
SECTION I.

PART V.—CRUSTACEANS, WORMS, RADIATES, AND SPONGES.

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ANALYSIS.

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Y.—CRUSTACEANS.

221. THE CRABS.

THE FIDDLER CRABS—*GELASIMUS PUGNAX*, Smith; *GELASIMUS PUGILATOR*, Latreille; *GELASIMUS MINAX*, Le Conte.

Three species of Fiddler Crabs occur upon the Atlantic coast of the United States, and are frequently utilized as bait. Congregating together in immense numbers, as they often do, and excavating their holes generally in convenient localities, above the reach of the tides, they might be easily collected in large quantities, were they better appreciated by the fishermen. Most dwellers upon the sea-shore are acquainted with that peculiarity of the Fiddler Crabs which has given to them their common name, and by which they are readily distinguished from our other Crabs. The males are provided with two very unequal claws, one being of large, the other of quite small size, in comparison with the size of the animal. Of these, the larger claw has been likened to a fiddle and the smaller one to a bow; hence the derivation of the name. The claws of the females are, however, of equal and small size.

The three species mentioned as living upon the Atlantic coast are *Gelasimus minax*, *G. pugnax*, and *G. pugilator*. The former species, which is the largest, ranges from the southern coast of New England to Florida, and lives upon salt marshes, usually farther from the sea than the others, and frequently where the water is nearly fresh. *G. pugnax* ranges from Cape Cod to Florida, and also occurs in the Gulf of Mexico and among the West Indies. "It makes its burrows only upon salt marshes, but is often seen in great companies wandering out upon muddy or sandy flats, or even upon the beaches of the bays and sounds." *G. pugilator* ranges from Cape Cod to Florida, upon muddy and sandy flats and beaches. Professor Verrill describes the habits and characteristics of these species as follows: ¹

"We find several species of Crabs burrowing in muddy banks along the shores of the estuaries, as well as along banks of the streams and ditches of the salt marshes. The most abundant of these is the marsh Fiddler Crab, *Gelasimus pugnax*, which is often so abundant that the banks are completely honeycombed and undermined by them. These holes are of various sizes up to about three-quarters of an inch in diameter, and descend more or less perpendicularly, often to the depth of two feet or more. Occasionally in summer these Crabs will leave their holes and scatter over the surface of the marshes, which at times seem to be perfectly alive with them, but when disturbed they will scamper away in every direction and speedily retreat to their holes; but occasionally, at least, they do not find their own, for sometimes the rightful owner will be seen forcibly ejecting several intruders. It is probable that at such times of general retreat each one gets into the first hole that he can find. Associated with this 'Fiddler,' another related Crab, the *Sesarma reticulata*, is occasionally found in considerable numbers. This is a stout-looking, reddish-brown crab, with a squarish carapax; its large claws are stout and nearly equal in both sexes, instead of being very unequal, as in the male 'Fiddlers.' It lives in holes like the 'Fiddlers.'

¹ Report upon the Invertebrate Animals of Vineyard Sound, etc., in Report United States Fish Commissioner for 1871-'72, pp. 336, 466.

but its holes are usually much larger, often an inch or an inch and a half in diameter. It is much less active than the 'Fiddlers,' but can pinch very powerfully with its large claws, which are always promptly used when an opportunity occurs.

"On the marshes farther up the estuaries, and along the mouths of rivers and brooks, and extending up even to places where the water is quite fresh, another and much larger species of 'Fiddler Crab' occurs, often in abundance; this is the *Gelasimus minax*. It can be easily distinguished by its much larger size and by having a patch of red at the joints of the legs. Its habits have been carefully studied by Mr. T. M. Prudden, of New Haven, who has also investigated its anatomy. According to Mr. Prudden, this species, like *Gelasimus pugilator*, is a vegetarian. He often saw it engaged in scraping up and eating a minute green algal plant which covers the surface of the mud. The male uses its small claw exclusively in obtaining its food and conveying it to the mouth. The female uses either of her small ones indifferently. In enlarging its burrows, Mr. Prudden observed that these Crabs scraped off the mud from the inside of the burrow by means of the claws of the ambulatory legs, and, having formed the mud into a pellet, pushed it up out of the hole by means of the elbow-like joint at the base of the great claw, when this is folded down. He also ascertained that this Crab often constructs a regular oven-like arch of mud over the mouth of its burrow. This archway is horizontal, and large and long enough to contain the Crab, who quietly sits in this curious doorway on the lookout for his enemies of all kinds.

"This species can live out of water and without food for many days. It can also live in perfectly fresh water. One large male was kept in my laboratory in a glass jar, containing nothing but a little siliceous sand moistened with pure, fresh water, for over six months. During this whole period he seemed to be constantly in motion, walking round and round the jar and trying to climb out. He was never observed to rest or appear tired, and after months of confinement and starvation was just as pugnacious as ever.

"Although some of the colonies of this species live nearly or quite up to fresh water, others are found farther down on the marshes, where the water is quite brackish, and thus there is a middle ground where this and *G. pugnax* occur together. This was found by Mr. Prudden to be the case both on the marshes bordering West River and on those of Mill River, near New Haven. They are abundant along both these streams. The holes made by this species are much larger than those of *G. pugnax*. Some of them are from an inch and a half to two inches in diameter.

"On sandy beaches near high-water mark, especially where the sand is rather compact and somewhat sheltered, one of the 'Fiddler Crabs,' *Gelasimus pugilator*, is frequently found in great numbers, either running actively about over the sand, or peering cautiously from their holes, which are often thickly scattered over considerable areas. These holes are mostly from half an inch to an inch in diameter, and a foot or more in depth, the upper part nearly perpendicular, becoming horizontal below, with a chamber at the end. Mr. Smith, by lying perfectly still for some time on the sand, succeeded in witnessing their mode of digging. In doing this they drag up pellets of moist sand, which they carry under the three anterior ambulatory legs that are on the rear side, climbing out of their burrows by means of the legs of the side in front, aided by the posterior leg of the other side. After arriving at the mouth of their burrows and taking a cautious survey of the landscape, they run quickly to the distance often of four or five feet from the burrow before dropping their load, using the same legs as before and carrying the dirt in the same manner. They then take another careful survey of the surroundings, run nimbly back to the hole, and after again turning their pedunculated eyes in every direction suddenly disappear, soon to reappear with another load. They work in this way both in the night and in the brightest sunshine, whenever the tide is out and the weather is suitable. In coming out or going into their

burrows either side may go in advance, but the male more commonly comes out with the large claw forward. According to Mr. Smith's observations this species is a vegetarian, feeding upon the minute algæ which grows upon the moist sand. In feeding, the males use only the small claw, with which they pick up the bits of algæ very daintily; the females use indifferently either of their small claws for this purpose. They always swallow more or less sand with their food. Mr. Smith also saw these Crabs engaged in scraping up the surface of the sand where covered with their favorite algæ, which they formed into pellets and carried into their holes, in the same way that they bring sand out, doubtless storing it until needed for food, for he often found large quantities stored in the terminal chamber."

As above stated, the Fiddler Crabs are sometimes used as bait; and at the mouth of the Mississippi River *G. pugnax* has been observed, in connection with the river Cray-fish (*Cambarus*), burrowing into and greatly damaging the levees.

YELLOW SHORE-CRAB OF THE PACIFIC COAST—*HETEROGRAPSUS OREGONENSIS*, Stm.

PURPLE SHORE-CRAB OF THE PACIFIC COAST—*HETEROGRAPSUS NUDUS*, Stm.

According to W. N. Lockington, these two species are by far the most abundant of all the California coast Crabs; but they are only eaten by the Chinese. The body of these Crabs is nearly square, and the claws large in proportion. In *H. oregonensis* the anterior half of the lateral margins on each side has two rather deep indentations, resulting in the formation of two large spine-like projections, which bend strongly forward; in *H. nudus* these characters are less pronounced. The four posterior pairs of limbs in *H. oregonensis* are also more or less hairy, while in *H. nudus* they are naked. The general color of the former species is yellow, of the latter purple; *H. nudus* also has marbled hands and attains a somewhat larger size than *H. oregonensis*, measuring at times two inches broad. Hundreds of one or other of these species of both sexes and of all sizes may frequently be found together, congregated under a single stone. *H. oregonensis* is especially abundant in muddy sloughs of salt or brackish water, where it literally swarms. Hundreds of uplifted threatening claws welcome the intruder who ventures near these mud flats when the tide is out. Both species occur at Puget Sound, and range thence southward to the southern limit of California. *H. nudus* also occurs at the Sandwich Islands. Both species are eaten to some extent by the Chinese, who spit them on wires and cook them over their fires.

THE OYSTER-CRAB—*PINNOTHERES OSTREUM*, Say.

"The 'Oyster-crab,' *Pinnotheres ostreum*, is found wherever oysters occur. The female lives, at least when mature, within the shell of the oyster, in the gill cavity, and is well known to most consumers of oysters. The males are seldom seen, and rarely, if ever, occur in the oyster. We found them, on several occasions, swimming actively at the surface of the water in the middle of Vineyard Sound. They are quite unlike the females in appearance, being smaller, with a firmer shell, and they differ widely in color, for the carapax is dark brown above, with a central dorsal stripe and two conspicuous spots of whitish; the lower side and legs are whitish. The female has the carapax thin and translucent, whitish, tinged with pink."¹

This Crab has been recorded from the Atlantic coast from Massachusetts to South Carolina. The females measure, when adult, about half an inch broad and a little less in length. From the European Oyster-crab (*Pinnotheres pisum*) our species differs in having a thinner and more membranaceous shell and a larger size. The colors are also different in the two species.

¹ VERRILL: Vineyard Sound Report, p. 367, 1871-'72.

Pinnotheres ostreum is eaten both raw and cooked, either along with the oysters with which it is associated, or as a separate dish. It is also pickled for domestic use and for the trade.

Another species of *Pinnotheres* (*P. maculatum*) frequently occurs in the shells of the common sea-mussel (*Mytilus edulis*) and the smooth scallop (*Pecten tenuicostatus*), between the gills of the animal. It attains a larger size than the Oyster-crab, and, as in the case of the latter, the females alone are parasitic, the males having only been found swimming at the surface of the sea. We have never heard of this species being eaten, probably because neither the mussel nor the smooth scallop has ever been used much as food in this country. In the summer of 1880, while dredging off Newport, Rhode Island, the United States Fish Commission steamer Fish Hawk came upon extensive beds of the smooth scallop, from a bushel of which nearly a pint of these Crabs were obtained. Again, in 1881, the same species was encountered in great abundance by the same party, in Vineyard Sound, in *Mytilus edulis*. As an experiment, they were cooked along with the mussels and found to be very palatable, although their shell is, perhaps, somewhat harder than that of *Pinnotheres ostreum*.

A third species of *Pinnotheres* occurs upon the west coast of the United States, in the shells of *Pachydesma* and *Mytilus californianus*.

THE ROCK CRAB—*CANCER IRRORATUS*, Say.

DISTRIBUTION AND HABITS.—This is the common Crab of the New England coast, where adult specimens occur in all depths of water from low-tide level to about twelve fathoms. Smaller specimens have, however, been obtained in from thirty to fifty fathoms, both near the coast and on George's Bank, Stellwagen's Bank, and elsewhere. Its entire range, so far as determined, is from the Straits of Belle Isle, Labrador, to South Carolina. In the Gulf of Saint Lawrence it is exceedingly abundant, but south of New Jersey it is rare. According to Prof. S. I. Smith,¹ this species is not common in the muddy bays of the New Jersey coast, but is thrown up in large numbers upon the sandy outer beaches; it is abundant on the sandy shores of the southern side of Long Island, and on the sandy and rocky shores of Long Island Sound; it is equally abundant, in similar situations, along all the rest of the south coast of New England and in Cape Cod, Massachusetts, and Casco Bays, but is apparently less common in the Bay of Fundy and at Halifax, Nova Scotia. "When found living between tides it is usually concealed among rocks or buried beneath the sand. It is usually much more abundant at or just below low-water mark, however, than between tides."

"The common 'Rock Crab,' *Cancer irroratus*, is generally common under the large rocks near low-water mark, and often lies nearly buried in the sand and gravel beneath them. It can be easily distinguished by having nine blunt teeth along each side of the front edge of its shell or carapax, and by its reddish color sprinkled over with darker brownish dots. This crab also occurs in the pools, where the comical combats of the males may sometimes be witnessed. It is not confined to rocky shores, but is common also on sandy shores, as well as on rocky and gravelly bottoms off shore. It is widely diffused along our coast, extending both north and south, and is common even on the coast of Labrador. Like all the other species of crabs, this is greedily devoured by many of the larger fishes, such as cod, haddock, tautog, black bass, and especially by sharks and sting-rays."²

EXTERNAL CHARACTERS.—The carapax of the Rock Crab is transversely suboval in outline, and about two-thirds as long as broad; the upper surface is moderately convex, with unequal

¹Trans. Conn. Acad., v, p. 38, 1879.

²VERBILL: Vineyard Sound Report, p. 312, 1871-'72.

but symmetrically arranged mammillations, some of which are scarcely defined. The surface appears nearly smooth, but is really covered with closely-placed, minute granulations. The eyes stand on short, stout peduncles, which lie in deep circular holes on either side of the middle of the front margin. Between the eyes there are three small teeth, and on each side, between the eyes and the outer edge of the shell, the margin is indented to form five broad and stout teeth. The claws are rather short and stout, the inner margins of the fingers bearing each a row of few, large, blunt, and sometimes double tubercles. The four posterior pairs of legs are similar to one another, long and slender, with pointed tips. The ground color of the carapax is yellowish, closely dotted with dark purplish-brown, which becomes a reddish-brown after death.

The only species of Crab upon our Atlantic coast which could possibly be confounded with the present one is *Cancer borealis*, of which a description is given following this. The differences between the two species being once pointed out, there is no difficulty in distinguishing between them.

ECONOMIC VALUE.—The Rock Crab is not much in demand as an article of food. It is sold to some extent in the markets at Boston, New Bedford, Newport, New York, and perhaps elsewhere within the limits of its range, generally, if not always, in a hard-shell condition. But even in Boston, where it could be easily supplied, its place is mainly taken by the common edible Blue Crab (*Callinectes hastatus*), which is sent there fresh from New York and other localities. The two species of *Cancer* are, however, more nearly related to the English edible Crab (*Cancer pagurus*) than is our own common edible Crab, and, were this kind of food more appreciated by the American seacoast inhabitants, there is no reason why the Rock Crab, as well as the "Jonah," should not be utilized to a very great extent. In some places, Newport for instance, the two species of *Cancer*, but especially the *Cancer borealis*, are preferred to the *Callinectes hastatus*, but this is not the rule elsewhere.

DEVELOPMENT.—The following account of the growth and development of this Crab, by Prof. S. I. Smith, will suffice, in a general way, for nearly all the American species of Crabs, and will serve to indicate the curious changes which take place before the simple crab egg becomes a well-developed Crab. Such an account as this becomes very valuable in many cases as a means of pointing out the essential details to be followed in the artificial breeding of marine animals.

"All, or at least nearly all, the species of Crabs living on the coast of New England pass through very complete and remarkable metamorphoses. The most distinct stages through which they pass were long ago described as two groups of crustaceans, far removed from the adult forms of which they were the young. The names *Zoea* and *Megalops*, originally applied to these groups, are conveniently retained for the two best marked stages in the development of the Crabs.

"The young of the common Crab (*Cancer irroratus*), in the earlier or zoea stage, when first hatched from the egg, are somewhat like the form figured [reproduced on one of the plates at the end of this volume], but the spines upon the carapax are all much longer in proportion, and there are no signs of the abdominal legs or of any of the future legs of the *Megalops* and Crab. In this stage they are very small, much smaller than in the stage figured. After they have increased very much in size, and have molted probably several times, they appear as in the figure just referred to. The terminal segment of the abdomen, seen only in a side view in the figure, is very broad and divided nearly to the base by a broad sinus; each side the margins project in long, spiniform, diverging processes, at the base of which the margin of the sinus is armed with six to eight spines on each side. When alive they are translucent, with deposits of dark pigment forming spots at the articulations of the abdomen and a few upon the cephalothorax and its appendages. In this stage they were taken at the surface in Vineyard Sound, in immense

numbers, from June 23 to late in August. They were most abundant in the early part of July, and appeared in the greatest numbers on calm, sunny days.

"Several Zoea of this stage were observed to change directly to the megalops form. Shortly before the change took place they were not quite as active as previously, but still continued to swim about until they appeared to be seized by violent convulsions, and after a moment began to wriggle rapidly out of the old zoea skin, and at once appeared in the full megalops form. The new integument seems to stiffen at once, for in a very few moments after freeing itself from the old skin the new Megalops was swimming about as actively as the oldest individuals.

"In this megalops stage the animal begins to resemble the adult. The five pairs of cephalothoracic legs are much like those of the adult, and the mouth-organs have assumed nearly their final form. The eyes, however, are still enormous in size, the carapax is elongated and has a slender rostrum and a long spine projecting from the cardiac region far over the posterior border, and the abdomen is carried extended, and is furnished with powerful swimming-legs, as in the *Macroua*. In color and habits they are quite similar to the later stage of the Zoea from which they came; their motions appear, however, to be more regular and not so rapid, although they swim with great facility. In this Megalops the dactyli of the posterior cephalothoracic legs are styliform, and are each furnished at the tip with three peculiar setae of different lengths and with strongly curved extremities, the longest one simple and about as long as the dactylus itself, while the one next in length is armed along the inner side of the curved extremity with what appear to be minute teeth, and the shortest one is again simple.

"According to the observations made at Wood's Holl, the young of *Cancer irroratus* remain in the Megalops stage only a very short time, and at the first molt change to a form very near that of the adult. Notwithstanding this, they occurred in vast numbers, and were taken in the towing-nets in greater quantities even than in the zoea stage. Their time of occurrence seemed nearly simultaneous with that of the Zoea, and the two forms were almost always associated. The exact time any particular individual remained in this stage was observed only a few times. One full-grown Zoea obtained June 23, and placed in a vessel by itself, changed to a Megalops between 9 and 11.30 a. m. of June 24, and did not molt again till the forenoon of June 27, when it became a young Crab of the form described farther on. Of the two other Zoea obtained at the same time, and placed together in a dish, one changed to a Megalops between 9 and 11.30 a. m. of June 24, the other during the following night; these both changed to Crabs during the night of June 26 and 27.

"In the two or three instances in which the change from the Megalops to the young Crab was actually observed, the Megalops sank to the bottom of the dish and remained quiet for some time before the molting took place. The muscular movements seemed to be much less violent than in the molting at the close of the zoea stage, and the little Crab worked himself out of the megalops skin quite slowly. For a short time after their appearance the young Crabs were soft and inactive, but the integument very soon stiffened, and in the course of two or three hours they acquired all the pugnacity of the adult. They swam about with ease and were constantly attacking each other and their companions in the earlier stages. Many of the deaths recorded in the above memorandum were due to them, and on this account they were removed from the vessel at each observation. In this early stage the young Crabs are quite different from the adult. The carapax is about three millimeters long and slightly less in breadth. The front is much more prominent than in the adult, but still has the same number of lobes and the same general form. The anterolateral margin is much more longitudinal than in the adult, and is armed with the five normal teeth, which are long and acute, and four very much smaller secondary teeth alternating with the

normal ones. The antennæ and ambulatory legs are proportionally longer than in the adult. The young Crabs in this stage were once or twice taken in the towing-net, but they were not common at the surface, although a large number were found, with a few in the megalops stage, among hydroids upon a floating barrel in Vineyard Sound, July 7."¹

THE JONAH CRAB—*CANCER BOREALIS*, Stimpson.

AFFINITIES.—The "Jonah Crab" is very closely related to the common Rock Crab, and is also to some extent associated with it in its distribution. The two species are so much alike in shape and general characters that they were originally regarded as the male and female respectively of one and the same species. They are, however, quite distinct, and after the differences have been once noticed there is no difficulty in distinguishing between them. The Jonah Crab differs from the Rock Crab in the much larger size of adult specimens, in the rougher surface of the carapax and claws, caused by the larger granules covering it, which are of irregular size, some being much larger than others, and by the serrations of the antero-lateral margins being crenate and the posterior ones armed with numerous sharp points, instead of being simple as in the Rock Crab. The legs of the Jonah Crab are also proportionately shorter and heavier than those of the Rock Crab. The color of *Cancer borealis* is yellowish beneath and brick-red above, the limbs corresponding more or less in coloration with the lower surface, but of a light reddish tint above.

DISTRIBUTION AND HABITS.—Besides being found in moderately deep water, the Jonah Crab, in certain localities, inhabits the rocks near low-tide level, in the clear waters of the ocean shores, but it never occurs in muddy or sandy bays and harbors where the Rock Crab abounds. The range of *Cancer borealis* is from the eastern end of Long Island Sound to Nova Scotia, but it is not found everywhere within these limits, being apparently local in its distribution and abundant only within certain more or less restricted areas. The principal localities where it has been observed are as follows: off Noank, Connecticut; off Watch Hill and Newport, and in Narragansett Bay, Rhode Island; Vineyard Sound, Noman's Land, and Salem, Massachusetts; Casco Bay, Maine; Bay of Fundy and Nova Scotia. In 1880, the United States Fish Commission found the Jonah Crab abundant everywhere in the lower part of Narragansett Bay from about low-tide level down to the greatest depths of the bay, and it was likewise very common off the bay, and off the north end of Block Island. The following account of the habits and distribution of this species is taken from Prof. S. I. Smith's account:²

"In habits this species differs very greatly from *irroratus*. The best opportunities which I have had for observing it were at Peak's Island, in Casco Bay, August and September, 1873. Empty carapaces, chelipeds, etc., of *borealis* were at first found in abundance scattered along the outer shores, far above the action of the waves, where they had evidently been carried by gulls and crows, and were also found in considerable numbers half a mile from the shore, in a forest of coniferous trees thickly inhabited by crows. For several weeks no living specimens of *borealis* were discovered, although the *irroratus* was found living in abundance all about the island, without, however, its remains scarcely ever being found scattered about with those of *borealis*. The *borealis* was finally discovered in abundance at low water on the exposed and very rocky shores of the northern end of the island. At this locality, between eighty and ninety specimens, all females and many of them carrying eggs, were obtained in a single morning. They were all found in situations exposed to the action of the waves, and were either resting, entirely exposed, upon the bare rocks and ledges, or clinging to the seaweeds in the edge of the waves, or in the

¹ S. I. Smith, Vineyard Sound Report, pp. 530-533, 1871-'72.

² Trans. Conn. Acad., v, p. 40, 1879.

tide-pools. They were never found concealed beneath the rocks, where, however, *irroratus* abounded. It is a much heavier and more massive species than the *irroratus*, and is consequently much better adapted than that species to the situations in which it is found. So many individuals falling a prey to birds is evidently a result of the habit of remaining exposed between tides, although the heavy shell must afford much greater protection than the comparatively fragile covering of *irroratus* would afford to that species if similarly exposed. The *borealis* was also found at a somewhat similar locality, but more exposed to the sea, on Ram Island Ledge, a low reef open to the full force of the ocean. One specimen of moderate size was dredged in the ship channel between Peak's Island and Cape Elizabeth, in ten fathoms, rocky and shelly bottom, and specimens were several times captured in lobster-traps, set at a depth of eight or ten fathoms, among rocks. Specimens were also several times found in stomachs of the cod taken on the cod ledges.

"In the vicinity of Vineyard Sound, this species was not infrequently found thrown upon sandy beaches, but never upon beaches very far removed from rocky reefs. The following are the localities where it was seen in greatest numbers: Along the sandy beach of Martha's Vineyard, from Menemsha Bight to Gay Head; the rocky island of Cuttyhunk; and the rocky outer shores of Noman's Land, where dead specimens were found in considerable abundance. In the vicinity of Noank, Connecticut, it was occasionally found dead upon the shores, and was several times obtained from lobster-traps.

"The largest specimens I have seen are two males, of almost exactly the same size, one from Casco Bay, the other from near Noank, Connecticut. The carapax of the specimen from Casco Bay is three and one-half inches long and five and three-fourths inches broad."

ECONOMIC VALUE.—*Cancer borealis* is supplied to the Newport markets in small quantities during most of the summer months, and is much esteemed there as food, being considered by many preferable to the Blue Crab (*Callinectes hastatus*). It is taken by the fishermen on the shore and in shallow water.

NAME.—The term "Jonah Crab," which we have adopted here for this species, is the one by which it is commonly known in and about Narragansett Bay, Rhode Island, and to some extent also about Vineyard Sound, Massachusetts, but apparently not elsewhere. The origin of the name we have not been able to ascertain. In most localities where it occurs it is confounded by the fishermen with the commoner Rock Crab.

THE COMMON CRAB OF THE PACIFIC COAST—*CANCER MAGISTER*, Dana.

This is the largest of the edible species of Crabs of the Pacific coast of the United States, and likewise the most important. It is the only species commonly eaten in San Francisco, although two other species inhabiting the same region, and which are described further on (*Cancer productus* and *Cancer antennarius*), are also edible and of good flavor. The carapax of adult males usually measures from seven to nine inches in breadth and four to five inches in length; the females average much smaller. The color of the upper surface is a light reddish-brown, darkest in front; the limbs and under surface are yellowish. The anterior margin of the carapax forms a nearly regular elliptical curve, reaching back to about the middle of the sides and interrupted by nine slightly prominent, sharp teeth on each side. At the termination of this curve on each side, there is a strong, pointed tooth, projecting directly outward, and forming the commencement of the postero-lateral margins, which are long and slope abruptly backward so as to leave but a narrow posterior margin. The surface of the carapax is slightly convex, undulated, and covered with papillæ; the claws are strongly toothed above and ribbed at the sides.

This species has quite an extended range, having been recorded from Sitka, Alaska, in the north, and from Magdalena Bay, Lower California, in the south; but whether these are its extreme northern and southern limits or not is unknown. In the Bay of San Francisco it is very abundant, and large quantities are constantly captured and brought to the markets in that city; it is also taken for food in Monterey Bay, California.

It occurs most commonly on the sandy bottoms, below low-tide level, and is seldom found, at least to any extent, between tide-marks. The supplies sent to the San Francisco markets come mainly from the San Francisco side of the bay, especially from the south side of the Golden Gate, between the city and the sea. They are also taken in abundance from about the wharves and piers in the Bay of San Francisco. Crab-nets baited with fish and offal are used for catching them. Nothing is known regarding the spawning season and habits of this species. The fishermen say they spawn in March or April. The occurrence of a female with spawn in the San Francisco market has not yet been recorded by any naturalist.

THE RED CRAB—*CANCER PRODUCTUS*, Randall.

This is a very common species in the Bay of San Francisco, although less abundant than the last (*Cancer magister*). It also attains a large size, adult individuals measuring from five to seven or more inches in breadth across the carapax, and from two and a half to four inches in length. The proportion of width to length is rather greater in the males than in the females. The antero-lateral borders of the carapax form an ellipse, broken in the center in front by a slight projection, by which the specific name was suggested. The teeth of the front and of the antero-lateral borders are distinctly separate in the adult, but in the very young exist only as wrinklins of the edge of the carapax. The postero-lateral margins are concave and short. The claws are of medium size compared with the carapax, and the posterior limbs are slender and plain. The color of adult specimens is an intense dark red or reddish-brown above and yellowish-white below; the young differ from the adults in their more variable coloring, some being of a dark reddish-brown, others yellow spotted with red, and still others banded with red and yellow. The shape of the carapax, with its produced front, sufficiently distinguishes this species of *Cancer* from all the others on the Pacific coast.

Cancer productus is found along the entire Pacific coast of the United States, and has been recorded from Magdalena Bay, Lower California, and the Queen Charlotte's Islands and other localities, in British Columbia. It is very abundant in the Bays of San Francisco, Monterey, and Tomales, and also occurs at Santa Barbara and San Diego. Its habitat is in the shallow water along the shores, principally in rocky sections, and it is frequently found between tide-marks, often taking refuge in pools under stones near low-tide level.

Stimpson, in 1856, recorded seeing this species in the San Francisco markets, but it is no longer taken there, unless by accident or inadvertence, the larger and more abundant *Cancer magister* fully supplying the demands. In case of the latter becoming scarce, however, *Cancer productus* would become an important article of capture.

THE ROCK CRAB OF THE PACIFIC COAST—*CANCER ANTENNARIUS*, Stimpson.

This species is of about the same average size as *Cancer productus*, and is tolerably abundant along the Pacific coast, from Queen Charlotte's Islands, in the north, to Magdalena Bay, Lower California, in the south. Although as regards edible qualities it is said to compare favorably with *Cancer magister*, it has not, up to the present time, been brought to the San Francisco markets. The carapax of adult specimens measures three and a half or more inches in length,

and from five to six inches across. The carpus and hand of the big claws are smooth or nearly so, and the external antennæ are very large and hairy. The margins of the abdomen and of other parts of the lower surface of the body, as well as the ambulatory feet, are very hairy, and this character, together with the great length and hairiness of the antennæ, serves as the best distinguishing feature of the species. Young individuals are more hirsute than adults. The color of the carapax is a dark purplish brown; the chelipeds in adults are marbled with purplish spots.

The Pacific Rock Crab does not often occur on the shore between tides; it appears to frequent deeper water than either *Cancer magister* or *C. productus*, being abundant in from two to three fathoms, always, however, among rocks.

THE MUD CRABS—*PANOPEUS HERBSTII*, Edwards; *PANOPEUS DEPRESSUS*, Smith; *PANOPEUS SAYI*, Smith; *PANOPEUS HARRISII*, Stimpson.

Four species of the so-called Mud Crabs occur upon our Atlantic coast: *Panopeus Herbstii* ranges from Long Island Sound to Brazil, but is not common north of New Jersey; *P. depressus*, from Cape Cod to Florida, and often carried much farther north with oysters; *P. Sayi*, associated with the last and having the same range; *P. Harrisii*, from Massachusetts Bay to Florida. *P. Herbstii* is rather the larger species, specimens from Florida and the West Indies measuring fully two inches across the back. The color is a dark olive above, the fingers of the claws being black, though lighter at the tips. This species is occasionally sold as food in the New Orleans markets, and is sometimes used as bait. The other three species are more or less abundant in numerous localities where they could also be obtained as bait. Professor Verrill refers to them as follows:

"Two small kinds of Crabs are very abundant under the stones, especially where there is some mud. These are dark olive-brown and have the large claws broadly tipped with black. They are often called Mud Crabs on account of their fondness for muddy places. One of these, the *Panopeus depressus*, is decidedly flattened above, and is usually a little smaller than the second, the *Panopeus Sayi*, which is somewhat convex above. They are usually found together and have similar habits. A third small species of the same genus is occasionally met with under stones, but lives rather higher up toward high-water mark, and is comparatively rare. This is the *Panopeus Harrisii*. It can be easily distinguished, for it lacks the black on the ends of the big claws and has a groove along the edge of the front of the carapax, between the eyes. This last species is also found in the salt marshes, and was originally discovered on the marshes of the Charles River, near Boston. All the species of *Panopeus* are southern forms, extending to Florida, or to the Gulf coast of the Southern States, but they are rare north of Cape Cod, and not found at all on the coast of Maine. They contribute largely to the food of the tautog and other fishes."¹

THE STONE CRAB—*MENIPPE MERCENARIUS*, Gibbes.

This is one of the two edible species of Crabs occurring upon the Southern Atlantic coast of the United States, *Oallinectes hastatus* being the other and more important one, on account of its greater abundance. The recorded range of the Stone Crab is from Charleston Harbor, South Carolina, to Key West, Florida, but the so-called Stone Crabs of the Gulf of Mexico probably belong, in part at least, to the same species, and it has also been recently collected on the coast of North Carolina.

¹ Vineyard Sound Report, pp. 312, 313, 1871-'72.

The Stone Crab is much stouter and heavier than the Blue Crab, of more solid build, and with a much thicker shell-covering both on the body and claws. There is, moreover, no similarity between the two species. The carapax of adult individuals measures about three inches in length by about four and a half inches in width, and the body is from one and a half to two inches thick. The large claws, when folded against the front of the body, measure about seven inches from elbow to elbow. One claw is somewhat larger than the other.

Prof. Lewis R. Gibbes has kindly furnished the following notes on the habits of this species as observed in the vicinity of Charleston, South Carolina:

"They live in holes in the mud along the borders of the creeks and estuaries of the coast, and are taken by the hand, thrust down several inches, sometimes fifteen to twenty, to reach the inhabitant at the bottom, at the risk of a severe bite from one or both of its claws. They can also be found in the crevices between fragments of any solid material, occurring near their haunts, such as rejected stone ballast, fragments of brick thrown out as waste from houses or other structures in the city or vicinity. Again, they occur in similar situations along the breakwater, constructed some forty years ago to protect a part of the front beach of Sullivan's Island, at the mouth of the harbor, from the destructive action of the waves. They offer a stout resistance to being dragged from their chosen retreat, by firmly pressing their powerful claws against the walls of their abode. From their holes in the mud they are drawn with some difficulty, with a quantity of the mud adhering to them; and if the walls of their retreat are solid, and cannot be removed from around them, they cling to them with such tenacity that not unfrequently they are brought out piecemeal, first one claw, then the other, and finally the body."

Professor Gibbes further states that the Stone Crabs are highly esteemed as food, and preferred to the Blue Crab, as the meat of their large claws is more lobster-like in texture and flavor. From the difficulty of capturing them, however, they are much less common in the markets than the Blue Crab, and command a higher price. They are also apparently less abundant. Like the Blue Crab, they are constant dwellers upon our coast, and could doubtless be taken at all times during the year. Soft-shelled specimens are seldom if ever brought to market.

In the Gulf of Mexico, according to Mr. Silas Stearns, the Stone Crab is not so universally common as the Blue Crab, although it is found along the entire coast. It seems to be most abundant on the southern and western coasts of Florida where the bottom, being more rocky than elsewhere, is best suited to its habits. In this section it lives in cavities in the rocks, and in deep holes which it excavates in the sand. It attains a larger size than the Blue Crab, measuring in adult species one or two inches more across the carapax than the latter species. The people living upon the coast where the Stone Crab is so abundant and so large esteem it highly, and regard it as an important food supply. Owing to the persistent way in which it keeps on the bottom, and in its hiding places, it cannot be captured as easily as the other species. The most common method of capture is, after finding its hole or place of retreat, to run the hand and arm down quickly and drag it out. To one unversed in this practice it seems a dangerous operation, but it is not so. The crab lies in its hole with its claws uppermost or outermost, and considering its well-known slowness and clumsiness of action, a man's strong grip finds no difficulty in controlling them. In other parts of the Gulf, away from the Florida coast, visited by Mr. Stearns, he did not find the Stone Crabs nearly so abundant. They were mostly confined to oyster beds and stone heaps, and were inferior in size to the Florida specimens.

As the Stone Crabs generally live more or less buried beneath the bottom, their movements are probably less affected by tides and changes of temperature than the Blue Crabs. They have never appeared for sale in the markets of any of the larger cities and towns of the Gulf coast, on

account of the difficulty of procuring them. By those who have eaten them they are considered decidedly superior to the Blue Crab in flavor.

THE GREEN CRAB—*CARCINUS MÆNAS*, Leach.

This Crab, which is one of the most common species on the coast of Great Britain, also abounds upon our Atlantic coast, from Cape Cod to New Jersey and perhaps farther south. It is very abundant in Vineyard Sound, Buzzard's Bay, and Long Island Sound. The body is of a bright-green color, varied with spots and blotches of yellow, making it very conspicuous; adult specimens measure about two inches in width and one and a half inches in length. The surfaces of the carapax and limbs are more or less granulated.

"The Green Crab, *Carcinus mænas*, occurs quite frequently well up toward high-water mark, hiding under the loose stones, and nimbly running away when disturbed. It may also be found, at times, in the larger tidal pools. It often resorts to the holes and cavernous places under the peaty banks of the shores, or along the small ditches and streams cutting through the peaty marshes near the shore."¹

It is most abundant between tide-marks, or near low-water mark, and is seldom found below a very few fathoms in depth.

The Green Crab is an article of food in some parts of Europe, where it occurs abundantly. In England it is occasionally used as bait, especially while in a soft-shell state. It is said to be often very annoying to the salmon fishermen in that country. "Trout and mackerel are reduced to skeletons in a very short time, and grilse and salmon often rendered unfit for market by an unseemly scar, the work of these marauders."²

In this country, the Green Crab is frequently used as bait on the Southern New England coast, especially for the tautog. In Vineyard Sound and Buzzard's Bay it is known to the fishermen as the "Joe Rocker."

THE LADY CRAB—*PLATYONICHUS OCELLATUS*, Latreille.

The "Lady Crab," or "Sand Crab," is abundant on nearly all our sandy shores from Cape Cod to Florida, and in the Gulf of Mexico; it ranges from low-water mark to a depth of ten fathoms. This species is easily distinguished from all our other Crabs by the shape and color of its carapax, taken in connection with the character of its posterior pair of limbs, which are modified into swimming organs, as in the edible Crab. Its body is nearly as long as broad, the margins rudely indicating a six-sided figure. The front lateral margins bear five spines each, which are directed forward, and the front margin is deeply indented on each side of a slightly projecting three-spined rostrum, to form cavities for the eyes. The front limbs, those bearing the claws, are long and rather slender, and the succeeding three pairs are simple in their structure. "The color of this Crab is quite bright and does not imitate the sand on which it lives, probably owing to its mode of concealment. The ground-color is white, but the back is covered with annular spots formed by specks of red and purple. The Lady Crab is perfectly at home among the loose sands at low-water mark, even on the most exposed beaches. It is also abundant on sandy bottoms off shore, and as it is furnished with swimming organs on its posterior legs, it can swim rapidly in the water, and has been taken at the surface in several instances, and some of the specimens thus taken were of full size. When living at low-water mark on the sand beaches, it generally buries itself up to its eyes and antennæ in the sand, watching for prey, or on the lookout for enemies. If disturbed, it quickly glides backward and downward into the sand and disappears instantly.

¹ VEBBELL: Vineyard Sound Report, p. 312, 1871-'72.

² WHITE: Popular History of the British Crustacea.

This power of quickly burrowing deeply into the sand it possesses in common with all the other marine animals of every class which inhabit the exposed beaches of loose sand, for upon this habit their very existence depends during storms. By burying themselves deep they are beyond the reach of breakers.

"The Lady Crab is predaceous in its habits, feeding upon various smaller creatures, but, like most of the Crabs, it is also fond of dead fishes or any other dead animals. In some localities they are so abundant that a dead fish or shark will in a short time be completely covered with them; but if a person should approach they will all suddenly slip off backwards and quickly disappear in every direction beneath the sand. After a short time, if everything be quiet, immense numbers of eyes and antennae will be gradually and cautiously protruded from beneath the sand, and after their owners have satisfied themselves that all is well the army of Crabs will soon appear above the sand again and continue their operations."¹

This species is used as bait on many parts of the coast, especially about Vineyard Sound and Buzzard's Bay. It is also an important article of food at New Orleans, Louisiana, and is occasionally taken to the New York markets.

222. THE COMMON EDIBLE OR BLUE CRAB—*CALLINECTES HASTATUS*, Ordway.

DISTRIBUTION.—The common edible Crab of the eastern coast of the United States, generally termed "Blue Crab" at the North and "Sea Crab" at the South, ranges from Cape Cod to Florida, and also occurs in the Gulf of Mexico, and is occasionally taken in Massachusetts Bay. Next to the Lobster, it is the most important crustacean of our waters in a commercial point of view. There are several species of the genus *Callinectes* living upon the coast of the Southern States. *Callinectes hastatus*, the genuine Blue Crab, is positively known to occur as far south as Louisiana, and is probably the only species brought to the New York markets. *Callinectes ornatus* inhabits Charleston Harbor, South Carolina, and extends southward from there, but to what extent has not been determined. Two other species, *Callinectes larratus* and *C. tumidus*, have been recorded from Southern Florida and the West Indies. Which of these four species occurs in the greatest abundance in the Gulf of Mexico, and is there most commonly taken for food, we are unable to state, as no careful examination of market supplies from that region has ever been made.

EXTERNAL CHARACTERS.—The shell of the Blue Crab is about twice as broad as long, including the stout, sharp spines which project from each side. Between the spine of each side and the eye of that side the margin is armed with about eight short and acute spines, which are largest at the side and gradually decrease in size toward the eye. Between the eyes, which are placed in slight recesses, the margin forms four broad, unequal-sided teeth, with a median spine underneath. The front limbs, including the claws, are similar in shape but somewhat unequal in size; they have several strong sharp spines above. The three succeeding pairs of limbs are slender, similar to one another, and terminate in sharp points. The posterior pair, however, end in an expanded oval joint, especially adapted for swimming. The entire body of this species is considerably compressed, the carapax being only moderately convex above; the surface, excepting near the posterior margin, is covered with minute granulations, which are more numerous over some portions than over others. The entire margin of the carapax and abdomen is bordered with fine hairs, and most of the joints of the limbs are ornamented in the same way.

The abdomen of the female is very broad, and when not charged with eggs fills in the entire

¹ VERRILL: Vineyard Sound Report, p. 338, 1871-'72.

space between the bases of the posterior pairs of legs. During the spawning season, however, the eggs are so numerous and form such a large mass that they throw the abdomen some distance out from the lower surface of the body, causing it to project almost at right angles with the upper surface of the carapax. The upper surface of the shell and claws is of a dark-green color, and the lower surface of a dingy white; feet blue; tips of fingers and spines reddish.

HABITS, USES, ETC.—The following account of the habits of the Blue Crab is by Professor Verrill:

“The common edible Crab or ‘Blue Crab’ is a common inhabitant of muddy shores, especially in sheltered coves and bays. It is a very active species, and can swim rapidly. It is, therefore, often seen swimming at or near the surface. The full-grown individuals generally keep away from the shores, in shallow water, frequenting muddy bottoms, especially among the eel-grass, and are also found in large numbers in the somewhat brackish waters of estuaries and the mouths of rivers. The young specimens of all sizes, up to two or three inches in breadth, are, however, very frequent along the muddy shores, hiding in the grass and weeds or under the peaty banks at high water and retreating as the tide goes down. When disturbed they swim away quickly into deeper water. They also have the habit of pushing themselves backward into and beneath the mud for concealment. They are predaceous in their habits, feeding upon small fishes and various other animal food. They are very pugnacious, and have remarkable strength in their claws, which they use with great dexterity. When they have recently shed their shells they are caught in great numbers for the markets, and these ‘soft-shelled Crabs’ are much esteemed by many. Those with hard shells are also sold in our markets, but are not valued so highly. This Crab can easily be distinguished from all the other species found in this region by the sharp spine on each side of the carapax. . . . They are usually brought to market early in May, but the ‘soft-shelled’ ones, which are more highly esteemed, are taken later. These soft-shelled individuals are merely those that have recently shed their old shells, while the new shell has not had time to harden. The period of shedding seems to be irregular and long continued, for soft-shelled Crabs are taken nearly all summer. The young and half-grown specimens of this Crab may often be found in considerable numbers hiding in the holes and hollows beneath the banks during the flood tide. When disturbed, they swim away quietly into deeper water. These small Crabs are devoured by many of the larger fishes. During flood tide the large Crabs swim up the streams like many fishes and retreat again with the ebb. They feed largely on fishes, and often do much damage by eating fishes caught in set-nets, frequently making large holes in the nets at the same time.”¹

Besides devouring living animals, the Blue Crab “feeds on dead animal matter in its various stages of putrescence, and is one of the many depurators of the ocean. It often buries itself in the sand, so that no part is visible but the eyes and anterior antennæ; these last are then in continual motion, the bifid terminal joint acting as forceps to seize and convey to its mouth the small molluscons animals for food. The shell is cast annually, and they are then known by the name of ‘soft-shell Crab,’ are very delicate, and in particular request for the table. In this state the Crab is incapable of any defense from its enemies; the male usually retires to a secluded situation for security, but the adult female is protected by a male whose shell is hard. They are then called double Crabs.”²

On different parts of the coast, Crabs in the soft state are known respectively as “Soft Crabs,” “Shedders,” or “Peelers.” The terms “Soft Crab,” “Paper-shell,” and “Buckler” denote the different stages of consistency of the shell, from the time of shedding until it has become nearly

¹Vineyard Sound Report, pp. 367, 368, 468, 1871-'72.

²SAY: Journ. Acad. Nat. Sci. Phila., i, p. 66, 1817.

hard again. For instance, immediately after shedding it is a "Soft Crab"; as the shell becomes slightly hardened it is called "Paper-shell," and just before reaching its normal hardness it is termed "Buckler."

Callinectes hastatus does not appear to be confined to salt and brackish water only, for it has been known to ascend the Saint John's River, Florida, a distance of one hundred miles, to where the water is sufficiently fresh for drinking.

According to Prof. Lewis R. Gibbes, of Charleston, South Carolina, the Blue Crab is abundant in and about Charleston Harbor, and is largely taken for food. Average-sized specimens measure about two and a half inches long and five to five and a half broad, including the lateral spines. It occurs, feeding and swimming on the bottom and between the bottom and the surface, in the deeper water of the harbor, and in the shallower waters of rivers and creeks. It is also found walking on the muddy borders of creeks or rivers, and on the marshes, when the tide is out. For market, these Crabs are occasionally taken by the fishermen in cast-nets while seeking fish, but the customary crab-net is a sort of dip-net attached to a pole. In the deeper water, it is sometimes necessary to entice the Crabs to the surface by means of bait attached to cords. Although Blue Crabs occur in this region more or less throughout the entire year, they are chiefly taken for the market in the spring and early summer months, as they are then in the best condition and most highly esteemed for their flavor. Both hard and soft shell individuals are eaten. They seem to be as common now as formerly.

Mr. Silas Stearns, of Pensacola, Florida, writes as follows concerning the habits, etc., of *Callinectes* in the Gulf of Mexico:

"The Blue Crab is more abundant than the Stone Crab, and is distributed along the entire Gulf coast. It is found out in the Gulf, in the bays and estuaries, and very often in fresh-water rivers and lakes that have close connection with some body of salt water. It lives in the shoaler waters during the summer months, from about April to November, and retires to the deeper water on the approach of cold weather, to remain half dormant until the first warm day or settled mild weather. Its first move in the spring is to the grass-covered shoals, where various kinds of fishes and other marine animals have just deposited their eggs, upon which it feeds greedily. All through the summer it is found in such places as these, acting both as a scavenger of decomposing animal matter and as one of the most dreaded enemies of small fish and their spawn. At high tide the Crabs come nearer to the shore than at low tide, and at all times the young are more venturesome than the old. Hiding under patches of seaweed, behind and under logs and roots of trees and in the sand, the young spend the period of high tide at the very water's edge.

"The period of spawning and shedding extends through several months, probably the entire summer, for some individuals are found loaded with spawn and others in a soft state during the whole season. This summer (1880), while at Saint Joseph's Bay, on this coast, I found large quantities of females, heavy with spawn, lying just at the edge of the surf on the sea-beach. They were quite inactive, and there were no males among them. While shedding its shell, and until the new shell has become sufficiently hard to protect it, the Blue Crab remains hidden in the mud or among seaweeds. This is the most active of all the Gulf species of Crabs. It swims easily and rapidly at the surface at times, and its movements at the bottom are remarkably swift. It is also very pugnacious, and not only fights its own kind, but also shows a bold front to its enemies, including man. The average size of the Blue Crab is about six inches broad across the shell.

"Being so common that people nearly everywhere along the coast can obtain any quantity for the mere trouble of capturing them, they have given rise to no defined industry excepting in

the larger cities. Outside of New Orleans, in fact, there is no regular trade in Blue Crabs. In the early spring they are trolled from deep water to within reach of a dip-net, by means of a piece of meat attached to a long string. Later in the season, when the water has become warmer, they may be dipped up with a dip-net all along the shore. About Pensacola, the catching of Crabs is classed among the sports. During warm summer evenings, parties of men, women, and children set out for secluded portions of the bay shore, where they pursue the Crabs, with torches and jigs or dip-nets, until they are tired. A midnight supper, made up mainly of the Crabs and fish they have taken, follows, and the enjoyment concludes with a moonlight sail homeward."

THE SPIDER CRABS—*LIBINIA EMARGINATA*, Leach; *LIBINIA DUBIA*, Edwards.

The Spider Crabs are inhabitants of shallow water along the Atlantic coast, from Western Maine to the Gulf of Mexico. The two species resemble one another very closely, but the *emarginata* is more thickly covered with spines than the *dubia*, which is also further distinguished by being narrower across the front, and by having a longer rostrum. As a rule, the latter species is found more commonly than the former in the very shallow water near shore, and its range is more restricted toward the north, not passing beyond Cape Cod.

Professor Verrill says of their habits, that "they are very common on muddy shores and flats. They hide beneath the surface of the mud and decaying weeds, or among the eel-grass, and are very sluggish in their motions. The whole surface of the body is covered with hairs, which entangle particles of mud and dirt of various kinds; and sometimes hydroids, algæ, and even barnacles grow upon their shells, contributing to their more-ready concealment. The males are much larger than the females, and have long and stout claws. They often spread a foot or more across the extended legs. The females have much smaller and shorter legs and comparatively weak claws."¹

The Spider Crabs are used as bait along the Middle Atlantic States, and probably elsewhere, within their range.

THE KELP CRAB—*EPIALTUS PRODUCTUS*, Randall.

The Kelp Crab of the Pacific coast is "easily recognized by its smooth quadrate carapax, with two distinct teeth on either side. It is the most common maoid Crab on the coast of California and Oregon, and is usually found among seaweeds on rocks, just below low-water mark. Its color is olivaceous when alive."²

This Crab is occasionally taken for food by the natives along the coast, but apparently has not yet found its way into the San Francisco markets. It has been especially recorded from Puget Sound, the mouth of the Columbia River, the Farallone Islands, Tomales Bay, entrance to San Francisco Bay, and Monterey.

THE RED ROCK CRAB—*ECHIDNOCEROS SETIMANUS*, Stimpson.

This is quite a large and very ornamental red Crab, which is not eaten, but is occasionally sold in the San Francisco markets as a curiosity. It is procured in moderately deep water about the Farallone Islands, which lie a short distance off the coast at San Francisco, California. The body of adult specimens measures about ten inches both in length and breadth, and the weight of such specimens is between six and seven pounds. The carapax is convex and exceedingly uneven, being covered with large tubercles and granules. The front and lateral margins on each side bear about eight principal teeth, and the beak is four-lobed. The right claw is much larger than the left, and both are covered with tufts of hair, and armed with teeth and tubercles. The

¹ Vineyard Sound Report, p. 363, 1871-'72.

² STIMPSON: Journ. Boston Soc. Nat. Hist., vi, p. 457, 1857.

ground color of the body is vermilion, the granules and spines being generally of a deep blue or purple; the entire carapax is covered with minute bristles. According to Dr. William Stimpson, who wrote concerning this Crab in 1857, specimens of this species then readily sold in the San Francisco market for five and ten dollars each. A certain demand for them still continues, but they are apparently brought to market only occasionally.

THE SAND BUG—HIPPA TALPOIDA, Say.

This is rather an odd species of Crab, related to the Hermit Crabs, from which, however, it differs greatly in appearance. The body is oval in outline and more than half as broad as long, the sides forming a nearly regular curve. The upper part of the body, formed mostly of the cephalo-thorax, is convex and rather plain, giving a decidedly bug-like appearance to the creature, as suggested by its common name. The tail, which is long and broad, is pressed up against the under surface of the body, reaching nearly to the front. The eyes are minute and placed at the ends of long, slender peduncles; the principal antennæ are about as long as the carapax, and are curved and strongly plumose.

"This species burrows like a mole, head first, instead of backward. It can also swim quite actively, and is sometimes found swimming about in the pools left on the flats at low water. It is occasionally dug out of the sand at low-water mark, and is often thrown up by the waves on sand-beaches, but it seems to live in shallow water on sandy bottoms in great numbers, for in seizing on one of the sand-beaches near Wood's Holl for small fishes, a large quantity of this species was taken. Its color is yellowish-white, tinged with purple on the back. It is one of the favorite articles of food of many fishes. Mr. Smith found the young abundant at Fire Island, near high water, burrowing in the sand. This species is still more abundant farther south."¹

The Sand Bug ranges from Cape Cod to Florida, but is much more abundant toward the South than at the North. On the New Jersey coast, and probably at other places farther south, it is used by the fishermen as bait. It is frequently called by them the "Bait Bug."

THE HERMIT CRABS—EUPAGURUS POLLICARIS, Stimpson; EUPAGURUS BERNHARDUS, Brandt; EUPAGURUS LONGICARPUS, Stimpson; AND ALLIED SPECIES.

There are numerous species of Hermit Crabs living upon our coast, in all depths from the shore down to several hundred fathoms. Three species which are of large enough size to be considered as desirable for bait occur, however, in localities where they might be easily taken by the fishermen. One of the species, *Eupagurus bernhardus*, is frequently used for that purpose in England, and could as well be utilized here. The other two species, living in shallow water, are *E. pollicaris* and *E. longicarpus*. *E. bernhardus* ranges from Cape Cod northward, and from low-water mark to depths of fifty fathoms and more. *E. pollicaris* ranges from Massachusetts to Florida, and occurs at low-water mark, but is more abundant on the rocky and shelly bottoms of the bays and sounds, and upon oyster-beds. *E. longicarpus* ranges from Massachusetts Bay to the Gulf of Mexico, and from between tide levels to a depth of ten fathoms.

The Hermit Crabs protect the hinder, soft portion of their bodies in any empty Gasteropod shell of sufficient size which is obtainable, carrying this shell upon their back. They move about very actively and are very pugnacious. Their savage dispositions toward each other has earned for them, in England, the name of "Soldier Crabs," but both in Europe and this country they are generally termed "Hermits."

¹ VERRILL: Vineyard Sound Report, p. 339, 1871-'72.

E. longicarpus is smaller than either of the other species, but is more of a littoral species, and therefore, as a rule, more easily obtainable.

A fourth species, *E. pubescens*, might be added to our list of available Hermit Crabs, but it is generally limited to deeper water than the others. It ranges from New Jersey to Greenland, but south of Casco Bay, Maine, has not been found as high up as the level of low tide. In Casco Bay and the Bay of Fundy, it sometimes, but rarely, occurs upon the shore, just below low-water mark.

"Active and interesting little 'Hermit Crabs,' *Eupagurus longicarpus*, are generally abundant in the pools near low water, and concealed in wet places beneath rocks. In the pools they may be seen actively running about, carrying upon their backs the dead shell of some small Gasteropod, most commonly *Anachis avara* or *Ilyanassa obsoleta*, though all the small spiral shells are used in this way. They are very pugnacious and nearly always ready for a fight when two happen to meet, but they are also great cowards, and very likely each, after the first onset, will instantly retreat into his shell, closing the aperture closely with the large claws. They use their long, slender antennæ very efficiently as organs of feeling, and show great wariness in all their actions. The hinder part of the body is soft, with a thin skin, and one-sided in structure, so as to fit into the borrowed shells, while near the end there are appendages which are formed into hook-like organs, by which they hold themselves securely in their houses, for these spiral shells serve them both for shields and dwellings. This species also occurs in vast numbers among the eel-grass, both in the estuaries and in the sounds and bays, and is also frequent on nearly all other kinds of bottoms in the sounds. It is a favorite article of food for many of the fishes, for they swallow it shell and all. A much larger species, belonging to the same genus, but having much shorter and thicker claws (*Eupagurus pollicaris*), is also found occasionally under the rocks at low water, but it is much more common on rocky and shelly bottoms in the sounds and bays. Its habits are otherwise similar to the small one, but it occupies much larger shells, such as those of *Lunatia heros*, *Fulgur carica*, &c. This large species is devoured by the sharks and sting-rays."

223. THE LOBSTERS.

THE SPINY LOBSTER OR ROCK LOBSTER—*PANULIRUS INTERRUPTUS*, Randall.

The well-known Spiny Lobster of the European coast, *Palinurus vulgaris*, is represented on the western coast of the United States by a closely allied genus and species, *Panulirus interruptus*. The Spiny Lobster differs from the common Lobster in wanting the large anterior claws, the first pair of feet being simple and without pincers, and in having enormously developed antennæ or feelers, which are very large around at the base, and as long as, or longer than, the body. The gills are similar in structure to those of the true Lobster, but number twenty-one on each side.

The California Spiny Lobster, which, in the region where it occurs, is often called simply "Lobster" or "Cray-fish," attains a total length of fourteen inches, the carapax in adult individuals measuring as much as five inches. Average-sized individuals weigh from three and one-half to four pounds. One specimen weighing eleven and one-half pounds has been recorded from Santa Barbara, but very large specimens are now rarely taken in that locality. It ranges southward from Point Conception, California, the most northern point from which it has been recorded being San Luis Obispo. At this place it is rare, but at Santa Barbara and to the southward from there it is very common. These Lobsters generally inhabit rocky ledges. In the winter they remain in deep water among the kelp, and are captured in lobster-pots; in the

¹ VERRILL: Vineyard Sound Report, p. 313, 1871-'72.

summer they move into shallower water, and are taken by means of dip-nets. The best bait for the traps is fresh fish, but any flesh will answer for this purpose. The spawning season for the Spiny Lobster is the early spring, when they are found in abundance close to the shore. At this time they are less fat than at others, and are not considered as good eating; some even regard them as unwholesome at the spawning time, but nevertheless they are eaten more or less continuously through the entire year. When abundant near the shore, catches aggregating five hundred pounds have been made by a single person in the short space of two hours. They are not as abundant now as formerly in the places where they are most extensively taken as food, this having resulted from overfishing, especially during the spawning season. There is, therefore, great danger of the species becoming exterminated, unless some stringent laws are framed to protect them.

224. THE AMERICAN LOBSTER—*HOMARUS AMERICANUS*, Milne-Edwards.

INTRODUCTION.—Although the Lobster is one of the most important of our food invertebrates, careful observations regarding its natural history, and especially its breeding habits, rate of growth, etc., have been strangely neglected. This fact is greatly to be deplored, considering that the Lobster has recently become the subject of important legislation by the several States which it inhabits, and that its cultivation by artificial means has been frequently attempted. It is now an undisputed fact that the abundance, as well as the average size, of Lobsters has greatly decreased in our shallow-water areas during the past twenty to thirty years, thereby forcing the lobster fishermen to resort to deeper water, and increasing the hardships of their profession. The question has, therefore, very naturally arisen as to whether this continued decrease can in any way be checked either by the enactment of proper protective laws, or by means of artificial propagation. Laws for the protection of the Lobster have been passed by all the States interested in this fishery, but their want of uniformity and the difficulty of enforcing them have diminished the benefits which it was hoped might result. The success attending the artificial breeding of several of our food-fishes has inspired the hope that similar methods might succeed with regard to the Lobster, and many persons are now awaiting with interest the results of experiments in that direction. It is very certain, however, that the breeding of Lobsters can never be successfully carried on until we have become acquainted with at least the main features of their natural history. The artificial cultivation of animals can only progress through the fulfillment of natural laws, which must be thoroughly understood before they can be properly applied. As it is, however, the would-be experimenter in the matter of lobster-breeding must still follow a very uncertain pathway, meeting with numerous failures which previous studies might have averted.

To assist in a small way toward overcoming this difficulty, and as a preliminary to the industrial report which will appear hereafter, the author has brought together the following few disconnected popular notes, taken in part from published works, but mainly derived from the observations of intelligent lobster fishermen and dealers, who have always cheerfully responded when called upon for information. It is hoped that the meagerness of these notes will act as an incentive to observers in this line of research.

RELATIONS AND STRUCTURE OF THE LOBSTER.—The Lobster belongs to the highest group of the Crustacea, the so-called *Decapoda*, or ten-footed crustaceans, which group is again divided into the *Brachyura*, or short-tailed Decapods (true Crabs), the *Anomoura* (Hermit Crabs, etc.), and the *Macroura*, or long-tailed Decapods (Lobsters and Shrimps). The members of the first group

range higher in organization than those of the two latter, and the Lobster must, therefore, be regarded as lower in the scale of being than our common Crab.

The Lobsters find some of their nearest allies among the common fresh-water Cray-fish of our rivers and small streams, with which they agree structurally in most particulars. The principal differences existing between them, beyond size and shape, are such as would be readily overlooked by the casual observer. One of the most important is as to the number of gills, of which there are twenty perfect ones on each side in the Lobster and only seventeen to eighteen on each side in the Cray-fish. Some of the gills also differ in structure in the two groups. The other structural differences need not be discussed here, nor do we propose to describe the anatomical peculiarities of the Lobster in this connection, as they have been fully treated of in numerous scientific publications which are easily obtainable. It will suffice for our purpose to pass over in review the principal external characteristics.

The body of the Lobster, as may be readily observed, is made up of two general divisions, an anterior one, called the carapax or cephalo-thorax, and covered by a single shell or shield above and at the sides, and a posterior one, termed the abdomen, consisting of six segments and a terminal flap, or telson. The dividing line between the head and thorax proper, which are both contained within the carapax, is indicated on the upper surface of the carapax by a transverse, curved groove. Underneath the thoracic portion of the carapax there are five transverse segments, corresponding to the pairs of legs, of which the four posterior pairs are subequal in size and much smaller than the anterior pair or claws. All of the legs are composed of several and an equal number of joints; the two posterior ones terminate in simple points, while the two in advance of them end in small claws. The anterior legs are very much enlarged, the joints very unequal in size and very unlike in shape, the terminal joint, forming the claw proper, being very greatly developed, hard and rugged, and very powerful. Each segment of the abdomen or tail also has a pair of appendages on the lower side. In the female, the anterior five pairs are small and slender, and constitute the so-called swimmerets, to which the eggs are attached after extrusion from the body and during incubation. The appendages of the posterior abdominal segment are large, and each terminates in two broad plates which lie at each side of the telson. In the male, the anterior pair of abdominal appendages are modified into the stiffened styles, by means of which the sex may be easily distinguished. The functions of these different appendages correspond with the same in the Cray-fish, which are described as follows by Professor Huxley:

“The Cray-fish swims by the help of its abdomen and the hinder pairs of abdominal limbs; walks by means of the four hinder pairs of thoracic limbs; lays hold of anything to fix itself, or to assist in climbing, by the two chelate anterior pairs of these limbs, which are also employed in tearing the food seized by the forceps [big claws] and conveying it to the mouth; while it seizes its prey and defends itself with the forceps.”

On the lower side of the body, in front of the claws, are several pairs of variously shaped small organs, which surround the mouth and subserve mastication. Still farther in front are two long feelers or antennæ, and two smaller feelers or antenules, and also the two compound eyes, situated at the ends of two short, movable stalks. The carapax terminates in front in a sharp, spiny, and prominent projection or rostrum, which reaches out between the eyes. The gills are situated on each side of the body, just inside of the carapax, in two cavities, called the branchial chambers, which open behind, below, and in front, so that the water has free entrance.

Three species of true Lobsters, constituting the genus *Homarus*, are now recognized by naturalists. They live exclusively in the sea. The American species, *Homarus americanus*, in

which we are now interested, is the largest of them all. Next in size, and of equal importance, is the European species, *Homarus vulgaris*, which differs but slightly from our own, the rostrum being narrower, and bearing teeth only on its upper margin, while in the former species the lower margin of the rostrum is also armed with teeth. The third species belongs to the southern hemisphere and attains a length of only about five inches. It is called *Homarus capensis*, and inhabits the region of the Cape of Good Hope. We are not aware of its being used as food.

NAME.—For a common and widely distributed marine animal, the American Lobster is surprisingly free from the long list of vernacular and local names which encumber some of our most important industrial fishes, such as the menhaden. The simple term "Lobster" belongs to it wherever it occurs, and in only a few rare instances have the fishermen dared to assert their well-acknowledged right of adding, through its means, a new word to their already somewhat lengthy and interesting vocabulary. On the coast of Rhode Island, Lobsters are sometimes called "Seacraws," from their resemblance to the fresh-water Cray-fish; and at Nantucket the young Lobster is termed "Grass-hopper"; but such names are not much used, nor are they of importance to our discussion.

The different stages during the process of shedding and subsequent hardening of the new shell and during spawning are designated by descriptive terms, such as "Black Lobster," "Soft-shell," "Berried Lobster," etc., which are described in full further on.

In and about Vineyard Sound, Massachusetts, two varieties of Lobsters are recognized, and these are distinguished as "School Lobsters" and "Rock Lobsters," or "Groundholders."

DECREASE IN SIZE.—Lobsters occur of all sizes up to about forty pounds weight, but the average size of all Lobsters now caught for market is probably not above two pounds weight. It is a well-attested fact that the average size, as well as the abundance of Lobsters, has steadily decreased from year to year during the past twenty years, and the markets are now supplied with a much smaller breed, so to speak, than formerly. Not that Lobsters grow less rapidly at the present time than in previous years, or have become in any way dwarfed in size, but the avaricious fishing which has been constantly carried on along almost the entire extent of their range has caught up nearly all the larger individuals and reduced the bulk of those remaining, suitable for market, to near the minimum prescribed by law, and there they will probably remain. Were the spawning Lobsters carefully protected, and due respect paid to the laws limiting the size of those taken for food, we might expect to find about as many Lobsters now as in any past time, though they might average smaller in size; but such, unfortunately, is not the case.

Just what the decrease in average size has been we have not sufficient data to determine; but it has occurred so recently and has been so marked that no one who is familiar with the facts can refuse to acknowledge it. A New Haven correspondent states that the average length of the Lobsters sold in the markets there to-day is about ten and one-half inches and the average weight about two pounds, against an average length of about thirteen inches and an average weight of about three and one-half pounds twenty years ago. A Boston correspondent, who has spent much time in studying the lobster question from a practical standpoint, writes that "they decreased rapidly until the law was enacted regulating the size of those brought to market, the enforcement of which arrested the apparent decrease. I would say here that the effect of a law regulating the size of those saved for food is, after a time, to bring a very large majority of those offered for sale to about the legal limits, and an improvement can only be looked for by increasing the limit from time to time."

AVERAGE SIZE AT PRESENT.—From many fishermen and lobster-dealers along the entire New England coast we have solicited information as to the average size of Lobsters taken by

them in their traps and sold as food, or received at the markets. The replies were numerous, and in many cases undoubtedly reliable. In four of the principal larger markets the average sizes were stated to be as follows, the length given being exclusive of the claws:

	Inches.
Portland, Maine.....	10½
Boston, Massachusetts.....	11-11½
New Haven, Connecticut.....	10½
New York City.....	10½-15

The larger Lobsters received at New York probably came from Eastern Maine, and the smaller ones from Southern New England.

According to the fishermen, the average size of Lobsters taken upon certain sections of the New England States runs about as follows, the wide range in the figures given in some cases resulting from the combining of data from different localities:

	Inches.
Coast of Maine, from Eastport to Portland.....	8-15
New Hampshire.....	11
Vicinity of Boston.....	10-13
Vineyard Sound to New London, Connecticut.....	8-12
Western Connecticut.....	8-10½

The average size is said to be somewhat greater in Eastern than in Western Maine, but even at the east the smaller sizes are taken to sell to the canneries. On the coast of Nova Scotia Lobsters, at present, run larger than on the coast of Maine. According to Capt. N. E. Atwood, small Lobsters are seldom seen at Provincetown, or at least were seldom taken there when the lobster fishery was extensively carried on at that place. In an entire smack load there would not be half a dozen individuals weighing under two pounds. The average size of Lobsters taken in the traps does not appear to remain the same at any one place throughout the year. In many places they are said to run largest during the summer, or from June until the latter part of August. This may not hold good, however, for all localities. About Vineyard Sound, Massachusetts, Lobsters average largest in June, and those taken at that time are called "June" or "Sand" Lobsters. They are lighter colored and have thinner shells than those caught the remainder of the year. School Lobsters average about the same in size in the same school, but the different schools may differ more or less from one another in the average size of the Lobsters composing them, and some at times consist mostly of one sex and others of the opposite sex.

LARGE LOBSTERS.—The male Lobsters are said, as a rule, to attain the largest size, and in most localities they average larger than the females. In some few places, however, we are informed that the females average largest, and where this occurs it may possibly result from the greater protection accorded the latter sex. A correspondent at Provincetown, Massachusetts, estimates that the larger females attain there a length of about fifteen to sixteen inches, and the larger males about eighteen to twenty-two inches. Although large Lobsters have been mostly exterminated from our coast, we still occasionally hear of the capture of individuals of unusual size. From fishermen we have obtained information regarding three monster individuals, weighing respectively thirty-five, thirty-eight, and forty pounds each, but no notice as to the year when they were taken. Lobsters of over forty pounds weight have been recorded, but we are inclined to look upon these giants with some distrust, as we cannot ascertain that any of them were actually weighed. From more reliable sources we learn that sixteen to twenty-five pound Lobsters, although by no means common, have been, and still are, occasionally found. They do not seem to have been confined to any one part of the coast, as they are recorded all the way from Eastport, Maine, to New Jersey.

Much of the information regarding large Lobsters was obtained from lobster-dealers, who have had them for sale in their markets. A dealer at New Haven states that twenty years ago twelve to sixteen pound Lobsters were common, but during the past ten years a Lobster weighing ten pounds has been rarely seen. A Boston dealer writes that during the past season (1880) he has received and sold several Lobsters weighing from twelve to fifteen pounds each. On the Nova Scotia coast, ten-pound Lobsters are said to be common now. The dimensions of these heavy individuals are seldom given. A specimen taken at Boothbay, Maine, and said to weigh between thirty and forty pounds, had such large claws that the meat from one of them was equal to that of an entire ordinary-sized Lobster. Another specimen, weighing thirty-five pounds, had a length of four feet. Seventeen to twenty-four pound Lobsters are stated to measure from three to three and one-half feet long, and ten-pounders from twenty to twenty-four inches. A nineteen-pound Lobster, shipped from Eastport, in 1875, measured three feet five inches in length, the claws being eighteen inches long and eight inches across.

LARGE LOBSTERS ON THE COAST OF ENGLAND.—Although the European Lobster never attains the extreme size of the American, still large individuals are occasionally met with. Mr. Frank Buckland makes the following records of large Lobsters observed on the coast of the British Islands: "The deeper the water and the farther from the shore, the larger are the Lobsters. The Skye and the Orkney Lobsters are probably the largest in the British Islands. At St. Maw's we heard of two Lobsters, one ten pounds and the other nine and three-fourths pounds, and at Durgan and Sennen of one of thirteen pounds. A large Lobster was caught in a large earthenware pot at Gosport in 1870; he weighed eight pounds ten ounces. In May, 1875, a Lobster, weight twelve pounds, was found at Saint's Bay, Guernsey." Another specimen caught at Hamble, near Southampton, was said to have weighed fourteen pounds.

COLOR.—The color of the Lobster is so varied as to almost defy accurate description, even in single individuals. It may be described in a general way as consisting of a groundwork of yellow or yellowish-red, covered with spots or mottlings of green, or more rarely blue. The mottlings are most numerous and dense upon the back, while on the sides of the carapax and lower surfaces of the claws the yellow generally predominates. Along the lower edge of the carapax, on each side, there is quite a broad marginal band of blue or bluish coloration, which also extends a short distance up the posterior margin of the carapax. Just above this band, which has a distinctly defined edge, the yellow (ranging in intensity from a light yellow to a deep orange) begins, and may be nearly plain for quite a breadth, or become at once covered with roundish spots of dark green or greenish or brownish olive, which increase in size and become more closely placed toward the dorsal surface, where they overlap to such an extent that the yellow seldom shows through. This combination frequently produces a very dark coloration on the back, which sometimes appears as a greenish-black. Often the entire carapax and abdomen assume a very dark shade over nearly all the sides as well as back. Sometimes the spots are fewer in number than ordinary and stand apart from one another, even on the back, producing the so-called "Spotted Lobsters." The green color is often replaced by different shades of blue. Occasionally a reddish coloration will predominate over the entire carapax. The rostrum is olive green, the spines it bears being of a deep, rich red. The abdomen corresponds in markings with the carapax. The depressed line running along the center of the back of the carapax is distinctly marked, being generally dark green. The tail-flaps are bordered along their posterior margins by a band of dark olive brown.

The upper surface of the big claws has a decidedly reddish or orange cast, the color deepening towards the ends, which are a very deep red, fading out to a whitish color just at the tips.

Over this groundwork the outer margin of the claw has a broad banding of dark olive brown or black, and numerous large spots of the same color cover more or less of the remaining surface. The under sides of the large claws are almost always an orange of variable intensity, the terminal joints being more intense than the inner ones, which are more or less marked with green or blue. The other legs are much lighter below than the claws, with green or blue markings, especially above and at the ends of the joints. The tips end in deep orange red, while the bunches of hairs which ornament them and other parts of the body are almost a ruby red, when the specimen has just been taken from the water. The soft skin covering the under surface of the abdomen, and the swimmerets are of a faint pinkish color, due to the presence of multitudes of very minute red spots.

These color variations of Lobsters probably depend, to a certain extent, upon the character or color of the bottom inhabited by them, but some of the varieties cannot be accounted for in that manner. The character of their food may also have some influence in the matter. Lobsters obtained from rocky bottoms more or less covered with sea weeds, and from dark grassy bottoms, are said to be generally much darker in color than those from sandy bottoms, and also to average shorter in proportion to their weight. Lobsters from open sandy bottoms are not only lighter in color, but also appear to be, usually, brighter. We have several recorded instances of red Lobsters from sandy bottoms, some of the specimens examined having been nearly as red as Lobsters ordinarily are after boiling. Nearly white Lobsters also occur occasionally in similar situations. One of the most curious color varieties we ever saw had numerous round, bright yellow spots, ranging in size from very small to about half an inch in diameter, scattered without order over the entire body. It is well known to all consumers of Lobsters that the shell of these animals quickly changes to a nearly uniform bright-red color on boiling.

DISTRIBUTION—GEOGRAPHICAL RANGE.—The American Lobster ranges along the Atlantic coast from Delaware to Labrador, and has even been found as far south as the northeastern corner of Virginia. A correspondent at Johnstown, Virginia, informs us that he has seen two or three stragglers taken in that neighborhood, and he believes them to have wandered naturally to that far southern limit, as he cannot account for their being carried there through the agency of man. The vicinity of the Delaware breakwater can be regarded with greater certainty as their southern limit, for there they occur in moderate abundance, and are occasionally fished for with lobster-pots. They are also sometimes taken on the fishing banks off Cape Henlopen and Cape May. The stonework of the Delaware breakwater seems, however, to form quite an attractive place for them at present, though previous to its construction they may not have existed there at all. They may be caught in the immediate vicinity of the breakwater in lobster-pots, and are also incidentally taken in gill-nets and on hand-lines, but the fishery is not carried on regularly, mainly on account of their scarcity, and partly from the fact that the pots are liable to be disturbed by the anchors of vessels seeking the protection of the breakwater. Mr. Burbage, of Ocean View, Delaware, states that he has occasionally seen small Lobsters in the surf along the beach, near Indian River Inlet.

Along the New Jersey coast, Lobsters have been recorded from a few places, but are nowhere very abundant. A fisherman of long experience about Cape May writes that he has never seen Lobsters in that region. Off Monmouth County they occur near to and south of Navesink. At Long Branch and Atlantic City small amounts are taken annually for local consumption and for shipment to New York and Philadelphia. Lobsters are more plentiful on a fishing ledge of rocks lying a short distance off Long Branch, and those found near the shore are supposed to be summer visitants from this locality. Several instances of large Lobsters are

recorded from this region—two in particular from off Atlantic City, weighing twenty and twenty-one pounds each.

After passing the New Jersey coast, we soon come to the region where Lobsters are more continuously abundant. At one time they were common in New York Bay, but the establishment there of large factories, which pollute the waters, has almost exterminated them and dwarfed the size of those remaining. Throughout Long Island Sound, Lobsters are moderately abundant, and are fished for at several localities. They become much more plentiful in the neighborhood of Fisher's Island, Block Island, Montauk Point, the Elizabeth Islands, Martha's Vineyard, and Noman's Land, all of which regions furnish a very important summer fishery. Nearly all favorable localities on the Massachusetts coast abound in Lobsters, though overfishing has nearly depleted some sections, as at Provincetown. New Hampshire supports a limited lobster fishery.

The Maine coast excels all others of the States in the abundance of Lobsters, which are more or less uniformly distributed from Portland to Eastport, some localities, however, being more favorable to their existence than others. The fishery for this State is much greater than for all the other States combined, Massachusetts ranking next.

The Provincial coast, or at least the Nova Scotian part of it, is said to be more prolific in Lobsters than Maine, though the fishery there is not of as long standing. We have little data as to the relative abundance of Lobsters on the Newfoundland and Labrador coasts, but they are apparently less common than to the south.

BATHYMETRICAL RANGE.—The Lobster ranges in depth from about low-water mark to at least eighty fathoms, and the fishery is regularly carried on in some localities in depths of fifty to sixty fathoms, especially during the winter. At Eastport and elsewhere on the Maine coast, in the summer, they are occasionally left upon the shore by the receding tide, either concealed under stones and seaweeds or partly buried in the sand. During the same season they may also be frequently seen about the wharves of some of the Maine sea-coast towns, attracted there by the refuse thrown over from the canneries. Twenty to thirty years ago, or before the fishery had made much advancement, Lobsters were of much more common occurrence in the littoral zone, and were often gaffed from the shore by the early fishermen. Even to-day, in some places, the pots are set in such shallow water that they are exposed at low tide. Several accounts of this shore fishery have been reserved for the industrial portion of the present report.

As explained elsewhere, Lobsters move towards the shore in summer, and away from it, or into deeper water, on the approach of cold weather. During the principal fishing season, which includes the warmer half of the year, they are most abundant in depths of a very few to about fifteen or twenty fathoms, and it is within these depths that the pots are mainly set.

OFF-SHORE RANGE.—Lobsters have been recorded from the fishing banks off Nova Scotia, from the fishing banks and ledges of the Gulf of Maine, such as Jeffrey's Ledge and Cashe's Ledge, and from other more southern off-shore banks. They have also been taken from the stomachs of cod caught on George's Banks. There is, however, no off-shore lobster fishery.

FRESH AND BRACKISH WATER.—Lobsters will not live in fresh or brackish water, although it is an unsettled question as to whether a slight admixture of fresh water is harmful to them or not. They are caught at the mouths of large rivers where the water is decidedly brackish on top, but when placed in surface cars at the same localities they are said to quickly perish, indicating that the water must be much more salt at the bottom.

CHARACTER OF THE BOTTOM.—Lobsters prefer rocky, gravelly, and sandy bottoms, and,

in shoal waters, especially those which are more or less covered with growths of the larger seaweeds. Vegetation is not, however, essential to their well-being, for they live on the barren sands, as at Provincetown, Cape Cod, and on rocky, stony, and hard bottoms, wherever they can find food. At the mouth of the Bay of Fundy, they are said to occasionally occur on the mud, and this fact is recorded of them in other localities. On rocky bottoms they remain more or less concealed under and among the rocks and stones, watching for their prey. In the Bay of Fundy and elsewhere they are often seen lurking under stones at low water, and about the wharves. The lobster-pots are generally set upon gravelly and sandy bottoms. In many localities the young, under eight or ten inches long, are often abundant in shallow coves or bays, which are more or less filled up with kelp and other large seaweeds. In such places as these they have been commonly taken in the beam trawl used by the United States Fish Commission for bottom fish, in Long Island Sound, Narragansett Bay, and Vineyard Sound. One cause assigned for the great decrease in the abundance of Lobsters in Plymouth Bay, Massachusetts, is the raking over of the rocky bottom for Irish moss, which industry is carried on to a very great extent, thereby uncovering and destroying the young and damaging their grounds.

MIGRATIONS.—The Lobsters inhabiting the shoaler grounds in summer move into deeper water, as a rule, on the approach of cold weather, and return again in the spring. In some localities, however, a few Lobsters are said to remain in moderately shoal water the entire year, especially toward the south. But all Lobsters do not leave their deeper abiding places in summer, for they appear to occur in greater or less abundance in all depths at all seasons. The extent of the fall migrations is not very great, but the Lobsters move off beyond the influence of the extreme cold into slightly deeper water, generally not far away, where the temperature remains milder and more uniform. Those who fish for Lobsters in the winter have, therefore, to set their pots at a greater distance from land than in the summer, but the winter fishery is of slight importance compared with the summer.

Lobsters are said to approach the shores of Nova Scotia in May and to recede from them in November, their winter quarters being in depths of ten to forty-five fathoms. In the summer they are abundant close to shore. At the mouth of the Bay of Fundy they generally come into shoal water in April, and move off again in October or November. During the summer months they abound under the shelter of overhanging rocks and among the kelp near shore. About five or six weeks are taken up by these migrations. They do not move in a body, but approach and recede gradually, as the temperature of the water changes. Throughout the coast of Maine the spring and fall migrations are about the same, but vary more or less according to the character and temperature of the different seasons. In the summer, they enter the numerous bays and indentations of the coast line, which they leave again in the fall. They leave the shallow waters of the coast of New Hampshire in December or November, and can be caught during the entire winter in depths of twenty fathoms. Boston Harbor has always been famous as a fishing ground for Lobsters, but in the fall it is completely deserted by these crustaceans, which repair to the deeper waters of Massachusetts Bay, where a winter fishery can be carried on. A sudden cold spell is said to send them off rapidly, and they have been known to entirely disappear from shoal water in the course of a day or two. Lobster fishing ceases at Provincetown, Cape Cod, the latter part of September, as the Lobsters become scarce after that time. In Vineyard Sound the fall migrations extend into the deeper holes not far distant from the summer grounds, but some individuals remain in comparatively shallow water the entire year. The same is true of Long Island Sound, where Lobsters do not move far from their summer haunts, but

merely seek the protection of deeper water, wherever they can find it. The season generally lasts from April to October. Off New Haven, Connecticut, Lobsters are occasionally taken in winter, on the deeper oyster banks, while dredging for oysters.

SCHOOLING.—Although Lobsters do not appear to school in the same manner as some fishes, still they often congregate in larger or smaller moving bodies, which travel from place to place, as though in search of food. On the central and southern New England coasts, especially about Martha's Vineyard and Noman's Land, two kinds of Lobsters are recognized by most fishermen—"School Lobsters," and "Rock Lobsters" or "Ground holders." The latter are said to remain more or less continuously in one place during the entire fishing season, while the former are migratory and uncertain in their movements. These two kinds of Lobsters are also stated to differ more or less from one another in appearance, especially as regards color, and the Rock Lobsters are supposed to average heavier than the School Lobsters, when of the same lengths. To what extent this habit of schooling takes place we have had no means of ascertaining, but for a short period during the spring and fall migrations it is probably more common than at other times. During the regular summer movements, the larger or stronger Lobsters are said to lead the schools, and the maimed or crippled ones to straggle on behind. The schools are apparently made up more or less of Lobsters of uniform size, as the fishermen will often catch the same sized Lobsters in their traps for a certain period, after which this size disappears and another takes its place. These changes are said to occur suddenly, and during some years quite frequently.

The strongest proof of the schooling of Lobsters is the fact that they will suddenly appear in great numbers in a region where none have been caught for several days, and as suddenly disappear therefrom without apparent cause. It is possible that the habit of schooling arises solely from the necessity of migrating, and that, while they ordinarily live more or less scattered over good feeding bottoms, yet when their common feeding ground becomes exhausted, or the temperature too severe, they are impelled to desert it in a body for some other more favorable locality.

ASSOCIATION OF MALES AND FEMALES.—The male and female Lobsters generally associate together in the same places, in about equal proportions; but some curious exceptions to this rule have been recorded. Capt. N. E. Atwood, of Provincetown, Massachusetts, writing in 1866, states that at that time about ninety per cent. of all the Lobsters taken at Cape Cod were females, while to the northward of Plymouth, on the west side of Massachusetts Bay, seventy-five per cent. of all those captured were males. In and about Narragansett Bay, the fishermen claim that, during July and August, about seven-eighths of the Lobsters taken are females, while during the balance of the season the two sexes are about equally abundant. At Eastport, Maine, it is said that, as a rule, more male Lobsters are taken than females. The above statements must be taken with some grains of allowance, from the fact that the fishermen may not always be able to readily distinguish between the two sexes, especially in the case of females not bearing eggs externally. The rude and hasty manner in which they handle Lobsters would also preclude their discriminating between the sexes with certainty, even though they were well acquainted with their anatomical differences. Prof. S. I. Smith examined quantities of Lobsters in the Provincetown market, on two occasions, in August and September, 1872, without finding any decided differences in the number of males and females. At Eastport, Maine, his examinations were made with even more thoroughness, and with the same result. Professor Verrill also states that he has found the males and females about equally abundant in market supplies received from New London, Stonington, and Waterford, Connecticut. It is possible that, at some seasons, or under

certain conditions the males and females may live more or less apart from one another, but the observations of scientific men indicate that this separation is not long continued, if it occurs at all.

Mr. S. M. Johnson, of Boston, has recently assured us that the great preponderance of females still holds true in the case of the Cape Cod region. Of the supplies received from there at Boston, during the summer months, he feels certain, from long-continued observations, that nearly if not quite ninety per cent. are females, and about seven-eighths of these bear spawn externally. The section of coast from which these Lobsters are obtained extends along the outer side of Cape Cod, from off Highland Light to Wood End Light. The Lobsters examined at Provincetown, by Prof. S. I. Smith, in 1872, may have come from the bay side of Cape Cod, whence Provincetown is supposed to receive its supplies for home consumption. The females may resort to the shallow waters of the outer side of the cape to spawn during the season when the fishery is carried on there, and this fact, if true, would readily account for their great abundance in that region, as has been noticed for so long a time. The males and females approach and recede from the shore together in the fall and spring.

WINTER HABITS.—Fishermen generally agree that Lobsters do not trap as readily in the winter as in the summer, even though the pots are set on what are supposed to be their winter grounds. The reason assigned for this is that they are not as eager for food nor as active in their movements in cold weather as in warm weather. This may be true to a great extent, but we think it is equally probable that they are scattered over broader areas in the winter, and their haunts are not as easily found. Evidence in proof of this idea has been recently furnished us by a prominent Eastern dealer, who has kept large quantities of Lobsters in confinement for the winter trade. The bottom of the area given up to their keeping is very muddy, and the surface of the water sometimes freezes over to a depth of twenty-two inches. On the approach of cold weather the Lobsters bury themselves in the mud, leaving only the long antennæ, the eyes, the tips of the claws, and perhaps a small portion of the front of the carapax, projecting above it. Over some parts of the inclosure the water is so shallow that the exposed appendages can be readily seen from the surface. In these positions the Lobsters lie, presumably all winter, unless disturbed, but whether or not they feed regularly has not been observed. If, however, a hoop-net, properly baited, is lowered in front of them, they are not slow to enter it, plainly indicating that they are still attracted by the bait, and it is just the same even after the surface of the water has become a sheet of ice. As the ice breaks up toward spring, and afterward, while the drift ice still remains in this area, the Lobsters become more timid and cannot be caught. They also seem to be easily frightened at loud noises, and perhaps retire deeper into the mud, for bait appears to have no attraction for them at such times. It is not possible, however, that they could be influenced in this manner in deeper water.

It is a question which may never be definitely decided, whether Lobsters bury themselves in the same manner in deep water as near shore. The temperature there would undoubtedly remain more favorable to them than in shallow water, but many of those caught in the pots in winter are more or less covered with mud.

MOVEMENTS.—Lobsters hold quite closely to the bottom and seldom leave it, unless it may be to escape an enemy, when they have been seen to execute a sort of swimming movement backward, by means of their tail, darting up from the bottom, but quickly settling down again. In moving about, they seem to skim over the bottom, using their four posterior pairs of feet, the anterior pair, or big claws, being held rigidly out in front of them, with the tips pointing inward and not far apart. The tail is also spread out and well expanded at the same time. The

movements of Lobsters can be easily studied in the shallow cars in which they are kept for market, providing there are not too many of them, as the bottom of the car should not be covered. Their actions appear easy and graceful, and their swimming powers may be tested by dipping them out with a scoop-net and allowing them to fall back again. If allowed to fall in tail foremost, a gentle flap or two of the tail is sufficient to give the body the proper slope in the water so that in sinking it falls obliquely and reaches bottom by a more gradual motion than would be the case if it fell directly downward. During the downward movement the tail may or may not be kept in motion. But in case the specimen is thrown in head first or sidewise, if it be in good, lively condition, it may give several vigorous flaps of the tail to right itself, and even swim off in one direction or another for a distance of several feet before settling down as in the former case. As a rule, however, the Lobster must be regarded as a bottom animal, exercising its power of swimming only in cases of emergency.

We have made the above remarks to correct the current impression among many people that the Lobster is a free swimmer and moves about in schools like many species of fish. For this belief there is no foundation in fact.

GROWTH, SHEDDING, ETC.—Soft-shelled Lobsters occur at all seasons of the year, but appear to be much less common in the winter than in the summer. The period of their greatest abundance is from June to September or October. There is, therefore, no strictly defined shedding period, and no possibility of determining, from present data, how often Lobsters shed. The shedding is connected with the growth of the individual, and when the body has attained such an increased volume that the hard covering or shell can no longer contain it, the latter breaks open, and the Lobster comes forth in a soft state, and considerably enlarged. The possibility, therefore, exists that in good feeding regions Lobsters may shed more frequently than in poor ones, for in the former it is natural to suppose that the growth would be more rapid than in the latter. Absolutely nothing is known, however, regarding this fact, and we must await future observations before generalizing. During the younger stages, shedding goes on quite rapidly, but as the Lobster increases in age it is probable that the shedding periods become much less frequent, and in very old individuals may cease altogether. There is, however, no conclusive evidence to prove that Lobsters ever attain a limit in size beyond which there is no further growth. Large individuals are occasionally taken with a very thick and heavy shell so scarred and worn as to indicate a prolonged and severe service. At times, the edges and angles of the shell and the exposed prominences of the claws are completely worn away. Large Barnacles are often found upon the shells of large Lobsters, and this fact is frequently cited as evidence that the Lobster had ceased shedding, or at least had not shed for several seasons. But after having examined the slates used by the United States Fish Commission as collectors for oyster spat, in Chesapeake Bay, in 1880, the writer can no longer regard this proof as very convincing. In the course of a month or two the common Barnacle of that region, a species of *Balanus*, which had attached itself to the slates in much greater abundance than the oysters, had attained a diameter of nearly an inch and gave promise of growing much larger in a short space of time.

The process of shedding is very interesting, and has been frequently witnessed, although it has never been minutely described by a competent observer. The following account has been furnished us by Mr. S. M. Johnson, of Boston. As a preliminary, the carapax generally, but by no means always, splits lengthwise along the middle of the back, often with a clean cut, quite to the rostrum. Otherwise, the carapax merely separates widely from the abdomen, on the upper side. The abdominal segments are the first to be withdrawn from their hard investment,¹ and

¹ This is contrary to what happens in the fresh-water Cray-fish.

as soon as they are free they are used in extricating the anterior portion of the body. The entire process requires a great amount of violent struggling and pulling, the claws occasioning the greatest difficulty, from being so much larger near the tips than at the base. Their fleshy portion, however, becomes somewhat soft and flabby so as to be easily extensible, and capable of being compressed down to a smaller diameter. The basal joint, called the thimble by fishermen, breaks lengthwise across the narrowest side, where a groove naturally exists, and the base of the next succeeding joint splits in the same way. The remainder of this second joint, and the following larger one, are compressed and flattened upon the upper or inner side, where the shell is thinner than elsewhere, the thin area being oval in outline, distinctly marked off from the surrounding surface, and more or less marked with irregular, elongate, depressed lines. Preparatory to shedding, this area, by the absorption of certain of its elements, becomes a thin, soft, and extensible membrane, or may be entirely absorbed away. No other hinderances lie in the way of the passage of the claws proper, which can be sufficiently compressed to work through the next joint above them, although the latter remains hard and firm.

The layer of skin which is to form the new shell begins to take on its distinctive character before the old one is cast, but does not harden to any extent. In this state it assumes a dark-green color and gives rise to the common fishermen's term of "Black Lobster," which is used to designate the Shedders. As the hard shell is cast, the soft skin exposed presents a velvet-like surface. The process of shedding goes on rapidly, as often happens in lobster-cars where the animals have been placed awaiting shipment to market. Lobsters which have had no marked indications of shedding, when placed in the cars, have cast their coat within a day or two afterwards. The hardening of the new shell also progresses rapidly. On many Lobsters the newly forming shell can be seen inside of the old one, and more or less closely adhering to it. It appears like a thin, semi-transparent, gelatinous lining of the old shell, and in some instances can be readily peeled off from it. Soft-shell Lobsters are sometimes called "Cullings," and those in which the new shell has become slightly hardened are named "Paper-shells."

Just before and after shedding, Lobsters remain quiet, almost dormant, and more or less concealed under stones or among seaweeds. Statements differ as to whether Lobsters seek food while in the soft shell state. They are said to be captured in the traps at times, often in great numbers; but as the food ordinarily preferred by them, and especially the baitings of the traps, require hard surfaces for their mastication, we do not know how to account for their presence in such situations. It is well known that hard Lobsters which entered the traps in that condition have shed therein, but in all such cases the cast skin should be present when the traps are brought to the surface of the water. It is possible that soft Lobsters are attracted into the traps by the smell of the bait, without the possibility of eating it. Most of the soft-shell Lobsters handled, however, are captured before shedding. Very many are often obtained in this way, but they are not considered good eating, as their flesh is described as thin and watery. They are mostly used as bait, although it is stated that they are also sold to the canneries.

Soft-shell Lobsters are more subject to dangers than the hard-shell, being helpless to protect themselves. They are greedily devoured by many species of fish, especially the cod, and are even said to be attacked by hard-shell individuals of their own species. When caught at this time, even if returned at once to the water, the slight handling they receive is said to generally kill them. Remaining, as they are supposed to, as much as possible out of harm's way, and probably not feeding while in the soft state, the mortality is undoubtedly much less than as though their habits continued the same.

The length of time required for the hardening of the new shell has never been recorded from observation. The fishermen's statements regarding it disagree, but the hardening goes on probably more rapidly in warm weather than in cold, as in the case of the edible Crab. A careful observer at Wood's Holl, Massachusetts, says that the shell becomes quite firm in the course of twenty-four hours. After three or four days it is supposed to be hard enough to enable the Lobster to go in search of food, but the hardening probably continues and the shell increases in thickness, even though it be very gradually, until the next shedding period.

A short time before shedding, the Lobster is said to be very full of meat and in the best possible condition for eating. This would seem to result naturally from the increased quantity of flesh which must accumulate within the shell preparatory to the Lobster's assuming a larger size. While shedding, but more especially while in the soft state, after the Lobster has expanded to its new size, the flesh is considered by most people as unpalatable, although it is probably as harmless then as at any time. The fishermen abhor soft Lobsters as a rule, and would not eat them under any circumstances, but customers are occasionally found. One fisherman correspondent very aptly expressed his dislike for them in the following terms: "They are sometimes eaten by aristocrats, but never by us." It seems very strange that soft Lobsters should be so unfavorably regarded, when we consider that the edible Crab is in its best condition just after shedding.

The female Lobster probably casts its shell soon after its spawn is hatched. The eggs are attached so firmly to the swimmerets that they remain hanging to them even after the young have gone forth, and there is no other way of getting rid of this great encumbrance to the abdomen than by shedding. This occurrence has been frequently observed in other species of crustacea, and probably happens in the case of the Lobster. In fact, we have numerous recorded instances of female Lobsters bearing spawn nearly ready to hatch, and with the new shell in process of formation. It is the common belief of lobstermen that Lobsters which have lost a claw, or been seriously maimed in any way, do not shed until after the injury has been repaired.

Prof. G. O. Sars describes the process of shedding with the European Lobster, *Homarus vulgaris*, as follows:

"The process of changing its skin is very tedious and dangerous for the Lobster, which may be imagined when it is known that not only the outer shell is changed, but even some of the inner parts, *e. g.*, the stomach-bag. The process occupies considerable time, and while it is going on the Lobster is sick and utterly unable to escape from its enemies or to defend itself against them. It is therefore but natural that under such circumstances it very easily dies in the traps. Even after the change of shell is over the Lobster remains weak for some time. It therefore hides among the stones at the bottom of the sea, and remains there until the new shell has become sufficiently hard and its strength has returned.

"The earliest changing of shell which I observed during my journey was in the first part of July, near Tananger. I here had an opportunity of observing a Lobster engaged in this process. It had just been taken out of a lobster-box, and could be handled without offering the least resistance. The shell on the back was burst in the middle, and the tail and the feet were nearly all out of the old shell, while the largest claw only stuck out half its length. This latter portion of the change of shell is evidently very dangerous, and, although I observed it for quite a while, I could see little or no progress. It is certainly a painful and dangerous process, and probably many a Lobster loses its life at such times. Immediately after casting its shell the Lobster is lean and miserable, and only obtains its proper condition after the lapse of considerable time. According to my observations, the change of shell takes place chiefly during the month of July. It certainly happens that some change later, but by far the larger number appear to shed during that month."

The following note regarding the shedding of the European Lobster, abstracted from a report by a Danish naturalist,¹ goes to confirm our previous statement, that the females shed soon after spawning:

"After the Lobster has emitted its roe, and the young have left the mother, she begins to shed. She therefore goes to safe places, and does not seem to care much for food while the old skin is being loosened; the shell finally opens in the back, and the animal goes into the water naked. It then looks as if it were covered with velvet, on account of the considerable formation of cells which is going on all over its surface. These cells afterward grow hard through small particles of lime and form the new shell. This shedding of the shell goes on from the middle of July to September, but not at the same time all along the coast, being earlier in the southern and later in the northern part. The Lobster thus gets sick, as it is called, toward the end of June near Sogndal, and the export must then cease, as the mortality among them becomes too great, while near Karmö it is still in a healthy condition till July 15. Farther north the shedding of the shell begins still later, and Lobster may be caught all through July."

RATE OF GROWTH.—Nothing is known regarding the rate of growth of the Lobster for any extended period of time. Just how many years must elapse before it reaches a length of, say, ten inches has never been determined, nor can we expect to solve this problem without a long series of careful observations, which it seems almost impossible to make. It is well known that the Lobster increases in size only when shedding. As the old shell is cast away the soft body rapidly expands to a certain extent, and then soon becomes invested again with a new hard covering. Knowing the frequency of the shedding periods, and the amount of expansion at each, we could easily determine the age of Lobsters of all sizes; but these are the very data which are lacking. It is probable that the rate of growth is not the same at all shedding periods, but is greater in the younger stages than in the older. The early transformation from the embryo to the first perfect lobster form are all accomplished during a single season by several moltings, but beyond this period we know nothing accurately concerning the intervals between moltings, but in a medium-sized Lobster they probably occur only once or twice a year.

We have collected from several sources a few data as to the amount of expansion at certain stages of growth, and although we cannot vouch for their accuracy, they are probably not far from correct. The measurements given are for the length of the entire body without the claws. One Lobster eight inches long before shedding measured ten inches after shedding; another measured ten inches before and twelve inches after shedding; a third ten and one-half inches before and eleven and three-fourths inches after shedding; and a fourth ten and one-half inches before and twelve inches after shedding. If these measurements had all been taken with care they would indicate that the rate of growth was not always the same in different individuals of about the same size.

The lobster fishermen have very different notions regarding the ages of Lobsters, and while some contend that they attain a marketable size in two or three years, others extend the period to eight or ten years. The matter is one of considerable importance, bearing as it does upon the framing of proper protective laws, and the feasibility of lobster culture and breeding.

Mr. Frank Buckland, in his report for 1877, gives the two following notes on the frequency of shedding and the rate of growth of the European Lobster. They are not, however, very satisfactory; and we cannot believe that the American lobster sheds as frequently after the first year or two.

"According to some careful observations made at the marine laboratory, Concarneau, it

¹ AXEL BÖCK: Om det norske Hummerfiske og dets Historie. Copenhagen, 1868-'69.

appears that the first year the Lobster sheds his shell six times, the second year six times, the third year four times, and the fourth year three times.

"The following table shows the rate of growth in a Lobster after each shedding of its shell:

Sheddings.	Length.		Weight.	
	Inches.	Ounce.	Drachms.	
Eighth.....	2	.....	1	½
Ninth.....	2½	.....	2	½
Tenth.....	2¾	.....	3	½
Eleventh.....	3	.....	5	½
Twelfth.....	3½	.....	9	½
Thirteenth.....	4	.....	10	½
Fourteenth.....	4½	1	4	½

REPRODUCTION—GENERAL REMARKS.—Comparatively little has yet been made known regarding the reproduction of the American Lobster and the habits of the female during the *spawning season*. This is very unfortunate, considering the important bearing of all such information upon the question of the artificial breeding of Lobsters, which, if it is feasible, may ere long have to be undertaken in order to replenish our already diminished supplies. Many obstacles have been mentioned as standing in the way of such an enterprise, but from the favorable beginnings already made in Europe, as well as in this country, we are inclined to believe it will terminate successfully.

Most of our larger crustaceans, including the Lobster and common Crabs, although living mainly upon the bottom when adult, have free-swimming young, which, as soon as they leave the egg, and for a more or less prolonged period, lead a very erratic life. Not only, however, do the habits of the young generally differ very widely from those of the adults, but the appearance and structure of the two are as widely unlike. As described under "shedding," the Lobster grows by a series of molts. A molting or shedding of the skin indicates that the animal has grown too large for its inelastic outer coat. Now, the very young, or the larva, as they are sometimes called, grow in the same manner as the adults. When the higher crustaceans first leave the eggs they are very unlike the parent, having a very much simpler structure and often resembling one of the lower groups of crustaceans. The larva of the Lobster, for instance, is somewhat similar in structure and appearance to one of the simplest groups of Shrimps, the so-called Schizopods.

The free-swimming habits of the young furnish some of the most serious obstacles to the breeding of Lobsters. The embryos, after hatching, rise to the surface of the water, where they spend much of their time, and are borne hither and thither at the mercy of the currents, being often carried beyond the favorable influences necessary to their development. In many Lobster regions along our coast, in calm and clear weather, large quantities of the young may be dipped from the surface of the water, in the eddies and smooth streaks formed by the meeting of tidal currents. In these quiet spots the varied minute animal life characterizing the upper strata of the sea are collected together in the same manner as bits of wood and clusters of seaweed, which, from their larger size, are more familiar to the dwellers upon our coast. In stormy weather this surface life descends, in greater part, to lower levels. This vagrant life of the young Lobsters exposes them to the attacks of all kinds of predaceous surface-feeding animals, which consume them in immense numbers. In this manner a great mortality occurs—a much greater one, undoubtedly, than would arise did the young remain upon the bottom, where they could find some shelter and protection from their enemies. The means of caring for and protecting these wayward young should be the first consideration of the would-be Lobster-breeder, and in this matter he will probably encounter his greatest difficulties. The length of time required for the young to attain

the adult size is another matter of prime importance, as the breeder's success must also depend on his producing an early harvest. The age of what may be considered adult Lobsters (ten to eleven inches) is not known, estimates by different observers placing it all the way from three to a dozen years. If the latter estimate be correct, we would be almost forced to consider lobster-breeding as an industry impracticable from the start, as the care, during ten or twelve years, of the number of young necessary to produce salable Lobsters in marketable quantities would involve an expense quite out of proportion to the prices which could be obtained for them. We very much doubt, however, this prolonged extension of the immature stage of the Lobster, although we have no direct proof to the contrary. Lobstermen, as a rule, consider that Lobsters grow to be ten inches long in the course of three to five years, and they base their conclusions mainly on the fact that the increase in size at each molt is considerable; but this question is discussed elsewhere in this report. We do not pretend to say that, in case the slow growth of Lobsters is proved, breeding would be without many good results; for, if the growth and habits of Lobsters could be well understood, much care and protection might be accorded them, which would materially increase their numbers. Any new and carefully made observations on the spawning habits and growth of Lobsters would be gladly welcomed by all who are interested in the lobster question, whether from a scientific or a practical standpoint.

SPAWNING SEASON.—Lobsters appear to have no definite spawning season, as they are found with eggs, in different stages of development, during the entire year. According to the statements of lobster fishermen and others who have had abundant means of observation in this line, spawning takes place mainly from March until September. It should be remembered, however, that the winter lobster fishery is of very much less importance than the summer, and that during the former season the number of Lobsters handled does not in any way compare with the number taken in the latter, so that the proportion of spawning Lobsters to non-spawning ones, in the two seasons, may not be as great as would seem to appear. Winter observations on the natural history of the Lobster, as well as of many other of our marine food invertebrates, are very much desired. It is said that on the northern New England coast, from Cape Cod eastward, Lobsters with spawn about ready for extrusion from the body begin to appear abundantly in March, and with the spawn or eggs on the outside, as well as hatching, are most abundant from June to September. In the Bay of Fundy, Lobsters spawn principally from the last of June to the last of August. Southward of these limits the spawning season begins earlier.

Considering, now, the fact that spawning Lobsters occur throughout the entire year, we are left without data as to the frequency of spawning in each individual Lobster. Did a short, definite spawning period exist for each year, we might assume that Lobsters spawned only once a year, or at least we could assert that they spawned no oftener than once a year. The only way of determining the fact positively would be to study individual Lobsters for a certain period of time, in their natural haunts and under natural conditions, and every one knows how difficult such an undertaking would be with most marine animals. As it is, the possibility exists of Lobsters spawning more than once a year, and there is no evidence to prove that they spawn with any exact regularity as to time. We have the statements of several individuals, some published and others not, to the effect that quite fully developed eggs are sometimes apparent in the ovaries when the Lobster is carrying spawn on the outside of the body. But there is no way of determining how long a time must elapse before the second lot of spawn might be fertilized and made ready for extrusion. We are justified in believing, however, that, as a rule, Lobsters spawn but once a year. In the Lobster, as in many other marine animals, only a portion of the ova is fertilized and developed at each spawning time, often leaving the ovaries still quite

expanded with their contents, and therefore we must always expect to find spawn in some stage of development within the adult female, whether she is carrying external spawn or not. This statement will serve to explain to lobstermen the fact, which they often regard with some surprise, of females carrying both internal and external spawn at the same time, the former, of course, far less developed than the latter.

The mature ovaries form two elongate lobes of considerable size, on the upper side of the body, just within the shell, and immediately before spawning Lobsters are considered to be in very good, if not the best, condition for eating; it is probable also that at about this stage the spawn first attracts the attention of most fishermen.

HABITATS WHILE SPAWNING.—Nothing definite seems to be known regarding the haunts of spawning Lobsters, or as to whether they change their ground at such times. It is probable that, to some extent, they do prefer certain localities for this purpose; but as Lobsters with spawn are taken by the fishermen in their traps at all seasons of the year, and in all depths, this rule cannot, by any means, be regarded as universal. By assuming that certain regions are more favorable for the development and hatching of the eggs, we can readily explain the great preponderance of female Lobsters with spawn on the sandy shores about Provincetown, Cape Cod, during the summer months. Yet, in direct contrast with this region stands nearly the entire coast of Maine, rocky in the extreme, where Lobsters are even more abundant, and where they probably reproduce in equal proportions.

SIZE OF SPAWNING LOBSTERS.—Lobsters do not generally begin to spawn until they have attained a length of about ten and a half to eleven inches (exclusive of the claws), which is about the legal size of marketable Lobsters. We are informed by several correspondents, however, that spawning Lobsters have been taken as small as eight, nine, and ten inches; but such as these are very rare. It is probable that they become mature at a smaller size at the South than at the North, as Lobsters average smaller in Southern New England than in Northern New England, and yet the age may average the same in both cases. Mr. S. M. Johnson, of Boston, who has handled many thousands of Lobsters, states that he has never seen from east of Cape Cod more than two or three specimens bearing spawn under ten and a half inches. He thinks that but few begin to spawn much under eleven inches in length, and this size, in his opinion, would be the proper limit below which none should be sold in order to fully protect the species.

PAIRING.—So far as we are aware, no one has ever witnessed the operation of pairing in Lobsters, and all that we know concerning it is mere conjecture. Many of the female Lobsters obtained from sandy bottoms, as at Provincetown, Cape Cod, are said, by observers, to have the carapax more or less abraded along the top, and also somewhat worn over a limited area upon the sides. This has led the fishermen to believe that, in pairing, the female Lobster lies upon her back with the male on top, clasping her about the carapax with his claws. While in this position any strong agitation of the water by the waves in slight depths would probably cause the pairs to oscillate backward and forward, and might account for the abraded carapaces of the female, which are said to be of common occurrence. This story has been told us by several reliable parties, entirely independent of one another; but we cannot say how much reliance should be placed upon it, and the evidence is certainly very slight.

A large New York dealer in Cray-fishes, who keeps large quantities of these lobster-like crustaceans on hand during their season, says that he has frequently witnessed them pairing, and that the males and females come together belly to belly, with the claws of one tightly clasping those of the other, and spread out so as to form with the bodies a rude Y-shaped figure.

NUMBER OF EGGS.—The Lobster, like many other crustaceans, carries a very large amount of spawn on the exterior of the body at each spawning time. The number varies with the age and size of the Lobster, but to what extent is not known. Mr. S. M. Johnson, of Boston, states that two and a half pound Lobsters bear externally, on an average, about twenty thousand eggs at a time, according to several careful computations, made by comparing the weight of a certain number of eggs with the weight of the entire mass of spawn attached to the swimmerets.

Two females which I examined at Eastport, Maine, in the summer of 1882, gave the following results as regards the number of eggs carried on the swimmerets. The first specimen, measuring $13\frac{3}{8}$ inches in length, had 875 grains of eggs, there being 20 eggs to a grain, making a total of 17,500 eggs. The second specimen measured 13 inches long and carried 480 grains of eggs, with 25 eggs to a grain, making a sum total of about 12,000 eggs. Neither of the above specimens, however, appeared to have their full quota of eggs, as many of the bunches seemed to have been more or less brushed away, probably by rough handling. In the last specimen, especially, had all the bunches been of equal and full size, the number would have been increased fully one-half.

According to Mr. Frank Buckland, "the [English] Berried Lobster carries five bunches of eggs on each side underneath the tail, making ten bunches in all. I have counted the eggs in one bunch and find that there are 2,496, making the number of eggs in this one lobster 24,960. Lobsters are found with berries all the year round; March, April, May are the months when they are fullest."

DESIGNATIONS OF SPAWN.—Lobster spawn is variously designated, on different parts of the coast, as "spawn," "roe," "eggs," "berry," "seed," "pea," "sweetbread," "coral," etc.; but in most places it is known simply as "spawn," "eggs," or "berry." On the Nova Scotia coast the term "coral" is sometimes used to designate the nearly mature spawn while still within the body of the Lobster, and after it has passed to the outside it is called "eggs." In the Bay of Fundy the terms "coral," "roe," and "sweetbread" refer to the spawn before extrusion from the body, and they may also be used in a similar way on other parts of the coast. In some portions of Long Island Sound, Lobsters with external spawn are called "Black-egg Lobsters."

THE SPAWN AS FOOD.—Before the spawn has passed from the body to the external appendages it is very much esteemed as food, and is generally eaten whenever it can be obtained; it is also canned. The external spawn, however, although sometimes used to garnish fish dishes and salads, is not usually regarded as edible.

EXTRUSION OF THE EGGS, ETC.—The spawning of the Lobster is accomplished in about the same manner as with the Cray-fish, regarding which many more carefully recorded observations are extant. According to Huxley, the fecundating material of the Cray-fish, which is extruded from a small aperture on the basal joint of the hindermost pair of legs, is a "thickish fluid, which sets into a white solid after extrusion." This substance is deposited by the male on the thorax of the female, between the bases of the hindermost pair of thoracic limbs. The apertures for the outward passage of the eggs are situated on the bases of the second pair of legs, back of the large claws. The eggs, "as they leave the apertures of the oviducts, are coated with a viscid matter, which is readily drawn out into a short thread. The end of the thread attaches itself to one of the long hairs with which the swimmerets are fringed, and as the viscid matter rapidly hardens, the egg thus becomes attached to the limb by a stalk. The operation is repeated until sometimes a couple of hundred eggs are thus glued on to the swimmerets. Partaking in the movements of the swimmerets, they are washed backward and forward in the water, and thus aerated and kept free of impurities."

The process of development is slow, and the young, when first hatched, bear a general

resemblance to the parent. For some time after they are hatched they hold on to the swimmerets of the mother, and are carried about protected by her abdomen. As they become more active they sometimes leave the mother when she is resting quietly and creep about a short distance off, but quickly return to her on the first semblance of danger. A few days later they gradually forsake her for good. The earlier stages of the embryo Lobster differ considerably from those of the Cray-fish, as described further on. The eggs of the Lobster are probably extruded in a similar manner, and are attached to the swimmerets by the same viscid substance. According to some American observers, however, the viscid substance is first extruded from the openings of the oviducts and appears as a thick, globular mass, which is brushed back over the swimmerets by the movements of the posterior pair of thoracic legs. The eggs are said to follow immediately afterwards and to be spread about in the same manner. Becoming thus securely attached to the swimmerets, they remain well protected and are kept constantly aerated by the movements of these posterior flaps until the young are hatched. Without further observations we cannot strongly indorse the idea of the viscid material being first excreted; but if such occurs in the beginning, there is still no reason why the eggs may not be also covered with the same substance as they are laid. The eggs are not attached to the smooth surface of the swimmerets of the Lobster, but to the long, slender hairs which project from along their sides. In that way they hang more loosely and can be given freer motion.

SHEDDING AFTER SPAWNING.—As explained under “shedding,” it is probable that, as a rule, the females shed their shells soon after their eggs are hatched, as there is no other way of ridding themselves of the broken egg-shells adhering so firmly to the swimmerets by means of the tough little threads. Lobsters with very ripe spawn have frequently been seen in a condition preparatory to shedding, thus, in a measure, corroborating the above conjecture. According to Prof. S. I. Smith this shedding after spawning is known to occur in some of the Crabs. This peculiarity is also affirmed with regard to the European female Lobster, as described elsewhere.

DEVELOPMENT OF THE YOUNG.—The earlier embryonic stages of the Lobster have been studied by Prof. S. I. Smith, of Yale College, whose observations, however, extended over only a limited period. They were made at Wood’s Holl, Massachusetts, and New Haven, Connecticut. Eggs with the embryos well advanced, taken from the females May 2, had the shape of slightly elongate spheroids, about 2.1^{mm} long and 1.9^{mm} across. “One side is rendered very opaque dark green by the unabsorbed yolk mass, while the other shows the eyes as two large black spots, and the red pigment spots on the edge of the carapax, bases of the legs, etc., as irregular lines of pink markings. . . . Fully one-half the embryo is still occupied by the unabsorbed portion of the yolk. . . . The eyes are large, nearly round, and with a central portion of black pigment. . . . The five pairs of cephalo-thoracic legs are all similar and of about the same size, except the main branch of the first pair, which is much larger than that of the others. . . . The subsequent development of the embryo within the egg was not observed.”

In the account of his observations, Professor Smith goes on to describe such of the embryonic stages following hatching as he was able to obtain. From his long and technical descriptions we extract only those portions which can be best understood by the general reader, and which it will be well for the breeder to become acquainted with to aid him in his practical labors. We would suggest here that the breeder himself, or some intelligent man in his employ, should familiarize himself with the workings of an ordinary low-power microscope, in order that he may follow the development of the young Lobsters under his care, and observe whether they are doing well or die off soon after hatching. Unless such precautions as these are taken, he might continue to work for a long time completely in the dark, and without knowing whether he was making

progress or not. A continuous series of observations would enable him, at all times, to follow the success of his experiments, or determine, perhaps, the causes of his failures.

The exact number of changes or moltings which take place between the last egg stage and the first stage having the general shape and characters of the adult, is not known. Professor Smith observed three such stages, but supposes others to be wanting. His account of these stages is as follows:

"The following observations on the young larvæ, after they have left the eggs, have all been made upon specimens obtained in Vineyard Sound, or the adjacent waters, during July. These specimens were mostly taken at the surface in the daytime, either with the towing or hand net. They represent three quite different stages in the true larval condition, besides a later stage approaching closely the adult. The exact age of the larvæ of the first stage was not ascertained, but was probably only a few days, and they had, most likely, molted not more than once. Between the third stage, here described, and the last there is probably an intermediate form wanting.

"*First stage.*—In this stage the young are free-swimming Schizopods¹ about a third of an inch (7.8^{mm} to 8.0^{mm}) in length, without abdominal appendages, and with six pairs of pediform cephalo-thoracic appendages, each with the exopodus developed into a powerful swimming organ. The eyes are bright blue; the anterior portion and the lower margin of the carapax and the bases of the legs are speckled with orange; the lower margin, the whole of the penultimate, and the basal portion of the ultimate segment of the abdomen are brilliant reddish-orange. The antennæ have large, well-developed scales, furnished along the inner margin with long, plumose hairs. . . . The anterior cephalo-thoracic legs, which in the adult develop into the big claws, are exactly alike and no longer than the exterior maxillipeds. The pediform (outer) branch is, however, somewhat stouter than in the other legs, and subcheliform (bearing an imperfect claw); the legs of the second and third pairs are similar to the first, but not as stout. The legs of the fourth and fifth pairs are still more slender, and styliform at the extremity, as in the adult." Very rudimentary branchiæ or gills are observed on all of the legs and the external maxillipeds. "The abdomen is slender, the second to the fifth segments each armed with a large dorsal spine, curved backward, and with the lateral angles produced into long spines, and the sixth segment with two dorsal spines. The posterior margin of the last segment is armed with a long and stout central spine, and each side with fourteen or fifteen plumose spines or setæ, which are articulated to the margin.

"In this stage the young were first taken July 1, when they were seen swimming rapidly about at the surface of the water among great numbers of Zoëæ, Megalops, and Copepods. Their motions and habits recall at once the species of *Mysis* and *Thysanopoda*, but their motions are not quite as rapid, and are more irregular. Their bright colors render them conspicuous objects, and they must be readily seen and captured by fishes. They were frequently taken at the surface in different parts of Vineyard Sound from July 1 to 7, and several were taken off Newport, Rhode Island, as late as July 15, and they would very likely be found also in June, judging from the stage of development to which the embryos had advanced early in May in Long Island Sound. Besides the specimens taken in the open water of the Sound, a great number were obtained July 6 from the well of a lobster-smack, where they were swimming in great abundance near the surface of the water, having undoubtedly been recently hatched from the eggs carried by the

¹ The Schizopods are a group of Shrimps, lower in organization than our common Shrimp (*Crangon vulgaris*), and very abundant along the New England coast. They generally swim in large schools, either at the surface or at intermediate depths between the surface and the bottom, often at some distance from land.

female Lobsters confined in the well. Some of these specimens lived in vessels of fresh sea-water for two days, but all efforts to keep them alive long enough to observe their molting failed. They appeared, while thus in confinement, to feed principally upon very minute animals of different kinds, but were several times seen to devour small Zoëæ, and occasionally when much crowded, so that some of them became exhausted, they fed upon each other, the stronger ones eating the weaker.

“Second stage.—In the next stage the young Lobsters have increased somewhat in size, and the abdominal legs of the second to the fifth segments have appeared. The rostrum is much broader and there are several teeth along the edges. The basal segments of the antennulæ have become defined, and the secondary flagellum has appeared, but is not subdivided into segments. The antennæ and mouth organs have undergone but slight changes. The first cephalo-thoracic legs are proportionally larger and stouter than in the first stage, and have become truly cheliform. The succeeding legs have changed little. The epipodi of all the legs and of the external maxillipeds have increased in size, and the branchial processes are distinctly lobed along the edges, and have begun to assume the form of true branchiæ. The segments of the abdomen have the same number of spines, but they are relatively somewhat smaller, and the last segment is relatively smaller and broader at base. The appendages of the second to the fifth segments differ considerably in size indifferent specimens, but are nearly as long as the segments themselves; their terminal lamellæ, however, are represented only by simple, sack-like appendages, without sign of segmentation, or clothing of hairs or setæ. The penultimate segment is still without appendages. Specimens in this stage were taken only twice, July 1 and 15. They have the same habits and general appearance as in the first stage, but are readily distinguished by the possession of rudimentary abdominal legs. In color they are almost exactly the same, only the orange-colored markings are perhaps a little less intense.

“Third stage.—In the third stage the larvæ are about half an inch (12^{mm} to 13^{mm}) in length, and the integument is of a much firmer consistency than in the earlier stages. The antennulæ are still rudimentary, and considerably shorter than the rostrum, although the secondary flagellum has increased in length and begins to show division into numerous segments. The antennæ retain the most marked feature of the early stages—the large size of the scale—but the flagellum is much longer than the scale and begins to show division into segments. . . . The external maxillipeds have begun to lose their pediform character. The anterior legs have increased enormously in size, and those of the second and third pairs have become truly chelate, while the swimming exopodal branches of all the legs, as well as of the external maxillipeds, are relatively much smaller and more unimportant. . . . The branchiæ have developed rapidly and have a single series of well-marked lobes along each side. The abdomen still has the spines characteristic of the earlier stages, though all of them are much reduced in size. The appendages of the second to the fifth segments have become conspicuous, their lamellæ have more than doubled in length, and the margins of the terminal half are furnished with very short ciliated setæ. The appendages of the penultimate segment are well developed, although quite different from those in the adult. The outer lamella wants wholly the transverse articulation near its extremity, and both are margined, except the outer edge of the outer lamella, with long plumose hairs. The last segment is relatively smaller and more quadrangular in outline, and the spines of the posterior margin are much smaller. The only specimens procured in this stage were taken July 8 and 15. In color they were less brilliant than in the earlier stages, the orange markings being duller and the whole animal slightly tinged with greenish-brown.

“In the next stage observed, the animal, about three-fifths of an inch (14^{mm} to 17^{mm}) long, has

lost all its schizopodal characters, and has assumed the more important features of the adult Lobster. It still retains, however, the free-swimming habit of the true larval forms, and was frequently taken at the surface, both in the towing and hand net. Although resembling the adult in many features, it differs so much that, were it an adult form, it would undoubtedly be regarded as a distinct genus. The rostrum is bifid at tip, and armed with three or four teeth on each side toward the base, and in some specimens with a minute additional spine, on one or both sides, close to the tip. The flagella of the antennulæ extend scarcely beyond the tip of the rostrum. The antennal scale is very much reduced in size, but is still conspicuous and furnished with long plumose hairs along the inner margin, while the flagellum is as long as the carapax. The palpi of the mandibles have assumed the adult character, but the mandibles themselves have not acquired the massive molar character which they have in the older animal. The other mouth organs have nearly the adult form. The anterior legs, although quite large, are still slender and just alike on the two sides, while all the cephalo-thoracic legs retain a distinct process in place of the swimming exopodi of the larva. The lateral angles of the second to the fifth abdominal segments are prolonged downward into long spiniform teeth; the appendages of these segments are proportionately much longer than in the adult, and the margins of their terminal lamellæ are furnished with very long plumose hairs. The lamellæ of the appendages of the penultimate segment are oval, and margined with long plumose hairs. The terminal segment is nearly quadrangular, as wide at the extremity as at the base, the posterior margin arcuate, but not extending beyond the prominent lateral angles, and furnished with hairs like those on the margins of the lamellæ of the appendages of the penultimate segment. In color they resemble closely the adult, but the green color of the back is lighter, and the yellowish markings upon the claws and body are proportionately larger.

"In this stage the young Lobsters swim very rapidly by means of the abdominal legs, and dart backward, when disturbed, with the caudal appendages, frequently jumping out of the water in this way like Shrimp, which their movements in the water much resemble. They appear to be truly surface animals, as in the earlier stages, and were often seen swimming about among other surface animals. They were frequently taken from the 8th to the 28th of July, and very likely occur much later. From the dates at which the different forms were taken, it is probable that they pass through all the stages here described in the course of a single season. How late the young, after reaching the lobster-like form, retain their free-swimming habit was not ascertained."

DEVELOPMENT OF THE EUROPEAN LOBSTER.—According to Prof. G. O. Sars, of Norway, the European Lobster agrees more or less closely with our own species in its spawning habits and development, as the following extract from his report will show:¹

"The propagating of the Lobster does not seem to be strictly confined to a certain season of the year, as Lobsters with roe may be found nearly all the year round. But the rule seems to be that the development of the young goes on during the summer months, from the beginning of July until the early part of September. The more developed roe can easily be distinguished by its lighter color, and partly, also, by the larger size of the eggs. A closer examination shows distinctly in every egg two dark spots, which are the eyes of the embryo. The more distinct these spots are the more developed is the embryo. When its development is complete the egg-shell bursts, and the young Lobsters come out. These are in the beginning very helpless and sink to the bottom, where within a very short time they undergo their first change of shell. Soon afterward their swimming apparatus, which has so far been surrounded by a skin, begins to work, and the

¹ Salt-water Fisheries of Norway. Christiania, 1878.

young Lobsters soon gambol about in the water, and come up to the surface, where they remain during the entire time of their future development. . . .

"At the fifth change their metamorphosis is complete, and therewith ends their pelagian life. The young Lobster has then entirely lost its swimming apparatus attached to the fore part of its body, and in its stead the well-known fringes have grown at the lower side of the back part of the body. These fringes are the only swimming apparatus which the grown Lobster possesses; in the female Lobster they also serve to keep the roe in position. The Lobster now leaves the surface and goes to the bottom, there to lead the same life as its parents. I am not positively certain how long a time is required for the entire metamorphosis, but I am inclined to believe that it consumes a couple of months.

"Even after the Lobster has reached its final development, it continues to change its skin regularly at least once a year, and continues to do so as long as it grows. Only when it has ceased growing this change of skin does not occur so often. We shall, therefore, always find that very large Lobsters are more or less thickly covered with scales, which is not so frequent in smaller specimens. . . .

"I did not succeed in obtaining Lobsters measuring from an inch to a finger's length, and so far as I know none are contained in any museum. I consider it as certain, however, that the Lobsters keep near the coast during this stage of their development. The reason why they cannot be caught with the bottom scraper is partly their quick movements and partly the circumstance that they hide among the algæ on the bottom of the sea. The fact that they cannot be caught in the common lobster-baskets is easily explained by these having such wide openings."

The following account of the reproduction of the European Lobster on the French coast is by the late M. Coste, well remembered from his many interesting and extensive experiments in several branches of fish culture. We have no means of determining how accurate these observations are, nor do we know whether they are the result of close study or conclusions derived from the accounts of fishermen. We offer them here as affording many valuable suggestions which may aid observers on our own coast. The seasons do not entirely correspond with ours:

"The Lobster commences breeding in the month of October, and the pairing takes place sometimes as late as January. The couplings are rare at the opening of the season, but increase in frequency to the end of December, and but few take place in January. The female emits the eggs in about fifteen or twenty days after the pairing. When they have reached the stage proper for their expulsion, the female applies the inner side of the tail against the plastron or shell immediately over the stomach, in such a manner as to form a cup or cavity, in which are to be found the openings of the oviduct, placed exactly behind the third pair of legs. Consequently when the eggs escape they fall into this natural cup or cavity, as described above. They are expelled in successive jets, to the number of twenty thousand in a single day.

"The Lobster emits at the same time, along with the eggs, a kind of adhesive liquid, which binds the eggs one to the other, and attaches them all to the small feet under the tail, where they remain in perfect shelter from all harm until they are sufficiently ripe for final expulsion.

"In order to forward and force the regular incubation of the ova, the females have the power to give them more or less light, as they consider requisite, by closing or opening the fold of the tail. Sometimes the eggs are kept quite covered, and at other times they give them a kind of washing, by moving the flanges of the tail in a peculiar manner. The incubation lasts six months, during which time the female takes such good care of the ova that it is rare to find an injured embryo or barren egg.

"It is during the months of March, April, and May that the actual birth of the young Lobster takes place. The females, in order to expel the embryos, now ready to burst the shells of the eggs, extend their tails, make light oscillations with the fan and its appendages, so as to rid themselves gradually of the young Lobsters, which they succeed in doing in a few days. The young Lobster, as soon as born, makes away from its parent, rises to the surface of the water, and leaves the shore for the deep water of the sea, where it passes the earliest days of its existence in a vagabond state for thirty or forty days. During this time it undergoes four different changes of shell, but on the fourth it loses its natatory organs, and is, therefore, no longer able to swim on the surface of the water, but falls to the bottom, where it has to remain for the future; according, however, to its increase of size it gains courage to approach the shore which it had left at its birth. The number of enemies which assail the young embryos in the deep sea is enormous; thousands of all kinds of fish, mollusks, and crustaceans are pursuing it continually to destroy it. The very changing of the shell causes great ravages at these periods, as the young Lobsters have to undergo a crisis which appears to be a necessary condition to their rapid growth. In fact, every young Lobster loses and remakes its crusty shell from eight to ten times the first year, five to seven the second, three to four the third, and from two to three the fourth year. However, after the fifth year, the change is only annual, for the reason that were the changes more frequent the shell would not last long enough to protect the ova adhering to the shell of the female during the six months' incubation. The Lobster increases rapidly in size until the second year, and goes on increasing more gradually until the fifth, when it begins to reproduce, and from this period the growth is still more gradual."

TRANSPLANTING OF THE YOUNG.—For the benefit of those interested in the question of breeding Lobsters by artificial means or care, we extract the following paragraph from a communication made by Capt. N. E. Atwood, of Provincetown, Massachusetts, to one of the New York papers about fifteen years ago:

"When we take a cargo of Lobsters on board of a fishing-smack and throw them into the well, many of the young are so far developed that when they strike the water the shell of the egg is broken, and you can see hundreds of thousands of little Lobsters on or near the top of the water in the well. After the cargo has been taken on board, the smack sails for New York, and during the whole passage the young are being hatched and are passing out through the holes in the bottom of the well. On the arrival of the smack at Fulton Slip the Lobsters are taken out and put in cars. If any of the eggs are on the Lobsters, not hatched, they are soon eaten off by eels, which go out and in the car as they please."

These observations of Captain Atwood are exceedingly interesting. It is probable that the numerous young Lobsters hatched on the trips of the Cape Cod smacks through Long Island Sound have contributed toward increasing the supply of Lobsters along that section of coast. It has amounted to a transplanting of Lobsters from one prolific region to another much less prolific, and the benefits thus inadvertently derived were possibly considerable. This traffic has long ceased, however, and young Cape Cod Lobsters no longer find their way into the waters of Long Island Sound.

FOOD.—The Lobster appears to feed upon most any kind of animal matter within its reach, but is said to prefer fresh fish as bait. Feeding naturally, it probably does not discriminate closely as to its food. It digs clams from the bottom and removes mussels from their places of attachment, sometimes crushing the shells in its claws, and afterwards devouring out the soft parts. Flounders and other bottom fish undoubtedly fall a prey to its appetite, and it has been seen to catch nimbly at small fish swimming by. Very probably it feeds upon all kinds of invertebrate life which

are palatable to its taste and live within easy reach of its claws. Sea-urchins even are described as furnishing food for it on the Nova Scotia coast. Flounders, sculpins, herring, menhaden, codfish heads, haddock, and bluefish are commonly used as bait in the lobster-pots. An experienced observer who has watched their habits under peculiarly favorable circumstances, on the coast of Maine, states that, in devouring clams, he has never seen them crush the shell, but as it were they absorb the meat from between the valves, leaving the latter intact. He has never seen them catch living fish, but could not positively affirm that they did not do so at times.

CASTING A CLAW.—As is well known, Lobsters have the power of dropping or "shooting" one or both claws, which may be more or less completely replaced by a new growth. Many incentives are quoted for this curious procedure, the principal ones being hauling, especially in cold weather, entanglement of the claws, and fright. Fright, or a sudden impulse to free themselves from impending danger or pain, is probably the main cause, however it may be produced. The break does not occur between any of the movable joints, but always at one particular point, near the upper end of the second or double joint, where it is smallest and encircled by a distinct groove. The claw cannot be broken off at this or any other place by main force without injury to the Lobster, causing it to bleed to death.

Occasionally in mild weather, but much more frequently in cold weather, Lobsters will shoot their claws if handled by them out of water. This also frequently occurs when Lobsters become entangled by their claws in the fishermen's nets. As they are drawn above the water, they will often, without a moment's warning, slide back into their native element, leaving their disjointed member behind. Loud noises, such as thunder, the firing of cannons, etc., are said to incite Lobsters to shoot their claws, and also the presence of very impure or fresh waters; but to what extent this happens we cannot say. When a claw becomes injured or broken, or perhaps crushed by an antagonist of the same species, so as to render it useless or painful, it is often dispensed with, in order that a new one may take its place. This process of dropping an old and growing a new claw is certainly a wise provision of nature, for this appendage is much subject to injury, and nothing more deplorable can be imagined than a Lobster with mutilated claws.

The practice of shooting a claw, even under natural conditions, seems at times to be a very common one. Out of one hundred specimens, averaging about eight or nine inches long, collected for natural history purposes in Narragansett Bay, in 1880, fully twenty-five per cent. had lost a claw each, and a few both claws. From each stump, in all these specimens, projected a short soft claw, still very imperfect in structure, and measuring from one-fourth of an inch to about an inch in length. In some of the specimens, one or more of the hinder legs were being reproduced in the same way. The fishermen state that similar specimens are also sometimes common in their catch. The breaking off of a claw, according to observers, is accomplished so quietly that the operation is scarcely perceptible. If a claw of a Lobster be seized by the hands while he is in the water, and he casts it, no unusual sensation is felt, but the claw is simply left behind, and the former owner darts quickly off. Soon after the break occurs, it is covered with a crust of coagulated blood, which prevents further bleeding until a skin has formed, from the center of which the new claw begins to grow. How long a time is required for the new claw to attain a size proportioned to that of the Lobster, if it ever reaches that size, is not known. However, the incipient claw remains soft and continues to grow probably until the first molt, after which its outer layer of skin is supposed to harden like that of the remainder of the Lobster. Specimens are frequently taken with hardened claws of regular shape, but of different sizes below the normal one, rather indicating that at least several moltings must take place before the claw can reach its full size.

The following incident, furnished by a correspondent, forcibly illustrates the process of shooting a claw and points a moral. A party who had purchased a number of Lobsters as food thought to keep them fresh overnight by hanging them over the side of his vessel, by means of cords tied to the claws. In the morning, when he went to examine his live stock, he found nothing but the claws remaining fast to the cords, the Lobsters having dropped back into their former abode.

DEFORMITIES AND DISEASES.—Lobsters are subject to many deformities or malformations, which generally occur upon the claws, and appear to originate from several causes. A broken claw is sometimes mended in an irregular manner, and there are frequent instances of what are termed double claws, resulting from the formation of a second projection or thumb upon either the larger or smaller branch of the claw, and which is more or less perfect in shape but immovable. Rarely the two branches of the claw are not regularly set with reference to one another, and instead of working in the same plane, and meeting edge to edge, they pass one another like the blades of a pair of scissors. The thumb or finger of one of the claws occasionally takes on an unusual or fantastic shape, or becomes greatly broadened and thickened, but the variations to which the claws are subject are too numerous to warrant description here. Many of them have been figured and discussed by Mr. Walter Faxon in the "Bulletin of the Museum of Comparative Zoology" for March, 1881. They probably arise in part from injuries received while in the soft state, but in great measure they have not been accounted for.

During the past winter, there was sent to the National Museum, from the coast of Nova Scotia, the carapax of a medium-sized Lobster, with two small round openings covered with membranes, placed symmetrically one on each side of the median line, a short distance back of the rostrum. By the person who sent the specimen, and who saw the Lobster when alive, these membranes were described as projecting slightly from the surface, and taking on the appearance of a second pair of eyes. Unusual but symmetrical markings also occur upon the dorsal side of the carapax. The specimen was so thoroughly cleaned and dried, however, before we received it—nothing remaining but the shell—that it is now impossible to form a correct idea as to the real import of these strange features.

Diseased Lobsters are not commonly met with. Individuals are occasionally found in a very emaciated condition, and some with soft spots like sores upon the body; but such cases are rare. Specimens are sometimes taken with small portions of the body gone, or with deep scars and dents upon the surface, the results of injury. It is usually the older individuals that are marked in this way.

PARASITES.—Lobsters do not appear to be much troubled with external parasites or messmates. Barnacles often grow upon the back and claws, and mussels sometimes attach themselves to the same places. The number of Barnacles is frequently so great and they cover so large a portion of the exterior surface as to seriously impede the movements of the Lobster, but this seldom happens. Fish-lice are mentioned by the fishermen as occasionally occurring on the Lobsters, but as we have never seen any specimens of such it is impossible to determine what they may be, if they are parasites at all.

ENEMIES.—All the larger bottom-feeding fish probably feed upon the Lobster, and the surface fish also greedily devour the young. Soft-shell Lobsters suffer most in this way, and are frequently found in the stomachs of cod taken by the fishermen. Sharks, dogfish, rays, tautog, and striped bass are also mentioned as being especially fond of Lobsters, but this list could undoubtedly be greatly extended without much trouble. Water-birds sometimes feed upon the smaller individuals in shallow water. During the earlier period of their existence, while they are still

free swimmers and very small, living mostly at the surface of the water, by far the greatest mortality must occur. At this time they are eaten in vast quantities along with other surface animals by the more active fish and invertebrates, and probably but a comparatively small proportion of those hatched from the egg ever survive this stage. We may, however, be justified in asserting that the greatest enemy of the Lobster is man.

Mr. Frank Buckland, in treating of the enemies of the European Lobster, says that "among the animate enemies the principal one, I believe, is the cod. A witness at Burghead stated that 'codfish are great enemies to Lobsters; he hardly ever opens a cod without finding young Lobsters in the stomach; this is particularly in February and March; has seen cod throwing up Lobsters on the deck of a vessel, as many as five or six Lobsters in one cod. These Lobsters would be three or four inches in length, or even smaller. Cod eat Lobsters all the season. In the spring, and in January, February, and March, there are many cod about.' Skates and congers, codling and haddock, also eat Crabs and Lobsters."

DESTRUCTION BY STORMS.—Mr. F. H. Baker, in a recent paper on American Lobsters, refers to their being occasionally destroyed in great numbers in shallow water by heavy storms. He cites as an instance the great Saxby storm on the coast of Nova Scotia, after which the dead Lobsters were piled up in immense numbers, in several places, "lining the shores like windrows of hay on a field in midsummer, the stench from which was overpowering as the Lobsters decayed in the sun."

DISTRIBUTION AND HABITS OF THE EUROPEAN LOBSTER.—The following account of the distribution and habits of the European Lobster, *Homarus vulgaris*, abstracted from a report by a Danish-Norwegian naturalist,¹ is inserted here to permit of comparison between these two closely related forms, and to fill up some of the numerous gaps in the history of our own species. The European Lobster is so similar to our own structurally that we are safe in assuming that the habits of the two are in the main alike. In comparing the European with the American species, however, it must always be borne in mind that the former never attains the extreme size of the latter, and also averages smaller in size, while the female begins to spawn when only six inches long, although at this size it may possibly be quite as old as the young spawning American female. There are so many important questions of practical value still unsolved regarding the American Lobster, that the suggestions set forth by this Norwegian report may lead to their proper investigation:

"The European Lobster seems to have its central location on the southwestern coast of Norway, and goes as far north as Finmarken, where, according to Lem, in his description of the Finmarken Laplanders, 1767, it is found north of Traenen, where he ate very fine ones on the island of Rödö, while formerly their northern limit was thought to be the island of Bröndö; but he also thinks that they would be found in Finmarken, if people only searched for them. It is very rarely found on the coasts of Iceland, where, according to Mohr's 'Islandske Naturhistorie,' it has been found by Dr. Poulsen in Gröndevig, but it does not extend to Greenland or Spitzbergen. It does not go into the Baltic, but is found all over the Kattegat, especially near Anholt, Hirsholmene, Laesö, and Hjelm, and, according to Mr. Fiedler's report, in the Great Belt as far as Sprogö. On the coast of Bohuslan it is very common, and is said to go into the Sound as far as the island of Hveen. On the west coast of Jutland, it is found wherever the bottom is stony, and it is very common near Heligoland. It rarely goes into the inlets on our western coasts, chiefly on account of their great depth. It is very rare in the inner portion of the Bay of Christiana, and not very common in the Limfjord. On the coasts of England, Scotland, and Ireland, it is

¹ AXEL BOECK: Om det norske Hummerfiske og dets Historie. Copenhagen, 1868-'69.

common wherever there is a rocky bottom, especially near Montrose, Orkney, Lewis, and Harris Island, and on the southern coast of England, near Land's End and the Scilly Islands. Near the Channel Islands it is common, as well as near several groups of islands on the French coast. In the Mediterranean it is not so common, although it is not entirely wanting; but its substitute as an article of food is another large species of Cray-fish, the *Langusta (Palinurus)*. It is, therefore, not spread over a very large extent of sea; but it is found in its central locations in very large numbers, and there becomes an important article of food and trade.

"Its general size is eight to ten inches from the point of the spine on the forehead to the tip end of the tail. It rarely exceeds this size where large fisheries are carried on; but now and then specimens of a much greater size are found in places from which none are exported, and where it consequently has time to grow before it is caught. Thus, Pontoppidan, in his 'Norges naturlige Historie' (part ii, p. 279), says that the very large Lobsters are called 'Størjer,' and that near Utvaer, on the Bay of Evien, a Lobster had been seen which was so large and ugly that nobody dared to attack it, and that it measured a full fathom between the claws. This seems certainly to be somewhat exaggerated; but I myself have seen the claw of one which must have been about eighteen inches long. Sir John Graham Dalyell says, in his work 'The Powers of the Creator,' 1827, that he had seen a joint of the left claw of a Lobster that measured nine inches in length. According to this, the whole claw must have measured eighteen to twenty-four inches, and the whole animal three to four feet. As a general rule, those that are taken in the fiords are larger than those that are caught near the islands toward the sea. The color of the animal when alive is generally a blackish-green, with several blue spots; but it may also be lighter, especially near the mouths of fiords, while farther out toward the sea it becomes much darker. I may mention as a curiosity that during this year (1868) I found a Lobster near Haugesund, one-half of which was of a greenish-black and the other of a light-orange color, there being a sharp and clearly defined dividing line, which ran lengthwise, and divided the Lobster in two halves of equal size.

"The Lobster lives close to the coast, where there is a rocky bottom, among the large algæ; but in winter, when the water grows cooler, it descends as far down as sixteen to twenty fathoms, while in spring, when the temperature of the sea rises, it stays at a depth of from one to four fathoms. It is altogether a coast animal, which very rarely seems to go any distance from its birthplace, if it can readily find there a sufficient supply of food. Sometimes, however, they have been seen in large masses swimming toward the land from the sea, and they have then been caught in nets, having been mistaken for a school of herrings; but this is only a consequence of local migrations, when it goes from the deeper into the shallower waters. It is not able to make its way through the sea for any length of time by swimming. Its structure certainly allows it to make quick and definite movements, and it can swim freely about in the sea, but this swimming never lasts long, as it cannot keep itself afloat very long. Neither is it able, while swimming, to catch and swallow its food; but it seizes its prey only when it can hold on to something. At the bottom of the sea it can chase its prey, if necessary, with great rapidity, but while eating it remains quite still. The Lobster is a very greedy animal, and can swallow great quantities of food, which it seems to find especially during the night by its scent, while during the day it keeps quiet and digests. Its food consists chiefly of the roe of fish, and of dead fish, but likewise of small crustaceans and other marine animals. When kept in confinement, it can live for a considerable time without food. The Lobster seems to be able to propagate when it is a little more than six inches long (at least, roe is only found in animals of this size); but when the Lobster reaches a length of eight inches it contains a great quantity of roe. A real act of

copulation takes place, the male Lobster placing its double male member into the outer genital opening of the female; and the eggs are impregnated while they are yet in the ovary. This pairing seems to take place from autumn to spring, or March and April, for it is highly probable that the roe is emitted from the ovaries immediately after copulation has taken place, just as with other crustaceans; and the emitted roe is found during the entire winter. After impregnation, the eggs are emitted from the outer genital openings of the female, which are found at the bases of the third pair of feet, but do not fall into the water, as they are held in a hollow which is formed by the bent tail, which, both at the end and on the sides, has leaf-shaped fringes that inclose the space formed by the bending of the tail. Under this tail there is fastened a double row of the so-called tail-feet, to which the eggs are strung by strong, slimy strings. The embryo now begins to develop in these eggs, which are quite numerous, two to three thousand in one female, according to the size, and occasionally as many as ten to twelve thousand. The formation of the embryo does not, however, seem to begin till the temperature of the water has become milder in spring, even if the pairing should have taken place in autumn or winter; for, although loose roe is often found in winter, it is never seen in any degree developed into embryos. This pairing and the development of the roe seem to take place at different times on different portions of the coast; for the fishermen themselves, who have such an excellent opportunity of observing them, are not agreed as to the actual time. The development of the embryo seems to take at least fourteen days from the time of commencement, and it can easily be observed till the young break the shells of the eggs and begin to lead an independent life. When the young Lobster comes out of the egg it measures only a few lines in length, and does not at all resemble the old Lobster, but has a different structure. It does not leave the hollow under its mother's tail immediately after being hatched, but lives there for some time, and later frequently returns to it. It is particularly distinguished by a less complete development of its feelers and tail-feet, and by the feet being exceedingly small but furnished with long, brush-like branches, with which it swims vigorously on the surface of the water. After having spent some time in this state, it changes its skin several times and assumes the shape of its mother, when it goes to the bottom. Its life from this moment till it reaches a size of five to six inches is entirely unknown; for no young Lobsters have been caught, either by fishermen or scientists, the smallest having been found in the stomach of the toad, so that it is probable that they spend this portion of their life at a greater depth, and live in a different manner and on other food than at a later period. There cannot, therefore, be any artificial hatching of Lobsters in the sense of artificial fish-hatching, but all that can be done is to keep the Lobster imprisoned during the development of the eggs, and thus protect it from the dangers which threaten it and its young. It is impossible to do anything for the tender young, as they die very soon when confined. I see, however, that several persons in France, and Mr. von Eris, in the lagoons of Triest, near Grado, have hatched several millions of young by keeping Lobsters with ripe roe at the bottom of the sea in perforated boxes.

“The greatest enemy of the Lobster, and one who sensibly diminishes its numbers, is man. When swimming near the surface during its youth, with a number of other small crustaceans, it becomes a welcome prey to the herring and the mackerel. As the grown Lobster keeps at no great depth, and where large fish of prey are not commonly found, it is not much exposed to them, but occasionally, when lying near the surface, it is taken by large birds of prey. An interesting scene may be witnessed near Bukkenö, north of Stavanger, where an Englishman has constructed a large pond, between some small islands, for keeping live Lobsters. Whenever the pond becomes too full of Lobsters, so that they do not find sufficient food, they leave the water and crawl about

seeking to reach the sea; but during their wanderings they fall an easy prey to large numbers of crows hovering round, which take them in their claws, fly high up, and let the unfortunate Lobsters drop down on the rocks, where their shells are broken, so that the crows can eat them in comfort. The crows are not easily scared away, but show a remarkable degree of sense, only flying away when any one approaches with fire-arms, and later they carry on their depredations in the early morning, when they have less to fear."

In addition to the above we have some interesting remarks on the natural history of the European Lobster, from observations made by Prof. G. O. Sars, about 1875, and published in 1878, in a report on the "Salt-water Fisheries of Norway." In prefacing his remarks, Professor Sars states:

"In order to judge of this matter (the protection required for the fishery) it is absolutely necessary to have as complete a knowledge as possible of the natural history of the Lobster. But in this respect very little progress has been made. Although the Lobster is one of the commonest marine animals on the coast of Europe, and has been made the subject of special investigations by many naturalists, its mode of life is still involved in darkness."

Farther on he gives the following general accounts of its habits:

"As to its organization and its analogy with similar crustaceans, the Lobster must doubtless be on the whole considered as a stationary animal. It never undertakes long migrations like some of our fish. The Lobster certainly moves about with great swiftuess and ease, aided by its strong tail and the swimming apparatus attached to it; but this mode of moving about is evidently not the rule. The hard-shell and ponderous Lobster must always make an extra exertion in moving about, and its movements cannot, therefore, be of long duration. People certainly talk of the so-called 'traveling Lobsters,' which are said to come from the open sea in large schools; and some even say that they have seen such schools many miles from the coast, moving about rapidly near the surface of the sea. If this is really so, I consider it as absolutely certain that these schools came from no very great distance, possibly from some of the elevated bottoms off the coast. The grown Lobster is, as every lobster fisher will know, in its whole mode of life a genuine bottom animal, and prefers a stony or uneven bottom, overgrown with algæ, where it finds good hiding-places for lying in wait for its prey. During summer and part of autumn, the Lobster goes on higher bottoms in the bays and inlets, and is then frequently caught quite near the shore among the algæ, at a depth of less than a fathom. Toward winter it again retires into the deep; and still later in the season it has almost entirely disappeared from those places where it was quite common during summer. Occasionally, however, it is, even in the middle of winter, found in deep water, and I have reason to believe that the Lobster never leaves our coast entirely, but considers it as its proper home.

"As may be judged from its powerful claws, the Lobster is a fierce beast of prey, that is not satisfied with small marine animals, but occasionally attacks all kinds of small fish that are unfortunate enough to come within its reach. The bait used for catching Lobsters consists exclusively of fish, principally small codfish and herrings. These must, however, be tolerably fresh; as soon as they begin to get old the Lobster leaves them to his cousins, the Crabs, which are less fastidious in their tastes, and they enter the baskets in great quantities.

"The Lobster is cautious and cunning. It never pursues its prey openly, but either endeavors to surprise it, in which it is greatly aided by its very highly developed sense of smell, or waits patiently among the algæ till some marine animal comes within reach of its claws. I have several times observed with what cautiousness and evident distrust the Lobster, attracted by the bait, has gone round the traps and examined them several times on all sides, before it has

gone in. Only when it is very hungry, as is especially the case later in summer, after the spawning season and casting of the shell is over, is it less cautious and more ready to enter the traps.

"The Lobster is best and fattest in the spring and early summer, while later in the summer and autumn it becomes thin, in consequence of which the English will not take it during those seasons."

COMPOSITION OF LOBSTERS.—According to a series of careful analyses by Professor W. O. Atwater, of Middletown, Connecticut, the composition of the flesh of Lobsters is as follows, the figures given indicating the average results obtained from three specimens received from the coasts of Maine and Massachusetts:

Proportions of edible portion and shell:	Per cent.
Total edible portion.....	39.77
Shell.....	57.47
Loss in cleaning.....	2.76
Proportions of water and dry substance in edible portion:	
Water.....	82.73
Dry substance.....	17.27
Chemical analysis calculated on dry substance:	
Nitrogen.....	12.54
Albuminoids (nitrogen × 6.25).....	78.37
Fat.....	11.43
Crude ash.....	10.06
Phosphorus (calculated as P ₂ O ₅).....	2.24
Sulphur (calculated as SO ₂).....	2.47
Chlorine.....	3.46
Chemical analysis calculated on fresh substance in flesh:	
Water.....	82.73
Nitrogen.....	2.17
Albuminoids (nitrogen × 6.25).....	13.57
Fat.....	1.97
Crude ash.....	1.74
Phosphorus (calculated as P ₂ O ₅).....	.39
Sulphur (calculated as SO ₂).....	.43
Chlorine.....	.59
Nutritive value of the flesh of Lobsters compared with beef as a standard and reckoned at 100.	61.97

The chemical composition of the flesh of the European Lobster is stated by Mr. Frank Buckland to be as follows:

	Flesh.	Soft internal matter.	Spawn.
	Per cent.	Per cent.	Per cent.
Nitrogenous matter.....	19.170	12.140	21.892
Fatty matter.....	1.170	1.444	8.234
Mineral matter.....	1.823	1.749	1.998
Non-nitrogenous matter and loss..	1.219	0.354	4.893
Water.....	76.618	84.313	62.983
	100.000	100.000	100.000

In connection with this table, Mr. Buckland makes the following observations:

"That phosphorus exists in large quantities in Lobsters may easily be proved. A Lobster in hot weather, when it ceases to be fresh, assumes a highly phosphorescent appearance when seen in the dark, equal, if not superior, to that of a glow-worm or luminous centipede. This light increases by friction . . . and this phosphorescent appearance is probably caused by the

chemical changes in the organic tissues, when life is no longer present to resist the ordained agency of decay and decomposition; in fact, it is a slow combustion by combination with oxygen.

"The presence of phosphorus in the Lobster is of great importance to the consumers of these sea luxuries; there is no substance which conveys phosphorus so readily into the human system in an agreeable form, and which the system so readily and quickly assimilates, as the flesh of Crabs and Lobsters."

225. THE CRAY-FISHES—ASTACUS AND CAMBARUS.

RELATIONS AND DISTRIBUTION.—The so-called "Cray-fishes" or "Craw-fishes" are common inhabitants of most of the fresh-water streams of the United States and Europe, but in this country they are not eaten nearly to the same extent as in some parts of the Old World, and they are not generally regarded here as a staple article of food.

The North American Cray-fishes, although belonging to but a single family, the *Astacida*, constitute two distinct genera, *Astacus* and *Cambarus*, and about thirty-eight species, three of which do not, however, occur within the limits of the United States. The Cray-fishes bear a striking resemblance to the Lobsters (*Homarus*), to which they are closely related, but there are several important structural differences between them, and none of the Cray-fishes grow nearly as large as the Lobster.

Europe contains only three species of Cray-fishes, all belonging to the well-known genus *Astacus*. They are *A. nobilis* Huxley (*fluviatilis*), *A. torrentium*, and *A. leptodactylus*. Much discussion has taken place among naturalists as to whether the above species are really distinct from one another, or merely form varieties of a single variable species. The relations of *A. nobilis* to *A. torrentium* are more marked than of those two forms to *A. leptodactylus*, but probably the specific differences pointed out are as good as exist between many other unquestioned species of the same group in this country. It matters little to us in this connection, however, what may be the true affinities of these forms to one another, as long as we can define them sufficiently well to speak of their relations to the fresh-water fisheries of Europe, as an introduction to our own species.

Astacus nobilis and *A. torrentium* are the edible Cray-fishes of Western Europe, and inhabit fresh-water streams generally. They "are intermixed over a large part of Central Europe. *A. torrentium* has a wider northwestward, southwestward, and southeastward extension, being the sole occupant of Britain, and apparently of Spain and of Greece. On the other hand, in the northern and eastern parts of Central Europe, *A. nobilis* appears to exist alone. Farther to the east a new form, *A. leptodactylus*, makes its appearance."¹ Those who have treated of the two western species of Europe from a practical standpoint have generally spoken of them as a single species, to which the old and well-known name of *fluviatilis* has been applied. This distinction corresponds with the views of the older European naturalists, and this species thus constituted, with its two or more varieties, is the common fresh-water Cray-fish of European literature, which has come to have a world-wide reputation.

The structure of the Cray-fish can be best described by defining some of the principal characters in which it differs from the common Lobster, according to Huxley. The general shape of the body with its appendages and the general make-up of the two forms are very similar; but the Cray-fish has only eighteen pairs of perfect gills or branchiæ at the most, and the Lobster twenty. "Moreover, the branchial filaments of these gills are much stiffer and more closely set" in the Lobster than in most Cray-fishes. The most important distinction, however, is presented by those gills which are attached to the bases of the thoracic limbs, and which number six pairs

¹HUXLEY: The Cray-fish, 1880, pp. 299, 300.

in both the Lobster and the Cray-fish. In the latter animals each of these gills forms a simple stem ending above in a plume and plate; in the former this "stem is, as it were, completely split into two parts longitudinally, one half corresponding with the lamina (plate) of the Cray-fish gill, and the other with its plume."

The shedding and the spawning habits of the Cray-fish correspond very closely with those of the Lobster, in connection with the description of which animal the subject has been discussed at some length.

As stated above, the American Cray-fishes belong to two genera, *Astacus* and *Cambarus*, while all the European species belong to the one genus *Astacus*. The only marked difference between the two genera is this, that while in *Astacus* there are eighteen gills on each side, in *Cambarus* there are only seventeen. This difference in structure is considered to be of sufficient importance to warrant the formation of the two genera, but the external differences, such as the variation in shape of the body, and in the proportionate sizes of the several external parts, which are more apparent and more striking to the superficial observer, have only specific value. On such differences as these are founded the thirty-two species of *Cambarus* and the six species of *Astacus*, belonging to the North American fauna. More careful and detailed studies of large collections of Cray-fishes from different parts of North America may serve to greatly reduce this number of species, and if such should follow, it would simply go to prove that some of the differences now supposed to be of specific importance are merely varietal. Strangely enough, all of the North American species of *Astacus* are limited to the western slope of the Sierra Nevada Mountains, that is to say, to that portion of our country most distant from Europe; while the genus *Cambarus* is confined to the intervening area between the Rocky Mountains and the Atlantic coast. The six species of *Astacus* are variously distributed through California, Oregon, Washington Territory, and British Columbia, but only one species, *A. nigrescens*, appears to be used as food, at least to any extent. This probably results from the fact that this is the only species found in the vicinity of San Francisco, outside of which city there is little or no demand for this sort of food. Adult individuals of this species exceed four inches in length, and when living are blackish in color; after death, however, they become of a light grayish tint. According to Mr. Lockington, of San Francisco, this species is brought to that city only in small quantities, the demand for it being slight. The supply is mostly obtained from Coyote Creek, Santa Clara County, and from the sloughs of the San Joaquin.

The genus *Cambarus* is pretty generally distributed throughout the region east of the Rocky Mountains. No Cray-fishes have ever been found, however, in the New England States, excepting in the extreme western parts of Vermont and Massachusetts and in Central Maine, and ten years ago no species had been recorded from most of the Western Territories, especially between the Rocky Mountains and the Sierra Nevada, where if any Cray-fishes should be found in the future it will be interesting to know whether they belong to the western genus, *Astacus*, or the eastern, *Cambarus*.

At present we know so little, comparatively speaking, of the invertebrate fauna of the rivers of the Territories that it is not at all strange we should have so few records of Cray-fishes from them; but it is very probable that Cray-fishes exist there in greater or less numbers. New England, on the contrary, has been too well explored to leave much doubt but that Cray-fishes are absent from it excepting in the localities above cited. To enter into a discussion of all the species of North American *Cambarus* would lead us away from the main object of this sketch, which is intended principally to point out the range and habits of those species known to be eaten. Suffice it to say that the species are more or less irregularly distributed, some States, or even sections of

Sates, having several species, and others again only one or two. Some species are very limited in their range, while others are widely distributed. *Cambarus acutus* is an illustration of this wide distribution, ranging as it does through a large number of the States from the Great Lakes southward to the Gulf, and from Missouri eastward to the Atlantic coast. *C. Bartonii* ranges from Canada to the District of Columbia and Kentucky; *C. obesus*, from Illinois to Louisiana, and from Missouri to New York and Virginia. *C. affinis* occurs in all of the Middle States and in Maryland and the District of Columbia, and *C. virilis* extends from Lake Winnipeg, British America, to Toronto in the east and Texas in the south. Very many of the species have been recorded from only a single locality each, but this does not necessarily imply a restricted range, as they may occur in other places in which no collections have yet been made.

ECONOMIC VALUE.—Although Americans, as a rule, do not regard the eating of Cray-fishes with much favor, these animals are probably used as food in many of the localities in which they are abundant and can be easily obtained. The French in this country are perhaps the principal consumers of this delicacy, as they are in Europe, where their own country can supply only a small part of the demand, great quantities being annually imported into France from Germany and other neighboring countries. In the United States the principal centers for the consumption of Cray-fishes are New York City and New Orleans, and we have been unable to learn of any other cities demanding a regular supply. New Orleans derives its supplies from the fresh waters near at hand, but New York depends upon more distant sources. The Cray-fish season in New York City begins early in the spring and lasts until fall, or until frost sets in. The first supplies come from the Potomac River at Washington, where the Cray-fishes are first taken soon after the breaking up of the ice in the river. About June 1 the weather becomes almost too warm for the shipment of Cray-fishes from Washington, and another more northern locality, Milwaukee and vicinity, begins to send supplies to New York. In the early part of July, Montreal adds her quota to the New York markets, and the shipments from these two latter localities continue as stated above until into the fall. The Potomac River Cray-fishes are larger than those from Milwaukee, while the Montreal species is the smallest of all. The Milwaukee Cray-fishes are most esteemed by epicures, their flesh being less coarse and of a finer flavor than any of the other species sold in the New York markets. The Potomac species is the darkest in color when living, but does not turn red by boiling, while the Milwaukee and Montreal species do. Small quantities of Cray-fish are very probably brought to New York City from the State and from New Jersey, but if so they do not pass through the larger markets, and there is no regular supply.

The Potomac River Cray-fish sent to New York is the *Cambarus affinis* Erichson, and the Milwaukee species is the *Cambarus virilis* Hagen. We have never examined specimens of the Montreal species. The New Orleans market Cray-fish is the *Cambarus Clarkii* Girard, while the San Francisco species, as already stated, is the *Astacus nigrescens*. One of the Lower Mississippi River species, either the *Cambarus Clarkii* or the *Cambarus acutus*, burrows into and causes much damage to the levees of the river in the vicinity of New Orleans.

HABITS.—Cray-fishes differ widely in their habits, and while some species prefer clear running streams, others live in more quiet waters, and still others upon muddy banks, where they dig holes, and remain much of the time out of the reach of water.

Dr. C. C. Abbott has given us the following account of the habits of three of our commoner species of Cray-fishes, which occur near Trenton, New Jersey.¹ They are *Cambarus acutus*, *C. affinis*, and *C. Bartonii*, which have already been referred to as living in regions where Cray-fishes are taken as food:

¹ American Naturalist, vii, 1873.

"It is difficult to say which of the three species is the most abundant in the general locality we have named, inasmuch as they seem to prefer different streams; one being a plant-loving, one a stone-haunting, and the third a mud-frequenting species. In their respective haunts each is apparently as numerous as is either of the others in its chosen home. . . . We have found *Cambarus acutus* to frequent running streams which have masses of vegetation growing in them, the animal in question resting upon the plants, usually near the surface of the water. We have found since our collecting excursions, on carefully approaching clear running streams, such as just mentioned, that this Cray-fish is to be seen resting on the plants, always with the head directed down-stream. If disturbed, they would dart backward, down to the roots, apparently, of the plant upon which they were sitting. After a lapse of about ten minutes they would return to their former resting place, creeping up the plant down which they had so suddenly darted tail foremost.

"The *Cambarus affinis* is apparently the river species of this locality. We have been able to find it, as yet, only in the Delaware River, usually frequenting the rocky bed, but also, in fewer numbers, on the mud-bottomed portions of the river. They are usually found resting under flat stones, well out from the banks of the stream, where the water is of considerable depth. Wherever the vegetation is dense, we have failed to find them; nor have we seen anything to indicate that it is a 'burrowing' species. . . . *Cambarus Bartonii*, it appears to us, is the one burrowing species of this locality. We have found in the deep ditches, with precipitous, muddy banks, a medium-sized Cray-fish, which in most respects accords with the species called *Cambarus Bartonii* Fabr. by Dr. Hagen. . . .

"Cray-fish are strictly omnivorous animals, but, although excellent scavengers, do not feed wholly upon decayed animal and vegetable matters. We have frequently noticed that *C. Bartonii* in an aquarium breaks off the short stems of the common river weed, and eats the main stem, after stripping it of its minute leaves. So the *C. affinis*, from beneath its sheltering flat stone, and *C. Bartonii*, in its safe burrow, will seize the minute young cyprinoids, that pass up and down the stream in such myriads, ever and anon peeping into the various little indentations in the banks. Such little fish, when once fairly caught by the big claws but by no means clumsy 'hands' of a *Cambarus*, have no chance of escape, and are soon torn to pieces."

Cambarus Bartonii described by C. Girard as *C. Diogenes*, constructs very interesting burrows on the meadow flats of the Potomac River at Washington, which Mr. Girard describes as follows:¹

"The holes, as they appear at the surface of the ground, are nearly circular, from seven-tenths of an inch to one inch and one inch and a half in diameter. The depth of the burrows varies according to the locations; this we generally found to be from sixteen inches to two feet, and sometimes to three feet and more. The construction of the burrow itself is often exceedingly simple; from the surface of the ground the excavation exhibits gradual slope, in direction more or less undulating, for a distance of from five to ten inches, when it becomes vertical for six or eight inches, and then terminates in a sudden bottle-shape enlargement, in which the animal is found. The bottom of the burrows having no subterraneous communication, no other issue except towards the surface, it is entirely isolated from its neighbors, and leaves no chance of escape to its inhabitant. The same burrow may have several external holes connected with it, several inclined channels, which, however, meet at the depth where it becomes vertical. We constantly found the cavity full of water, but this was in March and April; the bottom, for several inches, was filled with a soft and pulpy mud.

¹ Proc. Phila. Acad. Nat. Sci., vi, pp. 88-90, 1854.

"We generally found a single individual in each burrow, it being either a male or a female, the latter in March or April, carrying under the tail a bundle of her eggs. Sometimes, when numerous individuals are gathered on a small space, it may happen that the windings of the upper part of their burrows will accidentally meet and have in this case a communication which was not contemplated. Each individual, however, remains in its own apartment; so at least we constantly found to be the case. To accomplish the act of breeding, males and females must come together at one particular time. In one of the burrows which we examined we found a male and a female. We are inclined to believe that the male quits its retreat and goes in search of the female, as one individual of the former sex was found, at one time, walking over the surface of the ground.

"In the spring, and we are told in the fall also, the burrowing Craw-fish builds over the holes of its burrow a chimney of the maximum height of one foot, but most generally lower. This chimney, circularly pyramidal in shape, is constructed of lumps of mud, varying in size, irregularly rolled up, and piled up one upon another, and intimately connected together. Its exterior has a rough and irregular appearance, whilst the interior is smooth and as uniform as the subterraneous channel, and having the same diameter as the latter. The cementing of the successive balls of mud is easily accounted for when we bear in mind that the latter are brought up in a very soft state, and that their drainage and subsequent solidification on their exposure to the atmospheric air and rays of the sun are all that is required to unite these parts. . . . The last touch consists in shutting up the aperture. This is accomplished by means of several balls of mud brought up from underneath, deposited temporarily on the edge of the chimney and drawn back in close contiguity, so as to intercept all communication with the external world. The number of such chimneys is sometimes very great in one particular locality, distributed without any geometrical regularity, and recalling to mind the scattered habitations or village of a newly settled colony."

226. THE SHRIMPS AND PRAWNS.

THE COMMON SHRIMP—CRANGON VULGARIS, Fabricius.

This species of Shrimp occurs on both sides of the Atlantic, and is eaten both in this country and in Europe. It is, therefore, of considerable economic importance, though of less value than the larger Shrimp (*Penæus*) of the Southern States. *Crangon vulgaris*, on the American coast, ranges from Labrador to North Carolina, and from low-tide level to depths of about fifty fathoms. "It is found in greatest abundance in shallow water, and on sandy or weedy bottoms, but occurs also on muddy, shelly, and rocky bottoms, and extends at least to about fifty fathoms in depth. It varies much in coloration according to the location in which it is found. Upon the exposed and light-colored sandy shores of Southern New England, specimens are invariably translucent and very pale in color, so as to closely resemble the surface upon and beneath which they live, while upon dark-colored muddy bottoms they are very much darker in color. Specimens from a dark-colored muddy inlet of Vineyard Sound and others from dark muddy and sandy bottoms at Halifax, Nova Scotia, are very dark indeed, the pigment spots covering nearly the entire surface, and the caudal appendages becoming almost black toward the tips."¹

"When resting quietly on the bottom, or when it buries itself partially and sometimes almost entirely, except the eyes and long, slender antennæ, it cannot easily be distinguished by its enemies, and, therefore, gains great protection by its colors. When left by the tide it buries itself to a considerable depth in moist sand. It needs all its powers of concealment, however, for it is

¹S. I. SMITH: Trans. Conn. Acad., v, p. 56, 1879.

eagerly hunted and captured by nearly all the larger fishes which frequent the same waters, and it constitutes the principal food of many of them, such as the weak-fish, king-fish, white perch, bluefish, flounders, striped bass, etc. Fortunately it is a very prolific species, and is abundant along the entire coast, from North Carolina to Labrador, wherever sandy shores occur. The young swim free for a considerable time after hatching, and were taken at the surface in the evening, in large numbers."¹

According to White,² the common Shrimp are in spawn on the English coast during the entire summer; "the ova are of a dirty white color."

We have no published data as to the duration of the spawning season upon our coast, but "the young are hatched in the neighborhood of Vineyard Sound in May and June, and arrive at the adult form before they are more than four or five millimeters long. Specimens of this size were taken at Wood's Holl, at the surface, on the evening of July 3. Later in the season much larger specimens were frequently taken at the surface both in the evening and daytime.

"The young of the different kinds of Shrimp, *Crangon vulgaris*, *Palæmonetes vulgaris*, and *Virbius zostericola*, when hatched from the egg, are free-swimming animals, similar in their habits to the young of the Lobster. In structure, however, they are quite unlike the larvæ of the Lobster, and approach more the zoëa stages of the Crabs. When they first leave the egg, they are without the five pairs of cephalo-thoracic legs, the abdomen is without appendages, and much as it is in the first stage of the young Lobster, while the maxillipeds are developed into long locomotive appendages, somewhat like the external maxillipeds of the first stage of the young Lobster. While yet in the free-swimming condition the cephalo-thoracic legs are developed, the maxillipeds assume the adult form, and the abdominal limbs appear. The young of these Shrimp are very much smaller than the young of the Lobster, but they remain for a considerable time in this immature state, and were very frequently taken at the surface in the towing-net."³

Although *Crangon vulgaris* may be common in the southern part of its range (New York to North Carolina), it has not been often recorded from that region, and in fact we know much more about it on the New England coast, along the entire extent of which it is very abundant, though somewhat less so north of Massachusetts Bay. About Halifax, Nova Scotia, it is again abundant and of large size from low-water mark to eighteen fathoms, on sandy, muddy, stony, and rocky bottoms. It is common everywhere in shallow water and at low-water mark on most sandy beaches in the Gulf of Saint Lawrence. It also occurs in the Straits of Belle Isle. Since this report was in manuscript, *Crangon vulgaris* has been found by the Fish Commission to occur in different parts of Chesapeake Bay in immense numbers and of unusually large size.

The common Shrimp attains a length of over two inches, exclusive of the anterior appendages, but is generally smaller. In the neighborhood of New York and about New Bedford, Mass., it is taken as food. Northward from there it is, so far as we know, only utilized to a slight extent, and for bait only. It may perhaps be taken on the southern coasts, where it occurs, in connection with *Penæus*, which is sent in large quantities to New York, but from all the information we have been able to obtain, no notice is taken of it south of New York.

Mr. W. N. Lockington states that *Crangon vulgaris* is very abundant upon the Pacific coast of North America, ranging from Alaska (Mutiny Bay) to San Diego, California. It is smaller than *C. franciscorum*, with which it is found associated; and it is also less abundant in the San

¹ VERRILL: Vineyard Sound Report, p. 339, 1871-'72.

² Popular History of British Crustacea, 1857, p. 107.

³ S. I. SMITH: Vineyard Sound Report, pp. 528, 529, 1871-'72.

Francisco markets, although comprising no inconsiderable part of the total catch of Shrimp, and at some seasons it is more common than its congener. The average length of the specimens taken on the Pacific coast is said to be about two and a quarter inches, but large examples exceed three inches in length. This form, which is a sort of color variety, is easily distinguished from *C. franciscorum* by its black tail, and the large proportion of black upon its body, as well as by the different form of the hand, the movable finger of which is much shorter and folds transversely across the tip of the hand. From its black coloring it has received the name of "Black-tailed Crab."

This Shrimp is taken on the west coast in connection with *C. franciscorum*, and is sold fresh in the markets as well as boiled and dried for exportation to China.

THE CALIFORNIA SHRIMP—CRANGON FRANCISCORUM, Stimpson.

According to notes furnished by W. N. Lockington, this is the largest species of Shrimp on the Pacific coast of the United States, and is the Shrimp *par excellence* of the San Francisco markets, where large quantities are sold during nearly every month of the year.

The total length of the body, in the adults, ranges from three to three and a half inches, while in the same the length of the carapax is about seven-eighths of an inch.

From the Pacific coast variety of *Crangon vulgaris* this species can be distinguished by its larger size; by the absence of the black tail and large black spots, characteristic of the former; by the small dots of dark tint which mottle the surface; and most readily by the much greater length of the movable finger of the hand, which folds parallel with the side of the hand instead of across its extremity.

Crangon franciscorum has a somewhat limited range, not being known from north of Puget Sound, nor south of Point Conception, California. In San Francisco Bay and Tomales Bay it is exceedingly abundant, frequenting especially the sandy coves along their shores. Not only is this Shrimp largely consumed upon the coast when fresh, but it is also taken by the Chinese in immense quantities and shipped to China after boiling and drying. The Shrimp industry affords employment to a large number of Chinese, and constitutes an important factor in the export trade of San Francisco. The Shrimp are usually caught in purse-nets, which are conical in shape, about twenty-five feet long and ten feet across the mouth; they taper to the lower end, which is opened and closed by means of a "puckering string." It is said that no diminution in the number of Shrimp results from the continuous fishing, although the edible species of fish are nearly exterminated in San Francisco Bay.

A species of *Hippolite* (*H. brevisrostris*), of a uniform light crimson or scarlet color, occurs at the Straits of Fuca, in San Francisco Bay, and probably along the intervening coast. In San Francisco Bay it is taken with the *Crangons* for food.

THE COMMON PRAWN—PALÆMONETES VULGARIS, Stimpson.

The common American Prawn, which closely resembles the English species, although occurring in great abundance along some portions of our Atlantic coast, does not rank among our food invertebrates on account of its small size. It frequently makes up for that deficiency, however, by its great abundance.

The average length of specimens is about one and one-half inches. The body is translucent, almost colorless, but is "marked with irregular, ill-defined, dark blotches and spots, which admirably adapt it for concealment among the discolored and dead leaves of eel-grass, at or near the bottom," in which localities it is most abundant. The American Prawn differs from the

English, among other things, in the character of its rostrum and in its smaller size. The rostrum of the latter is divided or double at the tip, and specimens range in length from three to five inches.

P. vulgaris ranges from Massachusetts Bay to Northern Florida. North of Cape Cod, however, it is rare. It is very common among eel-grass, etc., in Vineyard Sound, Buzzard's Bay, Fisher's Island Sound, and Long Island Sound. Thence it has been recorded from the south side of Long Island, and from numerous points along the coast of New Jersey and the Southern States, as far south as Saint John's River, Florida. The localities inhabited by this species are described as follows by Professor Verrill:¹

"The common Prawn has its true home among the eel-grass (in brackish water), and here it occurs in countless numbers. . . . It is also very abundant in the pools and ditches (of the muddy shores in brackish water), even where the water is but little salt, and also occurs in immense numbers on the muddy bottoms."

It likewise abounds on the muddy bottoms in pure salt water. On sandy bottoms in both salt and brackish water it often occurs associated with *Orangon vulgaris*, but not in large numbers.

THE RIVER SHRIMPS—PALÆMON OHIONIS, Smith; PALÆMONETES EXILIPES, Stimpson.

Only two species of river Shrimp have yet been described from the United States east of the Mississippi River, and they seem to be used as food in only a few localities. At New Orleans, however, one species, the *Palæmon ohionis*, is very much esteemed.

In this species, the carapax or anterior part of the body is smooth, stout, and considerably swollen, with a short rostrum. Specimens from the Ohio River measured in total length of body from two to three and one-fourth inches, the carapax occupying about one-fourth of this length. The original specimens from which the species was described were from the Ohio River at Cannelton, Indiana, where it is taken for food. Since then it has been found over a larger area, including the vicinity of New Orleans.

Palæmonetes exilipes is a much smaller species than the above, measuring only about an inch and a half in total length. It has been recorded from Sandusky Bay, Lake Erie; Ecorse, Michigan; Somerville, South Carolina; and from fresh-water streams in Florida. It is probably quite widespread in its distribution, but we are not aware of its ever having been used as food, probably on account of its small size.

THE DEEP-WATER PRAWNS—PANDALUS BOREALIS, Krøyer; LEPTOCEROS, Smith; MONTAGUI, Leach; PROPINQUUS, Sars.

These species of Prawns, which resemble one another very closely in appearance and structure, are exceedingly abundant in the deeper waters of Massachusetts Bay, the Gulf of Maine, and elsewhere off the coast of New England, the British Provinces, and southward as far as Virginia, at least.

Pandalus borealis grows to a much larger size than the other three species, but all are large enough to serve as food, and sufficiently abundant in the localities where they occur. Unfortunately they never approach the shore, and the ordinary methods of taking shrimp in shallow water will not answer for their capture. If some means of taking them easily could be devised, they would undoubtedly find a ready sale in the Boston and New York markets, for they have an exceedingly good flavor.

Pandalus borealis attains a length of seven inches. As to color, it is, according to Professor Verrill, "thickly sprinkled with small, red, stellate spots, which, from closer aggregation, make the

¹ Vineyard Sound Report, 1871-'72.

tail deeper in color than the rest of the body. The spermaries are purplish-red, the outer membrane golden, ovaries blue, eggs ultramarine blue." Females carrying eggs were taken in August and September, 1877 and 1878, in and off Massachusetts Bay and off Cape Ann. The localities where this species has been found are as follows: Massachusetts Bay, off Salem, forty-five to fifty fathoms, mud, very abundant; Gulf of Maine, forty to one hundred and sixty fathoms, muddy bottoms, very abundant in some places. In the Gulf of Maine, it was found to be especially common in a region about fourteen miles southeast from Cape Ann, in fifty to about one hundred fathoms. It was also encountered twenty to thirty miles off Cape Sable, Nova Scotia, in depths of fifty-nine to eighty-eight fathoms, and thirty miles off Halifax in eighty-five to one hundred and ten fathoms. Beyond our seas it has been recorded from Greenland, Norway, and Bering Sea.

Pandalus Montagu and *leptoceros* differ from *P. borealis* in coloration, "in having the red more intense and arranged in clearly defined markings, of which those upon the carapax and abdomen are arranged in conspicuous obliquely transverse lines or bars, while the color upon the rest of the body and upon the appendages is collected in distinct specks, blotches, or annulations." The largest specimens which have been examined were from depths of ninety fathoms, off Cape Ann, and measured four and one-half inches in length. Specimens over four inches long have been obtained from several localities. Only a few individuals have so far been seen carrying spawn. They were taken in different places during the months of August, September, and October. These species range all the way from off the mouth of Chesapeake Bay to Greenland, and *P. Montagu* also occurs on the European coast as far south as the British Islands. They are more abundant than *P. borealis*, though of smaller size, and are common in much shallower water, as well as in the same deeper places resorted to by *P. borealis*.

In Massachusetts Bay, they inhabit depths of twenty-two to forty-eight fathoms, where the bottom is gravelly, sandy, and muddy, and have also been found on Stellwagen Bank. In the Gulf of Maine they are widespread and exceedingly abundant in many localities, being often associated with *P. borealis* on muddy bottoms. They live on all kinds of bottom, in depths of ten fathoms downward. They have been found east of George's Bank in a depth of four hundred and thirty fathoms; in the Bay of Fundy, ten to seventy-seven fathoms; off Nova Scotia, sixteen to seventy-five fathoms; in Bedford Basin, Halifax, twenty-six to forty-one fathoms; Gulf of Saint Lawrence, Labrador, etc. South of Cape Cod they range down to depths of two and three hundred fathoms.

Pandalus propinquus, which has been recognized only since this report was first written, occurs associated with the two last species south of Cape Cod.

The United States Fish Commission, in its explorations with the dredge and trawl along the New England coast during the past ten years, has constantly come upon immense schools of these deep-water Prawns, sometimes two or more of the species being associated together, at others occurring separately. It has been no uncommon occurrence for a peck or more to come up in a single cast of the beam trawl, and several such hauls have sometimes been made in a single day. These Prawns apparently move in schools, and it is often impossible to secure more than a single catch in any spot at one time. This fact may result from their moving in a regular body from place to place, and thus coming by chance in the course of the trawl at times, or, if naturally disposed to remain long in a single place, the appearance of the trawl must have the effect of frightening them away. They are active in their movements, and are thus seldom taken in the dredge. It has been the custom on the United States Fish Commission steamer, when a large haul of *Pandalus* has been made, after having selected the specimens required for scientific purposes, to turn the

remainder over to the mess, and there are many witnesses to testify to the superior character of the deep-water Prawns as an article of food.

The lobstermen of Biddeford Pool, Maine, who set their pots in the winter from four to six miles from shore, occasionally capture these Prawns, and here may be a suggestion as to the style of apparatus which might be tried advantageously for their capture. The openings would, of course, need to be of much smaller size than those of an ordinary lobster-pot. A light beam trawl of large size might, however, answer still better.

THE CALIFORNIA PRAWN—*PANDALUS DANÆ*, Stimpson.

According to W. N. Lockington, this is a moderately large species of Prawn, which is now commonly brought to the San Francisco market, and is caught in the open ocean between the Farallone Islands and Point Reyes. The length of the body in the adults, including the rostrum, is about five inches, while the average length of the carapax, excluding the rostrum, is about one and a quarter inches. Fresh specimens are finely marked with transverse zigzag lines of white, separated by bands of red.

Pandalus Danae has been recorded from the Queen Charlotte Islands and Puget Sound, north of which it is not known; its southern limit is possibly Point Conception, California, the most pronounced point of division between the northern and southern marine fauna of California, though this fact has not been positively determined. This Prawn has been much more abundant in the San Francisco markets during the past two years than formerly, and the reason assigned is that the fishermen, driven out of San Francisco Bay by the constantly diminishing supply of fish there, have been forced to resort to the open sea between the Farallone Islands and Point Reyes, where the Prawns live in large numbers. It has been noticed with spawn in November, December, and January. A second species of Prawn is occasionally brought to the San Francisco market, along with *P. Danae*, being obtained in the same places. It is of smaller size than *P. Danae* and of a uniform light pink color when fresh; it also differs from the latter in the size and shape of the rostrum, appendages, etc., and in the number of the rostral spines.

In 1879, several examples of a large species of Prawn, apparently identical with *Penæus brasiliensis*, of Brazil and the Southern United States, were brought to the San Francisco markets; in 1880 none were observed. This species is also recorded from the west coast of Nicaragua. Adult specimens examined at San Francisco measured seven inches in total length, including the rostrum. Compared with specimens from the Rio Grande, Brazil, no points of difference as regards form or proportion of parts were detected.

THE SOUTHERN SHRIMPS AND PRAWNS—*PENÆUS SETIFERUS*, M. Edwards; *PENÆUS BRASILIENSIS*, Latreille.

These are the large Shrimps or Prawns which occur in such immense numbers on the coasts of the Southern States, and are taken to supply the markets at Charleston, South Carolina; Savannah, Georgia; New Orleans, Louisiana; New York, and elsewhere. The two species are often found associated together, but *Penæus setiferus* is the more abundant, and is, therefore, more commonly seen in the markets. According to Prof. Lewis R. Gibbes, these species may be distinguished apart by the following characters:

"The common Shrimp (*P. setiferus*) has a groove on each side of the large spine that springs from the fore and upper part of the shell or carapax; these run backward and terminate about the middle of the length of the shell. In the same tray in the market will frequently be found other individuals, far less numerous, in which these grooves run the whole length of the shell, terminating just in front of the hinder edge or border of the shell, at the first joint. This form I have referred to the *P. brasiliensis* of Latreille.

Penæus

found in
the market
at New York
7/1/80

compare with the *T. setiferus*, 1880

“Full grown individuals of *P. setiferus* measure six or more inches in length, from the tip of the large anterior spine to the tip of the tail spine, and three-fourths of an inch deep and broad in the front or body part. These large specimens of both species are known in the markets as ‘Prawns,’ or ‘Sprawns,’ and the half-grown individuals are distinguished as ‘Shrimps.’ The Prawns appear in our waters generally in March, or in warm seasons as early as the latter weeks of February, and remain in season for two or three months, after which the supply diminishes, and they appear to retire for a time to spawn. To what region or localities they retreat I do not know, nor have I been able to learn anything concerning this matter from the fishermen. I may add that I have never seen one of these Shrimp carrying its eggs. It may be that they ascend our rivers for the purpose of spawning, and friends have called my attention to what they call ‘fresh-water Shrimp’ that differ in no respect from the common Shrimp, and yet are found in the rivers above the reach of salt water. In June and the succeeding months of summer, the half-grown individuals or ‘Shrimps’ are in season, and for tenderness of flesh and delicacy of flavor are preferred to the ‘Prawns.’ In the autumn they all disappear from our waters, and I suppose go southward or else into deeper water. As Prawns and Shrimps die very soon after being taken from the water, they cannot be sent fresh to any distance. They are used both as food and bait.”

According to Stimpson, *Penæus brasiliensis* “is often found in brackish water, and even ascends streams to points where the water is nearly or quite fresh. It was thus found in the Croton River at Sing Sing, New York, by Professor Baird, and by myself in a fresh-water creek near Somers Point, New Jersey.” From these places it ranges southward to Brazil, and is found more or less continuously along the Southern Atlantic coast, and the Gulf coast to Mexico. *Penæus setiferus* has not been recorded from north of Norfolk, Virginia, but thence southward its range corresponds with that of *P. brasiliensis*, at least so far as regards the coast of the United States.

Mr. T. E. Fisher, of Fernandina, Florida, who has been interested in the Shrimp industry at that place for several years, furnishes the following notes regarding the Shrimps and Prawns, which he distinguishes from one another in the same way as Professor Gibbes: “It is my belief that the Shrimp (smaller individuals) move out into deeper water at the beginning of winter and there remain until about the full moon in March or thereabouts, when they return to the bays and rivers in great quantities as ‘Prawns’ and ascend the rivers and creeks, I think, to spawn. This is the time when they are taken as food. After spawning, or about May or June, they return to the sea. From May to August the so-called Shrimp, which then appear, are quite small and used principally as fish bait; from August to December they grow quite rapidly. September and October are the best shrimping months of the season, and May and June are the only months when Shrimp are scarce, excepting during the colder months of winter, when they leave the coast for a time.” The seasons on the coasts of South Carolina and Eastern Florida, therefore, nearly correspond, excepting that in Florida, the climate being milder, the Shrimp remain upon the coast much later in the season or nearly all winter. Mr. Silas Stearns, of Pensacola, Florida, writes that “Shrimp are abundant on all parts of the Gulf coast, and especially so in the region of Louisiana and Texas. They live on the grassy or sandy flats, and among the weeds on the bottoms of bayous and lagoons, in both salt and brackish water. On the Florida coast they are found throughout the summer months, and appear to breed in the spring or early summer. In the fall they make up in schools, and seem bent on migratory movements. At this time a few are taken in seines and sold to the restaurant keepers of the cities. On the Louisiana and Texas coasts the habit of schooling is much more common, and as the Shrimp

are very abundant at all times during warm weather, they can be profitably caught for the market. Barrataria Bay, of the Louisiana coast, and Galveston and Matagorda Bays, of the Texas coast, are notable places for the shrimp fishery. The fact that these bays afford unusually good feeding grounds and hiding places for the Shrimp will undoubtedly explain their great abundance there. Shrimp of marketable size average about four inches in length. Their color tends to imitate that of the bottom on which they dwell. New Orleans and Galveston are the only cities of the Gulf coast which engage in the shrimp trade."

227. THE MANTIS SHRIMPS—SQUILLIDÆ.

THE MANTIS SHRIMP, OR SEA MANTIS—*Squilla empusa*, Say.

"The *Squilla empusa* is a very interesting creature, whose habits are still imperfectly known. It is often thrown on the beaches by the waves, and probably it usually burrows in the mud below low-water mark, but in certain localities it has been found burrowing at or near low-water mark of spring tides, forming large, irregular holes. The very curious, free-swimming young were often taken in the towing-nets. Large specimens are eight or ten inches long and about two broad. The body is not so stoutly built as that of the Lobster, and the carapax or shell is much smaller and softer, while the abdomen is much larger and longer in proportion. The legs and all the other organs are quite unlike those of the Lobster, and the last joint of the great claw, instead of forming a pair of pincers with the next, is armed with a row of six sharp, curved spines, which shut into corresponding sockets, arranged in a groove in the next joint, which also bears smaller spines. By means of this singular organ they can hold their prey securely, and can give a severe wound to the human hand, if handled incautiously. It also uses the stout caudal appendages, which are armed with spines, very effectively. The colors of this species are quite vivid, considering its mud-dwelling habits. The body is usually pale green or yellowish green, each segment bordered posteriorly with darker green and edged with bright yellow; the tail is tinged with rose and mottled with yellow and blackish; the outer caudal lamellæ have the base and spines white, the last joint yellow, margined with black; the inner ones are black, pale at base; the eyes are bright emerald-green; the inner antennæ are dark, with a yellow band at the base of each joint; and the flagellum is annulated with black and white."¹

This species of *Squilla* ranges from Cape Cod to Florida, but from its habit of remaining most of the time in its burrows it is not very commonly known or met with on the sea-shore, though it is probably very abundant in some localities.

"The Mediterranean species of *Squilla* are generally found at considerable depths; they live in sandy places, where they can easily procure their food, which seems to consist chiefly of annelids and fragments of the *Actinia effata*. According to Risso, the females when they wish to deposit their eggs, which they have under their abdominal appendages, retire to rocky places. The *Squilla* are timid, avoiding danger; they swim much after the fashion of Lobsters."² In Europe wherever *Squilla* can be found in sufficient numbers it is much esteemed as food, and the American species would probably be as wholesome. On the shores where it abounds it might easily be obtained by digging, and from deeper water by means of the rake dredge.

Two other species of *Squilla*—*Squilla dubia* and *Lysiosquilla glabriuscula*—also occur on the coasts of the Southern States, where one or more of these three species are said to be used as bait to some extent.

¹ VERRILL: Vineyard Sound Report, 1871-'72.

² WHITE: Popular History of the British Crustacea, 1857.

228. THE AMPHIPODS.

THE BEACH FLEAS, OR SAND FLEAS—*ORCHESTIA AGILIS*, Smith; SCUDS—*GAMMARUS LOCUSTA*, Gould; AND ALLIED FORMS.

The extensive group of *Amphipoda*, to which these species belong, consists entirely of small aquatic animals which, although not of direct importance from an economical point of view, still serve an important purpose in the general economy of nature, and deserve at least some mention here. Besides serving as food for fish, many of the species act as scavengers on the sea-shore, and, despite their small size, are, from their great numbers, able to dispose of a large quantity of dead refuse matter. Some of the species live entirely in the water, while others are exposed to the air during low tide, or even most of the time. The experiment of utilizing these small creatures in the preparation of skeletons for anatomical purposes has been tried with much success. Fish, cleaned of the bulk of their flesh, have been fastened to boards and anchored just below the surface of the water, near the docks in Eastport Harbor, and within the space of a few hours nothing but the bones remained, being cleaned as completely as by any other process, and with but little expenditure of time on the part of the naturalist. Several species upon our coast are abundant enough to act in unison in this way. Some of the deep-water species are as destructive to dead animal matter as are those which live near the shore. The cod and halibut fishermen often suffer from their depredations, as several of the deep-water Amphipods quickly attack the fish which die after being caught on the trawl lines before they are hauled up. The gills of the fish appear to be first devoured, but within a few hours they are able to eat out the entire muscular and visceral matter, leaving only the bones and skin. Cod and hake frequently die upon the trawls, and are thus destroyed, but halibut are more hardy and are seldom much injured.

The number of species of Amphipods upon our coast is very large, but we need refer here to only two or three species to illustrate their principal characteristics.

“These small crustacea are of great importance in connection with our fisheries, for we have found that they, together with the Shrimps, constitute a very large part of the food of most of our more valuable edible fishes, both of the fresh and salt water. The Amphipods, though mostly of small size, occur in such immense numbers in their favorite localities that they can nearly always be easily obtained by the fishes that eat them, and no doubt they furnish excellent and nutritious food, for even the smallest of them are by no means despised or overlooked even by large and powerful fishes that could easily capture larger game. Even the voracious bluefish will feed upon these small crustacea where they can be easily obtained, even when menhaden and other fishes are plenty in the same localities. They are also the favorite food of trout, lake white-fish, shad, flounders, scup, etc., as will be seen from the lists of the animals found in the stomachs of fishes. One species, which occurs in countless numbers beneath the masses of decaying seaweeds thrown up at high-water mark on all the shores by the waves, is the *Orchestia agilis* Smith, which has received this name in allusion to the extreme agility which it displays in leaping when disturbed. The common name given to it is ‘Beach-flea,’ which refers to the same habit. Its color is dark olive green or brown, and much resembles that of the decaying weeds among which it lives, and upon which it probably feeds. It also constructs burrows in the sand beneath the vegetable *débris*. It leaps by means of the appendages at the posterior end of the body.

“A much larger species, and one of the largest of all the Amphipods, is the *Gammarus locusta*, which occurs in great numbers beneath the stones and among the rock-weed near low-

water mark. The males are much larger than the females, and sometimes become nearly an inch and a half long. They cannot leap like their cousins that live at high-water mark, but skip actively about on their sides among the stones and gravel until they reach some shelter or enter the water, when they swim rapidly in a gyrating manner back downward or sideways. But although they can swim they are seldom met with away from the shore or much below low-water mark. The zone of *Fucus* is their true home. This species is abundant on all our shores, wherever rocks and *Fucus* occur, from Great Egg Harbor, New Jersey, to Labrador. Its color is generally olive-brown or reddish-brown, much like that of the *Fucus* among which it lives. The only good English name that I have ever heard for these creatures is that of 'Scuds,' given by a small boy, in reference to their rapid and peculiar motions. . . . Two other related species, of larger size and paler colors, but having the same habit of leaping as the *Orchestia*, though not in such a high degree, occur among the weeds, or burrowing in the sand, or beneath drift-wood, etc., a little below high-water mark. In fact, the sand is sometimes completely filled with their holes, of various sizes. Both these species are stout in form, and become about an inch long when mature. One of them, *Talorchestia longicornis*, can be easily distinguished by its very long antennæ; the other, *T. megalophthalma*, by its shorter antennæ and very large eyes. Both these species are pale grayish, and imitate the color of the sand very perfectly. When driven from their burrows by unusually high tides or storms they are capable of swimming actively in the water. They make dainty morsels for fishes and many shore birds, as well as for certain Crabs, especially *Ocypoda arenaria*.¹

THE BORING AMPHIPOD—CHELURA TEREBRANS, Philippi.

This very destructive little crustacean, which is of common occurrence on the European coast, from Southern Norway to the Adriatic Sea, has so far been noticed on the Atlantic coast of the United States at only two places, Wood's Holl and Provincetown, Massachusetts. At both of these localities it was found associated with the "Gribble" (*Limnoria lignorum*), in the submerged piles of old wharves. It is more than possible, however, that it is a common inhabitant of our coast, doing a certain amount of the damage hitherto ascribed to other boring animals. Without a careful examination, it is quite easy for an unskilled eye to confound *Chelura* with *Limnoria*, although they belong to very distinct divisions of the *Crustacea*.

The main characteristics of this animal by which it may be distinguished from all the other Amphipods, as well as crustaceans, are the three pairs of caudal stylets, the last pair being nearly as long as the body proper of the males, although much shorter in the females and young. As to color, the body is semitranslucent and thickly spotted and mottled above with pink.

Professor Allman, of England, who has studied living specimens, describes the habits of this species as follows:²

"*Chelura terebrans* is an active little animal, swimming on its back and employing its thoracic legs to adhere to the timber which it has selected for its ravages. . . . Its habits are truly xylophagous, and it excavates the timber not merely for the purpose of concealment, but with the object of employing it as food, which is apparent from the fact that the alimentary canal may be found on dissection filled with minutely comminuted ligneous matter. . . . Timber which has been subject to the ravages of *Chelura* presents a somewhat different appearance from that which has been attacked by *Limnoria lignorum*. In the latter we find narrow cylindrical burrows running deep into the interior, while the excavations of *Chelura* are

¹ VERRILL: Vineyard Sound Report, pp. 313, 314, 1871-'72.

² Ann. and Mag. Nat. Hist., xix, p. 361, 1847.

considerably larger and more oblique in their direction, so that the surface of the timber thus undermined by these destructive animals is rapidly washed away by the action of the sea, and the excavations are exposed in the greater part of their extent, the wood appearing plowed up, so to speak, rather than burrowed into. Upon the whole, *Chebur* would seem to be a still more destructive creature than even *Limnoria*."

229. THE ISOPODS.

THE GRIBBLE, OR BORING LIMNORIA—*LIMNORIA LIGNORUM*, White.

This little crustacean pest, which measures less than one-fifth of an inch in length, is a very common habitant of our Atlantic coast from the Gulf of Saint Lawrence to Florida, and also occurs abundantly on the coasts of Great Britain and of other parts of Europe. In spite of its small size, it is very destructive to all kinds of submarine wood-work, which it rapidly eats away. Its body, which is subcylindrical in shape, consists of fourteen segments, the anterior one being the head; the two ends are rounded and the sides are nearly straight and parallel to one another. The first seven segments, not including the head, bear each a pair of short legs. It makes its burrows by means of stout mandibles or jaws. In color it is grayish, the upper surface of the body being covered with minute hairs, to which more or less dirt usually adheres.

The Gribble generally lives above and just below low-water mark, but has been found at times, though very rarely, as low down as seven to ten fathoms. It gnaws burrows into all sorts of sunken or floating wood near the shore, and lumber or drift-wood left for some time on muddy shores is pretty certain to be attacked by it. The burrows are made to a depth of about half an inch, and when they become numerous enough to reduce the superficial layer of wood to a mere honey-comb, it scales off, leaving a fresh surface, which is at once attacked. Much damage is done by this little creature to the piles of wharves and other submarine wood-work all along our Atlantic coast, and numerous methods of stopping its ravages have been devised. It has been observed attacking the gutta percha of submarine telegraph cables. Professor Verrill describes its habits and the damage it has done on the American coast, as follows:¹

"It has the habit of eating burrows for itself into solid wood to the depth of about half an inch. These burrows are nearly round, and of all sizes up to about a sixteenth of an inch in diameter, and they go into the wood at all angles and are usually more or less crooked. They are often so numerous as to reduce the wood to mere series of thin partitions between the holes. In this state the wood rapidly decays, or is washed away by the waves, and every new surface exposed is immediately attacked, so that layer after layer is rapidly removed, and the timber thus wastes away and is entirely destroyed in a few years. It destroys soft woods more rapidly than hard ones, but all kinds are attacked except teak. It works chiefly in the softer parts of the wood, between the hard, annual layers, and avoids the knots and lines of hard fiber connected with them, as well as rusted portions around nails that have been driven in, and consequently, as the timbers waste away under its attacks, these harder portions stand out in bold relief. Where abundant it will destroy soft timber at the rate of half an inch or more every year, thus diminishing the effective diameter of piles about an inch annually. Generally, however, the amount is probably not more than half this, but even at that rate the largest timbers will soon be destroyed, especially when, as often happens, the *Teredos* are aiding in this work of destruction. It lives in a pretty narrow zone, extending a short distance above and below low-water mark. It occurs all

¹ Vineyard Sound Report, pp. 379, 380, 1871-'72.

along our shores, from Long Island Sound to Nova Scotia. In the Bay of Fundy it often does great damage to the timbers and other wood-work used in constructing the brush fish-weirs, as well as to the wharves, etc. At Wood's Holl it was found to be very destructive to the piles of the wharves. The piles of the new government wharves have been protected by broad bands of tin-plate covering the zone which it chiefly affects. North of Cape Cod, where the tides are much greater, this zone is broader, and this remedy is not so easily applied. It does great damage also to ship timber floating in the docks, and great losses are sometimes caused in this way. Complaints of such ravages in the navy-yard at Portsmouth, New Hampshire, have been made, and they also occur at the Charlestown navy-yard and in the piles of the wharves at Boston. Probably the wharves and other submerged wood-work in all our sea-ports, from New York northward, are more or less injured by this creature, and, if it could be accurately estimated, the damage would be found surprisingly great.

"Unlike the *Teredo*, this creature is a vegetarian, and eats the wood which it excavates, so that its boring operations provide it with both food and shelter. The burrows are made by means of its stout mandibles or jaws. It is capable of swimming quite rapidly, and can leap backward suddenly by means of its tail. It can creep both forward and backward. Its legs are short and better adapted for moving up and down in its burrow than elsewhere, and its body is rounded, with parallel sides, and well adapted to its mode of life. When disturbed it will roll itself into a ball. The female carries seven to nine eggs or young in the incubatory pouch at one time.

"The destructive habits of this species were first brought prominently to notice in 1811, by the celebrated Robert Stephenson, who found it rapidly destroying the wood-work at the Bell Rock light-house, erected by him on the coast of Scotland. Since that time it has been investigated and its ravages have been described by numerous European writers. It is very destructive on the coasts of Great Britain, where it is known as the 'Gribble.'

"The remedies used to check its ravages are chiefly copper or other metallic sheathing; driving broad-headed iron nails, close together, into the part of the piles subject to their attacks; and applying coal tar, creosote, or verdigris-paint, once a year or oftener."

THE SALVE BUG—*ÆGA PSORA*, Kröyer.

This is the largest species of Isopod living upon the New England coast, and attains a length of two inches and a breadth of one inch. It occurs as a parasite on the cod and halibut. In addition to its large size, when adult, it may be readily distinguished by its large eyes, which nearly cover the upper surface of the head, and approach closely together at their anterior extremities. The first three pairs of legs are adapted for clinging to the surface of the fish on which it lives. The body is oval, and broadest just in front of the middle. The Salve Bugs are used as an unguent by the fishermen, who sometimes collect them in large quantities.

230. THE ENTOMOSTRACANS.

This order of crustaceans includes a vast number of small, generally minute, free-swimming forms, frequently called water-fleas, which abound in both fresh and salt waters, and other and generally larger species which occur as parasites on fish and other aquatic animals. The former serve as an important article of food for many fishes, such as the menhaden and mackerel, while the latter are frequently injurious to them, being often strangely modified, and burrowing deeply into the flesh, from which they suck the juices, causing great irritation and at times perhaps death.

231. THE CIRRIPEDIA.

THE BARNACLES—*BALANUS EBURNEUS*, Gould, AND ALLIED SPECIES.

Several species of Barnacles (which belong to the natural group of *Crustacea*, despite the hard, mollusk-like shell of most of the species) occur upon our coast and serve as food for some of our fishes, but it is mainly their intrusion upon certain of the marine industries that gives them a place in this volume. A large species of Barnacle, *Coronula diadema*, Linné, growing upon the skin of one or more species of whales, is eaten to some extent by the west coast Indians.

In one group of Barnacles the animals are furnished with a fleshy stem or peduncle, by means of which they remain permanently attached to floating objects in the sea. The species of this group bear the general name of "Goose Barnacles." Our commonest species is the *Lepas fascicularis*. The other group of Barnacles, represented upon our coast by the "Rock Barnacle" (*Balanus balanoides*), "Ivory Barnacle" (*Balanus eburneus*), and other species, has no peduncle, but the several valves forming the conical shell are attached directly and permanently to the rocks or wood on which they happen to dwell. Some of the species of both groups grow upon the hulls of ships below the water-line, and in connection with seaweed and other species of marine animals cause the so-called fouling of the bottom, necessitating constant cleaning and scraping of the bottoms of vessels at considerable expense. Barnacles also stand as a serious obstacle in the way of oyster culture, as shown by the recent experiences of the United States Fish Commission. They grow with exceeding rapidity, very much faster than the oyster, and are so hardy as to defy any attempts at extermination. In the spring of 1880, when the experiments in the artificial breeding of oysters were being carried on in Chesapeake Bay, slates coated with plaster were used as collectors. To these the oyster embryos attached themselves in large numbers, and began their growth with good promises of success; but at the same time embryos of the Ivory Barnacle were fully as abundant in the water, and, attaching themselves in even greater numbers, rapidly outgrew the less hardy oysters. In many places they completely crowded the oysters out of place, and soon occupied entire surfaces. In other places, however, they were less numerous and interfered less with the oyster growths. It is very certain that this inconvenience must always remain as a certain check on all oyster-cultural experiments on our coast, and must seriously interfere with any attempts at artificial oyster-breeding. It is to be hoped, however, that future experiments will prove that the Ivory Barnacle cannot entirely destroy the profits of such an important industry, which, in consideration of the greatly impoverished character of some of our formerly rich oyster regions, it is very necessary should be started at once, and, if possible, carried to a high state of perfection.

The Ivory Barnacle ranges from Massachusetts Bay to Florida and the West Indies, while the Rock Barnacle inhabits the entire North Atlantic coasts of both continents. The habitats of our common species are given as follows by Professor Verrill:

"The common Barnacle of the rocky shores, *Balanus balanoides*, is also common on the piles of wharves and bridges, between tides, and also on the bottoms of vessels, etc. It never grows very large, although it may become so crowded together as to form a continuous crust. It is easily distinguished from the other species by its membranous base, which never forms a solid plate like that of the other species. The 'Ivory Barnacle,' *Balanus eburneus*, is also common on all kinds of submerged wood-work, whether fixed or floating. It is usually abundant on the piles and timbers of wharves, buoys, oyster-stakes, bottoms of vessels, etc. It is chiefly found below low-water mark if on fixed objects, and is even more common in the brackish waters of estuaries than in the purer waters outside, and it is capable of living even in pure, fresh water, for Prof.

Jeffreys Wyman has sent me specimens collected by himself about sixty-five miles up the Saint John's River, in Florida, where the water is not at all brackish. This species is sometimes found adhering to the carapax of Crabs, the shell of *Limulus*, and various mollusks. It is easily distinguished from most species on account of its low, broad form and its smooth, white exterior. It has a shelly base. The *B. crenatus*, common on shells and stones in deep water, also occurs on vessels. Other species are often found on the bottoms of vessels that have come from warmer latitudes. Some of them are of large size. One of the most frequent of these is *Balanus tintinnabulum*."

232. THE XIPHOSURA.

THE HORSESHOE CRAB—*LIMULUS POLYPHEMUS*, Latreille.

The curious form of marine animal called "Horseshoe Crab," "King Crab," and "Horse foot," ranges along our entire Atlantic coast, from Casco Bay, Maine, to Mexico, and gives rise to an important industry in at least one region—Delaware Bay. It is not, however, a true Crab, and its exact position in the animal kingdom is still involved in much obscurity. Some naturalists regard it as a low type of crustacean, while others place it among the *Arachnida*, or scorpions and spiders. Its nearest allies all occur as fossils, through many geological ages down to nearly the oldest of the fossiliferous series. Another species of the same genus, however, still lives upon the eastern coast of Asia.

The carapax of the King Crab is very large, with a regularly rounded outer margin, terminating in a spine at the posterior angles on both sides. The abdomen is much smaller, and from its hinder end, to which it is jointed, runs out a long, tapering spine. The basal portions of the feet on the lower side of the carapax serve as masticating organs.

The King Crab is sluggish in its movements, and spends much of its time more or less buried in the mud and sand of shallow water, coming up occasionally to high-water mark. It is most abundant on the muddy bottoms of shores and estuaries, where it burrows just beneath the surface, and feeds upon various small animals.

"At the breeding season, however, it comes up on the sandy shores to deposit the eggs, near high-water mark. According to the statements of Rev. S. Lockwood, the spawning is done at the time of high tides, during May, June, and July; they come up in pairs, the males, which are smallest, riding on the backs of the females and holding themselves in that position by the short feet, provided with nippers, which are peculiar to the males. The female excavates a depression in the sand and deposits the eggs in it, and the male casts the milt over them, when they again return to deeper water, leaving the eggs to be buried by the action of the waves. In aquaria, under favorable circumstances, the eggs hatch in about six weeks, but in their natural conditions they probably hatch sooner than this; under unfavorable conditions the hatching may be delayed for a whole year. The eggs are very numerous."

From several intelligent observers living on the Delaware Bay side of Southern New Jersey we have received interesting notes on the habits of the King Crab, as exemplified in that region, and which may also hold good for others. While this Crab is comparatively rare on the outer side of Southern New Jersey, on the inner side, along the shores of Delaware Bay, from Cape May to Reed's Island, it is unusually abundant. It is not, however, always present in the very shallow water near shore. During the breeding season, which is mainly confined to the months of May and June, but also extends slightly into July, the males and females approach and ascend the beaches in countless numbers, the latter to lay their eggs, the former to impregnate them. It

¹ VERRILL: Vineyard Sound Report, pp. 340, 341, 1871-'72.

is not an uncommon thing for the female, as she crawls up the beach, to be accompanied by two, three, and even as many as six males, the forward one clinging to the abdomen of the female, and the remainder fastened to one another in the same manner. As a rule, however, each female brings with her only a single male. After the spawning has been accomplished, they retreat from the beach in the same order. King Crabs are not equally abundant at all times during the spawning season, but are most plentiful on the beaches during the spring tides, which occur about the times of the new and full moon. Westerly winds suit them best for spawning, and they will not come ashore in large numbers during an easterly wind. They approach with the flood tide and leave soon after the ebb. The eggs hatch in July and August, at which times the sands become literally alive with the young Crabs. These soon disappear, not to return to the shore until they have attained a considerable size. After the close of the spawning season the adult Crabs are not seen in abundance about the shore, but probably live in slight depths of water near at hand. During the winter they are often taken out in Delaware Bay by the oyster dredgers. They are very much less abundant now than formerly, on account of so many having been caught from year to year for use as a fertilizer. It would appear as though a few years more of indiscriminate capture would result in their being entirely exterminated from the region. The men catch them mainly in their hands, as they come upon the beaches, but they are also captured in pounds and weirs.

The King Crab is rarely used as food for man, but is often fed to swine and poultry, and, after drying, is extensively employed as a fertilizer. It also serves as bait for eels and some species of fish. This species of Crab has been introduced on the west coast of the United States, the young, it is supposed, having been carried over mingled with the spat of the eastern oyster, which has been largely transplanted into the shallow waters of San Francisco Bay. It has also been introduced on the European coast.

Z.—THE WORMS.

233. THE ANNELIDS.

THE MARINE WORMS, BAIT WORMS, ETC.—NEREIS VIRENS, SATS, AND ALLIED SPECIES.

Marine Worms of many different kinds occur in great abundance along the entire Atlantic and Pacific coasts of the United States, and are available as bait, for which purpose a few species are frequently employed by both professional and amateur fishermen. They are generally easily obtained by digging with a spade or trowel into sandy or muddy shores, but are not common on exposed beaches of clear sand. They usually require for their existence a greater or less admixture of mud, gravel, and organic matter, the latter to serve as food. Shores which furnish the common clam (*Mya arenaria*) usually abound in Marine Worms of several varieties, which are overturned in digging for that mollusk. So far as we know, there is no regular trade in this marine product on any part of our coast; but occurring as they do within the convenient reach of most of the shore fishermen, these Worms may be obtained at short notice, and deserve mention here as forming an element of some importance in our marine fisheries. The following account of the habits of Marine Worms in general and of some of our commoner species is extracted from the report of Prof. A. E. Verrill:¹

“The Marine Worms or Annelids are very numerous under the rocks between tides, and concealed beneath the surface of the gravel and mud that accumulates between and beneath the stones and in crevices. Many kinds also live in the pools, lurking among the roots of the algæ, burrowing in the bottom, or building tubes of their own in more exposed situations. Many of these Annelids are very beautiful in form and brilliant in color when living, while most of them have curious habits and marvelous structures. Several species are of large size, growing to the length of one or two feet. Some are carnivorous, devouring other worms and any other small creatures that they can kill by their powerful weapons; others are vegetarians; but many are mud-eaters, swallowing the mud and fine sand in great quantities, for the sake of the animal and vegetable organisms that always exist in it, as is the case with clams and most of the bivalve shells and many other kinds of marine animals.

“All these Annelids are greedily devoured by most kinds of marine fishes, whenever they can get at them, and, since many of the Annelids leave their burrows in the night to swim at the surface, or do this constantly at the breeding season, they make an important element in the diet of many fishes besides those that constantly root for them in the mud and gravel, like the tautog, scup, haddock, etc. The young of nearly all the Annelids also swim free in the water for a considerable time, and in this state are doubtless devoured in immense numbers by all sorts of young and small fishes.

“One of the largest and most common Annelids found under rocks, burrowing in the sand and gravel, is the *Nereis virens*. It lives both at low-water mark and at a considerable distance farther up. It grows to the length of eighteen inches or more, and is also quite stout in its proportions. The color is dull greenish, or bluish-green, more or less tinged with red, and the surface reflects bright iridescent hues; the large lamellæ or gills along the sides are greenish

¹Vineyard Sound Report, pp. 317, 318, 341, 342, 1871-'72.

anteriorly, but farther back often become bright red owing to the numerous blood-vessels that they contain. It is a very active and voracious Worm, and has a large, retractile proboscis, armed with two strong, black, hook-like jaws at the end, and many smaller teeth on the sides. It feeds on other Worms and various kinds of marine animals. It captures its prey by suddenly thrusting out its proboscis and seizing hold with the two terminal jaws; then withdrawing the proboscis, the food is torn and masticated at leisure, the proboscis, when withdrawn, acting somewhat like a gizzard. These large Worms are dug out of their burrows and devoured eagerly by the tautog, scup, and other fishes. But at certain times, especially at night, they leave their own burrows, and, coming to the surface, swim about like eels or snakes, in vast numbers, and at such times fall an easy prey to many kinds of fishes. This habit appears to be connected with the season of reproduction. They were observed thus swimming at the surface in the daytime, near Newport, in April, 1872, by Messrs. T. M. Prudden and T. H. Russell, and I have often observed them in the evening later in the season. At Watch Hill, Rhode Island, April 12, I found great numbers of the males swimming in the pools among the rocks at low water, and discharging their milt. This Worm also occurs in many other situations, and is abundant in most places along sandy and muddy shores, both of the sounds and estuaries, burrowing near low-water mark. It occurs all along the coast from New York to the Arctic Ocean, and is also common on the northern coasts of Europe.

“With the last, in this region and southward, another similar species, but of smaller size, is usually met with in large numbers. This is the *Nereis limbata*. It grows to the length of five or six inches, and can easily be distinguished by its slender, sharp, light amber-colored jaws, and by the lateral lamellæ, which are small anteriorly and narrow or ligulate posteriorly. Its color, when full grown, is usually dull brown, or smoky brown or bronze-color anteriorly, with oblique light lines on the sides, and often with a whitish border to each of the rings, which form narrow, pale bands at the articulations; posteriorly the body and lateral appendages are pale red, and the longitudinal dorsal bloodvessel is conspicuous.

“Annelids are quite numerous on the sandy shores where the conditions are favorable. It is evident that these soft-bodied creatures would be quickly destroyed by the force of the waves and the agitation of the sand were they not provided with suitable means for protecting themselves. This is effected mainly in two ways: the sand-dwelling species either have the power of burrowing deeply into the sand with great rapidity, or else they construct long, durable tubes, which descend deeply into the sand and afford a safe retreat. Many of the active burrowing species also construct tubes, but they usually have but little coherence and are not very permanent, nor do they appear to be much relied on by the owners. There is, however, great diversity both in the structure and composition of the tubes of different species, and in the modes by which the rapid burrowing is effected.

“The large green *Nereis* (*N. virens*) is found on the sandy shores in places that are somewhat sheltered, especially if there be an admixture of mud or gravel with the sand to give it firmness and solidity. This species burrows deeply beneath the surface and lines the interior of its large irregular burrows with an abundant mucous-like secretion, which gives smoothness and some coherency to the walls, but does not form a solid tube. With this, and in greater numbers, the smaller species, *Nereis limbata*, is also found, and its habits appear to be essentially the same. Both this and the preceding can burrow rapidly, but much less so than some other worms, and consequently they are not well adapted to live on exposed beaches of moving sands, but prefer coves and harbors. The two large species of *Rhynchobolus* are much better adapted for rapid burrowing. Their heads are very small and acute, and destitute of all appendages, except four

minute tentacles at the end; the body is long, smooth, and tapers gradually to both ends, and the muscular system is very powerful, and so arranged as to enable these Worms to coil themselves up into the shape of an open spiral, like a corkscrew, and then to rapidly rotate themselves on the axis of the spiral. When the sharp head is inserted into the loose mud or sand and the body is thus rotated, it penetrates with great rapidity and disappears almost instantly. Both these species are found on sandy as well as on muddy shores and flats near low-water mark, and also in deeper water. The one usually most abundant is *R. dibranchiatus*. This is readily distinguished by having a simple gill both on the upper and lower sides of the lateral appendages. The other, *R. americanus*, has gills that are more or less branched on the upper side of the appendages, but none on the lower side; the appendages are also longer, especially posteriorly, and differently shaped. The proboscis is remarkably long and large, and when fully protruded it shows four large, black, sharp, fang-like jaws or hooks. Both these Worms are destitute of true bloodvessels, such as most of the allied Worms possess, but have the general cavity of the body filled, between the various organs, with bright red blood, which shows through the skin, giving a more or less red or purple color to the whole body and proboscis."

The principal species of marine Worms which are used as bait are the *Nereis virens*, *Nereis limbata*, *Diopatra cuprea*, *Arenicola marina*, *Clymenella torquata*, *Marphysa sanguinea*, *Arabella opalina*, and *Rhynchobolus dibranchiatus*.

The Earth Worm might also be mentioned in this connection, as it is likewise very commonly used as a fish-bait, especially in fresh waters. All sportsmen, from boyhood up, are acquainted with this simple form of bait, which is more easily obtained than any other. Large quantities are used annually, but no statistics can ever exist to determine the amount, which is irregularly distributed over the country.

234. THE LEECHES.

THE AMERICAN MEDICINAL LEECH—MACROBELLA DECORA, Verrill.

Structure of Leeches.—In the true Leeches, which belong to the order *Hirudinea*, the body is flattened, divided into numerous short and indistinctly marked segments, and bears neither bristles nor appendages of any kind. The head is small, with five pairs of minute, simple eyes, and each end of the body terminates in a sucker. "The mouth is armed internally with three pharyngeal teeth arranged in a triradial manner, so that the wound made in the flesh of persons to whom the Leech is applied consists of three short, deep gashes radiating from a common center." The stomach is large, and the nervous system consists of a "brain" and ventral cord. The Leech is hermaphroditic. The eggs, which range from six to fifteen in number, are contained in a sort of spongy, slimy cocoon, from half an inch to an inch in diameter. These are deposited near the water's edge and hatched by the heat of the sun. Respiration in the Leeches is carried on through small apertures arranged along the under surface of the body. The Leech swims with a vertical undulatory motion and moves both in and out of the water by means of its suckers, fastening itself first by one and then by the other, and alternately stretching out and contracting its body.

There are two or three species of Leeches, known as medicinal Leeches, which afford the most convenient means of drawing blood from the human body. They have been used by physicians for this purpose for many years, and have given rise to a very extensive and profitable trade. One of the species belongs to North America.

Distribution and structure of the American Leech.—Although numerous species of Leeches abound in the fresh waters of the United States and are related to the fisheries in various ways,

this region has so far afforded only a single species of true blood-sucking Leech, the *Macrobdella decora* of Verrill. This is, therefore, the only known Leech in our country of economic value. It is very widely distributed in the Northern United States, and was at one time quite extensively used by physicians. Being somewhat inferior in quality to the European Leeches, however, it has, since they have begun to import the latter regularly into this country, ceased to be considered as an official Leech excepting in a few places.

The American Leech has, according to Professor Verrill, a large, stout, and broad body, which is considerably compressed throughout. It is strongly annulated, and in extension is much elongated, gradually tapering anteriorly. The larger specimens measure twelve inches or more in length, and have a breadth of upwards of an inch. The head is rounded in front, and is furnished with three stout and prominent maxillæ, having the outer edge denticulate with numerous acute teeth. The eye-spots are ten in number. The breeding season is in the spring. The color above is a dark livid brown or olive green, with a median dorsal row of about twenty to twenty-two bright or pale red spots, which are sometimes obsolete, and a row of rounded black spots near each margin, corresponding in number, and nearly in size, with the red ones. The lower surface is a bright or dark orange red or reddish brown, sometimes with black spots near the margin. "This species is very common, and widely diffused in the fresh waters of the Northern United States. Its range northward and southward is unknown. It is the only true blood-sucking Leech known from the Northern States. It is capable of drawing blood from the human skin, but ordinarily subsists upon fishes, frogs, and tadpoles. It often attaches itself to the throat, and speedily kills them, even when of considerable size."¹

While the American Leech sometimes attains a length of twelve inches, four to five inches is the average adult size, and the majority of those sold in the shops measure only two to three inches. American Leeches are now seldom used by physicians. The foreign species are so easily obtained, so cheap, and so much more reliable in the majority of cases, that they are now given the preference nearly everywhere. The American Leech was formerly extensively employed, before they began to import the foreign species, and even for some time afterwards, in consequence of the continued high price of the latter. With the gradual decline in the practice of leeching the import trade in Leeches has also fallen off from year to year, the imports for the past few years being less than half those for 1856, and the price about one-fourth what it was then.

Cultivation and economic value of the American Leech.—Attempts have been made to breed and raise the American Leech in artificial ponds after the plan pursued in Europe, but always without success. The Leeches in these inclosures have never thrived well, and, in addition, the slight demand for them has tended to render all the attempts in this direction decidedly unprofitable. Mr. Herman Witte, of New York, has perhaps experimented more extensively in leech-culture in this country than any other person. His ponds, constructed very much like those in France, to be described further on, are located between Winfield and Newtown, Long Island, New York. They are five in number and cover an area of over fifteen acres. At present they serve merely as preservative ponds for surplus supplies of imported Leeches. Other artificial ponds have been started in the State of New Jersey and near Saint Louis, Missouri, but they were all speedily given up. Turtles, snakes, birds, and insects were said to have destroyed great quantities of the Leeches and discouraged operations. American Leeches, when they were in common use, were probably collected to a greater or less extent in most of the regions where they were employed. Eastern Pennsylvania, Bucks and Berks Counties especially, seems, however, to have furnished the principal collecting ground, in past times as at present. Numerous ponds in

¹ VERRILL: Report, U. S. Fish Commissioner for 1872-'73, p. 669.

Eastern Massachusetts, including the southern part of Cape Cod, were formerly noted for the large numbers of Leeches they contained, and during the early part of this century many Leeches were collected from them for medicinal purposes. Philadelphia is now the only large city where American Leeches are used by physicians, who prefer them to the European for certain kinds of treatment. The latter Leech is the more powerful, and extracts the most blood. According to the statements of Philadelphia leechers, about four American Leeches are required to do the work of one European, and the chief merit of the former arises from the fact that they can be used more freely and with less danger to the patient, and can also be employed on the more delicate parts of the body, where the European Leech would act too vigorously. They are especially recommended for the region about the eye, and several are sometimes used, distributed over a wider space, when it is thought best not to extract the blood from a single spot by the aid of an imported specimen. The American Leech does not attach itself as readily as the foreign, and often several specimens have to be tried before one can be found to fasten itself. They bite much less readily out of water than in. The bites of the two Leeches are different; that of the European being deeper and more pronounced and bleeding much longer after the Leech has been detached. The wound of the American Leech generally closes very soon after the Leech has been released, and sometimes immediately.

The European Leech.—The European Leech belongs to a different genus from our own, *Hirudo*, and by some authorities is considered to constitute two distinct species, *H. medicinalis*, the Gray Leech, and *H. officinalis*, the Green Leech. By others the Green Leech and Gray Leech are placed in the one species, *H. medicinalis* of Linnæus. "They are both marked with six longitudinal dorsal ferruginous stripes, the four lateral ones being interrupted or tessellated with black spots. The color of the back varies from a blackish to a grayish green. The belly in the first variety is of a yellowish color, free from spots, and bordered with longitudinal black stripes. In the second it is of a green color, bordered and maculated with black. This Leech varies from two to four inches in length. It inhabits marshes and running streams, and is abundant throughout Europe."

Prior to thirty years ago nearly all the northern countries of Europe contained Leeches, but most of the supplies came from Sweden, Russia, Poland, and Hungary. The swampy regions in which they lived were drained from time to time, for one reason and another, until finally vast areas which had once been profitable became dried up, to the almost entire destruction of the Leeches. Then, and for the first time was the extent of the injury fully realized over all Europe, and strenuous efforts were made to remedy the evil. Several governments, including the French, Prussian, and Hanoverian, offered premiums for successful results in leech-culture, but these efforts were rewarded only in the former country. At present the larger share of the Leeches used in Europe and this country come from the artificial ponds or meadows of Southern France, although many are also raised in Hungary and in other countries of Southern Europe. Paris is the principal receiving center, whence they are sent to England, to the English colonies, and the United States. The export trade to South America and the West Indies is largely carried on through the United States.

Leech culture.—The localities selected for leech-raising are swampy meadows, where the bottom is more or less firm and solid. A certain area having been chosen, it is divided into rectangular plots of different sizes by means of ditches. The breeding season is in June and July. At this time water is admitted only into the ditches, the meadow flats remaining dry. The eggs are laid in the loose, swampy soil at the margins of the ditches, and when the young creep out about six weeks, more or less, afterwards, the meadows are overflowed artificially to a

depth of six to eight inches. Before the young appear, however, as many of the old ones as possible are caught and transferred to other places. Otherwise they would consume too much of the food required for the young. The young Leeches are fed upon the blood of living animals, horses, cattle, etc., which are driven into the shallow water about twice a week and allowed to remain a certain length of time. The Leeches attach themselves merely to the feet, but find in those portions of their prey enough sustenance to cause them to grow rapidly and quickly attain the required size. Fresh blood obtained from the slaughter-houses and deprived of its fibrine by agitation is also supplied to them, or they are placed in it, while it is still warm, for a short time. The feeding is carried on principally in September and October, and again in April and May. During the winter the Leeches remain torpid at the bottom.

Extravagant statements have sometimes been published as to the manner of feeding Leeches in France. It is said that many of the owners of ponds are accustomed to buy up old and diseased horses, drive them into the ponds, and allow them to be overcome by the Leeches, which fasten to all parts of the body and kill them by a slow process of torture. This may occasionally take place, but we are assured by one who has had considerable personal experience in the matter that it is by no means a common practice. The quantity of blood sucked from the feet injures the horses but little; and they are taken out in time to prevent harm. Some single breeding establishments in Southern Europe cover an area of one hundred and twenty hectares. In about three years' time, the young Leeches, without being forced in their growth, attain a good medium size and are suited to the wants of physicians. Medium Leeches are about two inches long, and weigh three and one-half to four pounds to the thousand. The large Leeches weigh about five to five and one-half pounds to the thousand, and this is the preferred size. The European Leeches are graded in the markets as small, medium, and large. Only the medium and large Leeches are used in this country. The very large ones, however, are generally considered too dangerous for use, and are kept for breeding purposes. The foreign Leeches are transported and generally stored in wooden cases or pails, containing swamp earth or mold. The American Leeches, however, are usually kept in glass vessels of water.

American Leech ponds.—Mr. Witte's ponds on Long Island, where he attempted the breeding of American Leeches, occupied about three and one-half acres each, and were divided into five compartments by ditches, like the French ponds. As before stated, his efforts were unsuccessful, or at least unprofitably rewarded. In connection with these large ponds, Mr. Witte has since constructed thirteen others of much smaller size (about twelve by fifteen feet each) for the storage and feeding of Leeches, which are generally imported in larger quantities than are required to supply the immediate demands of the trade. He has had as many as one hundred thousand Leeches in these small ponds at a time, but the number varies.

Use of Leeches.—Leeches are not now used nearly as much as formerly, and the practice of leeching is gradually declining. From year to year the imports have constantly fallen off, and the price of Leeches has rapidly decreased. Whether this will continue until the old custom of leeching is entirely replaced by other methods of treatment or not cannot be predicted. It is evident, however, that in Philadelphia the practice has greatly revived during the past few years, and the best physicians are once more advocating the application of Leeches. About ten years ago the leeching practice reached its minimum in Philadelphia, and it has remained at a low stage until very recently. A well-known Philadelphia leecher says that thirty or forty years ago many more American Leeches were used in that city than European, but during the past year he has applied only about one hundred of the former. Another leecher of the same city states that formerly he applied on an average over three thousand American Leeches a year, while now he uses but a very few.

The varieties of Leeches.—The terms “Spanish Leeches” and “Swedish Leeches” have in this country lost their distinctive meaning. We are informed by a large importer that the Spanish Leech was a small green Leech brought here occasionally, thirty or forty years ago, by sea-captains. They were inferior to other varieties, and during the past twenty years none have been brought into the country, at least not through regular importing houses. The name “Spanish Leech” is, however, still used in the trade, and we have heard it frequently referred to by cuppers and leechers, who are probably ignorant of the real sources of their supplies. As to the Swedish Leeches, they were probably the first variety brought to this country when the import trade began some fifty years ago. They then came from the country whence they derived their name. Since the beginning of leech-culture in France, this same Leech has been raised there artificially, and it is claimed that the American supplies from France are wholly of this kind. The Leeches used in England are also said to be mostly descendants of the Swedish stock raised in France. Having been shipped originally to London by way of Hamburg, they received there the name of Hamburg Leeches, which they still retain. The Leeches used almost exclusively in France come from a native stock, which is now propagated artificially. They are small and of a green color.

In the German leech trade two kinds of Leeches are recognized, one of which is called the German Leech and the other the Hungarian Leech. The former has a black-spotted belly, while in the latter the belly is uniform in color. The first is a native of Germany, where it has become rare on account of the extent to which it has been caught up. It is now raised artificially. The Hungarian Leech is imported from Hungary, whence come most of the supplies now used in Germany. Other sources of supply are the principalities of the Danube and Ploguez en Posen. The Island of Porto Rico and other islands of the West Indies are said to contain medicinal Leeches. Most of the South American countries, however, on both sides are supplied from Europe via the United States, and Mexico receives some supplies from the same source.

ZA.—THE RADIATES.

235. THE ECHINODERMS.

THE SEA CUCUMBERS, OR TREPANG—*HOLOTHURIA FLORIDANA*, Pourtales; *HOLOTHURIA PRINCEPS*; *PENTACTA FRONDOSA*, Jeger.

The Sea Cucumbers, or Holothurians, are the highest members of the group of Echinoderms, which also includes the Sea Urchins and Star-fishes. They usually have an elongate, cylindrical, flexible body, covered with a muscular skin, which varies greatly in thickness in the different species. The mouth is located at one end of the body, and is surrounded by a circle of more or less complex tentacles or feelers. That division of the Holothurians to which the economic species belong are furnished with the so-called ambulacral feet, which are sometimes arranged in five longitudinal rows or series, and at others are scattered without order over the surface of the body. The body wall frequently contains numerous minute calcareous plates, of various shapes, which are often peculiar to the different species. Many of the species are quite worm-like in external appearance. The Trepang of Chinese commerce is the dried skin of a large species of Holothurian living in the South Pacific Ocean, and used as food in China.

The largest and one of the most conspicuous of the New England Holothurians is the *Pentacta frondosa*, which inhabits the northern Atlantic coasts of both Europe and America, from low-water mark to a depth of one hundred fathoms or more. It is of a brown color, and measures from a few inches to about a foot in length when expanded. The ambulacral feet form five double and irregular rows, and the tentacles are ten in number, and much branched. Dr. William Stimpson remarks concerning this species that, made into a soup, it is very palatable; but it has never been regularly used as food.

Holothuria floridana is a large dark-brown species, with the feet scattered irregularly over the body, and with smaller tentacles than *Pentacta*. It occurs abundantly on the Florida reefs, just below low-water mark, and grows to about fifteen inches in length. *Holothuria princeps* is another large Florida Sea Cucumber. One or both of these species, but more probably the former, gave rise, about 1870, to a limited industry on the Florida coast, to be described hereafter. Large quantities were collected on the reefs, cleaned of their internal organs, boiled, and then dried and shipped to China; but the industry was abandoned after two years' trial, probably having been unprofitable. Chinese coolies assisted in the work.

THE SEA URCHINS—*STRONGYLOCENTROTUS DRÖBACHIENSIS*, A. Ag.; *STRONGYLOCENTROTUS FRANCISCANUS*, A. Ag.; *ECHINARACHNIUS PARMA*, Gray.

The Sea Urchins are related to the Sea Cucumbers, but differ from them in form, and in the character of their external covering. The body is generally somewhat spherical in shape, but more or less flattened below, the mouth being placed near the center of the lower surface. The outer covering is built up of calcareous plates, closely fitting together, from which project a multitude of spines, sometimes of small, sometimes of large size, there being generally a great variation in size in the same individuals. The larger spines are generally arranged in regular series. There is a water system; five double rows of feet, which run from the center above to

the mouth below; and many pedicellariæ. The œsophagus is small and the stomach and intestine somewhat lengthened and curved upon itself. The sexes among Sea Urchins are distinct, the different individuals containing either ovaries or spermaries only. These are five in number, and resemble those of the Star-fish. This portion of the Sea Urchins (the ovaries) are the most important in an economic point of view, the ovaries alone being eaten.

The common or green Sea Urchin (*Strongylocentrotus drabachiensis*) has a very wide range, and is very abundant upon our northern coast. It extends from New Jersey to the Bay of Fundy, but south and west of the eastern part of Long Island Sound it is rare. Its bathymetrical range is from low-water mark to depths of over four hundred fathoms. Outside of the United States, it ranges from Nova Scotia to the Arctic Ocean; from Spitzbergen to Great Britain; from Bering Strait to the Gulf of Georgia; and along Eastern Siberia to Okhotsk Sea, and De Castries' Bay. This species "feeds partly on diatoms and other small algae, etc., which it cuts from the rocks with the sharp points of its teeth, and it is also fond of dead fishes, which are soon devoured, bones and all. In return it is swallowed whole, in large quantities, by the wolf-fish and other large fishes." The green Sea Urchin is not now eaten upon our eastern coast, and most Americans would probably regard its use as food with much repugnance, but it was formerly eaten by some of the native east coast Indian tribes, and is still favorably regarded by the Alaskans. Mr. Henry Elliott states that at Saint Paul's Island the villagers, principally Aleuts, search for it at low tide, under the shelter of the bowlders, which stand in the tide pools, on the rocky shores, during nearly all seasons. Usually the shells are broken, the ovaries removed and spread out like raw oysters on a plate, and eaten with salt, pepper, and vinegar. The old women, called "barbies," despise these condiments, however, and suck the Sea Urchins as small boys do eggs. The native Alaskan name for this Sea Urchin is "Repkie."

The common west coast Sea Urchin (*Strongylocentrotus franciscanus*) inhabits the coasts of Southern Alaska, British Columbia, and the United States, as far south as San Diego, California. It attains a much larger size than the green Sea Urchin, and is used as food in some localities. In Southern Europe a related species, *Strongylocentrotus lividus*, is much esteemed as food. •

The "Sand Dollar," or "Flat Sea Urchin" (*Echinarachnius parma*), of the New England coast differs so much from the Green Sea Urchin in appearance that it would scarcely appear to belong to the same group of animals, from a superficial examination. Its principal points of difference are its extremely compressed form and very small spines, which are nearly uniform over the entire body. The lower side is perfectly flat, and the upper but slightly convex. Its only importance from an economic standpoint arises from the fact that it furnishes an indelible ink, which might possibly be utilized in the arts, as it now is to a slight extent by the fishermen of some parts of the coast.

The Sand Dollar is commonly met with on sandy shores, but is seldom found living "except at extreme low water of spring tides, when it may sometimes be found on flats or bars of fine siliceous sand in great numbers, buried just beneath the surface, or even partially exposed. It creeps along beneath the sand with a slow gliding motion, by means of the myriads of minute extensile suckers with which it is furnished. It is far more abundant on sandy bottoms at various depths off shore. It has a very wide range, for it is found all the way from New Jersey to Labrador, and also on the North Pacific coast; and in depth it ranges from low-water mark to four hundred and thirty fathoms, off Saint George's Bank, where it was dredged by Messrs. Smith and Harger. When living its color is usually a rich purplish-brown, but it soon turns green when taken from the water. It gives a dark green or blackish color to alcohol, which stains very injuriously any other specimens put in with it. The fishermen on the coast of Maine and New Brunswick some-

times prepare an indelible marking-ink from these 'Sand Dollars,' by rubbing off the spines and skin, and, after pulverizing, making the mass into a thin paste with water. A number of fishes have been found to swallow this unpromising creature for food, and the flounders consume large numbers of them."¹

THE STAR-FISHES—*ASTERIAS VULGARIS*, Stimpson; *ASTERIAS FORBESII*, Verrill.

Only two species of Star-fish merit our attention in this report, not from any good they perform, out from their destructive attacks upon our oyster-beds, which they are said to damage to the extent of perhaps two hundred thousand dollars annually. These two Star-fishes, called *Asterias vulgaris* and *Asterias Forbesii*, are so closely related to one another and so similar in appearance as to require considerable skill at times to point out their differences; but when living the *Asterias Forbesii* can generally be recognized by its bright orange madreporic plate on the upper side of the body, the corresponding plate in *A. vulgaris* agreeing more closely in color with the surrounding portions of its disk. The fishermen do not distinguish between the two species; to them they are both alike, and both are designated under the common but descriptive terms of "Star-fish," "Five-finger," "Sea Star," or simply "Star."

The Star-fish, as its name implies, is a star-shaped animal, consisting of a central disk from which radiate, in the case of the species now under discussion, five elongate arms, which are not marked off or separated in any way from the disk, but exist merely as prolongations from it. The upper and lower sides are quite different from one another. "The upper side presents a rough surface of a greenish, brownish, reddish-green, or purple hue, which when it is dried turns to a yellowish-brown. This is the leathery membrane covering the skeleton of the animal, which consists of small limestone plates, united together at their edges by a sort of cartilage. This forms the framework of the arms and disk, and acts as a chain-armor, encircling and protecting all the soft parts within. On the lower side of the Star-fish this framework terminates in two series of larger plates. This armor is sufficiently flexible to allow the Star-fish to bend himself clumsily over or around anything he is likely to wish to climb upon or grasp." The entire upper surface is covered with many short spines, which are largest and thickest at the edges of the rays and upon the plates bordering the lower sides of the rays. Around the base of each spine there is a circle of curious little claw-like appendages called *pedicellariae*, which may serve to aid in clearing the upper surface, but whose functions are not satisfactorily made out. Scattered between the spines are little soft water tubes, and at one side of the disk on the back is a sieve-like arrangement, called the madreporic plate, for the admission of water.

The under side of the body is softer than the upper and much lighter in color. The mouth is in the center of the disk; it bears no teeth, but is surrounded by an elastic tube. Five furrows run from the mouth down the center of each arm. They are filled with numerous extensible soft tubes, terminating in a disk and arranged in four rows. These are the so-called feet of the Star-fish, and by means of them it moves about. The majority of the Star-fishes are bisexual, but in the two species under discussion the sexes are distinct.

Our common Star-fishes, and especially the *Asterias vulgaris*, attain a large size, specimens often measuring fifteen inches across, and upwards, on the Maine and Massachusetts coasts. From this extreme we find all the intermediate sizes down to the very smallest. They inhabit various kinds of bottoms, from above low-water mark to twelve or fifteen fathoms and deeper, but it is in shallow water that they do the most damage. They live on muddy, sandy, rocky, and shelly bottoms, and even on the piles of wharves, and are most abundant where they can find the

¹ VERRILL: Vineyard Sound Report, pp. 362, 363, 1871-'72.

greatest amount of food, and it is for the purpose of feeding that they visit the oyster-beds in such large droves. They are not always abundant in the same places, but seem to move about. Professor Verrill thinks "their habit of coming up to the shore may be connected with their reproductive season." They do not enjoy too brackish water, and oysters in such locations are safe from their attacks.

Asterius vulgaris ranges from Long Island Sound to Labrador, and *A. Forbesii* from Massachusetts Bay to the Gulf of Mexico. The former species is, therefore, essentially a northern one, and the latter a southern one, but over a certain region they overlap, and it is through this region and just to the south of it that most of the damage is done. *A. Forbesii* is the shore species where the greater part of the oyster-beds occur, and it must assume most of the blame for the thousands of oysters destroyed on these beds.

236. THE CŒLENTERATES.

THE CORALS.

Many of the common Florida Corals, from their graceful shapes and delicately sculptured surfaces, are highly prized for ornamental purposes, and have come to possess a certain commercial value. They are regularly kept for sale in most of the larger cities, such as Boston and New York, and unusually fine specimens frequently command a high price. The group of Corals, as popularly understood, includes members of two classes of the Cœlenterata, the Polyp Corals and the Hydroid Corals, both of which, and especially the former, present a great variety of forms. The principal ornamental Corals found on the coast of Florida are as follows: Among the Gorgonians occur the Sea-fans (*Gorgonia flabellum*), and the Sea-feathers or Sea-plumes (*Gorgonia acerosa* and *Gorgonia setosa*). Among the true stony corals are the Stag-horn Corals (*Madrepora cervicornis*, *prolifera*, and *palmata*); the Brain Corals (*Meandrina labyrinthiformis*, *clivosa*, and *sinuosa*, *Diploria cerebriformis*, and *Manicina areolata*); the Fungus Corals (*Agaricia agaricites* and *Mycedium fragile*); the Star Corals (*Orbicella annularis* and *carernosa*), and many others without common names, such as the *Oculina diffusa* and *Isophyllia dipsacea*. Only a single species of Hydroid Coral is commonly seen in show collections; it is the so-called Finger Coral or Sea Ginger (*Millepora alcicornis*), the latter common name having reference to the smarting sensation which it imparts to the skin, on handling, soon after it is taken from the water. Many foreign species of Corals, belonging to the above groups, are often to be seen in the natural history stores; they come mainly from the West Indies and the Pacific Ocean. Neither the precious Coral (*Corallium rubrum*) nor any other species approaching it in value to the trade occurs in American waters, but large quantities of the former are imported annually from Europe for making into jewelry.

THE JELLY-FISHES.

The Jelly-fishes, Sun-fishes, or Medusæ, which are well known to the sea-coast inhabitants as transparent and delicate floating animals, most abundant in the summer months, are, at times, a source of great annoyance to the net fishermen. These watery creatures, whose bodies contain only a very small percentage of solid matter, vary greatly in shape, and belong to several orders of the Cœlenterata. They have often been described and figured in popular books on natural history, to which the reader is referred for details concerning their structure and habits. The commoner species found on the New England coast are referred to as follows by Prof. A. E. Verrill.¹

"A fine, large specimen of the beautiful Jelly-fish *Tima formosa* has been sent me by Mr. V. N. Edwards, who captured it at Wood's Holl, April 30. He states that the same species was very

¹ Vineyard Sound Report, p. 449, 1871-'72.

abundant in February, 1872. It has not been previously recorded as found south of Cape Cod. Among the most common of the larger species in summer were *Mnemiopsis Leidyi*, which occurred in abundance at nearly all hours of the day and evening, and was very phosphorescent at night; *Cyanea arctica*, which occurred chiefly in the daytime, and was here seldom more than a foot in diameter; *Aurelia flavidula*, which was not unfrequently seen in the daytime; *Dactylometra quinquecirra*, which was quite common both by night and day in August and September; and *Zygodactyla groenlandica*, which was common in July, both in the day and evening, but was seldom seen later in the season. In the winter season the *Mnemiopsis Leidyi* is often abundant in Long Island Sound, and I have also observed it in New York Harbor in February, in large numbers. At Wood's Holl, Mr. V. N. Edwards found the *Pleurobrachia rhododactyla*, both young and nearly full-grown, very abundant in February and March. At Watch Hill, April 13, I found both adult specimens and young ones not more than one-eighth of an inch in diameter. It probably occurs through the entire year, for we frequently met with it in midsummer in Vineyard Sound. Mr. S. I. Smith also found it very abundant at Fire Island, on the south side of Long Island, in September. The *Idyia roscola*, so abundant on the coast of New England north of Cape Cod, was only occasionally met with, and in small numbers, while the *Bobina alata*, which is one of the most abundant species on the northern coast of New England, was not seen at all. The *Aurelia flavidula* is less common than north of Cape Cod, but was found in abundance in Buzzard's Bay, in May, by V. N. Edwards."

Many accounts have been given of the damage done to the nets of the fishermen by Jelly-fishes, when they have congregated together in large numbers. Mr. Fred Mather, writing from Saybrook, Connecticut, in 1881, says that "the Jelly-fish, called Sm fish here, are a source of great annoyance this year. They clog up the meshes of the nets, and the tide sweeps away either the net alone, or with its stakes."

The following extract from a letter by Mr. R. H. Stannard, of Westbrook, Connecticut, dated June 1, 1881, refers to the destruction occasioned in former years. "The Jelly-fish have been very destructive to pound fishing several times within the past thirty-five years, and there have been more or less of them every year in the Sound. In 1861, the best part of the season was destroyed, and, in 1868, one-half of the shad-fishing season was destroyed by the Jelly-fish taking away the nets and stakes. In 1878, Jelly-fishes were very plentiful; they stopped the shad fishing with pounds almost entirely, and to such an extent that the company did not pay expenses. This year, 1881, they have destroyed about one-third of the catch or season. If no Jelly-fish had appeared I believe the catch would have been one-third larger than it is."

ZB.—THE PORIFERS.

237. THE SPONGES.

GENERAL CONSIDERATIONS.—The natural group of Sponges with which the public have become familiar, through their constant use of the domestic varieties, remained until comparatively recent times in the much disputed ground between the animal and vegetable kingdoms. The careful investigations of several distinguished modern naturalists, however, finally established their animal nature beyond all question, and they were accordingly transferred to the kingdom in which they properly belong. But some years were yet to pass before their true affinities with other animals could be definitely determined, and they were grouped provisionally with the so-called *Protozoa*, a somewhat heterogeneous assemblage of such low forms as did not agree structurally with any of the four great branches or subkingdoms, then recognized as composing the animal kingdom. Still later researches have clearly proved that the Sponges have a much higher organization than the *Protozoa* proper, and propagate by means of eggs, while the members of the latter group do not. Compared as a whole with all the groups above the *Protozoa*, the Sponges appear to be the lowest in structure, and, moreover, they stand apart by themselves as a distinct group, which, in the more recent division of the animal kingdom by most authorities into some seven subkingdoms or branches, in place of the original four, assumes the rank of a subkingdom called *Porifera*, and comes into the plan of classification between the *Protozoa* and the *Celesterrata*.

The term Sponge conveys to the minds of most people simply the idea of an irregular, soft, flexible mass of open structure, whose exterior is generally much roughened by projecting points, and pierced by numerous holes, leading toward the interior, and whose structure, more closely examined, is seen to consist of a fine net-work of small, horny fibers. This typical Sponge, as we may term it, from its being the form most commonly known and observed, is the ordinary Sponge of commerce, which, though limited in its range to but a few tropical and subtropical regions, is collected in great quantities and sent to all parts of the world. The commercial Sponges, which are the only ones of economical importance to mankind, all belong to a single natural genus, *Spongia*, and form, so far as the number of species are concerned, but a small portion of the entire branch *Porifera*.

As stated above, the general conception of a Sponge is a fibrous skeleton, and nearly all Sponges possess a skeleton or the rudiments of one, but this varies greatly in character in the different divisions of the branch. In the commercial Sponges and their allies, the skeleton is horny and more or less flexible, consisting of fine fibers interwoven and joined together. In another group, the skeleton is composed of horny fibers intermingled with which are many siliceous spicules, causing it to have a much stiffer and harsher structure. In a third group, the so-called siliceous Sponges, the skeleton is entirely made up of siliceous spicules, which may be scattered singly through the soft substance of the Sponge, or joined together in bundles. These spicules vary in shape, some being simple and straight, and others pyramidal, star-shape, or granular. A fourth group, the calcareous Sponges, has a skeleton of calcareous materials, disposed in lines or columns at right angles to the walls. The recent members of this group have the

skeleton made up of calcareous spicules, while the fossil forms referred to the same have calcareous columnar supports, instead of spicular.

The soft and fleshy part of the Sponge, which is the truly organized portion, and upon a knowledge of which we must rely for a perfect understanding of the relations of Sponges, is the most difficult to study, as it is also the least known. It collapses and begins to decay almost on the moment of the Sponge being taken from the water, and alcoholic preparations are of comparatively little value for investigation. The structure of some forms has, however, been sufficiently well made out to give us a tolerably clear idea of what it must be in the entire group. Prof. A. Hyatt describes the general structure of the Sponge as follows:¹

“They are structurally remarkably uniform, though differing greatly in external aspect. They consist internally of a mass or layer of sarcode or mesoderm, containing a greater or less number of true cells, and have an ectoderm and endoderm of cellular tissue. The majority of the forms are supported by a skeleton of interwoven threads or spicules, or both, of various forms. The exterior is perforated by innumerable pores, leading into channels in the interior, which enlarge and join with groups of neighboring channels, forming large branches. These, in turn, form junctions with other branches, and finally all of them unite into one or several large trunks, which open outwards, like minute craters, on the external surface. These are lined with another membrane, differing from anything else of its kind in the animal kingdom. It is composed of minute cells, furnished on the free side with a long whip or flagellum, surrounded by a collar. Their interiors contain a nucleus and digestive vacuoles, and they, in all respects, resemble the independent animals known as flagellate infusoria. They take in and digest food in the same manner, and eject excrements in great profusion from the area inclosed by the membranous collar.

“The eggs and spermatozoa are derived from modified cells of the mesoderm, whereas the skeleton is either built up partly from the external membrane, and partly from the sarcode by exogenous growth, or by the transformation of the loose cells of the sarcode into spicule. The function of the smaller external pores is to admit the water, which is thus strained and deprived of its coarser floating material. It is then carried along the canals, by the motion of the cilia, and conveys its load of minute food to the ampullaceous sacs and zoöidal cells. The hydraulic pressure occasioned by the inward flow of the innumerable minute streams forces it through the larger trunks and out at the craters or ostioles with great rapidity.”

Their peculiar cellular structure caused the Sponges when they were first carefully studied to be looked upon as compound animals, but this idea has been refuted by more recent studies, and each individual Sponge is now considered, “in its simplest adult form, as homologically a single animal with the internal structure and functions of a colonial organization.”

The branch or subkingdom *Porifera* is divided into two classes, the *Calci Spongiæ* (calcareous Sponges) and the *Carneo-Spongiæ* (horny and siliceous Sponges).

The *Calci-Spongiæ* are again divided into two orders, and the *Carneo-Spongiæ* into four orders, the *Halisarcoidea*, *Keratoidea*, *Kerato-Silicioidea*, and *Silicioidea*.

The *Keratoidea* includes all the purely horny Sponges, and the only genus, *Spongia*, of direct importance to mankind. According to Professor Hyatt, the horny Sponges “appear to require for the production of the forms in abundance tropical or subtropical seas, and obtain by far their greatest development in the number of the forms and species in the West Indian seas. The typical forms, the commercial Sponges, are essentially confined to the waters of the Caribbean Islands, Bahama Archipelago, and the southern and western coasts of Florida, in this hemisphere, and to the Mediterranean and Red Seas in the other.

¹ Memoirs Boston Soc. Nat. Hist., ii, 1875-'77.

“Australia affords a few forms, and I have heard, though I cannot substantiate the fact, of some species on the Atlantic coast of Brazil. Bermuda also has a few of the commercial kinds, which, according to Mr. Goode's report, and the suite of specimens forwarded, are much coarser than the Key West, darker in color, and, in fact, just about intermediate between these and those of Australia. They are occasionally found in the stores, but, as a rule, are used only by the fishermen themselves, about their boats, the Bahama Sponges being preferred for domestic purposes by the inhabitants.

“The true *Spongia* are all shallow-water forms. In the Mediterranean, according to Eckhel, they are not found below thirty fathoms, and in our own seas about the same, probably, though not fished to greater than five fathoms. The greater part of the fishery is accomplished between the depths of three and twenty feet, according to the report of Dr. Palmer, from whom these remarks are principally derived. The commercial grades coincide very closely here and in Europe, but it is quite easy to show that each of them may be considered a distinct species, if one has an inclination to multiply in this direction. The three grades [of American Sponges], Glove Sponge (*Spongia officinalis*), subspecies *tubulifera*, Wool Sponge (*Spongia equina*), subspecies *gossypina*, and Yellow and Hard Head, both under the name of (*Spongia agaricina*), subspecies *corlosia*, correspond with remarkable accuracy to the three principal grades of commercial Sponges in Europe. These are the Bath Sponge, *Spongia officinalis*, the Horse Sponge, *Spongia equina*, and the Zimocca Sponge, *Spongia agaricina*. This result, in which three species appear on both sides of the Atlantic, as representing alone the marketable qualities of the genus *Spongia*, becomes of double interest when these varieties, or local species, as they might be called, are compared with one another. It is then found that the aspect of the surface is closely similar in each of the three; that subspecies *tubulifera* represents *Spongia officinalis*, subspecies *gossypina* offsets *Spongia equina* in the same way, and, lastly, subspecies *corlosia* has the same relation to *Spongia agaricina*.

“The whole group of *Keratosa* is confined to seas in which the differences observable between the winter and summer isotherms are not excessive. None are found north of Cape Hatteras and the island of Bermuda, and doubtless a similar limit occurs to the southward of the equator.

“The finer skeletons of the *Keratosa*, those of the genus *Spongia*, are only to be sought in the intermediate zone, where the waters are of equable and high temperature. Again, in examining the species of this genus with relation to each other, it becomes equally evident that they are finest and most numerous in archipelagoes or off coasts which are bordered by large numbers of islands or long reefs, or in sheltered seas.

“The Sponges near Nassau lie on reefs very much exposed to the action of the waves, often thirty miles from land, and always in currents, sometimes running three or four miles an hour. Such currents are usual wherever groups of islands confine the tide water within certain definite channels, and they have also the effect of concentrating the floating food in the channels, or wherever tides meet. Both of these conditions are essential to successful sponge growth, namely, a continuous renewal of aerated water and a plentiful supply of food, and are probably partially the cause of their abundance in such places.

“The shallow-water Sponges are coarser than the deep-water forms. This is probably due, in part, as in other species, to the quantity of sediment, which is, of course, less in deep than in shallow water, as, for example, at Key West in the winter time. I am informed that no fine qualities of any Sponges are found within the limits of the milky water, but all the finer qualities of the marketable kinds in the deepest water in which the species occur, except perhaps in the

case of the Reef Sponge. Glove, Reef, and Hard Head are fished in shallow waters, greatest depth two fathoms, and the other, and generally finer marketable varieties, in from two to five fathoms. This fact also explains in a measure, but not wholly, the greater coarseness of our own Sponges as compared with the European. For though it may be assumed, from the examination of the skeletons, that Mediterranean Sponges are much less exposed to turbid waters, and though it may be shown by the microscope that the primary fibers contain less *débris*, this does not wholly explain their greater fineness and elasticity. I think that we may attribute this either wholly or partly to peculiar climatic conditions.

"The coral reefs afford good holding ground for the bases of the colonies, and protection from the excessive surf of ocean shores, while they grow in water the remarkable clearness of which to a considerable depth is constant subject of remark. These are undoubtedly favorable conditions, as they are common also to the Mediterranean waters. The great quantity of calcareous sediment, however, which is churned by the waves in the winter, on the borders of a coral reef, is not present in the Mediterranean; and the average temperature also, which is very much higher than that under which the finest Sponge skeletons are produced in the Mediterranean, cannot be considered as favorable. These last, then, are probably the direct cause of the inferiority of the skeleton of the commercial varieties found in this association [*i. e.*, many of the American varieties].

"The coarsest quality of all the Mediterranean Sponges, the Gherbis sort and other coarse sorts, grow in localities along the coast, where they are most subject to the action of suspended matter in the water; but all of these are, however, on account of the clearness and medium temperature of the Mediterranean waters, as compared with those of other seas, of much finer quality.

"The coarser kinds of the same variety grow nearest the shore, and the finer kinds in deeper water, and also, according to Nassau spongers, are more apt to occur on marly ground, where the sediment is finer than upon other kinds of bottom. The openness which usually accompanies and appears to correlate with coarseness of the fiber must be considered as one of the elements of inferiority, which invariably accompanies a skeleton having a loose microscopical texture or mesh, and harsh or inelastic or easily torn fibers, but is also, though rarely, found in skeletons of very fine quality, especially at an early age. Thus it may be said that it is undoubtedly a common characteristic of all the inferior qualities of Mediterranean, and of all the Caribbean commercial Sponges without exception, which, though they may have very fine or very coarse or inelastic fibers, are always permeated in the interior and have the surface also cut up by larger and more numerous canals than the corresponding Mediterranean species."

238. THE GENUS SPONGIA AND THE AMERICAN COMMERCIAL SPONGES.

The skeleton of this genus, according to Professor Hyatt, is composed of solid, elastic fibers, the primary ones, those having their origin in the external integuments, being usually, though not invariably, more or less radiatory in their arrangements; but the secondary or connecting fibers are excessively irregular, and generally very closely intertwined. The primary fibers are particularly noticeable on the inner side of the walls of the large or excurrent openings. The skeleton exhibits a very rough surface, due to the development of large projecting masses of the secondary or connecting fibers, which are separated by horizontal channels of greater or less depth. The primary fibers protrude above the surface of the cushions or ridges thus formed, carrying with them more or less of the secondary fiber, and forming a series of superficial tufts, giving the skeleton a peculiarly hirsute aspect. The pores through which the water enters the

Sponges are very numerous, quite permanent in their positions, and irregularly scattered over the sides of the mass, often remaining open even in dried specimens. The cloacal canals are few in number, but exceedingly large, and their apertures are irregularly scattered about, but are almost always on the upper side of the colony. When living, the outer skin is of a dark brown, very dark purple, or a black color. The external layer is usually more or less filled with whatever sediment may be prevalent in the water, and, especially in the West Indies, with the siliceous spicules of other Sponges.

Only four species or six so-called subspecies of commercial Sponges, are recognized from the Florida waters, and these give rise to the five grades, known to the trade, in the order of their importance, beginning with the finest, as Sheepswool, Velvet, Grass, and Glove Sponges. These same grades and subspecies, with one exception, also occur among the Bahama Islands, the sponge fauna of Florida and the Bahamas being more or less identical, but the corresponding grades of these two regions are generally finest in the Florida waters, the Florida commercial Sponges ranking much higher than the Bahama, and commanding higher prices. Commercially, Bahama has two or three times as many grades of Sponges as Florida but these commercial grades are not of specific or even subspecific importance. They result from a division according to quality for the convenience of the trade. Notwithstanding the many Bahama grades, the best of the Bahama Sheepswool Sponges are inferior to the best Florida Sheepswool.

The following descriptions of the several Florida and Bahama commercial Sponges are taken from Professor Hyatt's memoir, "Revision of the North American Porifera," with notes on the corresponding Mediterranean species:

THE GLOVE SPONGE—SPONGIA OFFICINALIS, Linn., subspecies TUBULIFERA.

"This subspecies, as compared with other American subspecies, has a skeleton composed of remarkably fine fibers, which bleach out to a whitish brown color. The surface is covered with fine tufts of primary fibers, which are, however, very pliable. The surface is generally quite free from cushions and ridges, and the channels between these when they do occur are neither very deep nor long. The result of these characteristics is a form with a smoother surface and a denser looking skeleton than usual, pierced on the sides by numerous small apertures, very regularly distributed, and at the top by one or more large cloacal oscules. The form is generally dome-like, and is never, so far as I know, cup-shaped, though it may become exceedingly irregular, fistular, or even dendritic. The older specimens show a decided tendency to increase by the prolongation of the parts immediately around the apertures. Thus the main body of the Sponge becomes projected into numerous smaller conical or head-shaped masses like the young of variety *rotunda*, and crested masses like those of variety *disciformis*. At an advanced age the fiber becomes very brittle and unfit for domestic purposes."

This subspecies generally occurs abundantly upon hard bottom. While living its color is black; the largest specimen seen by Dr. Edward Palmer, who collected many specimens for Professor Hyatt, measured about eight inches in height by about twenty inches in circumference. It lives on the coast of Southern Florida (Key West), and among the Bahama Islands (Nassau), upon hard bottoms or reefs, in about six feet of water. Ten varieties are enumerated, all of which inhabit American tropical seas. They are as follows: *pertusa*, *mollis*, *prava*, *disciformis*, *rotunda*, *aperta*, *corulosiformis*, *duplex*, *exotica*, and *solida*.

The Glove Sponge ranks as the poorest of all the Florida commercial grades, and yet belonging to the same species, under the name subspecies *mediterranea*, are the Levant Toilet Sponges, the finest of all Sponges, and the fine-textured Turkey Cup Sponges. The different grades of the

subspecies *mediterranea*, some of which are of an inferior quality, occur on the eastern shore of the Adriatic, on the coast of Greece to Asia Minor, and thence to Tripoli and Tunis.

THE GRASS SPONGE—SPONGIA GRAMINEA, Hyatt.

“This is one of the Grass Sponges of commerce, and is perhaps one of the least variable of all the species. . . . The general structure is coarser than in *tubulifera*, and the interior is exceedingly open, owing to the large size and central situation of the efferent canals. The form is that of a truncated cone, fluted by deep furrows on the sides, and either infundibuliform or flat on the truncated surface. The large excurrent orifices are all upon this surface, or in the depression which takes its place. The smaller apertures are situated on the sides, invariably in the depressions between the ridges. The persistency of the former and of the latter ridges, and the situation of the different kinds of orifices, are by far the most characteristic features of this species. Notwithstanding these facts, and though I am obliged to describe this and some other forms as distinct species, I have great doubts of the truth of the assumption. It rests upon the evidence of many specimens, but they are all from one locality.”

This species occurs at Key West, Florida, where it grows abundantly on the coral reefs, either on smooth bottoms or attached to corals or other Sponges, in three feet of water and deeper. When living its color is black.

THE SHEEPSWOL SPONGE—SPONGIA EQUINA, Schm., subspecies GOSSYPINA.

“The typical variety of this species, usually called the Sheepswol Sponge, varies greatly in form. All of these forms, however, are characterized by a peculiar surface. The skeleton rises into large tufts over the entire surface, the larger oscula occupying the depressions between. Sometimes these are very numerous, the whole interior being very cavernous, and sometimes the structure is much denser, with fewer large openings and many small ones scattered between the tufts. Occasionally the depressions are filled up on parts of the Sponge, and a surface is presented having no large tufts, but only the small secondary bundles of fibers, which are especially characteristic of this variety. The result of this structure is to leave great hollows or rather a net-work of deep tunnels under the derm, which are apparent only after the drying of the specimens, when they become exposed by the universal contraction and cracking of the skin. The color when living is said by Dr. Palmer to be a shining black.”

The habitat of this species is Southern Florida and the Bahama Islands, where it grows in from three to sixteen feet of water and deeper. The largest specimen examined measured about nine inches high by thirty inches broad. The following five varieties are recognized by Professor Hyatt: *dendritica*, *porosa*, *alba*, *soltaria*, and *hirsuta*.

This is by far the finest of the American commercial Sponges, ranking much higher than any of the other grades. It is also the one most eagerly sought for, the supply being quite unequal to the demand. It takes the place of the finer Mediterranean grades for most purposes, and, though not so fine in texture, is more durable than the Turkish Sponges. In the same species are placed some of the best-known of the eastern grades, the so-called Horse Sponge, Venetian Bath Sponge, and Gherbis Sponge, which occur in numerous places in the Mediterranean Sea.

THE VELVET SPONGE—SPONGIA EQUINA, Schm., subspecies MEANDRINIFORMIS.

“This, the well-known Velvet Sponge of commerce, . . . differs from the preceding in its extreme forms by the absence of the pointed bundles or tufts, and the fibers are also perhaps slightly finer. The absence of the pointed tufts gives a smoother surface, since, as in the preceding variety, these are mainly composed of coarse primary fibers loaded with foreign matter, whereas

the connecting or secondary fibers are composed of pure keratose. The surface is also remarkable for the protruding, flattened cushions of fiber, which slightly resemble the convoluted ridges of a *meandrina*. Sometimes these cushions are transformed into long, solid brushes or pencils of fibers."

The localities from which this subspecies has been recorded are as follows: Biscayne Bay and Key West, Florida; Nassau, Bahamas; Havana, Cuba; Mauritius Islands; and the island of Fernando de Noronha, off the coast of Brazil. But one variety of this subspecies has been recognized; it is also in its typical form known commercially as the Velvet Sponge. Professor Hyatt writes of it as follows: "The forms of the specimens in our collection are more spreading than is usual in that variety (*meandriniformis*), and the texture is quite as soft, though denser, perhaps, when the skeleton is dry. The projecting cushions of fiber are similar in form to those of variety *meandriniformis*, but are joined together in larger masses by a tissue of fine superficial threads; also are often less dense and simply bridge the intermediate channels. This and the tortuous and rather shallow character of the channels give the surface a smoother aspect than is common in the skeleton of *meandriniformis*. The oscules are very large and have a peculiar ragged aspect in dried specimens. They look as if some one had made them by repeatedly running a knife into the animal while it was drying, and then omitted to clean out the interior thoroughly, leaving sharp pinnacles of dried sponge cuttings projecting inward, sometimes so as to fill the center, but oftener sticking around the center of the aperture, and more or less completely joined to the wall of the canal. This characteristic ragged look is sometimes also to be seen in the oscules of subspecies *gossypina*, but never so decidedly." This variety is found at Key West, Florida, and Nassau, Bahamas.

This is a fair grade of Sponge, rather rare, and not much in demand; in fact, the dealers often omit it in their enumeration of the American commercial Sponges. It is considered of little value by the trade.

THE GRASS SPONGE—SPONGIA EQUINA, Schm., subspecies CEREBRIFORMIS.

"The aspect of this species, commonly known as one of the 'Grass Sponges,' is very similar to that of *Spongia agaricina*, subspecies *corlosia*, variety *typica*. The difference consists principally in the aspect of the surface. This is broken up by parallel longitudinal ridges of irregular length on the sides, each ornamented with one or two lines of tufts. These ridges extend onto the upper surface, giving them a markedly radiatory arrangement. The larger orifices are situated in rows in the channels between the ridges." Six varieties are enumerated, as follows: *typica*, described above; *plana*, inhabiting Florida and Kingsmill's Islands; *divisa*, found upon hard, irregular bottom or corals, in about two feet of water at low tide, at Key West and Biscayne Bay, Florida, and at Stone's Inlet, South Carolina; *mexicana*, from Vera Cruz, Mexico; *caliciformis*, from Nassau, Bahamas; and *obscura*, from Nassau and the Bermudas. These several varieties differ more or less markedly from the typical specimens, some of them approaching other species in shape and general appearance. This grade is inferior in quality.

THE YELLOW SPONGE—SPONGIA AGARICINA, Pall., subspecies CORLOSIA AND DURA.

"The subspecies *corlosia* resembles very closely in external appearance the *Spongia dura*, or 'Hard Head,' but an examination of a full series of forms showed that very considerable differences exist in the texture, though superficially there is little or no distinction in the aspect of the surface. Dealers can identify these varieties instantly by the color, which is usually lighter than that of the 'Hard Head,' and by the touch, the 'Yellow Sponge' yielding much more readily and feeling less harsh under the fingers. These characters, however, only apply to the normal head-like forms and some of the varieties; many forms cannot be placed in either one or the other of

the two groups with any certainty." This subspecies occurs at the Bahama Islands and Florida. Three varieties are classed with it by Professor Hyatt, *gossypiniiformis*, from Nassau; *fusca* and *elongata*, from Biscayne Bay and Key West, Florida; the range in depth is from two feet of water at low tide to thirty feet or more.

This constitutes the second grade of American Sponges, and is very abundant. Although selling at a much lower price than the Sheepswool it forms an important article of commerce. The Mediterranean grade corresponding with it is the so-called Zimocca Sponge.

236. INJURIOUS SPONGES.

THE BORING SPONGE—*CLIONA SULPHUREA*, Verrill.

This is a common species of siliceous Sponge, which ranges along our Atlantic coast, from Cape Cod to South Carolina, in from one to fifteen fathoms of water. It begins to grow on mussel, clam, or oyster shells, mostly on dead, but also on living specimens, into which, when still very young, it excavates numerous burrows. "As it grows, it penetrates the shell in every direction, forming irregular holes and galleries, which continue to grow as more and more of the substance of the shell is absorbed, until the shells are reduced to a completely honeycombed, brittle mass, or a mere skeleton. Finally the Sponge begins to protrude from the surface, and grows up into mammiliform masses, or small rounded crusts, which continue to grow and spread in every direction, until finally they form masses six or eight inches in diameter. . . . Owing to the remarkable boring habits of this and other allied Sponges, they are very important in the economy of the sea, for they are the principal agents in the disintegration and decay of the shells that accumulate over the bottoms, thus performing the same function in the sea that fungi and insects perform on the land."¹

There is no question but that the offices of this Sponge are mainly for good, as stated above; but they often attack living shells, burrowing into them as far as the inner layer, and greatly irritating the animal, which will sometimes deposit one or more new coatings of shell structure, so as to cover up the little pores about to open into the inside. They probably also often cause the destruction of oysters. These burrows sometimes appear on the inside as little prominences, scattered over the surface. Masses of this Sponge, when full grown, measure a foot or more in length, and contain stones as large as one's fist, as well as a large quantity of sand. "This species is of a bright sulphur yellow color, and grows into hemispherical or irregular massive forms of firm texture, the surface being covered with scattered, low, wart-like, soft prominences, about an eighth of an inch in diameter, which contract when the Sponge is dried, leaving shallow pits."

Cliona sulphurea has the power of burrowing into submerged limestone as well as shells. A case of this sort was brought to notice in 1878, when a wrecked cargo of marble was discovered off Long Island, having lain there for several years. The pieces of marble taken up were completely riddled by this Sponge to a slight depth.

¹ Vineyard Sound Report, p. 421, 1871-'72.