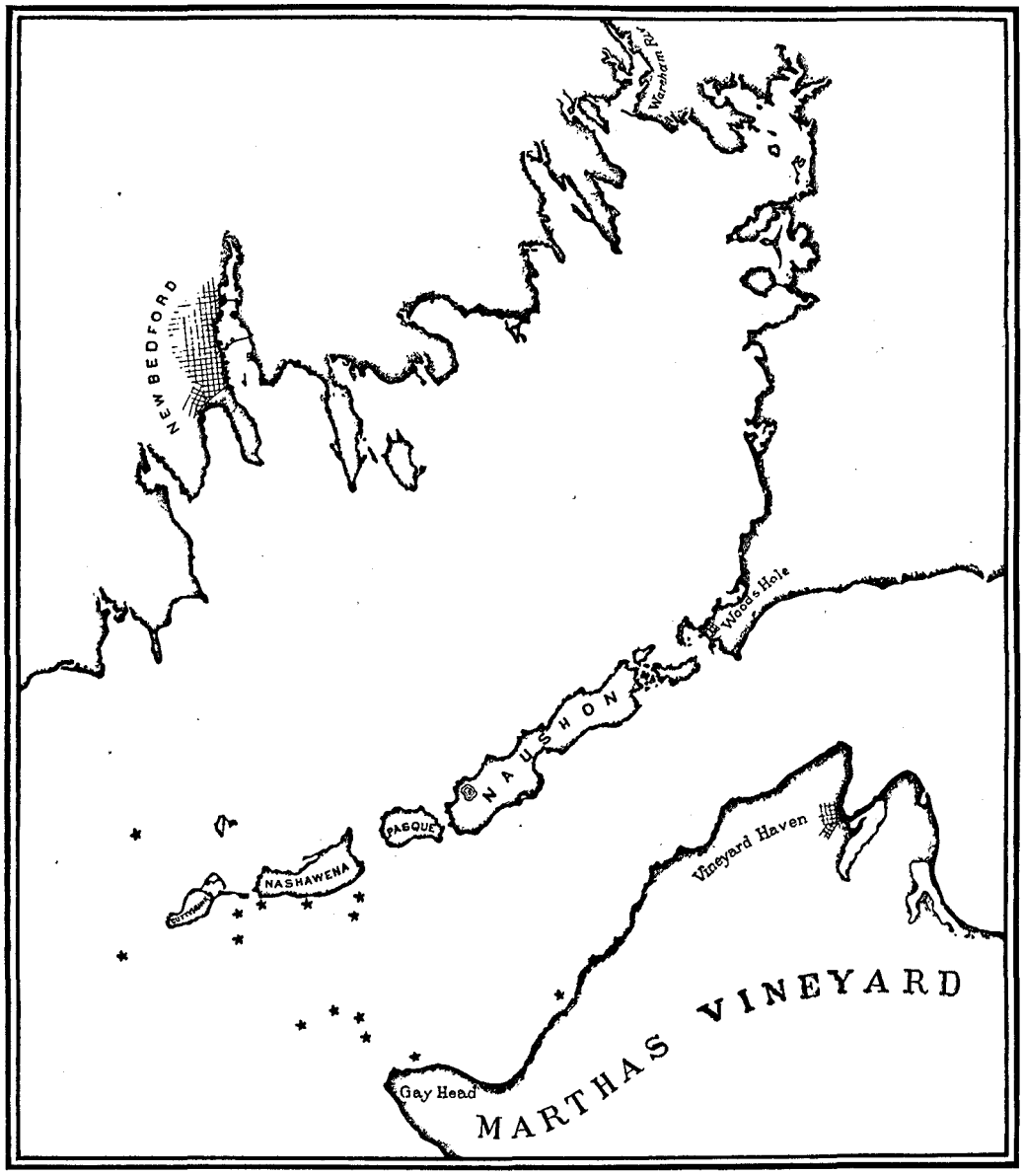

FIG. 14.—Local distribution of the actinian *Alcyonium carneum*, likewise a northern species, ranging from the Gulf of St. Lawrence to Rhode Island.

FIG. 15.—Local distribution of the "whelk" *Buccinum undatum*, whose range is from Greenland to "off New Jersey," and perhaps farther south.

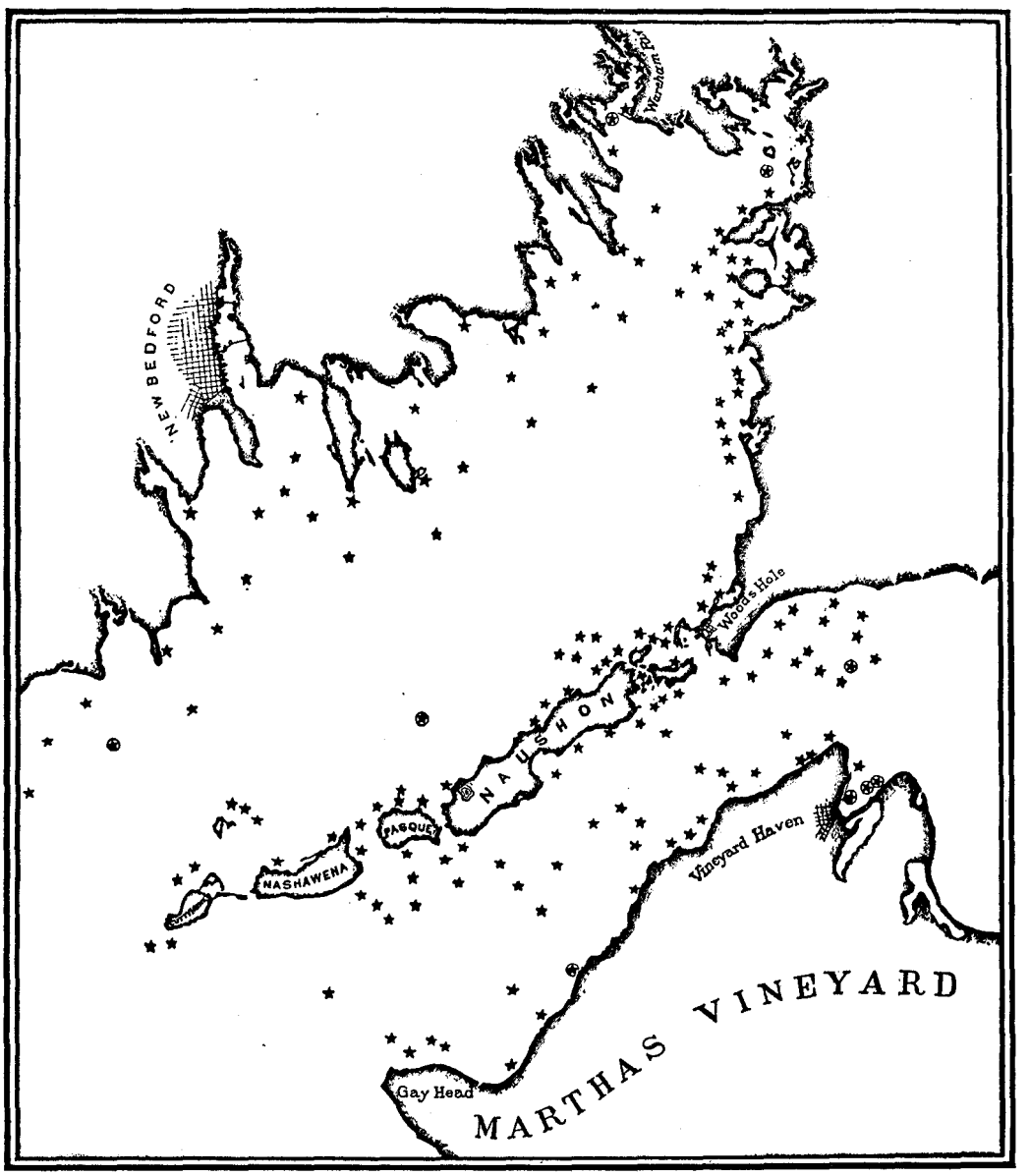

FIG. 16.—Local distribution of the common scallop, *Pecten gibbus borealis*, whose range extends from Nova Scotia to Florida.

FIG. 17.—Local distribution of the "smooth" or northern scallop, *Pecten magellanicus*, which ranges, on our coast, from Labrador to (off) Cape Hatteras, but which is said to be "rare and local south of Cape Cod." A comparison with the preceding species is significant.

FIG. 18.—Local distribution of the common purple sea-urchin, *Arbacia punctulata*, which ranges from Nantucket Shoals to Yucatan.

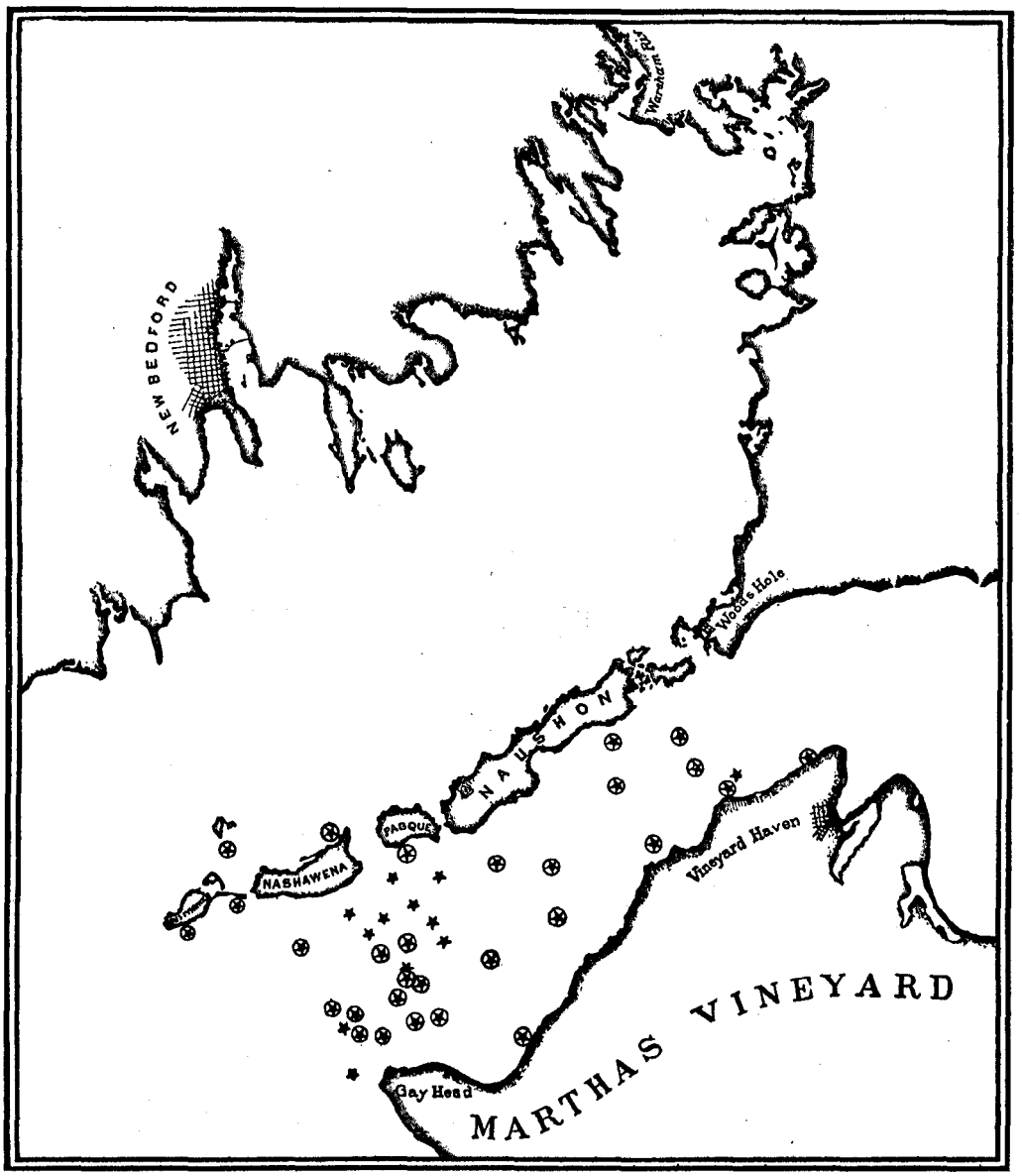

FIG. 19.—Local distribution of the green sea-urchin, *Strongylocentrotus dröbachiensis*, whose range is said to be "circumpolar; southward to New Jersey (not in shallow water south of Cape Cod)." Compare this with the preceding species.

FIG. 20.—Local distribution of the common starfish, *Asterias forbesi*, whose range on our coast is from Maine to the Gulf of Mexico. Distribution in local waters very general as compared with *A. vulgaris*.

FIG. 21.—Local distribution of the purple starfish, *Asterias vulgaris*, whose range, on our coast, extends from Labrador to Cape Hatteras, it being rarely found in shallow water, however, south of Cape Cod. A concentration in the colder waters is here evident, though the distribution in Vineyard Sound is fairly general.

FIG. 22.—Local distribution of the "boat shell," *Crepidula fornicata*. This species is most commonly found upon the shells of the larger hermit crabs, though frequently taken elsewhere. It ranges on our coast from the Gulf of St. Lawrence to the Gulf of Mexico.

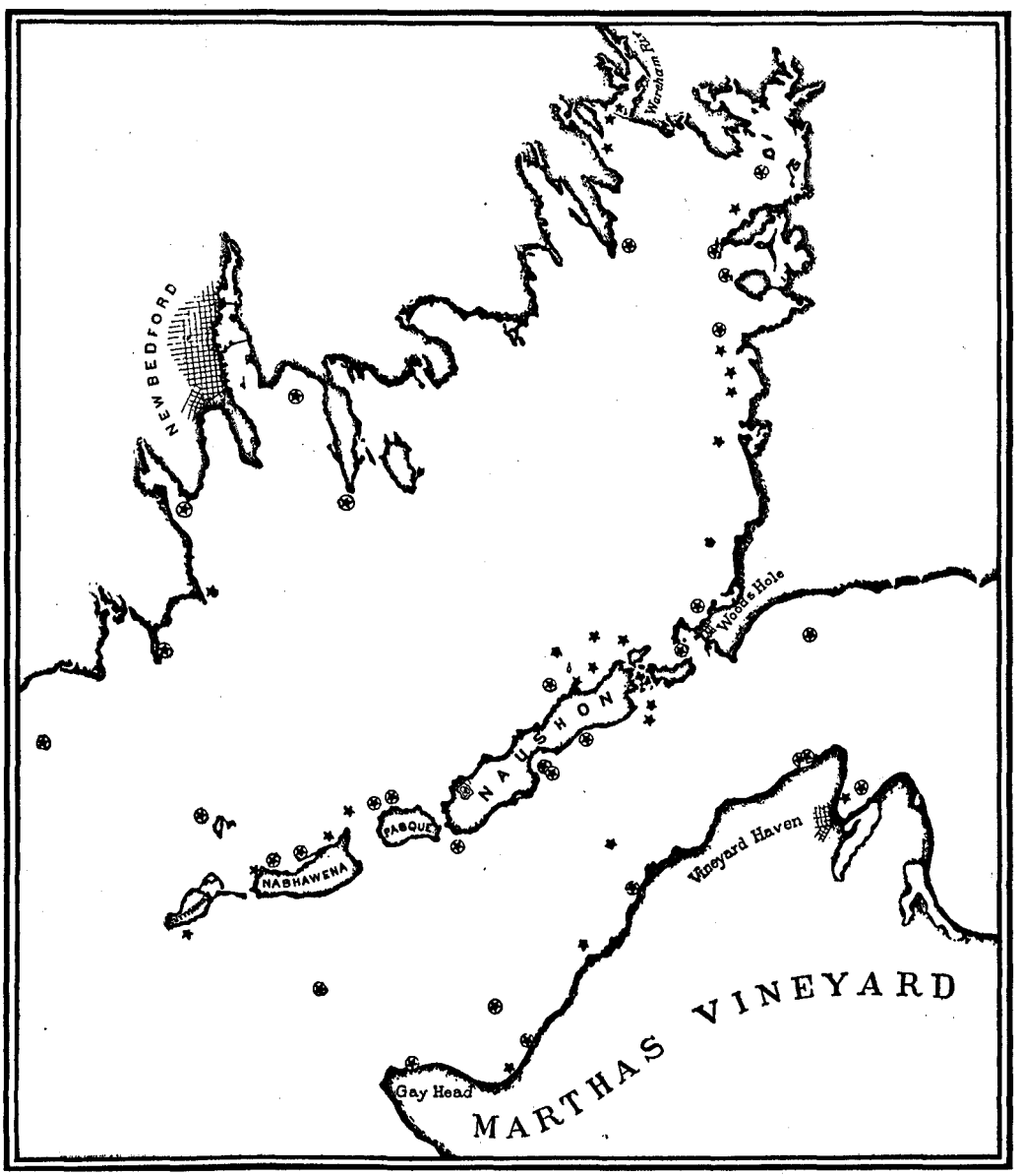

FIG. 23.—Local distribution of *Crepidula convexa*, a smaller species than the preceding. The present species is most frequently taken upon the shells of the small hermit crab, *Pagurus longicarpus*. It is interesting to note, however, that the distribution of the mollusk appears to be almost wholly restricted to the adlittoral zone, while that of the crab is much more general (see fig. 26).

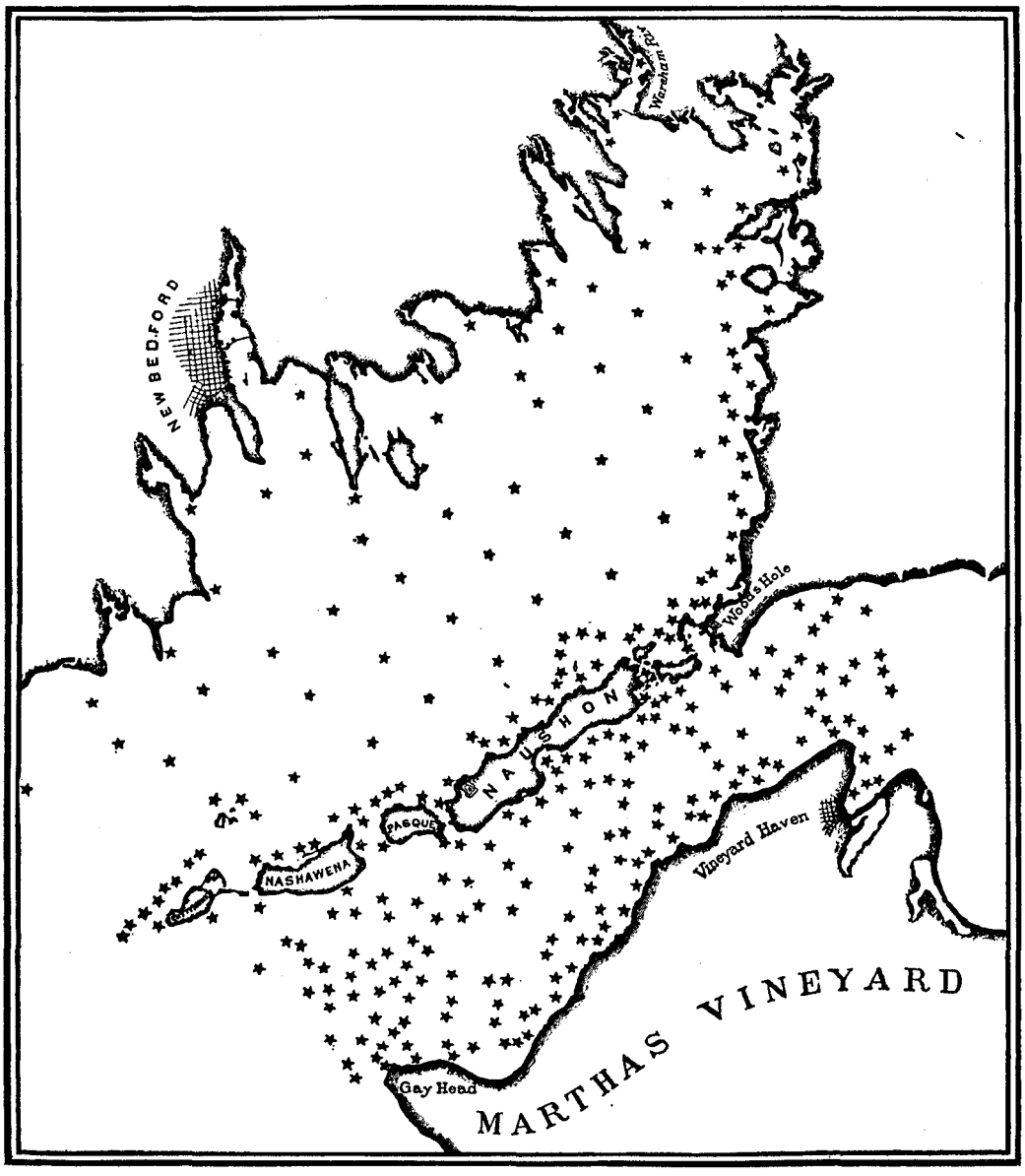

FIG. 24.—Local distribution of the hermit crab *Pagurus longicarpus*, whose range extends from Maine to Texas.

FIG. 25.—Local distribution of the hermit crab *Pagurus pollicaris*, whose range is from Cape Cod Bay to South Carolina.

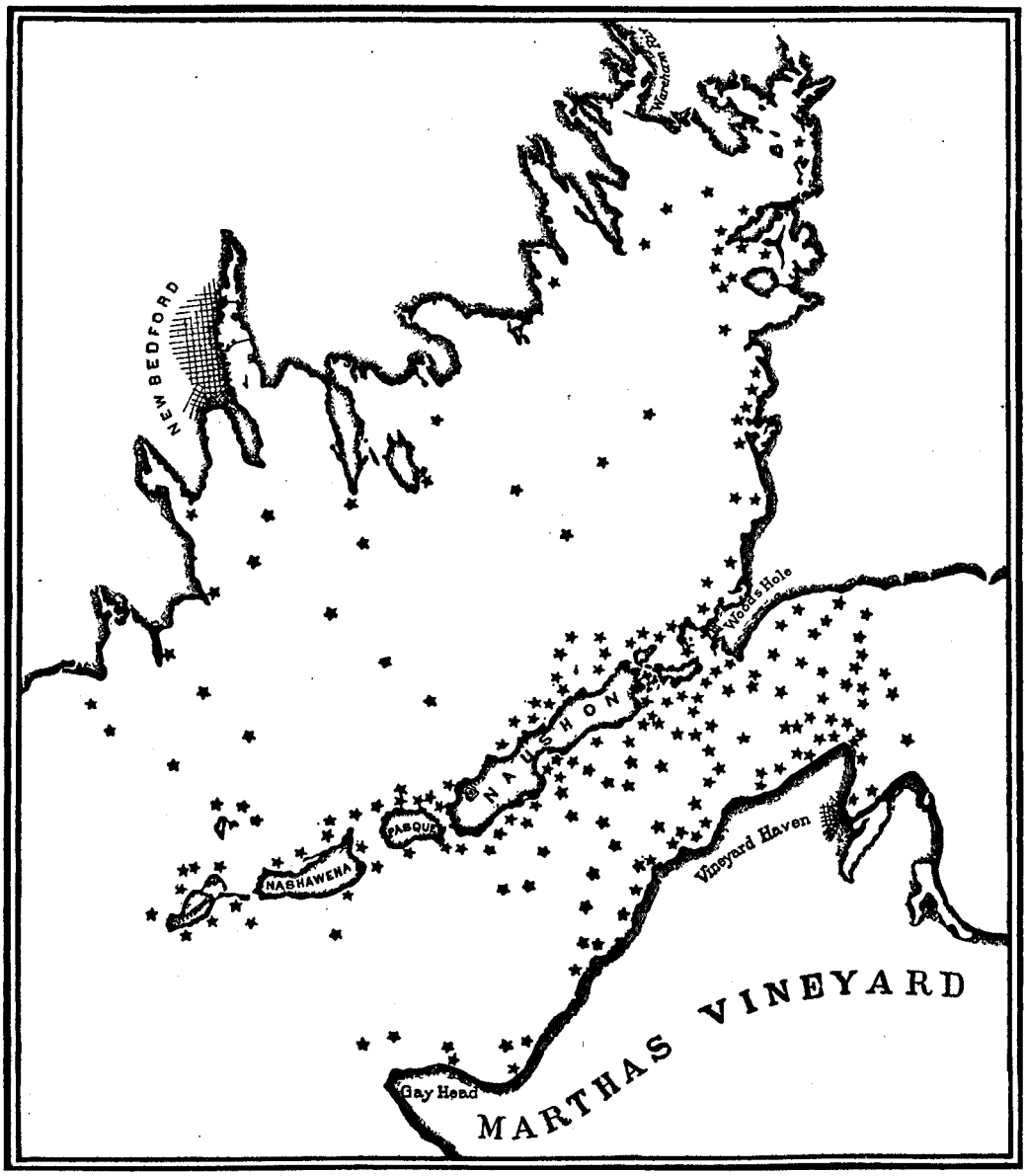

FIG. 26.—Local distribution of the hermit crab *Pagurus annulipes*, whose range is from Nantucket Sound to Florida. Note the absence of this species from the colder waters at the western end of Vineyard Sound, i. e., the very waters to which *P. acadianus* is restricted.

FIG. 27.—Local distribution of the hermit crab *Pagurus acadianus*, whose range is "from the Grand Bank of Newfoundland to the mouth of Chesapeake Bay."

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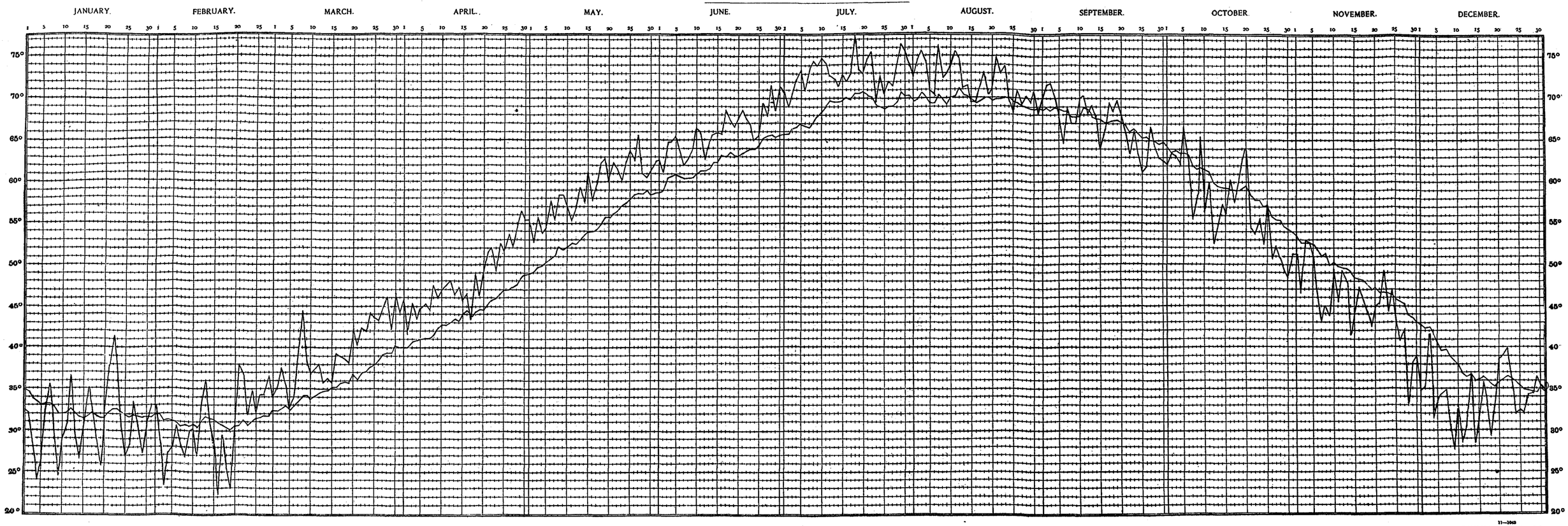
DIAGRAM SHOWING MEAN AIR AND WATER TEMPERATURE AT WOODS HOLE, MASS., FOR EACH DAY OF THE YEAR, 1902-1906, INCLUSIVE.

The less regular line represents Air Temperature, the more regular one, Water Temperature.



11—1063
THE NORRIS PETERS CO., WASHINGTON, D. C.

CHART OF VINEYARD SOUND AND BUZZARDS BAY

SHOWING

DEPTH AND CHARACTER OF BOTTOM AT DREDGING STATIONS OF U.S. FISHERIES STEAMERS FISH HAWK AND PHALAROPE DURING THE SUMMERS OF 1903, 1904, AND 1905

70°50'

70°40'

41°40'

41°30'

41°20'

NEW BEDFORD

Wareham River

Knob

Round

Dry Ledge Buoy

Kings Neck Lt.

Bird I. Lt.

Bow Bells Buoy

Ned Pt. Lt.

MATTAPOISETT HARBOR

Angelica Pt.

Spindle

Cataumet Harbor

Tank

Fairhaven

Palmers I. Lt.

Egg I.

NASKETUCKET BAY

SCONTICUT NECK

Ram I.

Cormorant Rock

West I.

Lt. Butler Flats

Clark Pt.

Fort

West Falmouth

Black Rock Spindle

Sippowissett Hotel

Water Tower

Falmouth

Observatory

Round Hill Pt.

Lt. Dumpling Rocks

Quisset Harbor

Weepecket Rock

Weepecket I.

Woods Hole

Nonamesset I.

Naushon

Barneys Joy Pt.

Mishaum Pt.

Robinsons Hole

Lone Rock Buoy

Naushon S.W.

Middle Ground

West Chop

East Chop

Vineyard Haven

Water Tower

Nortons Pt.

Pauls Pt.

Cedar Tree Neck

Indian Hill

Lucas Shoal

Kopeecon Pt.

Prospect Hill

Hen and Chicken Light Vessel

Penikese I.

Gull I.

Quicks Hole

PASQUE I.

NASHAWENA I.

CUTTYHUNK I.

Saw and Pigs Reef

Gay Head Lt.

Menemsha Bight

MARTHAS VINEYARD

EXPLANATION OF SYMBOLS

- Stones or Rocks.
- Gravel or Pebbles.
- Sand.
- Mud.
- Shells.
- Light house.
- △ C. and G. S. Triangulation station.

Depth in fathoms at each station indicated by the number in parenthesis.

Nautical Miles

½ 0 1 2 3

W F H. DEL

NOTE
Based on C. & G. S. Charts.

THE NORRIS PETERS CO., WASHINGTON, D. C.