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8.—NOTES ON LOBSTER CULTURE.

By RICHARD RATHBUN.

EXPERIMENTS BY THE U. S. FISH COMMISSION IN 1885.

The partial completion, in August last, of the new laboratory building at the marine station of the Fish Commission, at Wood's Holl, Mass., with its convenient system of salt-water piping, permitted the necessary experiments being begun at that time with respect to the artificial hatching of lobsters—a branch of fish culture the great importance of which has long been felt in view of the rapid decrease in abundance of that valuable food product. Unfortunately the hatching season had then closed, but it was deemed advisable to ascertain the best methods of handling the eggs, in order that there might be as little delay as possible in starting operations next spring.

Unlike most fishes, the lobster carries its eggs until they hatch. The eggs are fertilized while yet in the ovaries, and are soon afterward extruded, but the length of the period of development is not known. As they issue from the body of the female, they are coated with a viscid substance that soon hardens into short, tough, and very flexible threads, by means of which they are attached in bunches or clusters, of variable sizes, to the swimmerets and under surface of the abdomen or tail, the hinder feet, it is said, being used to aid in carrying them back and distributing them as they come from the apertures of the oviducts. The eggs are comparatively large (about one-twelfth of an inch in diameter) and hardy, and each lobster carries from about 12,000 to 24,000, according to its size.

The problem of lobster hatching on a practical scale is one that the Fish Commission has long had in view, but all of its marine laboratories up to the present time have been temporary structures, with insufficient accommodations and without the means of obtaining continuous supplies of water in suitable quantities. It was hoped that the new building would be finished early enough in the spring to permit of the beginning of hatching work in June; but the hinderances which are inevitable to all such projects interfered to delay actual operations for another year. The hatching of small quantities of lobster eggs, as well as the eggs of other species of crustaceans, had been successfully accomplished, from time to time, by members of the Fish Commission party interested in embryological studies, and the possibility of conducting hatching operations on a small scale, and of carrying the young through at least the first few stages of growth, needed no further proof; but the

question of how to care for large masses of eggs, and especially for the young after hatching, was yet to be approached.

In the fall of 1884, soon after the inner fish basin at Wood's Holl had been completed, Capt. H. C. Chester, in charge of the station, transferred to it several hundred female lobsters with spawn, thinking that some of the eggs might hatch during the winter, but, if not, feeling certain that something might be done with them in the early spring. Unfortunately for his experiment, the work on the outer basins necessitating the employment of a large steam dredger, which kept the water constantly loaded with sediment, and the frequent blasting of rocks, caused the destruction of his entire stock before any results had been reached. The method of continuing the work in the summer had not yet been decided upon, when an opportune letter, received from the Norwegian fish-culturist, G. M. Dannevig, announced the successful hatching of lobster eggs of the European species, detached from the body of the parent, and the rearing of the young through the three earliest stages. The manner of conducting his experiments was not described, but the fact that he had accomplished good results with detached eggs gave us a basis to work upon. His letter was as follows:

FLODEVIG, near ARENDAL, NORWAY, *July* 14, 1885.

DEAR SIR: I hereby take great pleasure in informing you that the experiments with the hatching of detached lobster eggs is progressing very favorably, that the young are doing well, and that some of them have attained what Prof. G. O. Sars calls the third stage.

The length of the young lobster soon after hatching is about 9^{mm}. After 8 days, when the second changing of the shell or skin takes place, it has attained the length of 12^{mm}, and after 16 days, when the third change occurs, it is about 15^{mm}. The mortality was rather large for some days, but is now only 1 to 3 in 24 hours, so that 95 still remain out of 200 which were picked out for an experiment. They are very greedy, but not so bad in killing one another as they were in the beginning. I feed them principally with the soft parts of our crab. They like it well, but their slender legs sometimes get entangled in the soft mass, and then they die. Five hundred newly-hatched individuals are now in a separate apparatus for further experiments. I wish to find out at what stage the greatest loss takes place. I have great hopes now that I shall master this question during the season, so that I can proceed upon a large scale next summer.

Very respectfully,

G. M. DANNEVIG.*

Prof. SPENCER F. BAIRD,
Commissioner of Fish and Fisheries, Washington, D. C.

* For a later account of this experiment, see letter of G. M. Dannevig, in Bull. U. S. Fish Commission, v, p. 446, 1885.

If a few eggs are cut from the swimmerets of a lobster and dropped into a jar of water, they will rapidly sink to the bottom, showing that their specific gravity is considerably greater than that of water. The knowledge of this fact led to the selection of the McDonald automatic hatching-jar, which has long been in use in shad propagation, for the first experiments, and a trial of about two months has demonstrated its superiority for this purpose over the other appliances that were tested. The principle on which the McDonald jar works has already been fully described,* and we need only mention here, for the purpose of showing its adaptability to the eggs in question, that the water entering through a long glass tube, reaching nearly to the bottom of the jar, causes an upward current of water through the jar, the force of which is regulated by the amount of inflow; the outlet is by means of a short tube passing only a little way into the upper part of the jar. The inlet tube is connected by rubber tubing with a supply pipe, and the outlet tube in the same manner with a waste pipe, and these connections being made, the movement of the eggs is entirely controlled by means of a stop-cock and the longer tube, the latter, by being raised or lowered, changing to a certain extent the force and character of the current. The flow is continuous and regular, and the jars need to be examined only occasionally, perhaps twice each day, for the purpose of forcing out the accumulation of sediment, as explained further on.

The eggs are readily cut from the swimmerets and under surface of the lobster by means of small sharp scissors, the curved kind used in dissecting being especially well adapted to this purpose, although most any kind will answer. By taking ordinary precautions no harm is done to the parent, the small threads joining the eggs to the body having no organic connection with it. Most of the eggs come off in bunches of variable sizes, some containing two or three hundred, and others less, down to a very small number, but more or less of them become separated in the cutting, and in every batch there are many free eggs. This lack of uniformity in the composition of each lot of eggs is a source of great annoyance in handling them, the free eggs floating up more readily than the bunches and tending to escape through the outlet pipe, but it is not detrimental to the success of the work. In preparing the eggs, they were transferred as rapidly as detached to the hatching-jars, previously filled with water, the eggs of each lobster being placed in a separate jar, as there is more or less variation in the specific gravity of the eggs of different individuals.

As soon as each jar had received its allotment, the cap with its tubes was fastened on, and a connection made with the salt water supply pipe. The specific gravity of the eggs was not determined, but they require a relatively strong current of water to raise them above the bottom, the average amount allowed to pass through the jars having been nearly a gallon a minute for each. The flow was so regulated as to give the

*Bull. U. S. Fish Commission, iii, pp. 183–192, 1883.

larger bunches of eggs a gentle rotary motion; but this caused the smaller bunches and the free eggs to rise sometimes to more than half the height of the jar and kept them quite strongly agitated. Although the eggs are very hardy, and in nature, while attached to the swimmerets of the parent lobster, are given but little motion, this greater activity appears to be essential to their well-being in the artificial hatching apparatus, for without it they soon die. Such a fate befell most of one lot contained in a McDonald jar, through which but a gentle current was allowed to pass, and in one of the hatching-boxes, where the supply of water was very much greater, though distributed over a much larger surface, so that no motion was given to the eggs, they all died inside of a week. The accumulation about the eggs of impurities from the water may have been the principal cause of this mortality; but as the eggs are well able to endure active motion and thrive best in a strong current, there can be no objection to pursuing that method. An illustration of the hardy character of the eggs is furnished by the fact that a small quantity left over night in a watch glass of sea water were alive and apparently in good condition in the morning, although the density of the water had been greatly increased by evaporation.

The chief annoyances to hatching work at the Wood's Holl station this summer were, first, iron rust, and, second, sediment from the harbor. The supply mains in use when the laboratory was first opened consisted of iron pipes without a protective lining; they had been down a year, and gave off such a large quantity of rust, which often appeared as a dense reddish cloud of exceedingly fine suspended particles, that the hatching-jars would become strongly stained inside of a few hours and the eggs themselves become perceptibly coated. After the cement-lined pipes had been substituted, this trouble ceased for the most part, but a great deal of sediment was observed in the sea water the remainder of the season, and notwithstanding the strong current passing constantly through the jars, a very perceptible deposit was formed over the lower-lying eggs in the course of every twelve hours. The lighter particles of sediment also collected to a large extent on the sides of the jars and tubing, and often adhered to the more buoyant eggs. Cloth filters were used to strain out these impurities, but they proved unsatisfactory, and the course finally pursued was to force out the sediment every morning and evening by momentarily increasing the flow of water to its utmost capacity, and then shutting it off, repeating this operation at frequent intervals for several minutes. The effect was thoroughly to stir up the sediment, which, being lighter than the eggs, remained longer in suspension and was carried off when the flow was again made normal. The eggs were transferred to clean jars every four or five days, and the old jars thoroughly washed.

By constant attention to all these details, the eggs were kept in a healthy and tolerably clean condition as long as the experiments were kept up. A neglect of these precautions always resulted in the de-

struction of many eggs, although in the first lot of eggs prepared, which suffered greatly from iron rust, and was frequently left without care, sometimes for days at a time, until they were well covered with sediment, fully one-third were living at the end of eight weeks, when I left the Wood's Holl station.

It does not seem practicable to keep the eggs of more than one lobster in each jar, as the eggs of different individuals differ more or less in specific gravity, and it is impossible to regulate the flow of water so as to give them all the required motion; but as the number is considerable in each, there is not sufficient excuse for attempting economy in that direction. The number of fertilized eggs carried by lobsters during the spawning season has been ascertained by careful computations in several cases, and varies from about 12,000 to 24,000, the latter number probably being rare. The most common number noticed during late years has been from 15,000 to 18,000.

The question of the amount of motion to which the eggs should be subjected is one deserving much consideration. The females with eggs contained in the aquaria at Wood's Holl remained very quiet most of the time, and the swimmerets and eggs were scarcely ever observed to be in motion. Confined within the narrow limits of an aquarium, with a strong light entering from all sides, it was not to be expected that their movements would be altogether natural. In nature, whether or not their swimmerets are kept moving regularly backwards and forwards, which is probably the case to a greater or less extent, the act of moving about in search of food or for change of ground must bring a constant change of water. With the Clark hatching-boxes, which are very successful for certain kinds of fish eggs, no good results were obtained, although the flow of water was much greater than in the McDonald jars. These boxes were tried in two ways, with a downward and an upward flow of water, but the eggs remained perfectly motionless, and at the end of a week were in such bad condition that they had to be thrown away.

The experiments above described merely indicate a method by which lobster eggs detached from the parent may be successfully kept alive for a considerable length of time with sufficient economy to commend the process to future practice. Had the experiments been made during the hatching season, more satisfactory results would undoubtedly have been reached. It is not expected that in actual practice the eggs will have to be kept very long in the jars. The extensive storage basins in front of the laboratory will afford accommodations for large quantities of "berried" females, which can be so arranged as to permit of their being readily examined from time to time and the condition of the eggs observed. As the eggs approach the last stages of development before hatching—a condition that is easily determined almost by the unaided eye—they can be transferred to the hatching-jars, and the final changes allowed to take place under constant observation. As the hatching is

limited to a period of about two months, it is probable that the eggs of many individuals reach maturity at about the same time, and a large number of jars can be manipulated together.

The principal object in hatching the eggs in jars is to have the embryos under control immediately after hatching; but the best methods of caring for the young have yet to be decided upon, and furnish an interesting problem for investigation next spring. It is probable that the embryos cannot be kept in the McDonald jar, as they swim at the surface and would soon all escape through the outlet tube. They can, however, be transferred to large aquaria, to the large wooden tanks now rigged on the lower floor for the keeping of fish, or to floating cars in one of the basins. The last plan will probably answer best when working on a large scale, as the embryos will thereby obtain some food from the surrounding waters, while in both of the former cases food would have to be supplied them.

A floating car suitable for the purpose has already been constructed, and now contains a number of berried lobsters, which it is proposed to keep over winter, if possible, in order to observe whether any hatching takes place during that season. This car is constructed on the plan of the ordinary fish cars, the openings being covered with a fine-mesh brass-wire cloth to prevent the escape of the young, but with the meshes large enough to permit of the entrance of such small life as the embryos would be likely to feed upon at the surface. The dimensions of this car are 5 feet long, 3 feet wide, and 2 feet deep, but larger cars will be used if necessary. It is now moored in the outer basin, opposite one of the openings in the wall, where it receives the full force of the current. A few McDonald jars will also be kept in operation, with lobster eggs, during the entire winter, for purposes of observation.

It is not known how long the young can be kept in confinement, nor at what age it would be advisable to turn them over to the care of nature, but it will probably be possible to transport them alive to any other portion of the eastern coast, as the distances are nowhere great.

NOTE.—Since the above was written, a letter has been received from Capt. H. C. Chester, superintendent of the Wood's Holl station, giving an account of the hatching of a few lobster eggs in one of the McDonald jars early in November. The eggs were detached from the lobster and placed in the jar November 5; they began to hatch November 8, three days afterwards, and continued hatching for a few days longer, but only about 50 young ones were observed. The remainder of the eggs are still in the jar, in good condition. A few of the embryos were transferred to an aquarium with running water, and others to a small vessel in which there was no change of water. The former lived about 20 hours, the latter about 36 hours. The temperature of the water in the hatching-jar November 5 was 54.3° Fahrenheit; on the 6th, 55°; and on the 7th and 8th, 56°.

NECESSITY OF ATTEMPTING THE ARTIFICIAL PROPAGATION OF LOBSTERS.

In a report to the U. S. Commissioner of Fish and Fisheries, on the lobster fishery of the United States, now in course of publication, the writer has given an account of what is known regarding the habits and abundance of both the American and European species, which differ but slightly from each other structurally. The investigations on which that report is based confirmed the fact, previously well known to those acquainted with the industry, that the abundance of lobsters, as well as their average size, has been rapidly decreasing from year to year on many portions of the coast, ever since the fishery has been vigorously pushed. A study of the habits of lobsters indicates that such a decrease is far more possible with that species than with the true fishes, which are, as a rule, more secure from the attacks of man.

That a decrease has taken place, and that in some regions it has amounted to a serious loss, is attested by the statements of numerous fishermen and dealers, which are quoted at some length in the report above mentioned.

All the States interested in the lobster fishery, excepting New Jersey, whose fishery is small, have enacted protective laws; but, either because these laws are inadequate or are not properly enforced, they have failed to stop the decrease, though they may have checked it more or less. As a result, the fishery is falling off in the United States, and we are even now dependent, to a greater or less extent, on the British Provinces for the supplies of our larger markets. The same trouble exists in Europe, where the lobster fishery is, of course, of much older date than in this country, and where it has been controlled by legislation for many years. Many elaborate reports have been published upon the European fishery by experts appointed to investigate its condition and needs, but they are apparently at as much loss there as we are here regarding the methods and benefits of protection. In Norway, which country possesses the most important European fishery, they have, as a last resort, sought relief through the aid of artificial lobster culture, and experiments to that end have been carried on for several years. In the United States, where the methods of fish culture are best understood and have been most productive of beneficial results, it is natural to suppose that the same course would have been often suggested, and such has really been the case. None of the trials up to this year have, however, been made according to the most approved methods of fish propagation, and insufficient means for carrying on any such practical experiments with respect to salt-water species of fish have alone prevented the Fish Commission from engaging in this work before.

It would be impossible, within the limits of this paper, to cite even a portion of the evidence bearing upon the decrease of lobsters which has

been collected, but following are a few of the remarks with which this subject is introduced in the report already referred to:

"An illustration of the rapidity with which the lobsters of a small area may be caught up, is furnished by a salt-water inlet on the coast of Maine, in which lobsters were at one time very abundant. This basin opens directly into the sea, and is sufficiently large to have afforded a remunerative fishery to several lobstermen. Two years' time was sufficient to reduce the supply of lobsters to such an extent that fishing became unprofitable. After an interval of about five years they again became abundant, and the supply was once more exhausted. Had this inlet not been so situated that it readily received supplies from without, it is probable that it would have required a much longer time to become replenished.

"On a much larger scale has been the depletion of the once noted grounds about Cape Cod, Massachusetts, which at one time furnished nearly all the lobsters consumed in New York City. In the early part of the century, this fishery was entirely in the hands of fishermen from other States, principally Connecticut, who came to Cape Cod with their smacks, and, after catching a load, carried it to New York or Boston. As early as 1812 the citizens of Provincetown realized the danger of exhausting the grounds about their town, and succeeded in having a protective law passed by the State legislature. More or less stringent regulations respecting the lobster fishery of Cape Cod have been in force from that time down to date, and they have probably done good service in prolonging the fishery; but the period of its prosperity has long since passed, as continued overfishing has so exhausted the grounds on almost every portion of Cape Cod that they are no longer profitable even to the few men who still set their traps there. From the sketch of this region, given further on, it will be seen that the decrease has not been a temporary one, although an entire rest for a long period of time might possibly allow it to recover more or less of its former abundant supplies. As it is, no large catches are now made, and but few lobsters are carried away from the Cape.

"The immediate vicinity of Provincetown has suffered most in this respect, but scarcely more than any portion of the coast from that town to Boston on the one side and to New Bedford on the other. A delay in the publication of this report enables the writer to add a note for the southern portion of this region, covering the period down to July, 1885. Vineyard Sound proper and the vicinity of Wood's Holl, Mass., have afforded but poor catches for a number of years, but the region about Gay Head has continued to attract the lobstermen down to the present time. Each succeeding year, however, lobsters have appeared to be less plentiful, and during the spring months and June of 1885 scarcely anything has been done. The fishermen are discouraged, and are forced to attribute the scarcity to overfishing, the possibility of which many of them have all along denied. At Cuttyhunk Island the catch for

1885 was less than one-fourth that for 1880, and the same was reported of the remainder of the Elizabeth Islands, No Man's Land, and Gay Head.

"In the waters of Rhode Island and Connecticut a large decrease of lobsters is reported by many of the fishermen, and the increased catch for the few years preceding 1880 was obtained only by the use of a much larger number of traps than was employed formerly. Although the fishery in those States was begun very many years ago, it is only within comparatively recent times that it has been extensively carried on.

"On the coast of Maine the evidences of decrease are very strong, especially as regards the shallower areas, but the rapid extension of the grounds into comparatively deep water has made the actual decrease less apparent. The rocky bottoms of the coast of Maine are also supposed to afford the lobsters greater protection than the sandy ones to the south, and in many places the traps cannot be set as closely together, nor is it probable that the lobsters in such localities move about as much in search of food.

"The greatest decrease has occurred within the past 15 to 20 years, or since the establishment of numerous canneries and of the perfected methods of transporting fresh lobsters to all parts of the country. The demand being so much greater than the supply, there are no restrictions on the amount of the catch beyond those imposed by the State laws or resulting from the scarcity of lobsters. Fish are among the greatest enemies of the lobster, and cod are known to consume enormous quantities; but nature has provided against their extinction by such means, and it is man alone who has disturbed the balance."

The above remarks were based mainly upon the fishery investigations of 1880, since which evidences of continued decrease have been constantly received. About a year ago, a prominent Boston dealer wrote that he was receiving large quantities of lobsters from Nova Scotia, as the Maine fishery was totally inadequate to supply the demand, the amount obtained from that State having been less than in previous years.

One of the strongest evidences of decrease in abundance is afforded by the continuous decrease in the average size of the lobsters sent to the markets. The exact amount of this decrease is not determinable, as no records bearing upon this subject were made prior to 1880, but the fact was granted by the fishermen and canners, even in those regions where a perceptible decrease in numbers was not admitted. The average weight of the lobsters marketed in most places in 1880 was estimated to be about two pounds each. A New Haven correspondent stated that the average length of the lobster sold in the markets in that place in 1880 was about 10½ inches, and the average weight about two pounds, against an average length of about 13 inches and an average weight of about three and one-half pounds 20 years ago. In Boston the market lobsters ranged but little above the limit in size permitted

by the State laws, and that seems to be the case nearly everywhere. In Portland, Me., the average length of the lobsters marketed in 1880 was about 10½ inches, and in Boston 11 to 11½ inches, while in New York City the range in size was from 10½ to 15 inches.

The facts above stated apply only to the larger distributing centers, where custom had prescribed the minimum limit in size of the lobsters marketed, before protective laws were enacted. At that time there was an abundance of large lobsters, and the smaller individuals were regarded as of little account for the fresh trade. They have, however, been used for a long time by the canneries on the coast of Maine, by the fishermen as bait, and to supply local demands. The quantity of lobsters consumed, measuring less than 10 inches in length, is, therefore, very great, and on some portions of the Maine coast the canneries make use of only those that are too small for the fresh-market trade. In fact, the greater proportion of the lobsters now canned are less than 10 inches long. From these statements it will be seen that there is a steady demand for lobsters of all sizes, and that but a limited protection is afforded either by laws or custom.

RANGE AND MIGRATIONS OF LOBSTERS.

The American lobster has been taken as far south as off Cape Hatteras, N. C., where a single medium-sized individual (13 inches long) was dredged from a depth of 49 fathoms, by the Fish Commission steamer Albatross, in 1884. Two or three examples have also been recorded from the northeastern part of the sea-coast of Virginia, but the Delaware Breakwater may be regarded as practically the southern limit of its range, although it is not at all common at that place, and is rarely fished for. Lobsters are somewhat more abundant off Atlantic City and Long Branch, New Jersey, where they afford a limited fishery, and in New York Bay and the adjacent regions they were at one time quite plentiful, but overfishing and the pollution of the waters have almost entirely exterminated them there. Passing eastward through Long Island Sound, they gradually increase in abundance as we approach the Block Island region, and from there to the extreme northern limit of the coast of Massachusetts, wherever the bottom was suited to them, they were formerly exceedingly abundant. The first important fishery originated along this section of the coast, Cape Cod at one time having furnished New York City with nearly all of its supplies. The sandy shores of New Hampshire are not so prolific in lobsters as are those of either of the adjoining States. Maine is now the principal source of supply for all the larger markets of this country, the yearly fishery of that State greatly exceeding in quantity and value those of all the other States combined.

Most of the British maritime provinces abound in lobsters which are especially plentiful on both the ocean and gulf coasts of New Brunswick and Nova Scotia, these two countries now affording the most ex-

tensive lobster fishery in the world. They appear to be much less common in Newfoundland and Labrador, possibly because they have been less fished for there.

Lobsters are not known to migrate, excepting over very short distances, mainly in the spring and fall, when they change their grounds, moving into deeper water on the approach of cold weather, and returning nearer to the shore in the late spring. The fall migrations are solely for the purpose of escaping the cold of winter, the shallower summer grounds probably furnishing a better supply of food. The extent of the movements depends more or less upon the character of the coast, for where the bottom slopes off very gradually they will need to go a much greater distance to reach a suitable depth of water than where deep holes occur near their summer grounds. The summer fishery is mainly in depths of a very few to 15 or 20 fathoms, the winter fishery in 25 to 60 fathoms. On the coast of Maine the traps are sometimes set in such shallow water that they lie partly exposed at low tide. Formerly some fishing was done along the shores by means of gaffs and dip-nets, but lobsters rarely occur in such favorable localities now.

It is supposed that lobsters do not travel much along the coast, though they probably change their grounds from time to time in search of food. On some portions of the coast the fishermen claim to have good evidence of the schooling of lobsters, and state that the schools appear and disappear suddenly, indicating the possession of certain migratory habits, but there is no proof that their migrations extend far, and they are very different in character from those of the true fishes. We have no evidence to prove that any one region has been directly benefited by large accessions from an adjoining region, and the extent to which some districts have been depleted by overfishing without subsequent recovery indicates that the supplies of one region are but little dependent upon those of another, at least not for immediate relief. The Cape Cod lobster fishery has been at a low standing for many years, and although but few men have engaged in the fishery of that region for a long time, there are, as yet, no signs of improvement.

SPAWNING SEASON AND HABITS, DEVELOPMENT AND RATE OF GROWTH.

Lobsters are found with spawn attached to the abdomen during the entire year. This fact is recorded of both the American and the European species, but the length of time they are carried before hatching and the limits of the hatching season are not precisely known. As regards the European crayfish, a freshwater crustacean closely related to the lobster Professor Huxley states: "The process of development is very slow, as it occupies the whole winter. In late springtime or early summer, the young burst the thin shell of the egg, and, when they are hatched, present a general resemblance to their parents. This is very unlike what takes place in crabs and lobsters, in which the young

leave the egg in a condition very different from the parent, and undergo a remarkable metamorphosis before they attain their proper form."

The smackmen of the southern New England coast claim that the eggs hatch in the wells of their smacks in the greatest abundance, from some time in May until late in July, but that at other seasons they have never seen any embryo lobsters, although the smack trade in lobsters is kept up during nearly the entire year. During the season mentioned, the surface of the water in the wells of the smacks often becomes perfectly alive with the young, and they may be scooped up by the hundreds of thousands. This evidence is tolerably conclusive as to the duration of the principal hatching season, and determines the period when experimental work in artificial propagation can best be undertaken. The fact that a few of the eggs contained in the jars at the Wood's Holl station of the Fish Commission hatched during November of this year indicates, however, that some hatching may take place at other seasons, as the conditions under which the eggs were kept were perfectly normal, the water being of about the same temperature as that of the harbor outside. Hatching is supposed to begin somewhat later farther north.

The writer was, at first, inclined to believe that the hatching continued to a considerable extent through the entire year, basing his conclusions upon the fact that, during the months of August and September last, eggs were found in various stages of development, from the freshly laid and totally opaque ones to others in which the dark greenish yelk sack occupied scarcely more than one-half of the area of the egg, the remainder being transparent and clearly showing the structure of the embryo. Some of these eggs, preserved in the hatching-jars, were carefully examined from day to day, and, although they exhibited a certain amount of progress, development was slow. It finally became evident that the development of the eggs was being retarded by some cause, presumably the lower temperature of the water, and this result, coupled with the statements of the fishermen, that embryos are seen only in May, June, and July, makes it probable that the hatching of lobster eggs at other seasons is only an accidental or occasional occurrence. It is also not at all improbable that the young hatched during cold weather perish soon after they leave the egg, as they did at Wood's Holl in November last.

The hardy character of the lobster eggs, before referred to, favors the idea of a long period of development, and they appear to be well adapted to endure the hardships of a long winter. The rough handling to which they were sometimes subjected, in connection with the experiments of last summer, did not seem to harm them in the least. It is also probable, from this quality of the eggs, that they are not destroyed to any extent, in nature, unless actually eaten from the swimmerets of the parent by predaceous fishes, and that the chief assistance which artificial culture can give, in an attempt to increase the supply, must be directed toward protecting the embryos from the period of hatching.

Embryo lobsters are seldom seen at the surface in the open waters about our coast and have rarely been taken in the towing net. Prof. S. I. Smith, who has studied the younger stages, obtained his specimens during July, mainly in Vineyard Sound, near Wood's Holl, Mass. Nothing positive is known respecting the habits of lobsters during the spawning season. It has been stated with reference to lobsters marketed in Boston, that berried lobsters are seldom seen measuring less than about 10½ inches in length, and it is probable that they rarely begin to spawn before attaining that size. However, a few smaller ones were observed at Wood's Holl during the summer of 1885. In a lot of fifty-two berried lobsters, examined at that place in September, three measured less than 10 inches, the smallest having been 9½ inches long; eight were between 10 and 10½ inches; ten between 10½ and 11 inches; fifteen between 11 and 12 inches; eleven between 12 and 13 inches, and five between 13 and 14 inches. The measurements were made from the tip of the rostrum to the end of the telson, not including the hairs.

The development of the younger stages of lobsters has been studied by Prof. S. I. Smith, for the American species, and by Prof. G. O. Sars, for the European. The eggs, when first emitted, are entirely opaque and of a dark green color, sometimes almost black. Professor Smith examined the well advanced eggs at Wood's Holl, in May. They were not perfectly round, measuring a trifle more than two millimeters (about one-twelfth of an inch) in their longest diameter. One side was still dark, due to the unabsorbed yelk mass, and the other more or less transparent, showing the eyes as two large black spots, and the outlines of the carapax and legs. All of these features are readily made out under a low-power objective. Soon after hatching they measure about one third of an inch in length, and resemble in appearance and structure a low group of shrimps, called the Schizopods, which are common on some portions of our coast. The eyes are bright blue, while portions of the body and its appendages are marked with orange of different intensities, rendering them very conspicuous objects. The swimmerets are not yet developed. In the second stage, which resembles the first, they have increased somewhat in size, and have obtained the rudiments of a portion of the swimmerets. In the third stage they measure about half an inch long, and the shell has become firmer than before. In the next and last stage observed, the embryo is about three-fifths of an inch long; it has lost all of the characters in which it resembles the Schizopods, and has assumed the more important features of the adult. It still retains the free-swimming habit and is very active in its movements, frequently jumping out of the water by means of its caudal appendages. This stage was frequently taken from the 8th to the 20th of July, and Professor Smith thinks that the larva passes through all of these stages in the course of a single season. The stages immediately following the above were not observed.

The young, like the adult lobster and the crabs, increase in size by molting, or casting off the shell covering the body, a new shell rapidly forming in place of the old one. During the first season, as above described, the molts are frequent, and the embryos remain at the surface of the water as free swimmers, but how long the young, after reaching the lobster-like form, retain this free-swimming habit was not ascertained. As the lobsters increase in size, it is evident that molting occurs less frequently, and in the adults probably only once a year.

The rate of growth of lobsters has not been determined, and at present we have no means of telling the age of a lobster measuring 10 inches in length. A few measurements have been made showing the amount of increase at certain molts, but it is not always constant, even for lobsters of the same size, and not knowing the frequency of molting or shedding, we have no way of computing the rate of increase. One lobster measuring 8 inches before shedding was said to measure 10 inches after shedding; another, 10 inches before and 12 inches after shedding; a third, 10½ inches before and 11¾ inches after shedding; a fourth, 10½ inches before and 12 inches after shedding. Ten-inch lobsters are probably at least five or six years old, but such estimates are only the result of guesswork, and may be very far out of the way.

EXPERIMENTS PREVIOUSLY MADE IN LOBSTER CULTURE.

In the United States the only practical attempts that have yet been made toward the artificial propagation of lobsters have been in connection with the so-called "parking" of lobsters—that is to say, their protection in large inclosed natural basins, primarily for the purpose of perfecting them for market, and of retaining conveniently at hand at all seasons a large reserve stock. In these parks the young lobsters taken by the fishermen are allowed to attain the adult size, the soft-shelled individuals to become hardened, and injuries to be repaired. Under such natural conditions, it is reasonable to suppose that the breeding habits would continue normal, and that large quantities of spawn would be hatched; but whether the young would survive and increase in sufficient numbers to render the scheme profitable, if carried on for this purpose alone, has not been determined, though none of the projects had been continued long enough to give satisfactory results, at last accounts. Two such parks in the United States have been specially called to our attention. The first was established on the coast of Massachusetts in 1872, and was afterwards abandoned, though for what reasons we do not know. The second was started in 1879 or 1880, on the coast of Maine, and is, we believe, still in operation.

The latter is a small inclosed bay, with a narrow entrance, through which the passage of all objects above a very small size is prevented by a screen of wire netting. This bay had previously furnished good lobster fishing, and was much resorted to by fishermen. It contains an

abundance of food suitable for lobsters, and toward the center has a sfficient depth of water, with soft bottom, to afford some protection to the lobsters during the colder part of the year. Into this park large quantities of soft-shelled lobsters, of lobsters minus one or both claws, as well as of young individuals under the legal size of 10 or 10½ inches, have been placed for growth and repair, and it is claimed that the results have been very satisfactory in that particular. At the beginning of cold weather the lobsters retire to the deeper parts of the bay, and at times, when the water has been calm and clear, they have been observed almost completely buried in the mud, with only their feelers, eyes, and a small portion of the front of the carapax exposed. Many of the injured lobsters first placed in the park were females with spawn, and since then berried lobsters have been purposely added from time to time. Young individuals of different sizes were said to have been abundant at last accounts, but in an experiment of this character a considerable lapse of time is required to test its merits. As such parks do not depend for their practical success solely upon the rearing of the young, but rather upon the perfecting of market supplies, which come from the traps in poor condition, it is possible that they may be made to pay if carried on economically. Their effect upon a general increase of supplies would probably never be very great.

So far as we are aware, experiments upon the propagation of lobsters in Europe have been confined mainly to Norway, and were commenced there in 1873. The first report upon this subject was published in 1875. The berried lobsters were kept in boxes, constructed so as to retain the embryos after hatching. The young remained alive for several weeks, and their habits and the causes of their destruction were carefully studied. The results of these experiments will be of great service in the treatment of the young at the Wood's Holl Station next summer. Mr. Dannevig's more recent investigations in the same line have been noticed above.

TRANSPLANTING OF LOBSTERS.

Of great interest in connection with the artificial propagation of lobsters, and bearing upon the same subject, is the question as to whether lobsters can be successfully transplanted from one region to another. This experiment has already been tried two or three times, but so far without success. The transportation of live lobsters long distances, even by railroads, has been accomplished, and they have also been carried from this country to England. Mr. Livingston Stone made three attempts to introduce the East Coast lobster on the coast of California, and on the last trial succeeded in planting a number of living individuals near the mouth of San Francisco Bay. As full accounts of these experiments have already been published by the Fish Commission,* we do not need to repeat them here.

*Report U. S. Com. of Fish and Fisheries, Part III, pp. 259–265, 1873–'75 (1876); Part VII, pp. 637–644, 1879 (1882).

The successful transplanting of lobsters must depend upon the new region affording conditions sufficiently like those of the old to favor the growth and reproduction of the species; but the relative conditions of different regions have never been carefully studied with this object in view, and we are to-day unable to state precisely in what manner the Pacific coast waters agree with, or differ from, those of the Atlantic coast. Neither the temperatures nor the specific gravity of the waters of the two coasts have been compared, and it is only through incidental experiments that the fact has been ascertained that a few species from each coast are able to live and thrive upon the other. The conditions that are essential to, or control the existence of a species in a new region undoubtedly vary more or less according to its organization, and the effects of changes of location upon the higher crustacea have been but little studied, if at all. Above all the new-comer must have the power to sustain itself in the struggle for existence with those forms which already occupy the ground, and have been accustomed to it from long habit. Careful studies and experiments in this line of research, with reference to marine forms, would be of great practical benefit to the aims of the Fish Commission, and would probably lead to the transplanting of many kinds of marine products to regions which are now poorly supplied with edible forms.

A sort of transplanting of young lobsters has been going on along the New England coast, and especially the southern portion of it, ever since the well-smack lobster trade began. The fact was mentioned above that immense quantities of embryo lobsters appear at the surface of the wells in the carrier smacks during the hatching season, and as the smacks journey along they work out through the holes in the bottom of the well, and are thus constantly adding to the supply of the regions through which the smacks pass. It is unquestionable that the abundance of lobsters on the southern New England coast has been partly kept up, and probably increased at times in the past, by this transplanting of the young, and this fact was noticed and referred to over thirty years ago. The fishermen have the greatest respect for the embryo lobsters that appear in the wells of their smacks, and take great pains that no harm shall come to them.

Numerous accounts have appeared in the newspapers, from time to time, since this transplanting occurred, to the effect that many young lobsters, supposed to be the progeny of those brought over by Mr. Stone, had been taken by the fishermen in the vicinity of San Francisco. Careful investigation, however, has failed to substantiate these reports, and the few small lobsters, so-called, that have been referred to naturalists, have proved to belong to another related genus, quite common on the California coast, but the species of which never grow to a length of more than 3 or 4 inches.

WASHINGTON, D. C., *December* 16, 1885.